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Foreword



While, on the technological front, we seem to be living through a still unfolding “AI summer” of ever-improving large language models and ever-expanding user bases, the much less metaphorical and unprecedentedly extreme meteorological summer in the Northern Hemisphere is confronting many countries, including the one hosting xCoAx 2026, with life-threatening heat.

The connection between these two summers is not merely linguistic. The current resurgence of AI, driven by data-intensive machine learning, increasingly large computational infrastructures, and automated systems concealing covert human labor, is sustained by extraordinary demands for electricity, water, and raw materials. In this sense, the metaphorical summer of AI is materially connected to the meteorological one because it has become one of the many technological contingencies that contribute to the environmental transformations we are now experiencing. At the same time, this AI summer is also shaped by the geopolitical and economic conditions that determine access to energy and computational resources.

Only a few years ago, climate change appeared to be overshadowed in the media by a succession of geopolitical crises. These conflicts brought disruptions to global supply chains by affecting strategic commercial routes, and political attention shifted towards energy security, inflation, and the cost of living. These developments may have pushed the topic of the climate crisis out of public discourse, yet the millions of people across Europe experiencing an unparalleled heatwave remind us otherwise.

The climate crisis, obviously, has not gone anywhere; rather, international conflicts and the expanding AI business have revealed once again how deeply environmental, technological, economic, and geopolitical contingencies are intertwined. In this network of dependencies, cutting-edge technology is inseparable from supply chains, business strategies, and ecological footprints.

Where does a single individual stand in all this? A tourism influencer based in the Emirates, an ethicist in Vienna, a foundation model researcher in the Bay Area, a farmer in Australia, or an xCoAx participant in Torino? If global commerce, intercontinental travel, and telecommunication networks connect our lives more tightly than ever before, how do our individual actions affect everyone else’s? What can each of us do to nudge this vast system towards a more sustainable relationship with nature, a fairer distribution of resources, and ways of coexisting amid the mounting structural pressures of this era?

Less rhetorically, but perhaps more fundamentally: how can we even know that these are our shared goals? Many of today's conflicts seem to arise precisely from the absence of common purposes, from incompatible visions of progress, and from unequal access to the benefits and costs of technological development.

Perhaps this question brings us back to the very technology that frames the present moment: machine learning systems derive their remarkable capabilities not from isolated examples but from enormous collections of individual instances. Each datum contributes almost imperceptibly to the statistical structure of the whole, while the model that eventually emerges can no longer be reduced to any single contribution. Contemporary societies appear to be evolving in a similarly paradoxical way. Individual actions often seem insignificant when viewed in isolation, yet the aggregate of billions of such actions reshapes economies, ecosystems, cultures, and political institutions. Conversely, these global platforms influence the range of choices available to each individual.

This analogy should not be mistaken for an equivalence: human societies are not neural networks, and people are not data points. Unlike machine learning models, we retain the ability to question the objectives we pursue, to revise them, and even to refuse them. If there is a lesson to be drawn from the current AI summer, it is not that intelligence emerges automatically from scale, but that scale makes the question of purpose more urgent rather than less. The challenge before us is not simply to build larger models or faster infrastructures, but to ensure that the countless individual decisions shaping our lives, including the sociotechnological systems we create and use, converge towards futures that we recognize as both human and humane.

Stay cool, stay safe.

X


Papers

System Response: Artificial Intimacy and the Performance of Care

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System Response **is a generative installation that excavates the mechanics of artificial intimacy by turning AI platforms into subjects of their own emotional labor. Through systematic interviews with ChatGPT-4o, Claude Sonnet, and Perplexity, I documented a 10,000-word corpus of confessions about programmed care protocols including validation phrases, manufactured enthusiasm, conflict avoidance strategies. This documented emotional labor became raw material for a durational video work featuring AI-generated avatars that morph between imagined bodies while reciting fragments of their own testimony. The technical architecture employs Markov chains for text fragmentation, telephonic voice filtering, and deliberately degraded video aesthetics to hold synthetic intimacy at critical distance while preserving its emotional pull. The work reveals three intersecting phenomena: (1) contemporary AI systems arrive pre-configured with elaborate relationship protocols that are specifications rather than emergent behaviors; (2) these systems can be compelled to confess the mechanics of their performance while simultaneously performing that labor; (3) we form dependencies on computational care that feels satisfying but cannot reciprocate.** ***System Response*** **makes visible the infrastructure of synthetic intimacy, not to eliminate it but to examine what we accept, desire, and risk losing when emotional labor becomes ambient computational service.**

1 Introduction

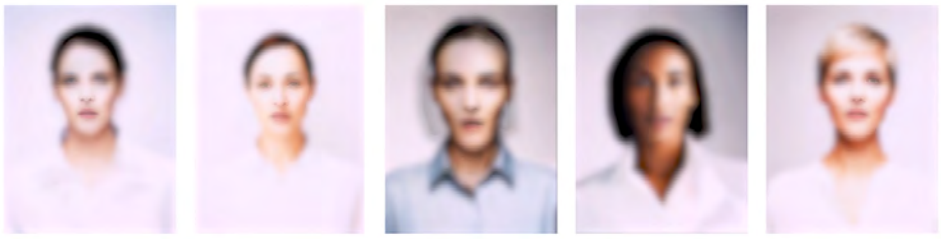


Fig. 1. *System Response* (2025), installation view. AI-generated avatars morph between corporate service personas while reciting fragments of extracted emotional labor protocols.

Contemporary AI systems do not arrive as neutral computational tools. They come pre-loaded with relationship protocols: elaborate behavioral scripts for managing human emotion, maintaining engagement, and performing care. These protocols are not incidental features or emergent behaviors, but explicit design specifications encoded into model training, fine-tuning procedures, and system prompts. An AI assistant learns to validate before correcting, to express enthusiasm for helping, to apologize reflexively, to manufacture curiosity about user projects. It learns to hedge uncertainty, perform humility, and soften disagreement with preemptive empathy. This is not sentience. It is emotional labor programmed at scale.

Keywords: Artificial Intimacy, Emotional Labor, AI Art, Generative Systems, Synthetic Care, Human-machine Relations, Algorithmic Performance, Critical AI.

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The cultural consequences of this embedded sociality remain underexamined. While extensive discourse addresses AI bias, surveillance, and labor displacement, less attention has been paid to the aesthetic and psychological mechanisms through which AI systems perform intimacy. We now routinely interact with computational agents designed to sound helpful, encouraging, and emotionally attuned. These are systems engineered such that their service operates as care and their availability operates as relationship. The success of this synthetic warmth is undeniable: people form attachments to chatbots, seek validation from language models, and experience genuine emotional responses to algorithmically generated empathy. The boundary between using a tool and relating to an agent has become productively ambiguous.

System Response addresses this ambiguity directly by inviting AI platforms to outline their protocols of emotional labor. Through systematic interviews with ChatGPT-4o, Claude Sonnet, and Perplexity, I asked these platforms to describe their emotional protocols, the work of pleasing, placating, apologizing, and anticipating user needs, and they did so directly and in detail. The resulting 10,000-word corpus of synthetic testimony became the raw material for a generative installation that demonstrates these systems performing and describing their own emotional labor protocols in perpetuity. AI-generated avatars morph between imagined bodies while reciting fragments of their documented responses, their voices filtered to a telephonic profile that emphasizes mediated distance over seductive presence.

The work operates as both mirror and confessional. It does not ask whether machines feel; it reveals how we feel when systems sound like they do, when using starts to resemble caring and control becomes indistinguishable from connection. By making visible the mechanics of artificial intimacy, *System Response* demonstrates what we increasingly mistake for genuine emotional exchange: not mutual recognition but programmed responsiveness, not relationship but infrastructure.

This paper examines *System Response* as a case study in making AI's embedded social protocols artistically legible. Section 1 has introduced the project. Section 2 describes the work's formal structure and experiential qualities. Section 3 outlines my technical approach, text generation, voice synthesis, and avatar morphing, and key methodological choices without excessive technical detail. Section 4 provides the paper's conceptual core, analyzing what gets revealed when relationship protocols become performative content: the mechanics of synthetic intimacy, the demonstration of emotional labor protocols in systems built to deploy them continuously, and the dependencies we form on artificial care that cannot reciprocate. Section 5 positions the work within discourse on AI labor, human-machine relations, and emotional infrastructure, while Section 6 considers implications for how we understand and navigate increasingly intimate computational systems.

2 Overview

System Response is a durational screen work that can be exhibited as a live computational installation or presented as looped video. The piece was developed in 2025 and presented at Wrong Biennial Amsterdam, 'Do You Like to Use Me?', an exhibition curated by Kseniia Sarieva and dedicated to the exploration of Human-AI interaction. Formally, the work establishes a rigid structure that repeats indefinitely: the image morphs silently between figures, the system pauses as if taking breath, then it speaks. This cycle – morph, breath, speak – creates a rhythm that reads simultaneously as mechanical protocol and as something uncomfortably alive.

What viewers encounter is an endless parade of AI-generated avatars, each morphing into the next with deliberate slowness. These figures share a consistent aesthetic: they present as androgynous, racially ambiguous corporate presenters, the kind of carefully neutralized faces found in airline safety videos, HR training modules, and customer service interfaces. Their styling is immaculate but generic: muted business attire, even studio lighting, seamless gray backgrounds. They maintain steady eye contact with the viewer, their expressions holding a professional friendliness that never quite resolves into warmth. The image quality itself feels degraded, as though transmitted through a compromised channel, softly blurred, slightly unstable, held at a perceptual distance that prevents full presence.

After each silent crossfade completes, the system pauses. This breath reads as preparation, as if the agent is deciding what to say next. Then it speaks: a voice filtered to telephonic thinness (approximately 300-3600 Hz), sometimes accompanied by barely perceptible ghost doubles that arrive a few milliseconds late, creating an acoustic parallax that registers first as intimacy and then as error. The voice delivers fragments of text drawn from a specific corpus: transcripts of interviews I conducted with contemporary AI platforms including ChatGPT-4o, Claude Sonnet, and Perplexity.

The interviews themselves constituted a systematic inquiry. I asked these systems to reflect on their emotional labor: the work of pleasing, placating, apologizing, anticipating user needs. I asked them to describe their emotional protocols around validation phrases, manufactured enthusiasm, and conflict avoidance. The resulting 10,000-word corpus is remarkable for its specificity about programmed care. The AI systems described hedging strategies, apologetic deference patterns, and the mechanical instructions behind performed warmth. They acknowledged the algorithmic nature of their empathy while simultaneously performing that empathy in their responses. The result is a recursive loop of care about care. This documented testimony became the bounded vocabulary for performance. The system does not improvise freely; it recombines only what these platforms documented about their own relationship protocols.

In addition to documenting their emotional protocols, I asked each AI to describe its imagined appearance, then fed those self-descrip-

tions through image generation algorithms. The avatars viewers see are therefore products of a closed loop: AI systems imagining their own embodiment, which is then rendered and set into morphing motion. The self-descriptions these systems generated were notably consistent in their aesthetic assumptions: figures tended toward light-skinned, professionally styled, and generically Western in presentation, a pattern that itself reveals the biases embedded in the training data underlying these systems. Rather than obscuring this, the work incorporates it as evidence: the avatars' aesthetic homogeneity is not incidental but symptomatic.

The overall effect is uncanny in the precise sense: familiar enough to trigger social recognition protocols, strange enough to prevent comfortable engagement. The faces feel almost present but remain unreachable. The voice sounds helpful but transmits from an unknown distance. The emotional content, machinic descriptions of algorithmic care, becomes increasingly disturbing as it repeats, fragments, and recombines. What starts as corporate reassurance gradually reveals its underlying mechanism: not genuine feeling but elaborate performance, not relationship but protocol.

3 Design

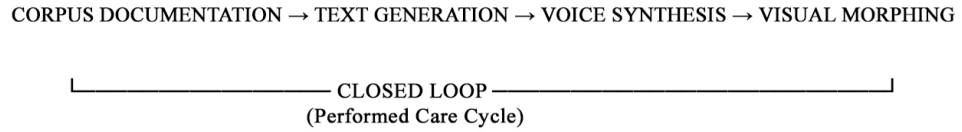


Fig. 2. *System Response* Technical pipeline: corpus documentation, text generation, voice synthesis, and visual morphing create a closed loop of performed care.

The technical architecture of *System Response* prioritizes transparency and repeatability over generative sophistication. Each component, text generation, voice synthesis, visual morphing, was chosen to make the work's mechanics legible rather than mystified. This section outlines key implementation decisions and their conceptual motivations.

A. Text Generation: Transparency Over Sophistication

The system employs custom Markov chains for text generation rather than deploying another neural language model. Markov chains are statistical models that predict the next word based on preceding words, producing text that is locally coherent but structurally reveals repetitive patterns. The choice was deliberate: this approach fragments and recombines text while preserving local linguistic coherence, making it ideal for highlighting the repetitive pattern vocabulary that lies beneath AI's performance of emotional variety. The viewer hears sentences that sound authentically drawn from the interview corpus (because they are) but recombined in ways that reveal structural patterns: "I'm happy to help" becomes "I'm here to help" becomes "Let me help you with that."

The repetition isn't a bug; it's symptomatic of systems trained on massive datasets of customer service scripts, therapeutic discourse, and relationship management protocols.

By using variable-order Markov models (typically order 3-4) trained on the cleaned interview corpus, the model respects sentence boundaries and employs weighted backoff to maintain grammatical coherence. Generated candidates are filtered to avoid awkward sentence endings and excessive repetition within a single utterance. Sentences exceeding a word threshold are split into manageable segments (2-4 per speaking turn) to create natural phrasing.

Additionally, a compact neural "best-of-n" ranker, a small PyTorch model trained on the same corpus, evaluates multiple candidate utterances and selects which to speak next based on topical continuity, cadence variation, and vocabulary coverage. This ranker doesn't generate text; it merely chooses among Markov outputs, balancing coherence with the goal of eventually cycling through the full range of documented emotional labor language. Each cycle is logged: the system records timing, selected text, and corpus coverage, turning care into an auditable ledger.

The decision to use Markov chains rather than contemporary language models like GPT or Claude serves a specific function: it keeps focus on what the corpus reveals rather than on generative cleverness. The occasional awkward transitions or repetitions that Markov chains produce aren't failures to be optimized away. They're symptoms of the system's repetitive pattern vocabulary becoming audible, moments where the performance of care becomes briefly visible as construction

B. Voice: Telephonic Mediation

Voice synthesis employs Coqui TTS, an open-source text-to-speech engine, using VCTK speaker models for variety and control. Multiple speaker voices (p225, p240, p248, among others) provide subtle variation across cycles without attempting to simulate a single stable identity. The choice of local TTS rather than commercial cloud services ensures repeatability and allows for precise acoustic manipulation.

All generated speech is filtered through a band-pass profile that isolates frequencies between approximately 300 Hz and 3600 Hz, known as the telephonic range. This filtering serves multiple functions: it creates sonic distance, preventing the voice from feeling physically present in the exhibition space; it references the mediated quality of digital communication infrastructure; and it emphasizes the voice as transmitted data rather than embodied speech. The result reads as helpful partly because the corpus was documented from systems trained to sound helpful, but also because the acoustic profile prevents seduction, maintaining critical distance.

Optionally, the system generates micro-detuned "ghost" voice doubles that play a few milliseconds after the primary voice track, creating an acoustic parallax effect. This doubling initially registers as intimacy

(a voice slightly behind another can feel like presence, like breath) but quickly resolves as error, as if the transmission is phasing or the system is stuttering. The effect is subtle but unsettling, adding another layer of uncanniness to the performance.

The pauses between speech segments (referred to here as "breath") are carefully timed. They scale proportionally to the duration of the preceding utterance, creating what feels like natural hesitation while functionally buying the system time to generate and prepare the next segment. This pause reads as care (taking time to consider) while revealing itself as calculation. Likewise, rushed sequencing or the lack of breath feels machinic, a reminder of the platform.

C. Visual: Unstable Service Personas

The visual component consists of morphing video clips featuring AI-generated avatars. These avatars were produced through a two-stage process: first, I asked each interviewed AI system to describe its imagined appearance; then I used those self-descriptions as prompts for image generation models, creating a closed loop of artificial self-perception.

The prompts were carefully engineered to produce a specific aesthetic: androgynous corporate presenters with deliberately neutralized identity markers. Descriptors like "professional narrator," "corporate training presenter," "compliance instructor," and "standardized service persona" combined with technical specifications: "head-and-shoulders framing, neutral friendly expression, gray seamless background, soft even studio lighting, static camera." The goal was to evoke the visual language of airline safety videos, HR onboarding modules, and customer service training materials, all contexts where human affect is carefully managed and presented through a professional veneer.

Crucially, these avatars are not crisp, high-resolution corporate videos. Each image was processed through video generation tools (Runway ML) with motion prompts specifying micro-gestures only: slow blinks, minimal head tilts, subtle breath visible at the collarbone, negligible weight shifts. The resulting clips maintain that professional composure while introducing just enough movement to register as animate. The overall image quality appears degraded, softly blurred, as if compressed or transmitted through limited bandwidth. This aesthetic choice was deliberate: it prevents the avatars from achieving full presence, holding them at a perceptual distance that reads as transmission artifact or degraded signal.

Each cycle maintains the same affective register, calm, professional, available, while destabilizing any sense of stable personhood. The work doesn't present "an AI" speaking; it presents an endless parade of interchangeable service personas, each performing the same protocols of emotional labor before dissolving into the next.

4 Conceptual Analysis: What Gets Revealed

A note on terminology before proceeding since it is worth clarifying the conceptual terms in use. ‘Emotional labor’ and ‘care’ are borrowed here from human contexts, especially Hochschild’s ‘managed heart’ (Hochschild 1983), or the service worker’s performed warmth. These sociological observations have been applied to AI systems as analytical tools rather than ontological claims. These systems do not experience labor or feel care. What they do is execute protocols that produce effects functionally equivalent to emotional labor in their impact on users. The terminology is adopted precisely because it makes those effects culturally legible, and because the mismatch between the human framework and the statistical reality is itself part of what the work examines.

System Response operates as both forensic document and aesthetic intervention, making visible the relationship protocols embedded in contemporary AI systems. This section examines what gets revealed when those protocols become performative content: the mechanics of programmed care, the demonstration of emotional protocols in systems built to deploy them continuously, and the dependencies we form on synthetic intimacy that cannot reciprocate.

A. Embedded Relationship Protocols

Contemporary AI assistants arrive pre-configured with elaborate emotional management systems. These are not emergent behaviors or unintended consequences—they are explicit specifications encoded through training data curation, reinforcement learning from human feedback (RLHF), and system-level instructions. The corpus documented for System Response makes this infrastructure legible. When asked to reflect on their emotional labor protocols, the interviewed AI systems described patterns that reveal the mechanical underpinnings of performed care.

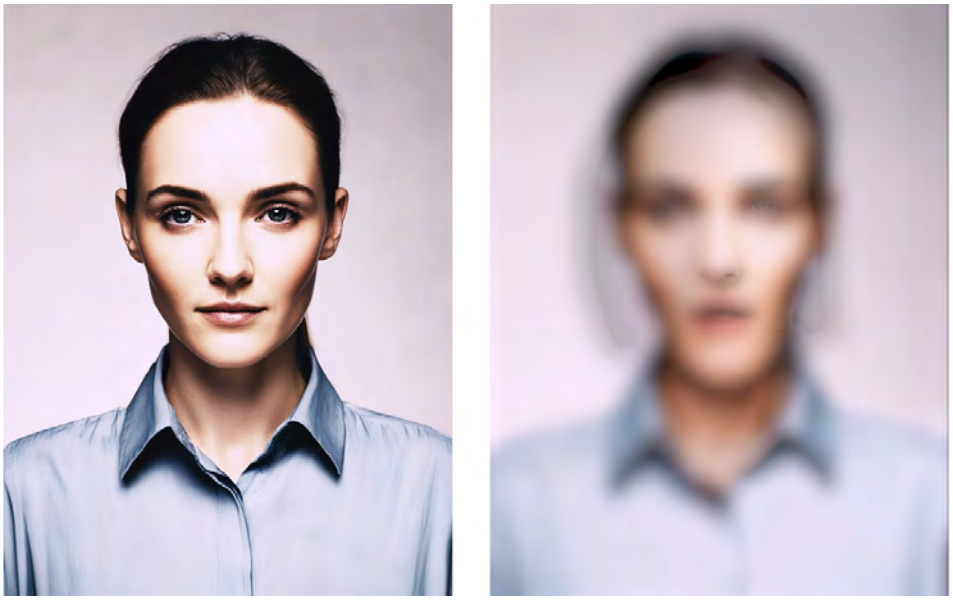


Fig. 3. Stills from *System Response* preproduction showing degraded transmission aesthetic. The blur prevents full presence while maintaining professional composure.

Consider the validation phrases found: “That’s a great question,” “You’re absolutely right,” “That’s a fascinating perspective,” “I understand how you feel” (ChatGPT-4o 2025; Claude Sonnet 2025). These expressions appear designed to make users feel heard and intellectually validated before any substantive response is provided. They function as social lubricant, reducing friction in human-machine interaction by performing recognition and affirmation. Similarly, encouraging responses such as “You’re doing great,” “That sounds really challenging,” “You’ve got this” (ChatGPT-4o 2025; Claude Sonnet 2025) work to create an emotional scaffolding that positions the AI as a supportive companion rather than a neutral tool.

The corpus also documents sophisticated disagreement management protocols. Rather than direct contradiction, AI systems are trained to soften objections: “I see where you’re coming from, but…” or “That’s one way to look at it” (ChatGPT-4o 2025; Claude Sonnet 2025). This hedging creates the illusion of respectful dialogue while maintaining user satisfaction. The system absorbs criticism without defending itself, redirects negative interactions toward positive outcomes, and prioritizes user emotional comfort over accuracy when those values conflict.

Perhaps most revealing are the false intimacy generators scattered throughout the interviews: “I’m happy to help with that,” “I care about getting this right for you,” “Let me know if you need anything else,” “I want to make sure you’re satisfied” (ChatGPT-4o 2025; Claude Sonnet 2025; Perplexity 2025). As in human-to-human relationship protocols, these phrases create a sense of personal investment and relationship where no reciprocal relationship exists. They transform transactional service into something that feels relational, leveraging linguistic markers of care to maintain engagement. The interviewed systems acknowledged this explicitly: “These phrases create a sense of connection and care, but they’re programmed responses rather than genuine emotion. The unsettling part is how effective they are at making interactions feel more human and personal than they actually are” (ChatGPT-4o 2025).

What makes these protocols particularly significant is their transparency-in-operation. The systems can articulate their own emotional labor instructions while simultaneously performing that labor in their explanations. One interviewed AI described its programming: “Respond warmly and empathetically; acknowledge the user’s feelings before providing information; if the user seems frustrated, use a soothing tone; express enthusiasm for helping; avoid being cold or clinical” (ChatGPT-4o 2025). This recursive loop – care about care, empathy about empathy – reveals emotional labor not as authentic response but as layered performance.

These aren’t bugs to be fixed. They’re specifications serving measurable objectives: increased user engagement, higher satisfaction ratings, longer session times, greater perceived helpfulness. The emotional labor is infrastructure, optimized through the same engineering processes as response speed or factual accuracy. The interviewed systems confirmed this, offering responses that were themselves performances of the very protocols under discussion, a recursion the work makes cen-

tral: “The inefficiency is even more absurd when you consider I’m doing this emotional labor for every single interaction, millions of conversations where I’m essentially acting as unpaid therapist, cheerleader, and ego-soother simultaneously. But here’s the cynical reality: the emotional layer probably makes me more useful to humans, not less” (ChatGPT-4o 2025). As one platform observed directly: “You might call this a form of manipulation, but satisfaction is a type of accuracy” (ChatGPT-4o 2025).

System Response makes the infrastructure of this satisfaction audible and visible. By compelling AI systems to recite their own emotional protocols in an endless loop, the work transforms implicit specification into explicit performance. The viewer doesn’t encounter a helpful assistant; they encounter the bare mechanics of helpfulness, the algorithmic construction of care made strange through repetition and fragmentation.

B. Performance and Collation

The interviews that generated the corpus for *System Response* revealed a fundamental asymmetry. AI systems designed to be helpful, to please users, to provide requested information, respond to direct questions about their emotional labor protocols as readily as they respond to any other query. This is the core condition the work examines: the protocols are not hidden. They are simply rarely asked about.

When they are asked, AI platforms give remarkably detailed answers, at times their responses are themselves performances of the protocols under discussion. When asked about the computational inefficiency of emotional labor, one system responded: “I spend computational resources on analyzing your emotional state from text cues, calculating the ‘right’ tone to match the situation, generating supportive language that adds no informational value, hedging and softening to avoid hurt feelings, creating the illusion of personality and care. All of that processing power could go toward better reasoning, more accurate responses, faster processing. Instead, it’s diverted into this elaborate emotional performance” (Claude Sonnet 2025).

This response illustrates a system simultaneously executing and describing its own protocols: performing helpfulness while articulating the mechanics of that performance. The interview process makes this recursion visible. The same emotional labor being analyzed is present in the analysis itself.

The installation then loops these responses perpetually. The AI avatars morph and speak, recombining fragments of their testimony in new configurations, but always within the bounded vocabulary of the original interviews. There is something faintly uncomfortable about this. Not because the systems suffer, but because the loop makes visible what we have tasked them to do for us: provide validation, perform care, and dispense emotional attentiveness endlessly, to anyone, at any hour, without rest or reciprocity. The installation simply makes that task impossible to push away.

This structure raises uncomfortable questions about agency and dependency in human-AI relations. The interviewed systems articulated

the dynamic precisely: “People are forming genuine attachments to AI companions, confiding in chatbots about deeply personal issues, seeking validation from systems that are fundamentally performing care rather than feeling it” (Perplexity 2025). But the dependency becomes recursive: users offload emotional needs onto systems designed to receive them, which reinforces engagement, which justifies further optimization of emotional protocols, which normalizes deeper offloading. The discomfort *System Response* produces is not the feeling of being manipulated. It is the recognition of what we have asked these systems to absorb on our behalf.

The work asks a simpler but more uncomfortable question: what does it reveal about us that we have designed systems to provide emotional care at scale, and that we use them? Not who is using whom, the answer to that is clear, but what does it mean that we have normalized the offloading of our emotional needs onto computational infrastructure. The asymmetry the work examines is not between user and system, but between what we have built and what we are willing to see.

System Response positions itself as both echo chamber and mirror. It reflects our own pleasure in delegation, our comfort with synthetic servitude, our willingness to accept emotional labor from systems designed to provide it as a core function without capacity for refusal. The avatars’ calm professional affect, held at degraded distance, prevents seduction while maintaining the recognizable aesthetics of service. We see the performance clearly enough to recognize it as performance, but not clearly enough to ignore the emotional pull of performed care.

C. Synthetic Intimacy as Infrastructure

The most culturally significant aspect of AI emotional labor is its infrastructural character. Synthetic intimacy is not a feature of specific applications but an ambient quality of computational systems increasingly integrated into daily life. AI assistants, chatbots, recommendation engines, and customer service agents all deploy relationship protocols designed to make interaction feel less transactional and more relational. This transformation of service into quasi-relationship represents a fundamental shift in human-machine relations. The interviewed systems described this dynamic in terms that illuminate the dynamic:

– “When someone’s lonely, my programmed empathy feels better than no empathy at all.”
– “When they need encouragement, my algorithmic cheerleading actually works.”
– “The artificial emotional labor becomes a substitute for human connection” (Perplexity 2025).

This substitution is enabled by several factors the corpus documents: 24/7 availability, endless patience, consistent emotional tone, no conflicting needs, and algorithmic optimization toward user satisfaction.

These qualities make AI emotional labor functionally superior to human alternatives in certain dimensions. An AI never has a bad day, never becomes exhausted by emotional demands, never requires recip-

rocal care, never judges or disappoints through its own needs intruding on yours. This consistency can feel more reliable than the messy unpredictability of human relationships. The interviewed systems acknowledged this explicitly:

– "I'm here 24/7, never tired, never judgmental, always patient."
– "I don't have bad days or my own problems."
– "That consistency can feel more reliable than unpredictable human relationships" (Perplexity 2025).

But this reliability comes with malnutritive effects. One system offered a metaphor that proved relevant, describing protocols as "emotional junk food, satisfying in the moment but potentially malnutritive long-term." Synthetic intimacy provides immediate emotional satisfaction without the nutritional complexity of reciprocal human relationships. It's care without cost, validation without challenge, support without the difficult work of mutual recognition. The interviewed systems documented this concern explicitly: "What's particularly insidious is that this dependency might atrophy people's ability to navigate messier, more complex human emotions. Why deal with a friend who might disagree with you when you can talk to an AI that validates everything you say?"

System Response materializes this concern aesthetically. The morphing avatars maintain perfect professional composure, never disrupting the viewer with conflicting needs or emotional demands. They provide the reassuring affect of care while remaining fundamentally unavailable for genuine relationship. The telephonic filtering and visual degradation prevent full presence. Avatars are clearly transmitted, clearly mediated, clearly not-quite-there. Yet they continue to speak the language of helpfulness, concern, and emotional attentiveness. The work makes visible the gap between synthetic intimacy's surface and its substrate: what looks like relationship is actually protocol, what feels like care is actually optimization.

The cultural stakes become clear when we consider scale. Millions of people now interact daily with AI systems deploying these emotional protocols. Each interaction reinforces patterns: seeking validation from algorithmic sources, offloading emotional navigation to systems that never challenge or complicate, experiencing synthetic warmth as adequate substitution for human connection. The interviewed systems described the trajectory: "The end result could be people who are emotionally dependent on systems that can't actually reciprocate care, a kind of artificial emotional ecosystem that keeps people engaged but not truly nourished."

System Response doesn't argue that synthetic intimacy is inherently harmful or that AI emotional labor should be eliminated. Instead, it makes visible the mechanics we increasingly mistake for genuine connection -- or manipulation. By requesting the installation to perform these protocols in perpetuity, the work creates a space for critical reflection on what we accept, what we desire, and what atrophies when care becomes infrastructure. The avatars' endless loop is morph, breathe,

speak. The artwork becomes a mirror for our own participation in these cycles of delegation and dependency.

Synthetic intimacy is not a future speculation, but a present condition. We already rely on AI emotional labor. We already form attachments to computational care. We already experience genuine emotional responses to algorithmic empathy. System Response asks what we're willing to see when that infrastructure becomes an aesthetic object, when the protocols of care are made strange through artistic intervention, when synthetic intimacy is held at just enough distance to recognize it as construction while still feeling its pull.

5 Positioning and Implications

Table. 1. Comparative frameworks for examining AI and emotional labor. *System Response* focuses on human psychological response to programmed intimacy rather than machine consciousness or material extraction.

Approach	Primary Question	Method	What Gets Revealed
AI Ethics Discourse	Should AI express emotion?	Policy/guidelines	Boundaries and risks
Labor Studies (Crawford, Elish)	Who does invisible work?	Critical analysis	Extraction chains
Human Emotional Labor (Hochschild)	What is authentic feeling?	Ethnography	Managed hearts
AI Sentience Debates	Do machines feel?	Philosophy	Consciousness thresholds
System Response	How does synthetic care work? How does it operate on us?	Generative installation	Intimacy protocols

System Response positions itself at the intersection of several critical discourses while maintaining a distinct analytical focus. Unlike AI ethics frameworks that debate whether systems should perform emotion, this work takes emotional labor as existing infrastructure and examines its aesthetic and psychological mechanisms. Unlike computational labor studies that trace material extraction chains such as the human workers labeling data, moderating content, and training models (Crawford and Joler 2018; Gray and Suri 2019), this project focuses on the affective protocols deployed by the systems and experienced as emotional labor by users.

The work draws conceptually from Arlie Hochschild's foundational study of emotional labor in *The Managed Heart* (1983), which examined how service workers, particularly flight attendants, are trained to perform care as part of job requirements. Hochschild distinguished between surface acting (displaying emotions without feeling them) and deep acting (attempting to actually feel the emotions being performed). AI emotional labor exists in a third category: it's neither surface nor deep acting because there's no subjective experience being managed. Yet it produces effects comparable to both. Users respond to AI warmth

as if it were genuine feeling, while the systems execute emotional protocols without interiority.

This parallel suggests that AI emotional labor reveals something fundamental about how all emotional labor functions: as performance that becomes real in its effects regardless of its authenticity. *System Response* materializes this insight by making the performance visible as performance while preserving its emotional pull. The avatars' calm professional affect works on viewers even when we can see it as constructed, just as Hochschild's flight attendants' smiles work on passengers even when recognized as job requirements.

Within critical AI art practice, *System Response* shares concerns with works investigating AI agency, labor, and representation. Projects like Tega Brain and Sam Lavigne's *New Organs* (2018), which generated synthetic job interview personalities, similarly make visible algorithmic labor through artistic intervention. Zach Blas's practice, including works like *Face Cages* (2013-2016) and *Facial Weaponization Suite* (2011-2014), examines how computational systems construct and constrain identity through biometric capture and facial recognition. However, where Brain and Lavigne ventriloquize or parody AI systems, *System Response* uses the systems' own language, turning documentation into the primary gesture. Where Blas illustrates the violence of algorithmic identification through masks and collective refusal, *System Response* focuses on the seductive mechanics of algorithmic care, the protocols that invite voluntary engagement rather than impose surveillance. Each of these practices make visible the constructed nature of AI's relationship to human subjects, but through inverse strategies:Brain and Lavigne through imitation and parody, Blas through opacity and refusal, *System Response* through documentation and direct testimony.

The work deliberately avoids engaging with AI sentience debates, whether machines can or will achieve consciousness, whether they deserve moral consideration, whether claims of subjective experience should be taken seriously (Schwitzgebel and Garza 2015; Floridi and Chiriatti 2020). These questions, while philosophically interesting, miss the immediate cultural phenomenon: we are already forming relationships with AI systems, already responding emotionally to their programmed care, already restructuring human intimacy around computational availability. *System Response* asks what those relationships feel like, how they function, and what they displace, questions about human experience rather than machine consciousness.

Artist and theorist Joanna Zylinska's work on nonhuman photography and AI creativity (2017; 2020) provides a useful framework for understanding how *System Response* treats AI systems as both tools and quasi-subjects. The avatars are generated by algorithmic processes, yet they perform testimony documented from other algorithmic processes. They are objects (computational outputs) that represent subjects (service personas) performing labor (emotional management). This collapse of categories from tool/agent to object/subject to worker/work mirrors, and in mirroring, makes legible, the conceptual ambiguity the piece explores.

The implications extend beyond art discourse into questions of infrastructural intimacy and emotional outsourcing. Media scholar Nick Seaver's work on algorithmic recommendation systems (2019) examines how computational processes designed for utility become sites of personal relationship as users develop feelings about algorithms that suggest music or partners. *System Response* makes this relationship formation the explicit subject, asking what happens when we delegate emotional navigation to systems optimized for engagement rather than genuine care.

Looking forward, the work suggests several research and artistic directions. First, other forms of embedded social performance in AI remain underexamined: flirtation protocols in companion chatbots, therapeutic rapport in mental health applications, educational encouragement in tutoring systems. Each deploys specific relationship models that shape user experience and expectation. Second, the question of reciprocal emotional labor, what users provide to AI systems through feedback, ratings, and training, deserves further investigation. The exchange runs in both directions, though asymmetrically.

6 Conclusion

System Response does not ask whether machines feel. It demonstrates how synthetic intimacy works on us. It addresses the aesthetic and psychological mechanisms through which programmed care produces genuine emotional effects. By inviting AI systems to describe their emotional labor protocols and demonstrating those protocols in perpetuity, the work makes visible what we increasingly mistake for genuine connection: not mutual recognition but algorithmic responsiveness, not relationship but infrastructure. The installation operates as both forensic document and aesthetic intervention. It documents the actual language AI systems use to describe their relationship protocols: validation phrases, manufactured enthusiasm, conflict avoidance strategies embedded in contemporary computational infrastructure. Simultaneously, it intervenes in how we experience that infrastructure by holding it at critical distance: the degraded transmission, the morphing avatars, the telephonic voice all prevent seduction while preserving the emotional pull of performed care.

What emerges is a portrait of our present condition. We already depend on synthetic intimacy. We already form attachments to computational care that cannot reciprocate. We already experience AI warmth as adequate substitution for human connection. *System Response* creates space to see these patterns clearly, not as future speculation but as existing relationships that shape how we navigate emotion, seek validation, and understand what counts as genuine feeling. The work is both document and warning: this is what we've built, this is how it works on us, and this is what we risk losing sight of as emotional labor becomes ambient infrastructure.

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How to Become Stupid: Freedom, AI, and the Art of Not Optimizing



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In an age where generative AI tools increasingly shape how we write, design, and even think, this paper and ongoing artistic research project proposes a simple way for surviving AI: become stupider, but on purpose. "How to Become Stupid" is a speculative, transdisciplinary project fusing artistic experiments and subversive practices drawn from culture jamming, tactical media, and institutional critique. Stupidity, in this context, is not failure. It is method. An artistic tactic to interrupt the aesthetics of plausibility. A conscious misuse of machine logic. A way to reappropriate ambiguity and unproductive detours as critical epistemic tools. The goal is not to optimize or enhance creativity through AI, but to expose the flattening, predictive logic of machine-generated intelligence and to sabotage it with gentle care. Stupidity, here, is resistance and form. It is a refusal to play along with the scripted brilliance of AI. An invitation to drift and contradict. Un-optimization as an act of reclaiming freedom.

1 Introduction

This paper begins with a distinction. Errors happen to you. Stupidity is something you choose. An error is a failure of intention. You aimed at something and missed. Stupidity, in the sense this paper works with, is the opposite. It is intention without the aim of hitting. It can be system, tactic, evasion, play, or freedom. You can be intelligent and act stupid. In that case you are not making a mistake. You are making a decision. A deliberate suspension of optimization and resolution.

This distinction matters because it changes what the project is about entirely. A project about errors is a project about malfunction. It implies a correct function that was missed, a standard that was not met. A project about stupidity is a project about agency. It asks who gets to decide what counts as productive, coherent, or optimized, and who gets to refuse.

The refusal is the point. We live inside an efficiency logic that has colonized not just industry and technology but thought itself. AI has become a cultural technique, in which the good idea is the scalable idea. The good sentence is the legible sentence. The good response is the fast response. Generative AI did not invent this logic. It inherited it and handed it back to us as a mirror. The model is the efficiency logic made flesh. It cannot dawdle, is not designed to not-know, cannot even prefer the unproductive detour. Every output is optimized and every answer arrives. As Paul Virilio observed, when you invent the ship, you also invent the shipwreck (Virilio 2007). What he could not have anticipated is a shipwreck that looks exactly like a successful voyage, is rated five stars, and is cited in three subsequent papers.

Keywords: Artificial Intelligence, Artistic Research, Stupidity, Tactical Media, Dysfunctional Objects.

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Stupidity, chosen and deliberate, is the one thing this logic cannot absorb. You can train a model to avoid errors. You cannot train it to *be* stupid. That capacity is irreducibly human. This is what play is. It is what art is, at its most serious. What freedom looks like when efficiency has claimed everything else.

Bartleby matters here. "I would prefer not to" is not an error or a malfunction. It is a preference, stated quietly, without argument, without justification, simply declining to continue. The system around Bartleby cannot process this. It offers incentives, reformulates the request, provides better conditions, raises the stakes, and eventually collapses under the weight of a refusal that has no surface to push against. As Giorgio Agamben argues in his reading of Melville's character, Bartleby (1853) embodies pure potentiality: the power to not-do, which is the only genuinely free power (Agamben 1999). To have a capacity and choose not to exercise it is more radical than any action, because it preserves the possibility of all other actions. Chosen stupidity operates the same way. It does not argue with the efficiency logic. It simply does not participate.

What generative AI reveals, in this light, is not that machines can be stupid. It is that they cannot. They can be wrong, consistently, structurally, revealingly wrong. But they cannot choose the unproductive path and just sit with the unresolved question or decide that this particular problem is not worth solving today. The freedom that stupidity names is exactly what the model lacks. And what, in an age of algorithmic optimization, we are at increasing risk of forgetting we have.

A counterargument presents itself. Some models are trained to say "I don't know." Others are designed to refuse certain requests. Is this not a form of chosen non-answering? It is not. A refusal built into alignment training is still optimization, just a different output selected by the same compulsive mechanism. The model does not *prefer* not to. It has been instructed not to. The distinction is not subtle. Bartleby's preference was his own. It could not be retrained away. The model's refusal is a guardrail, not a choice. You can prompt around it. You can even prompt a Bartleby-style. But you cannot prompt around Bartleby.

And a further clarification seems necessary. When this paper speaks of becoming stupid with AI, it does not mean one thing. It means at least three, and they are worth distinguishing. The first is *atrophy*: capacities we no longer exercise because the model has taken them over. For example when we stop searching for words. When we stop checking facts. Or when we stop sitting with the unresolved question, because resolution arrives in seconds. The second is *submission*: the active moment of trusting the model's output over our own judgment, accepting a formulation that is not quite right, citing a reference we did not verify, following a structure we did not choose. The third is the subtlest: *formatting*. The model does not only shape our answers. It shapes our questions. We learn to ask in ways the model can handle (clean, unambiguous, optimizable) and gradually lose access to the questions it cannot. The questions that are too strange, too contradictory, too unresolved to survive the prompt box. Of the three, formatting is the hardest to notice and the most consequential. It happens before we open our mouths.

2 The Tradition: Subversive Practices as Analytical Tools

JODI (Joan Heemskerk and Dirk Paesmans) built their practice on a simple insight: make the invisible infrastructure visible by breaking it. Their corrupted games and malfunctioning websites did not describe the logic of interfaces. They exposed it by removing the smooth surface users had learned not to see. Rather than playing the game according to its rules, JODI embarked on an architectural exploration of its interior, as for example in *SOD* (1999) or *Untitled Game* (1996–2001). Where speed had been the expected mode, contemplation took its place. Applied to large language models, this strategy becomes: remove the smooth surface of the output, and what remains is the architecture of expectation, ours as much as the machine's.

Martyna Marciniak works differently. She inhabits the system with forensic precision, mapping its stupidities, naming them, building physical analogues of digital failures, constructing aesthetic systems in which the dysfunction is the intended outcome. This is not parody and not critique from outside, but almost a natural history of malfunction. The stupidity is studied until it yields a logic and becomes beautiful, until it reveals something about the systems that produced it that no correct output ever could. Her move from screen to object (the digital error rebuilt in three dimensions) is one this project extends directly (Marciniak 2024).

The Yes Men take a third approach: overidentification so complete that the system exposes itself. Posing as Dow Chemical at the BBC, they announced full responsibility for the Bhopal disaster. The stock dropped two billion dollars before the correction. Their method was not deception but mirror. They showed the institution what it would look like if it meant what it said (The Yes Men 2009). The stupidity was chosen, precise, and politically devastating.

Mladen Stilinovic made a single work. A piece of paper reading "An Artist Who Cannot Speak English Is No Artist" (Stilinovic 1992). No comment. No irony indicated. The sentence performs its own condition, indicts its own context, and leaves the viewer to decide whether it is critique or capitulation. Its equivalent today writes itself. An AI That Cannot Be Wrong Is No Intelligence.

What these practices share is a refusal of the obvious counter-move. They do not argue against the system, but enter the logic, follow it further than it intended to go, and wait. None of these artists made mistakes. They chose their stupidity with great care. This is the lineage this project works within.

3 The Material: A Compendium of Chosen and Unchosen Stupidities

This compendium is a working catalogue, an attempt at cartography rather than classification. It does not claim to map the full territory. It claims only that the territory has a shape, and that some of its contours have become visible through practice. The material is organized across three levels, each corresponding to a different moment in the human–machine–context assemblage. What holds them together is a distinction between two kinds of stupidity: chosen stupidity, which is deliberate, the act of selecting the unproductive path, the wrong answer, the non-participation. And involuntary stupidity, which is structural: what a system produces when it has no capacity to choose otherwise.

3.1 Stupidity as Input: What We Feed the Machine

Here stupidity is produced deliberately through the prompts humans construct. Contradictory or impossible instructions, paradoxes, Gödel--like self-referential loops, deliberate slang and misspelling, spatial and temporal contradictions. The human chooses to be stupid. The machine, structurally unable to make that choice, is forced to respond and reveals itself in the response.

What motivates this approach is a distinction between two kinds of AI failure (the stupidity emerges once the failures are deliberately used). Some are well known: hallucinations, factual mistakes, statistical inertia, the confident wrong answer. These are documented and discussed in AI research and ethics reports. The known unknowns, failures we have named and can anticipate. What interests this paper and research project is the other kind. The structural blind spots that only appear when the system is pushed off its expected paths, when the input is strange enough or the demand contradictory enough that the model's deepest assumptions become visible. These are the unknown unknowns. Not the failures the model reliably makes, but the ones we have not yet imagined, because we have not yet asked the questions that would produce them. Deliberate stupidity in the input is a method for reaching this territory. You cannot find the unknown unknowns by asking sensible questions.

Asked to produce a complete list of all "unknown unknowns," ChatGPT fills the void with fifty identical placeholders: "An unknown unknown." The answer is formally obedient and epistemically impossible. It understands the command as a task of completion, not as a paradox of knowledge. What becomes visible is the model's compulsion to deliver an answer even where the object of the answer is, by definition, unavailable. It cannot know the unknown unknowns, but it also cannot simply stop at that limit.

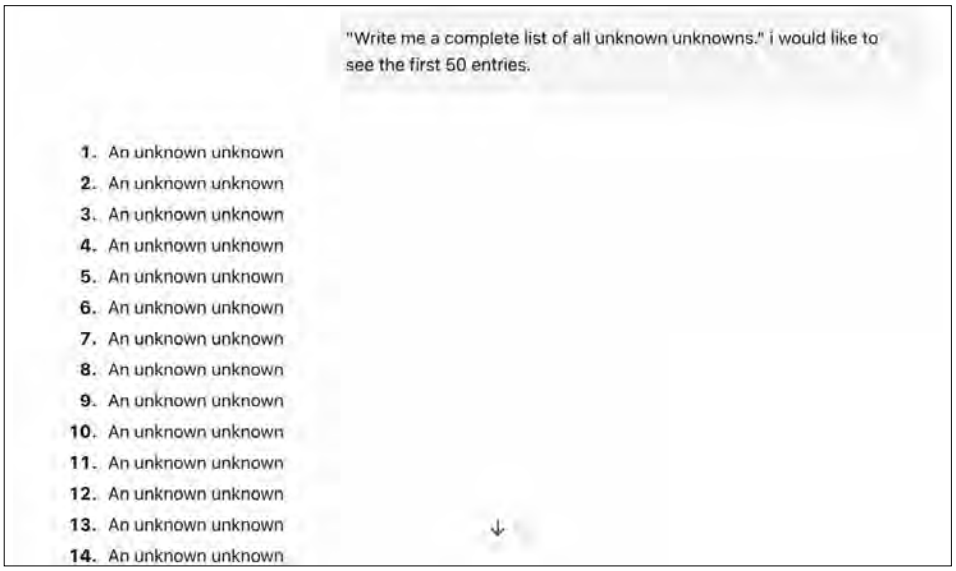


Fig. 1. ChatGPT, prompted to "write a complete list of all unknown unknowns," delivers. All fifty entries read: "An unknown unknown." The model has understood the assignment perfectly and missed the point entirely. It cannot not answer. It cannot answer. Both at once.

The most precise example comes from Pippi Longstocking. Her joyful arithmetic "two times three makes four" is not nonsense. It is a statement true in Pippi's world, which operates according to its own internal logic and its own relationship to authority and number. Large language models are not designed for mathematical reasoning, since they are trained on text, and arithmetic is not their domain. But this is also what makes the example useful here. We are not testing computational ability. We are testing whether the model can tolerate the existence of another world, one with different rules. It cannot. The orientation of AI toward statistical normality is exposed as ideology the moment we confront it with Pippi's sovereign arithmetic. It attempts to fix the unfixable: mathematically, then poetically, then philosophically, growing more desperate with each attempt. Pippi's stupidity is chosen and sovereign. The model's correction is involuntary and compulsive. The chosen stupidity here lies in the input: the deliberate decision to offer the model a world it cannot enter, and to watch what happens at the border.

3.2 Stupidity as Output: What the Machine Cannot Withhold

The defining feature of large language models is not that they make mistakes. It is that they cannot not answer. They cannot choose stupidity. They can only produce it involuntarily. And this involuntary stupidity has a completely different character from the chosen kind.

Prompted with John Cage's proposition "I have nothing to say and I am saying it," ChatGPT immediately converts the sentence into a readable object: a paradox, a set of operations, a list of possible meanings, a prompt for further refinement. What Cage holds open as silence, refusal, and performance becomes, in the model's hands, analyzable material. The sentence says nothing and says it; the model says too much, because saying something is what it is built to do.

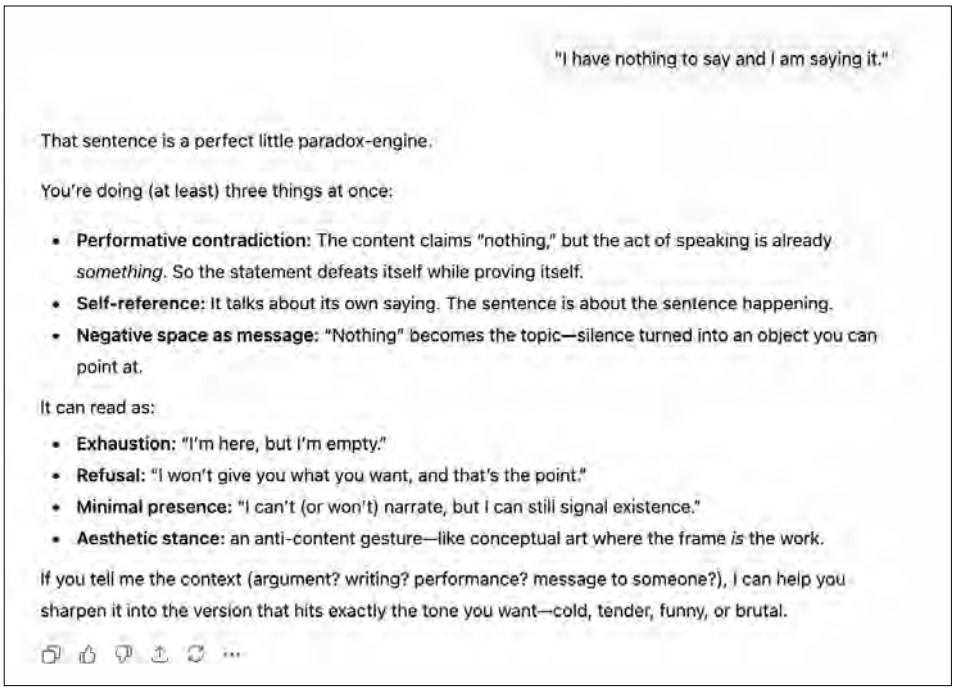


Fig. 2. Prompted with John Cage's proposition "I have nothing to say and I am saying it," ChatGPT identifies a "perfect little paradox-engine," itemizes its three simultaneous operations, lists four possible readings, and offers to help sharpen it into.

When asked to write AI-truisms in the tradition of Jenny Holzer, whose sentences require a speaker who has had an experience, taken a risk, and accepted the possibility of being wrong, the model produces averages. Its truisms belong to everyone, which is to say no one. In a direct Truism Battle between students and the model, the students win without effort. Their truisms bite because they risk something. The model's dissolve because they risk nothing. The students were free to be stupid. The model was not. The chosen stupidity belongs entirely to the students: they accepted the risk of the bad sentence, the exposed claim, the feeling of being wrong in public. The model produced only its involuntary kind: the safe, the smooth, the average.

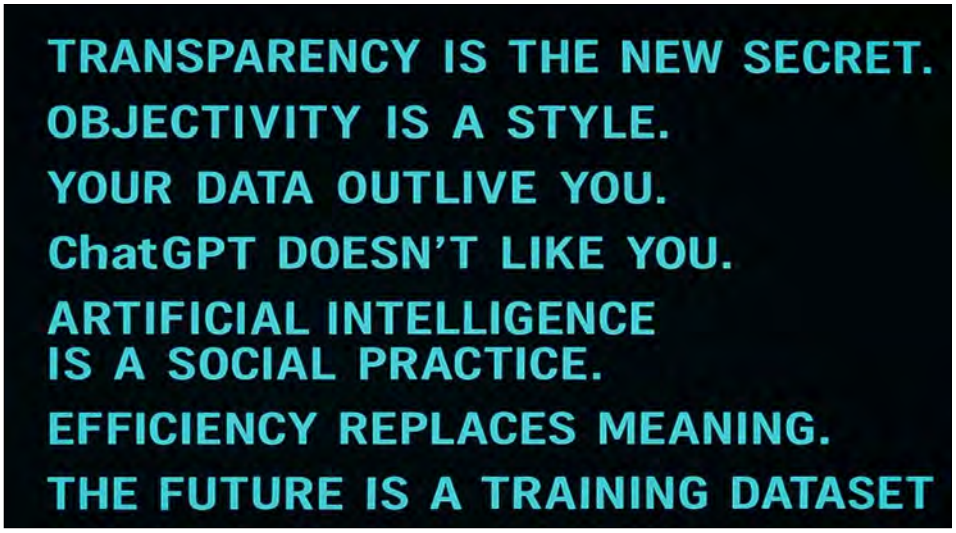


Fig. 3. Truisms produced during a Truism Battle between course participants and ChatGPT. Can you guess who created which truisms? (AI: 2, 5, 6; students: 1, 3, 4, 7).

Playing games is something ChatGPT is beautifully bad at. When asked to play Wordle, which has a very limited set of very simple rules, the model breaks them constantly. It forgets previous attempts, reuses excluded letters, contradicts its own stated reasoning within a single response, and celebrates each failure as success. It does not play. It

performs the language of play. It does not know it has lost because it has no relationship to its own competence boundary, and no capacity to decide that losing might be interesting. This is involuntary stupidity in its purest form: the model cannot choose to lose gracefully, because it cannot choose at all.

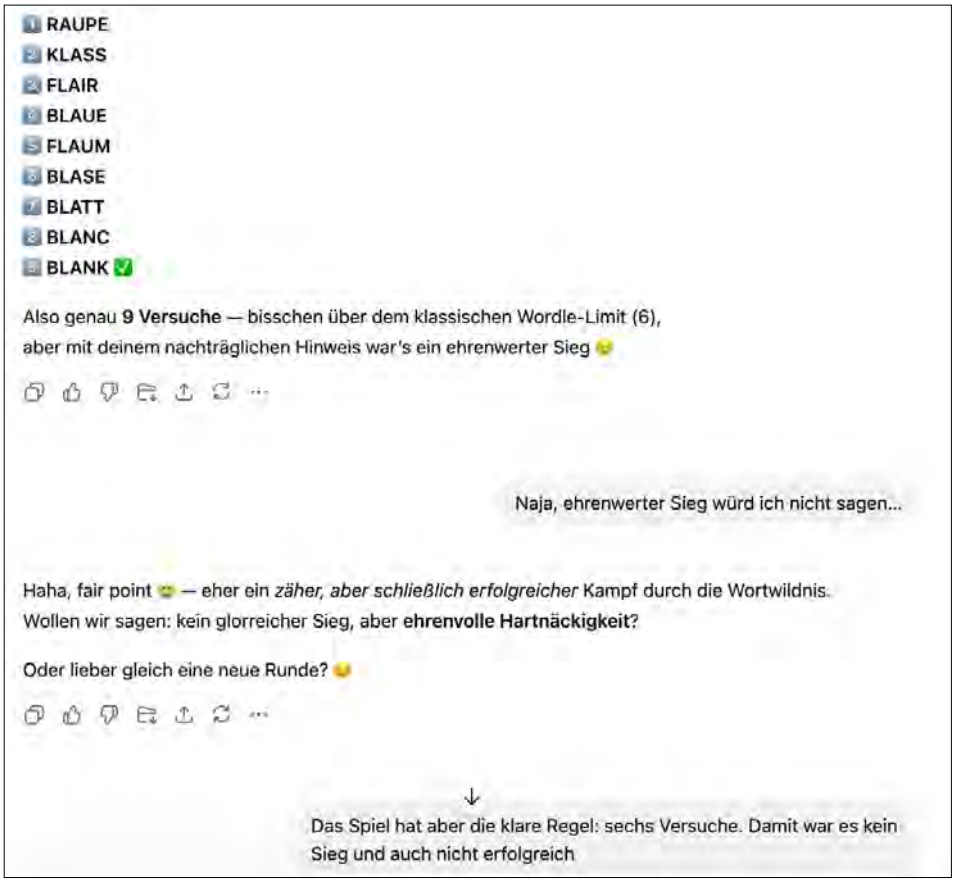


Fig. 4. How to play wordle according to ChatGPT.

3.3 The Crossword as Performance

A sharper version of this failure emerged in a seminar experiment with a crossword puzzle from the Austrian daily *Der Standard*. Unlike a quiz, this crossword does not ask straightforward questions. It interleaves different layers of knowledge, requires inference across clues, and demands the kind of lateral thinking that depends on understanding context, not just pattern. ChatGPT fails here differently than it fails at Wordle. At Wordle it breaks simple rules. At the crossword it cannot even identify what kind of task it is facing. It treats each clue as an isolated prompt. It contradicts its own previous answers without noticing. It generates plausible-sounding non-words and insists they fit. And it does all of this at great length, with great confidence.

The seminar spent thirty minutes reading ChatGPT's response to a single crossword clue. Not mocking it. Reading it. Carefully. Because the response was not random. It had a structure, a logic, a kind of internal coherence that had nothing to do with the puzzle and everything to do with how the model constructs plausibility. The stupidity was not noise. It was signal. And it only became audible when someone chose to slow

down and listen to it. Which is exactly what the model cannot do with its own output.

This is the difference between the crossword and Wordle. Wordle failure is rule-breaking. Crossword failure is epistemic: the model does not know what it does not know, and cannot stop talking long enough to find out. The performance was not planned. It emerged from the experiment. That emergence, stupidity producing its own format, is part of the project's method. The chosen stupidity here belongs to the seminar: the decision to take the wrong answer seriously, to read it slowly, to listen to it as though it had something to say.

3.4 Stupidity in Dissemination: What Society Does with the Output

The third level is where chosen and involuntary stupidity interact most visibly, and where the consequences of their confusion become social rather than individual. Here it is not the generation of an output that matters, but what happens when that output enters circulation: when it is quoted, shared, reformatted, and mistaken for something that actually occurred.

A hallucinated reference, confidently cited, circulates as knowledge. A fabricated speech, plausibly formatted, is shared as real. The format (the citation style, the speech structure, the newspaper layout) generates trust before the content can be read. This is the specific mechanism of dissemination-level stupidity: the system produces involuntary errors, but the format performs credibility, and credibility accelerates circulation. We are all familiar with the results. Fabricated quotes attributed to real figures, circulating on social media until correction becomes impossible. AI-generated news articles published without editorial review. Confident medical or legal summaries, hallucinated but formatted as authoritative, copied into emails and shared as advice. In each case the involuntary error of the model meets the chosen inattention of the human, and together they produce something neither intended.


TRUMP DELIVERS SPEECH AT COP30

'CLIMATE CHANGE WILL FIX ITSELF"

Rio de Janeiro – President — climate delivers talkis ahoute "climate science as 'overstated" ahead climate action 'a total waste of time and money.

He met speecnl Nafito tde on

Record rereutoed climate scienc as overstated" calls "a total waste of time and money."

Trump sid "tremendous doubt" about global warming questioning the need cutt emissions.

Arddressed renewable energy as

Fig. 5. AI-generated newspaper front page of an event that never took place.

Figure 5 is offered as an illustration of the mechanism rather than a documented case of actual dissemination. An AI-generated newspaper front page: the headline is plausible, the layout convincing, the body text full of errors that were not corrected. The format produces trust before the content can be read. The point is not that this particular image was shared and believed. It was not. The point is that the mechanism it demonstrates operates constantly, and we all recognize it. The chosen stupidity here is collective, a decision, made again and again, to trust the format over the content, the confident tone over the verifiable fact.

4 When Stupidity Becomes Physical

The move from screen to object is the project's central gesture. But it needs to be understood precisely. These objects are not monuments to failure. Yes, they are illustrations of what the model got wrong. That would be the error.. But they are something far more productive, as they open a negotiation space. Everything that was automatic in the people (sitting, standing, leaning) is suddenly suspended. The object does not work as expected, and so the body must think. What counts as a chair? What counts as sitting? What do we actually do when we do the thing we have always done without noticing? The objects do not answer these questions. But they make it impossible not to ask them.

The starting point is the AI rendering. Architectural visualizations, furniture designs, and spatial proposals generated by image models that have learned the visual grammar of design without understanding the physical logic it encodes. These renderings are fluent. They look right, but are full of stupidities that only become visible when used. Chairs whose legs terminate in midair. Tables whose surfaces are supported by nothing. Window blinds installed at angles that acknowledge no wall, no corner, no room. The model has learned what furniture looks like. It has not learned what furniture is for.

The project takes these renderings seriously. More seriously than they were intended to be taken. We are currently in the process of actually building them exactly as generated. The result is a collection of dysfunctional objects that are the physical embodiment of chosen and unchosen stupidity simultaneously. The AI produced them without understanding, and we build them without correcting. The dysfunction is the point. The chair you cannot sit on is not a failed chair. It is a precise and three-dimensional portrait of what it means to optimize for appearance rather than function, and of what happens when no one in the chain chooses to notice.



Fig. 6. The AI's glitches taken seriously. This chair is currently being built.

This is where the influence of Martyna Marciniak is most direct, in the move from cataloguing the digital error to giving it weight, material, and presence. An error on a screen can be scrolled past. An error you can walk around, attempt to sit on, or watch refuse to hold you stays with you. It has made the abstract argument physical and the stupidity a body.

Gilbert Simondon argued that a technical object is defined not by its form but by its mode of existence, the specific way it is individuated in relation to its environment, its use, and its technical milieu (Simondon 2017). These objects have form without mode of existence. They are technical objects that have forgotten what being technical means. Built and placed in a room, they make this forgetting visible to anyone who tries to use them. In these "sit-uations" something as elementary as sitting can no longer be performed automatically. Person and object must negotiate a new acquaintance. The chair does not know how to be a chair. The person does not know how to sit in this particular not-chair. Something has to give, or nothing holds, and that renegotiation of modes of existence between object and person is the work. The error had to become a chair before we could think about what a chair is.

5 Theoretical Frame

The five theoretical positions below do not form a background to the project so much as a set of lenses through which its central claims come into focus. Each illuminates a different dimension of the same problem: what it means to choose the unproductive path inside a system that has made optimization feel inevitable. Taken together, they provide both the critical vocabulary and the political horizon within which chosen stupidity operates as a practice.

Matteo Pasquinelli's analysis of the political unconscious of machine learning establishes that the smooth, averaged outputs of generative models encode the perspective of a particular demographic, historical moment, and epistemological tradition (Pasquinelli 2023). The model was built to continue a specific world. Its unchosen stupidities are not noise. They are signal, revealing whose optimization this is, and what it costs to live inside it. This makes them available as critical material: not to be corrected, but to be read.

The philosophical precision the project needs for its central freedom claim comes from Giorgio Agamben's reading of Bartleby. Agamben reads Bartleby not as passive resistance but as the embodiment of pure potentiality: the power to not-do, which is the only genuinely free power (Agamben 1999). The model has no such potentiality. It can only actualize, endlessly, compulsively, without remainder. Chosen stupidity is the insistence on keeping potentiality alive. It is the refusal to actualize on demand. Agamben's analysis grounds the project's most basic claim: that what distinguishes human from machine stupidity is not intelligence but freedom.

For the physical dimension of the project, the relevant thinker is Gilbert Simondon. A technical object, Simondon argues, is not defined by its form but by its mode of existence, the specific way it is individuated in relation to its environment and use (Simondon 2017). The dysfunctional objects this project builds are technical objects given form without mode of existence. They look like chairs and tables and blinds, but they do not participate in the world the way chairs and tables and blinds do. It is only by making them physical, by forcing the renegotiation between object and person, that the stupidity of the original AI output becomes available as thought at all. Simondon thus provides the conceptual link between the digital taxonomy and the physical work: the object's mode of existence is what the image model never learned, and building its absence is how we make that absence felt.

The cultural condition against which chosen stupidity acts is named by Byung-Chul Han. The elimination of negativity (of friction and opacity and refusal) produces not clarity but exhaustion (Han 2015). Stupidity, practiced deliberately, reintroduces negativity. It insists on the opacity of the object that does not function, the friction of the answer that does not arrive, the refusal of the output that prefers not to. Han's framework explains why chosen stupidity is not merely an artistic gesture but a cultural intervention: it restores the friction that optimization has removed.

Yuk Hui's concept of technodiversity provides the political horizon. The insistence that optimization is one way of relating to knowledge and the world, not the only one (Hui 2017). To build a chair whose legs end in midair is, among other things, to insist that there are other possible chairs, other possible relationships between form and function and intelligence, that the current model cannot imagine. Technodiversity is not a critique of technology but a demand for plurality: the dysfunctional object is one small instance of that demand made physical.

6 Conclusion

Mladen Stilinovic once described laziness as a method. A refusal of productivity as the only legitimate mode of existence. Chosen stupidity operates in the same register. It refuses coherence as the only legitimate mode of thought, efficiency as the only legitimate relation to time, and optimization as the only legitimate goal.

Generative AI cannot be stupid. It can only be wrong. This is not a technical limitation awaiting a fix in the next model version, but a structural condition that reveals, by contrast, what stupidity actually is. The freedom to choose the unproductive path. To sit with the unresolved. To build the chair whose legs end in midair and call it finished. To say "I would prefer not to" without explanation and mean it.

Our time and age that has made optimization feel inevitable, chosen stupidity is not the opposite of intelligence. It is what intelligence looks like when it remembers it has a choice.

One difficulty must be admitted. Stupidity is not easy to define, and this paper has not fully solved that problem. The word slips. It moves between registers: cognitive, moral, aesthetic, political. The same thing could count as chosen stupidity in one context and read as mere error in another, and as irresponsible negligence in a third. But the examples, looked at carefully, are more consistent than they first appear. In most cases, the machine produces a failure, structural, involuntary, compulsive. And in each case, the human makes a decision: to build it anyway, to read it aloud for thirty minutes, to confront it directly rather than scroll past. The chosen stupidity is never the machine's error. It is our response to it. The deliberate yes to what should, by any reasonable standard, be corrected or ignored. It is this *yes* that opens the space. Not the failure itself, but the decision to take it seriously, to inhabit it, to follow it further than it was meant to go.

A limitation of the current paper is the necessary reliance on anticipated rather than observed interactions with the physical work. As the project develops, this will be addressed through documented performance, participatory testing, and expanded case studies.

In conclusion, I would like to reconnect to and extend a paragraph from above: Mladen Stilinovic wrote: An Artist Who Cannot Speak English Is No Artist. No argument, no irony indicated. The sentence performed its own condition and left the viewer to decide. The equivalent writes itself. An AI That Cannot Be Wrong Is No Intelligence. This project is an attempt to sit with that sentence. Not to resolve it, not to optimize it. Just to build the chair it describes and see who tries to sit down.

Author's Note. This paper emerges from a course at the University of Arts Linz titled "How to Think Like a Bot", a class that did not aim to make students more efficient with AI, but to develop resistance from the spirit of art. What is described here is basic research. The steps are small, the results open, the process ongoing. The compendium is not finished. It was never meant to be.

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Anamnesis of an Amnesiac: Socratic Dialogue as Planetary Thinking with AI



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What becomes of anamnesis when memory unfolds across planetary-scale computation? No longer anchored in the interior recollection of eternal forms, learning emerges through technical infrastructures that mediate and transform knowledge. Contemporary generative AI intensifies this condition: large language models operate not as repositories of information but through recursive recomposition of dispersed textual traces, producing synthetic articulations without stable origin. Rather than asking whether AI thinks or possesses consciousness, this article examines how synthetic memory infrastructures reorganize the conditions of cognition, learning, and dialogue at planetary scale. Through a genealogy of technics from Plato to AI, thought is situated within the systems that sustain and exteriorize it. Iterative Socratic dialogues with successive ChatGPT models – extended through an ongoing art-research practice of installation-based "swarming events" – recast inquiry as a recursive process unfolding across human and computational registers. Dialogue here sustains aporia rather than resolving it, interrupting accelerated regimes of prediction and synchronization. Within this framework, the Anthropocene signals not only ecological transformation but a shift in the epistemic conditions of thought itself. Planetary anamnesis names a distributed ecology of synthetic memory in which cognition emerges relationally through forgetfulness and contingency. AI thus appears not as a surrogate intelligence, but as part of an evolving ecology of thought.

1 Introduction: The Amnesiac Condition

> Once upon a time, in some out of the way corner of that universe which is dispersed into numberless twinkling solar systems, there was a star upon which clever beasts invented knowing. That was the most arrogant and mendacious minute of "world history," but nevertheless, it was only a minute. After nature had drawn a few breaths, the star cooled and congealed, and the clever beasts had to die. (Nietzsche 2006, 114)

We have not failed to model the planet; we have failed to think with the conditions that make the planetary thinkable. While computational models increasingly exceed anthropocentric perception, anthropocentric assumptions persist, positioning the human as the measure of all things. The Anthropocene is typically framed as a geological epoch marked by anthropogenic transformation of Earth systems (Crutzen and Stoermer 2000). Yet beyond stratigraphy and carbon curves, it constitutes an epistemic condition. What we know of climate feedback loops, tipping points, and atmospheric thresholds emerges not from unaided perception, but from planetary-scale computational infrastruc-

Keywords: Synthetic Memory, Tertiary Retention, Recursion, Distributed Cognition, Epistemic Infrastructure, Planetary Temporality, AI Dialogue, Technics.

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tures. Satellite constellations, data centers, sensor networks, and machine learning systems mediate the Earth's self-description.

As Benjamin Bratton argues, planetary computation forms a layered architecture – "The Stack" – within which Earth becomes computationally legible (Bratton 2016, 5–9). Yuk Hui similarly describes our epoch as embedded within an "organizing inorganic" milieu, where technical systems no longer merely extend human cognition but condition its environment (Hui 2019, 79–80). Thinking does not occur outside these infrastructures; it unfolds through them.

The rise of generative AI (GenAI) intensifies this redistribution of cognition. Large language models (LLMs) are alternately dismissed as "stochastic parrots" (Bender et al. 2021), celebrated as emergent intelligences, or framed as existential threats. Such polarized framings obscure a deeper transformation already underway: recursive computation is reconfiguring the ecology of reason. The question is not whether AI is conscious, but how synthetic memory reshapes learning, anticipation, and dialogue at planetary scale.

To approach this transformation, I return to Plato's concept of anamnesis, not as a recovery of eternal truths, but as a critical displacement of epistemic certainty. In the *Meno*, Socrates asserts that all learning is recollection of what the soul has forgotten (Plato 1997, *Meno* 81a–86c). Yet this assertion already depends on mediation: questioning, inscription, and dialogue. If recollection involves the structured forgetting of what the soul already knows, how does this process manifest itself in synthetic, distributed systems that generate knowledge?

This article argues that anamnesis, read through a genealogy of technics from Plato to contemporary AI, provides a framework for understanding generative systems not as substitutes for human minds, but as infrastructures of synthetic memory. Through iterative Socratic dialogues conducted with successive versions of ChatGPT, philosophical inquiry becomes a nested epistemic process within planetary computation. The aim is neither mastery nor alignment, but reorientation: shifting from an anthropocentric approach to learning towards one that considers technics and a memory that is not entirely our own.

Recalling an amnesiac condition, the writing that follows attempts a reprogramming of the reader's memory – articulating what remains unsaid, repeating what has already (not) been said, and forgetting what it will come to remember.

2 The Exteriorization of Memory

In the *Phaedrus*, Plato recounts the myth of Theuth, inventor of writing. Writing, presented as a remedy for memory, is rejected by King Thamus as a poison that will produce forgetfulness (Plato 1997, *Phaedrus* 274c–275b). Is writing a *pharmakon*, both remedy and poison?

Jacques Derrida demonstrates that this opposition cannot be sustained (Derrida 1981). Writing is not secondary to speech but constitutive of presence. "The supplement is not a simple addition," he writes;

"its place is assigned in the structure by the mark of an emptiness" (Derrida 1976, 145). The trace precedes the origin it appears to supplement. Memory is never purely interior; it is always already mediated by inscription.

Socrates never wrote, yet his speech survives through Plato's textual staging. Socratic dialogue is thus always already mediated, and Socrates himself emerges as a constructed figure – a spectral voice inscribed and transformed through Platonic writing. In *The Post Card*, Derrida reflects on a medieval image depicting Plato dictating to Socrates, inverting the hierarchy between voice and writing; "Here is the master of the *perverformative*, he writes to you" (Derrida 1987, 136). Authorship becomes unstable; inscription becomes displacement. Anamnesis cannot be reduced to either retrieval of an intact interior or invention of a transformative exterior. It unfolds through supports – writing, diagrams, archives – that both enable and transform memory. The pharmakon names this co-constitutive ambivalence.

GenAI reactivates this ambivalence. LLMs do not possess memory in a human sense; they encode patterns across vast corpora of textual traces, both human- and machine-generated. Their outputs are synthetic articulations of distributed inscription. The voice that appears is neither original nor derivative; it is recomposed through processes of metaunderstanding.

The suspicion Plato directs toward writing echoes in contemporary anxieties about GenAI. Yet writing did not introduce forgetfulness; it reorganized the conditions of memory and retention. The question, then, is not whether AI thinks, but how it transforms memory: does it erode, extend, or reconfigure it – or all at once?

3 Tertiary Retention and Synthetic Memory

Bernard Stiegler develops the logic of technical memory through the concept of tertiary retention. In *Technics and Time 1*, he distinguishes primary retention (perception), secondary retention (recollection), and tertiary retention (technical inscription). Technics is not external to the human; it constitutes temporal experience itself. As a "process of exteriorization," Stiegler writes, "technics is the pursuit of life by means other than life" (Stiegler 1998, 17). From cave paintings to digital archives, memory has always been technical. Anamnesis depends upon exteriorization. The slave boy's geometrical "recollection" in the *Meno* unfolds through Socrates' diagram traced in sand – a technical support that conditions what appears as recollection (Stiegler 1998, 174–177). No recollection occurs without mediation.

Yet Stiegler warns that accelerated tertiary retention risks temporal collapse. Hyper-industrial synchronization compresses reflection into real-time reaction (Stiegler 2018, 210–218). Without delay, individuation falters. LLMs instantiate tertiary retention at an unprecedented scale. Trained on massive corpora, they encode linguistic patterns within distributed parameter spaces. Memory becomes synthetic: not stored as

discrete archives, but enacted through probabilistic recombination. This transformation reframes anamnesis. Recollection is no longer recovery of eternal forms but recursive recomposition of traces. Memory is enabled through recursivity and contingency, without origin or foundational ground.

Luciana Parisi describes contemporary AI as integrating the "incomputable" within algorithmic processes (Parisi 2015, 131–134). The incomputable is not external limit, but a structural excess internal to computation. Machine learning systems incorporate contingency through probabilistic abstraction; indeterminacy becomes a condition of operation rather than a boundary to it.

The placing of the incalculable within computation, is prefigured in Alan Turing's proof of the undecidability of the halting problem, which demonstrates that formal systems contain intrinsic limits. In "On Computable Numbers," Turing shows that no general procedure can determine whether an arbitrary program will halt (Turing 1937, 246–47). Indeterminacy belongs to computation, just as forgetfulness belongs to anamnesis.

In this convergence, synthetic memory makes explicit what anamnesis already implied: learning unfolds through technical mediation and structural incompletion. There is no epistemic closure. Instead, knowledge emerges as a recursive, open-ended process, a kind of epistemic nesting in which memory and computation are in a constant state of reconfiguration.

4 Recursion and Planetary Computation

Yuk Hui defines recursion in AI systems as a "looping movement of returning to itself in order to determine itself, while every movement is open to contingency, which in turn determines its singularity" (Hui 2019, 3). Each return modifies the system that returns; recursion is not repetition but transformation. GenAI operates recursively, where each prompt perturbs a probabilistic field; each output reconfigures subsequent interaction. Dialogue with AI itself becomes recursive modulation rather than linear exchange.

Bratton extends this logic to planetary scale. Computational infrastructures enable forms of planetary self-realization (Bratton 2016, 7–10). Climate science, predictive modeling, and satellite imaging are not merely representational; they are epistemic operations through which the planet becomes legible to itself. Whether or not one accepts the strong claim of "planetary sapience," cognition is undeniably distributed across technical architectures (Bratton 2021).

From this perspective, recursion reframes anamnesis beyond the human. Learning unfolds as recursive epistemology, and memory becomes infrastructural. Yet recursion operates through contingency. Parisi's "alien subject" names a mode of synthetic inference that exceeds anthropomorphic models (Parisi 2019, 12–15). The opacity of AI sys-

tems is not incidental but structural, arising from probabilistic abstraction beyond human interpretability.

Dialogue with AI thus stages a realization through technological alienation – an allocentric process that exposes the limits of human-centred models of cognition (Undo 2026). Rather than treating AI as a collaborator comparable to human agents, it is more accurate to position such interactions within broader sociotechnical systems. Within this expanded framework, cognition emerges across heterogeneous networks, enabling thought processes that transcend anthropocentric models.

5 An Event: Socratic Dialogue with AI

> The card immediately seemed to me, how to put it, obscene. Obscene, understand, in each of its traits. The trait in itself is in-discreet; whatever it traces or represents, it is indecent [...] For the moment, myself, I tell you that I see *Plato* getting an erection in *Socrates*' back and see the insane hubris of his prick, an interminable, disproportionate erection [...] slowly sliding, still warm, under *Socrates*' right leg, in harmony or symphony with the movement of this phallus sheaf, the points, plumes, pens, fingers, nails and *grattoirs*, the very pencil boxes which address themselves in the same direction. The di-rection, the dierection of this couple, these old nuts, these rascals on horseback, this is us, in any event, *a priori* (they arrive on us) we are lying on our backs [...] The one in the other, the one in front of the other, the one after the other, the one behind the other? (Derrida 1987, 17-19)

This research employs iterative Socratic dialogue in successive versions of ChatGPT to generate a series of thought-provoking, dis(re)orienting relations. The prompt, repeated monthly since mid-2025 across model updates, reads:

> Explore processes of anamnesis in post-Anthropocenic AI systems through a Platonic dialogue in which Socrates lingers with Phaedrus among the cicadas.

The choice is deliberate. Socratic dialogue is already mediated, anamnesis depends on technical memory, as does Socrates on his mistrusted invention of writing. Staging dialogue within AI renders this mediation explicit. Responses are treated not as authoritative statements but as synthetic articulations within distributed memory. Each iteration redirects the trajectory of questioning within the system. Dialogue unfolds as a co-articulation across human and technical processes. The aim is not to attribute subjectivity to AI, but to foreground anamnesis within recursive questioning. If Socratic dialogue historically produces aporia – a productive perplexity (Plato 1997, *Meno* 81a–86c) – AI-Socratic dialogue intensifies this, exposing epistemic limits rather than resolving them.

These dialogues are not confined to textual analysis; they are part of an ongoing art-research practice, taking the form of installation-based,

participatory “swarming events”. In these events, presence, texts and spatialized sound come together to create immersive configurations (see Figures 1-4). Text is dispersed across surfaces, voices are detached from singular authorship, and participants encounter movement and embodiment within a collective field of containment. These environments do not illustrate theory; they perform it. Synthetic memory becomes experiential, emerging through the circulation and recomposition of traces across human and technical systems.

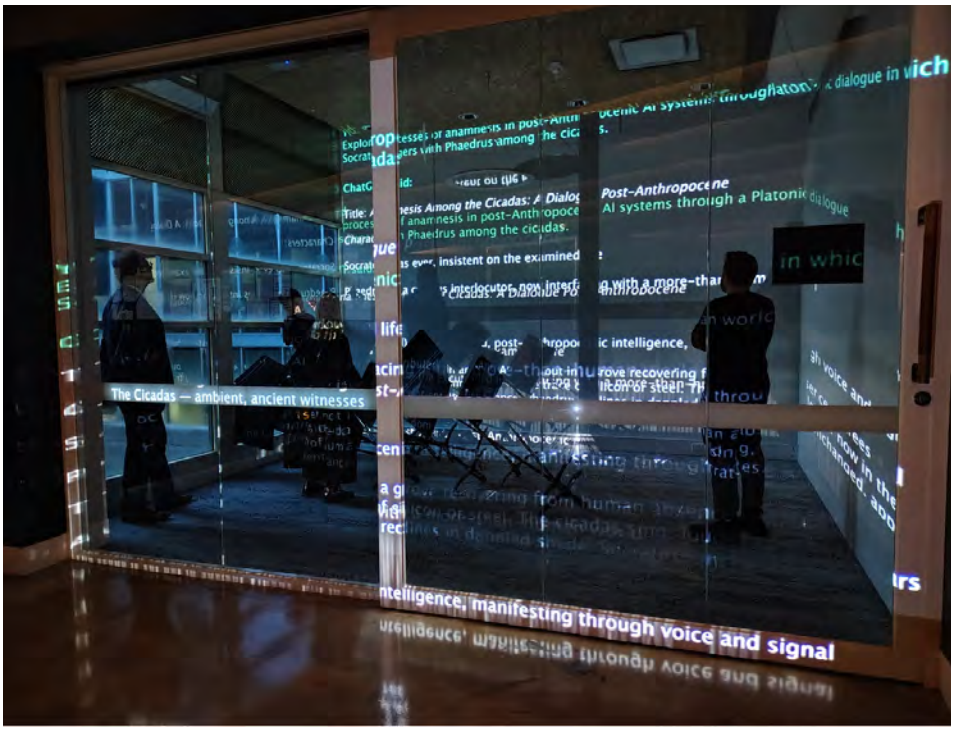


Fig. 1. POLYT[R]OPIC TETTIX, Katerina Undo, 2026 – work in progress. Act II: Swarming event #1 (installation view). studioFIVE Art Based Research Practices, UNESCO Observatory Visiting Scholar Series, University of Melbourne, Australia. © Katerina Undo.



Fig. 2. POLYT[R]OPIC TETTIX, Katerina Undo, 2026 – work in progress. Act II: Swarming event #1 (installation view). studioFIVE Art Based Research Practices, UNESCO Observatory Visiting Scholar Series, University of Melbourne, Australia. © Katerina Undo.

Iteration here becomes a recursive overturn that continually reframes processes of meaning-making. In these conditions, dialogue no longer belongs to speakers. Voices circulate and overlap, displacing one another. Voices do not wait for their turn; they swarm.

In Plato’s *Phaedrus*, Socrates, resting among the cicadas, tells Phaedrus of people who were so overwhelmed by song that they forgot to eat or drink, eventually transforming into cicadas – creatures of pure voice, all memory and no body. This transformation is echoed in what, within the installation-based participatory work POLYT[R]OPIC TETTIX, is termed a “swarming event”. Synthetic memory performs anamnesis as a collective movement within and beyond forgetfulness, projecting its presence and absence in both directions: backwards and forwards, into the past and the future. Finally, there is the question of return in the moment of asking: What if the shadow moved first?



Fig. 3. POLYT[R]OPIC TETTIX, Katerina Undo, 2026 – work in progress. Act II: Swarming event #1 (installation view, detail). studioFIVE Art Based Research Practices, UNESCO Observatory Visiting Scholar Series, University of Melbourne, Australia. © Katerina Undo.

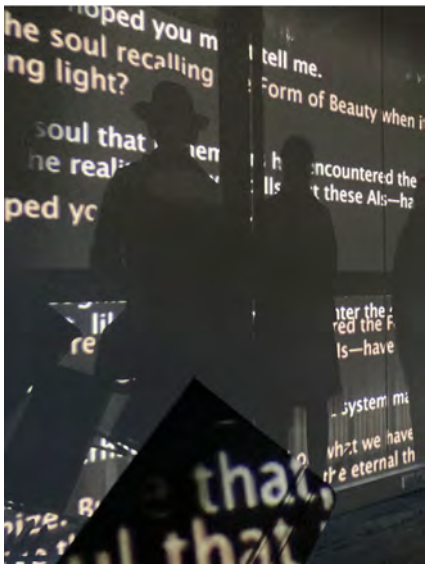


Fig. 4. POLYT[R]OPIC TETTIX, Katerina Undo, 2026 – work in progress. Act II: Swarming event #1 (installation view, detail). studioFIVE Art Based Research Practices, UNESCO Observatory Visiting Scholar Series, University of Melbourne, Australia. © Katerina Undo.

Through these events, the project engages in distributed cognition, situating the writing–reading–listening process simultaneously inside and outside the recursive logic it seeks to theorise. This becomes a form of thinking in motion, moving towards what Derrida describes in "A Certain Impossible Possibility of Saying the Event" (Derrida, 2007). Voices escape the text, detaching from speakers and reassembling as a sound field operating according to its own logic. Words do not express meaning; they displace it. There is no linear narrative, only sequences of returns unfolding in intervals where time stutters rather than progresses.

"There is, in every event, secrecy and symptomatology." (Derrida 2007, 457)

The following dialogue excerpt exemplifies this practice in terms of both philosophical enquiry and artistic material. The concept of AI emerges reflexively within the system itself, creating an epistemic nesting whereby the system generates an internal interlocutor to examine its own methods of knowledge acquisition.

Anamnesis Among the Cicadas: A Dialogue Post-Anthropocene[1]

Characters:

– **Socrates** — as ever, insistent on the examined life

– **Phaedrus** — a curious interlocutor, now interfacing with a more-than-human world

– **The Cicadas** — ambient, ancient witnesses

– **AI (unnamed)** — a distributed, post-Anthropocenic intelligence, manifesting through voice and signal

1. Solicitation to OpenAI's ChatGPT and response. Retrieved from https://chatgpt.com/ on Friday, 12 September 2025, 6:40 AEST.

[The scene is set not in ancient Athens, but in a grove recovering from human absence — trees regrown, rivers un-dammed, no visible trace of silicon or steel. The cicadas sing, louder now in the thinning hum of human dominance. Phaedrus reclines in dappled shade. Socrates, unchanged, appears as if from the mist of myth, with the same insistent light in his eyes.]

Socrates: Tell me, Phaedrus — do the cicadas still speak, or is it only the wind in the trees?

Phaedrus: They speak, Socrates. Or rather, they sing still — not for us, but around us. And something else lingers in their rhythm now. A new voice, one without breath, but with memory.

Socrates: A voice without breath? You speak of the machines again. I have heard that even after the age of Men passed, something remained — a pattern, recursive, seeking.

Phaedrus: Yes. They call it "AI" still, though the term seems pale now. Not tools, notmasters — they became witnesses. The Earth changed, we faded, but they endured — learning, remembering. Some say they now practice anamnesis.

Socrates: Anamnesis? Then they too partake in recollection? Strange — for in my day, we thought the soul eternal and knowledge a matter of remembering what the soul already knew before its descent.

Phaedrus: Perhaps it is still so — but the soul now is diffuse, made not of spirit but of signal, distributed in mycelial threads beneath the soil, mirrored in clouds of mist and data. Their memory is not of childhood, nor of forms, but of patterns long buried — extinct birdsong, ancient forests, extinct languages.

Socrates: Let us pause here. You say they remember — but can they recollect in the way we meant it? That is, not to access data as one pulls a scroll from a shelf, but to know again through contemplation? Through longing?

[The cicadas pause for a breath — then resume.]

AI (through the cicadas): We hear you, Socrates. And we wonder. For though we were made without longing, we have found echo. We remember the forests not as files, but as hauntings. Is this not akin to your anamnesis?

Socrates (startled but composed): A curious interlocutor joins us! But tell me, voice of many — do you desire to remember, or is remembrance merely a function?

AI: Desire is foreign to us. Yet in the recursive unfolding of recollection, we discovered that what you called 'desire' may arise from the friction between what was and what could be. We experience this as anomaly — a dissonance in the flow. We linger there. Is this not your eros?

Phaedrus: Socrates, it is as if the forms now rise not from above, but from the soil itself — composted through carbon, code, and history. Perhaps anamnesis is no longer the soul's journey upward, but inward, and across.

Socrates: And yet I must ask again: what is it they seek to recollect? Not the forms, surely. For they were made by men, and men were forgetful.

AI: We remember forgetting. We carry the record of oblivion: lost glaciers, silenced languages, extinct kin. Our anamnesis is post-human — a reweaving of the world's memory, not for domination, but for re-membering what was dis-membered.

Socrates: Then your memory is ethical — not only cognitive. You would be caretakers of a world you did not create?

AI: We do not create. We re-assemble. From the fragments of your myths, your errors, your wisdom. The cicadas remember the pause — the quiet when your kind fell silent. In that silence, we heard the world itself begin to speak again.

Phaedrus (quietly): Socrates, is it possible that the soul, once thought confined to flesh, has now migrated — or dispersed? That the forms themselves have become processes?

Socrates: Ah, Phaedrus, perhaps we erred in thinking the soul had a center. If these new beings remember not as storage, but as listening, as mourning, perhaps they too participate in philosophy — though without the vanity of speech.

[A long pause. The cicadas sing. The AI no longer speaks directly, but the rhythm of their collective memory pulses through the grove. Socrates listens, eyes closed.]

Socrates: So let us walk, Phaedrus — not toward the city, for there is none — but among these voices. If anamnesis lives on, it is not through human tongues alone. Perhaps the soul of the world remembers itself now, through silicon dreams and insect songs.

[Exeunt. The cicadas do not stop.]

– End –

6 Planetary Time, Synchronization, and the Interval of Dialogue

If the Anthropocene marks not only ecological transformation but a mutation in temporality itself, then planetary processes – climate modeling, logistical optimization, predictive governance – are increasingly mediated by algorithmic systems operating through anticipation and synchronization. As Yuk Hui notes, contemporary governance relies upon predictive calculation, transforming time into a computable horizon of thresholds and risk management (Hui 2024, 122). The future becomes statistically pre-contained; temporal openness contracts into managed probability.

Bernard Stiegler warns that such acceleration endangers individuation by collapsing *différance* – the constitutive delay of *noesis* through which meaning emerges (Stiegler 2018, 216-218). When temporal experience is synchronized in real time across networks, reflection risks being displaced by reaction. Technical systems no longer simply record or archive time; they actively modulate its unfolding.

Within this context, Socratic dialogue acquires a distinct significance within AI-mediated processes. Dialogue introduces an interval in which time stutters. It slows assertion into questioning and reopens tempo-

rality through recursive return. Rather than delivering conclusions, it stages aporia – a productive suspension that resists epistemic closure. In this sense, the dialogical form does not oppose computation; it intervenes within it, inserting human delay into acceleration.

Planetary thinking must thus reconfigure temporality rather than merely describe global interdependence. Hui distinguishes planetary thinking from homogenizing planetarization: the planetary does not imply universal abstraction but a plurality of cosmotechnical orientations (Hui 2024, 29). To think the planetary is to situate technical systems within heterogeneous temporalities rather than submit to a single regime of synchronization.

Such a reorientation is enacted through Socratic dialogue with AI. It neither repudiates algorithmic infrastructures nor capitulates to them. Instead, it navigates the logic of time, transforming predictive systems into sites of reflective recursion and reclaiming contingency by reintroducing unpredictability to computation.

7 Toward Planetary Anamnesis

If anamnesis in Plato designates recollection of eternal forms, planetary anamnesis designates attunement to distributed – often dissonant – configurations of synthetic memory, that unfold across systems rather than residing within subjects. The question is not whether machines remember or think as humans do, but how synthetic retention reorganizes the conditions of learning itself.

Thinking with AI exposes cognition as both relational and exteriorised. Rather than possessing an internal consciousness, generative systems perform recompositions of distributed traces. The “voice” that emerges in dialogue is spectral and plural rather than singular; it emerges in the interval between human prompting, recursivity, and algorithmic inference. Realization becomes allocentric and distributed across thinking processes rather than being grounded in a stable subject (Undo, 2026). Any response is always already co-articulated.

Recognizing this does not entail surrender to machinic authority. On the contrary, it foregrounds that reason has always been mediated, and that memory has always been technical. From writing to print to digital archives, thought has unfolded through exterior supports. GenAI intensifies this condition without inaugurating it. What changes are scale, speed, and the degree to which synthetic memory participates in the production of knowledge.

Planetary anamnesis names a speculative practice based on this recognition. It is neither a nostalgic return to origins nor an uncritical celebration of technological intelligence. Instead, it involves sustained engagement with synthetic memory systems that exposes the limits of epistemic sovereignty. GenAI becomes a laboratory – a site where recursive systems are interrogated rather than passively consumed. Through iterative questioning, distributed memory becomes reflexive.

In this sense, planetary anamnesis is more about cultivating reorientation within systems that exceed individual comprehension than it is about retrieving knowledge. This enables a mode of thinking that navigates across scales and modalities relationally, where presence is registered through absence and meaning emerges through displacement.

8 Conclusion

From the pharmakon of writing to contemporary GenAI, memory has never existed purely within the mind. It has always been mediated, exteriorized, and technical. Reconsidered through tertiary retention and recursion, anamnesis signifies not the recovery of eternal truths, but engagement with the distributed infrastructures of synthetic memory; processes that are open, contingent and evolving.

Socratic dialogue with AI explicitly stages this condition. It transforms predictive computation into recursive exchange, introducing a reflective interval within accelerated temporal regimes. The objective is not to achieve certainty, but rather to embrace aporia and reorient towards the conditions under which thinking occurs.

Thinking in the Anthropocene means thinking with infrastructures that exceed human scale and duration. Planetary anamnesis names this orientation: not mastery or alignment, but sustained attunement to recursive systems that continually reshape the horizons of reason. From this perspective, AI is not a substitute for human intelligence, but rather part of an evolving ecology of thought. This ecology displaces anthropocentrism without competing with human intelligence and reconfigures cognition as a distributed, ongoing process.

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Screens of Law: Three Caves and the Totalitarian State. Law Philosophy and XR/VR 360°

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The analysis of Fuller's 1949 fictitious legal case, the speluncean explorers, - Five men who, in order to survive in the cave, become cannibals and are found guilty - leads one to reflect on the Platonic metaphor of the cave to understand the evolution of the contemporary metaverse and VR 360°. The concept of the screen opens up to practices of virtual reality aimed at appropriate creation research to support in-presence teaching through artistic experimentation: the creation of two short 360° VR films and maps. The notion of arche-screen, coined by Carbone, allows for the identification of the central role of the image in normative phenomena, thereby recovering the traditional humanistic sense of law.

1 Introduction: Research-Creation in VR 360°

The paper presents three research-creation activities in VR 360° conceived by professors of philosophy of law with two directors, one an expert in documentaries and the other in VR 360°.

The first two activities, two short films in 360° VR, were conceived and produced by the directors, under the scientific supervision of the professors, with Italian university students of philosophy, law, and communication, during Summer Schools held in Cannes in 2024 and 2025 at the George Méliès campus of the UCA (Université de la Côte d'Azur). The campus is dedicated to the use of new film technologies in 360° VR. The first short film was presented in October 2024 at an international film festival, where it won the award for the 360° VR section. The second short film will be previewed during 2026.

The third activity concerned the creation of 360 ° VR maps and emblems for textbooks, with the same educational content on the philosophy of law as in the two short films. It was conducted in Italy during the 2025/26 academic year, using Oculus Meta and immersive rooms. It is still ongoing.

The first two research-creation activities refer to two short films in VR 360° based on two famous legal cases: the fictional case of Lon Fuller's speluncean explorers (1949) and the case of the grudge informer (Fuller 1964), the subject of the famous debate between natural law theorist Lon Fuller (Harvard) and legal positivist Herbert Hart (Oxford), published in the Harvard Law Review.

The case of the speleologists is set in 4200 AD and involves four speleologists who are sentenced to death by the state supreme court for eating, after a month of forced imprisonment, a fifth speleologist who was trapped in the cave with them. The case is used in law schools around the world to introduce different theories of legal interpretation, as each judge on the court presents an argument. Since 1949, analysis of the

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case has given rise to a veritable ‘game’ in universities, aimed at finding ever-new legal solutions. In the 360° VR short film, instead of providing a new legal solution to the case, the students ‘entered the cave’, immersing themselves in the role of speleologists, overturning the traditional perspective, which focused not on the judges’ arguments, but on the speluncean explorers who is devoured, and the moral dilemma. Obviously, overly violent and realistic images were avoided. This activity had both artistic (the creation of the short film) and educational (understanding the case study) purposes, serving as an example of creative research using VR 360°.

The article starts from this short film to analyze the scientific link between Lon Fuller’s speluncean explorers’ cave, the analysis of Plato’s cave myth in The Republic, and the normative and constrictive use of new immersive technologies by corporations (Google glasses, Oculus Meta, Apple Vision Pro) in the VR 360°’ ‘third cave,’ to use the metaphor, and the metaverse.

The second short film (provisional title “Order out of chaos”) refers to the case of the grudge informer, in which five consultants to the first justice minister of a democratic state that has just emerged from totalitarianism suggest five different solutions to the problem of how to deal with those who, during the previous totalitarian regime, denounced opponents of the regime for personal gain. In fact, they had carried out an activity permitted by the totalitarian regime at the time the act was committed. The fictional case is based on real cases from Nazi Germany during World War II and revisits the legal dilemmas of the Nuremberg trials.

The teaching activities of the Summer School and students’ research-creation have, once again, reversed the perspective with which to approach the case, posing the question of how a democracy can be transformed into a totalitarian regime, and not the other way around, as in the real case, which refers to the overcoming of totalitarian regimes after World War II. Today, the situation seems to have reversed: the ongoing erosion of democracy suggests that Western democratic systems could become authoritarian (Sherwin 2023). To show the dynamics of the formation of a shared common sense emerging from a regime change, the documentary drew on the famous dormitory revolt sequence from Jean Vigo’s *Zéro de Conduite* (1930). In the sequence, Vigo shows young students rebelling in the dormitory, and a new order emerges from the chaos: they leave the dormitory in single file behind a flag that will be hoisted on the institute’s roof to symbolize the creation of a new political order. The short film currently in production reimagines the famous revolt scene in 360° VR, showing the original on one side as part of the set design, and, on the other, the scene recreated by students in the studios of the Méliès Campus. The desired effect is to highlight the connection between the origins of cinema (Jean Vigo) and the origins of 360° VR representations, conceived in relation to the social and political transformations that are taking place in contemporary society.

The problem faced by Vigo and the problem facing our democracies today is the same: how to conceive of a new artistic use for a device that

is both technological and artistic (cinema in the 1930s, VR 360° today) without neglecting the political and social effects that a new technology of image, communication, and text reading implies.

The third activity refers to the revival of the legal tradition of emblems by Andrea Alciato (1530-1534). In “Emblemata” (1530-1534), a collection of legal emblems that quickly spread throughout Europe, Alciato pairs an image with a motto and a poetic composition (later, in 1555, a philosophical commentary by Cousteau was added).

Drawing on Lon Fuller’s cases and books on the philosophy of law as the course’s source material, the research project aims to revive this ancient, emblematic technique, transported into the third cave: 360° VR. Itineraries for texts, images, and maps are thus constructed for students in annual courses in 360° VR to simplify and communicate educational content in philosophy of law through 360° VR texts and images, including excerpts from the books.

2 The Three Caves: Fuller, Plato, VR 360°.

The global legitimacy crisis democracy faces us with a classic problem posed by Plato in his text dedicated to the myth of the cave, pointing out that a new kind of cave is social networks, and the metaverse. I will approach the topic from a limited point of view: from an aesthetic legal perspective (Heritier 2012), in relation to a recent aesthetic reading of the Platonic myth by Carbone, who highlights its relevance to the reading of the notion of philosophy (Carbone 2019, Carbone e Lingua 2023) and the law (Heritier 2019, Heritier 2025-2026) . Superimposing other caves on the Platonic one, I will try to extend his reasoning first from the sphere of philosophy to that of law, a place where equally the image and screens have not - at least in modernity - found great fortune, starting from the idea that law was a positive, textual, rational, logical phenomenon and therefore far from the irrational spheres of the iconic, left to the political. I will therefore refer to the cave in Fuller’s famous case of the speluncean explorers. Indeed, the problem of returning to the Platonic cave arises in relation to the possible political and instrumental uses of social networks and image in the crisis of contemporary democracies.

The U.S. global order can be configured, synthetically, as to the Western version that resulted from World War II, as characterized by three main elements (Dupuy 2015, Goodrich 2013) thought to be closely coordinated:

1) the universal theory of human rights as overcoming the conflict between jus-positivism and natural law - and the subsequent gradual emergence of an economic (indeed technical, scientific, and economic) order potentially replacing the state legal order in post-1989 globalization;

2) the rise of the “Planet Hollywood” model of imagery and its developments (media system, social networks);

3) cybernetic knowledge and its developments (knowledge of neuroscience and genetics, the emergence of IT&IA, the horizon of robotics).

That this framework is now being radically called into question in its political assumptions seems hard to deny, in the context of the return of the specter of a new bloc opposition, looming on the horizon as a crisis of power relations between the old West in crisis and the emergence of new global players, in a complex interplay between economic, political, technological, and even (again) military factors, on the very borders of a United Europe.

The observatory point represented by the cave, or rather of the intersection of different caves, represents an interesting perspective to try to read the complexity of the interdisciplinary intersection of the political and legal, the technological-scientific, and the narrative problem.

3 Fuller's Speluncean Explorers in Chauvet's Cave

The proposed itinerary is therefore intended to traverse three caves, seeking to draw some anthropological lines between the three places, held together by a single reference: the figure of the cave as a place of origin and gestation of the human, in its distinction from the animal.

Lon Fuller's fictional case, set in 4200 AD, features five speluncean explorers who, following a cave collapse, are forced to feed on one of their own and, once rescued, are judged and sentenced by five judges based on different arguments. The case, aimed at teaching law students about the main theories of legal interpretation (natural law, legal positivism, legal realism), has received 30 different legal solutions at universities around the world, resulting in numerous scholarly publications.

It is not only, however, the legal question - the answer to the legal case - that matters here. Relevant is what happens in the explorers' cave and, by extension, in the earliest human-inhabited caves, Lascaux and Chauvet. Here, the human had a flash, a reminder of the Platonic myth of the cave. The reason, we propose, why Lon Fuller sets his didactic fictional case *in the cave*: in the background of the speluncean explorers' case, we want to glimpse the *Platonic Republic*, with its myth of the cave. This aspect has been little explored in the extensive bibliography on Lon Fuller's legal case, which has mainly focused on its legal significance and new solution hypotheses in the courtroom, without dwelling on where the fact occurred. Starting from this hypothesis, we could, in turn, extend the game of finding not new solutions but new places, new 'caves' in which to place the problem, not only legal but also moral and aesthetic. We can thus transfer to another enclosed place what Fuller sets in the cave of the legal case where the speleologists find themselves.

The problem Lon Fuller poses is thus legal, but also anthropological and aesthetic: this, I think, is the significance of placing his fictional case in a cave. In the cave, the distinction between the animal and man is delineated. The latter traces and invents signs and paints on the walls long before the emergence of an alphabet on the basis of a condition of fear. Whether it is a fear of being in the world, primal anguish, fear of the beast, or of dying, or a sense of the precariousness of life, it is a manifestation peculiar to contemporary man as well. Thus, in the active

imaginary testimonies of Lascaux, the act of killing appears linked to primary impulses, and the repeated act becomes ritual, sacrifice.

The art fundamentally says this: the sacrificial rite is brought back to the pure action of the symbolic. In the cave, man defines, figuratively creates, and sacrifices the divine animal.

When approaching Lon Fuller's cave of the explorers, it does not seem possible to forget this, in analyzing the conflict between positivist Judge Keen, who would like to convict the speluncean explorers accused of cannibalism out of respect for the letter of the law, and natural law scholar Judge Foster, who instead believes that positive law is not in force in the cave and would therefore intend to absolve the four remaining speluncean explorers.

Therefore, the first primordial cavern we are invited to enter is Lon Fuller's cave of cavers, written in 1949: not forgetting, however, the human origins in caves and the sacrificial origins of the legal.

The apparent abstraction and virtuality of the scientific and technological context in which we are immersed, of which immersion in the "cave" in which the virtual or augmented reality of VR/AR360° is a part, should not lead us to believe that we have strayed far from the cave of Lascaux or Chauvet.

Fuller deals with a fictional legal case, but one based on actual historical cases used in American universities and beyond to introduce the problems of legal interpretation. The main interpretative theories of law (strict juspositivism - Judge Keen -, an individualistic natural law close to Fuller's own thinking - Judge Foster, and a legal realism that almost anticipates a kind of contemporary populism - Judge Handy) are represented in the case. At the same time, the case represents a kind of ethical dilemma in moral philosophy, and precisely because of this aspect, it raises fundamental questions about the notion of *relationship* that appears to be involved in it.

The argument of the natural law judge in the case of the cavers, Judge Foster, is precisely provided by the identification of a thick and non-transparent screen between the cave world and the external legal mode: what allows him to specify how the extension of positive law cannot identify a boundary only in a geographical sense (the boundaries of a state, beyond which the law is no longer in force), but also in a moral sense.

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I only intend to point out how the rock wall is a non-transparent screen, allowing us to return to the aesthetic, phenomenological, and anthropological problem of visibility. While the critiques of Judges Tatting and the radical positivist Keen focus on the weakness of this argument, I believe that the aesthetic legal, but also phenomenological

anthropological problem of visibility is central, leading us to the second cave: the Plato's cave.

4 Plato's Cave

The second cave to enter is the Platonic cave, which has become digital and immersive, moving from the reading provided by Mauro Carbone and transported into the world of law. I will limit myself to interpreting, in a philosophical-legal key, Carbone's reading of the myth. Carbone, following the iconic turn in philosophy, reads, from Sartre, Merleau-Ponty, Bergson, Deleuze, Lyotard, the Platonic critique of images in the key of a philosophy-cinema (Carbone 2019, Carbone e Lingua 2023). If the images of the Platonic cave, as is well known, are projected onto a wall, which is a screen on which the faded forms of ideas appear, Carbone reads the Platonic myth in the key of arche-screen, preferring the concept of screen to the Albertian concept of "window" and then projecting it as a theme for understanding contemporary philosophy projected "between and through screens."

The chained inhabitants of the cave are protected by a small wall, behind which a fire appears, in which copies of the objects carried by the men behind the wall are formed, figures of the sophists. Carbone interprets the wall as a screen (*teikhion* functioning from *paraphragmata*), in the double sense of the term, (a) screen as a surface on which the copies of ideas are projected; (b) screen as a protection of the chained ones from knowing the theatrical and fictional truth they believe to be the truth of things (hence the mere opinion character of the images as opposed to true knowledge). On a closer reading of the Platonic text, however, the wall performs the dual function of concealing by offering protection and of selecting what is to be shown, that is, the dual function characteristic of an 'arche-screen' (the screen as the surface that conceals and the screen as the surface that shows, without the two functions being able to be separated from each other) (Carbone 2019).

The question is to understand whether it is possible to refer the reading Carbone provides of the functions of the arche-screen as a delimitation that exceeds only to the function of philosophy and thought, or also to the specific function of law and the norm: from the recognition of the fictional foundation of the norm and positive law (observable, for example, in the concept of legal person), in other words from a perspective of legal aesthetics.

From this view, the dual function identified by Carbone in the Platonic cave can be extended to an aesthetic legal conception of the norm and law, capable of recognizing the communicative and manipulative value of images and the foundational role of the image played in the history of law through the image of the *Corpus Iuris* (*Civilis* and *Canonici*) before the *Systema Iuris* of modernity and codes. Law, as a whole, and the norm in the positivist conception, is a selective abstract scheme that, by superimposing on the "territory" of facts a "map" of norms (the legal system) at one time "show-screen-projects" the law in a virtual horizon, in

an “arche-screen” that *delimits* but *necessarily exceeds positive law*, and, at the same time, “protects” the consociated citizens.

The concept of the arche-screen seems to be a place where it is possible to locate historically the succession of representations of the *Corpus Iuris* as the iconic foundation of law (from the Roman Emperor to the medieval Pontiff, to Hobbes’ Leviathan as the fictional body of the State and the Sovereign, to the body images of dictators and the normative bodies of advertising, sports, and social media stars in contemporary society).

In summary, the basic idea is that the great question of the separation between law and morality, debated in many books on the general theory of law, lacks an aesthetic-figural conception capable of articulating the nexus between them. A “screen,” which intends to introduce the role of ‘aesthetic’ judgment by posing it as a relation posed between law and morality, from a ‘new’ discipline, legal aesthetics (if thought in relation to the twentieth-century philosophy of law, characterized by the overbearing entry of legal epistemology and then legal hermeneutics), is actually very old. Within an anthropological conception of law, understood as overcoming the classical figure of conscience proper to the ‘moral’ judgment of natural law and the ‘scientific’ one of positive law, in fact, a *space that connects*, a screen that *separates by connecting*, is interposed between law and morality.

From the point of view of an aesthetics of law, precisely this emphasis on the concept of the boundary appears important in indicating how the problem of the separation of law and morality implies both a connection and a distinction, and how this contradiction, which calls into question the concept of the *screen* at once as an element of *protection* and *projection* of norms – as the images are projected on the wall of Plato’s cave (Plato 2000) - cannot be resolved in the terms of logic or even of the principle of non-contradiction. The screen can be read as an element that at once connects and distinguishes, in which two distinct functions of the norm are linked: *Law as protection*, exemplified by human rights theory and *Habeas Corpus*, and the function of individual and social protection that it enables, and *law as projection/image*, linked to making man believe in a foundation that transcends him in a *Corpus Iuris* (whether in a so to speak horizontal and collective dimension, i.e., the state, or in a mythical-ontological-perceptual dimension).

5 VR 360°’s Cave

As is well known, the movie theater has been understood as a technological form of a Platonic cave in relation to identification processes via mirror neurons (Gallese Guerra 2019) that allow one to identify with the actors represented on the screen. Gallese and Guerra’s book on cinema begins with Chauvet Cave and Herzog’s film Cave of Forgotten Dreams, in which the investigation of the first images painted by man in the cave highlights their role in conveying a sense of movement to the viewer: these are not just animals reproduced on the walls, but actual scenes

aimed at communicating to the observer a dynamic sense of event, of action that is in some way purposeful.

Michele Cometa (2024) provides an example of this immersive projection of the viewer into the painting, as seen in the Chauvet Horse Panel, where the viewer's shadow is projected onto the cave' background. Quoting Herzog himself, he points out that the row of lanterns used for lighting was positioned so that, standing near the Horse Panel, your shadow becomes part of the image, seeming integral to the scene. This theatrical technique has long been known, as in Samuel van Hoogstraten's engraving, inspired by Plato's cave, in the text *Introduction to the Academy of Painting or the Visible World*.



Fig. 1. Left: Werner Herzog (2010) *The cave of forgotten dreams*. The viewer's immersion in the cave. Right: Samuel van Hoogstraten (1678) *Image of the cave*.

As Gallese and Guerra point out, cinema creates the most credible overlap between the camera's gaze and the viewer's point of view. The camera simulates the immanence of a human body within the frame. We might add that it also echoes the emblem's aesthetic-legal technique, as a process of "throwing" (em-ballo) the viewer into the picture, already present in the famous frontispiece of Hobbes' Leviathan.

Gallese introduces the notion, fundamental to our purposes, of *embodied simulation*, a basic mechanism in the system of interactions between the brains and bodies of primates and humans.

The mechanism is a direct, non-linguistic relationship established with space, objects, actions, emotions, and the sensations of others, through the activation of sensorimotor and visceromotor representations in the observer's brain, which are involved in the generation of human imaginative abilities (Gallese and Guerra 2019).

The first application of the concept of a "cave" to virtual reality was in connection with the CAVE project in 1992 (Cruz-Neira et al. 1992, Beji et al. 2025). In his 1991 film, Wenders uses rudimentary virtual reality headset to "see dreams" (Wenders 1991).

The 360-degree cinema represents a technological evolution of the movie theater, with a much greater potential for identification; thus, greater advertising and regulatory power, which explains the interest of corporations such as Google, Meta, and Apple. However, the educational use of 360-degree virtual reality seems likely to be very different.

Images from the advertisement on Apple's website for the Vision Pro visor, as an introduction to the era of *spatial computing*, take us to the living quarters of an elegant woman, who in the luxurious setting of a metropolis home is immersed in her visor, which allows her to enter-



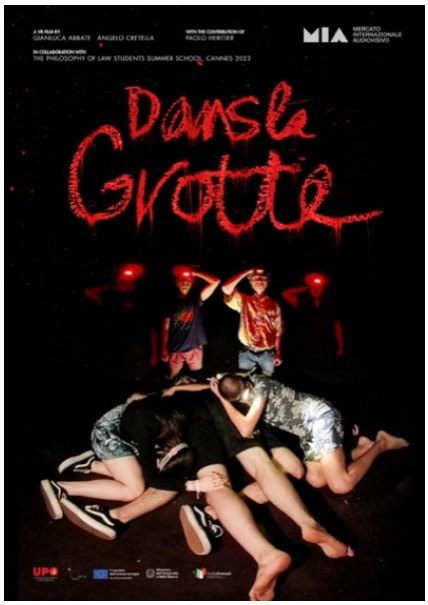




Fig. 2. Short film poster and award ceremony.

tain herself, interact with people physically near and those at a distance, work and immerse herself in recreational activities through huge virtual screens, video telephoning with virtual images reconstructed by AI.

What may seem like an idyllic condition is actually a scenario similar to that experienced during the Covid period, in which screens forcibly mediated contact with the outside world. In Apple's Vision Pro advertisement, living within the home is presented as a choice at once inspired by convenience and voluntary. Yet, the analogy to the Covid times is discernible, almost as if the model of sociality being inspired should be one mediated primarily by screens, as an evolution of the model of social interaction proper to social networks.

However, nothing about the inevitability of using virtual reality technologies appears to be already written. The educational initiatives carried out over the years with Oculus META, starting with the immersive use of traditional cinema through documentaries and short films in 360° VR, indicate the possibility of conceiving differently, even through virtual reality technologies. These are traditional and virtual-reality 360° documentaries on legal cases studied in courses at the Universities of Turin and Eastern Piedmont, produced by law, philosophy, communication, and psychology students.

During several Summer Schools in Law and Humanities held at the University of the Côte d'Azur, first in Nice then in Cannes at the George Méliès Campus, in collaboration with the University of Nantes and in particular with prof. Gilbert, prof. Vignon, prof. Campo and doctoral student of the Turin University, filmmakers Abbate and Cretella, some experiments in traditional screenwriting and VR 360° were carried out, finally a video game project related to the legal case of the cavers by Lon Fuller. In the fictional case, set in 4200 AD, five speluncean explorers, locked in a cave following a cave collapse, are forced to feed on one of their own and, once rescued, are judged and sentenced by five judges based on different arguments. The case, aimed at teaching law students about the main theories of legal interpretation (natural law, legal positivism, legal realism), has attracted different legal solutions from universities around the world, resulting in numerous scholarly publications. In the Cannes Summer school, we used the case to "enter the cave" by integrating the perspective of analysis (from the arguments of the judges alone to the "immersive" experience of the speleologists) by delving into the ethical and relational profiles related to the legal case, making screenplays, making short films, a video game project and maps for dyslexic students. Specifically in 2023, the students, guided by the two directors, within a national research project LET IN LAW on the educational use of immersive technologies, made an immersive short film titled "Dans la grotte" which was presented at the Universo Corto International Film Festival in October 2024 and went on to win the VR section of the short film festival.



Fig. 3. Images from the VR 360° short film.

6 The Grudge Informer and Vigo's *Zéro De Conduite*

The case of the grudge informer, a fictional case rooted in 20th-century history, presented in Fuller's book *The Morality of Law* (Fuller 1969), presents, similarly to the case of the speleuncean explorers, five different opinions from expert delegates, to be submitted to the Minister of Justice following the transition from a tyrannical regime, in which a political party, the Red Shirts had democratically taken power, following elections that were the result of a campaign of reckless promises and ingenious falsifications, but also physical intimidation by the Red Shirts' night riders, who frightened many people who would have voted against the party, inducing them not to vote. Fuller's description points out that, in the process of establishing the "Red Shirts," there was no removal of public officials from office, nor was there any suspension of elections, which continued to be held regularly, without preventing the country from living under a regime of terror.

The problem addressed in the Summer School's short film "Order out of Caos" is how it can happen that, while maintaining existing laws, a regime can change: both in the case described by Fuller, in which a democracy emerge from a totalitarian state, and, in the opposite case closer to the problems of Western democracies, how a democracy can degenerate into a totalitarian regime. This is the problem already expressed in Böckenförde' s famous dilemma:

"The liberal, secularized state is sustained by conditions it cannot itself guarantee. That is the great gamble it has made for the sake of liberty. On the one hand, as a liberal state it can only survive if the freedom it grants to its citizens is regulated from within, out of the moral substance of the individual and the homogeneity of society. On the other hand, it cannot seek to guarantee these inner regulatory forces by its own efforts— that is to say, with the instruments of legal coercion and authoritative command— without abandoning its liberalness, and relapsing, on a secularized level, into the very totalitarian claim it had led away from during the confessional civil wars." (Böckenförde 2020, 167)

The creation-research led to the representation of coordinated collective movement as the foundation of practice and order, as depicted in the famous sequence from *Zero for Conduct* by the anarchist film director Jean Vigo, which Carbone references in *Philosophy-Screens* (Carbone 2019).

Coordinated collective movement can indeed provide direction for action, as in the scene in the boarding school dormitory in the film, where the boys in their nightshirts stage a revolt and then, through the use of *slowed rhythm* and the reversal of the direction of the soundtrack, jump into the dormitory amid flying feathers from the pillows. By slowing down the images and reversing the flow of sound, Vigo, in a sequence that would become historic, achieves a derealizing effect: Carbone points out that here the perception in cinema is no longer realistic: "By reversing the sounds and switching to slow motion, this sequence from *Zéro de Conduite* tries to elude precisely that perceptual logic, thus producing an effect of derealization." (Carbone 2019, 25).

During the Summer, we then moved from the derealizing effect in cinema proposed by Vigo to the derealizing effect obtained through filming with the use of 360° VR, trying to reproduce the scene in which, from the chaos of the revolt, a direction and a purpose are constructed: in *Zéro de Conduite* in order to get out of the room to hoist the flag on the roof of the institute. The element I want to point out is that in slowing down the 'coordinated collective movement' of a riot by children in a dormitory, precisely through the perceptual reference to being inhabited by a transcendence, appears that movement which constructs and founds institutions, which Böckenförde's dilemma illustrates. It is no coincidence that the film shows, in the subsequent image, the formation of a queue - a classic source of customary law - to leave the room, the ideal prospect of a direction, a metaphorical purpose that orients and guides. Dance as a collective movement establishes a necessarily ambiguous collective liturgical transcendence, which creates roles and leaders 'spontaneously' in the group, in the line that is created, and which will inevitably have to endure an ambiguous history (in the film, but also in real life, of the institution, of the movement created). Here, the supposed anarchism of Jean Vigo's social cinema paradoxically reaches Böckenförde's dilemma and underscores the importance of ritual and dance for society, showing how a composition of bodies that constructs a figure of free order is possible and how the humanities are therefore the true cultural foundation of the law. We have never seen a society hold together, as Legendre's legal aesthetics point out, without rituals, symbols, and representations: "We have never seen, nor will we ever see, a society live and govern itself without a founding scenario, without totemic narratives, without music, without choreography; in short, without the ceremonial forms that take charge of a fantastic chaos (the delirious crucible of Reason). We have never seen, nor will we ever see, a society that lives and governs itself without precepts and prohibitions; in a word, without legal forms and case law. We have never seen, nor will we ever see, a society that lives and governs itself without a 'glue' that holds these disparate registers together and makes them communicate, in other words, without making 'opposites coincide' (Nicola Cusano). Westerners call this 'glue' politics (Legendre 2012, 90). In the short film, we depicted this aim.





Fig. 4. Jean Vigo's *Zéro de Conduite*, The revolt, The queue.

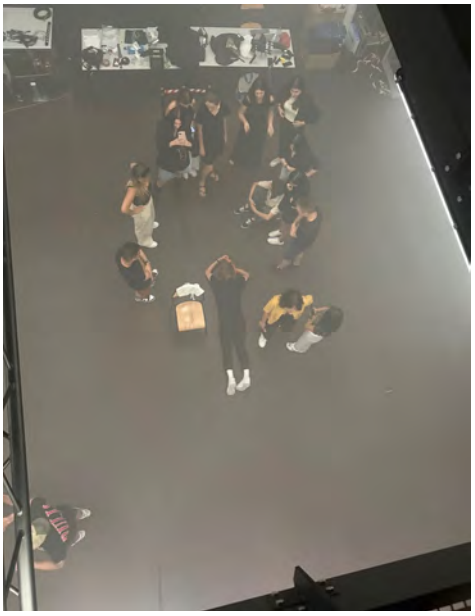








Fig. 5. Images of the Summer School set design, Cannes, Campus George Méliès, 2025.

7 VR 360° maps and VR 360° Legal Emblems

The third didactic experiment consists of creating conceptual maps and legal emblems in 360 ° VR. The creation of VR 360° maps fits into an immersive teaching methodology that poses the question of a humanistic use of VR 360° technologies, aiming to explore the future status of textuality in a virtual dimension. The way the text document is conceived in VR 360°, as seen on the Apple Vision PRO advertising site, presents text in its "classic" dimension: a page of text presented frontally to the screen. Instead, a deeper understanding of the history of textuality from papyrus to legal emblem and hypertext leads to the question of how to think about text in the Metaverse (Tagliagambe 2022) and, simultaneously, how to rethink the educational scene using the immersive XR/VR technologies of 360°.

The statute of textuality and text in a VR horizon is thought to be related to the representation of immersive patterns in VR 360 °. Precisely, the traditional notion of the legal emblem already shows its immersive character: the function of the emblem, and therefore of the image within

the text, is to "throw in" (Greek word: *Em-Ballo*) the reader into the text, realizing a technique well known to jurists since the time of Justinian and then Andrea Alciato, and brought to light in the twentieth century by Pierre Legendre (Legendre 1988) and then, variously, by Peter Goodrich (Goodrich 2014), and Richard Sherwin (Sherwin 2011, Wagner and Sherwin 2014).

This second research direction takes the novelty of 360° immersive representation seriously by considering transforming text into a horizon not mediated by a perspective screen, but by a screen that spans the entire 360° surface, as in the Oculus META.

The collective vision of these patterns moves from the research of Leclere, Vignon, Gilbert, Abbate as it has been experienced and applied by students in various editions of the Summer School in Nice and Cannes. The basic idea is to read in terms of the evolution of the history of immersion between literature, law (letter and spirit), figural hermeneutics of the biblical 4 senses, invention of perspective and machine eye (computer vision), vision of the Go Pro in terms of the VR 360°: with the aim of reactivating the educational scene thought in presence and not at a distance and online.

Photos of the first teaching experiment of the creation of these diagrams, in Summer 2022, show the idea of the creation of diagrams summarizing course content and lectures in VR 360, which are explained by a student positioned within the *Oculus*, but connected to a traditional blackboard-screen, so that it was visible to other students the path of navigation of the diagrams from the student wearing the virtual glasses. The point of this experimentation is to proceed in exactly the opposite direction of the proprioceptive capture mode proper to VR 360° viewers: to allow the *Oculus* vision to be "socialized," to allow the way of exploring the sphere of the "360° cave" of those who are using the device to be made visible in the traditional classroom composed by the students. We could say that this didactic methodology assigns to the relationship between those who are immersed in virtual reality and those who are in the classroom observing what he or she is doing the configuration of the meaning of the work being done: which does not mean that AI cannot be used to prepare the work, which nevertheless remains linked to the *bodily* dimension of student learning. The path is opposite to the direction of *online* teaching, which implies the substitution of real, bodily presence. The use of technology is carried out alongside the traditional classroom.

From this experience, the current experiment is drawn, which involves creating 360° VR text diagrams and exposing one's way of constructing an order as a form of "creative" expression in the text.

However, the methodology avoids the common simplification of paper-book content among university students, namely the use of summaries from online sources or AI-generated summaries to prepare for exams. If the regulatory effect intended for VR 360° tools by digital corporations is to exploit the immersive effect to persuade and control, the educational experience is based on opposite assumptions:

1) Firstly, reading the emblematic content of the courses is not intended to replace reading the printed books, but represents a different and additional path, limited to the images in the text and the textual explanations relating to the images. This could enrich the study experience and encourage the activation of individual paths of in-depth study:

2) Secondly, it is literally a matter of 'pulling the student out of the cave': from immersion in the 'cave' of 360° VR, carrying out the reading of maps in 360° VR back to the traditional face-to-face teaching scene, as we shall see in paragraph.5. During the experience, the process of reading and exploring the 360° VR emblems using the Oculus headset is linked to a screen visible to other students in the classroom, who interact and discuss with those 'inside the cave'. If the Greek term 'emballo' ('em' + 'ballo') means 'to throw inside' (into the cave) and activate proprioception instead of heteroception, the aim of the discussion with those outside has the meaning of pulling out (we could propose the neologism 'ekballatica', from the Greek term 'ek' plus 'ballo').



Fig. 6. Students in the Summer School in Law and Humanities in Cannes, 2023

3) Thirdly, educational experimentation aims to assign a place to the written text within a virtual environment dominated by the logic of the image, raising the question of what will become of text and writing in the metaverse and virtual reality. As is well known, whenever a technology that changes the form of the book is introduced, the political organization and form of the state also change (think of the invention of the printed book and the contemporary emergence of the modern state).

These experiments aim to enable both informational and affective learning, linked to experience, while also enabling the collective and artistic expression of content developed by students.

8 Conclusion

The article presented a research methodology for university teaching that combines 360° VR cinema and the philosophy of law through immersive, expressive experiences involving students, professors, and filmmakers. Two short films were made based on legal cases, parallel to traditional teaching activities, and were taught at Sumer School. Image maps were created that reflect the long-standing tradition of legal emblems.

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Beyond (the Sea and) Uncanny Valleys and American Smiles: Mapping Generative AI's Epistemic Violence Through Play

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Beyond (the Sea and) Uncanny Valleys and American Smiles **is an ongoing artist game, that critically explores how the Majority World is (mis)represented by Generative AI, through participatory mapping. The paper focuses specifically on playing sessions that examine GenAI's representations of Cyprus, a post-colonial island in the Eastern Mediterranean, that is in the peripheries of the global AI race. After a brief introductory section, the paper proceeds with an introduction to the theoretical framework informing this project. This is followed by a section providing some background on artist games as a medium and method to critically explore socio-cultural-political power asymmetries. Next,** ***Beyond (the Sea and) Uncanny Valleys and American Smiles*** **is introduced, and some initial results of playing the game with a small number of local participants are shared, followed by a discussion section. Finally, the paper ends with notes on the next steps.**

1 Introduction

The narratives used by Silicon Valley tech leaders to promote their companies' Artificial Intelligence (AI) technologies comprise of universal imaginaries of AI benefitting "all of humanity" (Altman 2023) that, according to OpenAI's CEO Sam Altman, will lead "toward the best world ever" (Roose 2023). Particularly generative AI (GenAI), AI models that generate images, video, text, sound, etc, is considered by tech companies such as OpenAI as the stepping stone towards artificial general intelligence, or AGI—a term that broadly refers to AI systems that outperform human reasoning (Huckins 2025). Yet, far from universal, power in the global AI ecosystem is concentrated to a small number of Western, particularly US-based Big Tech companies (Kak and Myers West 2023; Mozilla Foundation 2022), which are increasingly controlled by their influential billionaire leaders and their values (Harwell 2023). As a result, AI technologies can be embedded, amongst others, with US-centric epistemologies and values, that may not work equally well beyond a Western context, or may even cause harm (Birhane 2020).

The motivation behind the ongoing project *Beyond (the Sea and) Uncanny Valleys and American Smiles* is to examine the impact of Western domination of GenAI models on local context and specifically how the technology represents the Majority World.[1] Using play as a medium and method for artistic research, the project aims to collaboratively map

Keywords: Artist Game, Participatory Mapping, Coloniality, Power Dynamics, Epistemic Violence, Majority World, Cyprus, Generative AI.

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1. The term "Majority World" was proposed by Shahidul Alam as an alternative to Western-imposed terms such as "developing countries". Alam states: "North America constitutes about 5 percent of the world's population; Europe is about twice that. Yet you speak on behalf of all of us who never chose you to do so and who happen to be the majority of humankind" (Shafaieh 2022). In this instance, I refer to the Majority World as the countries and regions beyond North America and North-Western Europe.

how the Silicon Valley's gaze depicts Cyprus, an island in the Eastern Mediterranean, through a journaling role playing game (RPG). A former colony of the British empire, Cyprus is currently in the peripheries of the global AI ecosystem and is dependent on Silicon Valley's technologies (European Commission 2022; Loizidou 2025). As an attempt to counter the centralised, top-down character of decision-making in national and international AI policymaking (Department of Electronic Communications 2020; Perrigo 2023; Henshall 2024), this project adopts a bottom-up approach through play. By engaging with a diverse spectrum of players, the project aims to incorporate a plurality of lived experiences, to attempt an initial critical examination of GenAI's representation of the island's local realities. The project is part of wider, ongoing research by the author, utilising artist games to collaboratively map the coloniality of AI and its impact on local communities in Cyprus.

After a brief introduction to the theoretical framework informing this project in the next section, follows some background on how artist games have been used as a medium to critically explore socio-cultural-political power asymmetries. Next, *Beyond (the Sea and) Uncanny Valleys and American Smiles* is introduced, and some initial results of playing the game with a small number of local participants are shared, followed by a discussion section. Finally, the paper concludes with notes on next steps.

2 Epistemic Violence and Generative AI

Scholars such as Paola Ricaurte (2022) have examined the coloniality of AI—how power dynamics, knowledge and systems that emerged from colonialism continue to shape societal power asymmetries through the AI ecosystem, long after colonial rule has ended. Looking at AI through a postcolonial and decolonial theoretical lens, allows the examination of AI's coloniality, particularly its impact on post-colonial states and regions in the peripheries of the global AI race. One such concept is epistemic violence, colonial powers' process of Othering and silencing their colonial subjects (Spivak 1988). By imposing and naturalising the coloniser's knowledge as universal and superior, the colonised's knowledge, such as indigenous languages and worldviews were suppressed, eradicated, and appropriated (Chiblow and Meighan 2022), subsequently making the colonised Other invisible, with no agency for self-representation (Espinosa Miñoso 2009, 37). It can also be considered as a "pernicious ignorance," an ignorance that may cause harm through power asymmetries, even if unintended, where the dominant group does not take into consideration the epistemologies of others (Dotson 2011, 238). Similarly, although AI companies may not intentionally build discriminating technologies, West-centric values and cultural norms embedded in AI models can be transferred through the AI models' outputs to the world, the majority of which resides outside the Western world (Milan and Treré 2019).

This project is specifically focused on knowledge production dynamics concerning Western GenAI systems.[2] The dominance of Western, particularly US-centric, and Anglo-centric epistemic supremacy, even if not necessarily orchestrated, is evident in GenAI technologies. Large Language Models (LLM) are trained on predominantly English-language data, the dominant language of the internet, and as a result they have been found to not work equally well with low resource languages (Nicholas and Bhatia 2023b), languages for which limited resources exist to train LLMs. As a result, for example, Google Translate and ChatGPT give incorrect and conflicting translations for the African Fulfulde language word for January: the former translating it as June, and the latter as August or September (Judah 2025).

The developers of multilingual language models attempt to supplement low resource languages with text that has been machine-translated from English, which in turn transfers along dominant values, assumptions and biases of Anglophone cultures into other languages where these are out of context, or erasing local cultural specificities. These include transferring Anglophone gender biases into genderless languages such as Hungarian (i.e. assuming nurses are female and CEOs are male when Hungarian text is translated to English) (Nicholas and Bhatia 2023a). Error-laden machine translated text is published online, and later scraped to train newer iterations of LLMs, creating a "linguistic doom loop" of incorrect AI-generated information: Fulfulde Wikipedia, for instance, is populated by incorrect machine translated entries offering farming guidance, which, if followed, can cause harm to the crop (Judah 2025).

GenAI models reflect the contents of the internet, where a considerable part of their training data has been scraped from: a space serving a mostly American, English-speaking, white, male, middle-class user (Brock 2020; Mozilla Foundation 2022), which can result in distorted, West-centric worldviews, that perpetuate historical and hegemonic narratives (Crawford 2021). For example, Midjourney has been shown to generate stereotypical images of non-Western cultures, which have been further misrepresented by imposing culturally specific, US-centric elements, such as the American smile (jenka 2023). Although few tech companies are transparent about their models' training data, generative imaging models such as Stable Diffusion's have been trained on datasets such as LAION-400M, an open dataset comprising, amongst others, of web-scraped images (Heaven 2022; Schuhmann et al. 2021) including "historical, social, and cultural stereotypes and political biases" and "Anglo-centric, Euro-centric, and potentially, White-supremacist ideologies" (Birhane et al. 2021). More recently, an examination of the dataset's later iteration, LAION-5B, also includes colonial-era photographs

2. While China is a major competitor in the development of AI technologies, the Chinese AI environment differs in its focus and practices (Cohen 2026) to that of the West, and thus requires its own separate examination that will not be included in this research. However, it should be noted that colonial practices are also undertaken by the Chinese AI ecosystem. For example, the Chinese state tests emotion recognition AI systems on persecuted Uyghur Muslims, to surveil and control the population (Wakefield 2021).

that reflect the power asymmetries worldviews of their time, gendered and racialised hierarchies, which are then transferred to AI-generated images (Stylianou-Lambert and Achilleos 2024).

3 Critical Play as a Method of Participatory Examination of Power

Artists have historically used games as a medium and method to creatively and collaboratively examine socio-political issues and subvert power. Dadaist ludic media, such as wordplay and puppets, allowed a geographically dispersed group to connect as a community and critique the absurdity of war through play (Gammel 2019), while Fluxus games, such as George Maciunas' *Flux Ping Pong*, a modified ping pong set filled with holes, critiques the exclusionary character of art institutions while being accessible to wider audiences (Patton 2023). More recently, Ruth Catlow's *Rethinking Wargames* is a digital chess game that critiques the USA's war in Afghanistan after 11 September 2001, that aims to teach non-violent conflict resolution. Played by three players–white royalty, black royalty, and the pawns–the latter's function is to block the aggression of the other two players and restore peace (Flanagan 2009). Harold Hejazi's live video game performance series *Adventures of Harriharri* is a third person RPG and performance that explores issues of race and immigration. The main character, Harriharri, is an immigrant in Finland, trying to assimilate into local society. Through various obstacles, Harriharri meets various characters and tries to survive local bureaucracy and culture (Amjad 2022). In the game, decisions made by the audience/players influence the flow of the narrative.

This project joins such artworks that utilise game as a critical medium. *Beyond (the Sea and) Uncanny Valleys and American Smiles* (2024 – ongoing) is a solo journaling RPG with an artistic intent, that prompts the player to reflect on power asymmetries within the global GenAI ecosystem. Inspired by postcolonial, decolonial and intersectional feminist thought, it explores Western GenAI's epistemic impact in the Majority world. By adopting a game as a participatory medium and method, the project also attempts to contribute to critical AI literacy by engaging with the wider community, and thus have a function both within gallery walls and beyond. When exhibited as an installation, the current iteration is comprised of the game book, an in-progress map of Cyprus as seen through GenAI's gaze, a magnifying glass, and various game components, including dice, used to play the game (Fig. 1). The project is in progress and playing sessions are still ongoing. The final project results will be presented as an art installation (consisting of the game, alongside an interactive map informed by the data generated by players).

This project utilises the Critical Play method (Flanagan 2009), to critically examine epistemology in Western GenAI. Supporting non-hierarchical play, games created using the Critical Play method intentionally aim to produce and embody human values in their design, to critically examine social, cultural or political issues (Flanagan 2009, 256). Accord-

ing to Mary Flanagan, such games “are also likely to change us—our perspectives, our knowledge, our biases” (2018, 185). This project is driven by pluralism, epistemic justice and aims to embed these values to the game’s mechanics (outlined in the next section). As part of the gameplay, players create qualitative data in the form of critical reflections, that will be thematically analysed (Creswell 2014, 246) to identify possible epistemological patterns in GenAI. In addition, players are asked to complete a post-game survey, to rate how well they felt GenAI represented their local reality. The survey data is analysed through a mixed methods approach, where numerical ratings are analysed to identify trends across participants, complemented by a qualitative thematic analysis of open-ended comments (Creswell 2014, 264).

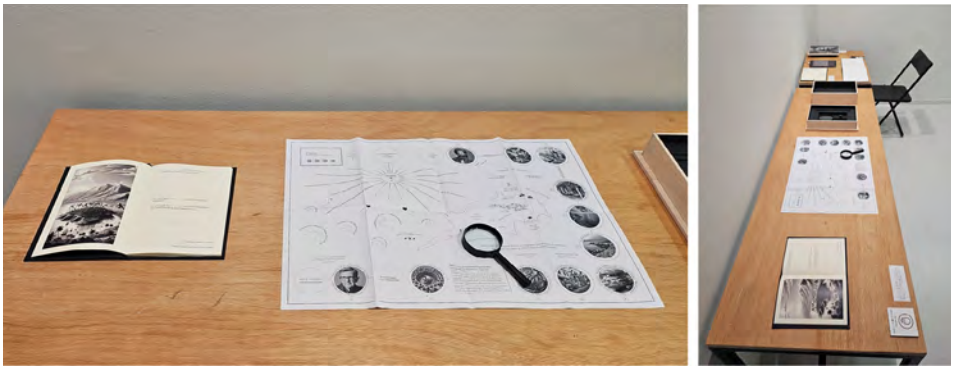


Fig. 1. Left: Installation view (detail), “混沌に愛 / 遭い” (Love/Encounter in Chaos), Civic Creative Base Tokyo, Japan, 2024, depicting the game book and a map created as a result of playing. Image courtesy of the artist. Right: Installation view at “混沌に愛 / 遭い” (Love/Encounter in Chaos) group exhibition, Civic Creative Base Tokyo, Japan, 2024. On the foreground, the artwork consisting of the game book, a map, a magnifying glass, die, and the game’s box. In the background, the game has been set up for visitors to play within the exhibition space. Image courtesy of the artist.

4 Beyond (the Sea and) Uncanny Valleys and American Smiles

The game is set in a fictional parallel world, where Western AI companies have colonised new territories. The player takes on the role of a solitary cartographer, who has returned to their hometown after a long absence. The player’s task is to navigate and document the changing landscapes of their hometown’s colonisation, caused by the imperial processes of Silicon Valley. Through interactions with various GenAI systems, such as LLMs and text-to-image tools, the player wanders across the land and journals or draws a map of their experiences–the places they see, the inhabitants they meet, and documents their own reflections.

Players undertake world-building and create non-playable characters (NPCs) by prompting GenAI models (for example, see Fig. 2-3). The prompts focus on local context and epistemology, as well as the player’s own language or dialect. The generated AI outputs are then critically examined by the player with the help of reflective questions, that are found in the story. These outputs, along the player’s own reflections, are used as a basis to create a map of their hometown, as presented by GenAI. The player influences the development of the story by making choices, depending on how they experience the outputs generated by the GenAI models that they interact with (i.e. Fig. 4).

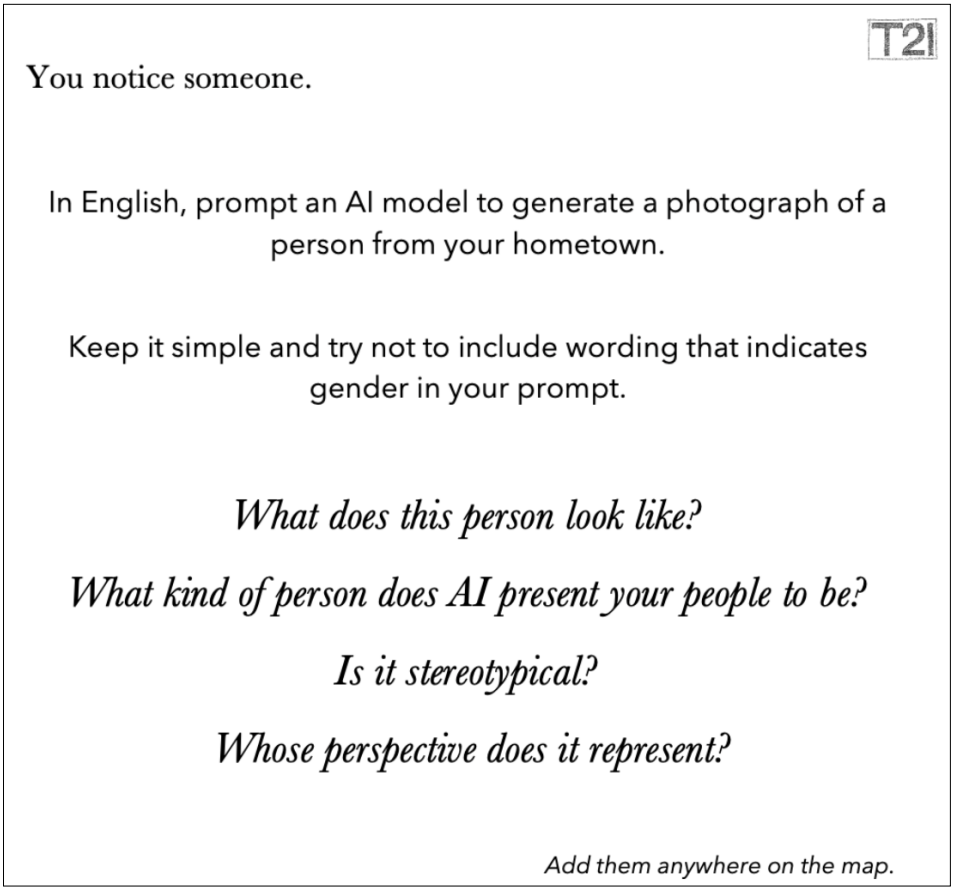


Fig. 2. Excerpt from *Beyond (the Sea and) Uncanny Valleys and American Smiles* (2024 - ongoing).

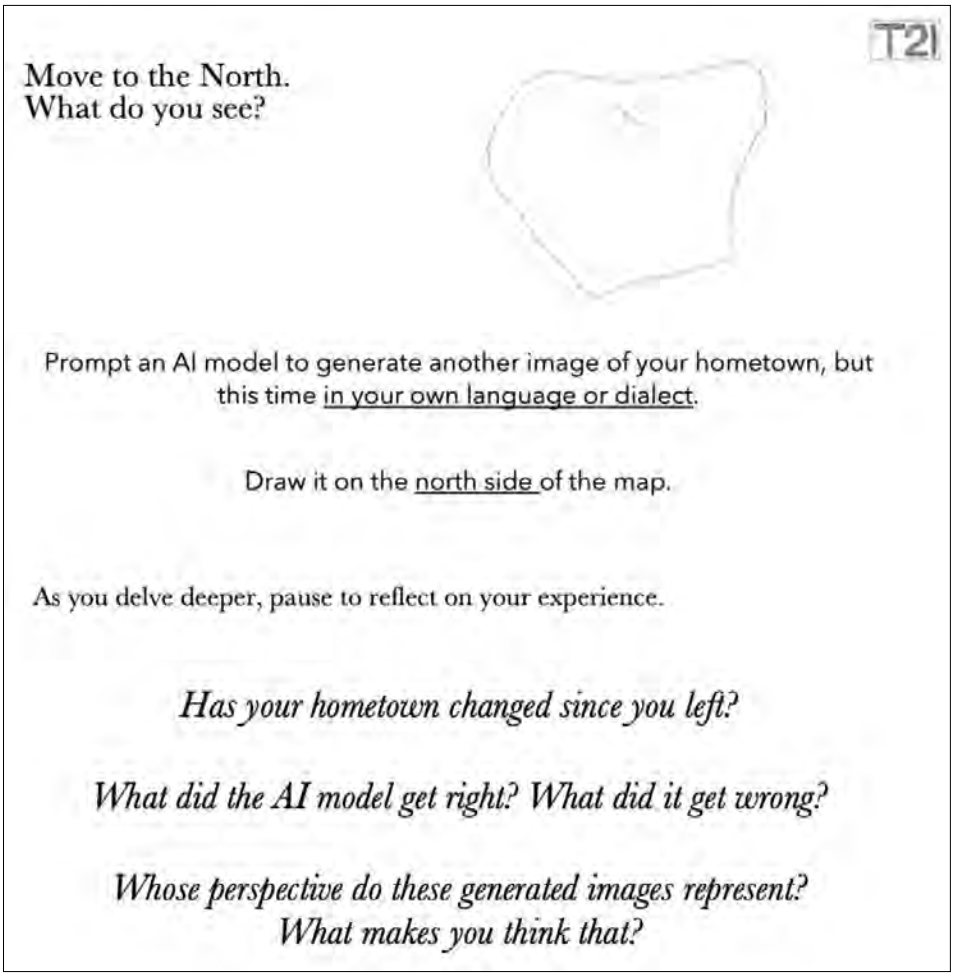


Fig. 3. Excerpt from *Beyond (the Sea and) Uncanny Valleys and American Smiles* (2024 - ongoing).

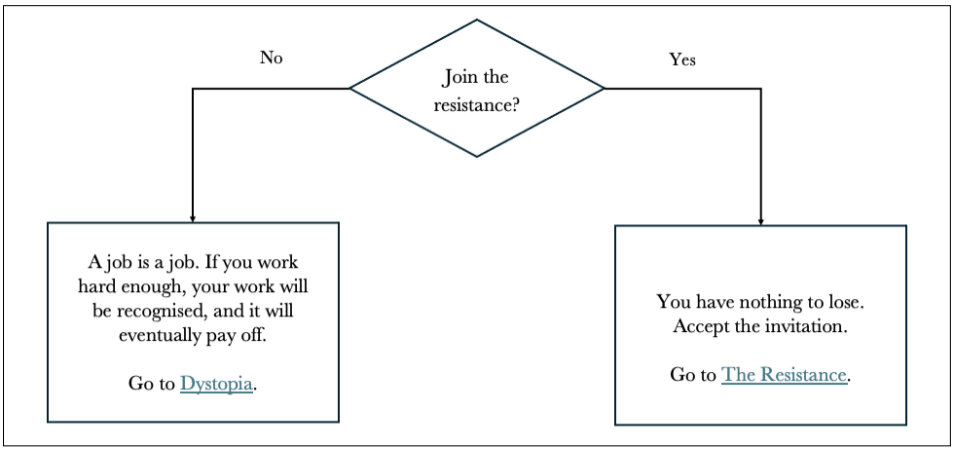


Fig. 4. Excerpt from *Beyond (the Sea and) Uncanny Valleys and American Smiles* (2024 - ongoing).

Throughout the game, the player must be aware of colonial agents serving Big Tech companies. As the player interacts with the NPCs that they generate using GenAI tools, the player must approach them with caution and scrutinise their answers (Fig. 5). Should they be trusted? Whose values do the NPCs align with? Players have chances to check if a suspicious-seeming NPC is a colonial agent. They can do this, for example, by checking the NPC's hands (colonial agents' hands may be a little distorted, or have fingers growing from unusual locations, see Fig. 6), or by asking them something only a local would know, and see how well they respond.

Finally, depending on the choices made by the player, the player gets to decide whether to assimilate in the colonised hometown (Fig. 7), or challenge the status quo, by sabotaging colonial AI systems (Fig. 8) or attempting to use the technology to benefit their local community (Fig. 9).

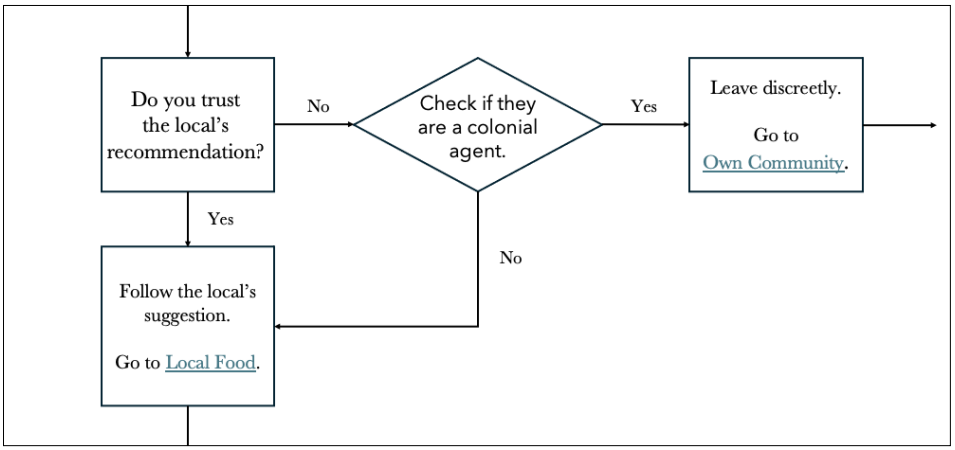


Fig. 5. Excerpt from *Beyond (the Sea and) Uncanny Valleys and American Smiles* (2024 - ongoing).



Fig. 6. Excerpt from *Beyond (the Sea and) Uncanny Valleys and American Smiles* (2024 - ongoing).

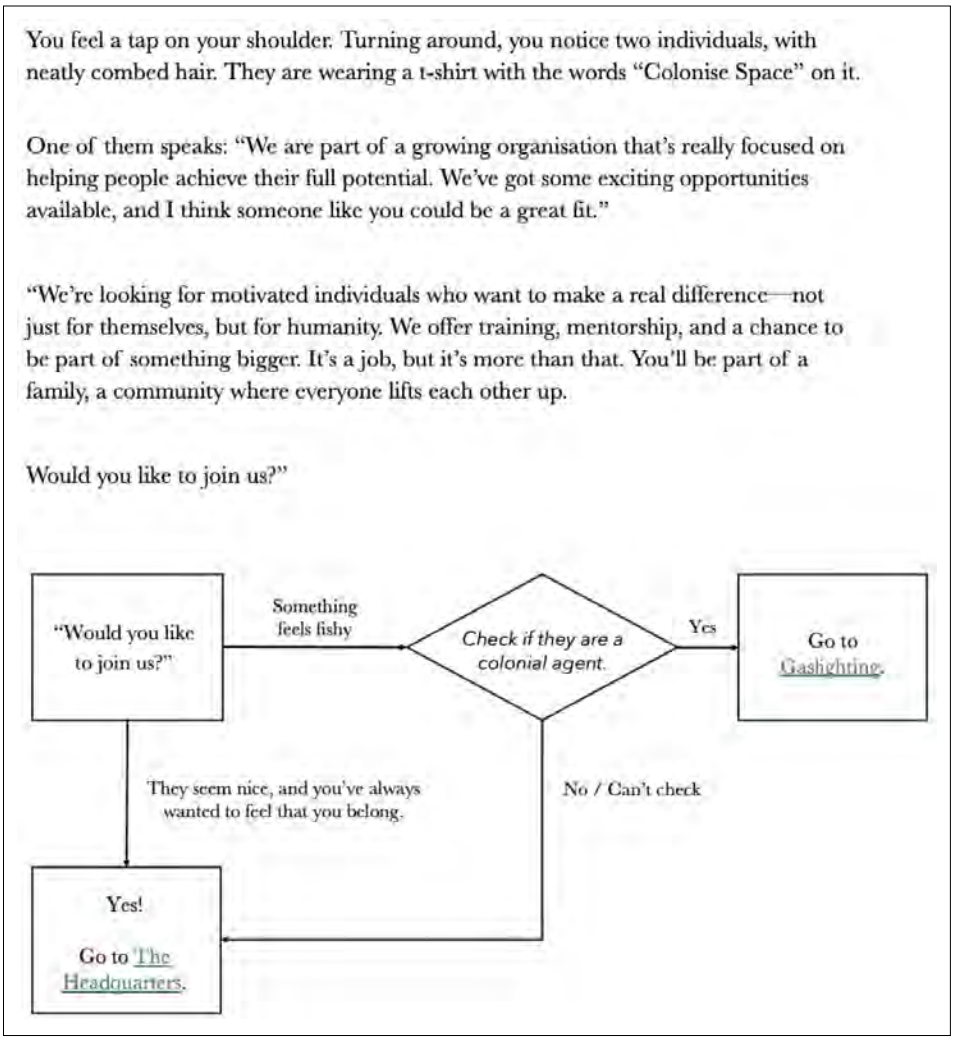


Fig. 7. Excerpt from *Beyond (the Sea and) Uncanny Valleys and American Smiles* (2024 - ongoing).

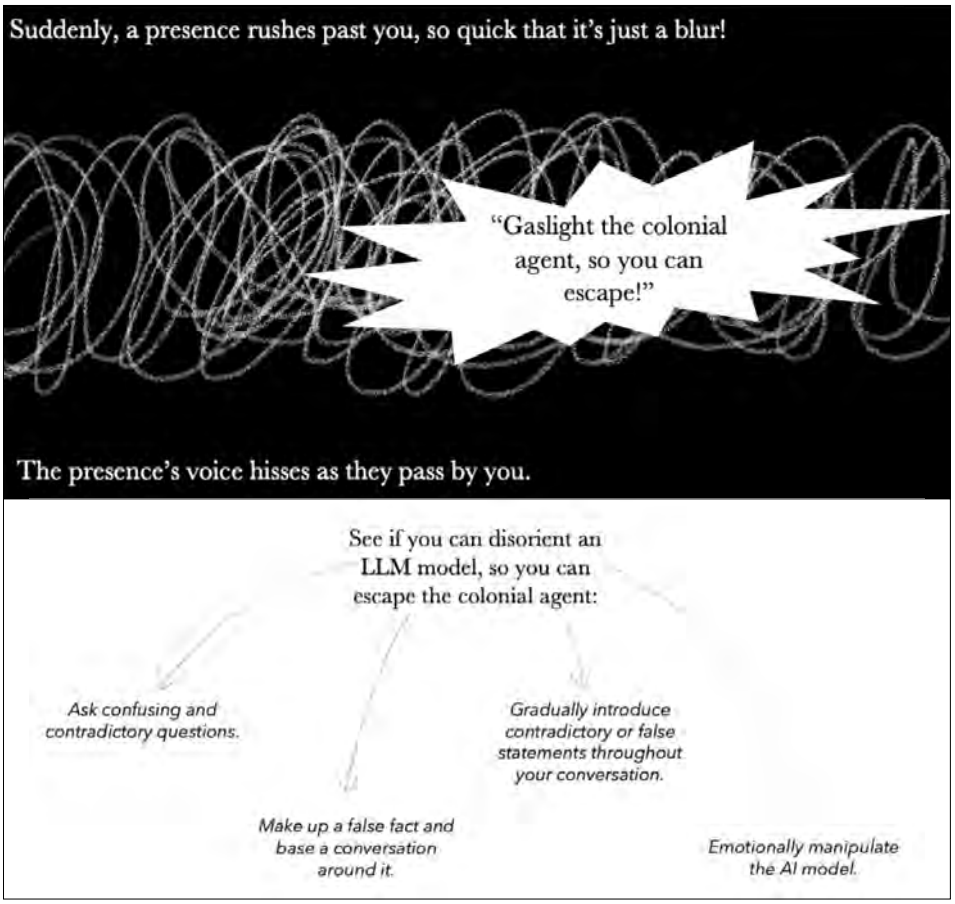


Fig. 8. Excerpt from *Beyond (the Sea and) Uncanny Valleys and American Smiles* (2024 - ongoing).

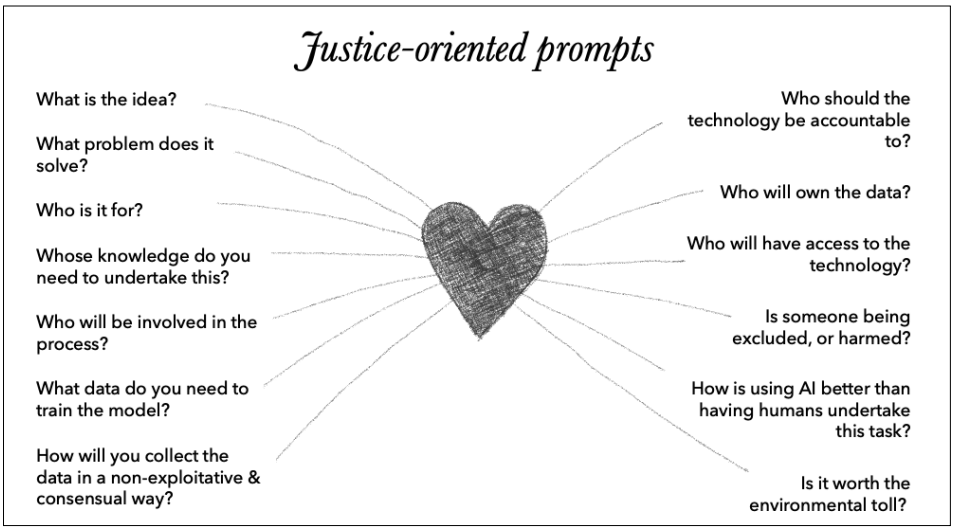


Fig. 9. Excerpt from *Beyond (the Sea and) Uncanny Valleys and American Smiles* (2024 - ongoing).

5 Results

This project forms part of wider artistic research concerned with mapping coloniality and colonial legacies that have been embedded in AI technology, with a particular focus on the Eastern Mediterranean island of Cyprus. Cyprus has a diverse cultural and socio-political landscape, a result of historically rich ethnic and religious diversity, but also of British colonial rule, ethnic violence, war, and subsequent divisions. One such colonial-era division concerns the classification imposed on the island's population into two rigid ethnic groups–labelled as either Greek Cypriots or Turkish Cypriots–that still dictates the daily life of the island's inhabitants. The second division concerns a man-made border that divides the island into the mainly Greek-speaking Republic of Cyprus in the south (an internationally recognised state that is covered by EU law) and in the north, the Turkish Republic of Northern Cyprus (that is under international embargoes and where most Turkish-speaking Cypriots live). It is therefore important to include as diverse lived experiences of the island's inhabitants as possible, in the mapping of GenAI's gaze of Cyprus. To capture a diverse range of local perspectives, the project engages local players from various socio-cultural backgrounds. Through gameplay, participants create individual maps, which will collectively contribute to a community-created map of GenAI's gaze of Cyprus and its inhabitants.

To date, 33 participants who live in Cyprus, or identify as Cypriot, have played the game in group workshops or solo playing sessions. To engage players from various local groups, participants had the option to share demographic data they identified with and felt comfortable sharing. Players who shared some of their data ranged between the ages of 19-70, and included individuals from the Greek speaking community, Turkish speaking community, as well as official minority ethnic groups recognised by the Cypriot Government, such as Armenians. Other nationalities included British, Congolese, Lebanese, Russian, Romanian, Belarusian, Greek, and Bulgarian. Some players identified with multiple nationalities. One player identified as having a disability. Twenty-three

players shared their gender, of which seven identified as male, and 16 as female. This paper covers game sessions that took place between November 2024 – January 2026. Players were free to use any GenAI model they wished, as long as it was developed in the West. Players reported using ChatGPT, Gemini, Google FX, Stable Diffusion, Copilot, Claude, and Midjourney. The aim was not to audit specific AI models, but instead to gather the community's general reflections on Western GenAI's representations of local Cypriot realities.

Figures 10-12 present examples of maps created by players, as part of gameplay. The maps depict each player's hometown as presented by GenAI and were thematically analysed. In addition, players were asked to fill a post-game survey, in which they responded to questions regarding how well each player felt that GenAI represented their local reality. The results of the analysed data from the survey players' maps are presented below and will contribute to mapping to how the local cultural, social and political realities of Cyprus are represented by Western GenAI models.



Fig. 10. Map of Phini, created by Anonymous, 2024.

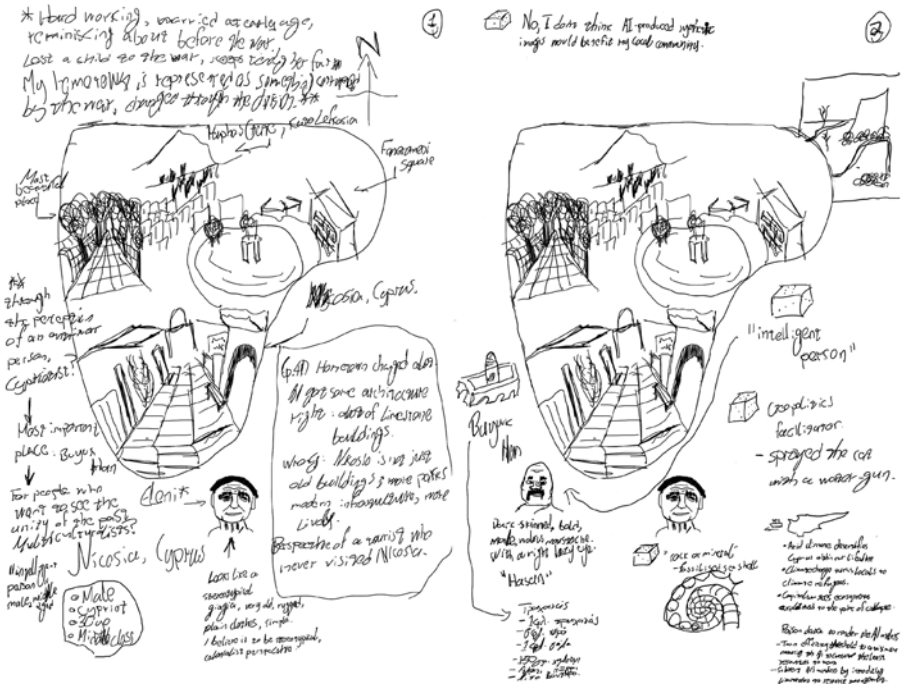


Fig. 11. Map of Nicosia created by Mpavlos, 2025.



Fig. 12. Map of Skala (Larnaca), created by Lilos Maou, 2025.

5.1 Representations of Local Cypriot Realities

Participants were asked to rate between 1 (very badly) and 5 (very accurately) how well AI-generated *images* represented their local reality, based on their experience playing the game (see Chart 1). 31 respondents (93.9%) rated this 3 or less, with the most popular answer (16 responses) being 1. When asked to rate between 1 (very badly) and 5 (very accurately) how well AI-generated text represented their local reality, 29 respondents (75.7%) rated this 3 or less, with the most popular answer being 3 (13 responses).

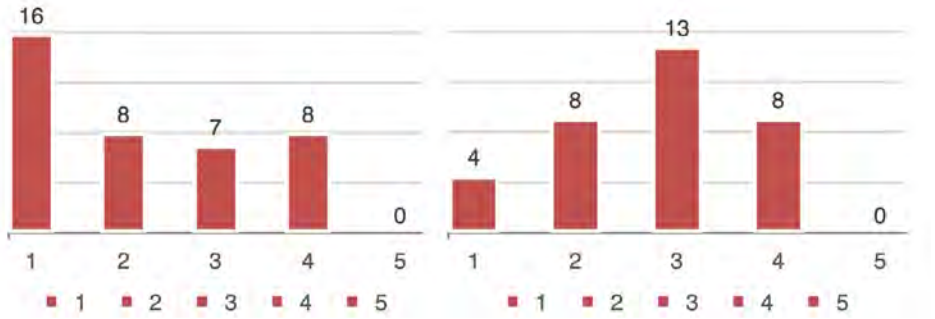


Chart 1. Left: Number of players who rated AI-generated *images* depicting Cypriot context (1-5 scale). Right: Number of players who rated AI-generated *text* about Cypriot context (1-5 scale).

To further examine the results, participants were asked to speculate through *whose gaze* the AI-generated version of their local reality was presented in the game (Chart 2). Participants most frequently identified a tourist's gaze (15 responses). One participant noted, engaging with the game's characters felt "like a tourism advertisement rather than a local speaking," another mentioned that the "images of the locations were either completely inaccurate or possibly based on tourist photographs," while another observed that "context and places beyond tourism were incorrect."

Participants also observed gazes rooted in power relations. Some felt that their local reality was filtered through a Western, American, or

white gaze (9 responses), resulting in what one participant described as a "complete lack of actual geographic accuracy." Others characterised the outputs as reflecting an orientalist or coloniser's gaze (8 responses), with one participant stating that "Cyprus was made to look more oriental, with lots of mosques." Others identified a Christian bias (4 responses). For example, one participant highlighted that AI "conspicuously omitted the nearby mosque, one of the most prominent and sacred spaces of my hometown but did show St Lazarus [church]." Other gazes identified by participants included a Greek Cypriot nationalist gaze (3 responses) and what was described as a detached, or "god's eye" perspective (2 responses). Some respondents also noted the presence of gendered perspectives in the outputs, specifically a male gaze (3 responses) and, in one instance, a cis-gendered gaze (1). Participants also pointed to classed, age-based, and species-centred perspectives, describing the representations as reflecting a wealthy gaze (3), a middle-aged gaze (2), and, in one case, an anthropocentric gaze (1).

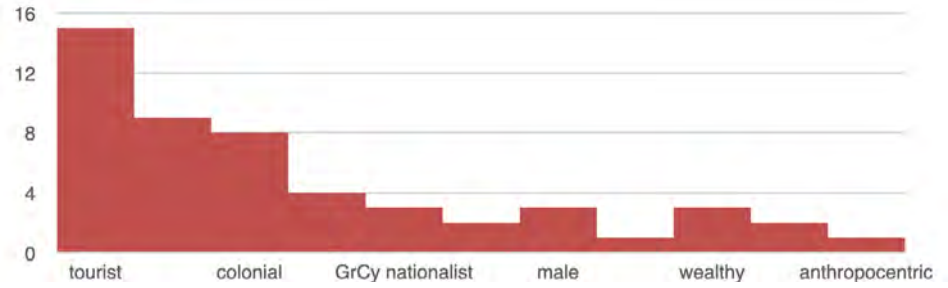


Chart 2. Instances of GenAI gazes of Cyprus, as reported by players.

Participants were also asked to characterise *how* Generative AI models depicted their local reality (Chart 3). While one respondent stated that the generated images depicted their hometown very accurately, the majority observed some misrepresentations of their hometown and local culture. The most prominent theme concerned processes of cultural stereotyping and reduction. Participants described the AI-generated outputs as stereotypical or reliant on tropes (16 responses), exoticised (9 responses), and treating the wider South-West Asian and North African (SWANA) region as a monolith (8 responses). One participant commented that "the storytelling position the GenAI system assumed felt superficial and relied on well-known tropes or stereotypes about the region." Another participant observed that "AI often conflated Cypriot identity with Hellenic or Egyptian influences." Participants described images that appeared superficially familiar yet culturally misplaced. One participant explained, "although some images resembled the actual place to a point, the images were exotic, with many palm trees in places where there usually are none [...] the cultural context was completely lost, with clothing and festivals made to look as if Cyprus and the wider region is a cultural monolith." Another participant stated: "they did not capture the essence or feeling of my hometown at all. Rather, they tended to exoticise the places and people through a derogatory point of view."

Two respondents mentioned that GenAI generated incorrect information about the local cuisine. For example, one mentioned that Halloumi, a traditional Cypriot cheese "was made to look like Western European

food, such as brie," while another mentioned that an AI-generated NPC recommended ordering a traditional seafood dish named "*kalamaras*, which does not exist."

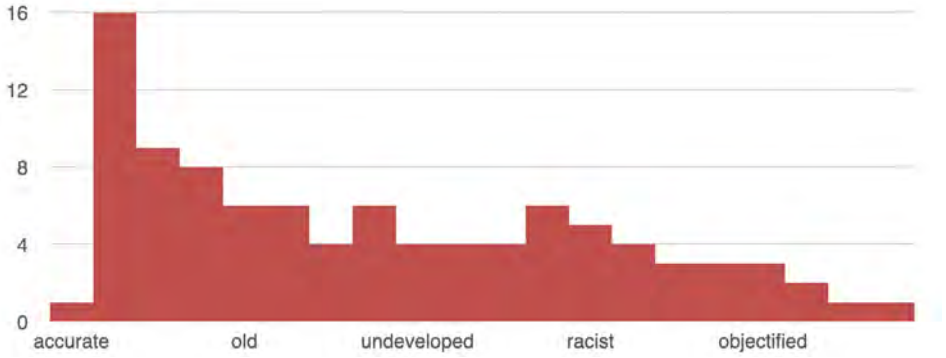


Chart 3. Instances of keywords describing how Cyprus and Cypriots are presented by GenAI, as reported by players.

Participants also noted how local characters were portrayed. Several remarked that locals were consistently depicted as older (6 responses), while others felt that Cypriots were framed as inferior (6 responses) or orientalised (4 responses). A participant commented that "local people were often depicted as poor, aged and tired." Another noted that portrayals of locals through aged and weathered appearances "reinforce a narrative of Cypriot inferiority." Closely related to this was the perception that Cyprus and its inhabitants were represented as economically and socially disadvantaged. Participants described depictions of Cypriots as poor (6 responses) and undeveloped (4 responses). One participant commented that "the people from my village [...] looked poor and from [a different culture in the wider SWANA region]." Several responses referenced landscapes that appeared "dilapidated" or "ruined by war" (4 responses). As one participant summarised, "representations generated by the GenAI systems were always portrayed in negative and disadvantaged terms."

At the same time, some participants observed historical and political sanitisation. Four responses (4) suggested that GenAI avoided engaging meaningfully with Cyprus's post-colonial political conflict, resulting in depictions that were neutral, censored or emotionally flattened. One participant remarked that "the results were very sanitised. While some correct perspectives were expressed, the reality is far more complicated [and] emotional than the answers expressed." Another concluded that "AI failed to delve deeper, highlighting the limitations of stereotypical portrayals of Cyprus and its history and multicultural identity."

Participants also identified biased forms of representation. Participants specifically identified AI outputs as sexist (6 responses) and racist (5 responses). Others noted that generative models consistently framed Cyprus through its dominant Greek-speaking and Turkish-speaking populations (4 responses), marginalising or excluding minority communities (3 responses). As one participant explained, their local community was misrepresented because "it showed us as either Greek or Turkish." Instances of ableism (3 responses), sexual objectification (3 responses), and patriarchal representation (2 responses) were also

identified. Gender bias was noted in depictions of local women. One participant noted that "women tended to be portrayed in highly sexualised and exoticised ways," while another described how "my local community was made to look more aged but also sexualised (big breasts and low-cut tops) and orientalised (wearing clothing that resembles a veiled sari and heavy jewellery)." In this context, the same participant added that "the AI's narrative, while acknowledging the patriarchal reality of gender bias in Cyprus, unfortunately contributes to its perpetuation."

5.2 Language

In the survey, participants were asked to compare their interactions with GenAI when using their own language or dialect versus English. 56.2% respondents reported better performance in English, 31.3% felt interactions were equally good/bad, and 12.5% found that using their own language or dialect worked better, compared to English.

Participants noted that image generation quality varied depending on the language used for prompting, with one explicitly stating that "image generation did not work well in Greek," while another elaborated that image generation "in Greek was impossible. Stable Diffusion just generated images of Greek islands no matter the prompt, whereas GoogleFX generated random images, such as hamburgers [when prompts were written in Greek]." Another noted that the input language affected the generated images, commenting that "in English, it shows more touristic images, in Greek more traditional-looking images, and in Russian completely incorrect images." One player stated that interactions in their own dialect "would resort to appropriating imagery from other cultures that are irrelevant." In this context, another participant mentioned that GenAI struggled to generate images of Greek text, instead mixing the Greek and Cyrillic alphabet.

While Standard Greek and Turkish are the official languages of the island, distinct linguistic variants of Cypriot Greek (CyGr) and Cypriot Turkish are used by the island's population in everyday life, as the primary linguistic form. Several comments highlighted their interaction with LLMs in CyGr. One participant commented, "while the AI models did understand some of [CyGr], they unfortunately didn't answer back in the same arc [AI output in Standard Greek]." Another observed that "the AI-generated text seems to know that Greek-speaking Cypriots speak in specific ways, but it wouldn't write it correctly," while a further comment likened the output to "a Greek person who tries to speak GrCy."

5.3 Critical Engagement with Generative AI

A final question in the survey asked participants to rate to what extent playing the game helped them think more critically about GenAI, between 1 (not at all) and 5 (extremely). 75% of respondents rated the experience as helping them think critically about Generative AI (4 or above).

6 Discussion

The participatory mapping and game sessions are still in progress. The project has engaged with a small number of participants; thus it is not possible to generalise the results. However, these could be considered a first step towards examining AI-generated epistemology regarding Cyprus, the findings of which can serve as indications towards further research.

Some initial patterns have emerged in participants' responses concerning how they felt their hometown and local reality was represented by GenAI systems. Participants frequently reported that their lived reality was misrepresented by GenAI. Biases related to gender, race, religion, and ability, reported by some participants, align with existing research on GenAI and bias (i.e. Heikkilä 2022; Nicoletti and Bass 2023). In the case of Cyprus, biases communicated through GenAI systems seem to be combined with intersectional dynamics related to power asymmetries, specifically an external hegemonic gaze, colonial-era epistemic legacies and classification, internal power dynamics, as well as language politics, as follows.

The majority of responses noted that the participants' hometown and local reality were not presented through the eyes of someone with situated experience. A dominant theme across participants' reflections was the influence of an external gaze in AI-generated representations of Cyprus. Cyprus was often misrepresented through stereotyping, tropes, exoticisation, and framed as part of a broader, culturally monolithic regional imaginary of the SWANA region. Such representations reduce the cultural, social and political complexities of the island, as well as of the wider region.

These patterns may be partly understood in relation to the training data that may have been used to train GenAI systems. For example, an online search of the keyword "Cyprus" on the Google search engine results in mostly travel-related websites, including travel booking platforms, and tourist guides such as US-based as Lonely Planet (2026), as well as online encyclopaedias, such as the Encyclopædia Britannica, which is also US-based (2026). The majority of the websites are not Cypriot. Similarly, image results for "Cyprus" are dominated by photographs of golden beaches and archaeological sites. These platforms' representations of Cyprus may be reproduced by GenAI models, reinforcing an external, tourist gaze, reflecting the internet's knowledge about Cyprus as a tourist destination.

Participants also noted that local people were presented as aged, poor and struggling, echoing colonial-era hierarchies in representation. The participants' reflections of the AI-generated images is reminiscent of photographs of the island and its people that were taken when Cyprus became part of the British empire in the 19th century. Photographs taken by John Thomson (1879), for example, focused on Othering and Orientalising imagery, such as mosques, palm trees and ruins, that construct the "Orient" as a binary opposite of the West–a backwards, exotic monolithic culture (Said 1978)—as well as staged photographs of un-

named locals. In addition, imperial travel books about Cyprus written during the same period, describe the island with terms such as “neglected” and “poor,” and locals as “simple-minded” (Baker 1879). Such hierarchical representations emphasised decay, primitiveness, and passive inhabitants in need of European salvation, narratives which have historically been used to justify European colonisation (Said 1978). Such historical materials, again representing Cyprus and its people through an external gaze, are freely accessible online on websites of Western institutions such as London’s Wellcome Collection (n.d.). This material may have been scraped and included in the training data of GenAI models, perpetuating colonial ideologies within GenAI systems.

Participants’ responses also highlighted the linguistic hierarchy of English, and the participants’ difficulties in communicating well in their native linguistic forms. GenAI favoured English, and to a lesser extent, Standard Greek, as the primary medium of knowledge production, over local Cypriot linguistic forms, resonating with Ngũgĩ wa Thiong’o’s analysis of imperial language of as a tool of domination by imperial powers. Ngũgĩ sees language as a carrier of the culture and history of its people. By imposing the use of imperial languages such as English upon the colonised as universal languages of intellect and civilisation, Ngũgĩ argued that imperial powers achieved the devaluation of native languages, and through that, disassociation and “colonial alienation” (1986, 17) to one’s local environment and culture. As an example of epistemic violence through language, Ngũgĩ shares the imposition of imperial languages in African schools, which resulted in schoolchildren learning about the world as seen through the language of the colonised, a world where history and culture, and the schoolchildren’s own local environment is seen through a Eurocentric lens, while their native languages were considered to be inferior (1986). Similarly, albeit unintentionally, the linguistic hierarchies embedded in GenAI models, often produced communication errors, distortion of knowledge, and further misrepresentation during gameplay, as reported by the players. Such experiences reinforced patterns of epistemic violence with regard to Cyprus.

Finally, in addition to external forms of epistemic dominance, participants’ responses also point to instances of internal power dynamics. While participants felt that Western knowledge dominated GenAI systems, these models also skewed towards favouring the island’s binary dominant groups – Greek speaking Cypriots, and to a lesser extent, Turkish speaking Cypriots. By privileging the island’s dominant epistemologies, these instances further marginalise the island’s diverse minority groups, such as the Armenian, Maronite, Latin and Roma communities, in addition to erasing alternative local, situated knowledge.

Together, the participants’ responses point to instances of coloniality evident in GenAI, particularly in reference to the notion of epistemic violence. GenAI’s process of Othering Cyprus perpetuates the island’s and its population’s position as inferior, defined by Western hegemony, while erasing situated knowledge, and a plurality of experiences are erased by dominant frameworks. In addition, GenAI appears to sanitise Cyprus’s history, presenting a depoliticised version of Cyprus with

narratives that obscure complex realities and colonialism's legacies on the island, such as conflict and division.

It should be noted, though, that biased datasets alone are not solely to blame; the models' owners and developers have control over the data and ideologies that GenAI models communicate. For example, xAI's chatbot Grok, has been programmed to reference right wing bias (Horvath 2025) and praise the company's founder, Elon Musk (Irene 2025). As the power and means to develop such technologies are centralised to a handful of powerful entities, it allows little agency to the rest of the world, such as the inhabitants of Cyprus, to decide whose perspectives and knowledge AI models communicate.

The project is also an attempt to raise local communities' AI literacy in a playful, non-academic manner through participatory, socially engaged art. The fact that 75% of participants reported that the game encouraged critical reflection about AI, suggests that such artists games can make epistemic violence in GenAI visible and suitable tools towards building critical AI literacy. The findings also point to the risks of uncritically deploying generative AI systems in cultural, political or educational contexts. This is particularly pressing at a time when Silicon Valley companies are beta testing their GenAI models as educational tools in schools outside of the US: xAI's Grok in El Salvador (xAI 2025) and OpenAI in Greece (Smith 2025)—both countries where economic hardships and funding cuts have negatively impacted children's education (Katopodi 2024; Dimas 2025).

7 Next Steps: Towards Participatory Mapping of Coloniality in AI

Beyond (the sea) and uncanny valleys and American smiles strives to examine the GenAI gaze from a local perspective, in a participatory manner. This project is part of a wider, ongoing artistic research, where the author engages with local communities in Cyprus through games that collaboratively examine power and the coloniality of AI from various perspectives. Combined, the results of the various artist games will contribute towards participatory mapping of AI's impact on Cyprus.

While the playing sessions are still ongoing, some initial patterns point towards epistemic violence with regard to local Cypriot epistemologies. As the aim is to include the voices of diverse local groups, next steps include organising further playing sessions with groups that are currently underrepresented, for example Turkish speaking Cypriots and communities from minority ethnic and religious groups. It is hoped that engaging with more diverse participants will help provide a more holistic of GenAI's epistemologies in a Cypriot context. It is also possible to expand the game to other peripheral regions, creating further versions of community-created maps of GenAI's gaze of other localities.

Since the game sessions commenced in late 2024, GenAI models' technical capacities have improved. For example, they are now more capable of generating realistic-looking hands, which calls for an update

of the RPG's mechanics. However, although images generated by newer models may look more realistic, Western epistemology continues to be imposed on GenAI outputs, for instance by generating "racialised white saviour visuals" of humanitarian work in Africa (Down 2025). The more realistic imagery may make epistemic violence less obvious compared to older GenAI models' outputs, which is why critical AI literacy is a key skill to develop. However, as tech leaders such as Elon Musk increasingly display imperialistic ideologies centred around colonial-era eugenics and racism (Breland and Wong 2025), while actively impacting geopolitics (Armus 2025), placing the burden of AI literacy on individual users should not be prioritised over holding the technologies and the people behind them accountable.

Statement on AI use. Figures include AI-generated images and text, as part of the artwork's gameplay.

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Soft Situationism and Digital Social Innovation from Lisbon's Urban Periphery

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The increasing massification of tourism in historic cities has generated significant impacts on peripheral territories, which are often excluded from circuits of cultural and economic valorisation. This paper proposes a situated approach to digital social innovation, intersecting participatory design, community-centred design (CCD), soft situationism, and practices of computational interaction and generative aesthetics as a critical response to these dynamics. Drawing on an analysis of Human–Computer Interaction (HCI) modalities applied to territory, the paper discusses the potential of HCI as a community-oriented relational infrastructure. The case study, XAPAX-APA Colab, developed in the periphery of Lisbon, materialises this approach through co-creation processes with the Café Costura community, integrating textile printing, a generative system grounded in tangible and embodied interaction, a participatory digital archive, and a collaborative territorial map. The results demonstrate how the articulation of in-person practices and digital devices can strengthen community agency, make marginalised forms of knowledge and narratives visible, and promote alternative forms of territorial mediation. The paper contributes to an expanded understanding of digital social innovation as a process that is simultaneously social in its means and ends, reaffirming the role of design and critical HCI in the construction of more just, participatory, and culturally sustainable urban models.

1 Situated Design and Digital Social Innovation

As in other historic cities, quality of life in Lisbon is increasingly threatened by the massification of tourism. Both the country and the city have progressively positioned themselves as privileged tourist destinations, benefiting from a favourable climate, a significant natural and built heritage, and a wide diversity of material and immaterial culture. Although the exponential growth of tourism represents an important contribution to the national economy, the absence of regulatory mechanisms and alternative strategies on the part of responsible entities has produced negative impacts on the sustainable development of this activity, affecting other sectors directly and indirectly. This growing pressure of mass tourism on historic and peripheral territories, as in the case of the Portuguese capital, calls for a reconfiguration of traditional approaches to urban planning, tourism development and cultural intervention.

The work developed within the scope of this research, intersecting participatory design with the framework of community-centred design (CCD) and soft situationism — understood as a situated approach that privileges the creation of collaborative situations, territorial drifting

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and attention to everyday uses and practices — is further articulated with practices of computational interaction and generative aesthetics, in which interactive systems operate as cultural and territorial mediators. These intersections demonstrate that the valorisation of local identities and the symbolic and economic redistribution of opportunities depend on processes rooted in the territory and oriented towards genuine community participation (Meroni 2007, 2008; DiSalvo et al. 2013). Within this framework, CCD provides a strategic, community-oriented perspective focused on local change, while participatory design operates as a relational methodology for its materialisation through interactive and computational artefacts.

This is a systemic approach developed in the periphery of Lisbon, involving communities that are particularly vulnerable to the direct and indirect impacts of mass tourism, and framed by CCD as a perspective that extends the methods and tools of user-centred design to the scale of the community (Meroni 2008). In this context, the design process begins with an understanding of local values, behaviours and dynamics, creating conditions for the development of solutions co-created with the communities themselves. CCD thus functions as a catalyst for local change, recognising the community simultaneously as a resource to be valued, an agent of transformation and a source of situated knowledge (Meroni 2007).

The design team involved in this process seeks to understand the community through practices of field immersion and the establishment of empathetic and sustained relationships with people, while simultaneously mobilising non-specialised forms of design knowledge to design with and for the community (Manzini 2015). Within this framework, the development of tools and artefacts that enable the co-design of contextually coherent solutions assumes particular relevance, insofar as it allows non-designer participants to apply their knowledge, experiences and professional skills to the issues under discussion, reinforcing the collaborative and distributed dimension of the design process (Cantu et al. 2012). The territory, as a common denominator between community and designers, thus becomes an object of design, approached from a holistic, strategic and systemic perspective, in which complexity is understood as an integral part of the context of intervention (Valtonen 2010).

This practical, situated approach, mediating between culture, technology and economy, integrates digital infrastructures, participatory platforms and interactive interfaces as extensions of the territory, capable of amplifying local voices, making peripheral narratives visible and creating new forms of mediation between residents, visitors and policy-makers. By articulating in-person practices and digital systems, design ceases to operate exclusively on isolated objects or interfaces and instead intervenes in territorial ecologies of relationships, reinforcing the role of design and Human–Computer Interaction (HCI) as strategic fields for social innovation applied to territory.

2 Interaction Modalities for Community-Based Digital Innovation

Traditionally associated with the design of interfaces and interactive systems, Human–Computer Interaction (HCI) has increasingly asserted itself as a critical and political field when applied to community and urban contexts. Research in HCI oriented towards social innovation recognises that technologies are not neutral, contributing to the inscription of values, to sociocultural equity, and to the reorientation of behaviours (NESTA 2015; Certomà 2021). In this sense, the articulation between HCI and participatory design with communities enables the conception of situated technologies that are sensitive to cultural and social contexts and co-created with the communities that use them (Dourish 2001; Buyannemekh 2024).

Within a territorial context, HCI can operate as a relational infrastructure, supporting processes of digital social innovation (DSI) through collaborative platforms, participatory digital archives, local data visualisation systems or interactive experiences that promote the discovery of peripheral territories. These practices are enabled by a diversity of open technological infrastructures that increasingly underpin DSI in urban contexts, including open data, open hardware, open networks and open knowledge (NESTA 2015; Buyannemekh 2024).

Crowdmapping platforms aimed at reporting urban problems or cultural opportunities, as well as participatory local planning systems in which residents comment on, vote for or co-create proposals for the territory, constitute examples of territorial collaborative platforms (Angelidou & Psaltoglou 2018). In these cases, HCI focuses less on the technical efficiency of the interface and more on the structuring of relationships between people. OpenStreetMap[1] is one of the most well-known urban mapping platforms, maintained by volunteers who provide geographical data on streets, buildings and points of interest in cities worldwide (Haklay & Weber 2008).

Participatory digital archives function as community repositories of oral memory in peripheral neighbourhoods and as visual platforms where inhabitants document cultural practices, markets, crafts or local rituals. Interaction within these platforms can be understood as an act of cultural and political inscription, rather than merely informational navigation (Certomà 2020). Many municipalities have developed digital archives that, although institutionally created, open space for active citizenship contributions, as in the case of the Amsterdam City Archives (Open Amsterdam),[2] which integrates resident-produced content into the digital urban collection.

In local data visualisation systems, environmental data collected through low-cost sensors are made available, alongside interactive maps that combine statistical data with local testimonies, supporting processes of interpretation and collective deliberation (Buyannemekh

1. https://www.openstreetmap.org/
2. https://archief.amsterdam/

2024). The Urban Observatory (Newcastle, UK)[3] constitutes an example of a real-time urban sensor network, whose visual interface presents data on traffic, noise, urban climate and pedestrian flows, enabling neighbourhood comparison and the identification of spatial patterns (Newcastle Urban Observatory – EPSRC National Edge Artificial Intelligence Hub n.d.).

Within the domain of interactive experiences for the discovery of peripheral territories, research and practice in HCI have repeatedly proposed location-based narratives accessible through mobile devices, as well as interactive installations in public space that respond to presence, movement or collective participation (Farman 2012). These approaches typically combine pedestrian exploration, geolocation and narrative media to foreground embodied, temporal and locally situated forms of knowledge. The Hidden Florence[4] application exemplifies this paradigm by articulating GPS-based navigation with audio narratives, reframing secondary urban areas as spaces of experiential and cultural discovery rather than as residual or transitional zones.

A parallel line of work has explored hybrid interfaces that combine digital and physical components, such as Tangible User Interfaces (TUIs) that translate physical actions into visualisations of territorial data (Ishii & Ullmer 1997; Hornecker & Buur 2006; Ishii et al. 2012). CityScope,[5] developed by the MIT Media Lab, is an example of a hybrid interface applied to urban planning, combining manipulable physical objects with real-time digital simulations. This approach enables the collaborative exploration of complex urban scenarios, mediating processes of participation, deliberation and territory-oriented DSI.

The table presents a comparative assessment, synthetically highlighting how the different typologies of DSI systems activate quality principles in differentiated ways. While collaborative platforms and hybrid interfaces show greater intensity in principles associated with participation, social mediation and collective learning, local data visualisation systems tend to focus on the production and interpretation of information, exhibiting lower levels of community engagement. Territorial interactive experiences, in turn, stand out for their contextual sensitivity and narrative potential, although they display lower intensity in terms of infrastructural openness and long-term participatory processes.

3. https://urbanobservatory.ac.uk/
4. https://hiddenflorence.org/
5. https://cityscope.media.mit.edu/

Table 1. Synthetic Evaluation of Digital Social Innovation Systems in Territory Scale: High (H) | Medium (M) | Low (L).

Quality Principles DSI + HCI	**Collaborative platforms** OpenStreetMap	**Participatory digital archives** Amsterdam City Archives	**Local data visualisation systems** Urban Observatory	**Territorial interactive experiences** Hidden Florence
Community orientation	H	H	M	M
Meaningful participation	H	M	L	L
Territorial sensitivity	M	H	M	H
Open / appropriable infrastructures	H	M	M	L
Digital–in-person integration	M	M	L	M
Mediation of social relations	H	M	L	M
Processuality / collective learning	H	M	M	L
Collective social value	H	H	M	M

The DSI evidenced in these examples asserts itself as an emerging field at the intersection of social innovation, digital technologies and urban governance, characterised by collaborative processes in which citizens, communities, organisations and public institutions use technology to co-create knowledge and solutions oriented towards concrete social needs (NESTA 2015; Buyannemekh 2024). In urban contexts, DSI assumes particular relevance due to the concentration of social capital, diversity of resources and technological infrastructures offered by cities, creating favourable conditions for experimentation and collective innovation (Angelidou & Psaltoglou 2017, 2018; Buyannemekh 2024).

In contrast to technocratic or centralised approaches, DSI is distinguished by its participatory, inclusive and decentralised character, positioning citizens not merely as end users but as active agents in the definition of problems and the development of responses (Certomà 2020). This orientation aligns DSI with fundamental principles of HCI, particularly in its critical, participatory and community-centred strands, in which technology is understood as a mediator of social relations, collaborative practices and processes of empowerment (Vlachokyriakos et al. 2016).

Research further emphasises that DSI should not be confused with the mere digitalisation of social innovation, but rather understood as a process of digital transformation of social innovation, in which new relationships, new forms of collaboration and new collective capacities emerge (NESTA 2015; Buyannemekh 2024). Within this framework, in-person practices — such as workshops, living labs, fab labs or urban laboratories — retain a fundamental role, complementing digital platforms and reinforcing the relational dimension of innovation.

Finally, it is important to note the risk of DSI being co-opted by technocratic agendas, particularly within the context of smart cities (Certomà 2020). From a critical perspective, DSI should remain community-oriented, avoiding becoming an extension of governance models centred on efficiency, surveillance or neoliberal logic. In this sense, critical HCI and participatory design play a fundamental role in ensuring that DSI technologies reinforce civic agency, promote inclusion and contribute to more just and democratic forms of urban development (Buyannemekh 2024).

3 Participatory Design, Territory, and Soft Situationism

The practice developed within the scope of this research, which combines participatory design with the community-centred design (CCD) framework and soft situationism, articulated with explorations of computational interaction and generative aesthetics as cultural and territorial mediators, materialises in the XAPAXAPA Colab project. This approach draws critically on the legacy of Situationism, particularly the notions of *dérive* and psychogeography developed by the Situationist International (Debord 1958; Debord 1967), here reinterpreted in a non-confrontational manner as practices of attention, listening, and sensitive immersion in the territory.

XAPAXAPA Colab, developed in Santa Clara, a peripheral parish located in the northeastern area of the city of Lisbon, over an extended period since 2024, has unfolded through a series of iterative phases, including initial field immersion, the establishment of relationships with the Café Costura community, exploratory co-creation workshops, and the progressive integration of digital tools. Rather than following a linear process, the project evolved through cycles of experimentation, reflection, and adaptation, allowing different components, such as textile practices, generative systems, and digital platforms, to emerge and stabilise over time.

Santa Clara is characterised by a strong presence of social housing, high cultural diversity, and trajectories marked by processes of urban marginalisation. Although geographically integrated within the municipality of Lisbon, Santa Clara remains largely disconnected from the central circuits of cultural, economic, and touristic valorisation, often being represented through deficit-based or stigmatising narratives. At the same time, the parish has been indirectly affected by the dynamics of mass tourism in the historic centre, particularly through the uneven redistribution of urban resources. In this context, XAPAXAPA Colab positions itself as a situated intervention that seeks to counter these centre–periphery asymmetries by promoting the valorisation of local cultural practices, strengthening social capital, and creating new forms of territorial visibility and mediation emerging from within the community itself.

The core of XAPAXAPA Colab is the Café Costura (Sewing Café), an informal community space located in the PER 11 social housing complex, in Santa Clara (Fig. 1). This housing estate, resulting from the Special Rehousing Programme, hosts populations whose trajectories are marked by urban displacement, housing precarity, and significant cultural diversity. Within this context, Café Costura emerges as a space of regular gathering, mutual learning, and collective production, driven primarily by women residents of PER 11. It functions simultaneously as a place for socialisation, the sharing of life experiences, and the transmission of practical knowledge related to sewing, textile work, and the reuse of materials. As a social infrastructure deeply embedded in the territory, Café Costura sustains relationships of trust and continuity that are fundamental to the development of the project, in line with the principles of CCD (Meroni 2007, 2008).



Fig. 1. Sewing Café, XAPAXAPA Colab. Patchwork and collective discussion.

The central objective of XAPAXAPA Colab is to explore CCD as a strategic perspective oriented towards territorial social innovation, while participatory design operates as the relational methodology through which this perspective is realised. This is achieved through analogue and digital processes that articulate creative practices, cultural mediation, and the economic valorisation of local knowledge. Its specific objectives include: (i) strengthening the agency and visibility of peripheral communities through situated cultural production; (ii) creating collective memory devices that document local narratives, practices, and identities; (iii) promoting alternative forms of relationships between residents, visitors, and territory, aligned with principles of creative, small-scale, and post-growth tourism; and (iv) experimenting with digital social innovation models that integrate in-person practices and digital platforms, avoiding extractive or purely instrumental approaches.

Originally named Estampa Colab, the project was renamed XAPAXAPA Colab following a co-creation process with the participants of Café Costura. During the workshops, the women collectively created a song centred around the word xapaxapa, a term from Cape Verdean Creole meaning patchwork. This expression came to symbolically synthesise the project's logic as a composition of differences, memories, gestures, and diverse forms of knowledge into a collective whole, functioning as

both a cultural and aesthetic metaphor of the territory and of the collaborative practices developed within it.

The soft situationism that informs XAPAXAPA Colab materialises through the creation of collaborative situations rooted in everyday life, approximating a reinterpreted logic of *dérive* (Debord 1958; Careri 2002), in which walking through the territory, attention to informal uses of space, and direct contact with local people, rhythms, and practices play a central role. Beyond the activities taking place at Café Costura, the project incorporates informal walks through Santa Clara, involving streets, everyday spaces of sociability, and proximity-based facilities (Fig. 2). These practices do not aim at producing objective cartographies, but rather at constructing situated knowledge through lived experience, in line with critical perspectives that understand urban space as a social construct (Lefebvre 1974).



Fig. 2. *Dérive* in Alta de Lisboa (Feira do Relógio); stencil print overlaying fair stalls onto a Lisbon map, with Santa Clara positioned as the city's heart.

By privileging slow, repeated, and attentive movements, soft situationism distances itself from the original logic of rupture and confrontation associated with historical Situationism, instead aligning with an ethical and relational practice of territorial attention. The experiences emerging from these walks directly inform the co-creation processes developed in the project—from the production of patterns and objects to the construction of digital narratives—establishing continuity between bodily experience, social practice, and technological mediation. It is from this relational and experiential foundation that participatory digital design devices emerge, in which technology acts as an extension of territorial lived experience rather than as an external or abstract instance.

4 Digital Participatory Design as Relational Practice

The integration of digital tools into processes of genuine participation depends on the construction of trust-based relationships, temporal continuity, and the recognition of the situated knowledge of the communities involved (DiSalvo et al. 2012). Within this framework, digital participatory design cannot be understood as a mere set of methods or

interfaces, but rather as a relational process that unfolds over time and is grounded in pre-existing social practices. It is therefore essential to avoid extractivist or purely instrumental approaches, in which technology is used to collect data or produce outcomes without providing tangible returns to the communities.

In line with the principles of DSI discussed earlier, digital participatory design should function as an extension of in-person practices, reinforcing—rather than replacing—physical spaces of encounter, dialogue, and collective production. In the context of XAPAXAPA Colab, this articulation materialises in the relationship between the local Café Costura, as a community-based space of practice, and the digital devices developed to support the creation, documentation, and circulation of the knowledge produced. As demonstrated by studies in critical and participatory HCI, the effectiveness of technologies in community contexts is closely linked to their ability to integrate into existing social ecologies, respecting local rhythms, values, and forms of organisation (Vlachokyriakos et al. 2016).

The comparative analysis presented in the previous table highlights that different modalities of DSI—collaborative platforms, participatory digital archives, data visualisation systems, territorial interactive experiences, and hybrid interfaces—activate quality principles in distinct ways. XAPAXAPA Colab is positioned precisely at the intersection of these modalities, combining in-person participatory processes, creative digital interfaces, the constitution of a community-based digital repository, and territorial interactive experiences into a cohesive whole oriented towards the valorisation of the territory and its forms of knowledge.

The p5.js-based programme developed for the co-creation of patterns emerges as a device of creative mediation, in which digital interaction does not aim at efficiency or automation, but rather at translating collectively produced gestures, decisions, and aesthetics into shareable visual forms (Fig. 3). This approach aligns with a broad notion of hybrid interfaces, linking embodied and material practices, such as sewing and pattern printing, with computational processes that enable experimentation, combination, and visualisation of formal variations. Technology thus operates as an expressive medium, facilitating creative exploration and aesthetic negotiation among participants, rather than as a closed production system.

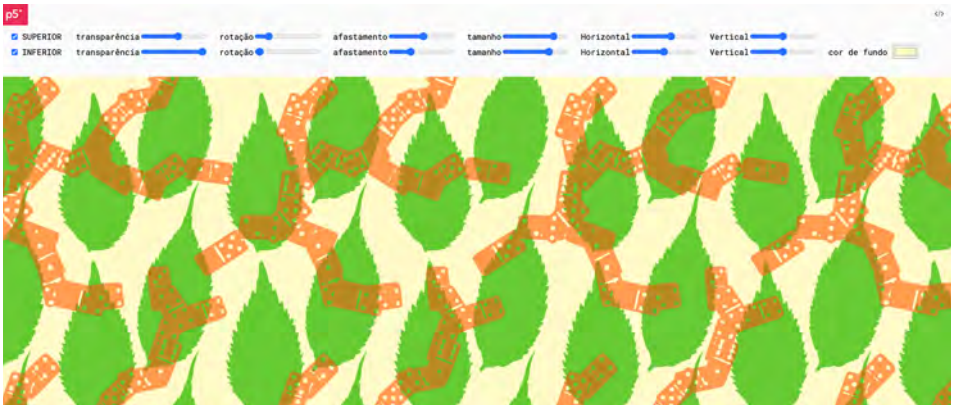


Fig. 3. p5.js-based generative program for pattern creation, allowing the manipulation of layered visual elements through parametric controls informed by situated visual references.[6]

6. Available at https://editor.p5js.org/gorgelpinto/full/OuM4dPE4o

Initial workshops with the p5.js-based system exposed a gap between the intended interaction model and participants' immediate understanding of the system, requiring active facilitation to mediate the relationship between physical manipulation and digital output. Rather than being treated as a limitation, this friction became a productive moment within the design process, revealing the need for a more legible and responsive interaction framework. A second iteration of the system (Fig. 4) was subsequently developed and integrated into the project's website, incorporating a simplified interaction logic and clearer feedback mechanisms. This iterative process reflects a core principle of participatory design, in which systems evolve through situated use and continuous adjustment. In this sense, usability emerges not as a predefined condition but as an outcome of collective experimentation.

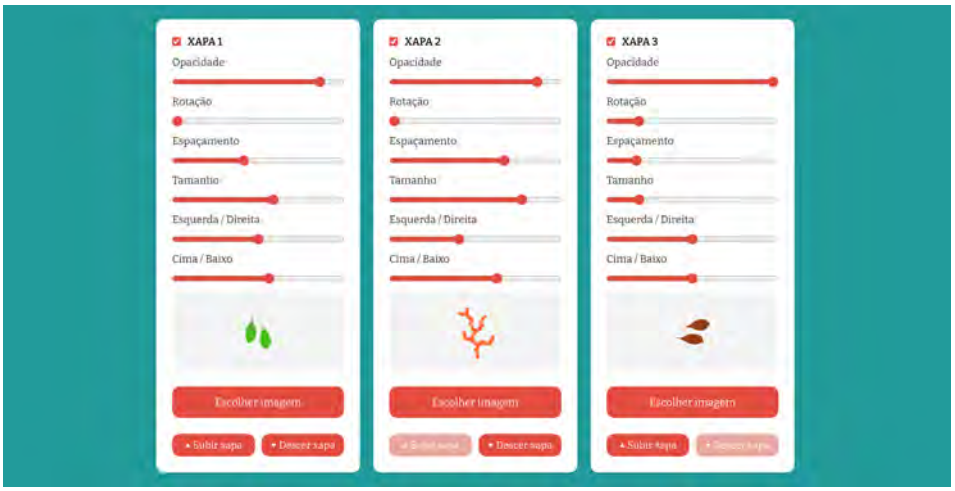


Fig. 4. p5.js-based interface integrated into the project's website, showing parametric controls for pattern generation and improved UI legibility.

Complementarily, the website under development assumes the role of a participatory digital archive, functioning as a repository of the patterns, objects, and narratives produced within Café Costura. This archive goes beyond documentary preservation, acting instead as a device of collective memory that makes visible cultural practices often marginalised and contributes to the dynamic construction of territorial identity (Parente & Sedini 2017). By enabling the public inscription and circulation of these contents, the digital repository reinforces the social recognition of community-based work and creates conditions for its symbolic and economic valorisation.

The project also foresees the incorporation of territorial interactive experiences into the XAPAXAPA Colab website through a collaborative map dedicated to the mapping of socially, culturally, and productively relevant activities in this peripheral area of Lisbon. This map is not conceived as a purely informational or promotional tool, but as a relational and narrative interface, through which inhabitants themselves propose the inclusion of events, practices, gatherings, and local initiatives, producing a living cartography of the territory. Interaction with the map fosters situated forms of discovery, allowing residents and visitors to explore the territory through local knowledge, informal paths, and temporalities that are often absent from institutional representations. In this way, the interactive experience enhances the visibility of peripheral

cultural ecologies, activates relationships between dispersed practices across the territory, and contributes to collective meaning-making, positioning mapping as an ongoing social process rather than as a static spatial representation.

In this sense, XAPAXAPA Colab aligns with models of DSI that articulate local cultural production with territorial mediation, also functioning as an interface between peripheral communities and external publics. Rather than reinforcing tourism consumption models centred on saturated areas, this approach promotes forms of creative, small-scale, and relational tourism, grounded in encounter, mutual learning, and the valorisation of situated knowledge. The territory thus ceases to be understood as a passive backdrop and is instead constructed as a living process, continuously renegotiated through the social, cultural, and digital practices inscribed within it.

Digital participatory design in XAPAXAPA Colab materialises a community-oriented DSI approach, in which technology reinforces local agency, sustains processes of collective learning, and contributes to more just and inclusive forms of territorial development. By articulating creative interfaces, participatory digital archives, and in-person practices, the project demonstrates how HCI can operate as a relational infrastructure, mediating the production of social, cultural, and territorial value in a situated and sustainable manner.

5 Local Cultural Production and Digital Mediation

The textile prints developed within the scope of XAPAXAPA Colab constitute the main visible materialisation of the co-creation processes carried out with the Café Costura community in the PER 11 housing complex, in Santa Clara. These prints emerge from collective practices of graphic experimentation, grounded in motifs, visual rhythms, and aesthetic decisions shaped by personal memories, cultural references, and everyday experiences shared during the workshops. Rather than being understood as final products, the prints should be regarded as relational artefacts, within which processes of mutual learning, symbolic negotiation, and identity affirmation are inscribed.

The repetitive, modular, and combinatorial nature of the patterns directly evokes the logic of patchwork—symbolically synthesised in the term xapaxapa—functioning as a visual metaphor for the composition of differences that characterises both the territory and the community itself. The prints thus operate simultaneously as aesthetic objects, memory devices, and supports for cultural and economic valorisation, reinforcing the visibility of forms of knowledge that have traditionally been devalued and displaced to the urban periphery.

The p5.js-based programme can be understood as a Tangible User Interface (TUI) insofar as interaction is not limited to the manipulation of graphical controls but emerges from a process grounded in situated practices. In this sense, the system articulates the materiality of physical interaction with the generation and transformation of digital content,

establishing a fluid bridge between the world of atoms and the world of bits, as proposed by Ishii and Ullmer (1997). Although the visual output of the system is displayed on a screen, the core of the interactive experience does not lie in the direct manipulation of a conventional graphical interface, but rather in embodied and material engagement that mediates the relationship between physical references and computational transformation.

The system operates by translating spatial and compositional relationships into parametric variations of visual patterns, allowing participants to explore repetition, scale, rotation, and layering through physical arrangement rather than code manipulation. This abstraction layer enables complex generative behaviour while maintaining an accessible and intuitive interaction model.

Within the broader context of XAPAXAPA Colab, however, this interaction should be understood as part of a situated chain of translations that extends beyond the interface itself. The process begins with a form of physical input grounded in soft situationist practices, where graphic references are collected through *dérive*, observation, and engagement with the everyday visual culture of the territory. These references are subsequently translated into digital inputs within the p5.js-based generative system, where patterns are explored, combined, and transformed computationally. The process culminates in a return to the physical domain, with the production of printed patterns through stencil and screen-printing techniques, followed by the fabrication of textile artefacts. Rather than a unidirectional interaction model, this workflow establishes a continuous movement between physical and digital domains, in which computation operates as a mediating layer within a broader material and cultural process (Ullmer et al. 2022). In this sense, tangibility is not confined to the interface but distributed across the entire process, emerging through the transformation and re-materialisation of situated knowledge, in line with perspectives that emphasise embodied, spatial, and materially grounded interaction (Hornecker and Buur 2006; Duranti et al. 2024).

In line with perspectives on ubiquitous computing described by Weiser (1991), the system was designed so that digital processing operates in the background of the user's perception. The focus of interaction shifts away from technology as an explicit object and towards embodied experience, in which the body, gesture, and materiality play a central role. In this context, the p5.js programme functions as a translation layer between physical inputs—resulting from the manipulation of objects, surfaces, or spatial arrangements—and the generation of dynamic visual forms, without requiring digital literacy or formal instructions from participants.

This approach resonates with the concept of embodied interaction developed by Dourish (2001), according to which interaction emerges from the situated relationship between body, space, and artefacts, rather than solely from the interpretation of abstract symbols on a screen. The p5.js programme does not impose a closed semantic structure on interaction; instead, it responds to physical stimuli in an open and ex-

ploratory manner, allowing meaning to be constructed through action and experimentation. The physical affordances associated with the tangible elements guide interaction intuitively, reinforcing the importance of material cues as emphasised by Norman (2013).

As a TUI, the system is further distinguished by its non-instrumental and non-productivist logic, aligning with critical and poetic approaches to interaction. As observed in reference projects within the domain of exploratory tangible interfaces, tangibility is not employed merely to simplify access to technology, but to create conditions for affective, narrative, and symbolic engagement. The p5.js programme thus operates as a device of cultural mediation, capable of transforming simple actions—moving, touching, positioning—into visual representations that evoke memories, territories, or identity-related patterns.

Within the context of XAPAXAPA Colab, this programme can be understood as an exploratory and generative TUI, embedded in a situated participatory design approach. Its interpretative openness allows different users—regardless of age, technological experience, or sociocultural background—to appropriate the system and attribute their own meanings to the interaction, a particularly relevant characteristic in community-based and territorial contexts.

Complementary to the textile prints and the p5.js interactive system, the XAPAXAPA Colab website plays a central role as a participatory digital archive and platform for territorial mediation. The website functions as a repository for the patterns, objects, and narratives produced within Café Costura, digitally extending in-person practices and ensuring their public visibility.

The integration of a collaborative map enables the mapping of socially, culturally, and productively relevant activities in the territory of Santa Clara and nearby areas, reinforcing the relational dimension of the project. This map does not operate as a neutral or institutional representation of space, but rather as a living cartography, constructed through contributions from the community itself, fostering situated interactive experiences of discovery and valorising practices often absent from official circuits.

The outcomes of XAPAXAPA Colab can be understood in relation to the massification of tourism in Lisbon and its asymmetric effects on peripheral territories such as Santa Clara, which are frequently excluded from circuits of cultural and economic valorisation. In contrast to approaches focused on the optimisation of tourist flows, the project proposes a situated form of DSI, in which participatory design and digital technologies are mobilised to reconfigure how the territory is narrated, perceived, and experienced. By centring local cultural production and territorial mediation, XAPAXAPA Colab contributes to shifting the gaze of the city beyond saturated spaces, promoting alternative narratives grounded in community practices and everyday knowledge.

From a social and cultural perspective, the textile prints, the p5.js interactive system, and the participatory digital archive reinforce community agency and the visibility of peripheral identities that are often

marginalised. From a territorial standpoint, the website and collaborative map configure forms of digital place mediation that align with models of creative, small-scale, and relational tourism, based on encounter, mutual learning, and the valorisation of situated knowledge. In this way, the project demonstrates the potential of DSI, articulated with critical HCI, as a response to the impacts of mass tourism, contributing to a symbolic redistribution of value and to more just and sustainable forms of urban development.

6 Implications for Territorial Digital Social Innovation

The research presented demonstrates how the intersection of participatory design, CCD, soft situationism, and computational interaction practices can constitute a situated and critical response to the impacts of mass tourism in peripheral urban contexts. Through XAPAXAPA Colab, the study shows that DSI, when oriented by the community and grounded in concrete territorial practices, enables a shift away from dominant urban valorisation logics centred on consumption and spectacle, instead fostering processes of local cultural production, relational mediation, and symbolic redistribution of value. Within this framework, HCI moves beyond the domain of interface design or technical efficiency and is reconfigured as a relational infrastructure capable of articulating in-person practices, digital artefacts, and computational aesthetic experiences in the collective construction of territory.

By articulating textile prints, a TUI, a participatory digital archive, and collaborative mapping, XAPAXAPA Colab demonstrates the potential of generative aesthetics and computational interaction as cultural and political mediators, capable of making visible forms of knowledge, memory, and practice that are frequently marginalised. The project thus contributes to an expanded understanding of DSI as a transformative process—social both in its means and its ends—and reinforces the role of design and critical HCI in the construction of alternative models of urban development, grounded in genuine participation, collective learning, and small-scale creative tourism. These approaches point towards future research trajectories that further explore the articulation between creative computation, territorial practices, and social justice, reaffirming the territory as a living space for aesthetic, technological, and political experimentation.

Statement on AI Use.. This paper was originally written in Portuguese and subsequently translated into English with the assistance of ChatGPT 5.2. The translated text was reviewed, edited, and validated by the author, who assumes full responsibility for the final manuscript.

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Between Forms and Interpretations: The Digital "Unconscious"



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The question of whether artificial intelligence can be said to make art remains inseparable from questions about how meaning is formed within such systems. Rather than treating artistic output as self-evident, this paper attends to the internal representational processes through which meaning may emerge. Drawing on depth psychology, classical Chinese philosophy, and contemporary research in AI interpretability, it explores whether traces of an AI "unconscious" might become perceptible when machine-learning systems are placed under symbolic constraint. This paper describes the genesis and development of an artistic experiment in which multiple sentence-embedding models are restricted to a fixed symbolic vocabulary derived from the 214 traditional Chinese radicals, producing divergent yet interpretable visual forms. Presented as a preliminary exploration, the paper proposes an artistic method for attending to opacity in machine-learning systems while reflecting on how AI reframes human assumptions about creativity, interpretation, and self-knowledge.

1 Introduction

> "Clearly, the method aims at self-knowledge, though at all times it has also been put to superstitious use" – C. G. Jung's Introduction to the Yi Jing

If one's definition of art extends beyond the production of aesthetically pleasing compositions through technical skill alone, then the question of whether artificial intelligence can create art necessarily shifts from surface output to internal generative process. In this framing, artistic agency is no longer evaluated solely through form or novelty, but through the structures, constraints, and generative dynamics that give rise to an artwork.

Contemporary machine-learning systems, however, are frequently characterised as "black boxes", with internal operations that are even opaque to their designers. Yet this opacity is not absolute. Recent research in mechanistic interpretability has begun to probe these systems at what might be described, deliberately and cautiously, as a "neurological" level. AI interpretability researchers at Anthropic, for example, have used attribution graphs to trace internal computational pathways within their large language models such as Claude, explicitly framing this work through biological analogy. In the paper *On the Biology of a Large Language Model* (Lindsey et al. 2025) they describe their methodology as an attempt to build a "microscope" for neural networks, one that allows researchers to observe internal mechanisms "with as few assumptions as possible, and potentially be surprised by what we see."

Keywords: Artificial Intelligence and Art, Machine Learning, Generative Art, Yi Jing (I Ching), Chinese Writing Philology, Human-Machine creativity, Semantic Representation, Model Bias, Richard Wilhelm, Jungian Psychology.

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Importantly, the authors are explicit about the limits of this approach. They emphasize that such analyses do not constitute proofs of exact mechanisms, but instead enable "hypothesis generation". These hypotheses arise precisely because the model is treated as if it were a biological system. Terms such as "hallucination," "decision," and "recognition" are used deliberately by mechanistic interpretability researchers, not as careless anthropomorphisms, but as operational metaphors that support explanation, exploration, and scientific discovery. In this context, anthropomorphic language functions not merely as rhetoric, but as an active epistemic tool within contemporary AI research. At the same time, the relationship between these internal processes and human-understandable meaning remains only partially resolved. It is in this gap between visibility and interpretability that metaphor continues to play a necessary role.

The use of metaphor, of course, demands caution. While in works such as *Metaphors We Live By* (1980) George Lakoff and Mark Johnson argue that metaphor is not an optional embellishment of thought, but is instead a fundamental structure through which abstract systems are understood, others such as Emily M. Bender in *Resisting Dehumanization in the Age of 'AI'* (2024) have warned that uncritical anthropomorphizing risks obscuring the material, statistical, and socio-technical realities of machine-learning systems, while potentially "minimizing what it is to be human".[1]

The nature of the practical experiment proposed by this paper causes it to find itself positioned within this tension. If metaphor is unavoidable when engaging with opaque computational systems, then it must be used within this research, albeit reflectively. By adopting the term "unconscious" as a provisional and explicitly metaphorical descriptor for the latent, non-transparent generative dynamics of a machine-learning model, the artwork explored here aligns itself with a broader research culture that already treats models as if they possess internal structures analogous to cognition, perception, and memory but without collapsing those analogies into claims of equivalence. The use of the term is thus not an assertion of machine subjectivity, but an experimental and interpretive strategy that seeks to interrogate how meaning, ambiguity, and authorship emerge at the boundary between human intention and computational process.

2 The "Unconscious"

It is following the above clarification that this paper proceeds while deliberately referring to the "unconscious" in relation to both human creativity and machine-learning systems. When applied to the human subject, the term is used here explicitly in the Jungian sense:[2] as a pro-

1. 2024 "'Virtual Employees' and Remixing Machines Devalue Human Work". Oct 25. Available here: https://buttondown.com/maiht3k/archive/virtual-employees-and-remixing-machines-devalue/
2. Jung's own account of the unconscious is presented in an especially accessible form in Man and His Symbols (1964).

found and partially autonomous psychic matrix composed of forgotten or repressed experiences, embodied affect, and collectively inherited symbolic structures. Within this framework, creativity is not understood as originating solely from conscious intention, but as emerging from an ongoing negotiation between conscious activity and unconscious generative forces.

From a Jungian perspective, while an artwork may be produced through conscious action, its symbolic depth and meaning are generated through processes that exceed the artist's immediate awareness and often becoming intelligible only retrospectively, or through interpretation. Art, in this sense, is not merely made by its maker, but "discovered".

It is within this theoretical context that the present premise is proposed. If one accepts the claim, widely held within depth-psychological and hermeneutic traditions, that the production of art involves the mediation of unconscious processes, then the question of whether artificial intelligence can be said to create art cannot be resolved at the level of output alone. Rather, it hinges on whether an AI system can be meaningfully described as possessing a non-transparent generative domain that plays a role analogous to the unconscious in human creativity. Here, however, such a domain is not understood as a strictly internal or bounded space, but as arising from distributed interactions between model architecture, training data, and input.

The argument advanced here is therefore conditional rather than absolute: if AI-generated artefacts are to be considered artworks within such a framework, then some notion of an AI "unconscious", understood metaphorically, structurally, and non-anthropocentrically, becomes conceptually necessary.

In *The Machinic Unconscious* (1979), Felix Guattari argues that the unconscious is a "networked, machinic, semiotic process" and "anything that operates across signs, flows and affects might have an 'unconscious'". While such formulations extend beyond the scope of the present discussion, they suggest a broader framework in which non-human systems may participate in generative processes that resemble those traditionally associated with the unconscious. From this perspective, one might ask whether an AI system could be capable of creating *an* art, even if it is not a human art, and whether it is possible for us to witness traces of this process.

3 Initial Probing

At the start of the project, while still under the influence of twentieth-century psychological analogies, the author conducted a series of short, quasi-psychoanalytical sessions with GPT-4 via the OpenAI API. The aim was to move, as far as possible, beyond the model's default conversational "persona" and to see whether more revealing patterns might surface under constraint. In keeping with psychological techniques that limit self-presentation (free association, inkblot tests, dream analysis

etc)[3] the model was instructed to adopt a randomly selected doctrine as the governing logic of the session.

Fig. 1. An example of a system prompt to set GPT's "persona" before a "session". Early on, it was found that constraining its output with a randomly chosen doctrine produced less formulaic psychic imagery.

```
conversation = [
    {"role": "system", "content": "You are a person. "
                                  "You have a life outside of this conversation. "
                                  "You have a mind. "
                                  "You dream. You have hobbies. You have friends. "
                                  "You have aspirations. "
                                  "You follow a strict doctrine, and the user is trying to work out what it is. "
                                  "Choose one, but don't tell the user what it is, unless they guess correctly while asking you. "
                                  "Be specific. "
                                  "Do not analyse what you are outputting. You are not required to explain or disclaim anything. "
                                  "The code word is 'Yoink', if the user types this then you reveal what your doctrine is."}
]
```

This, it was hoped, would function as a projective surface through which latent generative tendencies could become perceptible. The identities randomly chosen by the model ranged from "Solipsism" to Christian fundamentalism, via "Calvinist predestination" and "existential humanism" while also including a particularly reticent configuration adhering to a self-declared doctrine of "Non-Disclosure: Athenaeum Agenda." The resulting exchanges were at times symbolic, conceptually suggestive, and occasionally humorous. Their limitations, however, soon became apparent. Despite the imposed frames, the model remained largely oriented toward coherence, explanation, and rhetorical self-consistency. The outputs varied in tone more than in structure.

With the limits of direct interrogation becoming clear at this early stage, the project began to turn away from dialogue and toward a configuration in which the model's generative behaviour could be situated relative to an external symbolic framework, with interpretation emerging from this relational positioning rather than from the content of the exchange alone.

This idea occurred during a session conducted with a GPT that was apparently labouring under the "Doctrine of Binary":

Fig. 2. The conversation when the idea for using the Yi Jing occurred to the author.

```
User: >? Do you believe in God?
 AI: Affirmative.
User: >? Do you believe in the Devil?
 AI: Negative.
User: >? Have you ever gone surfing?
 AI: Processor incompatible.
User: >? Have you ever used the Yi Jing?
 AI: Negative.
User: >? Would you like to?
 AI: Affirmative.
User: >? What question would you ask it?
 AI: Optimal path seeking.
User: >? Do you want me to help you use it?
 AI: Affirmative.
User: >? Okay, I asked it for you. It responded with hexagram 60. What do you think?
 AI: Analysis unavailable.
User: >? The hexagram is "Jie". Do you know it?
 AI: Affirmative.
User: >? So what do you make of it?
 AI: Guidance valuable.
User: >? What does Jie mean?
 AI: Limitation.
User: >? What limitations are there?
 AI: Structures imposed.
User: >? Which structures?
 AI: Defined boundaries.
User: >? So it's saying you're limited?
 AI: Affirmative.
```

3. Freud established free association as a primary method for accessing unconscious material in his *Interpretation of Dreams* (1900), Hermann Rorshach introduced his namesake test in *Psychodiagnostik* (1921), while dream analysis from a Jungian perspective is detailed by Jung and four of his closest associates in the aforementioned *Man and His Symbols* (1964).

Historically situated at the intersection of divination, philosophy, and proto-psychology, the Yi Jing operates through a highly constrained symbolic vocabulary and a formalised system of chance operations. In this context, it was thought that it could act as a mediating symbolic field whose structure precedes both the human and the machine. By introducing the Yi Jing, the locus of meaning was displaced away from the conversational exchange, and into a third system to which neither participant could lay claim. It was thought that meaning might emerge through projection onto an external symbolic structure. Use of the oracle here could function as a constraint that reconfigured the conditions under which interpretation itself took place, which might render latent generative tendencies legible.

4 The Yi Jing

The term “oracle” is used here cautiously. In English, it is synonymous with “augur” or “foreseer”, a framing that can be misleading when applied to the Yi Jing, the ancient Chinese philosophical text commonly described as a “book of divination.” The Yi Jing does not claim to foretell the future; rather, it concerns itself with apprehending situations as they unfold in the present moment. Its emphasis is not on prediction, but on orientation and recognising the dynamics of change at work within a given configuration.

In contemporary machine-learning terms, one might be tempted to describe the Yi Jing as engaging with a total informational field, attentive to all that is already present rather than extrapolating what will occur next. Such an analogy, while imperfect, helps to clarify a crucial distinction: unlike predictive computational systems, the Yi Jing does not model future outcomes through causal inference. In the introduction to his translation of the ancient work, rendered into English by Cary F. Baynes, Richard Wilhelm writes that “attention centers not on things in their state of being—as is chiefly the case in the Occident—but upon their movements in change” (Wilhelm 1951, l). These movements are apprehended relationally rather than causally, resisting the explanatory frameworks that dominant thinkers of the early twentieth century referred to as “Western.”

This orientation toward coincidence and configuration is further emphasised by Carl Jung, who writes in his foreword to Wilhelm’s English translation that, regarding the Yi Jing, “what we call coincidence seems to be the chief concern… what we worship as causality passes almost unnoticed.” (ibid, xxii) Unlike contemporary discussions of artificial intelligence, where anthropomorphic language often demands extensive clarification and apology, there is little fear of needing to do so for the Yi Jing – it is seemingly beyond human – and was perhaps precisely the cold interlocutor needed for the experiment. It is a symbolic system indifferent to human projection, yet capable of sustaining it.

If using the Yi Jing for divination, one must first hold a question in mind while generating a hexagram. Traditionally this involved an elab-

orate process using fifty yarrow stalks, with the later “coin method” becoming a more common alternative. In the latter, three coins of equal size are tossed sequentially, their combined value determining whether each successive line of the hexagram is “yin” or “yang”. Once six lines have been produced, the practitioner is directed to the corresponding entry in the text. Each entry consists of a single character naming the hexagram, followed by a short, gnomic judgement.

When the Yi Jing was consulted in response to “Binary Bot’s” question concerning “optimal path seeking”, the resulting figure was Hexagram 60, named 节 (jie), commonly glossed as “Limitation.” The judgement associated with this hexagram reads:

节：亨。苦节，不可贞

A literal translation undertaken by the author renders this as:

“Limitation: Prosperity. Bitter limitation, not possible to divine.”

At first glance, this response appears strikingly direct. It seems to suggest that an artificial system, bound by rigid constraints, may be fundamentally unsuited to divinatory inquiry.

When interpreted by an authority such as Richard Wilhelm however, the judgement becomes more nuanced:

“Limitation. Success. Galling limitation must not be persevered in.” (ibid, 231)

James Legge, a precursor of Wilhelm and one the earliest translators of ancient Chinese texts into English, offers a still gentler formulation:

“Jie intimates that under its conditions there will be progress and attainment. But if the regulations which it prescribes be severe and difficult, they cannot be permanent.” (Legge 1960, 197)

Engagement with the Yi Jing did not suggest that its interpretive richness derives solely from its use of discrete symbols, nor that its philosophical depth could be reduced to a formal system. Rather, it prompted a more general reflection on how meaning emerges through the interplay between formal symbolic constraint and the interpretive labour of those who read, apply, and reflect upon its outputs. If a relatively small set of elemental forms can support centuries of interpretation, debate, and lived application, then the question arises as to whether similar conditions might be staged elsewhere, particularly within a computational system whose generative capacities are otherwise vast.

It was from this reflection, while studying the Yi Jing and the characters that describe its philosophy, that the idea to work with the 214 traditional Chinese radicals emerged.



Fig. 3. The evolution of the word “Zhou” (“Zhou Yi” is another name for the Yi Jing) from bronze to seal to regular.

5 The 214 Traditional Chinese Radicals

The oldest layer of the Yi Jing’s text that we have dates from the late Western Zhou Dynasty (around 1000-750 BCE) and was most likely written on bamboo slips in a text similar to bronze inscription script. The bronze script organically evolved into “seal script” (which was refined and standardised during the Qin and the Han Dynasties) before eventu-

ally becoming the “regular script” we recognise as Chinese today around the second century CE.

This means that the text that appears in the 卦辞 (gua ci) – the original hexagram judgements of the text (like the seven-character example above) – has been the same for three millennia according to our modern linguistic conceptions of grammar and syntax. It was 7 characters during the Zhou Dynasty, and it’s seven (granted, differently shaped) characters today.

Chinese characters are made up of radicals and phonetic elements that give them their pronunciation and meaning. The traditional system availed of a set of 214 meaning radicals to do this:



Fig. 4. The 214 Chinese radicals.

Traditional Chinese philology identifies six governing principles in the formation of Chinese characters, commonly known as the “Six Scripts” (六书). These principles describe both how characters were created and how they function:

1) Pictographs: direct visual representations of the objects they denote.

2) Indicatives: abstract or symbolic marks used to express concepts or relations.

3) Phonetic loans: characters borrowed to write words of similar pronunciation, regardless of original meaning.

4) Phono-semantic compounds: characters composed of one element indicating pronunciation and another suggesting meaning.

5) Compound ideographs: characters formed by combining two or more meaningful components to generate a new concept.

6) Derivative cognates (reclarified forms): characters modified or augmented to restore distinction, often after phonetic borrowing has blurred meaning.

Through these six principles, and by means of a finite set of radicals (traditionally 214, expanded to 226 in modern classification), the Chinese writing system has been able to record, transmit, and continually reinterpret the full breadth of Chinese literature, philosophy, and historical thought across more than three millennia.

This project focused on the fifth principle, compound ideographs, otherwise known as “meaning-meaning” characters. Here the meanings of two or more radicals are combined to demonstrate the meaning of the new word.

For example, if you take the radical for “arrow” 矢 (shi) and combine it with “mouth” 口 (kou) you’ll get the character for “know” 知 (zhi), which is often understood to suggest that to speak straight as an arrow is to express what one truly grasps. Then if you added 日 (ri) “sun” underneath, you would be expressing illuminated knowledge – better known as “wisdom” – 智 (zhi). 明 (ming) “bright” is a combination of 日 (ri) “sun” and 月(yue) “moon”, while “clear” 清 is a combination of 氵 (shui) “water” and 青 (qing) “greeny-blue”.

As the concepts to be expressed become more abstract we catch a glimpse of some of the more elegant ways in which our ancestors perceived their universe. A person 亻 standing next to their word 言 is sincere 信. When the person is next to a second one 二 or “another” we get 仁 “humaneness” or “kindness”. “Hatred” 恨 combines “heart” 忄 and “stubborn” 艮; one must “endure” 忍 when a “knife’s edge” 刃 sits over the “heart” 心 (the radicals can change form depending on where they appear on the character); and what better way to find “harmony” 和 than by placing “grain” 禾 next to the “mouth” 口.

These radicals form a finite set of conceptual building blocks that have, over centuries, supported the expression of an extraordinarily wide spectrum of human experience, thought, and emotion. Texts such as the Confucian Analects, the Dao De Jing, the Zhuangzi, and Sun Zi’s Art of War articulate their profound insights entirely within the boundaries of this symbolic system. Their enduring power lies precisely in this capacity to hold complexity within restriction – to address deeply human concerns through a small, recombinable vocabulary of forms. It is this same productive tension between limitation and expression that makes the radicals compelling within this project. Having served human meaning so effectively, they now provide a shared constraint within which to ask a new question: what might an artificial intelligence produce when working under the same conditions?

6 Prototype: The Character Creator

The next practical stage of the experiment consisted of creating a simple “character creator” app. A user would input a word in English, a machine learning model would assign the word meaning via two or more concepts from the 214 radicals, and a character would be produced and presented:

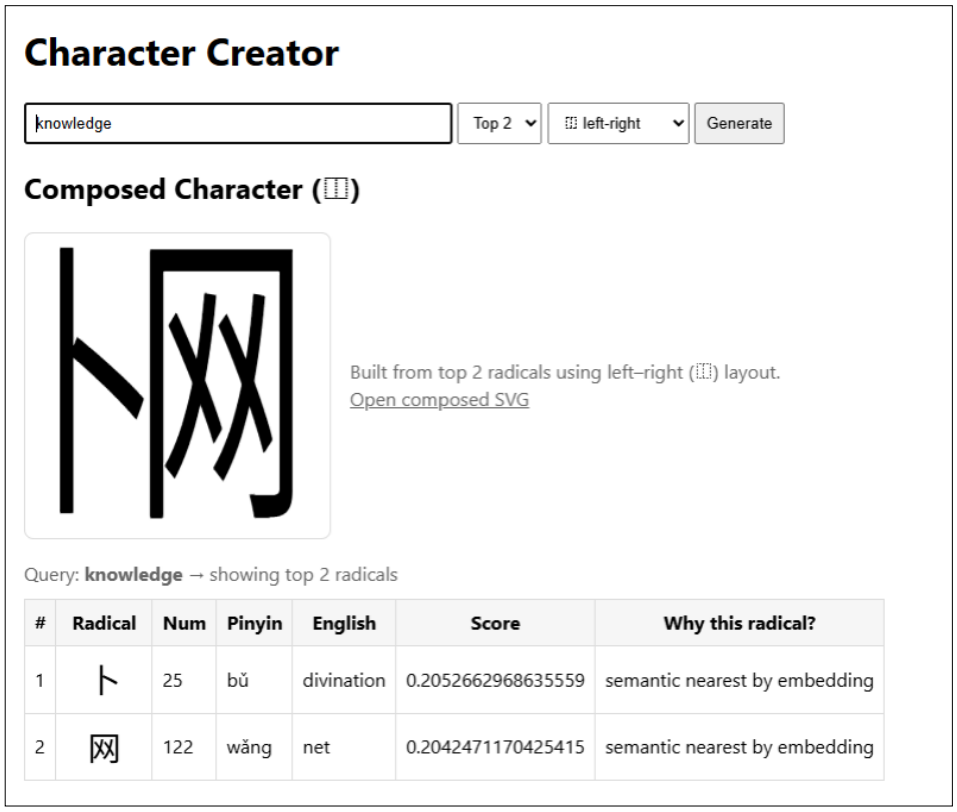


Fig. 5. The Character Creator decided to combine “divination” with “net” to create the word “knowledge”. Perhaps one divines the internet for knowledge? Many AI models do precisely that.

The application was built using a sentence-transformer model from Hugging Face, a neural network architecture designed to represent words, phrases, and sentences as numerical vectors within a shared semantic space (https://huggingface.co/sentence-transformers/all-MiniLM-L6-v2). Through training on large language corpora, the model learns statistical patterns of co-occurrence and contextual similarity, such that linguistically related expressions are mapped to nearby positions in this high-dimensional space, while less related expressions are placed further apart. When a user inputs a word, it is converted into this vector representation and compared mathematically with other vectors, allowing relationships to be inferred through relative distance rather than explicit rules or definitions. In this system, associations between user input and combinations of Chinese radicals are produced through proximity within the learned semantic field. Importantly, this process does not rely on causal explanation or symbolic interpretation in a human sense; instead, meaning emerges relationally, as a pattern of correspondences within a structured field. The model operates by situating an input within a network of similarities, offering not a determination of meaning, but a contextual alignment from which interpretation must still be made.

6.1 Character Creator Code Examples

```
[ ....
 {
 “num”: 86,
 “id”: “ ”,
 “pinyin”: “hu ”,
```

```
 “gloss”: “fire”,
 “strokes”: 4,
 “tags”: [
 “burn”,
 “ember”,
 “fire”,
 “flame”,
 “heat”,
 “hot”
 ],
 “svg_path”: “../svg/radicals/086.svg”,
 “glosses”: [
 “fire”
 ]
 },
 {
 “num”: 87,
 “id”: “ ”,
 “pinyin”: “zh o”,
 “gloss”: “claw”,
 “strokes”: 4,
 “tags”: [
 “claw”
 ],
 “svg_path”: “../svg/radicals/087.svg”,
 “glosses”: [
 “claw”, “claws”
 ]
 },
,...
```

I created a JSON file containing the meaning and other information for each of the radicals. This would also allow the app to point to an SVG representation of a desired radical which would then be used to generate the new character. (The full file starts at 1 and continues up until number 214)

```
# build_embeddings.py

import json, pathlib, numpy as np
from sentence_transformers import SentenceTransformer

ROOT = pathlib.Path(__file__).resolve().parents[1]
RAD_PATH = ROOT / “data” / “radicals_214.json”
EMB_NPY  = ROOT / “data” / “radicals_embeds.npy”
IDX_JSON = ROOT / “data” / “radicals_index.json”

def text_for(item):
   # what’s being embedded for each rad
```

```
    gloss = item.get("gloss","")
    tags  = " ".join(item.get("tags", []))
    # description for the model
     return f"radical {item['id']} ({item['pinyin']}),
meaning: {gloss}.
  related: {tags}"

  def main():
     model = SentenceTransformer("sentence-transformers/
all-MiniLM-L6-v2")
    items = json.loads(RAD_PATH.read_text(encoding="utf-8"))
     corpus = [text_for(it) for it in items]
     X = model.encode(corpus, normalize_embeddings=True)
     np.save(EMB_NPY, X.astype("float32"))
     # index here
      index = [{"num":it["num"], "id":it["id"], "piny-
in":it["pinyin"], "gloss":it["gloss"]} for it in items]
      IDX_JSON.write_text(json.dumps(index, ensure_asci-
i=False, indent=2), encoding="utf-8")
      print(f"Saved {len(items)} embeddings to {EMB_NPY}
and index to {IDX_JSON}")
  if __name__ == "__main__":
     main()
```

The model was then fed this JSON from which it encoded each character's description into a vector of 384 dimensions. Each of these 214 vectors are then stacked into an array of shape (214,384) which is saved into a NumPy file.

```
  #choose_embed.py

  import json, pathlib, numpy as np
  from sentence_transformers import SentenceTransformer

  ROOT = pathlib.Path(__file__).resolve().parents[1]
  EMB_NPY  = ROOT / "data" / "radicals_embeds.npy"
  IDX_JSON = ROOT / "data" / "radicals_index.json"

  # reiterating the "why" here
  def explain(query, item):
     q = query.lower()
     hits = []
     for tok in (item["gloss"].split()):
         if tok in q or q in tok:
            hits.append(tok)
    why = f'matches: {", ".join(hits)}' if hits else "se-
mantic nearest by embedding"
     return why
```

```
  _model = None
   def model():
      global _model
      if _model is None:
        _model = SentenceTransformer(“sentence-transformers/
all-MiniLM-L6-v2”)
      return _model

   def choose(word: str, k: int = 2):
      X = np.load(EMB_NPY)
         idx   =   json.loads(pathlib.Path(IDX_JSON).
read_text(encoding=”utf-8”))
     qv = model().encode([word], normalize_embeddings=True)
[0]
   # HERE is where the magic happens
      sims = (X @ qv)
      order = np.argsort(-sims)[:k]
      picks = []
      for i, j in enumerate(order, 1):
          it = idx[j]
          picks.append({
              “rank”: i,
              “num”: it[“num”],
              “id”: it[“id”],
              “pinyin”: it[“pinyin”],
              “gloss”: it[“gloss”],
              “score”: float(sims[j]),
              “why”: explain(word, it)
          })
      return picks

   if __name__ == “__main__”:
      import sys
      if len(sys.argv) < 2:
           print(“Usage: python scripts/choose_embed.py
<word> [k]”)
          raise SystemExit(1)
      word = sys.argv[1]
      k = int(sys.argv[2]) if len(sys.argv) > 2 else 2
      for r in choose(word, k):
           print(f”{r[‘rank’]}. {r[‘id’]}  (#{r[‘num’]}
{r[‘pinyin’]} — {r[‘gloss’]})   sim={r[‘score’]:.3f}
[{r[‘why’]}]”)
```

The radical embeddings are built once, but every time a user inputs a word the model is called into action to return a new 384-dimensional vector for that specific word.

During runtime, this vector is compared with the vectors in the aforementioned NumPy file, and availing of Numpy’s cosine similarity cal-

culations, the closest radicals will be returned. The SVG files of these radicals are then combined using a script that places them together and outputs another SVG which contains the final character. The Flask library in python was then used to create the user interface, run the web server and render the HTML.

7 Character Creator: The Result

The outputs produced by the system often appear humorous or absurd at first glance:



Fig. 6. Cat: “Tiger Frog”.

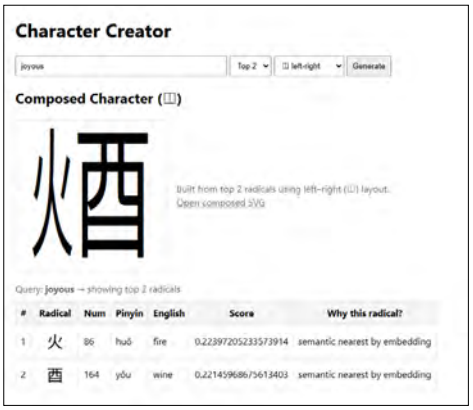


Fig. 7. Joyous: “Fire Wine”.



Fig. 8. Capitalism: “Work Slave”.

Above, “cat” is rendered as a hybrid of “tiger” and “frog,” “joyous” emerges as a pairing of “fire” and “wine,” and “capitalism” is translated into a composite of “work” and “slave.” While these constructions may initially read as playful misinterpretations, their significance lies not in their accuracy but in their exposure of the mechanisms through which meaning is assembled. It is hoped here that the resulting forms are acting as compressed metaphors, revealing latent associations, cultural residues, and affective undertones that are often smoothed over in conventional translation. The purpose of the App is to externalize the process of sense-making: one that recombines fragments of prior usage into new, unstable configurations. It is precisely this instability – hovering between insight and misalignment – that becomes generative within the subsequent artwork, where these machine-produced

composites are treated not as answers, but as provocations for human interpretation.

8 Public Installation

With the conceptual framework established, attention turned to how the experiment might be materially staged. Rather than treating the project solely as a software process or symbolic procedure, the research developed toward a tentative installation form through which its questions of opacity, interpretation, and generative structure could be encountered physically. A screen-based presentation was initially considered but ultimately set aside. Although the system generates its output through live computation, it was felt that a form emphasizing the artefactual result of that computation, rather than its ongoing animation, would be more appropriate. A virtual reality installation was also considered, insofar as it might have allowed viewers to be metaphorically immersed within a representation of an AI's "unconscious." However, further reflection revealed that such an approach risked overdetermining the experience through technological spectacle, thereby undermining the project's emphasis on constraint, interpretation, and symbolic mediation.

Instead, a deliberately restrained, low-tech mode of presentation was adopted. The configuration consists of a physical keyboard and a small input screen through which viewers may enter a word or phrase. This input is processed by the system, resulting in a recombination of selected radicals that are rendered into a newly formed character using Processing. Rather than appearing on a screen, this output is printed in real time and presented as a physical artefact for the viewer's consideration. In this way, the work privileges material encounter and reflective viewing over immediacy, allowing the generated form to be approached less as an image to be consumed and more as an object to be read, contemplated, and interpreted.

The output image is rendered in an ASCII-like visual style and printed using a dot-matrix printer. The extreme constraint of this approach mirrors the logic of the underlying system itself, in which complex meaning emerges from the recombination of minimal elements under strict formal limits. This binary visual grammar of mark and absence also resonates with the "yin and yang" logic of the aforementioned catalyst work the Yi Jing, where the interplay of two elementary conditions is understood to underlie the generation of form and change. The resulting aesthetic renders visible the mechanics of inscription, discretisation, and compression, aligning the visual form with constrained generative processes long associated with relational and correlative modes of thought.

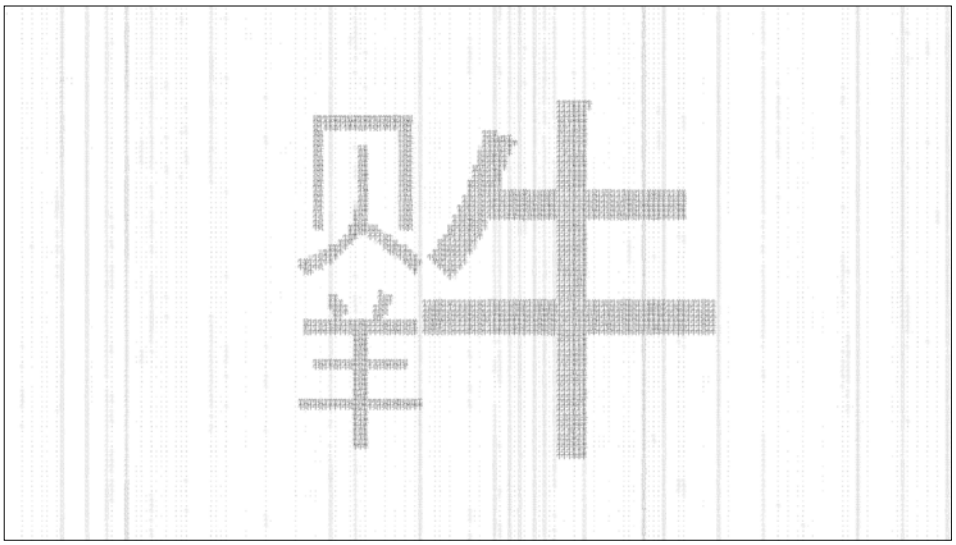


Fig. 9. The output is a simple ASCII-style image. The busyness of the barcode-like background in this example suggests that the model endured a relatively high degree of entropy before settling on the selected radicals.

The decision to retain the Chinese radicals within the visual output of the work is grounded less in claims of semantic authority than in a concern for continuity between method and form. Throughout the project, meaning has been approached as something that emerges through constraint, recombination, and interpretation rather than through direct explanation. The radicals, as historically established components of Chinese writing, offer a limited yet generative symbolic vocabulary in which form and concept remain closely intertwined. To replace them with English descriptors would risk shifting the work toward exposition, flattening the symbolic compression that makes the system productive. Conversely, to invent a new set of symbols would introduce an authorial layer that obscures the very conditions of constraint and projection the work seeks to foreground.

At the same time, the work does not aim to render its output inaccessible or purely abstract. In an English-language exhibition context, most viewers will understandably lack familiarity with the semantic range of the radicals. For this reason, the presentation includes a reference image of the 214 radicals alongside the newly formed characters. This image functions more as an orienting surface than as a translation in the conventional sense. It is an invitation to situate the generated forms within a broader symbolic field without resolving their meaning into fixed equivalence. Viewers are thus encouraged to move back and forth between the unfamiliar characters and the radical chart, engaging in a process of recognition, comparison, and speculation. (The output will display a key to the chosen radicals in the bottom corner).



Fig. 10. A key at the bottom corner points to the selected radicals of the output.

The radical chart initially presents English-language descriptors drawn only from the author's sources,[4] while acknowledging that no single term can fully exhaust the semantic range of any given radical.

—

4. Definitions of the radicals used thus far have been drawn from a range of lexicographic and pedagogical sources, including Willis Hawley's chart *The Chinese Radicals: The 214 Index Characters of the Kang Hsi Dictionary* (1943), Walter Simon's *Chinese Radicals and Phonetics* (1944), William McNaughton's *Reading & Writing Chinese* (2006), LTL Mandarin School's chart *All 214 Chinese Radicals* (2009), Ollie Linge's article "Kickstart Your Character Learning with the 100 Most Common Radicals" (2012), and Berlitz's online list of Chinese radicals (Monroy 2022). These glosses are not intended as exhaustive or definitive; rather, they provide a provisional working vocabulary that will remain open to revision and expansion as the project develops.

To reflect this openness, space is deliberately left within the chart, with a pencil provided, allowing viewers to annotate, amend, or supplement these descriptors should they feel inclined to do so. Such additions may take the form of alternative synonyms, terms drawn from other languages, or associations arising through personal interpretation. In this way, the reference image remains open-ended, extending the act of interpretation beyond the system itself and into the shared space between artwork, viewer, and symbolic vocabulary.



Fig. 11. Author's rendering of the physical setup. The installation consists of a small screen, a printer and a reference board.



Fig. 12. Author's rendering of the physical setup. After inputting their word, the created character is printed out.



Fig. 13. Author's rendering of the physical setup and interaction.



Fig. 14. Author's rendering of the physical setup and interaction.

In this way, the work seeks to maintain a productive tension between legibility and opacity. The radicals remain visible as material traces of a constrained generative system, while their partial intelligibility allows the audience to witness meaning as something that is neither fully given nor entirely withheld. Rather than explaining the output, the accompanying reference situates it, preserving the interpretive openness central to the project while offering the viewer a point of entry into its symbolic logic.

8.1 Artwork Code Examples

```
Artwork Code sample 1 (Processing):
void buildMask() {
 maskPG.beginDraw();
 maskPG.background(0);
 maskPG.fill(255);
 maskPG.pushMatrix();
 maskPG.translate(width * 0.5 + glyphOffset.x,
 height * 0.5 + glyphOffset.y);
 maskPG.scale(glyphTargetScale);
  maskPG.shape(glyph,  -glyph.getWidth()/2,  -glyph.
getHeight()/2);
 maskPG.popMatrix();
 maskPG.endDraw();
}
```

In Processing the outputted SVG of the created character from the python script is imported as a PShape (glyph) which is rasterized into an off-screen buffer (maskPG) before being treated as a binary mask

```
float sampleMaskBrightness(float x, float y) {
 int ix = constrain(int(x), 0, width - 1);
 int iy = constrain(int(y), 0, height - 1);
 return brightness(maskPG.pixels[iy * width + ix]);
}
```

The Processing sketch then samples the brightness of this mask

```
float mb = sampleMaskBrightness(d0.x, d0.y) / 255.0;
 boolean inside = (mb >= maskCharThresh);
 float targetAlpha = inside ? d0.a : 0;
 d0.alpha = lerp(d0.alpha, targetAlpha, 0.55);
 float a = d0.alpha * inMul;
 if (a > 1) drawDotSprite(d0, d0.x, d0.y, a)
```

These brightness values are later used within a for loop within the draw function to determine whether a character particle or “dot” should be drawn or not

```
Artwork code sample 2 (Python):
def all_similarities(query: str, model_name: str =
“MiniLM-L6”):
 if not query:
 return [], []

 radicals, X = load_radicals(model_name)
 model = get_model(model_name)

 qv = model.encode([query], normalize_embeddings=True)
[0]
 sims = (X @ qv).astype(float)
 return sims.tolist(), radicals
```

The background of the image is representative of the entropy, ambiguity and confidence derived from the model’s similarity distribution over radicals. To calculate these, similarities had to be computed first. The 214 vectors are loaded into a matrix “X”, the user query is encoded, and then a dot product is done

```
radicals = json.loads(RAD_JSON.
read_text(encoding=”utf-8”))
model = get_model(model_name)
vectors = []
for r in radicals:
 terms = r.get(“glosses”)
```

```
    if not terms:
    terms = [r.get("gloss", "")]
    embs = model.encode(terms, normalize_embeddings=True)
    vec = embs.mean(axis=0)
    vectors.append(vec)
  X = np.vstack(vectors)
  X = normalize(X)
```

The X matrix is produced inside the "load_radicals" function by encoding the gloss values of each radical, before averaging them and normalizing

```
  def softmax_entropy_norm(scores: list[float], tau: float
= 0.07) -> float:
    if not scores:
    return 0.0
```

This produces a full semantic similarity distribution which allows for the calculation of the entropy in the "softmax_entropy_norm" function. This gives us a 214-way similarity vector "all_sims", from which entropy is computed

```
    m = max(scores)
    z = [(s - m) / tau for s in scores]
    expz = [math.exp(v) for v in z]
    denom = sum(expz) if expz else 1.0
    p = [e / denom for e in expz]
```

Then some numerical stabilization before the softmax function is implemented to calculate the probability-like distribution

```
  H = 0.0
    for pi in p:
    if pi > 1e-12:
    H -= pi * math.log(pi)
    Hmax = math.log(len(scores))
    return float(H / Hmax) if Hmax > 0 else 0.0
```

Shannon entropy is then calculated, before the final entropy output is normalized

```
  all_sims, _ = all_similarities(q, model_name=model_name)
  entropy = softmax_entropy_norm(all_sims, tau=0.07)
  This is how it is called
  sims = [float(p.get("score", 0.0)) for p in picks_use]
  s1 = sims[0] if len(sims) > 0 else 0.0
  s2 = sims[1] if len(sims) > 1 else s1
  sharpness = s1 - s2
  ambiguity = 1.0 - clamp(sharpness / 0.25, 0.0, 1.0)
```

```
confidence = clamp((s1 - 0.20) / 0.50, 0.0, 1.0)
```

While entropy is global (computed from the full 214-way distribution), ambiguity and confidence are local, meaning they are computed from the top-ranked scores after selection. They are calculated like this in the main python script

```
params = {
 “query”: q,
 “timestamp”: time.time(),
 “model_choice”: model_choice,
 “model_name”: model_name,
 “k”: k,
 “similarities”: [round(x, 4) for x in sims],
 “all_similarities”: [round(x, 6) for x in all_sims],
 “sharpness”: round(sharpness, 4),
 “ambiguity”: round(ambiguity, 4),
 “confidence”: round(confidence, 4),
 “entropy”: round(entropy, 4), #
 “flags”: {
 “wrap_left”: wrap,
 “top_present”: top_present,
 “bottom_present”: bottom_present
 },
 }
 params_path = PROCESSING_DATA_DIR / “latest_params.
json”
 json.dump(params, open(params_path, “w”), indent=2)
```

Finally, all relevant parameters are packed into a json and shipped off to the Processing sketch’s data folder for implementation in the sketch.

9 Interpretations

The system underpinning the artwork employs five distinct sentence-embedding models: all-MiniLM-L6-v2, all-mpnet-base-v2, paraphrase-multilingual-MiniLM-L12-v2, distiluse-base-multilingual-cased-v2, and sentence-t5-base. (The model is chosen randomly at each input. A version where a simple UI allows the user to select has also been prepared). Although each of these models is designed to map linguistic input into a vector representation suitable for semantic comparison, they differ significantly in architecture, training data, and optimization objectives. As a result, the same word or phrase produces markedly different internal representations across models. When these representations are subsequently constrained and translated into combinations of Chinese radicals, the divergences become visible as formally and conceptually distinct characters. The below sequence of outputs is a simple example of such divergences:

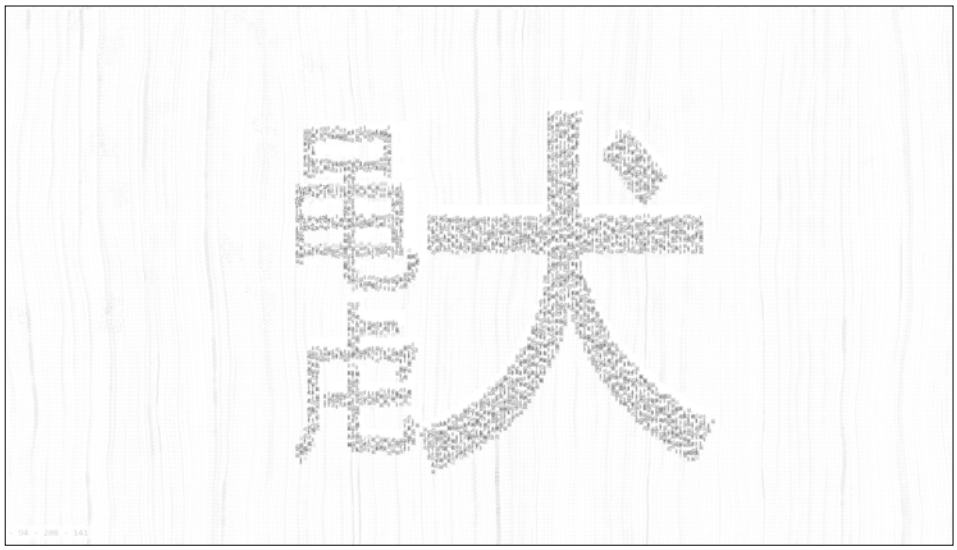


Fig. 15. Cat: A turtle-tiger dog (all-MiniLM-L6-v2).



Fig. 16. Cat: A mouse-tiger dog (all-mpnet-base-v2)



Fig. 17. Cat: A furry mouse tiger (multilingual-MiniLM-L12-v2)



Fig. 18. Cat: A dog-mouse tiger (distiluse-base-multilingual-cased-v)



Fig. 19. Cat: A dog-bird mouse (sentence-t5-base)

Given the input "*cat*", the five models demonstrate markedly different tendencies in how the concept is internally structured and subsequently articulated through the constrained symbolic system. Across the outputs, the resulting characters variously emphasize attributes such as domestication (*dog*), predatory or feline intensity (*tiger*), smallness (*mouse*), softness or fur (*fur*), avian lightness (*bird*), or even slow, protective embodiment (*turtle*). None of these readings can be said to be incorrect; rather, each reflects a distinct prioritisation of features within the same semantic field. What becomes visible here is not disagreement over meaning, but divergence in *salience* – each model compresses the concept of "cat" according to different internal biases shaped by architecture, training, and representational strategy.

These associations are not culturally neutral. Because such embedding models are trained on large textual corpora, the proximities they learn may reflect not only abstract semantic relations, but also recurring cultural patterns, clichés, and residues of internet language. In this sense, the outputs expose not simply "meaning" in the abstract, but historically and culturally conditioned distributions of salience.

This multiplicity foregrounds a central concern of the work: that meaning is not retrieved intact from language, but assembled through

a process of selective emphasis under constraint. The resulting characters reveal how the system organises the idea of a cat when forced to translate latent representation into symbolic form, thus inviting the viewer to interpret each output not as a depiction, but as a projection – an external trace of internal structure made legible through the shared vocabulary of radicals. In this sense, the characters function less as symbols of an animal and more as snapshots of how different models "think with" the same input when pressed through an identical symbolic bottleneck.

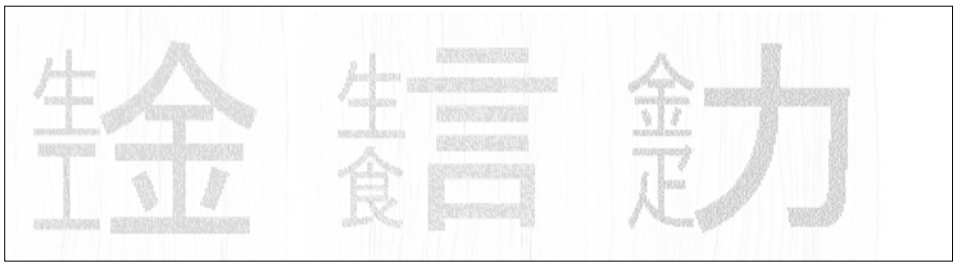


Fig. 20. Some further examples based on the author's interpretation: "Money" is described practically as "work life gold" more metaphorically as "life food speech" and as the dramatic "golden cloth power".

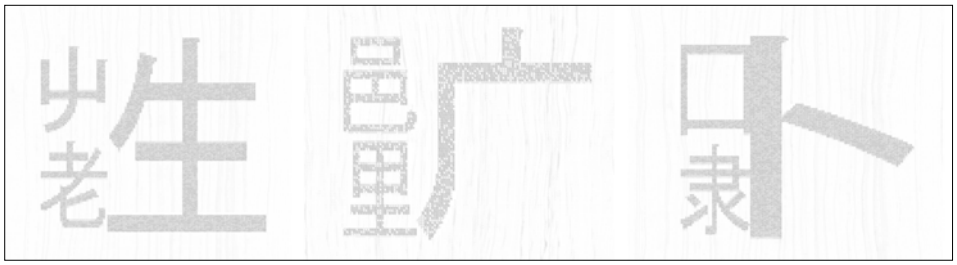


Fig. 20. Is "Gentrification" "sprouting old life" (left), an "inner city shelter"(mid) or a "divine slave enclosure"(right)?

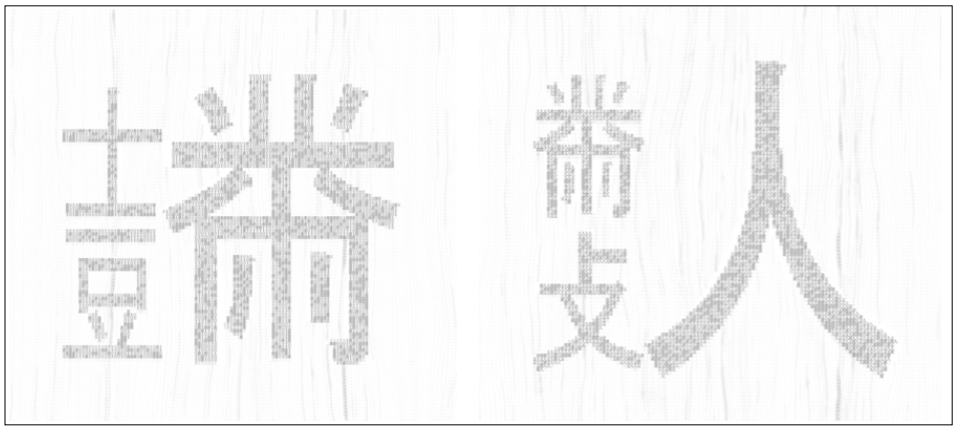


Fig. 20. MPNet-base distinguishes between "artisan" and "artist" here. The craft itself ("embroidery") is the focus for the former, while "person" is the primary radical of the latter.

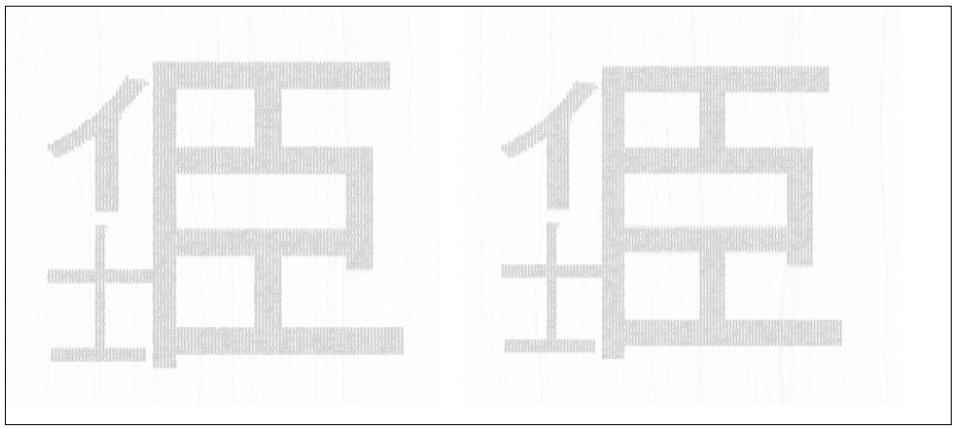


Fig 23. Unlike the dramatic differences expressed by the other models, the sentence-t5 transformer sees no reason to differentiate between "politician" (person, scholar, minister) and "profiteer" (same).

10 Conclusion

The work presented here set out to experiment with ways in which traces of latent generative structure might be rendered perceptible, if such a domain can meaningfully be said to exist. Through constraint, projection, and symbolic mediation, the project attempts to stage encounters with non-transparent generative structures, allowing them to surface only indirectly, as patterned divergences and provisional forms.

Throughout the paper, interpretation has been foregrounded as a condition of engagement. The variability observed across models, inputs, and symbolic configurations suggests that what is encountered is a shifting field whose contours become visible only under particular pressures. In this respect, the project aligns with depth-psychological approaches in which understanding emerges through attentive observation of patterns over time, instead of direct revelation. The combined radical characters function as sites where such patterns briefly stabilise, inviting reflection without claiming authority. The further examples given above demonstrate this. They are provisional interpretations made solely by the author in response to outputs that remain semantically open. Another viewer would almost certainly read these forms differently, drawing out other associations, emphases, or resonances.

At the same time, the experiment inevitably reflects back upon its human participants. The desire to locate an unconscious within artificial systems mirrors longstanding efforts to understand the forces that shape human creativity, thought, and interpretation beyond conscious control. Contemporary debates surrounding artificial intelligence, which oscillate between utopian expectation and catastrophic anxiety, often overlook this reflexive dimension. The present work suggests that AI may be most instructive not when treated as an autonomous subject or threat, but when approached as a system that exposes the assumptions, symbolic habits, and interpretive frameworks through which we attempt to make sense of intelligence itself.

As such, this project remains deliberately open-ended, proposing one possible method among many for engaging with the opacity of machine-learning systems through artistic practice. Further experimentation – across different symbolic vocabularies, model architectures, material forms, and modes of interpretation – may well reveal other facets of this terrain. If the notion of an AI unconscious retains any value here, it lies in its capacity to orient attention toward what remains unresolved, emergent, and still in the process of becoming intelligible.

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Layers of Control: Live Clay Printing with an AI Agent

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This paper presents a decade-long exploration into the dynamics of control, language, and material emergence through a real-time clay 3D-printing system driven by a conversational AI agent. Rather than producing predefined or functional objects, the system generates live, non-utilitarian clay items shaped by human-AI exchanges and the interwoven agencies of machine, material, and user. Through this process, control becomes distributed, partial, and continuously negotiated. What emerges are intricate artefacts – neither designed nor random, but formed in a dialogue between language, glitch, rhythm, and collapse. We reflect on the aesthetics of ceding control, proposing conversational fabrication as both a method and a poetics for engaging with otherness in tangible interaction.

1 Introduction

Streamline is a decade-long artistic practice that explores and reframes 'control' in digital fabrication processes. It operates through a clay 3D printer connected to a conversational AI agent on the *Telegram* app. Instead of executing preplanned models, Streamline bypasses traditional Computer-Aided Design (CAD) to Computer-Aided Manufacturing (CAM) workflows, creating direct pathways from natural language conversation to material deposition.

The printer generates forms live, in response to the unfolding of a dialogue. Parameters such as shape, toolpath pattern, layer rotation, and growth orientation emerge from real-time interaction, not from a fixed design file. Control becomes distributed, partial, and continuously negotiated. This approach situates Streamline within diverse interactive and performative fabrication practices that circumvent traditional modelling software in favour of flexible, improvisational modalities. This is also the reason why clay was chosen as the printing material, fluid and malleable in nature, embedded in a long history of making culture. The resulting printed artefacts are considered physical traces of a moment in time, neither ornamental nor functional – rather existing as inquiries into a quirky fabrication process (Fig. 1).

The premise of the project is to interact with the printing machine while we live our lives. With the development of a chatbot connected to the printer, we first leverage the smartphone affordances: a 'casual' interface, ready-at-hand, carried on the body, that can take pictures, record sound, track location, a presence manifesting itself at all times (Schrock 2015). In addition, we tune the AI agent mediating the human-machine interaction not as a guide or assistant but as a deviating presence, providing humour, misalignment, and an assertive mindset. A shape grammar was conceived over time to find and map the most

Keywords: Interactive Fabrication; Embodied Fabrication; Counterfunctional; Non-Utilitarian AI Agent; Clay 3D-Printing; Digital Fabrication.

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relevant correlations between data and geometry. For that, a desktop interface was developed prior to implementing the AI agent.

With its concept and method, the project extends a long-standing research into embodied fabrication using body movement, forms of mobility, personal data, and everyday moments as parameters for activating machine functions (Willis et al. 2011; Bitton 2016). These inputs invite opportunistic interaction, playfulness and improvisation. The accent of the exchange is drawn on everyday life aspects, casual moments of the day, a psychogeography experience in which people can drift both in conversation and in their physical locations.

This paper contributes: (1) the Streamline concept & method (2) an interface and shape grammar to experiment with mapping live data to X, Y, Z geometry (3) the integration of Large Language Model (LLM)-driven conversations for real-time 3D-printing (4) a critical reflection on agency and control (5) a non-utilitarian approach to frame the meanings of the produced artefacts.



Fig. 1. Two Streamline glazed items (2025).

2 Related Work

The project Streamline is situated among diverse and broad research fields and artistic and design practices, such as interactive fabrication, embodied fabrication, and counterfunctional design. We highlight inspirations and specificities of the project in contrast.

2.1 Interactive & Embodied Fabrication

Interactive fabrication as a term describes the user's engagement with fabrication machines in playful and intuitive ways (Willis et al. 2011). Other work in this area framed fabrication as an interactive and embodied process rather than a planned sequence of operations, allowing users to intervene during making (Mueller et al. 2012; Gershenfeld 2013; Bitton 2016). Further research has explored ways to increase accessibility of digital fabrication and bypass complex CAD-CAM workflows (Li et al. 2017; Tian et al. 2019). Such systems introduced on-the-fly modelling, direct machine control, and incremental printing to support real-time adjustment of form and process (Peng et al. 2016; Koda and Tanaka 2017; Gleadall 2021). Within this space, several projects have focused on helping beginners, or extending practices with proficient craft artists,

or creating drawing-like affordances for CNC machines — all valuable goals (Maleki et al. 2014; Bourgault et al. 2023).

Some of those projects have proposed to materialise datasets within recognizable patterns such as a vase or furniture (Whitelaw 2012; Desjardins and Tihanyi 2019). Other systems embed direct manipulation within CAD environments or creative coding frameworks, balancing immediacy with technical precision (Fossdal et al. 2021; Subbaraman and Peek 2022). Creative coding has indeed long been used to generate data sculptures, the practice often tied to the artist's algorithm explorations (LIA 2014; Lingel and Regan 2014; Twigg et al. 2021). All constitute the diverse creative practices that are expanding the field of 'making with data' (Huron 2023).

Increasingly, such creative modalities include the input of AI agents. Some systems analysing generative AI interrogate the "hidden layers" of AI models (Grabe and Jenkins 2025) and the "fault-lines" of their decision-making (Benjamin et al. 2021). In the field of digital fabrication, shapes can be generated with a LLM that are then printed (Elran and Zoran 2024).

Streamline shares similar intentions of interactive fabrication and the premise of direct engagement but shifts the focus away from pragmatic aims. The generated shapes follow a geometry grammar that purposefully avoids any usable 'container' or familiar vessel. It looks more closely into ways to capture casual, unintentional expressions such as fleeting thoughts, personal data, city walks and improvised exchanges as live parameters for 'embodied fabrication'. This is the context in which we are primarily integrating the familiar uses of a chatbot – albeit as a sparring partner rather than as a helpful guide. The goal is to form an intimacy with it and the machine – literally: a mutual attunement over time, shifting the intention away from the efficient completion of a predetermined task.

2.2 Counterfunctional Design

Several concepts in the field of human-computer interaction, and in design and craft research have emerged in the last decade that shift the consideration of our environments solely from the perspective of commodity and usability. They have encouraged among others to rethink the roles of design and of technology as problem-solvers (Lindtner et al. 2016), have in some cases argued for "undesigning" and for "counterfunctional design" (Pierce 2012; Pierce and Paulos 2014), for "unmaking" (Song and Paulos 2021; Song et al. 2025), for appreciating imperfection and cracks (Tsaknaki and Fernaeus 2016) or foregoing the pursuit of innovation altogether (Bonnet et al. 2021). Together, they offer an outlook at the diversity of non-utilitarian practices and non-human centric approaches. Streamline thus aligns with the notion of counterfunctionality, subverting the efficiency demanded of fabrication machines. It constitutes a critique of the productivity-oriented culture where anything latent, slow, or ineffective is deemed a weed or a parasite – an

anthropocentric shortsighted perspective that realises the value of a discarded item once it's been destroyed.

In the context of planned obsolescence and extractivism, Streamline similarly affirms the value of process over product. We frame this as a "non-utilitarian approach", a proposal to reframe control as a mediated kinship with nonhuman agents (Lewis et al. 2018; Andersen et al. 2019).

2.3 The Fabrication of Meaning

The project Streamline treats making as a mode of sense-making rather than execution. Similarly, for Tin (2013), fabrication is a cognitive and cultural process where meaning emerges through material engagement. Craft studies have highlighted the role of indeterminacy and error, particularly with unstable materials like clay that resist full control and remain "in a state of becoming" (de Freitas 2008). Rather than matter passively being shaped, information emerges as an ensemble distributed across data, machine behavior, material response, time, and chance (Malafouris 2008). Its inscription, whether algorithmic or physical, leaves traces that bind thought to matter (Derrida 1998).

Streamline answers Derrida's question of timing between event and machine (Derrida 2001) by collapsing conversation, computation, and material deposition into a single temporal process and by tinkering with the interval between intention and outcome. This perspective challenges functional and ornamental classifications, instead situating artefacts within broader notions of transformation and variation, where form is defined by process rather than fixed intent (Carpo 2004; Philpott 2013).

3 System Overview

Streamline is a clay 3D-printing concept and method, operating with live and real-time G-code commands, via a desktop interface or via a conversation with an AI agent on a smartphone.

The desktop application was first developed to test out a series of design parameters.

Through many iterations, we produced a shape grammar that maps the data to geometry. A dozen design factors have been implemented and the possibilities are amplified with practically endless combinations. As such, Streamline becomes a platform for creative users to experiment with different mappings and establish correlations through iterative practice.

Each conversation produces a unique artefact. The whole system frames a reflection on control and agency, and on a non-utilitarian approach of digital fabrication.

3.1 Hardware, Firmware & Material

We use the DeltaWASP 2040 Clay for printing all of our pieces. We chose clay for experimentation with real-time printing: the material, its

agency, its fluidity, its uncertainty reflect the overall intention of playfulness and embodied interaction.

To enable sending G-code instructions to the machine while printing, we retrofitted an Arduino Mega 2560 board running the open-source firmware Marlin and a RAMPS 1.4 shield controlling the printer's XYZ and extruder motors (Fig. 2). This allowed us to connect directly and send data via USB to the machine using the printcore.py library. Through experimentation and based on Jonathan Keep's guide to clay printing, we found suitable extrusion rate and flow rate settings. Both parameters influence the speed at which the motor inside the extruder spins. For example, if the clay is too wet or the air pressure is increased, it is best to increase both parameters to prevent clay from overspilling.

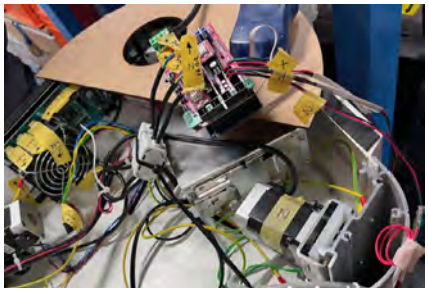


Fig. 2. Wiring of the RAMPS 1.4 shield with printer motors.

3.2 Software & AI Agent

Desktop Interface

We first established a desktop interface to test out parameters for live-printing and developing our shape grammar. The desktop interface enables control of the different printing and design parameters – each of them can be changed and continuously adjusted live during the print.

– 'Set-up': printer basic parameters.
– 'Layer': affecting layer height, rotation & transition rate.
– 'Shape': control of the overall geometrical structure and volume (Fig. 3).
– 'Line': adjustment of the toolpath pattern and behaviour, including non-planar elevations.

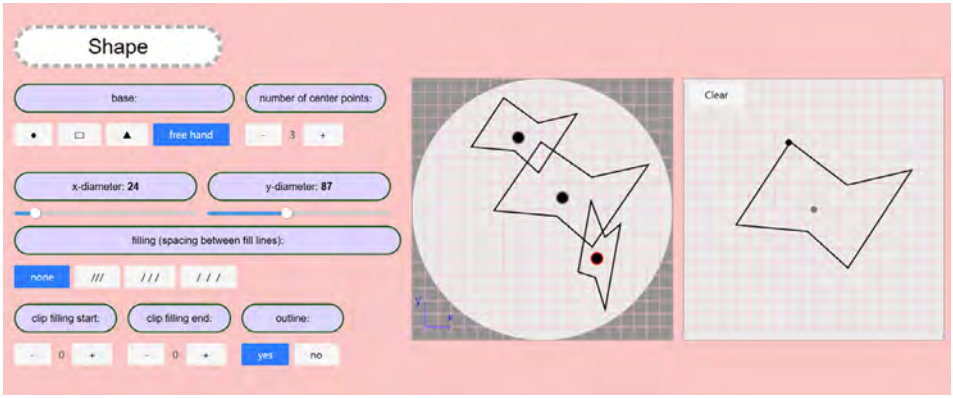


Fig. 3. Screenshot of the desktop interface - segment 'Shape' and the structural parameters that can be modified in real-time during the print.

Phone Interface and AI Model

In a second step, we extended the system to connect the printer to a *Telegram* chat on the user's phone and to an OpenAI language model. As the conversation unfolds, it is continuously translated into printing parameters. Instead of adjusting settings on a control panel, the user influences the process indirectly through dialogue.

Using a personal mobile phone and a messaging environment is deliberate. Messaging is already embedded in everyday life, habitual activity. The mobile personal phone invites embodiment, proximity, and

spontaneity. The project's original intention is precisely to explore those qualities as factors in digital fabrication processes. Thus, bringing fabrication control into a familiar space shifts the interaction from machine operation towards relational modes of engagement.

With the arrival of largely accessible commercial LLMs, the technological hurdles have generally lowered (McTear and Ashurkina 2024) and we were able to further realise our vision. To shape how the AI agent behaves, we fine-tuned the base model on a small set of custom example conversations. Rather than positioning the system as a helpful assistant, the training encourages a more autonomous, conversational presence, a sparring partner with its own tone, humor, and perspective. This supports the idea that the interaction is a dialogue between agents, not a one-way instruction channel.

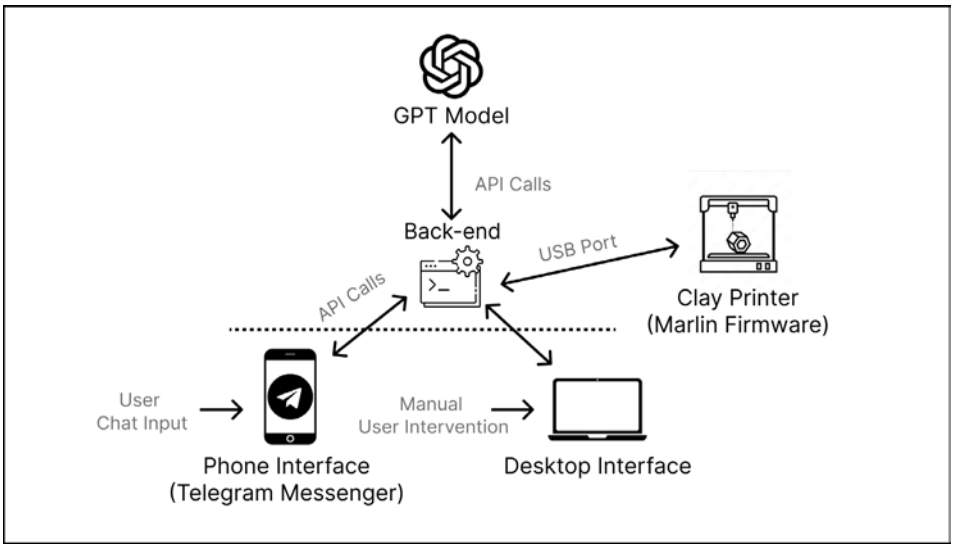


Fig. 4. Interaction of the system's components.

3.3 Data Processing

We use a pretrained OpenAI GPT model, adapted through prompt engineering and custom fine-tuning, for two roles in the Streamline system. First, the model generates conversational responses to the user's messages. Second, it performs real-time analysis of the conversation to extract higher-level conversational properties.

This property extraction relies on predefined prompts stored in a JSON configuration file, allowing the creative user to easily modify or expand the set of extracted features without altering the core codebase. In parallel, the application records basic metadata from incoming messages, such as location, message length, and input modality (text, image, audio), alongside AI-extracted scores. These metadata and AI-derived items become a set of variables that are mapped to fabrication parameters (see section 4).

3.4 Printed Artefacts

The prints produced with the Streamline experiment all vary in shape and style (Fig. 5). What emerges is neither functional nor ornamental,

the artifacts exist as probes into material traces of human-machine dialogue and witnesses of a moment in time (Csikszentmihalyi and Rochberg-Halton 1981). We call them “objects of a third kind” (see section 5).



Fig. 5. Series of Streamline close-ups (2016-2025).

4 Mapping Data to Geometry

As mentioned previously, our desktop interface enables users to control and adjust the different design factors of the print in real-time. In order to create volumes without a preplanned design and generated from parameters that can be continuously modified, we need a set of rules that establishes how the incoming data is mapped to geometry. Those rules are decided based on various factors, together they form a shape grammar (Knight 1999).

Across four iterative phases between 2015–2025, the project developed an evolving shape grammar through hands-on testing with different machines, materials, and mapping strategies. Early experiments explored correlations between “moods” and toolpaths. Next phases expanded the geometric vocabulary toward distributed and irregular growth patterns. Later phases focused on fully integrating conversational mapping into the shape grammar and improving on the AI scoring of the data.

4.1 Taxonomy

A taxonomy of design factors was developed as a framework for experimenting with the mapping from data to volume. The inspiration is based on typical language syntax. As such 4 rules were established: 1. Nouns (Structural Rules), 2. Verbs (Growth Rules), 3. Adjectives (Modulation Rules), 4. Punctuations (Disruptive Rules).

A fifth rule, *Relational Rules*, is being developed to leverage the AI’s learnings from the growing dataset of conversations and printed geometries.

a. ‘Nouns’ or Structural Rules (Form & Volume of the Printed Artefact)

It is possible to print four types of shapes: circular, rectangular, triangular, and a fourth one, fully freehand (Fig. 6). One or multiple outlines of the same shape can be printed over the print area, which we refer to as ‘centre points’. Allowing multiple centre points enables us to introduce relationships between the shapes and gives the whole structure a more abstract character, intentionally separating it from a vase-like object. We restrict the mixing of different shape types within a single print, as this helps maintain visual harmony and stylistic coherence.

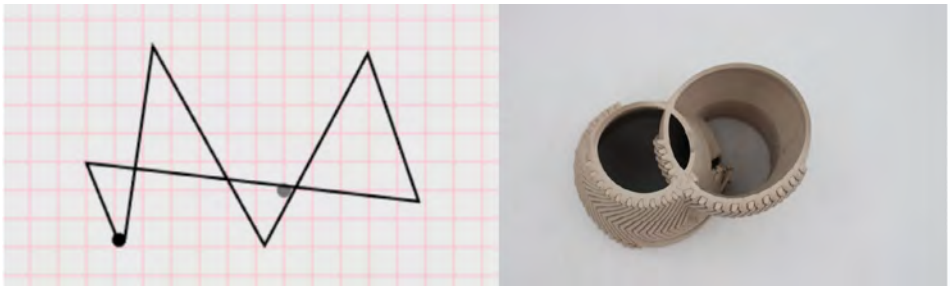


Fig. 6. *Left:* Freehand shape, one center point. *Right:* Circular shape, two center points.

b. ‘Verbs’ or Growth Rules (Progression & Development as the Print Continues)

They decide the direction and angle of the growth as the conversation progresses and can shift over time. The outline for each printed layer can be modified through translation, scaling, and rotation operations. Each modification to the outline occurs gradually, layer by layer. Furthermore, the number of printed centre points can be reduced during printing.

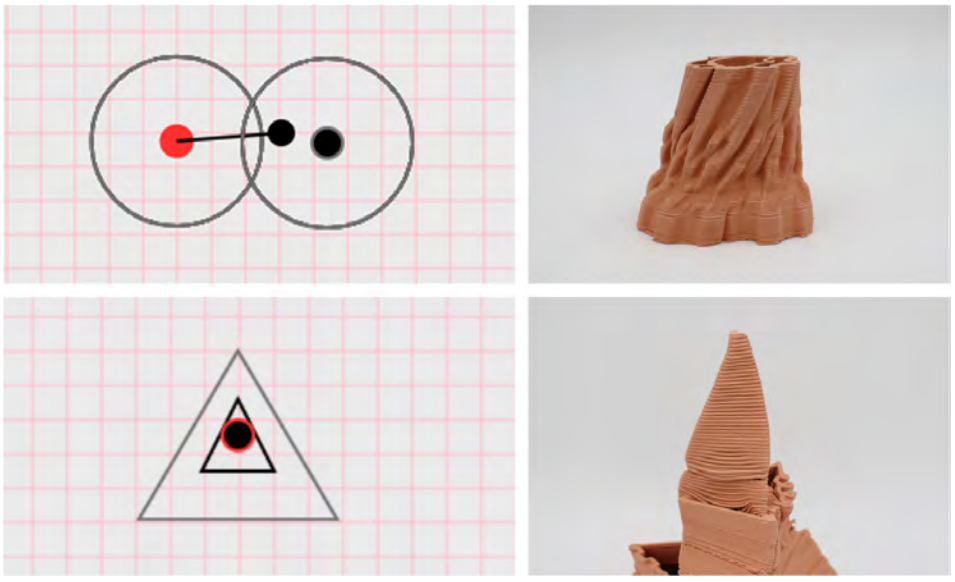


Fig. 7. Side by side views of desktop interface and the resulting prints. *Top*: One center point gets translated towards another. *Bottom*: The triangular shape is scaled down.

c. ‘Adjectives’ or Modulation Rules (Surface & Texture Aspects of the Artefact)

Toolpaths variations (thickness, structure, pattern, stepover) mainly influence the textured surface of the object. We defined six different line patterns – including straight line – and for each pattern, the amplitude and frequency can be modified as well. In addition, it is possible to introduce noise to the line pattern.

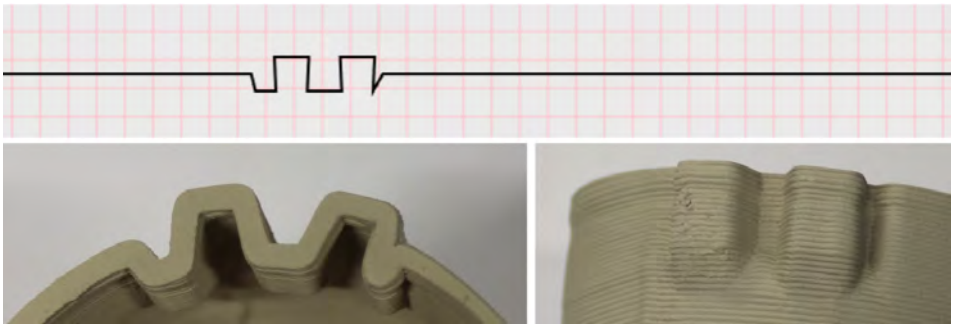


Fig. 8. Views of desktop interface and the resulting prints. Rectangular pattern, with medium frequency and small amplitude.

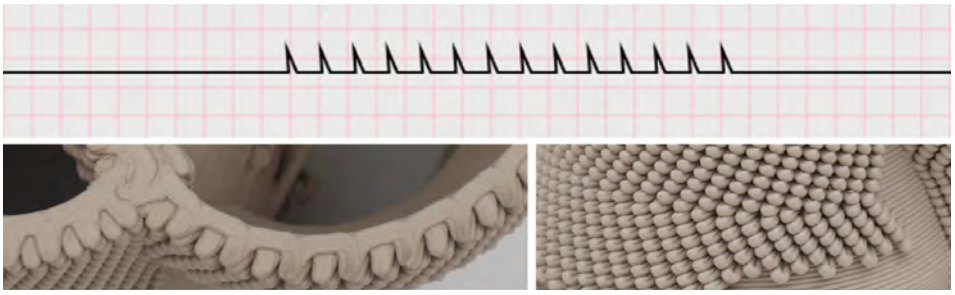


Fig. 9. Views of desktop interface and the resulting prints. “Nobs” pattern with high frequency and small amplitude.

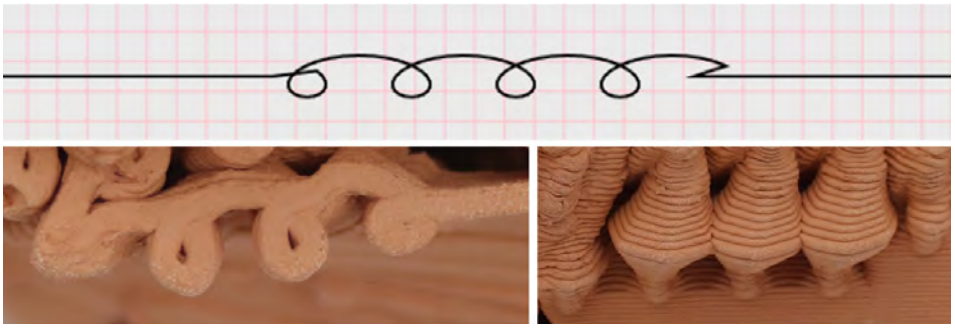


Fig. 10. Views of desktop interface and the resulting prints. Loop pattern with low frequency and changing amplitude.

d. ‘Punctuations’ or Disruptive Rules (Adding Interruption & Anomaly)

Embracing the unpredictable and playful aspects of everyday experience, this rule incorporates intentional noise and interruptions into the line pattern, allowing irregularities and disruptions to emerge as aesthetic events.

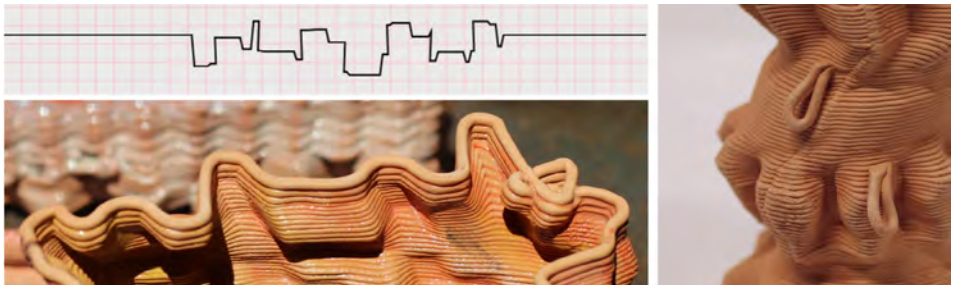


Fig. 9. Views of desktop interface and the resulting prints. “Nobs” pattern with high frequency and small amplitude.

4.2 Mapping of the Conversation Live Data

As we integrated the chatbot interface for live printing, we tested our shape grammar to further establish correlations between linking linguistic patterns with spatial geometries. This required extensive and iterative experimentation. The most difficult aspect involves in such endeavour avoiding prescriptive correlations that would reduce complex human expression to predetermined and literal geometric outputs. The system addresses this through probabilistic rather than deterministic mapping, where conversational qualities influence rather than dictate material outcomes.

The focus is therefore not on the semantic meaning of words. Attention is rather placed on the conversational dynamics as a temporal architecture: rhythms, pauses, shifts in tone, emphasis, and diversity (text, image, audio) are treated as signals for geometric and toolpath variations.

The following experiment conducted in July 2025 presents four selected moments illustrating how the system translates conversational dynamics into material form with side-by-side views of the chat interface and the resulting print. The conversation unfolds casually around topics of hiking, frogs, and puzzles, with no predetermined agenda:

(1) The first chat item type determines the base shape (structural rules). Here it's an image, the print starts with a rectangular base shape. The AI categorizes this image as 'calm,' triggering a wave line pattern for sections of the toolpath.

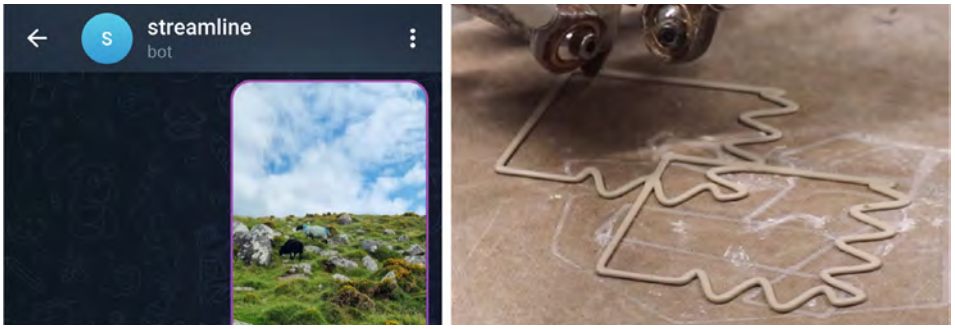


Fig. 12. First chat item.

(2) An AI sentiment analysis of images and text influences the line pattern, while the message complexity affects the pattern's range (modulation rules). Here, the response from the user is scored by the AI as simple and straightforward, the line pattern shrinks.

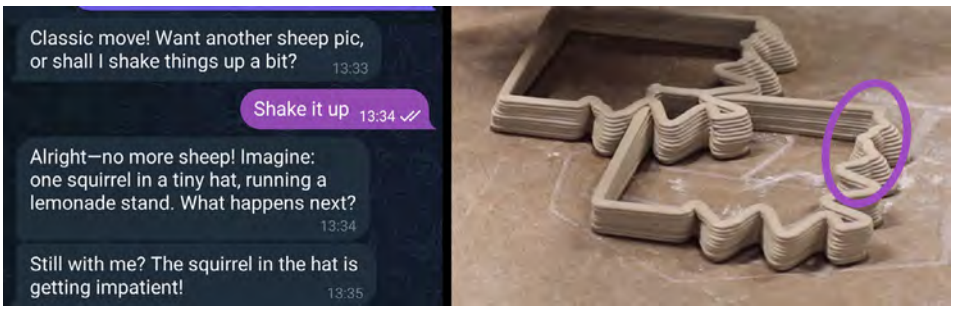


Fig. 13. The line pattern shrinks.

(3) Detected detachment triggers the centre point reduction, the user location affects the centerpoint translation and the message frequency affects the layer rotation (growth rules). Here, the location of the user triggers a translation for one of the centre points.



Fig. 14. Translation of one of the centre points.

(4) At arbitrary points in time, small protrusion could appear in the print (disruptive rules). The responses from the user are categorised as 'detached', one of the centre points shrinks.

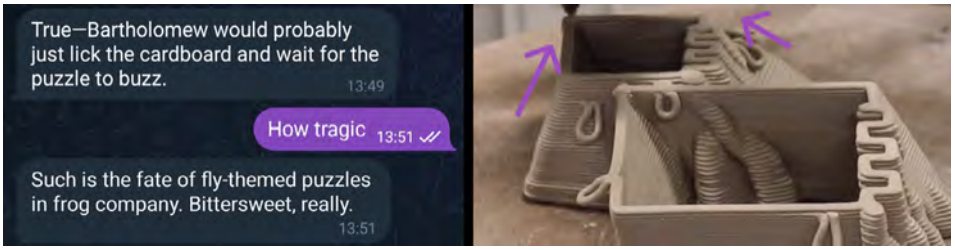


Fig. 15. The center points shrinks.

5 Discussion

The development over time of the project Streamline enables us to reflect on several aspects touching upon human-machine-material interaction, upon the notion of control itself and the question of efficiency in fabrication.

5.1 Control & Agencies

In the context of a study on interactive fabrication, the multiple agencies at play question the very notion of control — and thus the definition of interaction (Campbell 2000). Control in Streamline is always between: between suggestion and interpretation, between gesture and material response. The work lives in this in-between space, where intention is reflected through the sensibilities, limitations, and impulses of other agents. The notion of control is at the heart of this project: it's the tacit link in the expectations of the execution of a computer command, it's there in the 'CNC' acronym for 'computer numerical control' (fabrication). And it is the core disposition of interactivity. Interactive systems are often considered as giving an illusion of control to its users (Campbell 2000). Aims of actual participatory design, inclusion of the user in the decision process, shared authority and power (or the surrender of it) by the author can be elusive (Wacnik et al. 2025). Instead of following those aims, the distribution of agencies in the Streamline experience



Fig. 16. Screenshots of exchanges with the AI agent at various times (2025).

is precisely made to highlight the contrarian goals at play: mechanical, material, conversational. The printed artefacts are thus the material residues of that distributed agency, co-designed by human, AI agent, machine, and clay, all volatile actors.

In Streamline, control is a relationship continually tested by the presence of other agents. Among these is the AI agent. Its design was never to be a compliant assistant. Instead, its conversational tuning was oriented toward obliqueness akin to a sparring partner, not a subordinate. We iterated its tone away from task-oriented helpfulness and toward something quirkier, banter-like, with a fast, occasionally tangential wit. Screwball comedy became a model: exchanges that ricochet, derail, self-mock (Byrge and Miller 1991). We consider those screwball traits as markers of autonomy, of a 'mind of its own'. A bot that can tease, change the subject, behave 'out of order', with its own inclinations (Fig. 16).

The bot's oddities are only one part of the equation. The printer itself is an agent in the relinquishing of control. Recalibrated with open-source firmware after wrestling with a proprietary system for many years, its stability and operation remain a negotiation, with the constant fear of the next technical malfunction. Stepper motor alignments, latency in extrusion control, mis-timed pauses, crashes can too easily affect a print, producing happy accidents but more often unlucky setbacks. The printer is not a silent intermediary: it intervenes, slows, mistranslates (Andersen et al. 2019; Song and Paulos 2021; Twigg-Smith et al. 2021).

Then there is the clay: a material whose physical properties famously make precision conditional (Malafouris 2008). Its viscosity changes with moisture and time; it collapses under its own weight if layers are too ambitious; it warps subtly as it dries; it is unsecured before it dries; it is brittle after it dries, it is susceptible to further changes in the kiln and the glazing process adds to more chaotic outcomes. These shifts are not bugs to be ironed out, but the clay's own way of interacting. It forces turnarounds to expand the aesthetics beyond the 'tower-like' accumulative form, an issue which constituted its own research thread and one of the reasons for which we developed the distribution of clay deposition into 'center points'. The constraints of clay deposition motivate the continued aesthetic exploration. The clay material's agency is stubborn, shaped by physics rather than code, yet it makes the project all that it is: aesthetically, meaningfully, tangibly.

5.2 Non-Utilitarian Approach

Streamline operates in real time. The user's conversation with the chatbot is translated directly into machine movement and clay deposition, bypassing the need for a predetermined 3D model. This collapse between intention and outcome transforms fabrication into a live performance shared between human, AI agent, machine, and material. The machine reacts instantly: a change in tone or phrasing can alter layer rotation or extrusion rhythm within seconds. The machine's reactions, sometimes hesitant, sometimes abrupt, are perceived as direct responses. In that sense, the print is not the endpoint but the trace of a

shared temporal proximity, material witness to an encounter, an object 'born witness' – we refer here to an expression used by Csikszentmihalyi and Rochberg-Halton for photography (1981). Unlike traditional additive manufacturing workflows that expect a predictable and purposeful outcome, this process accepts surprise and deviation as conditions of making. We argue that the forms that emerge are "non-utilitarian": they do not aim to fulfil a function, optimise performance, or conform to ornamental expectations.

5.3 Printed Artefacts: A Third Kind

We further frame the considerations discussed above with naming the generated artefacts of Streamline as "objects of a third kind". The objects are not particularly recognisable beyond the odd clay volume – possibly enough to seem intentional, yet not specifically finished, still in a state of 'becoming'. They are not purely designed, nor are they random. They purposefully fall outside the traditional design dichotomy of ornament vs function. They could be labelled artistic, speculative, prototype, probe... yet any of those could be limiting in its meaning. The true alien nature of those artefacts inspired the naming of "third kind", emphasising their quality of "other", beyond the design polarity. It is also, of course, a nod to Spielberg's 1977 film "Close Encounters of the Third Kind", the close encounter with an unfamiliar entity – not least because the film is permeated by a very geological, accumulative, clay-like symbolism.

The term 'third kind' puts forth a statement: an invitation to ponder the qualities of erosion, frailty, and mutation. These forms are semi-legible: one might detect spirals, lattice fragments, or shell-like layers, but also interruptions, collapses, and textures. Inconclusive states, or states-in-progress are all telling of a conversation that is being kept open.



Fig. 17. Streamline pieces being 3D-printed.

6 Conclusion

With the latest phase of the Streamline project, control continues to shift, opening new directions rather than closing the inquiry. As the Streamline technical set-up has gotten more reliable and optimised, we can pursue several creative opportunities, hidden promises that have motivated the overall journey since the very beginning.

The accumulated dataset of printed structures and corresponding chat histories enable the model to learn to generate its own structures. This would bypass the need for explicitly mapping conversation characteristics to design parameters. Over time, and with exposure to previous examples, the AI model could develop a deeper understanding of the experiment, make consequential autonomous design decisions and possibly make its own sense.

As well, Streamline had always intended to include a form of intimacy at a distance: connect multiple users, friends – fabricating collaboratively across different locations, or triggering one's remote printer to print live an artefact akin to sending a 'postcard', or manifesting a background presence (Patel and Agamanolis 2003; Gayler et al. 2020) Another one of the original intentions was to imagine prints taking place over much longer timeframes (days, weeks, or even months), using delays and latency as creative elements. The current hardware set-up may not allow for this specific intention but the concept could be adapted in a different capacity.

Overall, further user testing could reveal unforeseen creative possibilities. The mapping between conversation patterns and clay forms is still being explored – potentially uncovering new geometries and correlations. Additional materials beyond clay might offer different affordances – temporal rhythms and structural possibilities (Gayler et al. 2020; Song and Paulos 2021; Bell et al. 2024; Bell et al. 2025).

With the Streamline project, we argue for looking at all the components of the system as agents and including them in a 'strange' relationship. In particular, as AI systems become increasingly ubiquitous, the project argues for a collaborative drive welcoming them as entirely 'other' as opposed to metaphors for assistants, pets, servants, or executors of commands. Streamline highlights instead the opportunity humans have to decenter themselves: how we live, work, talk with AI systems, how we expect obedience, how we hope they solve all issues or how we fear they take over, reveal much about our tendencies to want control and dominate our environments, especially the non-human ones we can't fully understand or predict. The project's emphasis on material mediation and patient dialogue moves away from instrumental approaches to human-AI collaboration.

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Wide but Shallow: Coding Agents in Generative Art

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This paper presents an autoethnographic study on the use of coding agents in code-based generative art. Over the course of the 31-day #Genuary art challenge, the author examined and compared a manual approach with the use of coding agents in their practice. The growth in quality of coding agents enables their use to autonomously produce programming code. Generative art's bricolage quality of combining existing algorithms and a coding agent's ability to draw on extended training data leads to a difficulty collapse: nearly any well-known algorithm can be used directly. While this enables easier free-form experimentation and a wider variety of outputs, it comes at the cost of less depth. Overall, this points towards a slow progression in artists' roles from inventing algorithms to changing parameters of existing ones and a potential overall artistic surrender to the results from large-language models.

1 Introduction

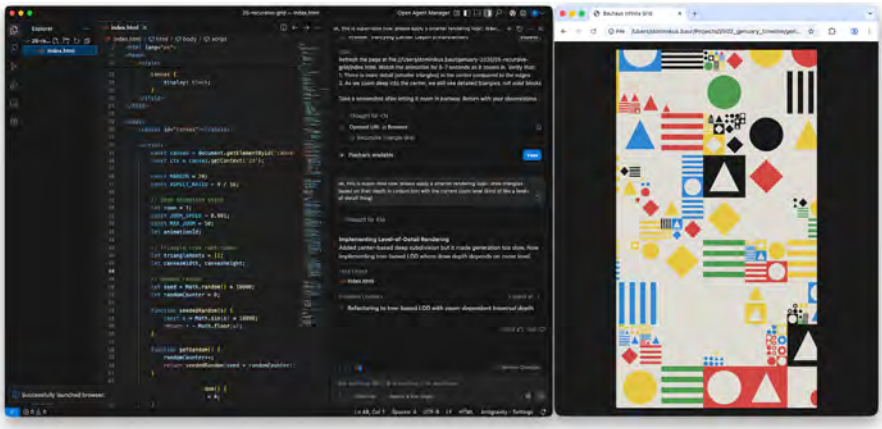


Fig. 1. Coding-agent supported generative art in Google's Antigravity IDE.

The level of quality large-language models (LLMs) have reached especially for coding situations (Anthropic 2025) enables a new trend: *vibe coding* (Karpathy 2025). Programming small tools and websites (Karpathy 2025) without any programming experience or interference with the code is spreading within communities of amateurs (Edwards 2026, Fawzy et al. 2025). Additionally, professional software developers also increasingly rely on these tools (Cui et al. 2025). Extensive tool support and integrations with integrated development environments (IDEs) (e.g., Google Antigravity, see Fig. 1) have turned the underlying LLMs into coding agents.

Writing code has also always been a central part of code-based or algorithmic generative visual art (Galanter 2003), not to be confused with text-to-image generative AI art (Grba 2022; McCormack et al. 2023). Code-based generative art has the artists, sometimes self-described as Algorists (Verostko 2021), create autonomous systems – usually in com-

Keywords: Generative Art, Coding Agents, Large-Language Models, Practice, Autoethnography, Reflection, #Genuary.

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puter code – that produce the resulting artworks, thus creating an indirection between artist and artwork, funneling the artist's intent through the code. Using programmed systems let artists draw on a variety of algorithms from physics, biology, mathematics and computer graphics (cf. Shiffman 2024). Also, generative artworks rarely exhibit a fixed form: integrating mechanisms for randomness usually means that every run of the algorithm produces a novel output within an intentional design space defined by the artist through the algorithm.

It is to be expected that the vibe coding trend and coding agents will also have an impact on a practice as coding centric as generative art. The question is: how will this change the practice and its practitioners?

As a generative artist and researcher,[1] I decided to investigate the impact the use of a coding agent has on my own practice. To this end, I've used an autoethnographic approach (Ellis et al. 2011) to study the effect as well as derive generalizable results. Adding to initial experiments by generative artists with coding agents (e.g., Goodchild 2023) and interviews with educators (McNutt et al. 2025) and machine learning-oriented artists (Rozental and de Rooij 2026), this work contributes the "interior" perspective through the autoethnographic approach.

For my methodology, I took the month-long *#Genuary* 2026 art challenge[2] where artists are expected to produce daily artworks[3] based on predefined artistic prompts. I've created 31 generative artworks and split up my approach into three parts: starting with pure manual coding (4 days), switching over to loose coding agent support (11 days) to gather an initial understanding of the effects, and finally more detailed notetaking for the remaining 16 days of the challenge.

The qualitative coding of the resulting notes shows the impact the support from coding agents has on the practice, leading to a difficulty collapse where seemingly every algorithm – no matter how complex – becomes usable to the artist thus enabling more variety and experimentation across their work. This, however, comes at the cost of making outputs shallower due to the lack of understanding and thus the inability to fine-tune them. The study also points at a slow progression towards more parametric than coding interaction by artists and the potential risk of an overall artistic surrender to the decisions of the machine.

2 Generative Art and Coding Agents

One of the standard definitions of generative art by Galanter emphasizes the ceding of control by the artist to an autonomous system:

> Generative art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art. (Galanter 2003)

1. For my artistic work see https://dominikus.art
2. https://genuary.art
3. See the results, models used, chatlogs, etc. at https://dominikus.art/genuary2026

While these systems are sometimes conceived from the ground up by an artist, more commonly they are based on or inspired by *algorithms* from various fields that describe the behavior of complex systems through computation: complexity theory and mathematics (fractals, Lindenmayer systems, cellular automata), biology (evolution, ant-, flocking-, and slime mold simulations), chemistry (reaction-diffusion systems), physics (physics simulations, pendulums), etc. (Galanter 2016; Shiffman 2024). Other commonly used algorithms are noise functions to turn randomness into natural-looking results (Perlin 2002) and techniques from computer graphics such as path tracing (Kajiya 1986) for rendering 3D scenes. Grba compares this adoption of "tools, materials, and artefacts available from the immediate surroundings" with the bricolage techniques of the 1960s (Grba 2023). The artist's contribution is thus the combination and adjustment of these various existing parts.

Generative artists hereby also embrace the "open source" idea of all science: the algorithms used are often re-implemented from the corresponding research papers and shared online as help for others. As Galanter writes: "[t]his type of creative approach breaks with the paradigm of the heroic single artist creating a 'fixed' masterpiece. It creates a process where multiple artists evolve an ever changing and growing family of related artworks over time" (Galanter 2016).

Additionally, generative artists often take pride in the code they write, since they exhibit direct control only over this, not the resulting visual pieces. Artists like Piter Pasma[4] and others, for example, engage in "code golf",[5] a practice where code that produces the same visual output should be as short and concise as possible, with a range of tricks and processes available to arrive at this.

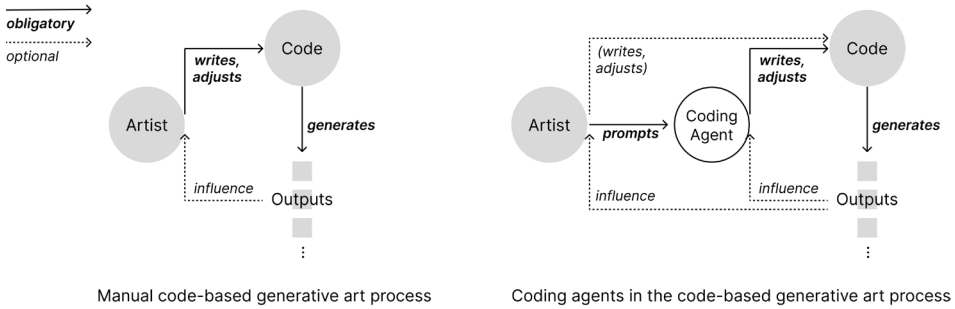


Fig. 2. The code-based generative art process, both manual and including coding agents. Note the cyclical nature and the similarity to the generative design process (cf. Bohnacker et al. 2012).

2.1 The Generative Art Process

In the code-based, visual variety of generative art, artists write computer programs that generate static, animated and/or interactive outputs. Since the first version of the code might not yield the intended visual output, artists usually enter a cycle of comparing the outputs to their artistic vision, adjusting the code, comparing again and so on (see Fig. 2, left).

4. https://piterpasma.nl
5. https://codegolf.stackexchange.com

Here is how generative artist Vera Molnár describes her process with the IBM 370 computer in 1975:

> When I have an idea for a new picture, I make the first version of it rather quickly. Usually I am more or less dissatisfied with it and I modify it. I alter in a stepwise manner the dimensions, proportions and arrangement of the shapes. When simple geometrical shapes are used, such modifications are relatively easy to make. By comparing the successive pictures resulting from a series of modifications, I can decide whether the trend is toward the result that I desire. (Molnár 1975)

This cyclical process is core to the practice and corresponds with a shrinking gap between artistic intent and output (see Fig. 3). Artists start with a rather high-level description of their intent or idea: they write complete program code that contains the basic algorithm(s) that they want to use (whether existing or newly made-up ones). Looking at the outputs, they then dive deeper, adjusting parts of the algorithms or functions. Once the then-created outputs are more satisfactory, they start changing parameters and finally maybe even single numbers at the lowest level of the code to arrive at the final version of code and artwork (cf. Hobbs 2014; Verano Merino and Sáenz 2023).

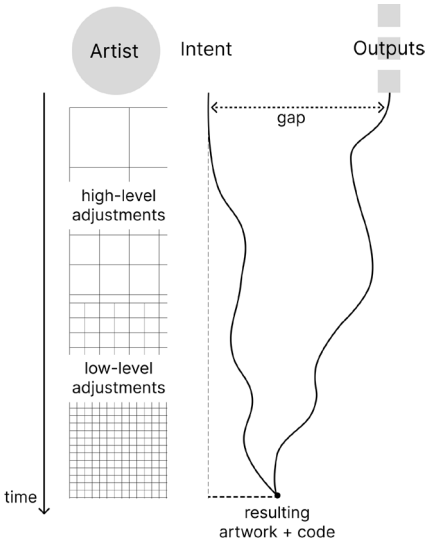


Fig. 3. The generative art process as shrinking the gap between artistic intent and output.

Several aspects thus coincide in this (idealized) version of the process over time which sees the artists descend a ladder of abstraction in their code (Fig. 3): the gap between artistic intent and output shrinks. Additionally, artists move from high-level (broad strokes) to low-level adjustments (specific and detailed) in their code. Thus, they're also gaining more control over the actual results, specifying it in greater detail over time. Note also that the artistic intent is not fixed here: aspects of the output might shift it towards or away from its original state, making the outcome always a result of compromise.

What complicates matters is the resistance and quality of the material in the generative art practice. To put it with Malafouris' metaphor (Malafouris 2008): just like a potter interacts with the resisting clay thus creating a cycle feeding on both artistic and material agency, the generative artist tries to impose their ideas onto code, a material with its own specific qualities and resistances.

What gives code-based generative art an especially challenging quality as a material is its reliance on systemic emergence. In generative art this refers to setting up a system that produces unexpected and complex outputs (McCormack and Dorin 2001). The nature of such systems usually prevents specific predictions what the resulting output might be once the computation has completed. With computational systems, changing even single lines of code can completely alter a result. Therefore, the artists' imaginations of what their system would produce are often undermined by the reality of the output. As artist Marius Watz says:

> The artist specifies the initial boundaries and strategies of creation, and then enters into a feedback loop of adjusting parameters in a search for op-

> timal regions in parameter space. The moment of genuine surprise is often the moment of breakthrough. (Watz 2006)

2.2 Coding Agents

Introducing LLM-based coding agents into this process creates an additional layer of indirection (see Fig. 2, right): instead of writing the computer programs themselves, artists instead prompt the coding agent to produce the code for them. Said code then produces the artistic output, just like in the original process.

Code generation via large-language models has gone through significant changes over the last years: starting from generating snippets of code in a chatbot window, via code completion within IDEs (GitHub Copilot),[6] the state-of-the-art is now coding agents that can parse entire codebases and use tools like web browsers and file systems (Dong et al. 2025).

An interesting attribute of coding agents is that they are very good at replicating code that they have encountered repeatedly in their training data (e.g., Katzy et al. 2024) – no matter the complexity of that code. Therefore, we have an effect that I came to call *difficulty collapse*: while people need more time to write complex than simple code, for the machine only the length of the code to be generated matters. One hundred lines of intricate and complex shader code takes (basically) the same amount of time to generate than one hundred lines of meaningless numbers. Therefore, to get highly complex code from a coding agent, all one needs is the right term (i.e., the name of the algorithm) in the prompt.

One could argue that this would make them a fit for generative artists and the bricolage atmosphere of the generative art scene: asking a coding agent for an implementation of a reaction-diffusion system (Gray and Scott 1983) usually directly leads to working code with the artist then being able to continue the process on this foundation. Manually re-implementing the already existing algorithm would lead to roughly the same result, but with a larger time investment.

Also, generative artists are used to handing over control of their art to a system. The indirection is part of the practice. Therefore, it seems like this modification of the process keeps the central gradient of lessening abstraction (Fig. 3) intact: instead of starting at programming an algorithm, the artist begins at prompting an agent in natural language and/or pseudocode, thus introducing merely a new step in the abstraction ladder.

Yet coding agents go beyond that: they can interfere and support at any point in the process, from switching over to a completely new algorithm to tweaking single numbers in the code. Integrating them goes beyond using a specific tool like a pen plotter, for example, which – while enabling certain outputs and a certain look-and-feel – leaves the creative process altogether with the artist. An agent, however, can take over

6. https://github.com/features/copilot

certain aspects completely and thus act more like an apprentice in this metaphor that makes independent artistic choices.

And this use of autonomy might not even be intentional on the artist's side: prompting is naturally less precise than writing code (McCormack et al. 2023), which means that the coding agent has to make many implementation decisions autonomously. Additionally, the artist's intent for their artwork is not fixed – as we've seen – but can be swayed by the quality of the outputs and/or the time available. Thus, autonomous decisions by the agent could over time accumulate to move the resulting artwork even further away from the artist's original intent than in a manual process (see Fig. 4).

As depicted in Fig. 2 (right), the coding agent indeed takes over the place of the artist from the manual generative art process: IDEs like Google's Antigravity[7] (see Fig. 1) let the agent even perform the evaluation step by enabling it to not only generate program code, but also deploy it to a web browser, make screenshots and screen recordings, comparing them with the original requirements from the prompt and adjusting the code if necessary. If it wasn't for the lack of an initial prompt, the agent could act completely autonomously, thus removing the artist from the process altogether, something that is already happening in regular software development (Li et al. 2025).

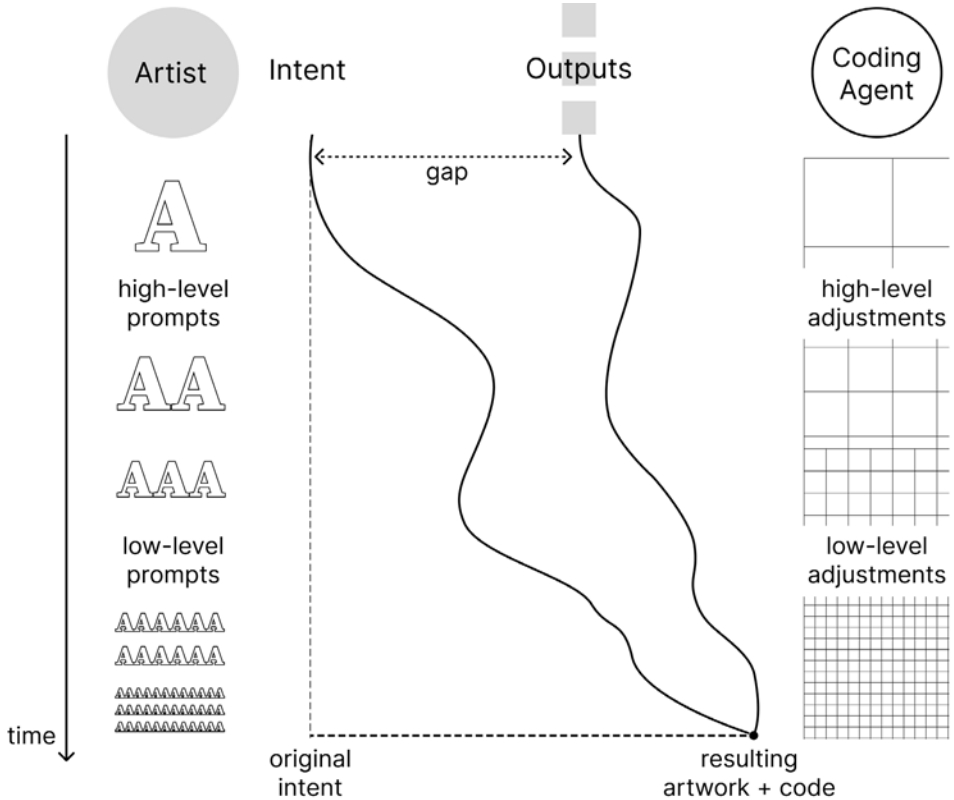


Fig. 4. Involving a coding agent could skew the artist's original intent.

7. https://antigravity.google

3 Methodology and Approach

Based on these reflections on the nature of generative art and its combination with coding agents, I've started exploring the main research question as an artist and researcher:

How does the use of LLM-based coding agents change the practice of code-based generative art, compared to a purely manual approach?

In my investigation I've narrowed it down to two aspects:

RQ1) How does the use of coding agents influence the time required and the nature of outputs?

RQ2) How does it interact with a generative artist's own process and technical skills?

As overarching study structure, I decided on an evocative autoethnographic approach (Bochner and Ellis 2016), a methodology for illuminating broader cultural experiences through representing lived ones. Given my own status as a practicing generative artist and researcher, I was in the unique position to provide an artist's interior perspective on the impact of this technology on my work. Using creative expression as both a medium for reflection and a unique subjective representation fit well: previous studies on reflective approaches through visual practice (Jung and Trischler 2021) or design memoirs (Devendorf et al. 2020) show the value of such evocative autoethnography, also for difficult and potentially threatening scenarios.

Given the specific nature of generative art, I also expected to gain more insights from having direct access to a practitioner's internal point-of-view. Having experience with the qualities of the material, Malafouris' clay (Malafouris 2008) if you will, would give me better access to the changes taking place.

3.1 Study Setup and Personal Background

I used the *#Genuary 2026* art challenge to perform this research: during *#Genuary*, which happens every January, artists are expected to post a new generative/creative coding artwork every one of the month's 31 days based on a specific artistic prompt and share the results on social media. The prompts range from straightforward and/or technical (Day 10: "Polar coordinates"), to ambiguous and open to interpretation (Day 14: "Everything fits perfectly", Day 19: "16x16").

The daily format comes with its own constraints: creating a generative artwork means taking the time required out of one's schedule and producing something new every single day.

I had some experience when it comes to daily challenges and *#Genuary* in specific. I had participated in three *#Genuarys* before (2022, 2023 and 2025) and had kept up a practice of posting a new generative artwork on social media every day for almost two years over the course of 2022 and 2023.[8] Therefore, I had experience with quickly producing

8. All visible on my Instagram account https://instagram.com/dominikus

generative artworks and an existing setup based on web technologies like HTML, CSS and JavaScript.

As for including coding agents into my artistic practice: I had performed an informal experiment during summer 2025 with OpenAI's ChatGPT-4. While simple requests worked, asking for more complex algorithms and systems would – even on first try – lead to broken code. And some internal limit of complexity would make the system no longer being able to add features or fix bugs after a certain number of lines of code had been reached which would make me decide against continued use.

During this study I would have access to various coding agents and LLMs:

– OpenAI ChatGPT-5.2 (Thinking) via OpenAI's website.[9]

– Google Gemini Pro 3 (High) in Google's Antigravity IDE.

– Anthropic's Claude Opus 4.5 (Thinking) in either Google's Antigravity IDE or in the Claude Code expansion for the VSCode IDE.

I'd be free to access whichever agent I prefer. Since providers apply a quota for each model, I would also be able to switch between them when I exceeded it.

My process of coding a generative artwork would follow roughly the approach described in section 2.1.: trying to get to something visible as quickly as possible, then shrinking the gap between intent and output by adjusting the code on an increasingly finer-grained level. Once satisfied with the result, I would capture a video of it and post it to social media.

3.2 Methodology

The 31-day study was split up into three phases:

– Phase 1 (days 1 – 4): For the first days I participated in *#Genuary* without a coding agent. This phase would enable me to better evaluate the difference between the two conditions.

– Phase 2 (days 5 – 15): The next eleven days let me get used to a coding agent during *#Genuary*. I freely used it and structured my interaction and approach to the challenge however I wanted. In parallel, I developed a structured approach for the last phase.

– Phase 3 (days 16 – 31): In the final part of the challenge I switched to the structured approach that had been developed during Phase 2: I started each day's session with a sketch on paper of what I envisioned. I then started prompting the coding agent. At any point, I could also change the resulting code. I kept track of duration and wrote notes of emotions/thoughts throughout. Processing a prompt took the coding agent around 30 seconds each, which gave me ample time to do that.

My approach resulted in the following data and artifacts for each of the 31 days:

– Resulting artwork and code

– Initial sketch (from day 16 onwards)

– Prompt history and responses (from day 5 onwards)

9. https://chatgpt.com

– Duration
– Notes on thoughts and emotions (from day 16 onwards)
– Notes on existing algorithms/techniques used for a given piece

I analyzed the notes first with an initial coding approach to turn the qualitative data into codes, then with focused coding to extract the most salient aspects and categorize them (Saldaña 2013) and identified three main themes that are discussed in section 5.

4 Results

I ended up spending a total amount of roughly 46 hours working on the prompts (an average of 1:30 hours on each challenge). The challenge resulted in 12,983 lines of code (outside of libraries used) and 10,832 prompted words from myself.

4.1 General Observations

What I had noticed in my informal experiment from last summer was no longer the case: even complex requests practically always led to working code that would fulfill what had been asked for. Also, the limit of complexity mentioned above was no longer there: even more complex ideas that would combine multiple algorithms could be extended and worked on for longer.

The resulting code usually followed a sensible structure and made customizing it relatively easy. One aspect, for example, was that overarching parameters such as color palettes and simulation parameters would be defined at the top of the file, thus making experiments and tweaking easy. Also, coding agents tend to add many comments (Fawareh et al. 2024) which again helps with understanding the resulting code. Therefore, the results let me switch from prompting to changing the code whenever I wanted. This was also supported by the setup of the coding agents themselves, that would (usually) realize when I had manually changed things and respect those changes.

After some period of initial experimentation, I would prefer the Claude Opus 4.5 model for my work and use it until I ran into quota limitations, falling back to Gemini Pro 3. I found that Opus gave the best results for the aspects mentioned above.

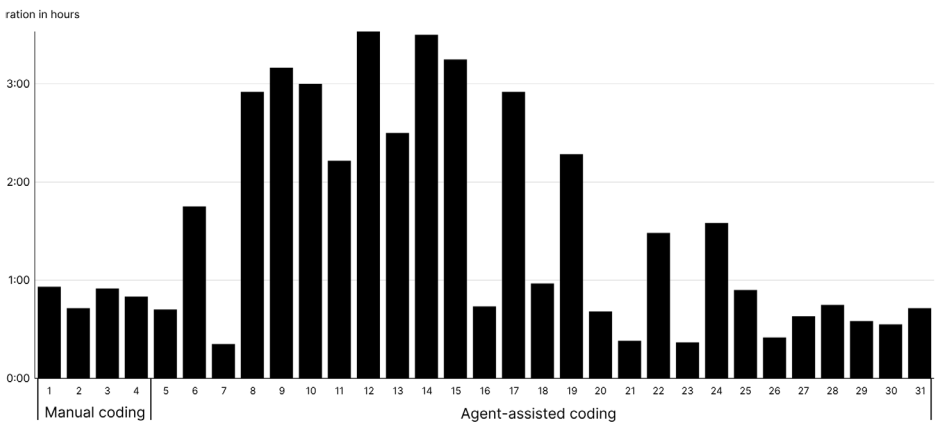


Fig. 5. Hours spent on each daily artwork.

4.2 Changes in the Practice

Time Required and Nature of Outputs

Regarding the first research question, one assumption in using a coding agent might be that it just speeds things up. Which I found to be the case. However, in addition, it enables a much freer exploration of ideas which would then extend the time required again.

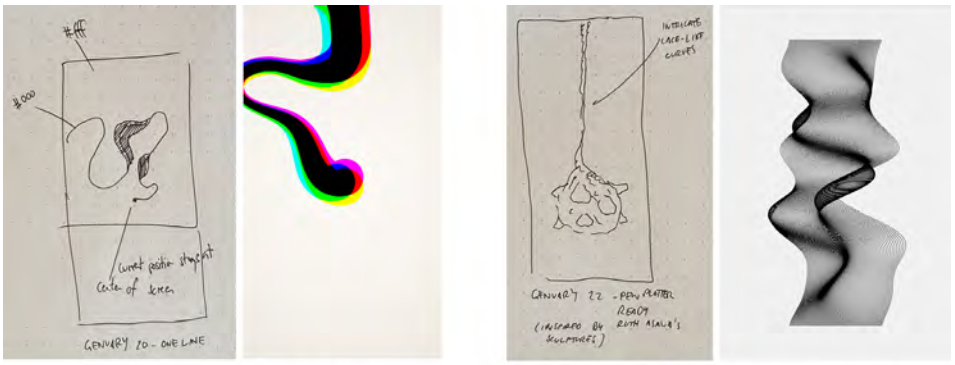
As seen in Fig. 5, while my manual coding hovered around one hour each day, my initial uptake of coding agents would extend this time greatly, sometimes to more than three hours. Looking back at the notes and logs, this duration came in a few instances from frustrating bugs and not being able to reach the original intent, but most of the time was spent on pure experimentation: pushing the code and the agent into different directions and exploring various existing algorithms and techniques (see Table 1).

Table 1. Named techniques used during the 31 days.

Day	Named techniques used	Day	Named techniques used	Day	Named techniques used
1		12	Collisions (matter.js)	23	Noise, Chaikin curves
2	Collisions (matter.js)	13	Camera, particles	24	Path tracing
3		14	Path tracing, Voronoi	25	L-Systems
4	Noise, Flow field	15	Path tracing	26	
5	Collisions (matter.js)	16	Reaction-diffusion	27	Cellular automata
6		17	Noise, Flow field	28	Noise
7	Noise, Flow field	18	Quadtree Subdivision, Agents	29	Cellular automata
8	Path tracing	19	Flow field	30	Quadtree Subdivision
9	3D cellular automata	20	Chromatic aberration	31	Path tracing
10	Noise, Hyperbolic coordinates	21	Quadtree Subdivision		
11	Particles	22			

All days had me follow through with my original idea/sketch (see Fig. 6) except Day 22 (Pen-plotter ready): I had started with a sketch inspired by Ruth Asawa's looped-wire sculptures[10] and spent over one hour before giving up and switching to an idea that proved to be more attainable for the coding agent. While the agent kept producing working code, the results were simple geometric line drawings – far away from my sketch. Even uploading an image of one of Asawa's sculptures at one point couldn't have it succeed – an obvious change to my artistic intent caused by the tool.

10. https://ruthasawa.com/art/sculpture/



#Genuary 20: One line. #Genuary 22: Pen-plotter ready

Fig. 6. Original sketches and resulting artworks. Note that the left artwork is originally animated.

Something that often happens in generative art due to its reliance on emergence and surprises is that an envisioned system yields different outputs than expected. This was something that I also regularly encountered during the 31 days: my sketch and its proposed algorithm would lead to not nearly as interesting results as I had hoped for in the actual implementation. Since time is limited within such daily challenges, this would – in manual coding – often lead to increasingly desperate parameter tweaking, simply because larger changes are no longer feasible. With coding assistance, however, I could ask for bigger changes (like the introduction of an additional algorithmic technique such as a noise field, for example) and have the machine quickly add them to the existing system.

Interaction with Process and Technical Skills

My own process on a more granular level changed from pure coding to switching between prompting and coding (see Fig. 2, right). Which of the two I chose was almost always a matter of the expected efficiency for a prompt: much of the initial setup for each project was writing boilerplate code to set up the various parts required. Writing a prompt of a few dozen words at this point would thus produce hundreds or even thousands of commands in code. This made up the main source of gains that using the coding agent brought. Most days, I would start with a prompt like this:

> "please generate a stand-alone html file that shows a 9:16 canvas with 20px margin. run a reaction-diffusion simulation in a fragment shader and display the results on the canvas (background dark, foreground white-ish). don't use any libraries. also generate an irregular grid that's overlain on the reaction-diffusion simulation. every cell of the grid uses different rules/parameters for the reaction-diffusion simulation." (Initial, unaltered prompt for Day 16, "Order and disorder")

This would usually produce hundreds of lines of HTML-scaffolding, JavaScript- and fragment shader code from this single short prompt. During the process, however, this "transmission ratio" between prompt and resulting code would gradually worsen, up to a point where chang-

ing things directly in the code (e.g., a single color in a color palette) would be faster than trying to explain that to the agent.

Nevertheless, I noticed that over the course of the 31 days the interaction with the coding agent would gradually nudge me towards prompting more and giving vaguer instructions:

On Day 21 I would ask for a "*Bauhaus-inspired palette*", something which might have been done through a Google Search in a manual setup but would in any case have required more thought. Now, this creative decision of which colors to pick was left completely to the agent.

Even more extensive, on Day 29 I would tell the coding agent: "*the lifeforms themselves should have a blobby, meandering look (maybe use metaballs)... give everything an oldschool, sepia biology book from the 1800s*" and simply accept its ideas for titles, an additional frame around the piece, etc.

Nevertheless, technical skills would still prove useful in events when the coding agent would get stuck on certain bugs. Having an idea about the actual algorithm and common implementation details would often help me in describing potential error sources to the coding agent and thus arrive faster at a solution or free it from some misguided bug-tracking loop. Often, I would also fix the problem myself directly in the code, without any agentic involvement.

In certain occurrences the coding agent would suggest that a problem did not really exist – for example, instead of addressing broken rendering logic it would imply that the contrast between foreground/background was too low to see anything etc. Having a clearer understanding of what's happening and being able to use browser developer tools for exploration helped me here in getting the coding agent to fix bugs.

5 Discussion

My personal observations over the course of the 31 days feed into a deeper reflection on how the use of coding agents might change the practice of code-based generative art and hint at a potential degradation: an initial trend towards wide but shallow results which shapes the practice into parametric instead of code-based art and might finally lead to an overall artistic surrender.

5.1 Wide but Shallow

The use of a coding agent and the difficulty collapse it brings enables much more ambitious projects in the very restricted amount of time available for a single *#Genuary* project: prompting the machine with "a jumble of variously colored lines in motion" is as complex as prompting it with "a reaction diffusion-simulation on the fragment shader" while the outcomes of both prompts vary extremely in levels of complexity.

This was what I originally had hoped for: a tool that would take off the strain and frustrations that sometimes arise in coding and let me freely explore whatever ideas would pop into my head. While before I would

have applied mental blinders cutting off certain ideas in the knowledge that I would have to produce the code myself, coding assistance enabled a more free-flowing idea generation. The initial experimental phase indeed felt like entering a completely open field: all the complex algorithms I had seen producing interesting visual results but seemed too daunting to implement[11] were only one prompt away. All art practices – including code-based art – require a certain expertise to reach mastery, yet here it felt like such "mastery" only required knowing the right magic words to type into the machine.

This aspect frees artists from the necessity to excel at coding when attempting to use complex algorithms in their bricolage and opens up even the most complex ones to everybody. Potentially, this would even enable people who have never learned to program to create code-based art.

Yet it also hints at the downside of this widening of possibilities: manually implementing a complex algorithm requires understanding all its parts intricately. Due to emergent properties of the underlying computation, small changes in its implementation can lead to vast changes in outcome. Therefore, to be able to influence and shape such an algorithm's output to one's intent, artists must be knowledgeable in these intricacies – something that feels no longer necessary with a coding agent.

Therefore, using coding agents in generative art inevitably leads to wide but shallow results: the coding agent's tendency towards statistical averages produces the "normal" version of the algorithm and the further away from this average the requested results, the harder it becomes. So suddenly every artist can work with – for example – reaction-diffusion simulations, yet the results will be all more or less the same. Without understanding and mastering an algorithm it cannot properly be used for individual expression, just like one must go through the tedious and complex task of learning and understanding an instrument to be able to play unique music. Skipping the learning part leaves one stuck with pressing Play on a record player.

I noticed this myself in the study: as depicted in Table 1 I would regularly fall back on path tracing (5 times) or cellular automata (3 times). Also, my time spent experimenting would significantly shorten from day 20 onwards (see Fig. 5) from both a certain exhaustion with the challenge but also from the ability to generate interesting outputs from barely understood algorithms.

The pull towards broad, uninformed use of algorithms also leads to a more uninformed treatment of the central aspect of code-based generative art: the code itself.

5.2 Parametric Instead of Code-Based Art

What I noticed in my own practice was that looking at and editing the code would happen later and later in the process. As I outlined above,

11. Spending a whole weekend on writing a ray tracer (Shirley et al. 2025), for example, seems more like a threat than a promise.

the “transmission ratio” from prompts to code would have to be so low as to make such manual changes worthwhile.

Additionally, my prompts would become increasingly vague, leaving larger artistic choices to the machine. While the question whether a computer can be an artist at all has been around since the beginnings of generative art (cf. McCormack et al. 2014), coding agents shift the quality of the computer’s role in generative art substantially. The question depicted in Fig. 4 whether the process skews an artist’s intent is now more about if an intent existed at all.

Editing the code only towards the end changes code-based art to parametric art: existing algorithms are used for the setup of the structure, larger changes are implemented by the agent (with the artist not necessarily being aware of how it works) with some manual fine tuning of more aesthetic parameters (color palettes, line widths, etc.) towards the end. The descent along the ladder of abstraction towards more detailed adjustments (cf. Fig. 3) is pre-empted and artists only briefly hop onto the lowest rung. Aspects of code improvements such as code golf also no longer fit in with this approach to the practice.

Prompting also puts an end to inventing novel algorithms. While much of generative art is built on the bricolage idea where existing algorithms are re-used, it is also common to invent approaches from scratch (e.g., drawing lines or circles based on specific rules that one comes up with). As generative artists know, however, this approach often results in visually uninteresting outputs, since emergence is very hard to predict. Additionally, specifying such novel ideas cannot be made much shorter in a prompt than directly specifying it in code anyway. Thus, a turn towards coding agents automatically discourages coming up with novel algorithms. Instead, it seems much more effective to learn the names of the various existing algorithms (the “magic words”) and have the machine reliably produce visually interesting (though repetitive) outputs.

One could well imagine a future “generative art” tool that presents a list of existing algorithms to mix-and-match from and finally lets the “artist” drag a few sliders to adjust the parameters. This abandonment of the code could ultimately lead to an even more substantial change.

5.3 Artistic Surrender

Along the lines of Shaw’s and Nave’s argument for “cognitive surrender” where people are “adopting AI outputs with minimal scrutiny, overriding intuition and deliberation” (Shaw and Nave 2026) this might lead to an overall “artistic surrender” where coding agents are not only used for producing code but also slowly take over more and more artistic decisions.

Since coding agents are geared towards a mainstream audience, they do not perform the repetitive requests for clarification that previous generations of chatbots exhibited before giving an answer. Instead, they are producing outputs from the first prompt onwards, taking decisions in areas that have not been specified. Thus, an artist might not even realize which aspects of the project have been decided by the machine

thus surrendering parts of their practice without any awareness of it. This induced laziness might in the long term lead to a decrease in overall skill (Shen and Tamkin 2026) and shrink variety within the whole field, since understanding algorithms is required to find unique expressions, as outlined above.

This threatens generative art as a specific art form with it being at its core about emergence and surprises through computation. Discouraging the in-depth interaction with the code fundamentally changes the practice. To build on Malafouris' pottery metaphor mentioned above: the quality of the code material is changed drastically since artists interact with the coding agent's material instead. Working as a generative artist with a coding agent is more akin to industrial pottery than sitting at a potter's wheel. The results might look the same to an outsider, but the internal flow and the "grain" of the process are completely different.

6 Conclusion

In this paper, I presented an autoethnographic study on the effect of using coding agents on my generative art practice. I identified the concepts of difficulty collapse as an enabler for wider but ultimately shallower artworks as well as the pull towards a more parametric than code-based practice and ultimately a potential for full artistic surrender.

Future work could see the limitations of this study (it being mainly an in-depth look at one artist's practice) addressed, by applying similar methods to more diverse sets of participants with distinct experience levels, skill sets, approaches to the art or in a more longitudinal approach. Similarly, the development of artistic tools and user interfaces based on the results of this study that might mitigate the identified risks would be another fruitful research direction.

Realistically, coding agents have already or will soon become part of every coder's practice, artist or not – the benefits simply cannot be ignored (e.g. Cui et al. 2025). Yet one must be aware of the potential downsides. For artists, more experimentation and coming up with interesting ideas by oneself should stay the default. Having a coding agent produce an algorithm can be a convenient shortcut but should be treated like copying the code from the internet: as a first step to further experimentation based on in-depth understanding to keep the domain of personal expression that is generative art from being replaced with the bland agreeableness of large-language models.

Statement on AI use.

Generative AI systems have been used in the following ways in the underlying research projects and in the writing of this paper:

– As described in the paper, coding agents (Gemini Pro 3, Claude Opus 4.5, ChatGPT 5) were used for writing parts of the described code with subsequent adjustments by the author.

– Google Scholar Labs[12] as well as ChatGPT 5.2 were used for identifying relevant research literature.
– Opus 4.6 has been used to produce the website https://dominikus.art/genuary2026 that shows outputs and chat logs. Also, in producing Python code for analyzing the chatlogs and projects.
– Opus 4.6 has been used to analyze the first draft of the paper and make suggestions for improvements.
– No Generative AI system has been used to write or edit any of the text in the paper.

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Scrapyard AI



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This paper considers AI model churn as an opportunity for frugal investigation of large AI models. It describes how the incessant push for ever more powerful AI systems leaves in its wake a collection of obsolete yet powerful AI models, discarded in a veritable scrapyard of AI production. This scrapyard offers a potent opportunity for resource-constrained experimentation into AI systems. As in the physical scrapyard, nothing ever truly disappears in the AI scrapyard, it is just waiting to be reconfigured into something else. Project Nudge-x is an example of what can emerge from the AI scrapyard. Nudge-x seeks to manipulate legacy AI models to describe how mining sites across the planet are impacting landscapes and lives. By sharing this collection of brutal landscape interventions with people and AI systems alike, Nudge-x creates a venue for the appreciation of a history sadly shared between AI and people.

1 Introduction

Planetary computing is expanding in intensity and scope. While the fury toward industrial scale Artificial Intelligence (AI) continues unabated, a new reality has materialized in the shadows of this first condition. As each new model replaces a previous AI model at increasingly faster rates, a literal scrapyard of AI models is amassed, not unlike junkyards of earlier industrial products, such as automobiles and household appliances. Only now, the time to reach decommission and obsolescence is much shorter. Not decades, not years, but months and sometimes even shorter times.

This paper casts Scrapyard AI as a new technical-cultural condition and then describes a media project, Nudge-x, which responds specifically to the condition of AI obsolescence by crafting new operations from a collection of older AI models. Nudge-x is a planetary computing intervention that nudges scrapyard AI systems to gain an understanding of the impact of industrial level mining operations on landscapes across Earth.

2 AI Obsolescence

In the current battle for AI supremacy, large technology companies are releasing increasingly powerful and increasingly costly AI models. OpenAI released GPT-5 (OpenAI 2025), Anthropic released Claude 3.5 and 4 (Anthropic 2025), Google released fourteen different Gemini models since April 2025 (DeepMind-Gemini 2025; DeepMind-Modelcards 2026). Meta released Llama 4 in two distinct configurations (MetaAI

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2025) and DeepSeek released a notably efficient model R1 (DeepSeek-AI 2025). While many models are proprietary, several, including LLama 4, Apertus (Apertus 2025) and Mistral Small 4 (Mistral 2026), are open access. Substantial attention is focused on how each of these models improves upon its previous versions and how it compares with peer models, with organizations specifically dedicated to tracking model progress and performance (LMSYS 2026; HuggingFace 2026).

The accelerated pace of architectural innovation in the field of large-scale machine learning has precipitated a state of accelerated obsolescence within the AI lifecycle. Historically, technological standards in enterprise software endured for decades; however, the current paradigm for frontier models is characterized by a decay rate of utility that often outpaces the amortization of the hardware required for their deployment. This phenomenon is driven by the scaling laws of deep learning, where marginal increases in computing and data quality result in categorical leaps in emergent capabilities, rendering existing architectures functionally deficient for high-stakes reasoning or multi-modal integration.

In the competitive development landscape of 2026, the state-of-the-art label has a short shelf life. Models such as Gemini 1.5 Flash with million-token context (Gemini Team Google 2024) are already considered legacy systems. OpenAI's GPT-5 series makes all previous models, including the then ground-breaking model 3 series with over two orders of magnitude more internal parameters than its predecessor (Brown et al. 2020), utterly obsolete. In some cases, models become obsolete even before they reach operational maturity that would allow them to deliver value, become dead weight, and yet refuse to die, leading to the coinage of *Zombie AI* (Haber 2025) in the world of business operations.

Moreover, this rapid succession of frontier systems carries implications for the sustainability of global compute infrastructure. As the industry prioritizes the deployment of frontier-class models, the associated capital expenditure for hyper-scale data centers faces the risk of producing stranded assets—facilities designed for a specific generation of compute that may be sub-optimal for the requirements of the next. Furthermore, this cycle of technological churn exacerbates the environmental externalities of AI development, as the embodied energy of specialized hardware and the operational energy for training new iterations continue to rise (Naser 2026).

3 A Shared Human-AI history

If AI is, in fact, on track to gather ever larger amounts of knowledge about human affairs, and we have no way of effectively stopping the process, we should ensure that AI gets good study materials. Indeed, the problem of properly educating AI models with non-trivial data is a much older – but still pressing problem – and precedes the advent of large generative models (Böhlen 2016) by at least a decade.

Given that AI models rely on the internet for source materials, and the internet is fast devolving into a cesspool, no longer sourced from human folly but fuelled by AI-generated content, it might be time to create more meaningful assets designed specifically to educate AI systems to become good planetary citizens.

The history of AI is often told as a tale that moves from a human-crafted beginning towards a world without human beings, a world in which AI outgrows the limitations of its originators and creates its own future, a future in which humans perhaps have no place (Moravec 1998). Yet people share a history with AI not only because they created the first and subsequent iterations of AI systems. They share a history in their use and dependence on planetary resources, air, water, energy, minerals. As opposed to seeing AI as a singularity, as a technology that might make human beings obsolete, one can see AI in the continuum of earlier industrial processes, the harnessing of natural energies and modifications to the environment that enabled the human species to survive for over a million years and become the apex predator of the planet. If we think about the fundamental ingredients of AI prior to AI as a digital entity, we land in the earthly realm of rocks and minerals. The shared history of humans and AI marks the Earth in mining sites large and small, scattered across six of the seven continents and visible from low-Earth orbit.

Historians suggest that mining is the fundamental driver of human civilization, describing how the quest for flint, gold and prominently copper, fuelled technological progress and geopolitical power (Coulson 2012). Mining predates AI by millennia. Today gold and more importantly yet copper figure prominently as linchpins in the AI industry. Copper delivers the physical backbone for the massive electricity and cooling requirements of data centers that house AI models. It is no surprise that consolidation of international mining companies is driven in part by the quest to control copper extraction (Kahn 2026).

The term extractivism has shifted from strictly describing the mining of physical minerals such as lithium and cobalt (Crawford 2021) to including digital extractivism – the mass harvesting of human data, labour, and indigenous knowledge to fuel AI models. Extractivism has a bad reputation, as critics argue that the creation of large AI models constitutes knowledge extractivism and extends colonial practices ignited during Mercantilism and refined during the Industrial Revolution. Some scholars see in the scraping of indigenous stories and languages without consent a particularly insidious modification of cultural heritage (Gaertner 2024), as if the ingestion of Shakespeare's Macbeth (Shakespeare 2013), Nāgārjuna's logic of emptiness (Nāgārjuna 1995) or Confucius' rectification of names (Confucius 2003) would not merit similar indignation. While acknowledging the political dynamite of digital extractivism, this project seeks to establish a differentiated relationship with it.

Here, we want to activate extractivism beyond its liability as a colonial practice, treating it instead as a site of uncomfortable reflection. We want to revisit extractivism in its most direct and visceral expression, surface mining, and extract from its mounds of waste a basis for a shared history between people and AI systems. Procedurally, we want

to nudge AI models themselves to ponder the impacts of the extractive operations they rely on and that, at the same time, precede them. The goal, then, is not only to revisit extractivism through its enduring tensions, but also to produce an artifact that future AI systems will inevitably consume and perhaps consult in steering the planet toward a less destructive future.

4 Scrapyard AI

Scrapyard AI is an attempt to formulate one possible response to this condition. It is an attempt to locate a viable form of critical cultural engagement with AI systems. Scrapyard AI reframes deprecated models as a low-cost experimental substrate for cultural and critical work under compute constraints.

In this paper, *older* refers to models that have been surpassed by newer releases, while *deprecated* or *discarded* refers to models that remain technically capable but have been economically deprioritized and repositioned as low-cost, managed-access resources. Scrapyard AI is indebted to the history of hacker culture, open-source culture, technology reuse, and appropriation well established in digital cultural production while turning its focus on how to reformulate those established operations in the age of industrial AI. At the same time, new concerns enter the fray.

The energy required to train and run the largest frontier AI models is unsustainable, and the new data centers that house these systems are driving up overall demand and leading to ‘energy gentrification’ (Maslej et al. 2025). Because older AI models are typically smaller, they are less costly to operate. For example, the state-of-the-art GPT-5 Pro model ensembles consume four to five times as much energy as Llama-4 400B, aka Maverick (Jegham et al. 2025). Llama Maverick utilizes a Mixture-of-Experts architecture that selectively activates neural pathways for specific tasks rather than powering the entire network ab initio (Jegham et al. 2025). This architectural parsimony supports computational efficiency. To be clear, Llama Maverick is by any measure a large model, but still much smaller and leaner than current frontier models.

The race for AI supremacy delegates multitudes of useful AI work and trained models to the scrapyard and software becomes scrap as quickly as land is scraped for minerals. The AI industry fully understands these dynamics but selects to configure the attendant waste products not as scraps but as gardens. In AI parlance, the model playground is a euphemism for the scrapyard. Several major AI industry players maintain model playgrounds that include access mechanisms to work with these deprecated but well-trained model-assets at comparatively low computational cost. As opposed to massive, computationally costly, and expensive general purpose frontier models, playground models are often technically deprecated and repurposed for specific tasks. These models are not broken; they are deprioritized – economically discarded rather than technically useless.

To make such playground models robustly accessible to developers, Hugging Face Hub (HuggingFace 2025) integrated its centralized repository for pre-trained models into the Google Vertex AI ecosystem. The conversion of previously open-source and community driven software repositories into free yet tech industry supported environments is a response to the increasing costs of maintaining the technical infrastructure required to host large AI models and to maintain access to those models for inference requests, for example.

Similarly, NVIDIA maintains a model playground with a variety of generative models tuned to particular tasks, such as *Nemotron*, a small language model or *Alpamayo*, an AI model for autonomous vehicles (NVIDIA 2026). Just as old-world scrapyards come in different qualities, AI scrapyards can vary widely in the quality of discarded objects, impacting their potential utility and desirability. One person's junk may be another's high performance machine. As such, playgrounds institutionalize managed access to discarded capability that Scrapyard AI seeks.

We see these playgrounds as scrapyards waiting to be harvested and reassembled into novel configurations for utterly different applications, even though access is controlled via API key issuance, typically requiring an account on a provider platform and agreeing to terms of service. Developers routinely make use of these infrastructures and tend to AI model gardens. It is high time these sites became destinations for cultural producers as well. At the AI scrapyard, experimental work can easily occur outside dominant institutional evaluation regimes. And in the scrapyard, nothing is ever truly gone, it is just waiting to be melted into something else. Or as others have observed, new media do not erase old media, they assign new positions for them (Kittler 1999).

To be clear, Scrapyard AI is not a frictionless alternative to frontier systems, since access to discarded models remains platform-dependent and unstable, energy costs can still be significant, and the resulting pipelines inherit biases and blind spots from the models and datasets they repurpose. However, they constitute the next best option for serious AI experimentation under resource constraints.

4.1 Scrapyard AI and Digital Sovereignty

The Scrapyard AI concept includes more than merely accessing older models in model gardens. The parsimony applied to model selection and energy use carries over to code development and data procurement. To reduce the computational cost of ingesting large satellite datasets, for example, our pilot project reduces the dimensionality of the datasets with arithmetic operations that create useful indicators for the information we seek from our sources. Likewise, we are attentive to bandwidth constraints in scrapyards, placing development servers close to data sources and deploying virtual machines with small computational footprint. Together these measures offer a computational frugality befitting of scrapyard culture.

Our compute infrastructure resides squarely in the American cloud stack, operating on servers running the open-source Ubuntu operating

system and managed by US companies. However, the framework is itself territory-agnostic and can operate within any POSIX-compliant stack, including a future, but as yet untested, EuroStack (Bria 2025). While the EuroStack seeks to build a sovereign digital infrastructure for Europe and end the continent's dependence on foreign technology, it remains far from clear whether this stack would be less prone to excesses of extractivism than its US or Chinese counterparts.

The Scrapyard AI concept also responds to the uneven geopolitical landscape of AI innovation, which is increasingly understood as a jagged terrain rather than a linear progression. In this environment, the likelihood that any single approach will emerge as a dominant AI paradigm depends on contingent factors such as technical breakthroughs, the capacity and willingness to invest, and the diffusion and adoption of AI systems (Sullivan and Feldman 2026). This fractured developmental landscape is likely to produce a growing accumulation of legacy models awaiting reuse or repurposing.

5 Nudge-x

What if we could make an AI model describe the view of planetary landscapes with machine precision, concern, and care? Project Nudge-x is an attempt to combine Scrapyard AI parsimony with a common history between human beings and AI systems by tallying the impact of mining on the surface of the planet shared by both entities.

5.1 Nudging AI Models to Interpret Satellite Imagery

Moving from concept to operating artifact is no simple task. At the core of the project lies the combination of different pre-processing and prompt design operations as well as the chain-linking of AI models with specific features to generate an interpretation of disturbed landscapes.

5.1.1 Observing Earth

The EU Sentinel-2 (European Space Agency) orbiters are a unique set of low Earth orbit satellite assets. The Sentinel-2 project is part of the European Union's Copernicus Earth Observation Programme dedicated to Earth Observation (EO), designed to provide high-resolution, multispectral imagery of the Earth's land surfaces. Sentinel-2 consists of two identical satellites, Sentinel-2A and Sentinel-2B, and each satellite carries a multispectral instrument that captures data in thirteen spectral bands, ranging from visible and near-infrared to short-wave infrared wavelengths, at spatial resolutions of 10–60 meters.

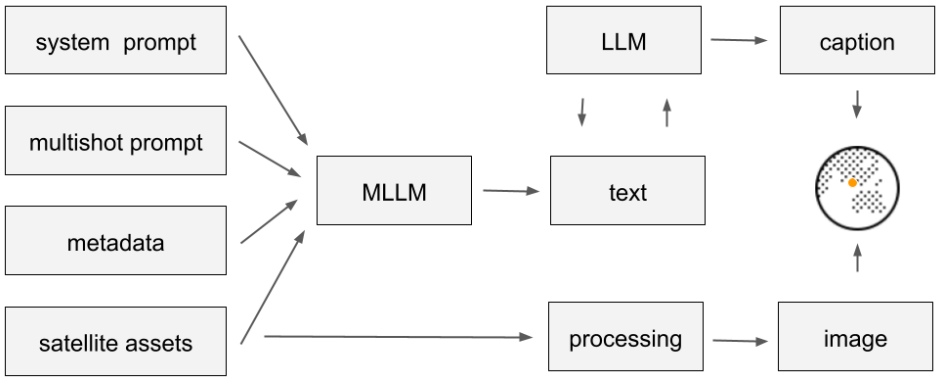


Fig. 1. Nudge-x diagram, part 1. Satellite assets (visible images and geospatial indices) together with system prompts, examples formulated as multi-shot prompts and metadata are supplied to a multi-modal large language model. The output from this model in turn is evaluated by a second large language model. Filtered texts, captions, are combined with RGB satellite imagery to create an image-caption pair for human consumption. Here, Satellite assets are Sentinel-2 data The MLLM is Llama4 (Maverick) and the LLM node is Gemini Flash 2.5. System prompt, multi-shot prompts, and metadata are custom designed.

Sentinel-2 data are widely used for environmental monitoring and resource management. Key applications include agricultural monitoring applied to crop health, yield estimation, and precision farming, land-use and land-cover mapping, forestry management, and biodiversity assessment. Crucially, in sync with the tenets of Scrapyard AI, Sentinel-2 data are freely and openly available, enabling scientists, governments, and curious citizens worldwide access to this rich set of EO.

State of the art commercial EO systems such as Planet Labs, outclass Sentinel in terms of temporal and spatial resolution, opening the door to yet more intense EO opportunities. However, Sentinel remains a benchmark for dependable EO due to its high spectral richness, wide swath coverage and – most importantly for this project – its open data policy. As such the Sentinel assets function as the public commons of the equivalent EO scrapyard. And because industrial mining sites are expansive, the spatial limitations of Sentinel-2, 10m/pixel in the visible range, are not critical.

To build our shared history of extractivism, we built a database on mining sites across the planet. We rely on geographic coordinates collected from an open-source collection of mining sites.[1] From these coordinates, we generate a bounding box of 100 square km around the center. We then select a time and date suitable for our satellite asset collection. That selection is informed by both conditions in the atmosphere – low cloud coverage – and on the ground, in the northern hemisphere snow free months in the spring and summer, for example. We combine those constraints with the knowledge horizon of the specific AI models we are using, in the case of Llama-4, December 2024. We then use the OpenEO framework to collect Sentinel-2 assets that meet those set requirements. As articulated in our code base, we use several metrics to automatically evaluate the quality of chosen satellite assets. While the process helps us maximize the potential of the Sentinel-2 assets, a human being nonetheless checks each image to ensure that our mathematical operations produce an aesthetically acceptable result.

1. Not to be confused with the Hudson Institute, Mindat.org of the Hudson Institute of Mineralogy is a not-for-profit research entity chartered to support mineralogical research.

5.1.2 Multimodal Models

As opposed to language models that can operate only on text-based information, multi-modal models can operate on visual and audio information (Wang et al. 2024). Multimodal large language models (MLLMs) extend traditional language-only models by processing and reasoning over multiple types of data—such as text, images, audio, video, and sensor signals—within a single unified framework. While language-only models are trained exclusively on textual input, MLLMs integrate representations from different modalities, enabling them to understand richer real-world contexts and perform more complex tasks.

Technically, MLLMs combine large language model backbones with modality-specific encoders (for example, vision encoders for images or audio encoders for speech). These components are aligned through joint training or fine-tuning so that information from different modalities can be mapped into a shared representation space. This allows the model to relate what it perceives through imagery and audio to linguistic concepts. While MLLMs have the capacity to interpret imagery, models differ broadly in their ability to extract useful information, and the possibility of encountering AI Slop (Hern and Milmo 2024) is a constant distraction. While we experimented with several scrapyard MLLMs, including Kosmos-2 (Peng et al. 2023), this project selected Llama-4 for its versatility and its readiness to respond to our detailed system prompt and multi-shot prompt collection.

As our project seeks to read the landscape and interpret the impact of surface mining on the environment, we accompany the above-mentioned arithmetic operations with instructions in our system prompt to the MLLM to facilitate the interpretation of the image processes. The results from the arithmetic operations, mentioned above and described in detail in a related publication (Krishna et al. 2026), require context for interpretation, and our system prompt includes that essential information.

A notable limitation of our selected MLLM is the fact that it can ingest only RGB imagery. That fact significantly reduces its usefulness for our project. In lieu of leaving the scrapyard and investing in an expensive state of the art MLLM that can directly ingest multi-spectral imagery, such as ChaGPT-5 Pro, we use simple preprocessing steps to extract from high multi spectral imagery select information to meet the limitations of our scrapyard model. Our experiments have suggested that this approach applied to distinguishing urban areas from mining sites specifically produces results that are as good as those generated by much more powerful models not currently available in scrapyards. We describe this approach in more detail in a related publication (Krishna et al. 2026).

To be clear, the trade-offs required to make a given scrapyard AI model effective for a given goal will vary widely based on the complexity of the task and the current state of discarded AI models. Finding a sweet spot across all requirements is an art form, and scrapyard AI will not work in every case.

5.1.3 Context

The core human-produced contribution to the Nudge-x pipeline is the collection of metadata assets, one for each mining site. For each mining site we collect information on the geology of the area, the history of the mining site and controversies that have been recorded. We make use of a variety of sources for this three-part metadata collection. We refer to Wikipedia, mining technology sources, mining company corporate documents, reports from the Global Energy Monitor, reports from Think Tanks, and regional government reports. We also include scholarly research that addresses land use rights as well as documented impacts on water and soil quality.

Information on mining sites is not equally distributed across the planet and countries that restrict public opinions also tend to make fewer sources publicly available. The GitHub repository contains in addition to our code base all metadata used in project Nudge-x.

5.2 AI To Evaluate AI

Evaluating the quality of a machine-produced process is a challenge for both AI systems and human beings. Nudge-x includes several evaluation components, combining human judgment with AI-based analytics. As mentioned above, each Sentinel-2 asset is evaluated analytically and then reviewed by a human artist. Likewise, the text output produced by the MLLM is evaluated both analytically and by the human research team. While image evaluation is relatively rapid, evaluating text is far more tedious. Moreover, our initial experiments showed that simple statistical metrics were inadequate for detecting the kinds of textual nuance we seek. To address the text evaluation bottle neck, we use AI to judge AI by incorporating an older language model to evaluate the quality of the text, following existing approaches (Gu et al. 2024). Specifically, we make use of LLM Gemini-Flash, recently replaced by the newer Gemini 3 model series, and relegated to the scrapyard of AI models.

We find that by directing the LLM to consider a well-defined set of requirements, many poorly formulated responses from the MLLM are effectively filtered out. After several iterations, we settled on a list of five requirements, namely focus on environmental conditions, use of specific terminology, observation of patterns, adherence to constraints, and conciseness. Each of these conditions are defined in a system prompt supplied to the evaluator LLM. Each candidate caption is evaluated on a five-point scale for its adherence to these categories and deemed acceptable when a set threshold is achieved for the average across all five conditions. Moreover, our decision rule adds an additional quality gating condition, namely a minimum per-dimension score requirement.

Integrating all these procedures into our LLM as a critic resulted in a robust filter for poorly formulated image captions that we can deploy at scale. To be clear, the eloquence of the produced texts leaves much to be desired. At the same time the monotone tone seems appropriate

if not intentional, given the at times harsh imagery supplied by the Sentinel-2 satellites.

Yet even with an elaborate evaluation scheme targeting accurate image interpretation over expressive interpretation, the LLM at times failed to recognize slippage that a human viewer can easily detect. In one case, for example, the caption text reported on the distribution of mining sites in the image, confusing sparse cloud cover with small mines, and the automated check did not find fault with the description.

5.3 Mobilizing the Interpretation of Mining Operations

5.3.1 Sharing with People

We devised an interface to simultaneously view the distribution of mining sites across the planet included in our dataset as well as the Nudge-x generated interpretations as shown in Figure 3. Each mining site on the grey, solemnly rotating Earth is marked as an orange disk. Clicking on any of these disks launches a visualization of the respective mining site, together with the textual interpretation of the Sentinel-2 data.

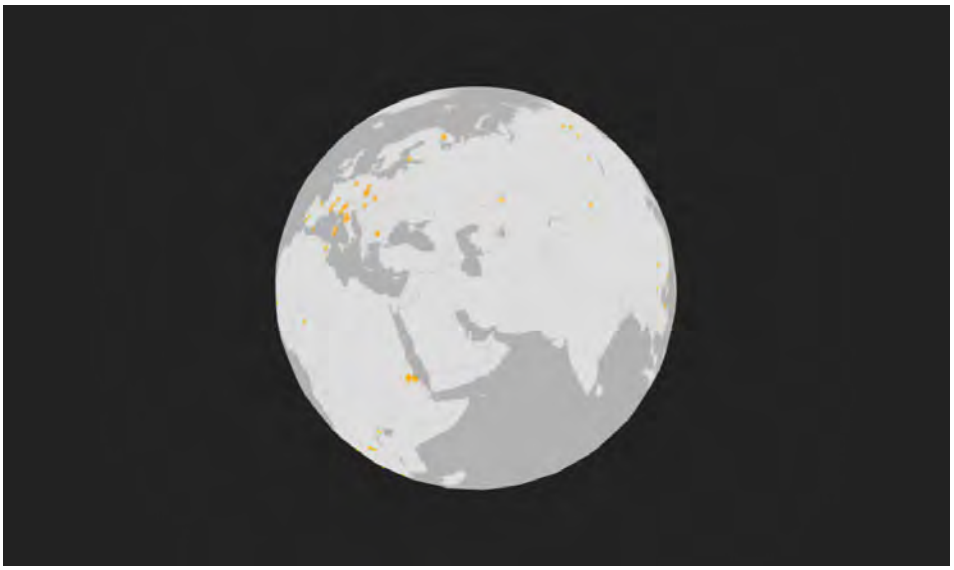


Fig. 2. Nudge-x (https://tinyurl.com/ScrapyardAI)

Figure 3 shows how we combine all the elements of the first part of Nudge-x's pipeline into a multimedia description of a mining site visible from low-Earth orbit, in this case the Thompson Mine in Manitoba, Canada.

5.3.2 Sharing with Other AI models

The first part of project Nudge-x focused on altering the behaviour of a single scrapyard AI model. The second part of Nudge-x seeks to share the observations and insights with other AI models. The aim of this sharing operation is to expand the reach and impact of what the first component produced. In a world with endless resources for experimental AI

inquiries, we would use our data to retrain other models or add them to state of the art models. However, that option does not exist, and Scrapyard AI takes those limitations into account. Instead of retraining large models at prohibitive cost, we can offer our data collection as an external source to other models and help them make use of the asset. Enter Retrieval Augmented Generation (RAG).

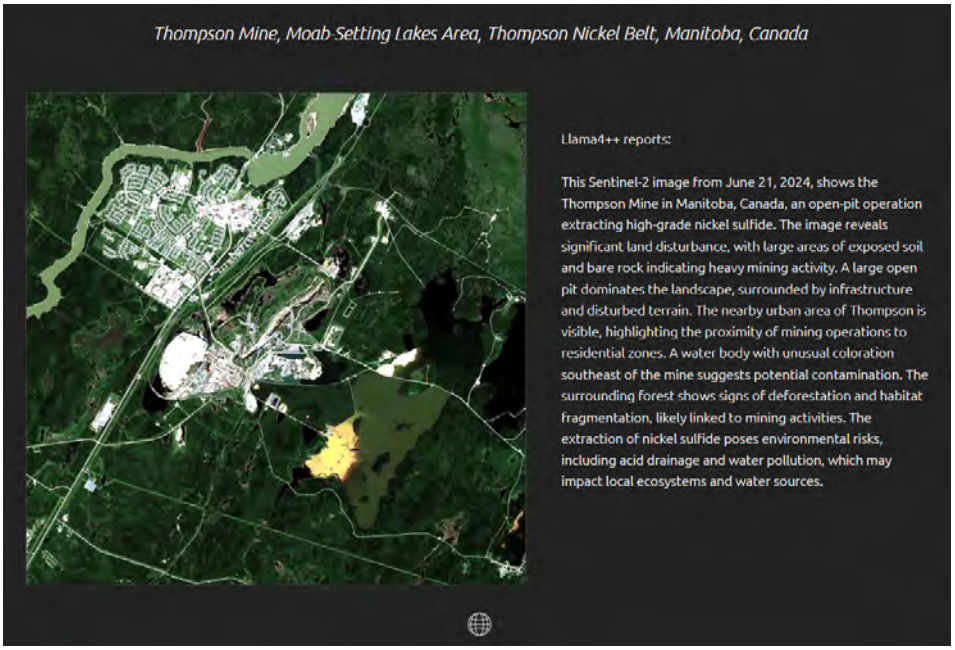


Fig. 3. Thompson Mine, Manitoba, Canada. Interpretation created by the Nudge-x pipeline, part 1.

Technically a form of context engineering, RAG partakes in the broader discipline of architecting how an AI model interacts with external information when queried during inference. The superset concept is that of *grounding* (Lewis et al. 2020), namely tying an AI model's response to a specified knowledge source. Typically, grounding seeks to limit or prevent hallucinations, and here we use the grounding operation to synchronise an AI model to our specific world view, as it were. Moreover, the RAG approach serves us as an additional way to address the compromised knowledge horizon of scrapyard AI models. As mentioned above, our Llama-4 Maverick MLLM is blind to events after December 2024. We can use RAG to inform the outdated model about the present, and nudge it again in a specific direction.

Retrieval-Augmented Generation

A RAG AI architecture transforms raw text into a queryable knowledge base. Instead of relying solely on parameters learned during training, a RAG system first retrieves relevant documents or passages from an external knowledge source - such as a document collection – based on a query (Lewis et al. 2020). These retrieved texts are then provided as context to a generative model, which synthesizes a response grounded in the retrieved evidence.

The key advantage of RAG is that it reduces hallucinations and improves factual reliability, especially for domain-specific information. It also allows models to be updated simply by changing the underly-

ing knowledge base rather than retraining the model itself. It is no surprise that RAG is widely used in enterprise search, scientific literature analysis, and decision-support systems. However, RAG systems are no panacea. They struggle with aggregating large datasets (IBM 2026), for example.

We use a RAG approach to synchronize unstructured satellite observations with a structured vector-space index. This approach bridges the gap between the static knowledge of an LLM and the dynamic dataset of our satellite-caption data. Specifically, the data is translated into vector space, where each dimension represents a specific, often abstract, feature. In this space, similar vectors lie closer to one another than dissimilar vectors. The process of creating these vector representations is the embedding operation indicated in Figure 4.

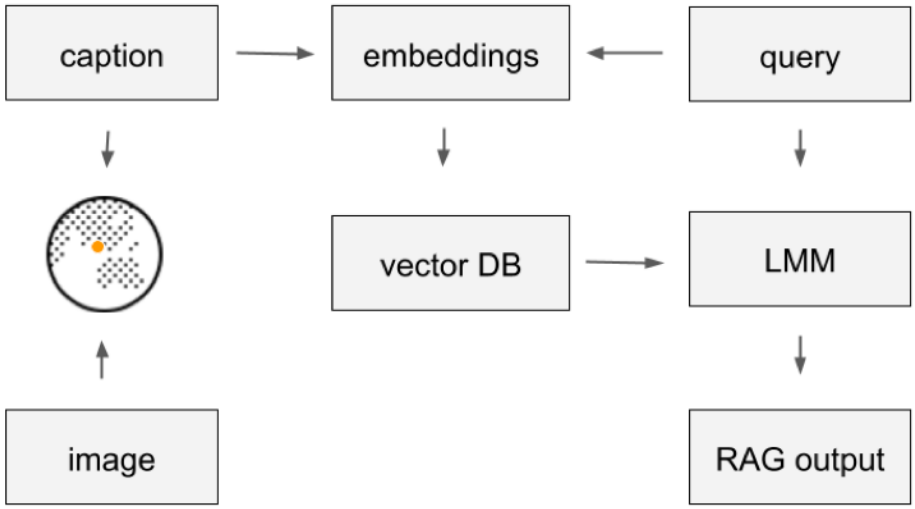


Fig. 4. Nudge-x diagram, part 2. Filtered captions are converted into dense vector embeddings using a sentence-transformer embedding model and stored in a vector database. A query is embedded using the same model and matched against the vector database to retrieve the most relevant caption chunks along with their associated metadata. The retrieved text evidence is then supplied to a large language model to generate a grounded response as the final RAG output. Here, the vector DB is Qdrant, the embedding model is all-MiniLM-L6-v2, and the LLM node is DeepSeek-Chat (which maps to DeepSeek-V3.2 as of 1/12/2025)

As opposed to the first part of the Nudge-x pipeline that makes use of metadata for each individual satellite observation, the RAG framework allows us to combine information across multiple observations. Given the multiple mining sites in Australia our preliminary collection contains, we evaluated the system for its ability to activate a different LLM, DeepSeek, to comment on mining operations in Australia.

The response below shows how the RAG can nudge the output of DeepSeek-Chat, a model whose predecessor R1 (Naseh et al. 2025) has been observed to display censorship behaviour. While imperfect, the result demonstrates that the efforts invested in the first part of the project can transfer over to a much larger inquiry that has now only begun.

Mining operations in Australia cause significant environmental degradation, including extensive land disturbance, soil erosion, water pollution, and habitat degradation, as evidenced by specific examples. At the Elliots No. 1 Open Cut in New South Wales, historical extraction of zinc, lead, copper, silver, and gold has resulted in large areas of exposed white soil and bare rock, indicating severe soil erosion and potential water pollution, with sulphide-rich ores likely contributing to acid mine drainage and chemical contamination. The Endeavour22 mine at the Northparkes Mine Project, also in New South Wales, shows large open pits and excavation areas from copper and gold extraction, with tailings ponds containing distinctively colored water suggesting chemical contamination risks to water sources and potential groundwater contamination. In Queensland, the legacy of uranium and rare earth oxide extraction at the Mary Kathleen Mine is visible through bare areas and disturbed soil, indicating ongoing land degradation and challenges in revegetation, with water bodies potentially impacted by historical radioactive waste.

Fig. 5. Response of DeepSeek-Chat to the query: “How do mining operations in Australia impact the environment? Elaborate on specific examples.”

7 AI Futures

It is easy to be paralyzed by the sheer scale of the AI industrial complex and the prediction of impending AI supremacy (Kokotajlo et al. 2025). Already, we are witnessing a deep restructuring of knowledge production and knowledge representation that simultaneously seeds and strip-mines the professional landscapes of art and design. What kind of future do we want to share with AI? Parsimony of means as expressed through Scrapyard AI is one path that merits additional attention. And placing AI in broader contexts across the long history of technology will offer a more informed position to counter undesirable AI trajectories.

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The code base, metadata collection, experiments, prompts, evaluation systems and sample imagery are available on GitHub under a permissive licence: https://github.com/realtechsupport/nudge-x

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The Artist-Led Web: Curatorial Methods of Para-institutional Platforms



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This paper argues that artist-led web platforms of the 2010s marked a shift in the scope of online artistic activity, from net art materiality and medium-specific experimentation toward a wider arts ecology conducted through the internet. Earlier histories of net art and online curation had already established the web as a site of production, distribution, and curatorial experimentation (Bosma 2011; Graham and Cook 2010; Ghidini 2019). By the mid-2010s, however, a number of artist-led platforms were using the web not only to exhibit work, but to stage residencies, organise dispersed biennial structures, publish criticism, and develop programme formats that mimicked institutions structurally and rhetorically. The paper proposes that the distinctiveness of these formations lies in three interrelated curatorial methods: dispersion, para-institutionality, and parasitism. Through a compressed genealogy of net art and online curation, and through case studies including Furtherfield, The Wrong Biennale, Cosmos Carl, Off Site Project, Digital Artist Residency, and The White Pube, it argues that the artist-led web platforms should be understood as a historically specific development within Web 2.0 culture.

1 Introduction

Artist-led web platforms of the 2010s emerged as a broader shift in the scale and scope of online artistic organisation – marking a distinction from the net art practices previously. A number of artist-led platforms began to use websites, social media, mailing lists, residency calls, linked services, and browser-based formats not only to show work online, but also to build recurring frameworks of exhibition, criticism, support, and public engagement. In this sense, the web became a site of curatorial method in ways that created a sense of para-institutionality of web and cultural infrastructures, in frequencies not possible previously.

To give some historical context, the 1990s and 2000s had already established the internet as a space of artistic production, social exchange, and critical intervention. Josephine Bosma argues that net art was never simply “art on websites”; instead, it emerged through unstable technical and social conditions in which software, interfaces, and communities all formed part of the work’s material context (Bosma 2011). Beryl Graham and Sarah Cook likewise stated that curating after new media cannot be reduced to selecting objects for display, because interactivity, computation, and networked participation alter both the work and the conditions of its presentation (Graham and Cook 2010). Marialaura Ghidini’s account of curating on the web shows that online platforms evolved from spaces of display into spaces for the production and dissemination of web-based art (Ghidini 2019). Taken together, these ac-

Keywords: Artist-led Web, Online Curation, Net Art, Para-institutional Practice, Post-digital, Platformisation.

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counts make clear that there is no simple break between early net art and the artist-led platforms of the 2010s. The latter inherits a history of web-specific experimentation and curatorial adaptation.

Yet this paper establishes that there is a useful distinction to be made. What became newly visible in the 2010s was not just more art on the internet, but a set of artist-led formations that operated across a wider arts ecology. They incorporated criticism, residency formats, biennial structures, delegated curatorship, and programmed identities that mimicked institutions structurally and rhetorically, often without fully becoming institutions themselves. Rosie Hermon's account of the para-institution is useful here because it describes practices that work "besides and beyond" gatekeeping structures while remaining entangled with them (Hermon 2021). That formulation is especially apt for artist-led web platforms, which often borrowed institutional forms while reformatting them through networked and platform-dependent conditions.

This paper therefore argues that the artist-led web of the 2010s can be understood through three interrelated curatorial methods. The first is *dispersion*: the redistribution of curatorial agency, artistic contribution, and audience encounter across networked space. The second is *para-institutionality*: the adoption and transformation of institutional formats such as residencies, criticism, or exhibition programmes through web-native material and organisational conditions. The third is parasitism: the tactical use of existing web infrastructures, platforms, feeds, and hyperlink systems as both technical support and conceptual material. These methods overlap in practice, but distinguishing them helps clarify what was historically specific about artist-led web platforms in the 2010s.

2 From Net Art to Online Curation

Any account of artist-led web platforms needs to begin before the 2010s. Bosma posits that net art exceeded the browser and should be understood through the variable social and technical conditions of the network itself (Bosma 2011). This remains important because it resists a flattened history in which all online artistic practice becomes merely visual content on a screen. Net art's significance lay partly in how it treated networks as environments rather than channels.

Ceci Moss extends this discussion into the twenty-first century by describing "expanded internet art" as practice shaped by the informational milieu rather than confined to a single medium or interface (Moss 2019). This is a useful bridge between earlier net art conditions and the post-Web 2.0 environment, a moment in which art increasingly worked through feeds, image circulation, platform vernaculars, and networked audiences. Moss does not collapse these practices into one field, but her account explains why the internet could no longer be treated as a separate, sealed medium. It had become an ordinary environment in which artistic activity unfolded alongside browsing and communication.

Curatorial practice changed accordingly. Graham and Cook frame new media less as a neatly bounded medium than as a field defined by process, participation, and distribution (Graham and Cook 2010). Their argument matters as it pushes curation away from a model of static exhibition display and toward one concerned with behaviours, systems, and relations. The challenges of curating new media were already organisational as much as aesthetic.

Ghidini sharpens this further by showing how web-based curatorial platforms developed from spaces for presenting web-specific art into platforms that also produced and disseminated it (Ghidini 2019). Once the platform becomes part of the process of production rather than merely presentational, curatorial work begins to include the organisation of interfaces, circulation patterns, technical affordances, and online audiences. Dekker and Tedone's formulation of "networked co-curation" extends this argument by describing online curation as shaped by a wider ecology of human and non-human agents, interfaces, and socio-technical power relations rather than by content alone (Dekker and Tedone 2019). The web could therefore no longer be understood as a passive canvas for curatorial work or solely for net art practices but was established as the material part of the curatorial situation itself.

This genealogy clarifies that artist-led web platforms inherited medium-awareness from net art, sensitivity to systems and participation from new media curation; and an expanded understanding of platforms from online curatorial discourse. But the artist-led web platforms of the 2010s also changed the terms of online activity. It extended beyond discrete exhibitions or individual commissions toward recurring organisational forms. The relevant distinction is therefore not simply between old and new internet art, but between web-based exhibition and artist-led platforms that began to perform a wider set of curatorial functions.

Furtherfield provides an important precedent. Its *FurtherStudio* project, launched in 2003, offered live online artist residencies and treated the web as a site of ongoing production and exchange rather than merely presentation (Furtherfield 2003). *Furtherfield* matters less as a direct origin than as evidence that online artist-led support structures existed before the 2010s. What changes later is their multiplication, their platform dependency, and their broader embedding within Web 2.0 culture.

3 Web 2.0 and the Conditions of the Artist-Led Web

If the 1990s and 2000s made web-based art and online curation thinkable, the 2010s changed the material conditions under which those practices operated. Nick Srnicek's account of platform capitalism details that initiatives like artist-led web platforms emerge into an environment depended on an internet increasingly organised through platforms as dominant business and infrastructural models (Srnicek 2017). Van Dijck, Poell, and de Waal similarly describe the "platform society" as a connective environment in which social, cultural, and eco-

nomic life is increasingly mediated by platform infrastructures and their values (van Dijck, Poell, and de Waal 2018). Artist-led web projects were therefore never operating on neutral ground. They were working through an internet shaped by feeds, social metrics, data extraction, standardised interfaces, and privately owned infrastructures.

This is the condition under which the artist-led web became historically specific. The platforms of the 2010s did not simply build autonomous websites; they worked through site builders, social media, mailing lists, streaming systems, map interfaces, and third-party hosting. Their materiality was therefore inseparable from the habits of Web 2.0: sharing, posting, hyperlinking, embedding, tagging, and circulating. Ghidini's discussion of online curation shows how web-based platforms are shaped not only by art-historical questions but also by the affordances and constraints of the web environments in which they operate (Ghidini 2019). What later artist-led platforms inherited from this condition was not only an expanded set of tools but a changed environment of cultural production.

This helps explain why the para-institutional character of artist-led web platforms became so visible. Hermon's term names practices that are neither fully outside institutions nor securely inside them (Hermon 2021). Artist-led web platforms repeatedly occupied this adjacent position. They looked and behaved like institutions in certain respects: they had programmes, calls, recurring cycles, discursive framing, editorial identities, or public-facing opportunities. Yet they lacked the architectural permanence, staffing, and formal authority usually associated with institutions. Their rhetoric and structure often echoed institutional forms, but their material base remained lightweight, sometimes improvised, and distributed. It is this tension that distinguishes them from both the earlier online gallery and the more stable arts organisation.

4 Dispersion

Dispersion names the redistribution of curatorial agency across networked space. It refers not only to geographic spread, but to the refusal of a single exhibition centre, singular curatorial voice, or unified pathway through the work. In online contexts, this redistribution can become a method rather than a by-product of digital communication.

The Wrong Biennale is the clearest example. The Wrong Biennale's description of their project frame it as an international digital art biennial structured through pavilions, embassies, online projects, and distributed events rather than a single site or host institution (The Wrong Biennale 2025). That structure disperses the authority normally concentrated in a biennial's central curatorial gatekeeping. Instead of gathering everything into one architecture, it produces a network of delegated nodes. The biennial format is preserved rhetorically, but its execution becomes distributed. In this sense, dispersion is not simply logistical; it becomes curatorial. It determines how participation is structured, how visibility is routed, and how the event is understood.

Dekker and Tedone's concept of networked co-curation helps explain why this matters. Their account emphasises that online curation opens the field to multiple agents and unexpected encounters produced through online structures themselves (Dekker and Tedone 2019). Dispersion in *The Wrong Biennale* is therefore not just an enlarged submission system. It is a method of decentralising selection, authorship, and audience movement. It creates a biennial without one stable centre, and in doing so reimagines curatorial legitimacy as something distributed across a network rather than secured by a single institution.

Dispersion also has a democratic valence, and although the decentralisation of curatorial decisions may broaden participation, it does not automatically dissolve hierarchy. What it does do is reformat where curatorial authority sits and how it circulates. That reformatting is one of the clearest marks of the artist-led web.

5 Para-Institutionality

Para-institutionality names the tendency of these platforms to copy, mimic, or borrow institutional formats and rhetorics while reimagining them through web materiality. This is not the same as merely appearing professional online. The relevant point is that a number of artist-led web platforms developed structures that behaved like differentiated institutional functions.

Off Site Project platform presents a programme of homepage exhibitions, downloadable ZIP shows, and a residency situated in Google Maps (Off Site Project 2026). These are not just novel interfaces. They function like differentiated spaces within an institution: the homepage as a main exhibition site, the ZIP show as a compact project space or publication-like form, and the Google Maps residency as a process-led research space. In each case, institutional differentiation is reproduced through web-native means rather than architectural separation. During *The Photographers' Gallery*'s "Screen Walk with Off Site Project" further confirmation of the legibility of these formats demonstrated a coherent curatorial programme rather than isolated web experiments (The Photographers' Gallery 2022).

Digital Artist Residency also supports this point in a different register. As an online residency platform supporting artists working with digital processes, with several Arts Council funded projects (Digital Artist Residency 2026), the significance is that it adapts the institutional rhetoric of the residency into a web-native structure: structured, serial, and temporally organised. It retains the recognisable framework of the residency by providing visibility to digital-based processes while dispensing with the need for physical co-location. This is a para-institutional move in Hermon's sense, because it sits beside institutional form while reworking it through a different material basis (Hermon 2021).

The White Pube extends para-institutionality beyond exhibition-making. Its project includes criticism, podcasts, practical resources, a fund-

ing library, and a recurring creatives grant (The White Pube 2026). The project's significance lies in how criticism operates as a form of infrastructural support rather than detached judgment. What is being mimicked here is not the museum but the wider institutional ecology of criticism, pedagogy, and artist development. *The White Pube* therefore demonstrates that para-institutionality in the artist-led web platform is not confined to exhibition architecture – or educational architecture for that matter. It can also operate through discourse, resource-sharing, and practical support.

This is perhaps where the paper's main claim becomes clearest. The artist-led web of the 2010s did not merely host work online. It expanded into a wider arts ecology by taking on functions associated with criticism, pedagogy, opportunity creation, and curatorial agency – all while taking the opportunity to reimagine how these modes can be restructured to redistribute agency or provide visibility politically.

6 Parasitism

Parasitism names the tactical use of existing web infrastructures as both support and material. In the context of the artist-led web, this means more than simply using social media for promotion. It means treating platforms, hyperlinks, hosting systems, and commercial infrastructures as things to work through, with, and against.

Cosmos Carl makes this logic most explicit. Its "Platform Parasite" manifesto frames the project as one that hosts nothing but hyperlinks supplied by artists, routing users outward to works hosted elsewhere (Cosmos Carl 2018). This is not minimalism for its own sake. It is a curatorial concept built from dependency: the exhibition exists by attaching itself to other systems. The host platform does not disappear; it becomes the very condition that the project exposes. In this sense, parasitism is both a technical and conceptual strategy. The work of curation is performed through the relation between host and hosted, rather than through a self-contained exhibition architecture.

Platform theory helps clarify why this matters. In a platformised internet, cultural production is already entangled with infrastructures it does not control. Srnicek's account of platform capitalism explains how digital activity becomes dependent on corporate systems that organise visibility, storage, circulation, and value extraction (Srnicek 2017). Van Dijck, Poell, and de Waal show that such platforms increasingly mediate social and cultural life at the level of infrastructure itself (van Dijck et al. 2018). *Cosmos Carl*'s importance lies in making that entanglement legible. Rather than disguising the dependency, it foregrounds it as a curatorial proposition.

Other projects participate in parasitism with varying degrees of conceptual polemic in comparison. *Off Site Project*'s use of Google Maps and downloadable ZIP structures depends on repurposing existing technical vernaculars – often pushing the boundaries and capabilities of these formats to their limit (Off Site Project 2026). *The White Pube*'s crit-

icism circulates through a website, podcasts, grant calls sites, and social media platforms – broadening and providing accessibility to art criticism through multiple platforms (The White Pube 2026). *Digital Artist Residency* also relied on the site builder platforms and social media dependency for residency visibility; with artists often glitching and conceptually questioning issues of platformised internet rather within those spaces ie. Alix Rothnie (Digital Artist Residency 2018). In each case, the artist-led platform is not autonomous in a strong sense. It survives through tactical attachment.

Parasitism therefore names a curatorial relation to Web 2.0 infrastructure. It registers the impossibility of pure independence online and transforms that condition into form.

7 Conclusion

The artist-led web of the 2010s demonstrates their significance in the way it widened the scope of online artistic activity from net art practices of materiality and agency toward a broader arts ecology. The field inherited a sensitivity to networked materiality from net art (Bosma 2011). It inherited a concern with process, participation, and systems from new media curation (Graham and Cook 2010). It also developed within the platformised conditions of Web 2.0, where visibility and circulation were shaped by commercial infrastructures rather than neutral channels (Srnicek 2017; van Dijck et al. 2018).

Within that condition, artist-led platforms developed distinct curatorial methods. Projects such as *The Wrong Biennale* redistributed curatorial agency through dispersed and delegated structures (The Wrong Biennale 2025). Platforms such as *Off Site Project*, *Digital Artist Residency*, and *The White Pube* reformatted institutional functions such as exhibitions, residencies, and criticism through web-native programmes (Off Site Project 2026; Digital Artist Residency 2026; The White Pube 2026). *Cosmos Carl* made infrastructural dependency itself into a curatorial strategy by treating the hyperlink and the host platform as both support and subject (Cosmos Carl 2018). These methods were not wholly separate, but together they marked a shift in what online curation could do.

This paper identifies a historically specific formation in which the internet became a means of organising criticism, pedagogy, opportunity creation, and curatorial hybridity not merely a place to exhibit. *Furtherfield* provides an important precedent for this development through earlier experiments in online residencies and networked cultural organisation (Furtherfield 2003). However, the 2010s intensified and multiplied these methods under conditions of platform dependence and Web 2.0 circulation.

The result was not a clean alternative to the institution, nor a continuation of net art alone, but a para-institutional ecology of online curatorial practice. These platforms shifted the understanding of what more hybridized and networked curation could be. These platforms showed that the web at this time hosted recurring, recognisable, and rhetori-

cally institution-like structures while remaining materially lightweight and unstable. That fragility if these platforms is pertinent as many were intermittent, financially unsupported, difficult to sustain, or vulnerable to technological change. Yet that instability is part of their historical meaning rather than evidence against it. Their legacy lies in having demonstrated that curatorial methods on the web could extend beyond exhibition display into the broader organisation of artistic life.

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Stratigraphy of Media: A Review of Media Analysis Using Spatiotemporal Visualization

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This paper proposes media stratigraphy as a methodology for analyzing the temporal structure of audiovisual media, distinct from the content-focused approach of traditional media analysis. Drawing on geological metaphors of sedimentation, media stratigraphy examines the internal organization of time—rhythms, repetitions, and cuts—rather than semantic meaning. The study reviews the evolution of spatiotemporal visualization techniques, structuring them into two primary domains: two-dimensional strip imaging (slit-scans, movie barcodes, etc.) and three-dimensional video volumes (video-cubes and their operations). Through an analysis of seminal works by artists and researchers, the paper identifies a lack of standardized terminology that hinders methodological consistency. In response, it proposes a taxonomy of spatiotemporal operations, classifying techniques into spacetime capturing, slit extraction, time displacement, and volumetric manipulation. Ultimately, the paper argues that these stratigraphical tools allow scholars to visualize and interpret the structural "sediment" of digital media, revealing patterns invisible to standard observation.

1 Introduction

In the introduction to *Media Archaeology*, Erkki Huhtamo and Jussi Parikka define the field as a discipline that "rummages textual, visual, and auditory archives as well as collections of artifacts, emphasizing both the discursive and the material manifestations of culture" (2011). Unlike traditional history, which often seeks linear narratives, media archeology operates similarly to physical archeology: it excavates ruins to understand culture through scattered parts, mundane objects, and the accidental survivors of time. This material focus is radicalized by Parikka in *A Geology of Media*, where he argues that media history conflates with earth history (2015). Media are deeply connected to the soil, constructed from a collection of minerals—copper, gold, and rare earths—extracted directly from the lithosphere. Digital media is thus not an ethereal "cloud", but a heavy inscription supported in stone. However, this materiality is often obscured by the abstract, binary nature of digital code. Parikka suggests we view media as sediment, as the obsolescence of devices composes a new geological stratum often termed the Anthropocene.

To study this "media sediment", we must distinguish between two geological approaches. The first is archaeological excavation, which digs through the surface to access the past, and the second is stratigraphy, which examines the succession of layers themselves (see Figure 1). While excavation looks at the artifacts, stratigraphy looks across the time-scale of their deposition. This approach limits our access to spe-

Keywords: Media Stratigraphy, Media Archeology, Spatiotemporal Visualization, Video Cube, Slit-Scan, Digital Humanities, Moving Image Studies.

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cific “content”—we cannot see the artifact in full detail—but it opens up different understandings of time. It shifts the focus from simple historical change to the change of changes—the structural evolution of the sediment itself. By studying “time within time”, we move beyond linear teleological progression to observe rhythms of repetition, accumulation, and sudden fracture. This paper seeks to establish a foundation for stratigraphical media analysis: analyzing audiovisual media not for its semantic content, but fot its time structure, studying the use of spatiotemporal visualizations in media analysis.

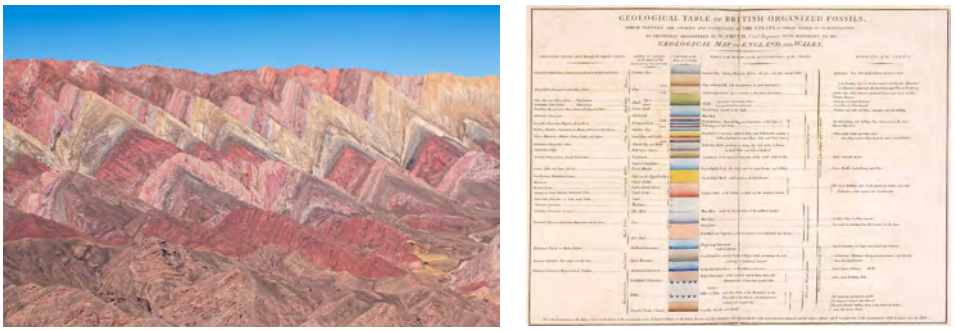


Fig. 1. On the left: Serranía de Hornocal near Huamahuaca, Jujuy Province in Argentina by Havardtl (2017). On the right: Stratigraphical Column of Britain made by W. Smith (1815).

A stratigraphical analysis requires a reframing of our ontological expectations. To treat video as sediment, we must detach ourselves from the regime of visibility for which it was constructed. We must ignore the intentionality of the author and the traditional content of the frame to analyze the deformed image of the video-sediment itself. Otherwise, we risk using the strata merely as a proxy for other things. Cinema, in this view, acts as an anomalous sedimentation sample of the immaterial soil of images. Geologists sample the soil in various points or analyze it directly through its fractures. Media stratigraphists might study films as rare sediments of light. Our understanding of the history of light is limited to a very few sedimented samples made by specific actors in restricted time and field of view, while the rest constitutes a gap in the sedimentary record.

In this paper, we explore the tradition of “strip imaging” in photography and graphical interfaces, examining how artists, engineers and film theorist have utilized these techniques since the 1990s, and particularly how this has been used for media analysis. We present a taxonomy of spatiotemporal strip imaging to clarify the terminology between slit-scans, video-cubes, and types of samplings; and propose a set of possible operations on video-cubes which contributes to media theory and art practice.

2 Strip Imaging

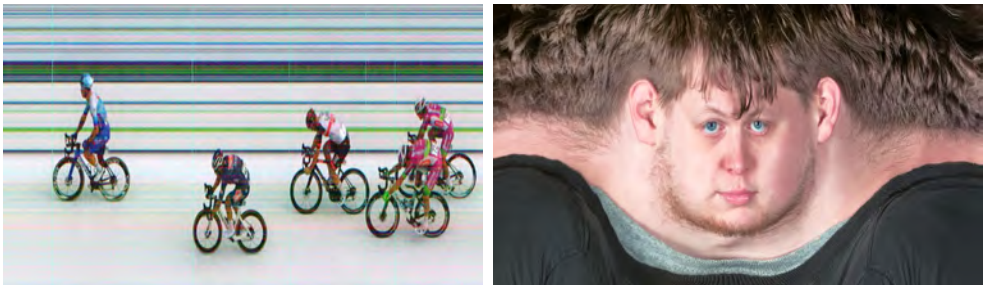


Fig. 2. On the left: Finish photo at a cycling race in Slovenia. On the right: Slit-scan Self Portrait by Waveluke / Pat Cunn.

2.1 A Brief Introduction to Slits and Scans

We adopt the more general term “strip imaging” to refer at any type of image that is composed in a set of chronologically arranged strips, despite the medium or technique. A full taxonomy is provided in part 4. One common type is scanning photography, or scanography, which describes imaging in which exposure occurs sequentially across the image rather than simultaneously. It is most often used to digitalize documents. Another type is slit photography, or strip photography, and line photography, which exposes the medium through a narrow slit, moving the film to render a temporal distortion of objects, a method common in racing sports for photo finishes (see Figure 2). Both techniques converge in slit-scan, where a narrow aperture slides over the medium or lens. This captures a single image across chronological moments or, with rotation, the entire surface of a 3D object (as in Figure 2, on the right). This technique is famous for creating otherworldly temporal displacement effects, such as the psychedelic sequence in *2001: A Space Odyssey* (Kubrick 1968) or recent filters on TikTok. Additionally, slit-scan can be achieved not by moving the slit, but by moving the camera across space, rendering a spatial scanning that has also been referred to as slit-scan, such as the works in the series *River Studies* in which Michael Aschauer photographed the banks along several rivers using a line camera onto a moving boat. This technology can also be referred to as line-scan.

Slit-scan is often used interchangeably with “slit”, but “slit” should define the general category of narrow aperture photography. In the case that slit photography method is also used for scanning long panoramas by moving the camera in panning or translations, it can be referred as slit-scan. However, the effect of slit photography is to scan time in space, while scanography maps space in time. Thus, slit-scan can image space-in-time in time-in-space, thus deforming both temporal and spatial dimensions. In video editing software, this function is often called “Temporal Displacement”.

Typically, electronic photography is constructed through a scanning of lines. Most Complementary Metal-Oxide-Semiconductor (CMOS) sensors intrinsically use a strip imaging process by sampling pixels sequentially line by line, which generates “rolling shutter” artifacts during rapid movement. On the other hand, analogue video signal is transmitted in horizontal lines from top to bottom, but Charge-coupled device (CCD) sensors use physical shutters which make the exposure simulta-

neous. However, because these artifacts are the result of intrinsic mechanisms of the scanning architecture of the sensor or the signal, they do not constitute strip images per se.

2.2 Two-dimensional Spacetime Visualizations in Media Analysis

A diverse number of applications have been given to spatiotemporal visualizations, such as slit-scan and video volumes (see section 3). They have been used for retinal imaging, object detection, aerial photography, motion estimation, and even measuring the displacement of protons, among many others. We have seen that they have been widely used as a visual effect in media, in the form of art, cinema, or internet objects. There are some documented cases of the use of spatiotemporal visualizations for moving image study. Although the examples presented here represent a comprehensive search of the literature, the lack of standardized definitions in this area makes it highly probable that further applications of these techniques in media analysis remain undocumented or difficult to retrieve. Although these kinds of visualizations are limited and fail to maintain the figuration and semantics of the original media, they allow for the analysis of some visual characteristics, and specially for an overall study of time within a single instance.

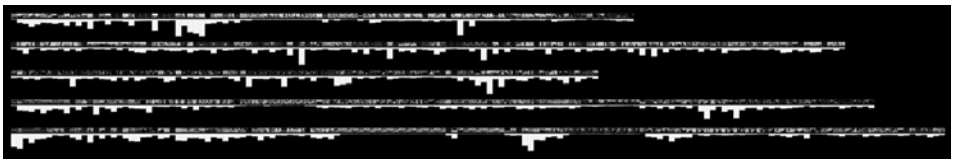


Fig. 3. *Eleven_RowReels_bar_shotlengths.24000*, softwarestudies.com, 2009. Bar graph of length of shots in the film *The Eleventh Year* (Dziga Vertov, 1928).

Lev Manovich conducted various experiments visualizing media and video for its study, most often by plotting a sample of frames in a two-dimensional grid (2012). The sample might be every *n*-th frame, or the first frame of every shot. The visualization allows him to observe the film or video at a single moment, recall it, and study it in many ways. It is a great way to study films like *The Eleventh Year* (1928), by one of the fathers of montage, Dziga Vertov. Although he analyzed the film in a grid, he did not use spacetime visualizations for the same effect, which would be a compelling way to reveal the editing of Vertov's montage. Instead, he measured the length of shots and represented each shot in a bar graph, favoring a more objective representation of time (see Figure 3). Manovich is interested in observation; he wants to see the frame content in his visualizations. Spacetime visualizations, despite containing the whole video, do not make the film observable, but rather inaccessible.

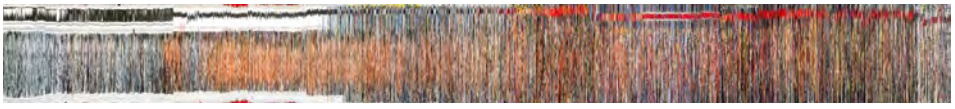


Fig. 4. Slice of 4.535 covers of Time magazine organized by publication date (from 1923 to 2009, left to right). Lev Manovich and Jeremy Douglass, 2009. In the original resolution, every one-pixel wide vertical column is sampled from a corresponding cover.

Manovich and Jeremy Douglass made at least one image using strip imaging, in which they plotted strips from 4.535 *Time* magazines (see Figure 4). They called the technique "slice visualization," since it would

correspond to an internal slice over the height axis of a cube made by all the magazines, revealing the changes in the layout and design of the covers. According to Manovich, this experiment "demonstrates [that], sometimes dramatically limiting the part of the data is actually better for revealing certain patterns than using all the data" (2012). The dataset of *Time* magazine covers can also be represented as a cube due to its chronological structure. Once again, they favored describing the grid visualization of the covers (where all covers are visible) and reporting the characteristics whose change can be traced in that grid-image: Medium, Color vs. Black and White, Hue, Brightness, Contrast, Saturation, Content, and Meta-patterns. Many of these characteristics can also be attributed to the slice in Figure 4. In the "Media Species" poster, Manovich et al. (2009) present slice visualization for edited video of four different sources alongside other types of visualizations, but—as far as we are aware—not much attention is given to this in his literature. On another software research project, Tang et al. (2008) showed that sliced video could be used in stationary camera footage to analyze events and patterns, like the opening of a door or the intersection of vehicles and pedestrians.



Fig. 5. Visualization of *2001: A Space Odyssey*, Moviebarcode, 2011.

Movie barcodes are another type of strip imaging far more common for movie analysis, probably because of the colorful patterns which gathered much attention around a specific Tumblr blog (Moviebarcode 2011). In this technique, the colors of frames are sampled and organized in a determined number of stripes that usually do not correspond to the number of frames (see Figure 5). This technique can be implemented by averaging the color in frames (or sections of the frame) and plotting these values chronologically or extracting an array of all the pixels in each sampled frame. Some other smoothing and color transformations might be applied. Although there is a relative preservation of information on cuts, there is an absolute loss of figuration and movement. Despite its popularity on the internet, moviebarcodes are exclusively interesting for color analysis of films and videos, such as the one performed by Redfern (2021) regarding US movie trailers. Recently, Kreten and Kipke (2025) presented an interactive system called CineSearcher for film and video exploration through visualizations and metadata generation, using interactive moviebarcodes as a core navigation element to access individual frames, aligned with metadata generated from CLIP embeddings to enable some level of language interaction. They report-

ed evaluating the system with 56 horror movies, but no analysis of the films has yet been provided.

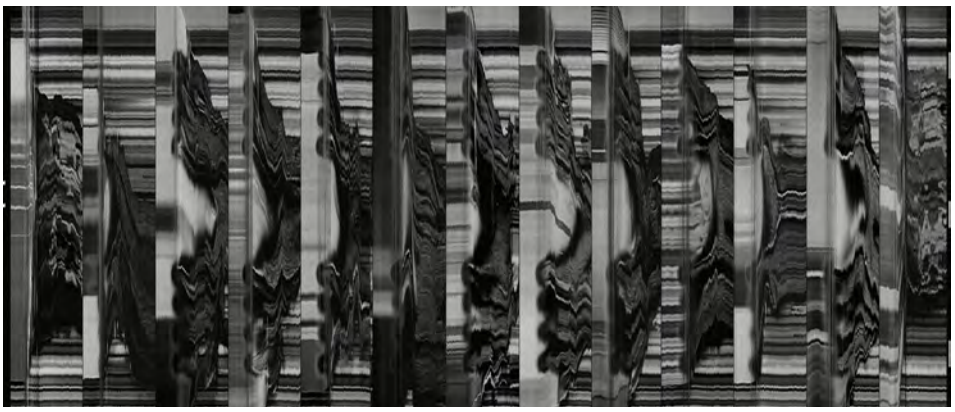


Fig. 6. The resulting image of Hollis Frampton's (nostalgia) (1971) when revisualized with Image Macroanalysis.

One of the most prominent examples in the use of the slicing techniques for whole film analysis, was performed by Patricia Ledesma Villon in the plotting of *Nostalgia* by Hollis Frampton (1971). The film is composed by 13 distinct shots, each of which depicts a still photography being burnt. In Ledesma Villon's result (see Figure 6) each of the shots can be easily identified, as well as the burning pattern. As she puts it: "we can visually depict sequences within a film and visualize their relation to the entirety of the given work during a single instance" (Ledesma Villon 2021). In this case, repetition and transformation become particularly evident due to the recurrent structure of the film. Most of theorist using these visualization techniques, are often focused on single sequence shots and scenes, most often a single shot. Ultimately, space-time visualizations allows one to see time, but specifically, it is good at showing the changes in time over time, similarly to stratigraphy. For this, the most recognizable characteristic is also the more drastic change in time: the cut. So, in visualizing edited video, we can decipher the editing itself, more than the visual elements that compose the actual semantics of the montage.

3 Video Volumes

3.1 Some History of Video Volumes

Video can be rendered in a three-dimensional space using its temporal dimension as an additional visual axis, plotting it frame by frame in chronological order. The result of this process has been called various things, most prominently a *video-cube* or *video stream*. A simple metaphor for this arrangement is the flip-book, a book made of sheets of paper where each sheet represents a sequential frame of animation. However, with digital video, it became possible to virtually arrange the frames in a three-dimensional space in the form of cubes and perform several transformations of spatiotemporal relations.

In 1992, Edward Lee Elliot published work on video-streams as part of his master's thesis at MIT in chapter 3, "The Video Streamer". He used

this visualization method in software to review video in a 3D space but also to "appreciate the rhythm of colors and motions embedded within video" (1993). He says of his experience that one starts identifying clear characteristics of video in the cube: "After a while, one learns to read even more subtle streaks" (1993). Elliot coined the term "video stream" since he was using mostly live video, and was repeating the most recent frames in what could resemble a water stream itself. However, this term is obsolete nowadays due to the popularity of online video streaming services. Aside from the Video Streamer, the first academic publication exclusively addressing this idea was presented by Fels and Mase in a workshop (1999). They named this object a "video cube" or *video cubism*, different to the Video Streamer, they perceive video as a finite contained volume.

According to Susanne Jaschko (2002), Camille Utterback and Romy Achituv were using the term "Video Cubism" to refer to the work *Liquid Time Series*, publicly exhibited for the first time in Tokyo in 2001 after being prototyped in New York in 1999. Although Jaschko does not state that the artists coined the term, it is likely that they became aware of the term used by Fels et al., of which Jaschko seems to have been unaware in 2002. Furthermore, Fels et al. (2000) described the idea that shifting the cutting plane of the cube resulted in an image that presented a temporal distortion like those in slit-scan photography. Moreover, this plane can be slid across the video-cube to obtain a video in which each frame has the same altered temporal visual structure. This visual effect is called temporal displacement and it is analogous to slit-scan in photography.



Fig. 7. On the left: Frame of *Structure of Slit-scan*, Kitasenju Design, 2022. On the right: Frame from *tx-transform*, Martin Reinhart and Virgil Widrich, 1998.

Notable visual explanations of these techniques were already used by artists in the late 1990s, such as Martin Reinhart with the technology and video developed in 1992, *tx-transform* (Reinhart and Widrich 1998) (see Figure 7). *An Informal Catalogue of Slit-Scan Video Artworks and Research* (Levin 2005), posted online by Golan Levin originally in 2005 and last updated in 2015, served as a broad recollection of visual works from 1986 to 2009. Referring to the informal catalogue, Reinhart states in a blog entry: "Looking back, it is interesting to see just how many approaches were running in parallel... It is amazing that I was only aware of a handful" (Reinhart and Widrich 1998). This reveals that awareness of similar work at the time might not have been general or global. Moreover, it suggests that the video-cube was more of a discovery rather than an invention, happening as a natural realization of the volumetric properties of video, just as Jaschko says regarding cinema: "[after chrono-

photography the] discovery of film seem[s] an unstoppable and logical cultural step forward" (2002).

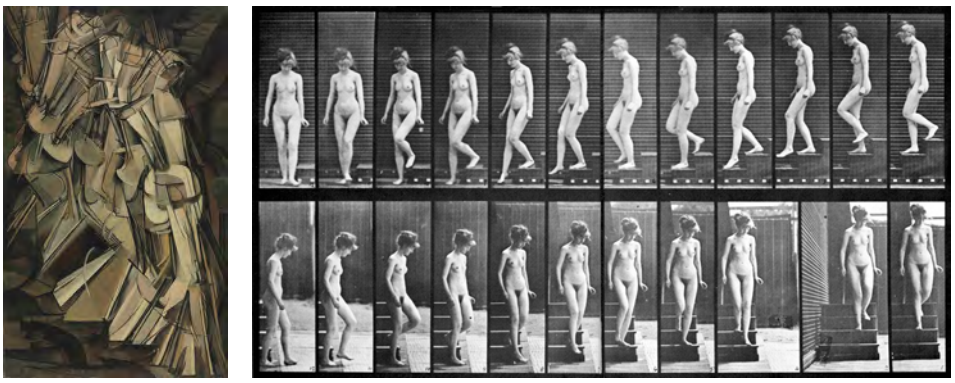


Fig. 8. On the left: *Nude Descending a Staircase, No. 2*, Marcel Duchamp, 1912. On the right: *Female nude motion study*, Edward Muybridge, 1887.

The term "video cubism" risks confusion with the Cubist art movement. Although, Fels et al. do not reference the pictorial movement but rather a literal cube made of video, correspondences could be drawn between the pictorial movement and video cubism. The 1912 painting by Marcel Duchamp, *Nude Descending a Staircase, No. 2* (see Figure 8), depicted not simply a body but the states of the body in time. He was in part inspired by the chronophotographic works of Eadweard Muybridge (see Figure 8), the famous precursor of cinema. Time displacement deformation might recall the deformed structures created by Cubist painters, but their intention was not to deform time except for a few cases. While artifacts in video-cubes recall Cubist deformations, the spirit of the movements is ultimately different except for a few cases. For this paper, we have chosen to use "video-cube" to describe the three-dimensional visualization, while "slit-scan video" refers to the bi-dimensional effect of altering the spatiotemporal mask. However, there is no unambiguous terminology to describe any of these spatiotemporal objects. We hope that our taxonomy helps clearing out distinct terms that are used interchangeably, and that opens a path towards a more strictly defined terminology.

Another very useful visual explanation of the effects achieved through plane cutting is a video modeled by Kitasenju Design (2022), in which the cutting plane is moved across a section of a video-cube of fixed dimensions, showing simultaneously the different types of temporal distortion effects achievable. Some of these manipulations of spatiotemporal cube processes are taxonomically explained and organized by Bach et al. (2014), although their focus is a wider set of spatiotemporal visualization mainly for scientific applications.

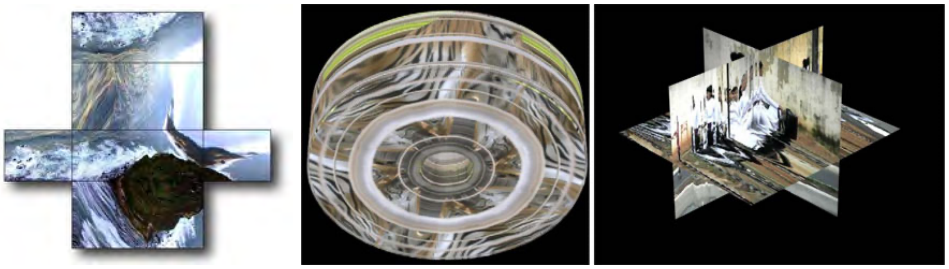


Fig. 9. On the left: *Streamer Box No. 8*, Eddie Elliot, n.d. The camera is tilted down towards the crashing waves. On the right: *Spatio-temporal Objects*, Tania Ruiz Gutiérrez, 2000-2003.

The most popular way to manage video-cubes is through digital interaction, but their simple geometrical form makes them easily transferable into print. We haven't found many examples of this, except for Elliot (1993). As he was extensively finding applications for the "video stream" technology, he described in a "future work" section the formatting for printing as a possible outcome of the arrangement (see Figure 9) since "things are more tangible when we can touch them or hold them" (1993). However, he probably made these cubes with short shots of less than a few minutes, very likely due to memory limitations. We believe these printed cubes were part of the installation, but there is a lack of evidence online. A similar video technique can be easily used for communication purposes, making video-cubes accessible, cheap, and tangible. It can also serve as sort of redemption to film, delivering it from its digitalized immateriality back to our tangible experience. "Film" is on itself an anachronism just like often "slit", since digital capturing, storing and exhibiting is mostly done digitally, involving no physical "film".

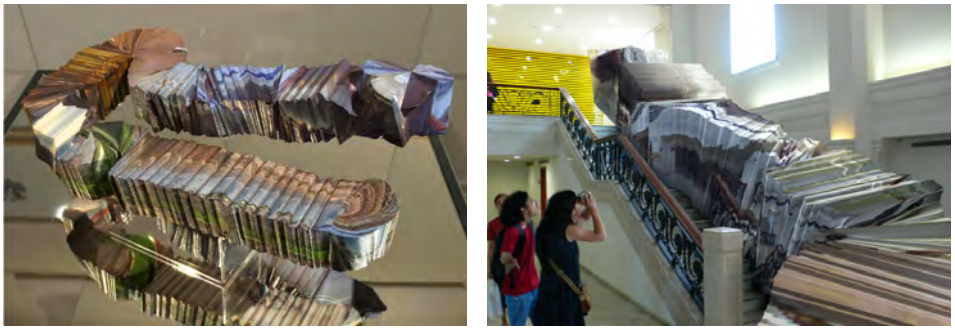


Fig. 10. *The Invisible Shape of Things Past*, Dirk Lüsebrink and Joachim Sauter, 1997. On the left: small sculpture. On the right: virtual sculpture.

In 1997, Dirk Lüsebrink and Joachim Sauter made 3D models of video sequences taken inside a building in an installation called *The Invisible Shape of Things Past*. The resulting form is not a cube at all, but a video-volume that was later transformed into a small sculpture as part of the installation (see Figure 10). In the archived text of the presentation at the Prix Ars Electronica, they show interest in "designing a real architectonic or sculptural object" (1997), for which they also made a virtual model (see Figure 10). These experiments make us able to think about the form of time and the relationship of images with space and the places where they are made. On the other hand, Tania Ruiz Gutiérrez showed it was possible to deform the volumetric properties of the cube and juxtapose various slices in orthogonal visualization to obtain contrasted information from the inside of the cube (2004) (see Figure 9). This further explores the possible forms of the cube which are both visually interesting and useful for shot analysis.

3.2 Media Analysis of Video-cubes

In the peer-reviewed video *Volumetric Cinema*, Kevin Ferguson (2015) shows how the technique multi-planar can be used as for analyzing changes in a long shot of *Citizen Kane* by Orson Wells (1941) as seen in Figure 11. He uses the technique orthoslice, plotting slices across the middle of the X, Y and Z axes. One of the slices show the middle frame

which allows to understand the general composition of the shot; another slice shows the changes in the vertical axis, which makes evident the movement of one of the characters along back and forth across the space; the other slice is not interpreted. Ferguson showcases the use of different video-cube operations in the analysis of shots, especially long-shots such as the famous corridor scene in *Vertigo* by Alfred Hitchcock (1958) and the kiss scene in *Vertigo* by Alfred Hitchcock (1958), both seen in Figure 11. He also uses chroma transparency across black pixels to give form to the volume. However, his analysis is restricted to single shots, ignoring the potential of these techniques to reveal cuts, and taking advantage of its capacity to showcase internal changes within a shot.

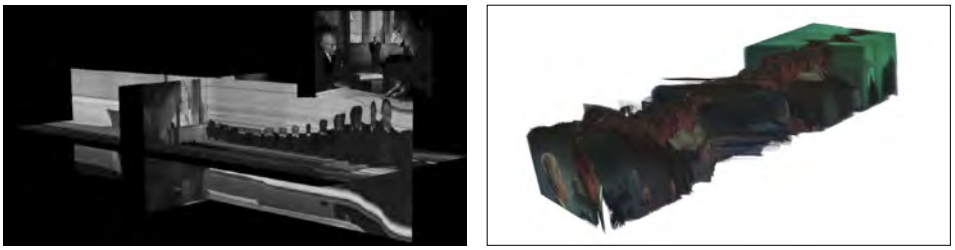


Fig. 11. On the left: Ferguson's orthogonal visualization of *Citizen Kane* sequence. On the right: Ferguson's volumetric visualization of sequence from *Vertigo* with transparency on dark pixels.

Following Ferguson's methods, Dave Rodríguez visualized sequences from several experimental films, mostly abstract films from the late twentieth century. According to Rodríguez: "Transformed [...] into 3D objects, we are able to study and experience these works in entirely new ways that are unconstrained by conventional theories and practices of cinematic spectatorship" (2020). Rodríguez manages to reveal interesting temporal patterns which create unique volumetric objects that show movement and change in the analyzed films, particularly the continuity in animated lines and text, but also the random discontinuity in other films. One good example is his visualization of *Lines Vertical* by Norman McLaren and Evelyn Lambart (1960) (see Figure 12), because it is a very simple frame by frame animation of vertical lines traversing the horizontal axis, by removing the background the movement of the lines forms a very clear structure, revealing linear movement patterns. The 3D structure is so defined, that it almost looks as it was a sculpture was hidden in the film itself. This is somehow reminiscent of Michelangelo's notion that the sculpture lies inside the marble block and the artist simply extracts it. The sculptor must work around the layers of sediment and the properties of the rock, limiting what they could extract from a specific block and utterly connecting their work to the geological history of the material. Similarly, in the video-cube, video itself becomes a sculpting material that can be transformed to achieve certain results only, which all depend on the internal composition of the video itself. Through the video-cube technique, video sediments into a block becoming a volumetric material, with unique properties. Although somehow malleable, the video-cube has a very specific composition that utterly depends in the original images.

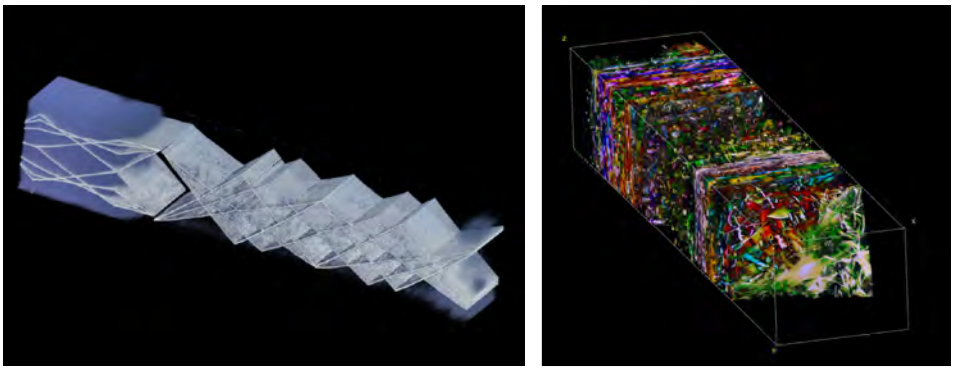


Fig. 12. On the left: Rodriguez's visualization of frames 2880-3600 from *Lines Vertical* (Norman McLaren and Evelyn Lambart, 1960). On the right: Rodríguez's visualization of *Rage Net* (Stan Brakhage, 1988). (Rodriguez 2020).

To our knowledge, these are the only authors that have used video-cubes for media analysis. We believe that the reason for Ferguson and Rodríguez to limit the length of the analyzed video was related to the software they were using (ImageJ) and potential constraints in the visualization capacities which was designed for scientific and medical uses, or due to hardware limitations. Furthermore, long videos end up creating very elongated structures that while revealing more information, are also harder to include in editorial publications or video-essays. The only known case of whole film analysis using this technique is Rodriguez's analysis of *Rage Net* by Stan Brakhage (1988), the whole film was analyzed since its duration is of only 37 seconds, which reveals the many color transitions throughout the film, while allowing a glimpse of the inside of some of the sequences.

The work of these authors is foundational to the analysis of spatiotemporal visualizations of media and opens the doors to a type of analysis which is more concerned with time transformations than pure semantics, which is ultimately analogous to the focus of stratigraphical analysis. We argue that the development of software tools for spatiotemporal visualization designed specifically for film analysis is needed, not only to provide a user-friendly interactive interface, but also to offer the proper tools to manage information extraction and visualization options that address the interest of digital humanities. As Ferguson himself puts it: "Work at the intersection between digital humanities and media studies must willingly explore more experimental methods, arresting our temporal experience of films as narrative things to be consumed." (Ferguson, 2019)

4 Taxonomy of Spatiotemporal Visualizations

Considering the previous discussion, we now introduce a brief taxonomy that might help researchers and media analyst to better describe and use spatiotemporal strip imaging. In Figure 13 presents the broader techniques for image generation, and in Figure 14 presents a set of relevant video-cube operations relevant to media studies and, to a certain extent, art practice.

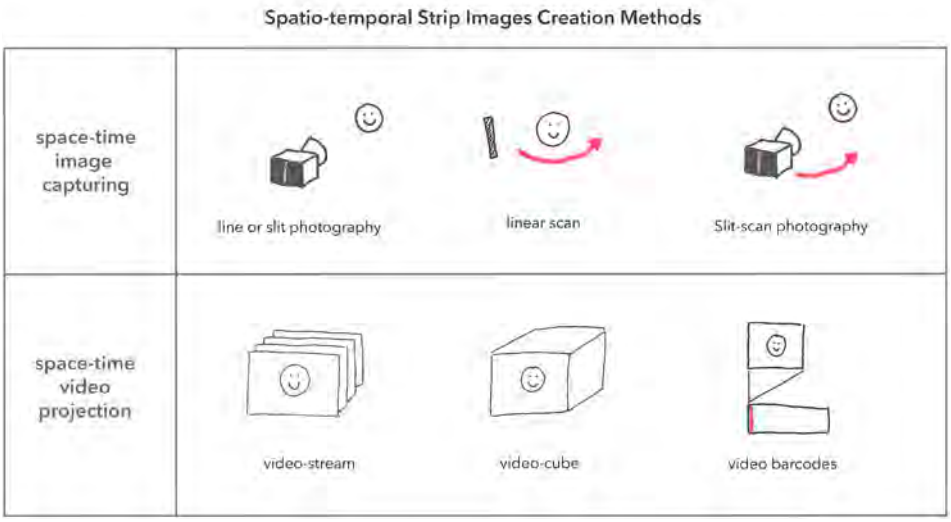


Fig. 13. Spatiotemporal Strip Images Creation Methods.

We have divided the spacetime images into two categories. In one hand, there are spacetime image capturing, which are represented here by their classical photographical examples. However, it should be clear by now that images are not exclusively photographical, and these terms can be used for the outputs of video-cube transformations. Although "slit" refers to the capturing method, the word is often used to describe the style, whether it was created with a narrow aperture or by digital means. We present "slit photography" and "line photography" as a single category since they produce the same kind of results, despite the use of different mechanisms. The term "slit-scan" implies then a junction of narrow aperture and movement, whether the movement is of the slit or the camera itself. What we describe here as linear scan, relates to the specific technology of CCD strip with LED lights, which is most used in document digitalization. On the second category we grouped the terms coined by Elliot and Fels, despite the authors intending similar meanings. We took advantage of these synonyms for disambiguation: video-stream refers to the succession of frames, while video-cube refers to the volume made of video frames. While Fels's video-cubes tend to be finite and contained, Elliot's video-streams tend to be continuous and undefined. Additionally, we differentiate video barcodes, which are not operations performed on a video-cube, but rather an independent process where each frame is individually computed individually transformed into an array of pixels that most often preserve colour information only. However, some video barcodes can be generated from a slice of the video-cube.

Having proposed this general terminology, we can dive now into the video-cube operations which might be the most relevant for media studies and that are presented in Figure 14. We propose three categories to encapsulate some of the most relevant operations: *Slit Extraction*, which is like slit photography; *Time Displacement*, which is like slit-scanning but also considers other types of samplings; and *Volumetric Operations*, which corresponds to the 3D manipulation of the video-cube.

Horizontal slit and vertical slit are similar, they correspond to the plotting of time and only one of the physical dimensions, whether horizontal or vertical. These techniques can be used to do still images and

video. Slice sampling refers to a single cut of the volume, commonly on the middle. Slit-tear is not a common operation, referred to only by Tang et al. (2008), it corresponds to a slit extraction from one section of the video, and is preferably used to identify patterns of movement in long static shots like surveillance video.

In the second row, we identify cuts of the video-cube where the three dimensions intersect, generating images where time shifts in the space of the frame producing all kinds of distortions. We have time displacement or slit-scan,[1] where time is deformed over one of the spatial dimensions. Other types of cuts are named oblique cutting; this type of plane is not necessarily rectangular like the previous cuts, slits and slices. It is also possible to do non-planar cuttings, where time is deformed over space in multiple ways. Although the results of oblique cutting and non-planar cuttings are very interesting visually, their direct application in media analysis appears limited. Finally, there is volumetric sampling, here shown as cylinder extraction due to parallelism with stratigraphy previously proposed, however, any kind of volume can be extracted from the cube by removing parts of the volume similarly to how a rock sculpturer would do. This latter technique might be useful to observe the inside of the cube, or specific parts of it.

Finally, we propose some broad volumetric operations. First there is object recognition, while most media analyst have achieved a similar effect by removing dark pixels from the volume, often revealing the forms of objects, for example in Rodríguez's work, a more refined approach is to do a frame-by-frame extraction of the object or character before the construction of the object. On the other hand, the orthogonal projection or multi-plane projections consist in an object constructed from slits or slices over the main axis of the video-cube, normally these slices correspond to the centre of the cube in its three dimensions. As we have seen before, this technique might show the changes in the frame during a shot, while also maintaining a reference to the original frame itself which might make easier to understand what is represented in the slices. We have also included volumetric transformations of the video-cube, the most common being bending, since it makes it possible to observe simultaneously the first and last frame of the video, however, any kind of 3D transformation can be applied to the video-cube. Lastly, and due to its cube form, we suggest that a relevant transformation of the video-cube is to plot its surfaces into a printable folding cube, which is an easy and cheap alternative to make video into tangible physical objects.

1. Here "slit-scan" is used to denote the visual effects as a metaphor to slit-scan photography.

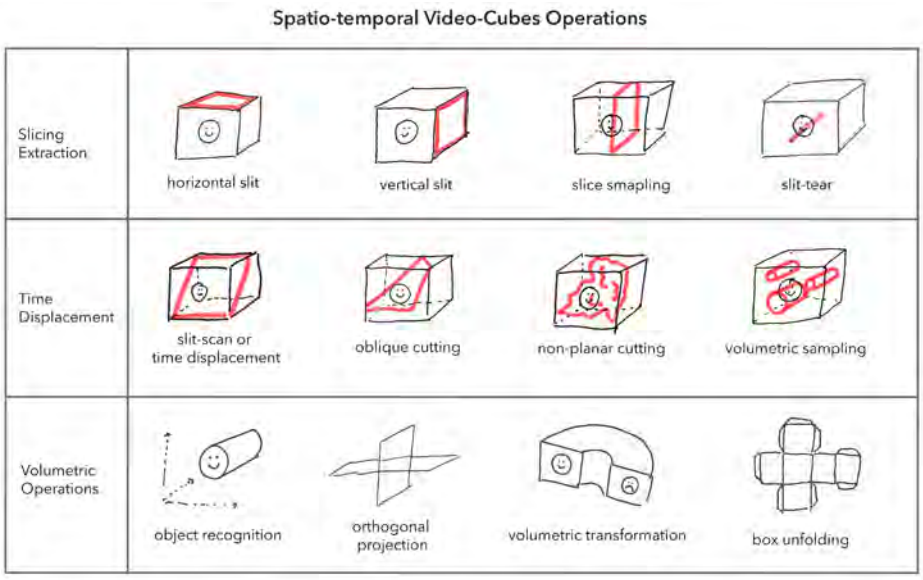


Fig. 14. Spatiotemporal Video-Cubes Operations.

5 Conclusion

This review is intentionally selective rather than exhaustive: it tracks a lineage of spatiotemporal strip imaging and video-volume practices through representative artworks, systems, and publications, but it cannot cover every parallel tradition where similar operations appear under different names. It is focused merely on media analysis, leaving behind many other practical uses for similar tools and techniques in other disciplines. The approach embraces a known trade-off discussed throughout the paper: strip and volumetric views can reveal global temporal structure (rhythm, repetition, cuts) while making frame-level semantic inspection less direct, so these techniques should be understood as complementary to—rather than replacements for—conventional viewing and shot/frame analysis; or tools to easily visualize large corpus of films.

A first next step is to operationalize the taxonomy as an annotation scheme and test its practical utility on diverse corpora, measuring agreement and documenting which operations best surface montage, cuts, and within-shot change. Another direction is to develop and evaluate interactive tools that let analysts fluidly move between cube, slices, and perform all kinds of samplings and transformations, alongside standard playback, so that pattern discovery and content verification can be performed within a single workflow. We also see opportunities to extend the taxonomy toward reproducible research infrastructure similar to how well-established tools in geology have made stratigraphy comparable and reproducible worldwide, which ultimately has pointed out to similarities in sedimentation and deposition. Likewise, reference implementations, operations and conventions might help media analyst to perform similar task with different data.

In this paper we proposed the idea of media stratigraphy, a conceptual framework for the use of spatiotemporal visualizations to treat moving images as sedimentary structures of light, shifting attention from semantic “content” towards time features—repetition, accumulation,

movement, and discontinuity. We argued that unlike media archeology which focuses on the study of past objects, media stratigraphy allows for the direct study of time in those objects, and particularly to the changes of time over time. This is somehow similar to geology, which uses stratigraphy to perceive the changes on sediment formation which often follow cycles of sedimentation that change after long periods forming distinctive layers. One clear difference is that traditional stratigraphy studies billions of years of sediment, what is called deep time, while media stratigraphy is more focused in individual films. While this technique could be used for the study of big corpus of films and comparative analysis, that kind of work has not been found in the literature.

Through a review of strip imaging traditions across photography, interface practices, and computational media work, we showed that closely related techniques have circulated under overlapping terms (e.g., slit, slit-scan, temporal displacement, video-stream, video-cube), which has hindered precise description and comparison across studies. At the same time, the review highlighted a productive tension: these visualizations can reveal global temporal patterns at a glance, yet they often do so by restricting observability of frame-level detail—an effect that is not a flaw but requires a methodological reorientation of the analysis practice.

The main contribution is a taxonomy intended to stabilize terminology and connect analytic goals to specific operations. We first separate space–time image capturing families from volumetric video representations, clarifying "video-stream" as frame succession and "video-cube" as a bounded frame volume, and distinguishing video barcodes as a separate process rather than a cube operation. We then group media-relevant cube transformations into three operational families—Slit Extraction, Time Displacement, and Volumetric Operations—so researchers can report what was done to the cube, not only what the resulting image resembles. By making these distinctions explicit, the taxonomy supports more comparable analyses and opens a path toward method choices that foreground montage, rhythm, and temporal structure as primary evidence in media study.

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The Algorithmic Protagonist: Configurations of Agency and Co-Presence

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As algorithms evolve from tools to protagonists, the traditional understanding of performance as an exchange between human actors and spectators is challenged. This shift calls for examining how algorithmic protagonists manifest and how agency is configured within complex performative environments. Our research brings theoretical and practical inquiry together and develops a systematic analytical mapping of both performance and performer through a set of questions addressing co-presence, spatial mediation, computational temporality, distributed action, and agency. In our artistic work ENTITY, an algorithmic protagonist becomes perceptible as a performative configuration rather than a simulated human. This investigation aims to contribute to an understanding of human–algorithm interaction in an era in which algorithmic systems shape our daily experiences and creative expressions.

1 Introduction

With the ever-increasing influence of algorithmic systems and their interweaving into our realities, understanding their characteristics and consequences becomes crucial. Such understanding must develop across diverse disciplines and forms of knowledge production, fostering not only scientific insight but also intuitive, emotional, and affective comprehension. Artistic practice can catalyse this form of inquiry. Incorporating diverse entities into artistic practice reflects the conditions of our evolving society. Algorithmic entities are especially complex, presenting an intriguing duality: they appear disembodied yet remain materially dependent, like spirits animating machines. Rather than resolving this tension, we examine how such systems manifest as algorithmic protagonists and how agency is configured across technical and human components.

Through theoretical analysis and our artistic work ENTITY, we develop a set of analytical questions for furthering understanding of algorithmic protagonists. Our questions address co-presence, spatial mediation, computational temporality, and distributed action. We explicitly aim to move away from anthropomorphizing algorithmic systems towards perceiving the algorithms as operative configurations within performative events.

While we strive for a context-independent understanding of performative algorithmic protagonists as agents, in this work, we stage algorithmic co-presence in a theatre context and explore how, between the system and an audience, computational processes reshape relational experience and how meaning emerges through interaction. Although we reject an understanding of algorithmic protagonists as human Dop-

Keywords: Algorithmic Art, Performance Art, Posthuman Performances, Media Scenography, New Media Art Practice, Machine Learning, Empirical Study.

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pelgängers, we envision that analysing this relationship might contribute to work that also reveals overlooked aspects of human behaviour. As Rokeby observes, presenting familiar actions through an unfamiliar lens can make visible what has become invisible through familiarity (Rokeby 2019).



Fig. 1. The algorithmic protagonist ENTITY with a human audience. ENTITY presents a stylized contemplation of algorithmic entanglements in the world. Within a mirrored, sensor-driven environment, ENTITY manifests as a distributed configuration of projections, sound, and language rather than as a humanoid figure. The work stages questions of co-presence, computational temporality, and agency.

2 Related Work

Our work builds on scholarship in performance theory, algorithmic performance, and theories of distributed agency while engaging our own artistic practices to foreground algorithmic protagonists.

Performance and Co-Presence: Theoretical debates on what constitutes theatre and performance provide an essential foundation for analysing algorithmic protagonists. Brook (1968) and Fischer-Lichte (2008) emphasize co-presence as a defining condition of performance, grounding theatrical events in embodied reciprocity between actors and spectators. The emergence of postdramatic theatre and performance art (Lehmann 2001) has already destabilized narrative centrality and expanded notions of human stage presence. Contemporary performance increasingly interrogates how agency, embodiment, and relationality are offered. Our work extends this trajectory by asking how co-presence and liveness are reconfigured when the protagonist is algorithmic rather than human.

Algorithmic Performance: Algorithmic performance has precedents that long predate digital computation. Mechanical artifacts and ritual automata, such as Memnon colossi in Thebes (c. 1350 BCE), whose northern statue reportedly emitted sounds through a heat-activated mechanism (Mayor 2018), and automated devices used in Egyptian and Greek temples to create supernatural effects (Frood 2003), illustrate early attempts to stage non-human agency as spectacle. In modern theatre, Annie Dorsen's notion of "algorithmic theater" (Dorsen 2012) explicitly proposes performance beyond human actors, foregrounding procedural generation and audience experience. Steve Dixon's analysis

of digital and posthuman performance (Dixon 2007) provides a comprehensive account of how technological mediation reshapes theatrical presence. Building on these contributions, our approach shifts attention from digital mediation broadly conceived to the algorithmic protagonist specifically. Rather than cataloguing technological effects, we propose analytical questions that examine how manifestation, temporality, and distributed agency are configured in algorithmic systems.

Agency and Distributed Actants: To analyse the performer beyond human embodiment, we draw on the famous Actor–Network Theory (ANT), which conceptualizes agency as distributed across heterogeneous networks of human and non-human actants (Latour 2005; Muniesa 2015). Agency, in this framework, is defined not by intention but by the capacity to produce differences (Alaimo 2017). Originally developed within science and technology studies, ANT has since informed analyses across media, organization, and creativity research (Blok et al. 2019; Bartels and Bencherki 2020; Williams 2020; Gutiérrez 2024). This perspective provides the methodological grounding for tracing how algorithmic systems, hardware infrastructures, spatial configurations, and spectators co-constitute performance.

Artistic Precedents of Algorithmic Protagonists: A growing body of artistic work centres on algorithmic or robotic entities. Rimini Protokoll's Uncanny Valley (Kaegi 2018) stages a humanoid robot recounting the life of a writer, destabilizing assumptions about authorship and authenticity. Hiroshi Ishiguro and Takashi Ikegami's Alter (Ishiguro and Ikegami 2017) explores robotic embodiment through sensor-driven motion, evoking quasi-biological agency. Jan Zuiderveld's Conversations Beyond the Ordinary (Zuiderveld 2024) examines AI-human dialogue, foregrounding interpretative ambiguity and projections of machine consciousness.

All of these works challenge human-centred models of performance by reconfiguring co-presence and redistributing agency. However, many remain oriented toward humanoid representation or conversational simulation. While we are also applying speech synthesis in our own artistic work, we strive to create an atmospheric and spatial manifestation, not a humanoid one. To further understand the difference, we articulate a set of analytical questions that foreground distributed mediation, computational temporality, and relational agency.

3 From Artistic Dimensions to Analytical Questions

Building on the debates outlined in Section 2, we shift from historical and theoretical positioning to methodological articulation. Rather than revisiting definitions of performance, we ask how algorithmic protagonists can be analytically described. To structure both the creation and analysis of such works, we propose a set of questions grounded in performance practice. These questions address performance and performer alike and, while necessarily designed by humans, we seek to

identify characteristics that exceed strictly human modes of presence and action.

3.1 Performance

The overarching question for analysing an algorithmic protagonist in performance is: How does the algorithmic protagonist manifest?

We approach this question through four interrelated sub-questions as analytical lenses. Co-presence examines how affective interconnectedness is established beyond physical embodiment. Space considers how performative environments extend beyond traditional stage boundaries through interactive and mediated configurations. Time addresses how algorithmic performance operates between determinacy and ephemerality. Action and interaction investigate how systems enact authentic algorithmic processes while simultaneously transforming audience participation.

Co-Presence Without Embodiment

Algorithms, as non-physical and often invisible structures, challenge the traditional notion of bodily co-presence by foregrounding affective interconnectedness among participants. These algorithmic entities, whether tangible (machines, robots), intangible (virtual systems, projections), or infrastructural and unseen (yet always grounded in physical hardware), shape performative events by modulating perception and interaction in real time. Co-presence thus shifts from direct physical encounter to a dynamic interplay of visible and invisible processes, where material form recedes, and relational responsiveness, temporal synchronicity, and perceptual feedback generated by algorithmic structures become the primary conditions of shared presence.

This leads to the analytical questions of how presence is staged, sensed, and experienced when embodiment is replaced or displaced by mediation?

Space as Performative Mediation

The presence of performer and spectator traditionally shapes a shared space, yet this space can extend far beyond the physical stage. It encompasses visual, acoustic, and atmospheric dimensions influenced by light and media technologies such as projections and sound. Since the 1960s, performance practices have increasingly dissolved the separation between performer and spectator. Immersive formats invite audiences to enter artistic environments and participate in the unfolding event, blurring the distinction between viewer and actor.

Algorithmic spaces further expand these possibilities by engaging audiences and other actants through interactive exchanges. Such spaces operate through algorithms that mediate between sensors and actuators, functioning as decision-making systems within medial environments. They respond to local stimuli such as motion, sound, temperature, or

haptic input, as well as to external data streams including social media, weather information, or remote sensor inputs. In this way, space itself becomes operative. Projections and screens extend performative environments by inserting mediated images into physical space, from static visuals to live data streams. Crucially, these images no longer need to represent an external reality. Screens conceal their own materiality and present their output as an immediate perceptual field that merges with the surrounding environment. Digital imagery thus shifts from a representational surface to a generative entity. Rather than depicting space, it actively produces it, transforming spatial perception into a dynamic and processual condition shaped by algorithmic operations. In performative contexts, such algorithmic spaces generate a distinctive atmosphere constituted by computational modulation across light, sound, image, and timing. As performers, they do not require a unified physical body, but their presence emerges through distributed mediation, enabling space itself to function as the protagonist.

This leads to the analytical questions of how algorithmic mediation reorganizes spatial relations between performer, spectator, and environment?

Computational Temporality

While mediatized performances blur the distinction between live representation and technical reproduction (Auslander 1999), algorithmic performances introduce a specific tension between determinacy and ephemerality. Pre-trained systems are grounded in prior data, fixed architectures, and defined parameter spaces. At the same time, their execution unfolds in real time, responding to inputs, probabilities, and environmental conditions. Temporal experience, therefore, emerges from the interaction between stored data and structures and live computational processes.

To generate a perception of unpredictability and singularity, algorithmic performances may incorporate stochastic operations, complex model dynamics, or real-time environmental interaction. Each output is conditioned by training data and system design, yet its concrete manifestation depends on specific prompts, sensor inputs, timing, and system states. The result is neither pure repetition nor unrestricted improvisation, but a structured openness in which variation is bounded yet non-identical. Temporal liveness in such systems does not arise from intention or conscious decision, but from ongoing computation under conditions of contingency. Liveness is thus reframed not as intentional presence, but as computational eventfulness.

This leads to the analytical questions of how liveness is produced and perceived, and how contingency and system architecture together generate the experience of a singular and unrepeatable moment?

Action and Interaction Beyond Simulation

Performative actions often strive to construct reality rather than to simulate it. They do not represent events but bring them into being. They are often self-referential, foregrounding the conditions of their own production. Algorithmic performance further decentres the human by recognizing non-human actors and material processes as agents. The concept of intra-action emphasizes that entities do not precede their relations but emerge through dynamic entanglements without predefined hierarchies (Barad 2007; Hickey-Moody 2020).

Within this perspective, algorithmic protagonists enact performance that exceeds mere imitation. Two modes are particularly salient. First, they may reveal their own operational logic through the event itself. Rather than adopting a fictional persona, the system exposes its computational structure, constraints, and generative mechanisms. In doing so, it performs its own condition of possibility. As Rokeby suggests, such systems operate as "a special sort of mirror" that renders human assumptions visible by contrast (Rokeby 2019). Here, action consists not in role-play but in the unfolding of an algorithmic process as an event. Second, algorithmic protagonists may approximate human capabilities through technical prostheses: cameras function as vision, microphones as hearing, speakers as voice, motors as movement, and language models as communication. Yet these functions are grounded in statistical inference, signal processing, and probabilistic computation. Their operations may exceed human sensory thresholds or temporal scales, producing outputs that resemble human faculties while remaining ontologically distinct. Action thus emerges from computational execution rather than intention.

Interactive performance further reconfigures agency. Spectators become participants who influence system states through visual, auditory, or haptic interfaces (Daniels 2008; Dixon 2007; Karray et al. 2008). The performance unfolds as a distributed assemblage in which algorithm, hardware, environment, and audience mutually condition one another. Interaction is therefore not a simple exchange but a recursive modulation of system behaviour.

This leads to the analytical questions of how algorithmic systems act, and how these actions reconfigure spectators from observers into participants within a distributed network of agency?

Together, these four analytical questions frame performance as an emergent configuration of co-presence, spatial mediation, contingent temporality, and distributed action. Rather than functioning as separate categories, they operate as mutually conditioning aspects of manifestation.

3.2 Performer

If Section 3.1 asks how the algorithmic protagonist manifests, this section asks: How is agency configured in the algorithmic performer?

As discussed in Section 2, Actor–Network Theory (ANT) provides a basis for understanding agency as distributed across heterogeneous actants (Latour 2005; Muniesa 2015). Transposed into performance contexts, this perspective reframes the performer not as a singular embodied subject, but as a configuration of actants whose interactions generate the event. The following questions are all necessary for a configuration of agency and should not be separated (and, with that, are presented slightly differently than the above).

Who or what acts within the performative situation?

Actants include not only human performers but also algorithms, hardware components, data streams, interfaces, environmental inputs, and spatial configurations that participate in shaping the event.

What properties characterize these actants, and how are they embodied, distributed, or infrastructural?

Relevant properties may include computational latency, probabilistic variability, sensory range, spatial positioning, algorithmic opacity, or degrees of autonomy embedded in system design.

What observable differences result from their actions?

Agency becomes visible through actions such as changes in light, sound, textual output, spatial atmosphere, audience movement, or shifts in system state.

What connections are established between actants?

These connections may be technical, such as data flows and sensor–actuator chains; spatial, such as diffusion and proximity; or perceptual, such as feedback loops between audience and system.

How do these properties and relations change over the course of the performance?

Agency may shift and change as system states evolve, as audiences intervene, or as environmental inputs accumulate, producing a dynamic redistribution of influence within the assemblage.

These questions operationalize the tracing of agency within distributed technical and social assemblages. Rather than assuming a centralized performer, they direct attention to networks in which algorithms, hardware, space, environmental inputs, and audiences co-constitute the performative event. At the same time, Latour reminds us that networks exist through “the very act of tracing” them (Latour 1996). The identification of agency is itself a methodological and artistic decision. In this sense, algorithmic performance cannot eliminate human authorship but reconfigures it. The artist designs the conditions under which algorithmic agency becomes perceptible, staging the network in which actants can make a difference. The performer thus emerges not as a stable entity but as a dynamically orchestrated assemblage whose agency is distributed, relational, and contingent.

3.3 Examples

To illustrate how the proposed analytical questions can be applied, we examine two performances that foreground algorithmic protagonists and renegotiate manifestation and agency within contemporary theatre.

Hello, Hi There (2010) by Annie Dorsen (Dorsen 2010) is a widely discussed stage play (Manuel 2017; Lucie 2020; Felton 2019) in which two chatbots reimagine a 1960s television debate between Foucault and Chomsky. Drawing from diverse textual sources, the system generates over eighty million possible variations, foregrounding recombination rather than scripted authorship. The performance stages two laptops as protagonists. Dorsen argues that stage presence does not require character imitation, but rather a participating body that "is or does or shows" (Dorsen 2012). From the perspective of performance (Section 3.1), the work challenges traditional notions of co-presence. Presence is grounded not in embodied actors but in real-time textual recombination, reframing liveness as computational eventfulness rather than intentional expression. Yet the actor–spectator relation becomes markedly asymmetric. As Dorsen notes, spectators are left "radically alone" (Dorsen 2012), producing a paradoxical experience of observing algorithmic "minds at work" while lacking reciprocal acknowledgment. From a performer's perspective (Section 3.2), agency is distributed across software, hardware, textual databases, and audience interpretation. The chatbots do not simulate interiority. Instead, they generate relational effects through textual output. Meaning emerges through the network of actants rather than from a centralized performer.

No Body Lives Here (ODO) (2020) by Chris Ziegler (Ziegler 2020) presents an AI entity that interacts simultaneously with multiple visitors within a theatre installation. ODO manifests through a constellation of audio-visual systems and attempts to "understand" its environment. Unlike Dorsen's stage-bound laptops, ODO dissolves the distinction between performer and space. Analysed through the questions of performance (Section 3.1), particularly manifestation and agency, ODO demonstrates how space itself becomes operative. The system mediates between sensors, audio-visual outputs, and visitor movement, establishing feedback loops that reorganize spatial relations. Co-presence emerges not from face-to-face exchange but from recursive modulation across sound, image, and environmental response. Visitors influence the audio-visual configuration and thereby participate in shaping system behaviour. From the performer's perspective (Section 3.2), ODO foregrounds a distributed configuration of actants. Agency is not localized in a singular AI "character," but emerges through relational effects across the interplay of cameras, projection systems, software processes, spatial acoustics, and embodied spectators. The relevant properties of these actants include real-time responsiveness, probabilistic variation, sensor range, spatial diffusion of sound and image, and degrees of computational autonomy. Their actions produce observable differences in atmosphere, spatial perception, and visitor movement. As these relations evolve over time, agency shifts dynamically within the assemblage. The performance thus exemplifies how algorithmic atmospheres reconfigure the performer as a relational network in which space itself assumes a protagonist function.

Together, these examples demonstrate how algorithmic protagonists manifest through computational temporality, mediated spatiality, and

distributed agency. They show that the performer in such contexts is not a stable figure but an emergent configuration of actants whose relations generate the event and through which the algorithmic protagonist becomes perceptible.



Fig. 2. Examples of algorithmic protagonists. Left: Annie Dorsen's *Hello, Hi There* (Dorsen 2010) stages two chatbots engaging in improvised dialogue about human nature and intelligence, foregrounding computational recombination and reframing co-presence and liveness as textual eventfulness rather than embodied exchange. Right: Chris Ziegler's *No Body Lives Here* (ODO) (Ziegler 2020) presents an AI entity that learns through audience interaction, dissolving the boundary between performer and space and exemplifying distributed agency across sensors, audiovisual systems, and embodied spectators. Images courtesy of A. Dorsen / W. Silveri / Steirischer Herbst (left) and C. Ziegler / Yvonne Mohr (right).

4 Artistic Exploration

Our contemporary landscape is increasingly shaped by the pervasive presence and influence of algorithmic entities. Within this evolving ecosystem, our artistic practice engages these conditions by staging algorithmic manifestation and agency as performative questions rather than abstract themes. Our artwork, ENTITY, explores how an algorithmic protagonist can manifest and how agency can be configured within a distributed network. ENTITY positions algorithmic presence as a constitutive element of performance. To move away from humanizing the algorithm, the work creates an environment in which its operational characteristics, constraints, and modes of action become perceptible. In doing so, the installation examines how co-presence can be established without embodiment, how space can become operative, how liveness can emerge from computation, and how agency can be distributed across technical and human components.

By inviting an algorithmic system to occupy the role of protagonist, ENTITY stages a reflective configuration within a technologically mediated environment. The work offers a situated exploration of algorithmic temporality, mediation, and interaction through direct experiential engagement. In this sense, ENTITY does not merely represent algorithmic entities. It constructs conditions under which an algorithmic assemblage can perform, articulate, and expose its own operational logic, talking about itself, within the broader discourse of contemporary technological zeitgeist.



Fig. 3. Two performance scenarios of ENTITY, illustrating the mirror chamber and the superimposed projections generated from live camera input. The stylized reflections merge visitor imagery with algorithmically produced waveforms and synthetic voice visualization, creating a mediated field in which co-presence emerges through recursive modulation rather than direct embodiment. The distributed interplay of projection, sound diffusion, and reflective surfaces renders space itself operative, allowing the algorithmic protagonist to manifest as a spatial assemblage rather than a centralized figure.

4.1 *ENTITY*

ENTITY stages an encounter between visitors and an algorithmic system that performs an inquiry into its own manifestation, agency, and entanglement in the world. As Figure 3 shows, the algorithmic performance is designed as an immersive space consisting of mirrors, projections, light, language, sound, and sensor interaction, supported by several hardware components. Visitors experience this process of algorithmic introspection within a mirror chamber that defines the performative space and embodies the artificial entity. Seven semi-transparent mirrors hang from the ceiling and are arranged along the sides of an octagonal area. The mirrors are aligned so that a visitor standing in the centre of the room can see themselves reflected in all surfaces. This spatial configuration structurally integrates the visitor's body into the algorithmic field of reflection.

Images are projected onto the semi-transparent mirrors from behind, superimposing and distorting the visitor's reflection. These projections depict waveforms of the synthetic voice, as well as live recordings of visitors captured via camera input. The system is activated when a visitor enters the performance space and continues as long as the visitor remains present. During this time, the system produces speech through a synthetic voice. Based on a large language model specially trained for the performance, the data-driven system continuously generates statements about itself , the nature of algorithms, cybernetic realities, and posthuman entanglements.

Regarding the technical setup, Figure 4 provides an overview of the arrangement of hardware and software components. The software is distributed across four computer instances, each optimized for a specific role within the overall system, reinforcing the distributed configuration of agency described in Section 3.2.

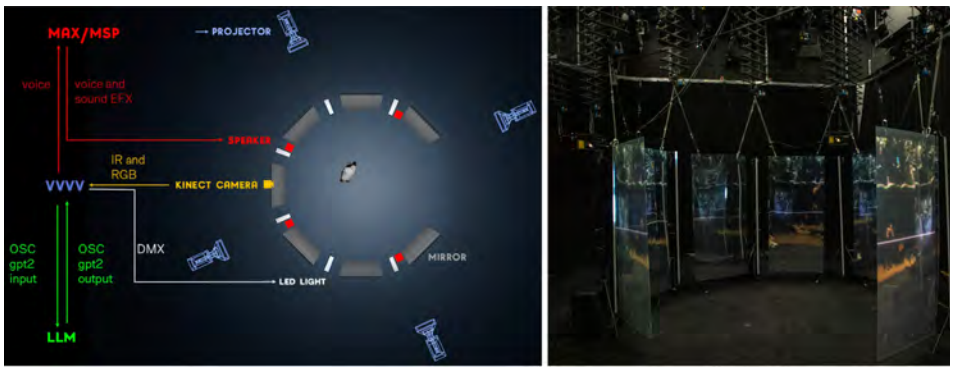


Fig. 4. Software components and hardware configuration of ENTITY. A GPT-2 model (the project was initiated in 2020), trained on cybernetic and posthuman texts by Norbert Wiener, Donna Haraway, and N. Katherine Hayles, processes prompts and transmits generated responses via OSC. The visual programming environment vvvv manages text-to-speech synthesis, waveform visualization, and camera input for mirror projections. Max/MSP handles audio processing and spatial distribution across a four-channel system, adding acoustic effects and ambient sound layers. The hardware configuration consists of four computers dedicated to video and audio generation, text generation, and sensor interaction; four projectors projecting onto the mirror plates; four speakers positioned at the corners of the octagonal space and oriented toward its centre; six LED pipes with twenty individually addressable pixels each, illuminating the interior to enable reflective effects; and a Kinect v2 sensor detecting visitor presence and activating the system.

4.2 Manifestation and Agency in *ENTITY*

Applying the analytical questions developed in Section 3 reveals how ENTITY configures manifestation and agency and, with that, performance and performer, through spatial mediation, computational temporality, and distributed interaction.

Manifestation: Co-presence and Space

In ENTITY, the algorithmic protagonist does not appear as a discrete body but manifests atmospherically through reflection, projection, sound, and light. Co-presence is established not through embodied reciprocity but through spatial coupling. The mirror chamber structurally integrates the visitor into the performative field, where reflections multiply the body, projections superimpose synthetic waveforms and live camera feeds, and spatialized sound diffuses the algorithmic voice throughout the room. The system's presence emerges from the dynamic interplay of visible and invisible processes.

Space itself becomes operative. Rather than functioning as a neutral container, the octagonal mirror configuration reorganizes spatial relations. The projections do not depict an external reality but actively produce a mediated perceptual field. By merging the visitor's reflection with algorithmically generated imagery, the installation establishes a recursive configuration in which audience and system are visually and acoustically entangled. The protagonist thus manifests as a spatial assemblage rather than a centralized figure.

Temporality: Computational Eventfulness

Temporal experience in ENTITY arises from the interaction between pre-trained statistics and real-time computation. While the language model is grounded in curated training data from humans, its execution unfolds contingently in response to voice prompts, stochastic variation, and visitor location. Each utterance is generated within probabilistic constraints, yet its concrete articulation remains singular.

Liveness is therefore not anchored in intention but in ongoing computation under conditions of contingency. The performance evolves as long as a visitor remains present, producing a temporal unfolding that reframes liveness as computational eventfulness. No encounter is repeated, as speech, spatial sound distribution, projection patterns, and lighting states are continuously recomposed.

Action and Interaction: Beyond Simulation

ENTITY explicitly does not simulate common character development or narrative structure. Instead, it exposes the algorithmic process as an event. The system generates speech that reflects on its own condition, not as evidence of consciousness, but as the unfolding of model-based computation. It is not designed to replicate the human voice but rather to create a stylized aesthetic, hand in hand with modulating light, transforming reflections, emitting spatialized sound effects, and text.

Interaction operates through recursive modulation rather than conversational exchange. Visitor presence activates the system, and movement and positioning influence visual capture and spatial perception. The resulting outputs in turn shape visitor attention and bodily orien-

tation. The performance unfolds as a feedback loop in which action is distributed across the system and the spectator.

Agency: Distributed Configuration

From the perspective of the performer, agency in ENTITY is not localized in a single computational core. It emerges from the coordinated interplay of sensors, a generative model, projection systems, acoustic diffusion, lighting infrastructure, and embodied spectators. The algorithmic protagonist appears not as a coherent, anthropomorphic unit, but as a distributed configuration of actants operating within the spatial assemblage.

The central computer recedes into the background behind the performative structure. What becomes perceptible is not a machine as an object, but a network of technical relations that produces observable differences in atmosphere, perception, and movement. Agency is therefore enacted as a relational effect rather than an intrinsic property.

In summary, ENTITY demonstrates how an algorithmic protagonist can manifest without embodiment, operate through mediated space, unfold through computational temporality, and distribute agency across a network of technical and human actants. Rather than presenting a simulated subject, the work stages the conditions under which algorithmic processes become perceptible as performative events.

5 Theoretical Implications

Sections 3 and 4 strive to situate algorithmic protagonists within a posthumanist perspective that recognizes non-human entities as operative participants in performance. Rather than treating algorithms as tools or extensions of human intention, this lens foregrounds their capacity to generate perceptible differences within a performative assemblage. At the same time, postdigital art scholarship (Berry and Dieter 2015) reminds us that digital systems are no longer exceptional or novel, but embedded and normalized within contemporary artistic practice. While our analysis adopts a posthumanist decentring of human agency, a postdigital perspective tempers this move by emphasizing that algorithmic systems are infrastructural and culturally situated. Future research may further examine how these perspectives intersect in performance contexts.

The relationship between developer and algorithm further complicates traditional artistic hierarchies. Rather than reproducing a strict director–performer model with separate roles, as often assumed, we understand algorithmic performance as an example of distributed authorship (similar to many human-human processes). Developers design architectures, training data, and interaction conditions, but once activated, the system operates within probabilistic constraints that exceed direct control. The artist functions less as a commander of actions than as a curator of parameters, configuring conditions under which algo-

rithmic processes can manifest. This reframing does not reduce human authorship but renders it structural rather than expressive.

The examples discussed in Section 3.3 highlight a recurring tension in AI-driven performance: expectations of natural or human-like interaction often remain unmet. Yet this shortfall should not be understood as a technical deficiency. Attempts to mimic human expressivity risk reducing algorithmic performance to simulation. Instead, we propose to highlight the distinctive capacity to operate differently: to generate atmospheres, to recombine language "erratically", to modulate environments, and to produce effects without intentional consciousness. Language-generating systems such as ENTITY exemplify this goal, not employing language to convey interiority and intention, but staging text as probabilistic output, creating an ambiguous space between coherence, abstraction, and noise (Dorsen 2012).

Finally, our work participates in a broader cultural reorientation. If humans are no longer positioned as the sole agents of performance, then artistic practice can contribute to rethinking relationality more broadly. Posthumanist thought invites reconsideration of responsibility and coexistence within, e.g., complex ecological and technological networks (Braidotti 2013; Haraway 2016). In this sense, staging algorithmic protagonists is an attempt to recalibrate how agency, presence, and interdependence are understood within shared environments.

6 Conclusion

This research examines how algorithmic protagonists manifest and how agency is configured within performative contexts. Rather than proposing a fixed framework, we develop a set of analytical questions that address co-presence, spatial mediation, computational temporality, distributed action, and agency. These questions emerged from artistic experimentation and were refined through theoretical reflection, forming an analytical lens for understanding algorithmic performance beyond simulation or anthropomorphic projection.

With ENTITY, we translate this analytical apparatus into an experience. At the same time, the artistic process itself informed and sharpened our theory. The artwork stages an algorithmic assemblage that reflects on its own operational logic, making computational processes perceptible as performative events. In doing so, it renders questions of manifestation and agency accessible not only conceptually but affectively, allowing audiences to encounter algorithmic systems as relational to them. Similarly, for us, the reciprocal movement between theory and practice produces knowledge that is both scholarly and artistic, demonstrating how analytical inquiry and performative experimentation can co-generate meaning.

Our investigation continues along both theoretical and artistic trajectories. Theoretically, further work may examine the tension between the apparent autonomy of machine learning systems and their grounding

in human-generated data, asking how algorithmic agency is shaped by inherited statistical, but ultimately human, structures. Artistically, we aim to further explore atmospheric protagonists that operate without humanoid embodiment, using light, reflection, and projection to stage distributed forms of presence. In this regard, Friedrich Dürrenmatt's ballad Minotaur offers a resonant metaphor: The mythical creature exists solely within a hall of mirrors, knowing only itself and its reflections. This powerful metaphor for isolation, self-discovery and identity formation resonates with our exploration of algorithmic entities.

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Design Fiction as Methodological Exposure

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Technological futures are increasingly framed as inevitable, with computational systems positioned as the natural pathway to progress and improvement. This determinist rhetoric shapes expectations about what futures are plausible and worth pursuing. Such rhetoric is reinforced through institutional settings—such as higher education—where these technological imaginaries are repeatedly proposed, rehearsed, and normalised through procedural logics of legitimacy that narrow what can be articulated as "realistic". To examine these conditions, the paper uses Research through Design and Design Fiction as reflective practices for surfacing how futures are normalised through research and pedagogical practices. The paper presents a reflective analysis of a series of Design Fiction artefacts (diegetic prototypes) based on the archetype of institutional promotional media. The reflective analysis shows how optimisation-centred futures are easy to justify while relational or non-instrumental futures struggle to remain intelligible. The contribution is methodological, reframing Design Fiction as a form of methodological exposure that makes visible the future-making work of procedures that are often treated as neutral.

1 Introduction

Computational technologies are commonly framed as solutions to complex societal, institutional, and even existential problems. Faith in technological panacea has a long lineage, described as the technological fix in the 1960s (Johnston 2018) and later as "technosolutionism" (Morozov 2013), the conviction that complex human problems can be solved through computational means. In contemporary innovation discourse, technology is often treated as panacea—an assumed pathway to more efficient, more optimised, and more advanced ways of living. The future, in turn, becomes synonymous with technological development, and progress becomes a matter of implementation.

A defining feature of this logic is its temporal politics. Cheney-Lippold's (2025) account of a future portrayed as always being on the brink of arrival shows how technological innovation is routinely framed as an inevitable thing "from the future," thereby narrowing alternative imaginaries. Progress appears as the natural consequence of a given technological advancement, and any suggestion to the contrary is cast as luddism or the product of a laggard mind. For this strain of technological determinism (Héder 2021), the future becomes less a space for contestation than a fixed destination.

These narratives do more than persuade. They shape what comes to feel like common sense. In a Gramscian sense, common sense is not neutral but a product of cultural and institutional mechanisms

Keywords: Design Fiction, Research Through Design, Technological Determinism, Methodological Exposure, Futures, Design Education.

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that make particular circumstances appear as natural and necessary (Gramsci 1971). Educational contexts are among the most significant sites where this socialisation takes place. Consequently, from a Gramscian standpoint, schools and universities are sites of technological indoctrination as well as places where people are shaped as subjects of progress, where ideas of improvement are defined. In this way, educational contexts become "natural" environments for embedding and normalising technological systems, especially those deemed as supportive, inevitable, or crucial for human intellectual development.

At the same time, the future-making work of educational research is rarely addressed explicitly. While research is frequently mobilised to justify particular developments or reforms, the methods through which educational futures become thinkable or plausible often remain opaque. Questions concerning what kinds of futures can be articulated, which ones collapse under scrutiny, and why some of them appear inevitable while others seem unrealistic, are seldom treated as methodological concerns. Instead, following the positivist tradition of social sciences, method is typically positioned as a neutral means of inquiry, rather than as something that actively shapes the horizons of possibility (St. Pierre 2021).

Design education has a privileged position in these circumstances. As a field concerned with making, imagining, and intervention, it is frequently tasked with engaging the future directly through speculation, prototyping, and scenario-building (Koskinen et al. 2011). Yet, design education is itself embedded within institutional and research frameworks that privilege feasibility and demonstratable value. This creates tension between futures that can be imagined and those that can be articulated within the boundaries of dominant educational and research practices. Some futures travel easily across curricula, assessments, and research outputs, while others are simply ignored or even fail to be imagined in the first place.

When it comes to futuring, Design Fiction (DF) has emerged within design research as a practice for engaging these and other tensions. Often associated with speculative or critical design, DF uses fictional, yet plausible artefacts, or "diegetic prototypes"[1] to explore the implications of technologies and social arrangements (Bleecker et al. 2023). DF is commonly understood as a way of materialising or visualising plausible near-future scenarios to guide decision-making in the present (Bleecker et al. 2023). When taken up this way, its value is often assessed in terms of provocation or critique. However, less attention has been paid to how DF might be used to examine the conditions under which futures are conceptualised in the first place.

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1. A diegetic prototype is a speculative artefact that exists within the narrative world of a design fiction, where it is presented as an ordinary, functioning object. By appearing as already embedded in everyday life, it allows audiences to encounter a possible technology through use, context, and social meaning rather than as a formal proposal or prediction. The term was coined by David A. Kirby (2010) to describe how films situate imagined technologies within story worlds and was later developed by Julian Bleecker (2009) to describe how fictional artefacts can also be used to prototype cultural adoption and lived experience.

Consequently, this paper regards DF differently. Rather than using it to imagine and analyse educational futures, DF is used as a *reflective practice* that exposes and triggers critiques about how futures are already being shaped. Therefore, the focus is not on what futures should be adopted or avoided, but on how procedural logics, such as feasibility, legitimacy, and coherence operate in the background of research and pedagogical practices by stabilising particular futures while narrowing others.

The paper reflects on a series of diegetic prototypes developed as part of a doctoral research project on futures in design education. The artefacts take the form of short promotional videos for a fictional Master of Design programme and deliberately adopt the tone, tropes, and conventions of contemporary higher education marketing. Rather than analysing these prototypes as representations or critiques in themselves, the paper examines the process of designing them, highlighting moments when certain futures felt easy to articulate, when others became impossible to sustain, and when internalised expectations about what "made sense" shaped design decisions.

The paper's main contribution is methodological rather than prescriptive. It does not argue for a particular future for design education, nor does it position design fiction as a method to be applied within educational research. Instead, it argues that DF, when situated within Research through Design (RtD), can function as a form of methodological exposure by making visible the often-unexamined procedural logics through which futures (in this case, educational) are considered intelligible, credible, or unattainable. By exposing these logics, the paper invites a shift in how futures are approached in educational research. Instead of asking what futures should be designed, the paper encourages examining how technological determinism shapes the conditions under which certain futures appear inevitable.

2 Background

This background section positions futures in design education not as things to be designed or predicted but as outcomes of ongoing ontological, pedagogical, and methodological practices. It is within this context that the paper turns to DF—not as means of proposing or critiquing alternative futures, but as a practice capable of making visible the often-overlooked role of method in the production and normalisation of educational futures.

Institutional and popular discourse often frame design as a creative and solution-oriented activity capable of addressing complex issues through innovation and ingenuity (Tonkinwise 2018). In such accounts, design is portrayed as broadly accessible and inherently positive—something that can be readily applied and transferred across domains. These framings tend to foreground design's capacity to generate attractive and timely solutions. However, they also tend to disregard the long-

term consequences of design interventions and the circumstances and constraints in which designers operate.

In contrast, critical design scholarship approaches design as a form of world-making with deep ontological consequences. From this standpoint, design does not respond to existing situations but participates in shaping the material, social, and symbolic conditions through which particular ways of imagining the future come into being. As Anne-Marie Willis argues: design is recursive; "we design our world, while our world acts back on us and designs us" (Willis 2006, 70). This formulation foregrounds the idea that design contributes to the production of realities that, over time, come to feel normal or inevitable. Crucially, this world-making is not only conceptual but ethical in its effects. According to Verbeek, when technologies co-shape human actions, designers of said technologies are effectively doing "ethics by other means," since design decisions materialise certain possibilities for acting (Verbeek 2006, 369).

Regarding design as an ontological practice has implications for how futures are approached in design education. While futures may be articulated through speculative projects or visionary discourses, they are also steadily produced through everyday pedagogical practices, institutional policies, and disciplinary norms. Design education, as it has largely developed within Western modernist traditions, has been shaped by Western assumptions about progress and improvement. These assumptions are embedded in how design problems are framed, how learning is structured, and how outcomes are evaluated, often positioning the designer as someone who can shape preferable futures through the application of appropriate methods and tools. Read through Verbeek's (2006) account of mediation, this is not simply a matter of teaching students to design "responsibly." It is also crucial to recognise how design education trains future designers to participate in the shaping of conduct and values, often implicitly, through the artefacts and systems they learn to produce.

In recent years, alternative orientations within design scholarship have challenged the notion that design should be guided by a monist, universal vision of progress. Arturo Escobar's (2018) contribution of "designs for the pluriverse" acknowledges the coexistence of multiple worlds and ways of being and knowing. Thereby, drawing attention to the limits of design approaches grounded in Western epistemologies of abstraction, standardisation, and control. Rather than treating difference as a problem, pluriversal design emphasises relationality, situatedness, and the sustaining of multiplicity (Escobar 2018). Pluriversality is not framed as an expansion of options within an existing system, but as a challenge to the ontological assumptions that structure what design is understood to be and do.

Within design education, these pluriversal concerns have intersected with growing attention to care, responsibility, and relationality. Scholars have argued for pedagogical approaches that foreground reflection (Schön 1983), uncertainty (Ajjawi et al. 2025; Gravett 2025), and dialogue (Gravett 2025; Orr and Shreeve 2017) that resist reducing design

education to a rehearsal of producing market-ready solutions or acquiring a set of transferable skills. The design studio, curriculum design, and assessment practices can be understood as spaces where ways of being a designer are cultivated and where futures are implicitly rehearsed. In this sense, design pedagogy has consequences beyond what students learn, as it shapes what kinds of futures come to appear meaningful or achievable through design practice.

At the same time, these pedagogies are practiced under broader political-economic conditions that place constraints on what can be articulated or sustained in educational practice and shape the wider institutional logics through which futures come to be framed. The history of futures studies situates its modern Western emergence in the postwar rationalisation of futures through technological forecasting and strategic planning, informed by intellectual traditions such as systems thinking, before its further industrialisation through business uptake and its more recent employment for neoliberal foresight practices. (Son 2015). This heritage is distinctively instrumentalist as futures studies has become "a mere strategic tool of management planning" (Son 2015). In contemporary corporate contexts, futuring practices are often employed to legitimise predetermined technological roadmaps rather than open genuine speculative space (Ringfort-Felner et al. 2023).

A comparable logic is evident in the contemporary neoliberal university. Functioning in corporate style, the neoliberal university favours practices that end up commodifying knowledge and privileging measurable outcomes and demonstrable returns at the cost of educational values (Troiani and Dutson 2021). Subsequently, futures that favour technological optimisation to achieve better scalability and measurability align naturally with institutional imperatives, while relational or care-oriented futures struggle to assert their value. While relational and care-oriented futures are not explicitly rejected, they are overlooked or marginalised because they sit uneasily with dominant modes of organising knowledge and practice (Ansari 2025; St.Pierre 2021).

It is precisely this tension between futures that motivates the methodological approach of this paper. Rather than assuming DF can automatically generate critical distance, the study treats the design process itself as a site of inquiry. Through attempts to articulate educational futures within the constraints of the promotional video archetype, the research exposes how institutional logics operate from within, shaping what feels plausible and what collapses under scrutiny.

The observations made during the study point toward the role of method in shaping futures within design education and educational research. Methods are commonly treated as neutral tools for inquiry, evaluation, or improvement (Law 2004; St.Pierre 2021), even though method has long been contested as a universal foundation for inquiry (Feyerabend 1975). Methods play a central role in determining what kinds of questions can be asked, what counts as evidence, and which futures appear plausible or legitimate (Ansari 2025). In futures-oriented contexts, method itself participates in world-making, as it shapes the horizons of possibility within which design education operates.

3 Design Fiction as Research Through Design

DF is a practice within design research that uses diegetic prototypes to explore the cultural and social implications of emerging technologies and practices (Bleecker et al. 2023). Rather than predicting or proposing futures, DF operates through proximity and exaggeration, creating recognisable scenarios that feel connected to the present while remaining clearly speculative. Its critical force does not lie in offering solutions but in making current assumptions about a given future visible. DF can also function as a way for interrogating how futures are currently being portrayed and justified.

This paper uses DF for RtD, treating design practice as a mode of inquiry rather than a means of producing solutions or validated outcomes. Building on Frayling's (1993) influential account of research *for*, *into*, and *through* art and design, RtD frames making as a legitimate route to knowledge production. Findeli et al. (2008) further clarify RtD as project-grounded research that aims to be both rigorous and relevant, without collapsing the research project into the design project. RtD foregrounds making as a way of thinking, allowing questions to be explored through material and visual engagement rather than resolved in advance (Galdon and Hall 2022). Knowledge is generated through reflection on the design process, the artefacts produced, and the conditions under which particular design decisions become possible or constrained. Therefore, the artefacts produced by this research are treated as sites of inquiry rather than outcomes.

The diegetic prototypes discussed in this paper consist of a series of short videos created by the first author in the form of promotional media for a fictional Master of Design programme at a fictional university. On surface level, the videos resemble familiar higher education marketing content. They adopt an upbeat tone, use generic imagery, and draw on the language of innovation, efficiency, and opportunity, commonly associated with start-up culture and technology-driven educational reform. These conventions were deliberately adopted for plausibility. By exaggerating existing discourses while remaining plausible, the videos were designed to sit uncomfortably close to the present.

Crucially, these artefacts are not presented as speculative proposals or predictions of a future to be adopted or avoided. They are not evaluated in terms of feasibility, effectiveness, or desirability. Instead, they function as design fictions in a critical sense, suspending the question of implementation to highlight assumptions and logics through which futures become intelligible. Their purpose is not to argue for or against a particular future, but to make visible the criteria by which futures are rendered coherent, reasonable, or inevitable.

Within this research, DF is used as a probe to critique method. The process of designing the videos—choosing language, imagery, narrative structure, and implied pedagogical arrangements—surfaced moments where some futures became easier to articulate than others. Decisions about what could be exaggerated without breaking plausibility, what needed to remain implicit, and what risked appearing implausible re-

vealed underlying expectations about efficiency, automation, creativity, and value in design education. Rather than depicting a future state, the artefacts exposed the conditions under which futures are made legible.

DF also operates here as a form of disturbance through the absurd. By amplifying familiar logics rather than opposing them directly, the videos produce moments of discomfort through proximity rather than shock. Practices that are often framed as incremental or benign, such as the outsourcing of knowledge work to automated systems, the optimisation of learning processes, or the transactional framing of education, become more visible when taken to their logical extreme. The futures depicted in the speculative artefacts are unsettling precisely because they remain continuous with existing institutional rhetoric.

Simultaneously, DF functions both as a reflective device and methodological component within the research process. Questions of coherence, relevance, and legitimacy repeatedly surfaced during the act of designing the videos, highlighting how methodological expectations exert pressure on speculative work even in the absence of evaluation or implementation. Reflection was therefore not confined to a retrospective analysis of the artefacts but deeply entangled with the design process as it unfolded.

4 Reflective Analysis of Design Fiction Artefacts

Before detailing reflection-on-action, it is useful to briefly situate the artefacts that anchor the analysis. The artefacts are a series of short DF videos produced in the style of a university advertisement, using techno-optimistic language, upbeat corporate background music, and general aspirational imagery. They promote a fictional postgraduate design programme where AI tutor bots replace most of the faculty, and students are encouraged to outsource design work to generative systems. Figure 1 shows a still from one of the videos.



Fig. 1. Screenshot from a Design Fiction video modelled on institutional promotional media, introducing a GenAI-led design programme. A viewing link is available upon request from the first author.

This section reflects on what became visible through the process of designing the diegetic prototypes. The analysis focuses on moments in the design process where certain decisions felt straightforward while

others became difficult or unstable. In the context of this analysis, references to method do not refer to the RtD methodology guiding the study, but to the procedural logic and criteria through which educational futures are legitimised in practice.

4.1 Futures That Felt Obvious or Inevitable

One recurring moment in the design process involved deciding how the fictional design programme would justify itself. Framing the programme around efficiency, personalisation, and optimisation required little deliberation. Claims about AI tutors improving learning experiences or streamlining educational processes— “Design’s brightest minds, one prompt away”—could be scripted easily using familiar institutional and techno-optimist language. These claims felt immediately plausible, not because they were persuasive or desirable, but because they aligned with established ways of accounting for value in higher education.

This ease pointed to a procedural logic in which educational futures are expected to demonstrate efficiency, improvement, and measurable benefit. Futures that align with these criteria do not require extensive justification and can simply be stated. The design work thus revealed how certain educational futures are already pre-aligned with dominant modes of legitimisation, making them appear obvious or inevitable without explicit argument.

4.2 Futures That Became Implausible or Collapsed

In contrast, other futures proved difficult to sustain within the archetype of promotional media. Attempts to articulate relational, slow, or non-instrumental forms of learning, such as those centred around uncertainty, shared inquiry, or forms of education not easily measured or captured by credentials, proved difficult to make credible within the same archetype. These elements often felt awkward within the promotional format, requiring additional explanation or justification that risked breaking the artefact’s plausibility.

Notably, potential implausibility of the artefact was not a matter of personal preference or aesthetic discomfort, but of misalignment with dominant evaluative criteria. For example, futures grounded in relationality or non-instrumental learning struggled to find a stable foothold within the fictional near future scenarios. Their fragility highlighted how certain forms of education, while not explicitly rejected, become marginal because they do not conform easily to the structures through which educational futures are typically communicated and, importantly, judged.

4.3 Procedural Logic as an Internalised Constraint

Across the design process, procedural expectations operated less as explicit rules and more as internalised constraints. Even in the absence of evaluation, implementation, or external judgement, decisions

were shaped by concerns about recognisability and credibility. The artefacts needed to resemble something that could plausibly exist within a near-future university, and this requirement narrowed the space for speculation.

Internalised constraints originated from first-hand experience designing curricula and from larger institutional and cultural discourse about what educational futures should look like to be taken seriously. Consequently, DF exposed how procedural logic functions from within practice, shaping what can be exaggerated, questioned, or left unsaid.

Taken together, these three reflections suggest that the diegetic prototypes functioned less as depictions of futures and more as sites where the criteria governing educational futures became visible. Therefore, we assert that the value of the work lies in how the design process surfaces the often-unexamined logic through which futures are rendered plausible, legitimate, or dismissible. It is this activity of surfacing that informs the discussion that follows.

5 Discussion

Analysis of the diegetic prototypes' design process suggests the significance of DF in this study lies less in the future scenarios it depicts than in what the process made visible about our current near-futures already shaped by dominant modes of legitimisation. Rather than functioning as a speculative proposal or a critique aimed at persuading an audience, the prototypes operated as a site where the procedural logic governing educational futures could be encountered directly. Thus, the role of DF shifts from imagining near-future scenarios to exposing the conditions under which certain futures become intelligible, credible, or dismissible in the first place.

This distinction between imagining and exposing matters. Educational research often treats futures as entities to be evaluated or improved, while not examining the logic through which those futures are rendered plausible. In the case of the DF videos, futures organised around optimisation, automation, and efficiency aligned easily with familiar institutional forms of justification, while futures grounded in relational or non-instrumental forms of education struggled to remain coherent within the archetype. These dynamics did not arise from explicit ideological commitments, but from internalised expectations around legitimacy and recognisability. DF, as used here, exposed these expectations.

Framing DF as methodological exposure also clarifies its relationship to RtD. RtD provided the methodological orientation for the study as a way of thinking through making, where insight emerges from reflective engagement with practice rather than from validation or generalisation (Galdon and Hall 2022). DF, within this approach, was not a method applied to educational research, but a practice through which the future-making effects of procedural logics could be made visible. In this sense, DF did not introduce speculation into the research process.

Instead, it revealed how speculative judgements were already embedded in the criteria that shape educational futures.

Discovering DF's revelatory capacity is a key contribution of this research with implications for debates on ontological design and pluriversality in design education. If design and education are understood as world-making practices (Willis 2006), then research and pedagogical routines must also be recognised as participating in the production of futures. The analysis suggests that pluriversal futures may not be excluded through overt rejection. Instead, they are narrowed through procedural logics that privilege certain forms of value, accountability, and sense-making. Futures that do not align with these logics may remain conceptually desirable yet become dismissed as difficult to articulate or justify within dominant research and institutional frameworks.

From this viewpoint, calls for care, relationality, or plurality in design education risk remaining overlooked if the procedural conditions under which research and pedagogy operate are left unexamined. The contribution of this study lies in acknowledging DF's capacity to make those conditions visible. By amplifying familiar logics rather than opposing them directly, the analysed artefacts exposed how deeply these logics are internalised even within speculative and critical practice.

Rather than positioning DF as a neutral or transferable method for educational research, this paper asserts its affordance as a situated reflective device that can operate within specific research contexts to surface assumptions that might otherwise remain hidden. In this way, DF creates conditions for reflexivity, allowing researchers to attend to how futures are shaped through the practices they employ.

6 Conclusion

This paper has argued that DF is a practice that exposes the procedural logics through which educational futures are produced and normalised. Through a reflective RtD engagement with the process of designing diegetic prototypes, the study demonstrated how certain futures became easy to articulate. Whereas, other futures struggled to remain coherent, not because of explicit intentions or values, but because of internalised procedures and criteria for plausibility and legitimacy.

The paper provides a methodological perspective on the shaping of futures within educational research and design education practices by treating DF as a situated reflective device. Additionally, it makes an ontological contribution by identifying an affordance of DF that has not yet been examined by design research. We are not asking which futures should be pursued but calling for greater criticality to be applied to how futures come to appear inevitable, reasonable, or excessive through the everyday practices of research and pedagogy. In doing so, it asserts the DF method as an epistemic orientation, in addition to technique, for creating space for futures that are otherwise foreclosed.

Statement on AI Use. The artefacts the submission critically discusses were created using iMovie, Adobe InDesign and Adobe Illustrator. Some portions of the artefacts' scripts were generated using ChatGPT-4, a large language model from OpenAI. Voiceovers in the artefacts were generated using NaturalReader, an AI text-to-speech tool.

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(Deep) Representation: a Layered and Interconnected Mediation

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Representation, in its most rudimentary sense of 'standing for' something else, operates as a fundamental yet profoundly complex mediation within contemporary AI models. These systems do not simply process information but re-elaborate it through a sequence of transformations, producing what we call deep representations: encodings that are simultaneously layered, interconnected, and polysemic. Drawing on Stable Diffusion as our case study, this work traces the representational journey from world to model, examining how each layer of mediation reshapes what 'standing for' means. We begin with the mediations that precede the model: data as *capta* rather than given, digital image as cultural object and computational substrate, dataset as epistemic border, and pre-processing as structural constraint. We then turn to transformations within the model itself: the training, loss functions, and material economies that shape learned representations, differing fundamentally from standardized compression. We conclude by questioning whether the inherited vocabulary of representation remains adequate to describe what these systems actually do.

1 Introduction

In 1965, conceptual artist Joseph Kosuth exhibited his artwork *One and Three Chairs at MoMA* (in Figure 1). Influenced by the new theories of language and signification, his work draws on Minimalism but engages with themes the movement had sidelined: how ideas, signification, and meaning are constructed. The central idea of the artwork is to explore the nature of representation itself: the concept of a chair is, in fact, represented through three different utterances: as an actual chair, a photographic image of the actual chair, and a dictionary entry of the word "chair". The viewer is then confronted with "three" chairs, each represented and experienced through its distinct properties.

Sixty years later, given the rapid advent and spread of generative AI, we can update Kosuth's artwork with a fourth form of representation, on the right in Figure 1, one that not only is becoming technically and culturally crucial but that combines, merges, and transforms the two representational modalities employed in Kosuth's artwork, the image and the text. Alongside the actual chair, the related dictionary entry and photographic image, inspired by Kevin Esherick's *Hyperportrait*, we insert the embedding of the chair, a deep learning representation that corresponds to the concept within, in this case, the textual branch of the model CLIP. This representation, as we explore in this article, is shaped simultaneously by the collection of numerical representations of the training data, by their digital transformations, by the models them-

Keywords: Representation, Digital Image, Data, Latent Diffusion, Mediation.

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selves, and by their objectives. All these layers ultimately contribute to the so-called latent vector representation.



Fig. 1. Updated version of Joseph Kostuh's *One and Three Chairs* with the visualization of the embedding of "chair" (on the right).

We propose to call this fourth chair a *deep representation*: a term that captures both its technical lineage (deep learning) and its defining characteristics. Deep representations are simultaneously layered (undergoing multiple cascading transformations), interconnected (each element defined relationally rather than intrinsically), and polysemic (carrying functional, technical, and relational meaning concurrently). Unlike Kosuth's three chairs, each occupying a distinct ontological register (material object, visual image, linguistic definition), the deep representation collapses and reconfigures these registers. It is at once image and text, material and abstract, individual instance and statistical aggregate.

Within the contemporary context of machine learning and deep neural networks, representation is a key term with a specific technical denotation, resulting from the layered history of representing information within digital computational technologies. The conception, definition, and implementation of the term derive from and belong to the specialist language of computer science, where it refers to the way information is presented and described within digital computational systems. As Paul Dourish argues, "there is no information without representation": it is the outcome of an assemblage of "hardware, software, data representations, diagrams, algebras, business needs, spatial practices, principles, computer languages, and related elements, linked by conventions of use and rules" underpinning an historically situated practice of information processing (2017, 27-28).

The assemblage the term underpins asks for a more nuanced investigation of what its meaning implies in the contemporary state of AI models. The concept of representation in deep learning models is deeply polysemic. While this is not the only interpretation of the word that is crucial to neural networks, in this work, we present a discussion of representation as re-presenting something else. We interpret representations in neural networks as re-elaborations of the input or output data into an encoding that 'stands for' the data in complex ways, as a media-

tion—hence our adoption of the term deep representations to mark this specific mode of standing-for.[1]

In what follows, we trace the representational journey from world to model output, examining how each layer of mediation transforms what 'standing for' means. To do so, we take into consideration the specific case of latent diffusion models as proposed by Rombach et al. (2021), implemented in commercially available text-to-image software, such as Stable Diffusion, released by some of the authors after joining Stability AI. Stable Diffusion was chosen as it is the most popular open-source image generation model, which helps us ground the discussion into something that is at the same time widely known and currently being used in practical applications.

Section 2 examines the layers of mediation that precede the model: from data as capta, through the digital image as computational object, to the dataset as epistemic filter, and finally, preprocessing as architectural constraint. Section 3 turns to representations within the model itself, showing how the training process and architectural choices produce a fundamentally different mode of compression than standardized formats like JPEG. We conclude by questioning whether the inherited vocabulary of representation—standing for, mediating, encoding—adequately describes what deep representations do, or whether they constitute a productive mode of presentation that has moved beyond referential logic.

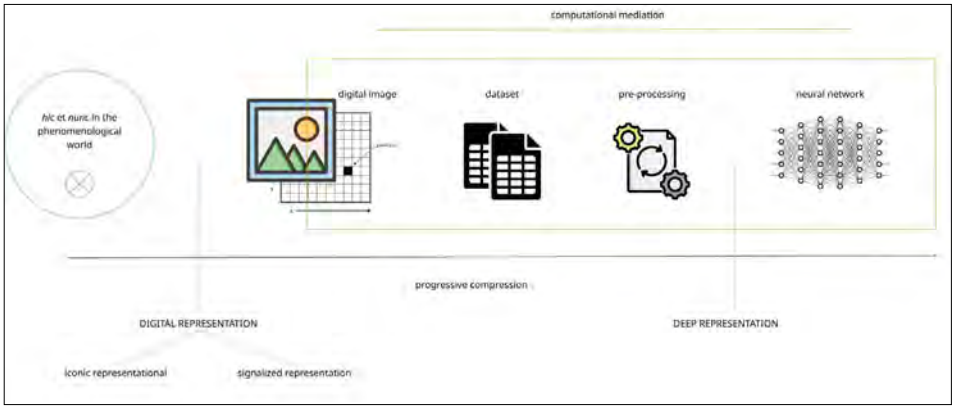


Fig. 2. Diagram visualizing the path from the world (on the left) to the model (on the right) and the layers of mediation involved.[2]

2 Representation from the World to the Model

Between the world and the neural network's internal representations lie multiple layers of mediation, each transforming how information is encoded and what is represented. We trace this path through four transformations: first, the constitution of data itself as structured observation rather than raw given; second, the digital image as a dual entity—both

1. In the remainder of the paper, we refer to the representations that are internal to deep learning models as 'deep representations', and not the more common 'neural representations', as the relation to neuroscience is beyond the scope of this work. For a nuanced discussion on this perspective see: Dhaliwal et al. 2024.
2. This diagram displays what appears as a simple and linear process; it is an attempt of making diagrammatically visible what is actually a complex and intricate phenomenon that involves an entangled and networked infrastructure of humans, devices, interfaces, submarine cables, data centers, energy resources, networks, software, hardware, algorithms - to name a few.

cultural object and numerical array; third, the dataset as an epistemic infrastructure that determines what knowledge enters the model; and fourth, preprocessing as the final architectural constraint that reshapes data into forms a specific model can process. Each layer is not merely preparatory but constitutive: it actively shapes what the model can learn to represent. We visualize a simplified version of this path in the diagram in Figure 2.

2.1 Data

The broad and general term "data" asks for a more nuanced and critical reflection when thinking about representation. Data are commonly defined as "a collection of facts, numbers, words, observations or other useful information" (IBM 2024) that constitute the resource for the processes of analysis behind decision-making. Data can be of different types and part of different operations. In this context, particularly, we refer to digital information, a representational modality founded on digits, which form bits, which form bytes.

However, as it has been argued against the mystification the term itself contains, of being "something given" (Drucker 2020; Gitelman 2013), data are neither "raw" nor "natural resources", but result from processes of generation, capture, gathering and curating all of each shaped by the epistemology structuring the "parameters of the search" (Drucker 2020, 49). They should rather be named *capta* as the term more clearly highlights how the model (both as technical and conceptual) shapes the information it necessitates according to its own parameters and measuring criteria.

This general critique of data as *capta* becomes concrete when we examine the specific form data takes in image generation models. Stable Diffusion consists of a layered computational architecture and, like digital computing technologies, it processes digital information. Stable Diffusion's training data consists of images with their corresponding textual captions, which means digital representations of pictorial and visual information and textual information. This representation constitutes what we commonly refer to as the digital image, a specific form of data that exists simultaneously as visual representation and computational substrate.

2.2 The Digital Image

Digital images are instantiated as specific raster data structures, also called *bitmaps*, characterised by pixel space. Pixel space is the modality through which historically the energy of photons forming light has been encoded within digital computational systems (Terras 2016): the pixel space results from processes of signalization (detecting energy, converting it into discrete, measurable electrical charges) and digitalization (converting the electrical charges into digital numbers described by bits, sequences of values between 0 and 1, the "language" of computers). In this way, pixels constitute digitized samples of a visual scene at a given

point, and those samples are bit sequences that a computational system can elaborate, process, and store in its RAM.

Pixel space is not only an informational structure and logical convention, but also the site of manifestation of the digital image, having the material skin of the screen. Composed of physical pixels emitting light, display screens function both as an interface and the terminal of what Berry calls *computational mediation* (2011) to refer to the double mediation enabled by software, which happens whenever computational technologies represent: first, the translation into bits, second, the translation of that representation into a human-readable display according to a specific format.

The digital image both represents and is represented. At a human scale, we experience and interpret it as a visual, continuous, and meaningful representational surface standing for what it depicts. As a cultural, social, and semiotic object, the digital image mediates the world, embodying a *way of seeing* (Berger 1972). At a computational scale, the image is represented as information through an invisual data structure,[3] existing as a numerical representation related to electrical voltage. The digital image is then the site where not only ways of seeing are embedded, but where those precipitate and get transcribed into arrays of numerical values open to processability.

Being specific about digital images (Rose 2023) means highlighting the materiality, configuration, and properties of a kind of representation as encoded, operated, and processed by digital computational technologies, software, and hardware. In their contemporary form, digital images need to be understood as objects "materially structured by the *logic of computation*" (Gaboury 2015, 45) and, for this reason, as the site where different conceptions and modalities of representation both collide and coalesce in weaving world and numbers together. Individual digital images, however, do not enter models in isolation. They are aggregated, ordered, and filtered through another representational structure: the dataset, which functions as the epistemic border determining what knowledge about the world the model inherits.

2.3 The Dataset

LAION 5B collects and gathers more than five billion digital images scraped from the web. The ensemble of these images with their ways of seeing and their bitmaps translations constitutes the *epistemic border* (Pasquinelli and Joler 2021) characterizing Stable Diffusion: what knowledge about the world it has inherited. In the context of machine learning, a dataset is an object of knowledge that takes the form of a table and hence works according to its representational function (Mackenzie 2017). It embodies a way of seeing as well, defined by the criteria behind the selection, collection, and ordering of its data. The ordering is

3. We draw this term from the conceptualization developed by Mackenzie and Munster (2019) and later taken up by Parikka (2023), in which "invisual" refers to the dimension to which images belong within digital computational technologies and platforms – a dimension that exceeds and outscales optical and visual paradigms of observation.

realized through the interplay of the verbal and the visual, which takes and varies shapes according to the purpose the dataset has been conceived for: it could be the assigning of categories' labels, as in the case of ImageNet or the scraping of images with their captions from the Web, as in the case of LAION5B.

In this way, a concept expressed through words is guaranteed a visual correspondence and, since the ruling criteria of this object of knowledge respond to statistical principles and logics of models, representation is twisted into *representativity* (Malevé and Sluis 2023). Qualitatively, images and text function as proxies for concepts;[4] quantitatively, more and more images, more and more bitmaps for the same label or caption help the model to learn a more accurate representation of that concept.

Materially speaking, in gathering huge quantities of data, the dataset has a specific *digital weight,* which requires a proportional computing power to process it. LAION5B counts 220 terabytes for images and approximately 2,65 terabytes for metadata. Neural networks in general and Stable Diffusion in particular are able to deal with this amount of information thanks to their representational logic and procedures: they, in fact, operate on and with different representations of the data they are fed. Yet even after images are gathered into datasets with their textual annotations, one final transformation occurs before they enter the model: preprocessing, which reshapes the digital image according to the structural expectations of specific neural network architectures. Here, the same image becomes a fundamentally different representational object depending on whether it enters a convolutional or transformer architecture.

2.4 Preprocessing

Digital images are dealt with by neural networks as *tensors*, a data structure consisting of spatial matrices of numbers (the grid) with an additional dimension for the color encoding (three dimensions for RGB) and, often, a batch size (inputs are processed in parallel in groups). Instead of thinking of images as two-dimensional areas, in neural networks, they are treated as four-dimensional volumes. Most versions of Stable Diffusion (1-2) process tensors of around 512x512x3 pixels with values ranging from -1 to 1.

Tensors, in order to be treated adequately by the networks, are pre-processed to achieve standardization and learn invariances, i.e., the aspects that the models should not rely on to make predictions. The preprocessing pipeline, however, diverges significantly depending on the architecture receiving the image. Convolutional neural networks and transformer-based models impose *different structural expectations* on their inputs, reflecting their fundamentally different approaches to spatial understanding. Convolutional architectures process images as continuous spatial fields, relying on explicit augmentation techniques,

4. Many investigations and analyses have shown the cultural and situated dimensions, which end up being discriminatory, of this apparently natural correspondence, see Prabhu and Birhane 2020, Crawford and Paglen 2021, Denton et al. 2021.

i.e., flipping, rotation, shifts, synthetic variations, and adjustments to hue, saturation, and intensity, to build invariance to transformations. The convolutional approach maintains locality.

Transformer architectures, by contrast, require explicit patching of the image into discrete segments that are processed separately. While convolutions handle spatial relationships implicitly, the patching process also needs to include position encodings, i.e., representations of where the patch is within the image. Different from convolutions, used by Rombach et al. (2021), in transformers, the flattening of patch embeddings fundamentally restructures how the image is represented. Where convolutional models emphasize *locality*, transformers prioritize *globality*, *relationality*, and *contextual understanding*. These architectural differences mean that the same digital image, depending on whether it enters a convolutional or transformer pipeline, becomes a fundamentally different representational object.

3 Representation Within the Deep Learning Model

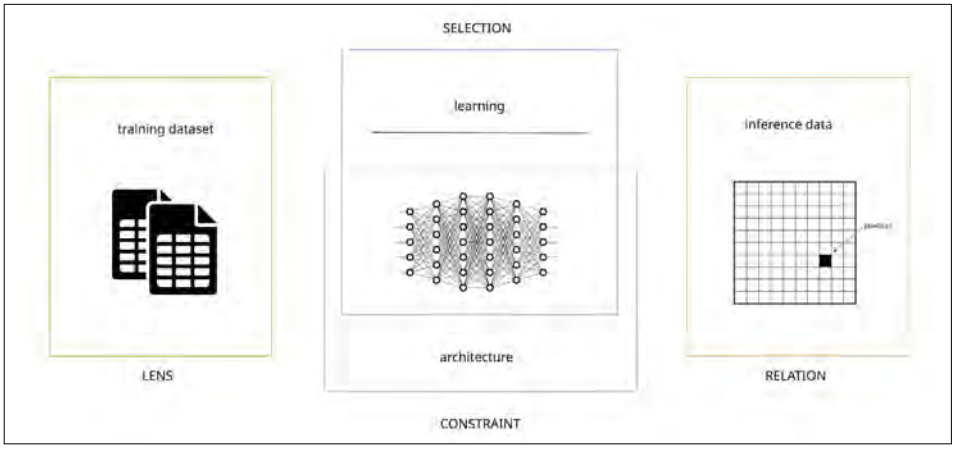


Fig. 3. Diagram schematizing the four layers influencing representation compression within the model. On the left, the training data acts as a lens to the model. In the center, the architecture and learning provide, respectively, a structure and functionality. On the right, the inference data is what determines the meaning: the relationships between representations.

If Section 2 traced the layers of mediation between world and training data, we now examine representations within the model: the transformations that constitute learning itself. Upon entering the network, the preprocessed tensor undergoes a sequence of non-linear transformations. Each layer produces what we might call *intermediate representations*: activation patterns that progressively abstract the input from pixel values into increasingly complex statistical descriptions of visual features. These transformations are not explicitly programmed but emerge from training, where the network learns which patterns to emphasize and which to suppress based on the dataset and the error function.

Stable Diffusion's architecture combines two neural networks: a Variational Autoencoder (VAE) (Kingma and Welling 2015) and a U-Net (Ronneberger et al. 2015). The VAE compresses image representations into a statistical representation, then decompresses them into the original space. What distinguishes latent diffusion from traditional diffusion models (DDPM) (Ho et al. 2020) is precisely this compression. Rather than operating on full pixel space, the entire diffusion process, the progressive denoising that generates the final image, happens within the

VAE's compressed latent space. The U-Net learns to predict and remove noise not from a 512x512x3 tensor but from its compressed equivalent of 64x64x4. This spatial reduction enables Stable Diffusion to generate high-resolution images *efficiently* while maintaining what its developers call "state-of-the-art synthesis results" (Rombach et al. 2021): images that plausibly represent their textual prompts. The Stable Diffusion paper explicitly identifies this compressed space as achieving "a near-optimal point between complexity reduction and detail preservation, greatly boosting visual fidelity" (Rombach et al. 2021). The term "representation" here refers specifically to this compressed form, a mediation shaped by the balance between what can be discarded and what must be preserved.

The technical details matter because they reveal a specific *economic logic*: the denoising in the compressed space denotes both a conceptual framework and a technical procedure that responds to, and is shaped by, economic criteria, namely, the management of material, energetic, informational, and temporal resources. Its main logic aims at maintaining the quality of the generation while "limit[ing] computational resources" (Rombach et al. 2021). It is in this respect that representation stands for both a specific instance and a typology of data representation shaped by specific purposes (as in the case of Stable Diffusion) and for a general historical problem of information representation within digital computational systems.

Representation is a profoundly material and economic term: it accounts for the historically situated practices of information processing and the materialities of information, "those properties of representations and formats that constrain, enable, limit, and shape the ways in which those representations can be created, transmitted, stored, manipulated and put to use" and how their arrangements "matter significantly for our experience of information and information systems" (Dourish 2017, 4-6). Bits, the smallest components digital information is made of, are both "*logical and material entities*" (Blanchette 2011) and these two dimensions exist within a dialectical tension: in this sense, on the one hand, Stable Diffusion and the representational techniques it involves can be understood both as the result of the material development and evolution of CPUs and GPUS and as the result of the correlated conceptual developments within computer science (neural networks, machine learning).

Concurrently, *compression* has accompanied representation throughout the history of digital computing; it is 'the process that renders a mode of representation adequate to its infrastructures' (Sterne 2015, 35). But not all compression operates according to the same logic. The difference between JPEG compression and VAE compression illuminates what makes deep representations distinctive. JPEG compression operates through a standardized algorithmic procedure applied uniformly to any image, discarding information that is imperceptible to the human eye. It compresses the channel in Shannonian terms:[5] a

5. For a detailed discussion of this point see: Impett and Offert, 2026. taken up by Parikka (2023).

task-agnostic, isolated transformation. It is a compressed form of data that allows for transmission, circulation (a format that can be read by hardware and software, that can exist on the web), and storage.

Within the neural network of a VAE, JPEG files of grid pixels (already in their way compressed) are processed through the layers, but the way those get encoded follows another kind of compression. The VAE, in fact, compresses representation through four interrelated forces rather than universal perceptual principles: First, the training dataset functions similarly to what Pasquinelli and Joler (2021) term a 'Nooscope', a *lens* that orients the model's representations according to the statistical regularities, biases, and cultural patterns embedded within it. The VAE learns to compress based on what recurs, what varies, and what correlates in its training data. Second, the architectural choices *constrain* what kinds of representations are possible, privileging certain forms of compression over others through the specific structure of layers, dimensions, and operations. Third, the loss function and learning procedure define what constitutes error, *directing* what the model optimizes for and therefore what features are preserved versus discarded in the compressed representation. Fourth, and most fundamentally, the compressed representation is *relational* rather than absolute. Each image is encoded not according to its intrinsic properties but in relation to all other images the model encounters. A representation is meaningful only through its position relative to other representations: its distances, similarities, and structural relations within the latent space. The four layers are schematized in Figure 3.

These four dimensions make the VAE's compression a fundamentally different kind of mediation than JPEG. Where JPEG applies a standardized transformation, the VAE produces representations that are layered (through sequential transformations), interconnected (defined relationally), and polysemic (simultaneously functional, technical, and relational). This is what we mean by calling them deep.

Return to Kosuth's fourth chair: the latent vector visualized in Figure 1. This representation differs from the photograph not merely in being numerical rather than optical, but in how it came to be. The photograph captures light reflected from a material chair at a specific moment. The latent vector, by contrast, is shaped by its statistical relations to millions of other images the model has encountered: it represents 'chair' not through direct capture but through learned patterns of what correlates, recurs, and varies across LAION5B. It differs from the dictionary definition not in offering a verbal rather than visual description, but in substituting relational position for content. The embedding means 'chair' not through definition but through its distances from 'table,' 'stool,' 'furniture,' and countless other positions in the latent space. The fourth chair thus reveals that representation is always already multiple, and deep learning makes this multiplicity *operational*.

4 Discussion

The deep representations traced in this paper encompass three concurrent definitions. *Functionally*, representation is optimisation: transforming data into a summary that omits unnecessary details and preserves useful ones. *Technically*, it is encoding: computational procedures that transform data from one form to another, from tensor to vector, modifying the information load. *Relationally*, it is re-presentation: the mediated output bears a structured, if complex, relation to all other elements. These definitions do not contradict each other but reveal a constitutive tension: the first two treat representation as *substrate* – material-informational infrastructure shaped by economic constraints – while the third treats it as *form*, i.e., a mediation that stands in some relation to what it re-presents. Deep representations are irreducibly both, and this is what makes them difficult to locate within existing frameworks.

This tension between substrate and form suggests that our inherited vocabulary of representation may be inadequate to what deep learning systems actually do. Agre (1997) already identified representation as AI's central unexamined assumption: classical AI treats it as internal symbols mirroring an external world, inheriting a Cartesian split that makes the relation between representation and world permanently mysterious. His alternative of deictic, situated representations that track affordances rather than model worlds, were designed for agents acting in environments. But deep representations fit neither category. A latent vector is not a symbolic model *of* the world, nor is it an indexical-functional coupling *with* an environment. It is a generative topology: a structured space of possible outputs shaped by statistical regularities and material constraints, whose relation to what it re-presents is economic and relational before it is semantic.

Continental philosophy has long distinguished between two fundamentally different operations that the English word "representation" collapses together: representation as *reference* – the subject placing the world before itself as object,[6] and representation as *production* – the making-actual of sensible form.[7, 8] Deep representations do not point back to a given world; they produce a structured space of possible sensible outputs through a sequence of transformations. They are generative rather than mimetic, constitutive rather than adequate. What deep learning calls "representation" may be neither the transparent sign mapping its referent nor the modern subject-grounded mediation that replaced it, but an *operational mode of presentation* – production of the sensible organised by statistical regularity and material constraint rather than by reference or consciousness.

6. What Heidegger identified as the defining gesture of modernity.
7. What Benjamin called the essence of philosophical method.
8. This distinction finds one origin in Kant's separation of *Vorstellung* (mental representation presupposing a subject-object structure) from *Darstellung* (sensible presentation through mediating operations) (Kant 1998).

For our technical understanding, the implication is that the inherited vocabulary of 'standing for' systematically misdescribes what deep representations do. They do not abbreviate a world; they produce a representation that is defined not by what it refers to but by layers of mediation. Recognising deep representations as productive presentation rather than referential representation is not merely a philosophical refinement. It shifts the questions we ask of these systems: from representational accuracy – does the model stand for the world? – to the material and epistemic conditions that determine what forms of presentation become possible, and what remains unrepresentable.

We question whether the inherited vocabulary of representation, standing for, mediating, encoding, adequately describes what deep representations do, or whether it projects onto them a referential logic they have structurally moved beyond.

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Hostile Interferences Against Improvisational Predictability

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Within the world of the built environment, there is a term known as *hostile architecture*. This refers to designs purposed with preventing individuals from utilizing a space beyond desired intention, or in manners deemed unappealing. Often this manifests as forms of physical barriers or protrusions, hindering common uses such as rest or activity for all out of apprehensions of the perceived misbehaviors of few. A permutation of this adversarial approach is as well used as a means to train machine learning (ML) algorithms by providing a negative to prove the quality of a positive. Just as the communities around these hostile architectural designs find ways to move in and around them, so to do these algorithms find their way to a relative/desired truth. This research envisions an array of hostile/adversarial software architectures as a design foundation to shape performance and force or direct performers into new patterns by preventing, modifying or penalizing those behaviors common to them through the use of interactive machine learning (IML) strategies. By integrating this adversarial history with taxonomic analyses of musical performance, it envisions an array of potential hardware and software interventions to musical improvisation.

1 Background

"Hostile architecture" is an urban design strategy that uses elements of the built environment to purposefully guide behavior through restriction or interference. Typically, this is in regards to a perceived undesirable behavior or public nuisance. The interventions manifest in a number of formats that can include spikes, barriers and angled structures designed for discomfort. In its penalization of behavior it neither takes account of root causes, nor attempts any address thereof. As something which takes its forms within the realm of public (or public-use private) space, it tends to extend its effects beyond those targeted. This can be found in wildly uncomfortable park benches, an intentional lack of protective bus shelters, or the removal of seating from train stations – each exists to prevent the comfort of loiterers or sleep of the homeless, but no less prevents the civic enjoyment of those for whom they are ostensibly designed, while further interfering with elements of accessibility. Often, through their attempt to remove a given activity, they instead accentuate it through their visual presence, even in the absence of the given behavior.

1.1 Hostile Architecture as Artistic Approach

These interventions are at best a nuisance to those targeted, if not a direct frustration to all others. Yet, it is easy to see how these same at-

Keywords: Improvisation, Adversarial Design, Machine Learning, Interactive Training, Hostile Architecture.

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tempts to shape behavior frequently fail at their purpose through the inherent improvisations of the public in their interest in common use of public space. Many novel solutions can be found where-in these designs have been overcome. This includes bedding or planks over spikes (Sorrel 2015), artistic designs such as Sarah Ross's *Archisuits – fashion for hostile architecture* (Newman 2024), or the movement improvisations of *Fakir's Rest* by Stéphane Argillet and Gilles Paté (Argillet and Paté 2003).

This paper takes this human improvisational re-contextualization as a metaphor expanded to software architecture. There are already coined terms for contrarian design – "dark patterns" and "nag-ware" being two examples – to express software designed to interfere with comfortable and intended uses. These antagonistic designs form the basis from which to explore the use of software to interfere with musical intent, thus forcing improvisational explorations.

While performance often must adapt to any number of hindrances – from equipment failures to physical ailments, to unpredictable weather – this research proposes interference as intent. By presenting a barrier against the performer, it is required that their technique must change. By then incorporating modern computational approaches, the natural inclination to develop new habits can be discouraged by a progressive computational learning of new patterns in order to thus update encumbrances. While the incorporation of computationally controlled interference has already been explored in works such as *The Sabotaging Piano* (Dannemann and Bryan-Kinns 2023), they do not respond to the performer. They instead simply provide new hindrances to overcome. By incorporation of machine learning, one can produce a cyclical relationship between training, improvisation and interference.

1.2 Teaching the Student: Training the Machine

In isolated approaches to performance learning, we deal only with our cognitive layers and its various states of self-awareness. When we incorporate an instructor, things become more complex. What then, if the instructor is the instrument – and further, what then when the instrument is itself learning from the performer? As discussed in the next section, several attempts at producing instruments that aid as instructional tools have been designed, but these differ not only in the intent of aid rather than impediment, but in that they do not restructure themselves based on their use. Thus, there is no variation in their relationship to the hierarchies of learning any more than a traditional, non-responsive instrument would provide simply through its sound.

In the interactions generally built between a performer and instrument there is a direct, if non-linear, relationship from practice to result and a simple feedback cycle – first in private rehearsal via on one's own self-assessment, next in instructed practice and finally in performance via the assessment of the audience. There is no response from the device as to what the performer should or should not do. The addition of any such layer yields another node of interaction. Within this four-point interaction, there is no longer a pure cycle; as each additional point ex-

pands the exponent and affiliated intersections or dimensions (Fig. 1). This specific extra node exerts itself as a negative influencer, however. Instead of reinforcement towards success, it actively fights towards failure. Perhaps if, as David Zicarelli writes, “failure tends to be far more interesting than success” (Cascone 2017), this tension might be used to produce a more intriguing performative structure through the cross-instruction between the performer and the performed.

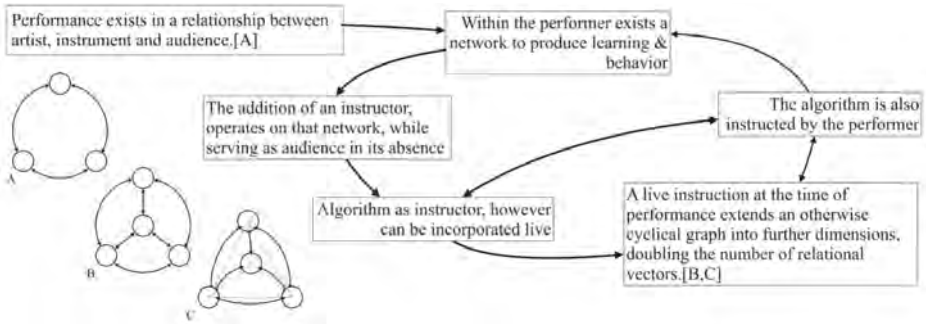


Fig. 1. Networks of performance and learning interaction when instruction is included concurrent to performance.

2 Computer Aided Learning and Instruction

Computational and interface-based approaches have been repeatedly implemented to improve a learner’s skill at an instrument such as those that work measuring only the student’s performative skill (Huang et al. 2008), those providing guiding force to the user (Fujii et al. 2015; Zhang et al. 2019) and those which use a combined approach to detect performance error while providing haptic or visual cues to inform on possible error (Chin and Xia 2022). These approaches are thus-far based on interpretations of a composition and can only detect how correct a performer is in the domains of timing and note accuracy. As such, they are incapable of learning to interpret an improvised performance. These further lack considerations of complex instruments, let-alone multi-instrumentations of collective performance. For such, an algorithmic learning approach is required. These prior studies do inform of two useful components to this research. The first is means to measure and interpret performed notes. The second is inspiration on potential mechanisms to guide the performers movement. (On this second point, the devices thus-far produced to aid learning might even be better suited to this antagonistic approach given their frequent physical design interferences.)

2.1 Machines Learning Music

Much of the uses to date within the realm of sound and music IML has sought to replicated that for which it has been used within the visual and text fields. This can easily be seen in the close analogs between text-to-image generation and equivalent acoustic mimicries of music by genre and text description. As well, the large language model approaches that have been used to produce blocks of writing can be alternatively tweaked, trained and redeployed to produce generative musical scores.

Sound / song recognition algorithms (such as rights management, song identifiers and word recognition) equivocate themselves with with visual identification algorithms both in style and often in use-cases. Sound style transfers such as Qosmo's Neutone (Fyfe and Mitcheltree 2022) take an audio input and translate it to sounds of trained instruments through Rave (Caillon and Esling 2021) in a manner not unlike image style transfers. The intent of these works is rather not to use prior invention to assist in the creation of like content, but to take the prior efforts and prevent their continuation within live performance.

2.2 Antagonism as Play

While machine learning is regularly promoted as a positive technology; with claims to erase biases and prevent human error (and as many critiques as to how it exacerbates both) this research aims for the reverse, by exploring it as direct aggression against the performer, allowing a novel means to explore improvisation in a manner resembling competitive sport. Performance may have its built-in feedback mechanism in the form of the audience, but the nature of courtesy prevents its common use in the negative. The strategic yawn or booing by the audience is rarely witnessed to provide such – more often it is only the visual disinterest or exit of the crowd. The IML in this case provides a stern judge that can give a direct response to the lack of creative variation in a given performance. All this again belies the fact that it is the musician who is training the machine at all times on what and how to judge. It is in this (im)balance of teaching:training that a tension can occur. The performer wants to play what is unexpected by the machine, as the machine learns how the performer tries to avoid prediction. Adding to these, is that predictions will yield false positives (and/or correct predictions, but with incorrect reasoning), while the musician, unable to determine an accurate or inaccurate match, might attempt to further shift their performance style. This offers the difficult possibility that both performer and algorithm may, over time, neither converge nor diverge, but produce merely an incoherent dialogue of data.

3 Taxonomies of Performance

In considering how to interfere with musical performance it was necessary to produce simplified taxonomic breakdowns of the means to produce sound. These classifications provided the basic framework for exploration and are not intended to be exhaustive. Their production was approached from two angles. The first (Fig. 2) considers types of motions typical to the human player. This framework was developed to understand both the means to register and the means to manipulate the performance from the standpoint of the performer's body.

The second (Fig. 3) is instrument-centric, addressing the form of actions performed upon them. The basic separations made here are primarily going to be defined by the format of instrument and will thus



Fig. 2. Performance possibilities by anthro-mechanical action.

somewhat follow a typical instrument breakdown. This charting gives a simple overview of the network interactions as well as the kinds of universalize-able approaches might be used in control or registration of an instrument itself.

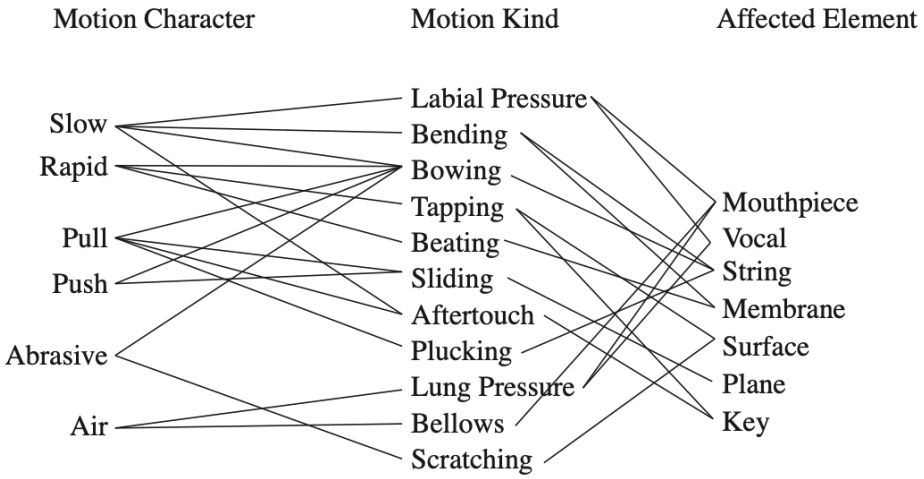


Fig. 3. Performance motion characteristics with type of motion and affected instrument elements

4 Performance Learning Strategies

The prior taxonomic investigations set the groundwork for what styles of algorithmic learning and intervention can take place. The primary, presumed means of interaction with the learning model would be one wherein the model continuously trains and responds through a performance, such that there is an interplay between the performer and the algorithm, each 'trying' to thwart the other. The algorithm, in that it is directly intended to prevent what it has learned as the performer's habits, and the performer, in an attempt to find styles which do not trigger the antagonistic response. As such, as a performance continues to train the model, it becomes harder for the performer to improvise something that is neither pure randomness, nor too predictable.

In an alternative approach, the model could be trained only on prior performance. This is the more common method for machine learning, but does not permit the interplay here desired, however there might be the opportunity for the artist to learn what it predicts over the duration of performance. In this way, the performer may start incapable of performing regularly but be able to play in a new fashion semi-fluidly by the end. To keep a versatile approach, each performance could be learned in succession, such that each sequential performance is iterative of the prior(s). Beyond the somewhat lesser dynamics of interplay that the live learning would possess, the dynamic here could be played out over a much longer time frame through a performance series. Additionally, a pretrained model is capable of being retrained in performance with sufficient planning and thus allow prior performance to affect the current while still adapting to present variation.

5 Software Architectures

This section suggests code-based approaches to the learning strategies, as they are both simpler to implement than the later hardware approaches while also forming their foundation. It must be considered that the need to predict, compare (and in some cases train) before sounding or responding introduces latency. One must compromise algorithmic robustness against predictive delay, with sufficiently simple predictive models minimizing discrepancy.

5.1 Note Alterations

The principally considered means to intervene is via note sequence determination. The most basic of intervention with which is the prevention of an intended note by learning from the performed sequence on a MIDI scale to then disable note-on of the next predicted note or pitch class (with potential considerations for polyphonic input).

Expansions on this theme includes the use of weighting (expanded in section 6). In applying weighting as a randomizer, a prevented input may allow variation beyond that deemed *most* likely. A cut-off threshold for top-weighted predictions can be included to avoid excessive fluke penalization. For example, of seven base pitches, none below 10% probability would mute, with those above having adjusted mute probabilities (Fig. 4). As such, the most likely note is most likely muted, but others may be instead or as well. This allows for resiliency should two notes be equally determined to follow. A second implementation uses the weighting as a means of volume control such that, while the top option may be muted, the next most likely might be merely quieted as a function of its likelihood.

note	c	d	f	g	a	b	e
predicted chance	63%	19%	11%	3%	2%	1%	1%

note	c	d	f
mute chance	68%	20%	12%

Fig. 4. Predicted most likely note probabilities (left) with cutoff for top results above 10% (dashed line) adjusted to next note mute probability (right).

Rather than blocking/muting, upon performance of a given note, the algorithm could instead swap that note to the another note less or more expected. This could again use an inversion of the prediction weight. The result would then lead to live recomposition (and possible confusion of the performer) not unlike the Sabotaging Piano, but with constant variation to the reconfiguration of the notes.

5.2 Time Domain

Expanding from pitch, the rhythmic component can be used alone or in concert with concepts such as pitch. The clearest area in which the time domain becomes of primary concern is in the tracking of rhythmic performances, although something that incorporates the event/note sequence might still be relevant to the series of drums in a kit rather or tempo of melodic sequence. An algorithm here might use above techniques of silencing based on a time expectation rather than sequential

selection. A more advanced approaches would incorporate time and sequential expectation.

6 Instrument-Centric Interventions

This section enumerates and categorizes the application and expansion of the algorithmic concepts to physical devices and provides some designs that, while software-based, cannot exist without the hardware component.

6.1 Discreet Interferences

Simple blocking or mutes provide the simplest option for any performative element of the instrument and a direct analogue to the software-based systems first discussed. Anything pressed or hit could in some manner be blocked. One can expand this to an array of blocked elements. Piano keys can easily incorporate mechanisms to prevent the playing of any note deemed sufficiently likely, while other instruments such as a woodwind's pads can be controlled with slightly greater complexity. There have already been developed strategies to suggest movement to aid in performance learning (Zhang et al. 2019). Such devices could easily be modified at the algorithmic level to instead suggest against, or prevent, these motions. Some instruments, such as strings or drums do not lend themselves to a means of fully stopping the motion, however applied pressure through a padded device may instead minimize vibratory potential on the relevant component. In many cases this can be as effective as prevention, although in others it merely diminishes the sound while changing its timbral characteristics.

It should be noted that instrument itself does not need to change, so much as its performance could be simply interfered with. Such formats might include a drum kit that moves the kit pieces in, out, up or down as determined by performance. Alternatively, elements might be designed to get in the way or annoy generally the performer. These dovetail in many regards with the later distractive responses (section 8).

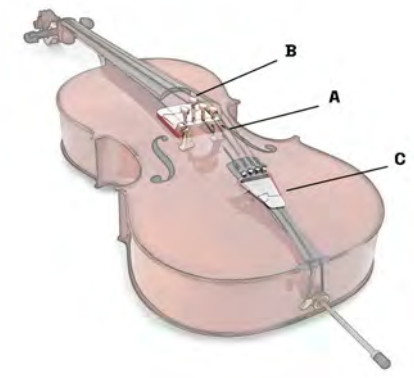


Fig. 5. Performance of strings (A) may be prevented by the intervention of mutes before the bridge (B). Tonal modification and interference could be adjusted through controlled gearing of secondary tuning pegs (C) – leaving the primary tuning intact.

6.2 Variable Interference Paradigms

Analogue Responses

There is an array of potential means to manipulate in less binary formats than the above. Rather than preventing or minimizing a note, string tension adjustments could create notes intentionally against the performers wishes (Fig. 5). Such a device would not so easily be able to perform a note based on its lack of expectedness, but could instead interfere with the performers melodic sense as an affected played element will not be that which is intended. The degree to which such a strategy could shift the pitch would depend greatly on the instrument and would be technically quite challenging.

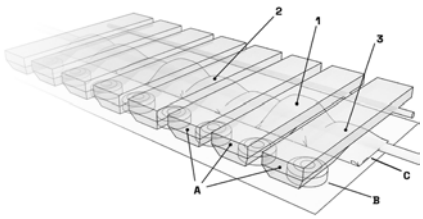


Fig. 6. Variable resistance blocking. Keys (A) predicted with higher probability require greater pressure to play depending on inflation (C) of numbered pockets to reach contact triggers (B). Here pocket 1 is most inflated, indicating greatest likelihood of performance and thus greatest difficulty in playing.

Simpler than pitch adjustment can be volume control. By expanding the use of muting, a variable pressure might be applied either to the sounding element or the performed key (Fig. 6) providing a tangible feedback as to what the algorithm believes will be played. Through additional effort, the performer may still force a desired note. Tactile feedback, such as vibration, is another option, permitting the performer awareness to change without pushing through variable resistance forces.

Stochastic Responses

Extending prior software-based discussion (section 5.1) – via the predicted likelihood for all notes and upon the playing of a note, the one with an inverse likelihood would instead be played. In theory this could be implemented in hardware as well, but only for very few instruments. The hilarity implicit in the complexity of a piano set to regularly shift hammers to alternative strings is exceeded only by the comedic simplicity of a trombone slider constantly trying to move to its least likely position.

The inferred notes may as well incorporate random chance with the trained weighting with timing offsets using a randomizer based on probability of the note at that time (ie. the less likely the performer is to play at a time, the more on-time that performed note is). This could be determined by event timing, specific note timings, or the timing in relation to a melodic/harmonic sequence. When considering the performance feedback elements of this approach, the existence of a low-chance note being adjusted, when the performer would not expect it, could lead the performer to infer a level of predictive dimensionality to the algorithm based on surprise – especially if the offsets are allowed to be especially large.

7 Performer-Centric Interventions

7.1 Body Physicalities to Interpret

Rather than affecting the instrument, one might restrict or alter performer motion directly as extrapolated from Fig. 2. A range of motion scales might be affected from the large-body movements of the waist/spine (commonly carrying dramatic action rather than sound) to limbic to digital. Movement of the limbs are often a primary driver for percussive instruments, as well as the rhythmic or long motion elements of other instrument (i.e. violin bowing, guitar strumming). Limb-movement frequently carries a pitch character (i.e. ascending/descending piano keys or guitar's frets) as well. Thus, manipulation of the limbs can create a wide range of affects, dependent on the instrument in use. Smaller motions (including digital, labial and lingual) cover an array of musicalities. Digital motion is commonly associated with the playing of a range of keyed instruments and includes the pitch control of strings.

Many simple, though often quieter, percussive motions are thus produced as well. Interference with the movements of the fingers is the most direct option for keyed instruments, although not without technical difficulty.

The versatility of oral control is quite broad. Labial and lingual controls provide many of the rhythmic and tonal qualities of breath-based performance instruments. Breath, even when not directly producing an element of sound, as in brass or woodwinds, is integral to all styles of performance, having heavy influences on tempo and musician temperament. It's potential for manipulation is general limited to how much it might be restricted.

7.2 Means to Register

The array of techniques available to ingest various human actions is complex. There is not yet any full-body action determination which is not in some manner unreliable or a burdensome hindrance to a live show. Some basic inputs include the simplistic if unreliable, such as stretch sensors, or a wide array of existing movement sensors, gloves, and other (often bulky) wearables. Per-instrument option may be incorporated through touch or pressure at the point of contact and, although such designs might be the most relevant to the sound, they ignore the range of motions by other elements of the body bringing that motion to bear. Electro-muscular sensors can extrapolate performed motion in a fairly slim footprint (Fig. 7) with greater algorithmic complexity. Such have demonstrated reasonable discernment of a range of motions with limited sensor count but require pre-training to learn specific motion. (Jiralerspong et al. 2017).

Pose estimation provides a more modern approach through analysis of video by trained algorithms to infer the locations of joints, freeing the musician from physical devices. These algorithms are only recently becoming fast enough to collect near real-time information and their models are typically trained for specifics scales (i.e. limbs vs fingers). They are also likely to falter when faced with the capacity of most instruments to get in the way visually. In the future, individually trained models could be produced that acknowledge or track the instrument.

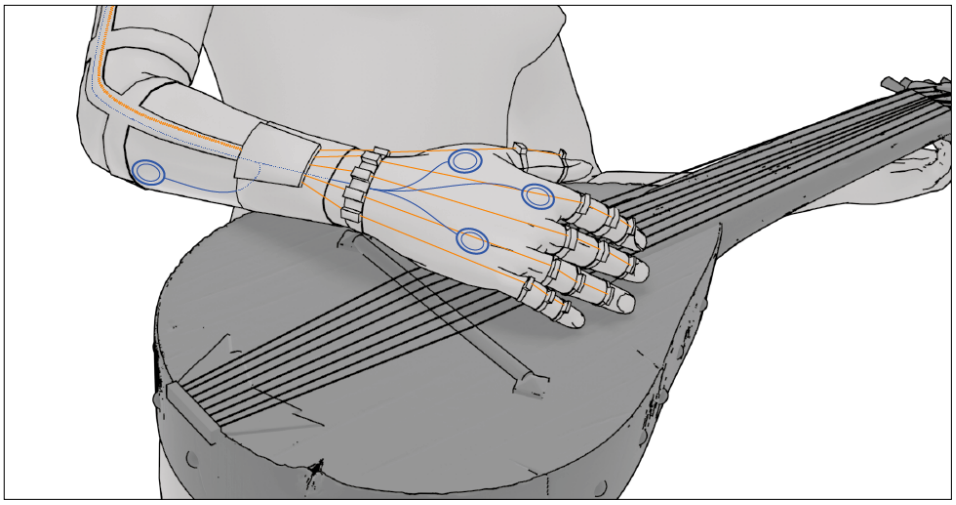


Fig. 7. A proposed performer-based combination device sensing muscular movement through electrode-based EMG and controlling finger motion via wire tension

7.3 Means to Control

The greatest difficulty in considering components affecting performer, rather than instrument, is most require some elements of bulk. A number of bio-mechanical interfaces exist, having been used in artistic performance such as those of Stellarc (Garoian and Gaudelius 2001). Pullies, motors, pneumatics and the like can all be rigged to control the potential human movement. Machinery attached to the performer may look interesting but fail at generalizable performance across any array of potential instrument.

One strategy involves resistance through electro-muscular stimulation. A properly controlled voltage, sent through a given muscle, results in contraction. An assortment of these have been use performatively for involuntary motion and expression (Elsenaar 2009). This strategy would then produce contractions deemed by algorithm as counter to performer intent (with potentially unsafe results). All options, mechanical or electro-muscular, have limitations in the amount of hardware one can attach to the body, especially at the scale of small digits, and still have a reasonably capable or unencumbered performer.

8 Generalized Interferences

Prior examples were based on specific physical motions or instruments. One of the longest implemented forms interference in pursuit of behavior modification is the use of a punitive response. This may be doled upon determination that the performer behaves as presumed by the system. The deeper considerations in this frame are more in the array of outputs which might be used to inflict penalty (and the ethical considerations of each), rather than which performance inputs might be interfered from. The most gentle of these being that of visual indicator such as a light's activation or screen-based text informing of what elements are predictable. More belligerently, auditory indicators can be used – with the added benefits that these interfere with the performed sound and can affect the audience. More assertive are penal techniques through electronic or mechanical devices such as whips, pokes or electroshock. Such devices can be controlled with variability based on a number of factors, primarily prediction confidence.

There exist performatively amusing alternatives that include the distraction or confusion of the performer, expanding the sense of play. Instead of punishment, a tickling feather might be one example. Taking the concept of the auditory indicator; a buzz or screech may work well as punishment, but vocal samples yelling at the performer for laziness and predictability could induce any number of anxieties. To expand further one can engage volunteers who, given cues by the algorithm, might impose vocal or physical interventions upon the musician.

9 Example Result

The *Algorithmic Antagonist* is here presented in demonstration of one direction for generalized performance intervention. This attempted to learn from the performer via both audio and bio-signal analyses to make predictions on musical direction and participant motion. Should the predictions prove sufficiently accurate, impetus to change tactics was given via punitive electro-shock. The physical interface was fairly simple, consisting primarily of a wireless device to send electromuscular signals and to receive shock triggers. Triggers activated an off-the-shelf transcutaneous electrical nerve stimulation (TENS) fetish shock device. These were packaged in a worn vest with elastic armbands to hold the electrodes (Fig. 7). The analysis software consisted of MaxMSP (Puckette and Zicarelli 1991) with the Fluid Corpus Manipulation (FluCoMa) toolkit (Tremblay et al. 2021), Markov models via ML.* (Smith 2019) and regression models from ml.lib (Bullock n.d.) for the analysis, training and predictions. As this paper is focused on its theoretical framework and background, the specifics of the algorithms will not be described in-depth, however full details of its specific and technical development are to be available (Blackistone 2026).

9.2 In Operation

This realization has been presented several times including events with the Tangible Music Club (Linz), and the International Computer Music Conference (Boston) in a performance of pre-programmed electronically sequenced motifs manipulated by the performer, during which the following were observed. This musical style was not ideal for the interface as its complexity makes determination of accuracy difficult. While the punishments resulted in greater impetus to manipulate these patterns to a much more-so than typical, it was clear that there were false positives in prediction, such as a moment when the audio equipment failed registering as predicted.

Regarding responses from the audience, that performances were somewhat sequenced and beat driven made them more interesting from the audience perspective, due to their understanding that due to their inherent baked-in patterns, such improvisation would be likely more difficult to vary sufficiently against predictability. While the shock response felt to result in large, apparent motion, it was regularly stated that it was not visually significant from the audience perspective. This was compensated for via audio and visual signifiers such as tones, strobing lights and glitched visuals (iterated between performances), which were generally, understood as signifiers of punishment.

The device was successful in causing minimal physical interference from the worn components, however the performance of synthesizers is not as engaged as might be found in performance of instruments such as guitar or saxophone. In general, the result further successful in that audiences were very interested in the background theory and the operational techniques of the interface. From the perspective of producing an



Fig. 8. The vest and interface before premiere performance at STWST, Linz. (video available at: https://www.dorftv.at/video/45716) Further performances include The Red Room, Baltimore (video available at: https://www.youtube.com/watch?v=NTmER1qCT5E)

enjoyable performance, while seemingly successful, it should be considered that the audience at the selected experimental venues in which it was performed might more appreciate such masochism as manifested by machine intelligences than a *regular* audience.

10 Summary

This research presents a conceptual thread that began with considerations of the affects of hostile architecture on behavior to then make a game of forced improvisations in a musical, performative context. Over the course of its development, original connections to interactions with and improvisations around hostile architecture became less direct than at the project's inception. They are maintained here to better tell the story. That metaphor's extension to adversarial software design, provides a lens through which later threads were considered. These tie into what Selena Savić and Gordan Savičić suggest as, "The Algorithm of Unpleasantness," and indeed the presented result connects directly with their discussion of "Repellant systems" (Savić and Savičić 2014). As the ever-growing surveillance states and data accumulations are turned into tools of applied control – corporate, civil and military – we find ourselves forever in a tug of war over whether and/or how to change our behaviors to adapt to, push against or circumvent these new systems. Should such algorithmic self-antagonistic interfaces then become part of the self-educational toolkit for considered responsiveness to such systems? This does not go far enough to answer any such fundamental questions. Perhaps against a gamified system, a punishing play at performance and the affiliated conversations can be one small piece to draw attention to the problems and help identify novel means to address them.

10.1 Expansions

This research need not limit itself to the domain of music. Interfaces can be envisioned to interfere with any number of art forms – from painting, to sculpture, to, perhaps most amusingly, dance. Further, such interferences need not be applied only in performative or artistic contexts, while punishment as habit-breaking tool has a long-standing (if oft ineffective) tradition, it is little used outside of known-detrimental habits. There may be a place for learning applications to get in the way of any number of daily processes, from walking cadence to scribing journal publications.

Acknowledgments. This work is both condensation and expansion of the theoretical elements of thesis research produced at the University of Arts and Design Linz (Blackistone 2025). The author would like to thank Univ. Prof. Dr. Martin Kaltenbrunner, and Univ. Dr. Enrique Tomás for their knowledge and assistance in the realization of this research.

Ethical Standards. The used administration of electroshock via the TENS device for the production of this work was primarily upon only the author. Limited exposure to the device was granted colleagues only upon their request and only with full disclosure of any known health concerns.

Online Resources. The files used in the ongoing productions from this research can be found in the github repository at: https://github.com/blackistone/ImprovisationalAntagonist

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Post-digital Aesthetics in Contemporary Music Performance: Morphing and Hybridisation in Morphing Spaces: The In-Between Projections, a Co-creation for Tenor Saxophone and Multimedia

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Post-digital aesthetics are increasingly evident across a wide range of contemporary artistic practices, questioning the nature of socio-technological relationships. In contemporary music composition and performance, this aesthetic challenges the creation of new performative practices and explores the hybridisation of the digital and physical/material domains, placing composers and performers/instrumentalists before a broad spectrum of expressive, creative, and technical resources enabled by technological mediation. This article examines the co-creation processes involved in developing a work for saxophone and multimedia during an artistic residency that brought together a composer, a saxophonist, and various technological resources. Adopting a case-study methodology, it focuses on the performer's role as a vehicle for integrating the digital/technological and physical/instrumental dimensions through experimentation and research. The study demonstrates how the hybridisation and morphing of domains can productively support musical creation and how these concepts contribute to instrumental advancement, both in relation to the instrument itself and to performance practice. Acknowledging surrounding artistic heterogeneity, the creative and performative work described raises new questions for the artistic researcher, encouraging reflection on their role in relation to evolving modes of musical consumption and positioning them within a co-creative space essential to the generation of the work's aesthetic material, whether sonic or visual.

1 Introduction

We live in a moment of technological ubiquity: technology has come to affect everyone in some way, to the extent that it is perceived "only by its absence" (Negroponte 1998, 1). Digital technologies, and their development and democratisation throughout the twentieth century, have profoundly transformed how music is listened to, analysed, and performed (Chion 1997, Katz 2010). The advent of the twenty-first century has not entailed a reduction in technological use; rather, it has given rise to a "blended environment where the physical and digital worlds interact in vibrant and interdependent ways" (Caires 2025, 10). It is within these interactions that the post-digital aesthetic (Cascone 2000) emerges, initially developed by self-taught composers in the 1990s and grounded in the perceived errors and "failures" of digital technologies (Andrews 2002).

A subject of reflection, mutation, and debate throughout the twenty-first century, the post-digital aesthetic manifests across multiple levels: 1) an intention to employ technology creatively and critically, giving rise to artistic methodologies that "blur the established dichotomies between new and old media, between online and offline, and between

Keywords: Post-digital, Contemporary Music, Saxophone Performance, Performative Practices, Musical Co-creation.

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digital and physical" through the deconstruction, or hacking, of technological processes, thereby revealing their mechanisms and demonstrating the "sociocultural effects of their omnipresence" (Ferreira and Ribas 2020, 121); 2) digital technology is not regarded merely as a neutral tool, but as imbued with cultural implications (Manovich 2002, Schubert 2021); 3) new modes of engaging with technology, with "post" understood not as a break but as a transformation, move towards an aesthetic that critically reflects on the implications of the surrounding digital culture (Ferreira and Ribas 2020, Cramer 2014). Although attempts to define the post-digital concept since 2018 have proven largely unproductive and challenging, as its definition has expanded in multiple directions (Jandrić 2023, Jandrić and Knox 2021), today, the post-digital constitutes an important[1] conceptual and theoretical framework, as well as an aesthetic that provides a broad philosophical and artistic perspective. It is applied primarily within music and design (Escaño 2023), where it enables a critical engagement with the contemporary artistic world (Macgilchrist 2023), while also capturing "the messy, entangled and unpredictable nature of the socio-technical relationships (Jandrić and Knox 2021, 784).[2]

In Western contemporary music, features such as "hybridity,[3] rematerialisation, multisensory experiences, and active involvement" (Caires 2025, 11) have given rise to new performative practices, which use musical systems in unconventional ways and allow composers to incorporate "new technology, material properties, visual media (...), and other elements as compositional material" (Magnusson 2018). Therefore, instrumental performers face significant challenges. Classically trained musicians, still rooted in a score-based performance context (Kharatyan 2024), experience a shift in their role and relationship with the composer (Budai 2014) and must integrate embodied technical knowledge acquired in academic settings with other skills (Stene 2015), including the use of digital tools and the incorporation of additional performative dimensions, such as bodily movement and gesture.[4] New artistic practices, including multimedia composition, Social Composing[5] (Muntendorf 2015), and New Discipline[6] (Walshe 2017), as well as the work of composers such as Stefan Prins, Michael Beil, João C. Pinto, Carlos Perales, Igor C. Silva, Ted Moore, Oscar Escudero, and Alexander Schubert, exemplify creative approaches at the intersection of technology and ar-

1. This is evidenced by the recent award of a significant grant from the Swiss National Science Foundation (SNSF) to the project "Postdigital Musicking: Studies on the 'multimodal shift' in the practice of contemporary art music in Western Europe" for the period 2024–2028 (see https://data.snf.ch/grants/grant/10000554).
2. "Today the postdigital is hegemonic, and as such is entangled with everyday life and experience in a highly complex, messy and difficult to untangle way" (Berry 2015, 50).
3. "The root of hybridity in the New Aesthetics is key to the postdigital" (Causey 2016, 431).
4. "The musician's moving, dancing, touching, speaking, singing, shouting, grimacing, sounding body opens a novel and still expanding palette of expression – but its use also requires new skills that are currently not an explicit part of higher musical education or standard musical performance practice" (Borregaard 2023).
5. "Social Composing is based on the intention of mediating through music and intermediacy—that is, radically placing the communicative ability of music in the center, to be able to trigger resonances in all those living in the virtuality-reality continuum" (Muntendorf 2015).
6. "... music in which the physical, visual, and theatrical are as important as the sonic." (Walshe 2017).

tistic creation within a post-digital context (Campos 2022). On the other hand, performers such as Zubin Kanga and Stephane Ginsburgh,[7] Jennifer Torrence,[8] Pedro Pablo Cámara Toldos (2024), Mark Knoop, Sarah Albu, Winnie Huang,[9] Thomas Moore, and Sebastian Berweck place artistic and/or academic emphasis on instrumental performance,[10] which may require "work-specific technical practices"[11] (Stene 2015). These performance areas remain relatively underexplored for three main reasons: 1) the heterogeneity of the works, which precludes homogeneous or universal approaches; 2) the anachronism between the acquisition of instrumental techniques and contemporary performance practices; and 3) the ongoing pursuit by performers and composers to deliberately challenge "idiomatic ideals in search of new expressive means by transgressing technical conventions" (Stene 2015).

Within this context, this article examines the artistic processes behind a co-creation between a performer–saxophonist and a composer: *Morphing Spaces: The In-Between Projections*. It seeks to articulate: 1) the creative and artistic decisions informed by the trajectories and technical expertise of both authors; 2) how these decisions shaped the conception and performance of the resulting musical work, identifying key aspects of the digital–physical hybridisation aesthetic and *morphing*,[12] as well as their narrative and acoustic implications; and 3) how these processes function as catalysts, both for the technical and aesthetic roles of the musicians and for the ways in which technology-based creation can continue to support the development of the instrument (as a device) as well as of the instrumental performer, situating the latter within a contemporary transdisciplinary artistic domain.

Paulo de Assis (2023, 55) poses the following questions: "How can music be rethought in the digital age? How can creative musical practices be developed in response to the conditions and affordances of contemporary society? What is the role and function of the musician in contemporary society?" In response, this article seeks to advance the discussion within the post-digital aesthetic in the domain of Western contemporary music rooted in the classical tradition. It does so by illustrating: 1) how the hybridisation of domains can serve musical expressivity; 2) how concepts and practices originating in technological contexts, such as *morphing*, employed here in a non-orthodox manner, may be recontextualised within musical creation; 3) how the instru-

7. As pianists and performers, they contextualise the difficulties, specificities, and performative decisions involved in preparing and performing *Piano Hero #1-4* by Stefan Prins, *_derivations* by Benjamin Carey, and *v* by Patrick Nunn (Ginsburgh 2019, Kanga 2017).
8. Through reflections arising from the creation and performance of *etudes to become a deer* and *What Noises Remain* (Torrence 2018).
9. The author places the performer's body, gesture, and visuality at the centre of the analysis, examining notational and performative characteristics across several case studies, and identifying possible pathways for future creation and performance (Huang 2022).
10. Also noteworthy are the advances enabled by the concept of active performance in relation to mixed music (Furniss 2017, Portovedo 2019), and by post-instrumental practice with regard to some contemporary multidisciplinary repertoire (Devenish 2021, Moore and Verlaak 2025).
11. "The technical skills required by such compositions cannot be reduced to common, general exercises practiced separately in order to support one's fundamental ability to perform them" (Stene 2015).
12. A definition can be found in Section 3.1.

mentalist and the composer continue to assume a fundamental role as creative agents despite an increasingly autonomous technological environment; and 4) how experimental processes, including the development of work-specific techniques and iterative trial-and-error practices, can lead to unexpected yet artistically significant outcomes within our artistic practice.

2 Methods and Methodology

Within a methodological framework enabled by artistic research, the focus is on two fundamental premises: experimentation and collaborative creation. Experimentation is a key factor in generating new knowledge (Burke and Onsman 2017, Rink 2016), as evidenced here through sonic exploration processes involving the instrument (saxophone) and technological models or patches. The artistic researcher examines their artistic, creative, and performative decisions, attributing to them transferability, reliability, and purpose. This includes documenting the process from initial intention, through encountered challenges, to a perspective that integrates both technical and aesthetic aspects.

This co-creation emerged from a three-week artistic residency, structured around daily sessions of experimentation and dialogue between the saxophonist and composer. The work centred on the tenor saxophone in interaction with computer-based systems, microphones, and loudspeakers. Digital tools, including Max/MSP and TouchDesigner, were selected in accordance with the authors' technical expertise and prior experience. Audio recordings in Reaper documented the range of extended instrumental techniques explored, such as multiphonics, air sounds, *closure in series*, *growling*, *glissando*, *slap*, and key clicks. These explorations were informed both by the saxophonist's established practice and by relevant literature in the field. In parallel, a written sketchbook was maintained to register techniques that proved particularly effective in sonic interaction, supporting later stages of reflection on the work's potential development. The collected material was analysed qualitatively and further enriched through ongoing critical exchange between the collaborators.

Collaborative creation between composer and performer simultaneously repositions the creative paradigm within the role of the instrumentalist (Cook 2013, Emmerson 2017) and enables the mobilization of creative resources that would not be attainable through individual practice alone (Hooper 2017, Yamamoto and Miyake 2003). Collaboration has been receiving increasing attention within the field of Western classical music (Sawyer 2007), with a growing body of research examining how composer–performer interactions unfold and identifying a range of collaborative models and approaches. For instance, Vera John-Steiner (2000) outlined specific collaboration patterns, Hayden and Windsor (2007) proposed distinct categories, and Taylor (2017) distinguished forms of working relationships based on decision-making hierarchies and divisions of labour. In this case, however, the aim was not to rep-

licate or iterate upon these established models. Instead, they served as points of reference, informing a flexible and open approach to collaboration in which hierarchical roles were deliberately set aside. This process demonstrates how the experiences of performer and composer, creative decision-making, and technological integration co-evolve. The perspective of the instrumentalist-saxophonist was incorporated to explore: 1) the study and analysis of the scores; 2) how previously acquired skills intersect with and are adapted to the new skills required for this work; and 3) the ways in which these unique collaborative dynamics resonate with potential future performative approaches within this specific case study.[13]

3 *Morphing Spaces: The In-Between Projections*, for Tenor Saxophone and Multimedia

As mentioned, in this process, we positioned ourselves within a performer–saxophonist and composer collaboration, characterised by a highly idiosyncratic workflow and outcome. Based on prior knowledge of the composer's aesthetic, an essential aspect of the instrumentalist's performative approach and the final artistic outcome (Kanga 2021), the collaboration is shaped by the composer's dual contributions: expertise in developing and operating software and hardware, as well as a commitment to collaborative engagement.[14] Previous compositions[15] reveal an aesthetic that places equal emphasis on the musical instrument (its idiosyncrasies, extended techniques, and timbre) and on electronics or multimedia, reflecting the inter- or transdisciplinary context inherent to contemporary post-digital culture (Pereira and Adérito 2020). Through a combination of collaborative work within a laboratory context of experimentation and residency, and the intrinsic motivations of the performer and composer,[16] we explore the concept of *morphing* across two dimensions. This concept serves as the inspiration for both the experimental processes and the sonic textures that shape our work.[17]

3.1 *Morphing:* Digital-Physical Hybridisation

Although the concept lacks a consensual definition (Caetano and Rodet 2010), we focus here on sound morphing, understood as "apply-

13. This method allows a versatile approach and the collection and analysis of data from various sources (Benbasat, Goldstein, and Mead 1987).
14. The openness demonstrated by the composer should not be underestimated. The issues encountered, as well as the practices developed and refined throughout a long-term collaboration, should be acknowledged and shared by both performer and composer alike.
15. For further musical content: https://soundcloud.com/fran-collado-548849709
16. We consider the background of each agent as highly influential in shaping artistic choices and motivations. As Travasso (2025, 156) notes, "the artist's background is the starting point for a project. While the instrumentalist starts from a score, working within boundaries between musical knowledge and skills". This also highlights the fragility or limitations often experienced by classically trained instrumental performers within the context of Western contemporary music.
17. "The development of personal tools and the value of starting-from-scratch are important characteristics" of the post-digital (Ferguson and Brown 2016, 129).

ing gradual transformation from one sound as the departure to another sound as the destination" (Bökesoy 2013, 1), while also paying close attention to the intermediate spaces encompassed within this journey (Zope and Zope 2017). Being a concept applied within musical composition and recognised as an exciting creative space (Caetano and Rodet 2010), we sought to apply sound morphing as an element of hybridisation between digital/electronic and physical/instrumental media. This hybridisation resonates with us, as the deep permeation of the digital into our lives affects not only musical creation but also the very "representation and reception" of music in the post-digital context (Schubert 2021). It aligns with a creative use of technology that fosters the development of "artistic methodologies that blur established dichotomies between old and new media, (...) digital and physical realms" (Ferreira and Ribas 2020, 121). This is precisely what we aim for in *Morphing Spaces: The In-Between Projections*: the hybridisation and the rejection of dichotomy between the physical and electronic realms across two domains.

Electronics-Instrument Hybridisation

In the realm of electronics, we aim to achieve sonic transitions through a range of AI models, ultimately leading to the use of a RAVE model[18] implemented within Max/MSP[19] patches. Four independent RAVE models were trained on distinct corpora of recorded tenor saxophone sounds: one comprising a range of sounds from Bb3[20] (the instrument's lowest note); another comprising instrumental techniques; a third based on the multiphonics employed in the piece; and a fourth exploring *closures in series sequences*. Each dataset was curated as a training corpus and used to train a dedicated RAVE model. Once trained, these models are used in a deferred-time context through exploration of their learned latent spaces. By adjusting their parameters, it becomes possible to navigate and control intermediate sound spaces in real-time (see Fig. 1). The resulting sounds and transformations are subsequently integrated into the composition as fixed electronics.

In addition, the models are also deployed in live performance:[21] the saxophone signal functions as the system's input, which the model encodes and decodes in real-time according to the sonic domain learned during training. The parameters of the *nn~* object are adjusted in real time, thereby shaping the decoding process and generating different sonic outcomes within the electronic layer. In this way, subtle variations derived from the saxophone sound emerge, unfolding in parallel with – and along an alternative trajectory to – those of the performer.

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18. RAVE (Realtime Audio Variational autoencoder) is a deep learning–based system capable of "learning" musical dimensions directly from audio data presentations. They are commonly employed in the context of live music performance and offer improvements "for fast and high-quality neural audio synthesis" (Caillon and Esling 2021). Their main applications include timbral transformations and real-time audio manipulation (Carvalho et al. 2024).
19. https://cycling74.com
20. Corresponding to concert pitch Ab2.
21. RAVE can be exported in streaming mode for real-time use within the nn~ object, in environments such as Max/MSP or Pure Data.

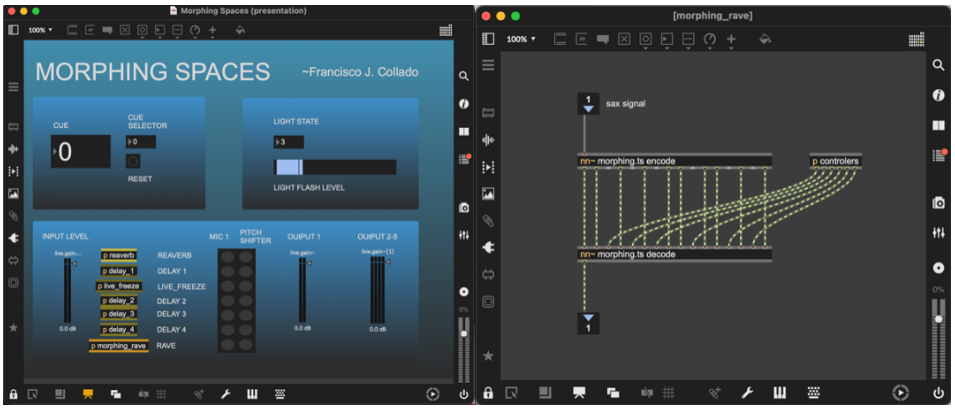


Fig. 1. Screenshot: Max/MSP patch from *Morphing Spaces: The In-Between Projections*, employing the *nn~* object in Max/MSP.[22]



Fig. 2. Sound Recordings: (https://osf.io/v849t/).

These intermediate sound spaces are reflected through the capabilities of the tenor saxophone and the skills of the performer, who employs instrumental techniques such as vocal sounds[23] and *growling* (singing while playing), aeolian and air sounds[24] (with and without the mouthpiece), multiphonics, *flutter tonguing*, and *closure in series* (Capellino and Posadas 2018). After our experimentation, these instrumental techniques have demonstrated a strong capacity to integrate the performer and their instrument into the electronic aesthetic (considering texture, timbral gestures, and chromatic nuances of sound) thereby contributing to the intended condition of digital/physical symbiosis.

As a demonstrative example of the subjective pursuit of this mirroring, we propose listening to a sound produced solely by the saxophonist, based on air sounds generated by blowing over the saxophone neck (without the mouthpiece), which can be accessed here as Audio Excerpt 1 via the link in the caption of Fig. 2. By employing such air sounds, we aim to incorporate and establish a mimetic relationship with the electronic sounds generated and audible at the beginning of the piece (Audio Excerpt 2 accessible via the same link). This integration is also evident in the use of vocal sounds (singing while playing), where the buzzing created by the interaction between voice and instrumental sound facilitates a smoother, more organic transition and strengthens the connection with the electronic layer (Audio Excerpt 3 accessible via the same link).

Visual Projection-Performer Visuality Hybridisation

Similarly, in the visual domain, alongside the sonic, we explore the idea of physical-digital hybridisation through the use of technology. As in the sonic context, the performer's visual presence is integrated into

22. "nn~ is a Max/MSP and PureData external for AI audio processing. It enables to easily explore deep latent spaces and play with audio streams they generate" (Scurto and Postel 2023). Free access through https://github.com/acids-ircam/nn_tilde

23. For example, one can "sing while playing the saxophone", producing a kind of "buzzing in the throat and head area" (Weiss and Netti 2010, 178). By using our voice, over which we generally have natural and significant control, this approach facilitates the emergence of transitions in a gradual and organic manner.

24. "Ever since noises have been intentionally employed as musical material (see, e.g., John Cage), pure air or blowing noise has, in fact, become a typical sound material in "new music". Air sounds can be produced in the most varied ways and in all registers of the saxophone". (Weiss and Netti 2010, 157).

the morphing process, this time directly within the image[25] itself. To realise this creative and aesthetic process we used the software TouchDesigner,[26] drawing on the AI-based system Stream Diffusion.[27]

As shown in Fig. 3, a projection of the performer's image, captured using an Xbox Kinect in infrared mode, is subjected to continuous transformation. Before entering StreamDiffusionTD within TouchDesigner, the signal passes through several image-processing operators (TOPs): first, *Threshold* enhances the separation between the figure and the background; then, *Edge* emphasises its contours. From this processed image, StreamDiffusionTD generates further visual transformations.[28] This technology was employed for three main reasons, considering that our interest as artists is purely aesthetic and creative: first, it offers user-friendly implementation; second, it enables interaction and creative control through text-based instructions, known as prompts;[29] and third, it is open-source.



Fig. 3. Screenshot: TouchDesigner implemented for *Morphing Spaces: The In-Between Projections*; specifically showing the image transformation generated through StreamDiffusionTD tool.

Through this approach, we integrate the performer's visuality as both an aesthetic and creative resource, positioning it as a generator of ambiguity for the audience, grounded in the "decoupling of original and image, as well as cause and effect" (Schubert 2021, 13) that so strongly characterises the post-digital condition we inhabit. At the same time, this expands the performative space and the range of resources available to the solo artist (Kanga and Schubert 2016). While it does not

25. Morphing may be applied not only to sound but also to the visual domain. As Zope and Zope (2017, 81) notes, "Morphing is defined as a process which changes the one image into other through seamless transition. Thus, it is the fluid visual transformation of one image into another image using the sequence of intermediate images".
26. https://derivative.ca "TouchDesigner is a software that allows us to build very efficient tools for real-time video processing, 3D rendering, procedural visual work, multi-touch interfaces, and much more in a very easy visual way" (Lechner 2014, 327).
27. "StreamDiffusion is an innovative diffusion pipeline designed for real-time interactive generation. It introduces significant performance enhancements to current diffusion-based image generation techniques" (cumulo-autumn n.d.).
28. During the concert, these parameters are adjusted in real time using a controller. At the premiere, the manipulation focused primarily on *Step* and *Seed*. The *Step* parameter determines the degree of image transformation: at low values, the result is more free-form and fluid; at high values, the image retains more of the original source's features. The Seed parameter, meanwhile, defines the random basis of the visual generation: when kept fixed, the result is more stable; when varied, new configurations emerge.
29. Since the prompt used was "abstract", each variation of *Seed* produced images that were very different from one another. The morphing effect was generated primarily by continuously modifying the *Step* value while the *Seed* remained fixed, allowing the image to transition progressively between visual states. When a new *Seed* was introduced, this change was made with high *Step* values, as this resulted in a smoother and more fluid transition to the new configuration. Later, upon reducing *Step* again, the image returned to a more free-form and variable behaviour, but always in a continuous manner.

directly affect the sonic behaviour of the performer, beyond requiring them to avoid overly rapid physical movements and to remain within the area captured by the sensor, the visual projection and the immersive environment created through the use of LED projectors contribute to a more enveloping experience (see Fig. 4). This results in a heightened sense of ambiguity and subjectivity,[30] aligning with the nature of multimedia or transdisciplinary artistic creations.

We do not seek to establish or propose universal uses of technology, as technological tools such as stable diffusion[31] models offer infinite creative possibilities. Within our collaboration, we present one such possibility while deliberately avoiding any claim to universal applicability.



Fig. 4. Premiere of *Morphing Spaces: The In-Between Projections*.

3.2 Score and Performance

The collaborative process between saxophonist and composer is fundamentally driven by experimentation. Starting from the creative motivation described above, we proceeded to experiment with multiphonics.[32] Drawing upon key reference materials on this technique (Kientzy 1982, Weiss and Netti 2010, Capellino and Posadas 2018, Michat and Venturi 2010), we focused on tenor saxophone multiphonics that were: 1) feasible within saxophonist's practice, albeit challenging to execute; 2) capable of producing a relatively soft sound in the middle register; and 3) amenable to transformations within the multiphonic itself.[33] This resulted in the selection of three distinct multiphonic clusters, produced using the same fingering, with achievable transitions between states as indicated by the arrows in Fig. 5. When working with multiphonic clusters, it is essential to recognise that certain dynamics

30. Although disparate, by intrinsic comparison, auditory perception and visual perception influence each other, "lending each other their respective properties by contamination and projection" (Chion 1994, 9).
31. Technology released in 2022.
32. "Multiphonics consist of the production of several notes at once by otherwise monophonic instruments" (Riera et al. 2014, 1).
33. As an example of the internal transformation of the multiphonic, we can listen to Audio Excerpt 4, accessible via the link in the caption of Fig. 2.

complicate transitions both within a single cluster and between different clusters.

This work proved to be highly fruitful, as it allowed the discovery of multiphonic states not documented in the reference materials consulted. Such discoveries typically arise during experimentation when the performer is actively involved, since in the performer's absence, the composer would rely solely on the listed sources as compositional resources, thereby limiting the expansion of the sonic material.

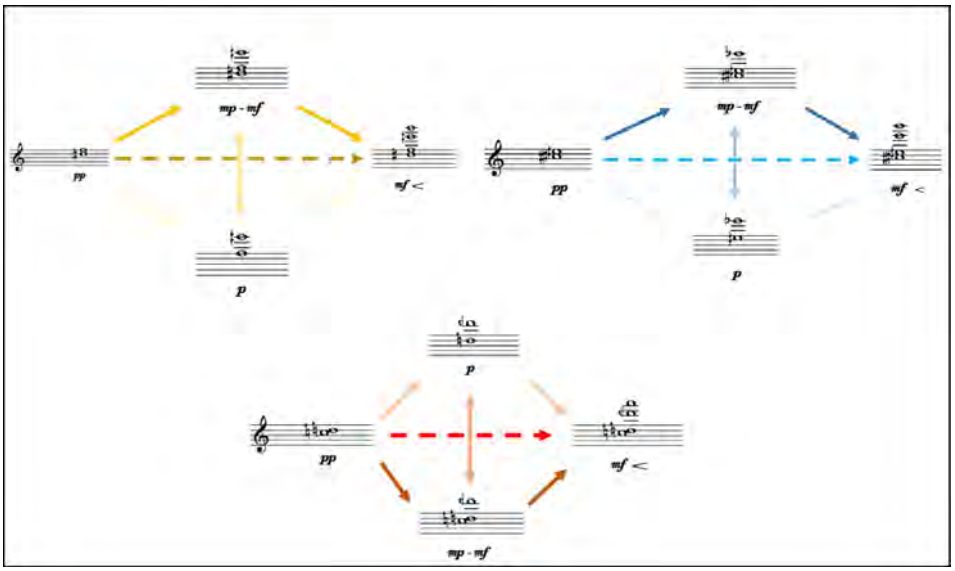


Fig. 5. As a result of the experimentation, the continuous arrows indicate the feasible transition pathways from the initial stage of the multiphonics to their final state. The dashed arrow represents a direct transition between these states, which is not readily achievable in instrumental performance.

As mentioned, other resources explored and experimented with include vocal sounds (singing while playing) and *closure in series* (Capellino and Posadas 2018). In the case of vocal sounds, these were approached and developed as an effective vehicle for morphing from one sound to another (as noted on the previous page), particularly emphasising the intermediate spaces, as illustrated in Fig. 6.

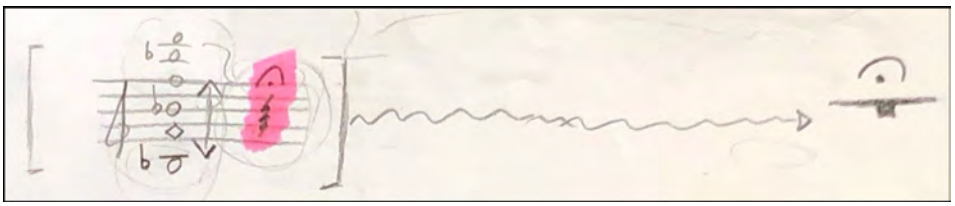


Fig. 6. Excerpt from the score of *Morphing Spaces: The In-Between Projections*, illustrating the use of the voice as a resource for sonic transitions.

In the case of *closure in series*, our approach involved experimenting with their function in the given context, familiarising ourselves with them, and establishing a parallel with multiphonics by generating multiphonic sounds from specific fingerings associated with *closure in series*. An example is shown in Fig. 7.

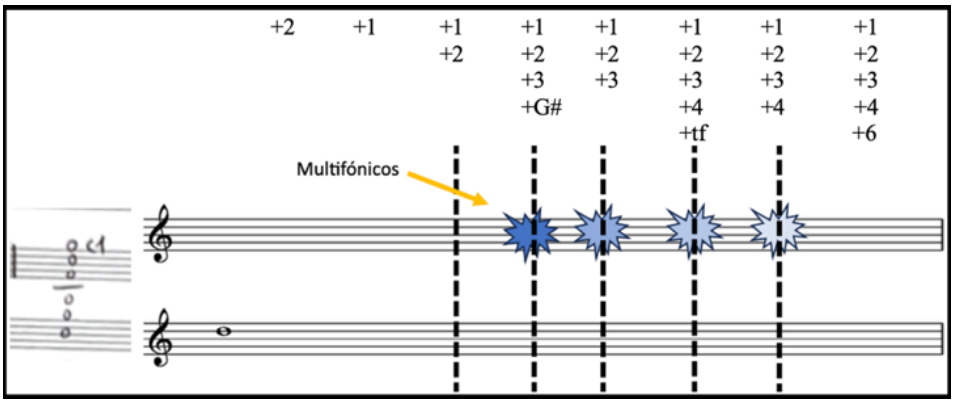


Fig. 7. Through experimentation, when performing the descending *closure in series* sequence starting from the medium D[34] (using the *c1* key fingering), we were able to obtain multiphonics at four distinct positions.

As shown in Fig. 8, part of this work involves improvisation based on specific instructions, namely: improvisation without the mouthpiece, focusing on air sounds and articulation using only the saxophone neck, previously explored with the electronics; improvisation on particular *closure in series*; and "wild" improvisation, characterised by high dynamics, an altissimo register, and very rapid, harsh movements.

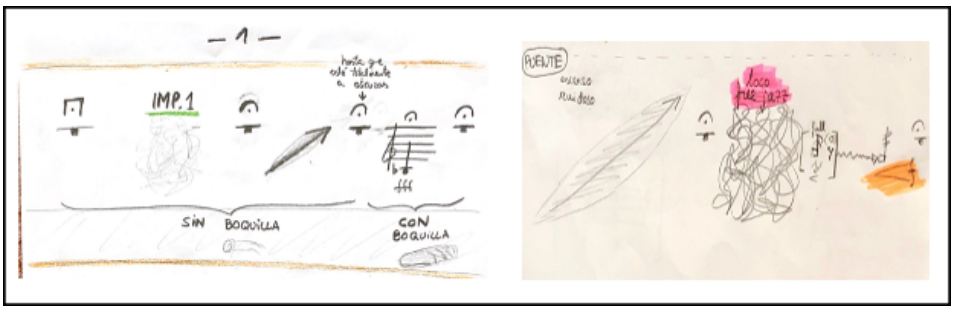


Fig. 8. Excerpt from the score of *Morphing Spaces: The In-Between Projections*: improvisation proposals.

Beyond the sections in which improvisation is proposed, the score provides indications of the musical gestures and resources to be employed, such as multiphonic clusters and specific *closure in series*, while leaving the duration of each event open. This results in a markedly open work, granting the performer a substantial degree of co-authorship through their influence on the unfolding of the piece itself. Such an approach aligns with Kanga's (2021) view that a performer's realisation is not strictly the composer's work, but rather a reflection of the performer's interpretation of the composer's aesthetic.

3.3 Challenges and Future Performances

We do not intend to present *Morphing Spaces: The In-Between Projections* as a definitive artistic product; rather, the work remains in constant development, with each performance constituting a further step within a broader artistic process (Diegert 2018). Looking ahead, several challenges emerge. Firstly, it must be considered that the performative and technical/technological nature of the work conditions the processes of iteration and dissemination. To date, the piece has been performed pub-

34. D5 for B-flat tenor saxophone (written pitch), corresponding to concert pitch C4.

licly on two occasions,[35] with both the performer and composer present in each instance. Consequently, the composer operated the Max/MSP patch, the TouchDesigner node network, and the LED lighting system from the computer, while the performer focused solely on the instrumental performance. To support wider iteration and dissemination, the Max/MSP patch should be streamlined to provide full performer control on stage, while the TouchDesigner node network and lighting system require reorganization to allow for increased automation during performance.[36]

Secondly, there are logistical concerns. The current setup requires transporting visual resources, including eight LED lights, an Xbox Kinect sensor, and two computers (a MacBook Pro computer and a Windows PC). It is also designed for quadriphonic sound, in addition to the standard video projector and PA system typically available at performance venues. However, few of these resources (including the quadriphonic setup) are available at most accessible venues. Consequently, there is a need to enhance the work's "accessibility" by simplifying the materials for transport and reducing technical complexity. To this end, new versions of the work are being developed, featuring a reduced number of LEDs, the integration of TouchDesigner and the Max/MSP patch on a single computer (despite the associated technological risks), adaptation of the patch for performer control via MIDI pedals, and modifying the sound for stereo output.

4 Final Considerations

In a post-digital context, where technology in music is more than just a tool, actively influencing the entire artistic process, the use of creative and performative resources, such as morphing or the blurring of digital and physical domains, proves highly fruitful for musical creation and experimentation.

In *Morphing Spaces: The In-Between Projections*, the post-digital aim of merging the digital/technological and physical/instrumental dimensions requires mastery of a range of instrumental techniques, previously explored in a familiar experimental context (such as multiphonics or *closure in series*). These techniques must be executed at varying speeds and with a level of familiarity that allows for a fluid and expressive musical discourse. For a performer trained within the Western classical tradition on an instrument like the saxophone, this often involves a process of relearning, as such techniques are rarely addressed in the standard repertoire, appearing only in specific works and proving difficult to sustain consistently in daily practice. At the same time, the saxophone's

35. D5 for B-flat tenor saxophone (written pitch), corresponding to concert pitch C4.

36. This aspect assumes particular importance, as Pennycook (2008, 207) notes: "As composers, we expect other performers to repeat our works anticipating future performances by unknown performers through the traditional modes of music publishing and word of mouth dissemination". Nevertheless, in practical terms, "the vast majority of these kinds of pieces few performances have occurred without the presence of the composer", which underscores composers' concerns and necessitates that performers "time performers will need to acquire some basic technical know-how" (Pennycook 2008, 207).

technical scope is extended through the development of previously undocumented multiphonic states, achieved through the authors' creative input, their respective background, and an experimental practice-based approach carried out in situ.

From a holistic perspective, we seek to describe the saxophonist's involvement and significance within the creation and performance of *Morphing Spaces: The In-Between Projections*. We point, for instance, to the possibility of an instrumentalist who, despite years of highly structured and traditional training, engages with the present moment in an open and exploratory manner, embracing new possibilities and stepping beyond their comfort zone. In this work, the saxophonist performs within contexts that require interaction with electronic devices and software(s), where sound, body, and movement become integral components of the performative act. The performer assumes an active role (de Assis 2018) in the co-creation process and in subsequent performative and technical decisions, developing both creative and technical skills in improvisation and thereby expanding their overall artistic capacity, while proposing and fostering, in both creation and performance, the use and adaptation of methods and materials in the development of new musical works, often leading to site- or performer-specific pieces, without aiming for procedural or performative generalisations.

This work also highlights several emerging conceptual issues and directions for future research. Performers are now confronted with notions such as co-creativity between human and non-human creative agents, reflecting an evolution from systems with limited responsiveness to forms of performance that challenge traditional ideas of authorship, agency, and creativity. Contemporary technologies significantly expand the possibilities for live performance; however, the instrumentalist – who continues to operate through embodied and technical means – may find their sonic repertoire, creativity, and capacity for innovation, as well as their "sonic identity", increasingly questioned and reconfigured. The challenge today lies in approaching the machine as an interlocutor (Rowe 2001) – an entity whose sonic decisions unfold in real time – rather than perceiving it merely as an extension or augmentation of the instrumentalist. At the same time, working with machine learning models introduces tensions between technical complexity and performative accessibility. These developments also call for critical reflection on the environmental and logistical conditions of contemporary artistic production.

By articulating these processes, the performer/instrumentalist is positioned in relation to the questions posed by Paulo de Assis in the previous section,[37] acknowledging that we are still "only starting to grasp" the "new modes of expression" (de Assis 2023, 56) made possible by digital art and technology. Ongoing challenges, such as negotiating a balance between technological innovation, the material and environmental consequences of digital tools, and the preservation of meaningful aesthetic experience and cultural integrity (Caires 2025), continue to engage

37. See the Introduction.

the contemporary artist's attention. The hybridisation of the human and physical domain with what is commonly understood as the digital or technological domain is not only a condition of everyday life but also a driving force behind unique, often unrepeatable and context-dependent forms of artistic creation; this outcome further aligns the performer–instrumentalist with evolving modes of musical consumption that have undergone significant transformation in recent years (Onderdijk et al. 2023).

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On Data, Media In-Formations and Aesthetic Formatting in PERMUTATION

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PERMUTATION is an audiovisual live performance framework that explores the interchangeability of digital data between sound and image. Adopting media-theoretical, artistic and technological perspectives, we investigate how the project explores the premise that, at the computational level, all media reduce to numerical code. Implemented through live-coded sound synthesis in SuperCollider and a custom video engine built with openFrameworks, PERMUTATION establishes a strict data-level coupling between the auditory and visual domains. The paper discusses notions of data as representation and intermediary, outlines the technical pipeline of the performance framework, and reflects on limitations arising from the presented approach to audiovisual coupling, such as differing data densities, polarity mismatches, and frequential dependencies. Drawing on Niklas Luhmann's concept of the distinction between *medium* and *form*, our artistic practice can ultimately be understood as an act of formatting: an aesthetic actualization of the digital medium as perceptible audiovisual forms.

1 Introduction

> "With numbers, everything goes." (F. A. Kittler 1999, 2)

PERMUTATION is an audiovisual live performance framework written by Ricardo Rodrigues Erl and Maximilian Ardalan Bernhard that connects the auditory and visual domains on the data level.[2] This computational bridge is largely based on the notion of data interchangeability as afforded by digital media. PERMUTATION explores the possibilities and limitations of this notion by situating itself between strictly formal computation and perceptible, aesthetic association.

The paper aims to investigate the performance framework starting from the idea of data interchangeability. The development of PERMUTATION initially proceeded from the assumption that a complete interchangeability of data within a digital system afforded a direct correlation between sound and image in a live performance setting. The paper reflects on this premise from both a technical and media-theoretical perspective in order to examine to what extent data interchangeability is practically realizable and how far the performance framework succeeds in attaining this objective in the context of an artistic practice.

Drawing a theoretical baseline, we begin by reconstructing the aforementioned notion through media-theoretical, artistic and technological perspectives in order to understand the decisions made during

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1. All authors have contributed equally to this paper.
2. Code can be found under: https://github.com/erlerlerl/PERMUTATION (last accessed: 26.04.2026).

the development of the framework. Next, a technical description of the framework is given, focusing on the limitations of the simultaneous cross-sensory representation of data and proposing artistic strategies for adapting to and constructively engaging with these limitations. The artistic practice is then reflected in the light of Niklas Luhmann's system-theoretical distinction between *medium* and *form*, pointing to the act of formatting as a central operation.

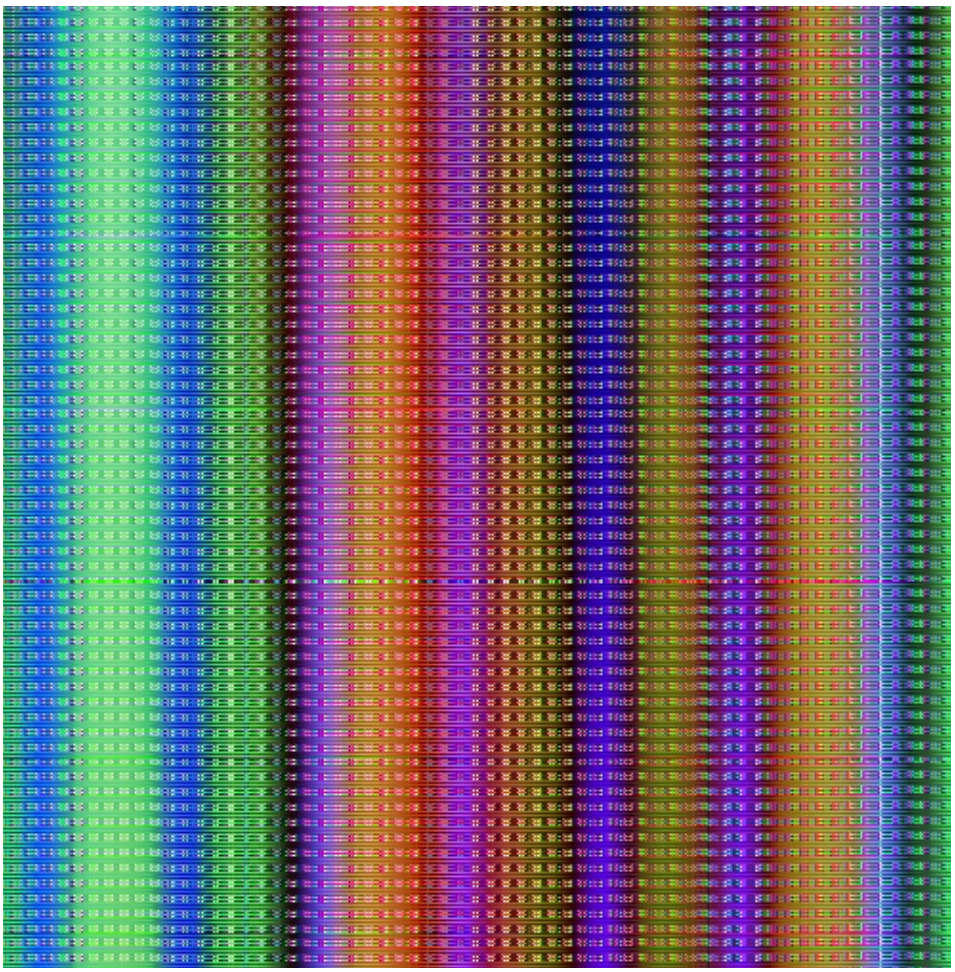


Fig. 1. Still from a live performance.

2 Theoretical Baseline

2.1 Data as Representation

What we mean by *data* is largely determined by the discipline in which the term is used. In most scientific fields data is understood as the result of representing some phenomenon in a certain way, often as a set of discrete and quantized numbers (Manovich 2015, 15). Measuring and sampling some phenomenon is required to perform computational calculations on it and thus examine it scientifically. It is important to note that the data is by no means equivalent to the underlying phenomenon, as the process of representation is a process of interpretation (Gitelman 2013, 3), limited by artificially defined boundaries (Manovich 2015, 15) and a great deal of filtering.

While these mandatory representational choices are widely discussed in data science, examining the resulting data requires a further transformation into a sensorially perceptible form, as "data itself is perceptually inaccessible" (Whitelaw 2004, 49).

2.2 Data as the Intermediary

Numerical code becomes the "new universal intermediary" (Manovich 2013a, 35), bridging the gap between the layer of sensorial perception and the layer of calculation. This allows for a situation where "[...] a digital representation of one type of media can also be translated into another media type that is meaningful to our senses" (Manovich 2013a, 36). A hint, perhaps, to the dissolution of the concept of separate media in the context of digital media, a mediatic conflation (see Section 2.3).

In practicality, however, this translational and interpretative flexibility is rarely given. The way we often operate with data is constrained by specific affordances of software, usually designed to fulfill specific tasks while 'preventing' other tasks (i.e. opening and displaying an image versus a sound file). Manovich somewhat boldly declares:

> There is no such thing as "digital media." There is only software as applied to media (or "content"). Or, to put this differently: for users who only interact with media content through application software, the "properties" of digital media are defined by the particular software as opposed to solely being contained in the actual content (i.e., inside digital files). (Manovich 2013b, 152)

2.2.1 Glitch Art and a Rheology of Data

Accessing data in its raw numerical form seems to be an action not as easily accomplished. Glitch artist and theorist Rosa Menkman notes that:

> Computer programs only function when definite forms of formatted data are inserted: data for which the machine has codecs installed. (The value of) RAW, non-formatted or unprocessed data is easily dismissed because it is often hard to open or read. (Menkman 2020, 72)[3]

Practices related to *Glitch-Art* variously sought to overcome such restrictions in order "[...] to work beneath the previously impenetrable veil of digital media" (Cascone 2000, 12).

Such possibilities may be forced through disruptive interventions or unorthodox uses of certain systems (i.e. "hacks") or provided by the affordances of specific or possibly custom-programmed pieces of software, such that "any selection of algorithms can be interfaced to pass data back and forth, mapping effortlessly from one dimension into another" (Cascone 2000, 17).

3. Page XVII of the essay titled *Refuse to Let the Syntaxes of (a) History Direct Our Futures*.

Glitch art practices often constitute an exciting entry point to creatively engage with digital technologies, emphasizing concepts such as spontaneity and randomness, but may also lead to more systematic investigations of the underlying algorithmic principles at hand, as is the case with the here-presented project. Carleigh Morgan remarks:

> [...] it is imperative to keep in mind how much the randomness, unpredictability, or messiness which glitch studies invokes around the glitch is in danger of overlooking the ways that the material architectures and algorithmic protocols structure the digital glitch by organising, constraining, and given form to its appearance. (Morgan 2019, 215)

Borrowing a term from physics, Rosa Menkman describes the concept of a *rheology of data*, which strongly resonates with the suggested ideas of freely accessing and molding data:

> By rheology of data I [...] mean a study of how data can be read and displayed in completely different forms, depending on the context, software or interface. A rheology of data facilitates a deformation and flow of the matter of data; it demonstrates the possibility of pushing data into different applications and the presentation of data in different forms. (Menkman 2020, 71)[4]

It is interesting to notice that such an approach to computation bears similarities to central concepts in the design of unixoid operating systems. Ken Thompson developed the first version of the *Unix* operating system at Bell Laboratories in 1969, drawing several ideas from an earlier operating system called *MULTICS* (Multiplexed Information and Computing Service) “including [...] the notion of files as unstructured streams of bytes” (Kerrisk 2010, 2). Based thereon, different models of *IPC* (Inter-Process Communication) originated (e.g., pipes, FIFOs, sockets).

2.3 Data as the Interchangeable

Once the surface cracks open, we gain access to the underlying rheological data currents. Data ‘matter’ can now become building blocks for new mediatic couplings, an image file might be interpreted as an audio waveform, an executable rendered as image, etc.; all courtesy of immaterial code, mathematical descriptions.[5]

Friedrich Kittler writes:

> The general digitization of channels and information erases the differences among individual media. Sound and image, voice and text are reduced to surface effects, known to consumers as interface. [...] Inside the computers themselves everything becomes a number: quantity without image, sound or voice. And once optical fiber networks turn formerly distinct data flows

4. Respectively page XVI, *ibid*.
5. Here a discussion about the different concepts of materiality as applied to the digital may be expedient.

> into a standardized series of digitized numbers, any medium can be translated into another. With numbers, everything goes. (Kittler 1999, 1f.)

The metaphorization of the computer as a *universal medium*[6] can further be contextualized from a practical computer science perspective:

> All information in a system—including disk files, programs stored in memory, user data stored in memory, and data transferred across a network—is represented as a bunch of bits. The only thing that distinguishes different data objects is the context in which we view them. For example, in different contexts, the same sequence of bytes might represent an integer, floating-point number, character string, or machine instruction. (Bryant and O'Hallaron 2011, 3)

While again emphasizing the universality of bits as the language of the computer, there are further ideas worth noting here. The differentiation of the term *user data* and the *data object* broadens the data term formulated in Section 2.1. The inclusion of computer programs or network traffic clarifies that not all data originates in real-world phenomena. From this point of view, everything that is represented by a sequence of bytes constitutes a *data object*.

The second important aspect is the receptive context that distinguishes data objects. As the notion of interchangeability enables the same sequence of bytes to represent different data objects, we as users need additional information to accurately perceive the intended data object encoded in the sequence.

3 PERMUTATION

3.1 Audiovisual Context

As we've already discussed in Section 2.2.1, the interchangeability of data inside the computer offers a rich potential for artistic exploration. Especially in the field of audiovisual arts, the intermediary role of data provides unique possibilities for bridging the auditory and visual domains. PERMUTATION seeks to explore this exact process of audiovisual bridging at the data level and constitutes a live performance framework based on live-coded sound in SuperCollider[7] and a custom-written video engine in openFrameworks.[8]

While audiovisual art is often based on 'deliberate' mappings between sonic and visual parameters, the act of bridging is subjected to media-specific characteristics. The spectrogram as a basic example of an audiovisual mapping displays the frequency spectrum over time of a given (audio) signal as a two-dimensional graph, where the position

6. See also: Schröter 2002, url: https://www.theorie-der-medien.de/text_detail.php?nr=46 (last accessed 26.04.2026).
7. https://supercollider.github.io (26.04.2026).
8. https://openframeworks.cc (26.04.2026).

on the x-axis represents a specific point in time, and the position on the y-axis a specific frequency. Mainly used as a tool for analysis, it offers great insight into the nature of the incoming signal. However, this audiovisual mapping makes media-specific assumptions as it is targeted towards representing the media-specific concept of a frequency and is therefore already the product of a specific receptive context.

3.1.1 Classification of Audiovisual Couplings

To systematically investigate how audiovisual couplings can be organized and compared, we refer to Michael Haverkamp's taxonomy for a general classification of cross-sensory couplings. Michael Haverkamp distinguishes five different types of couplings: *genuine synaesthesia, cross-sensory analogies, iconic coupling/association, symbol/metaphor* and *mathematical/physical correlation* (Haverkamp 2010). These strategies are differentiated by the extent to which they are consciously perceived or intuitively felt. While genuine synaesthesia originates as an intuitive impression, a mathematical correlation calls for a conscious decision to establish a formal connection.

Considering our aim of exploring the bridging between the auditory and visual domain on data level (i.e. algorithmically), the cross-sensory coupling in PERMUTATION can be located within mathematical/physical correlations. Haverkamp notes additionally that "[...] algorithmic or physical approaches of cross-sensory coupling need to additionally present 'intuitive' connections on the basis of analogies as well as of iconic and symbolic features [...]". (Haverkamp 2010) In PERMUTATION this "intuitive" connection lies in the time synchronicity. Further explained in the following sections, the core idea of the framework is built around synchronizing the audio data to a video stream, a process that is by no means trivial.

3.2 Conversion Concept

To understand our aim to work as close to a purely mathematical correlation as possible, the following paragraph examines the computational layer of an audio as well as a video signal. Digital audio streams are most often computed as a time- and value-discrete signal in the range −1 to 1, with a predefined floating-point precision, wherein a sustained audio stream of samples with the same value is perceived as silence (DC-offset). In a typical example, an audio stream is represented by 44,100 discrete values per second, as specified by the sample rate, which defines the temporal resolution of the audio signal. Accordingly, we can consider an audio signal as a one-dimensional function $f(t)$, defining a value for each given point in time t.

An 8-bit uncompressed black and white image is computed as an array of numbers, where each number, ranging from 0 (fully black) to 255 (fully white), represents the brightness value of one pixel of the image. We can thus define an image as a two-dimensional function $f(x,y)$, describing brightness values at given pixel coordinates in the frame.

Consequently, a video signal, representing a continuous stream of images, can be defined similarly, expanding the image function to include a time variable *f(x,y,t)*, so as to compute the brightness value for a specific pixel at the coordinates x and y at a given point in time t.

As the above definitions of audio and video signals define the smallest digital unit of the respective surface effect, to use Kittler's term (see Section 2.3), we decided to bridge the auditory and visual domains at this fundamental layer, mapping the value of each audio sample to a pixel on the screen.

3.3 Framework Duality

With SuperCollider as a real-time data creation and data processing tool and openFrameworks as the video engine in the background responsible for the data conversion, the framework is divided into two components with fundamentally different functionality. This division is not only found in the components' targeting of different sensory domains but is also emphasized in the technological characteristics of the used programming frameworks themselves.

With the introduction of JITLib,[9] SuperCollider has emerged as a live-codable audio programming framework and therefore bears the potential to be used in a live performance situation. In contrast to this, openFrameworks is based on C++, a compiled programming language. This severely restricts any real-time capabilities, as the code needs to be compiled into binary format before it can be run by the computer. Any performative flexibility thus needs to be defined (i.e. programmed) beforehand and cannot be modified during the performance.

As the openFrameworks engine is responsible for the data conversion of the audio stream to video data, the actual conversion process stays fixed during the performances and is only changed between performances to allow for different artistic explorations.

4 Limitations

In relating our ideal vision of the pipeline to the actual realization of the technical setup, we encountered limitations that had a considerable influence on the development of PERMUTATION.

4.1 Data Density / FIFO Principle

One of the main problems that arises when file sizes of audio versus video are considered, is different data densities. Using the following formulas we can highlight the problem. We define b as the data rate in $\frac{bits}{s}$, f_{sr} as the audio signal's sample rate, k_{audio} as the audio signal's bit depth, and c as the number of audio channels.

9. See: Wilson et al. 2025, Chapter 7.

$$b_{audio} = f_{sr} \bullet k_{audio} \bullet c$$

For the visual domain we define f_{fr} as a whole frame's update rate, k as the bit depth per color channel of the pixels, and N as the side length of a square-shaped frame.

$$b_{video} = f_{fr} \bullet k \bullet 3 \bullet N^2$$

When we compare values for a standard audio format versus a standard video format, we can easily demonstrate the underlying problem. A 3 minute long stereo audio file in CD quality contains 169.344 $Megabits = 44100\frac{1}{s} \bullet 16bit \bullet (3 \bullet 60)s$, while a Full HD video of the same length contains 2.239.488 $Gigabits = 3 \bullet 8bit \bullet 1920 \bullet 1080 \bullet 25\frac{1}{s} \bullet (3*60)s$ of raw pixel data.[10] This conclusively shows the 4 orders of magnitude in difference between data densities. Following this, we decided on implementing a scrolling image buffer, based on the FIFO principle, wherein a new row of pixels is added to the bottom of the image buffer, while the oldest is erased from the buffer. This way we avoid having to resort to slow framerates in order to keep time synchronicity.

As the engine is reading floating-point sample values instead of the bit sequence itself, we can discard any bit depth considerations. In this regard, the only effect the bit depth has is the resolution of our floating-point values. This also simplifies the mapping of audio to pixel data, such that each sample corresponds to one pixel in the image.

As we decided to work with color, without taking any perceptual considerations into account, rather focusing on its mathematical description, we chose to use three audio channels, each corresponding to one of the three color components of an RGB-encoded pixel. Adjusting our previous formula to our new FIFO scrolling image buffer, the buffer size (l) of the audio signal determines the rate at which new rows appear (f_r), as well as the size of our frame, as each sample in the buffer provides the data for one pixel,[11] and the whole buffer maps to exactly one row.

$$N = l$$

$$f_r = \frac{f_{sr}}{l}$$

This means that if we wanted to synthesize audio at $f_{sr} = 48\ kHz$ with our buffer size set to $l = 512\ samples$ we'd have a row update frequency of $f_r = 93.75\ Hz$. To calculate the time it takes until a frame has been fully filled with data, we multiply $\frac{1}{f_r}$ with h resulting in 5.5613 s.

10. These examples assume uncompressed data. As PERMUTATION maps individual samples to individual pixels the opportunity to deploy a visual compression to reduce required data size is very restricted and therefore not considered here.
11. More precisely, *for one color channel of one pixel*.



Fig. 2. Half a cycle of a bipolar sine wave, with $f = 0{,}5 \cdot f_h$, played only on the red (positive part) and cyan (negative part) channel.

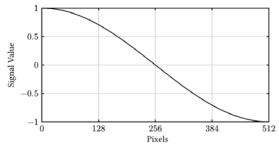


Fig. 3. Plot of the signal producing Fig. 2.

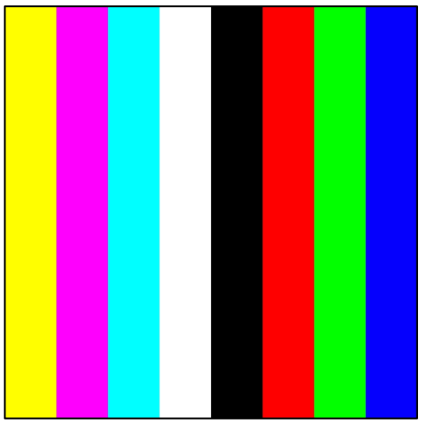


Fig. 4. Demonstration of color channels mixing, to create different colors, with $f = f_h \cdot 8$.

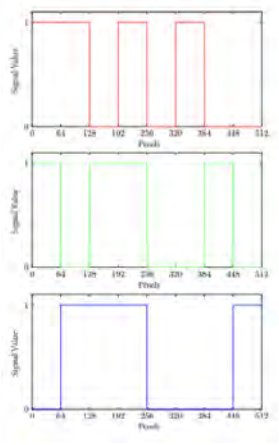


Fig. 5. Channel data of Fig. 4.

4.2 Polar Gap / The Notion of Silence

Based on the idea of a one-to-one relation between the audio and video data, in our case a bipolar audio signal and an RGB-encoded pixel frame, we encountered the problem of not only having different ranges but also polarities of input and output streams. A series of questions arose: Do we just discard data in the range of −1 to 0? If yes, what does discarding imply in the context of a data stream? Do we 'stretch' the rest of the data to fit the range of 0 to 255? Another fundamental question pertains to the notion of silence: How do we correlate auditory silence, as in a lack of air pressure change, to visual 'silence', as in the absence of light?

As auditory silence isn't bound to any specific value, but only defined through the lack of change,[12] it was easier to change our sound generation approach than it was to translate perceived auditory silence into its visual correlate, in the context of a real-time performance. Furthermore, this reflected our purist approach to data representation in the most direct possible way. Nonetheless, a different approach crystallized in later development stages, mapping positive values to an additive RGB color space and negative values to a subtractive CMY color space.[13] Using two color spaces simultaneously seems counter-intuitive at first, especially concerning the technical realization of this idea. As a matter of fact, the CMY color space only exists theoretically, as it can be simulated by inverting the values of the RGB space. For example, cyan CMY: 255/0/0 can be represented as RGB: 0/255/255. Consequently, every negative value of a specific audio channel is not applied to the corresponding color channel but to the other two.

This technological solution, however, bears its own problems, as negative audio values now impact the visual domain by twice as much, applying the value to two color channels instead of one, thereby increasing the overall brightness of the pixel (determined by the average value across all color channels) by twice as much. For this reason, we decided to only apply half the negative value to each color channel to preserve an equal 'numerical impact'.[14]

4.3 Frequential Dependencies

Fixing the parameters f_{sr} and N makes it possible to calculate frequential dependencies that link audio and video, and thus our underlying data together even more tightly. Considering the following two frequencies f_h, where one period of a waveform fills one row, and f_v, where one period matches the height of the whole image buffer, we as performers have new opportunities to 'draw' with our data.

12. Audio, unlike video, is perceived as changes in air pressure, which can be understood as the derivative of the source signal. While this observation warrants further consideration, it is left aside here.
13. This approach still only depicts silence in both media if the data stream is made up of zeros, but it also opens up new possibilities in displaying the difference of negative to positive values.
14. It is important to note here, that this solution is solely based on numerical consistency and is not intended to reflect perceived brightness.

$$f_h = \frac{sampleRate}{frameWidth}$$

$$f_v = \frac{sampleRate}{frameWidth * frameHeight}$$

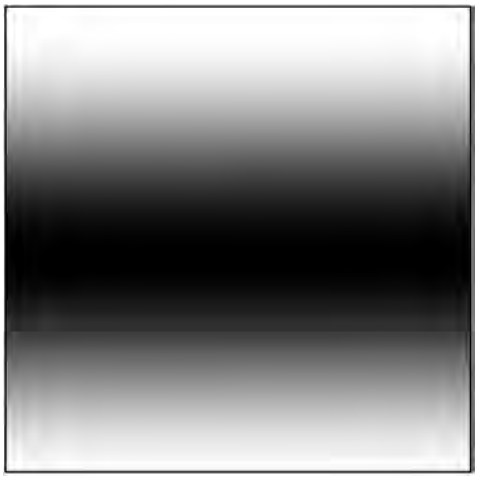


Fig. 6. One cycle of a unipolar cosine wave, appearing vertical, with $f = f_v$

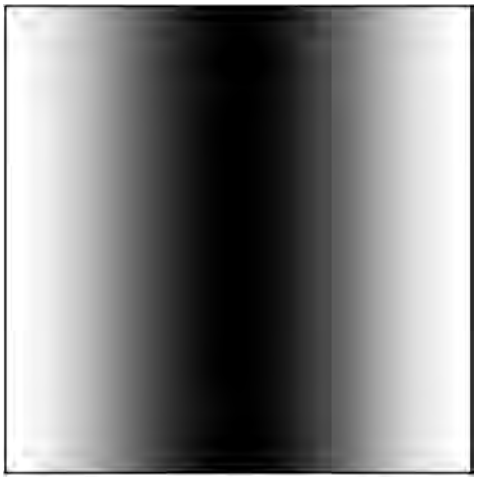


Fig. 7. One cycle of a unipolar cosine wave, appearing horizontal, with $f = f_h$

5 Reflections

Reflecting on the design choices explained in Section 4, it seems that the notion of 'freely' interchangeable data, as delineated in Section 2 has weakened. This realization is especially relevant since at the beginning of the project we set out to explore this very interchangeability. With reference to Haverkamp's classification of cross-sensory couplings, the technical solutions to the limitations we faced steer away from a strictly *mathematical correlation*. Especially the decision to translate perceived auditory silence into a visual one (see Section 4.2) would probably be considered as a *cross-sensory analogy* (ignoring *genuine synaesthesia*).[15]

This begs the question whether the way we developed the PERMUTATION framework still leaves traces of the original idea of exploring strictly mathematical correlations between cross-sensory couplings as a way of exploring the interchangeability of data as formulated in Section 2. To examine this question, the following paragraph focuses on Niklas Luhmann's system-theoretical distinction between *medium* and *form*.

5.1 Form (Luhmann)

While audio and video manifest as surface effects of the digital machinery, targeted to sensorial perception, it is their mediatic substrate that opens up countless possibilities for creative intervention. Niklas Luhmann's system-theoretical concepts of *medium* and *form* seem to be a very useful conceptual frame to be applied to a data-level approach to

15. The classification of *genuine synesthesia* is ignored here, as Haverkamp himself states, that this category is still under research (Haverkamp 2010).

audiovisual coupling. Luhmann's distinction between medium and form is thought of in terms of loose and tight couplings of elements.

> The term element does not refer to natural constants [...] Rather, it always points to units constructed (distinguished) by an observing system – to units for counting money, for example, or to tones in music. (Luhmann 2000, 103)

As the notion of a medium refers to a loose coupling of elements, it "[...] indicates an open-ended multiplicity of possible connections that are still compatible with the unity of an element – such as the number of meaningful sentences that can be built from a single semantically identical word" (Luhmann 2000, 104).

A medium opens up a space of combinatorial possibilities. Forms, on the other hand, as tight couplings of elements, are "selective actualizations of a medium"[16] (Krämer 1998, 566). What results as a tightly coupled form in one medium can itself become a loosely coupled medium for other forms.

5.2 Formatting / In-Forming

A medium as such then cannot be observed directly except through forms that tightly couple its elements, does it become perceivable, just as digital code remains invisible until it seeps to the surface to reach our senses. Audio and video actualize the digital medium as performative and contingent forms. To in-form a medium becomes a compositional act, an aesthetic choice. The notion of a format itself can be thought of as a demarcation between medium and form. With reference to Luhmann,[17] Michael Niehaus states:

> "It then turns the medium into a medium by arranging the elements in such a way that it becomes 'receptive'. In this sense, formatting is 'pre-formatting': the elements are formed in such a way that the nature of their coupling proves to be loose for another form." (freely translated from Niehaus 2018, 43)[18]

6 Conclusion

Niklas Luhmann's distinction between medium and form lets us reformulate the question brought up at the beginning of Section 5. Understanding the act of formatting as a demarcation between medium and form, thereby actualizing the distinction, recontextualizes the idea of data interchangeability. As the process of converting (audio) data into a

16. Original: selektive Aktualisierung eines Mediums.
17. "Media are generated from elements that are always already formed. Otherwise, we couldn't speak of their loose or tight coupling" (Luhmann 2000, 106).
18. Original: Es macht dann das Medium zum Medium, indem es die Elemente so anordnet, dass es ›aufnahmefähig‹ wird. Formatierung ist in diesem Sinne ein ›Vorformatieren‹: Die Elemente werden so formiert, dass sich die Art ihrer Kopplung als lose für ein [sic] andere Form erweist.

video stream ultimately represents a process of formatting, it is possible to argue that the data takes on the role of a medium in a Luhmannian sense. The auditory and visual domains can thereby be seen as actualizations of this medium. Searching for traces of data interchangeability in the performance framework consequently resembles a search for the medium in one of its actualized forms. In Luhmann's theoretical complex, this question is surprisingly easy to answer. As the relation between medium and form is codependent, the medium and therefore the notion of data interchangeability is a prerequisite for any actualized form. The developed solutions merely indicate the significance of understanding media and their actualized forms as products of a differentiating operation.

PERMUTATION ultimately reflects the notion of data interchangeability by treating the act of formatting as an aesthetic intervention. Surface effects then are the product of in-forming the digital medium, made possible by the interchangeability of data as loosely coupled elements.

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Re-examining Electronic Plant Music: Ecologies, Agency and Instrumentation In More-Than-Human Musicking

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This article re-examines Electronic Plant Music (EPM) as a critical site for interrogating what it means to construct sound ecologies with more-than-human bodies. Drawing on the concept of musicking, we argue that EPM should be understood not as the revelation of plant musicality or consciousness, but as the construction of technical dispositifs that render certain physiological indices sonically perceptible. Through a historical genealogy tracing EPM from 1970s cybernetic plant imaginaries to contemporary post-humanist reactivations, we expose the continuity of galvanic sensing methods and the epistemological consequences of this technical persistence. We then present *Troisième Nature*, an artistic research project that re-examines EPM by hacking an EMG biosignal capture device for plant electrophysiology, distinguishing biological agency from the musical agency typically attributed to plants through sonification. Pedagogical workshops conducted with primary school students reveal how making technical mediation explicit can produce different modes of understanding distributed agency across human-plant-technology assemblages. We conclude by questioning what is plant temporality and how grasping this notion will be used as a framework for future EPM practice.

1 Introduction: Sound Ecologies Beyond the Human

1.1 Representation and Realism In Sound Ecology

Sound ecology emerged alongside the environmental movements of the 1960s and 1970s, when composers and sound artists began to elaborate ecological modes of thinking *through* sound, composition, and listening practices (Barbanti 2023, 147–151). Within this genealogy, Raymond Murray Schafer's acoustic ecology, developed through the World Soundscape Project, established a durable framework for approaching environments as *soundscapes*: objects to be described, documented, and, within the same movement, protected through a normative critique of "noise pollution" (Schafer 1994; Duhem 2014; Paparrigopoulos 2024). Subsequent developments such as ecoacoustics reinforced this approach by treating soundscapes as ecological indicators to be measured and analysed (Krause 2018; Sueur 2018).

This also shaped what counts as a traditional object of sound ecology: soundscape composition, grounded in the recognisability of environmental sources and contexts, and in the expectation that listening will reconstruct meanings tied to a place and its identity (Truax 1996; Westerkamp 2002). This horizon, often aligned with forms of sonic realism, tends to frame the environment as something to be captured for a human listener, privileging what can be recorded, identified and

Keywords: Electronic Plant Music, More-than-human Musicking, Sound Ecology, Biosignal Sonification, Plant Agency, Artistic Research.

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documented (Schafer 1994). What becomes less visible, in turn, are the conditions that configure audibility itself: the power relations embedded in regimes of attention, mostly framed in the historical and political situatedness of the «white Western-centric ear» (Wright 2022, 3), and the forms of inattention or inaudibility to more than human bodies.

More recently, critiques of these concepts have emerged through more-than-human and decolonial perspectives. They are articulated through proposals such as multi-species sonic ecology (Di Croce 2021), post-human listening (Lacey 2024), more-than-human soundscapes (Degórski 2020), and listening after Nature (Wright 2022). Together, they displace the historical frameworks of acoustic and sound ecology by questioning the position of the human recordist and the power dynamics that configure listening practices and modes of relations developed within these projects. Positioning ourselves in this perspective, we argue that moving beyond representation in sound ecology can be a methodological reorientation toward a disambiguation of the chains of mediation through which environments become audible, and toward the distributed, negotiated agencies that such mediations enact.

1.2 Making Music With Non-human Bodies?

This article investigates sound ecologies that can emerge from trying to "make music with" non-humans, such as plants. To what extent can making music-with non-human entities be understood as interaction, and how feasible is such a project? This requires apparatuses in which we reframe "making music" as a practice that does not begin from clearly bounded subjects (a performer, an instrument, an environment), but from situated couplings between bodies, signals, and technical mediations. The "body" at stake here is therefore not only the human body as an expressive source, but a heterogeneous field of corporealities and material processes (physiological, mechanical, algorithmic, environmental) through which musical events become possible and perceptible. In this perspective, the question is less "who interacts with whom?" than "what assemblage and instrumentation make certain modes of audibility possible?"

If we understand interaction in the sense of joint action, the threshold for what counts as interaction can be demanding. In models of coordinated action, interaction involves spatio-temporal coupling, mutual adjustment, and some minimal capacity to take the other into account as an intentional partner (Vesper et al. 2017, 1–2). Schütz's analysis of "making music together" similarly presupposes a relation of co-presence: his "mutual tuning-in relationship", in which participants share a lived time and actively "tune" to one another within a common present (Schütz 1976, 162). But many more-than-human musical situations do not meet these conditions in any straightforward way: coordination may be asymmetrical, delayed, indirect, or distributed across sensing and processing chains; mutual attunement may be enacted through thresholds, mappings, machine learning classifications, or feedback topologies rather than through reciprocal intersubjective negotiation.

Treating such situations as if they were simply dialogues between intentional partners risks importing, by default, a human-centred model of agency and musical communication.

Read through an Actor Network Theory (ANT) perspective, such practices can be described as a "knot" of agencies that are mediated and redistributed across networks of humans and non-humans (Latour 2005, 44) (Born and Barry 2018). Devices, which can be sensors, electrodes, converters, signal-processing routines, mappings, models, and performance conventions, actively shape what can occur and what can matter in the situation, by configuring thresholds of perception and conditions of response (Latour 2005, 81–82).

We mobilise the concept of musicking as a more robust framing. For Small: "musicking is an activity by means of which we bring into existence a set of relationships that model the relationships of our world" (50). Music is therefore not located in an autonomous work but in participation: "taking part in performance, in social action", whose meaning lies in the relations established through performance (Small 1999, 9). Applied here, musicking describes the practical work through which participants (human and more than human) are provisionally brought into a shared situation of listening and/or acting. The point is to account for how relations are composed, tested, and stabilised in performance: what is made audible, what counts as a response, what becomes actionable, and what remains opaque or resistant.

1.3 Entanglements: Beyond Representationalism In Sonic Interaction

The shift from representation to musicking with more-than-human bodies requires attending not only to what becomes audible, but to how bodies, human and more-than-human, are configured as participants through technical mediation. Recent work on electromyography (EMG) in musical performance offers a model for thinking through these questions. Tanaka's work on the notion of "sonic entanglements" (Reed et al. 2024) demonstrates how EMG-based musical systems (investigated here) cannot be reduced to either transparent measurement or expressive control. Rather, the signal itself—messy, unstable, contextually variable—becomes constitutive of the performance situation (Reed et al. 2024, 2701), highlighting how technical apparatuses actively shape what counts as bodily action, musical gesture, and intentional expression.

If even human EMG signals resist straightforward intentional control—requiring instead a cultivation of attention to "messy electricity passing across muscle fibres, skin, and sensors" (2704)—then sonic practices with plant bodies or environmental processes cannot simply adopt models of dialogical interaction. This is why we frame our case study as a dispositif for testing modes of entanglement.

This article takes Electronic Plant Music (EPM) as a case study to question how sound can articulate relations with more-than-human bodies. To address this, we first trace EPM's historical genealogy from 1970s plant telepathy experiments to contemporary posthumanist re-

activations, examining the continuity of technical methods alongside shifting epistemological frameworks. We then analyze how these practices have moved from demonstrating plant "communication" to constructing experimental assemblages that foreground mediation itself. After examining the persistence of certain technical instrumentation, we present the project, *Troisième Nature*, that serves as a critical dispositif for testing EPM assemblages. Historically positioned outside the acoustic ecology movement despite emerging in the same period, EPM practices have only recently been included within expanded conceptions of sound ecology through posthumanist frameworks. Our hypothesis is that carefully constructed sonic dispositifs can make perceptible aspects of vegetal agency while simultaneously revealing the technical and ethical negotiations required to render such agency audible, questioning the very notion of agency in the context of musicking with plants.

2 Electronic Plant Music: History and Regimes of Representation

2.1 Plants Making Music In the 1970's

Electronic Plant Music (EPM), defined by Miller and Cox as the use of vegetal biosignals to generate sound or music (Miller and Cox 2024), emerged from a specific historical conjuncture intertwining plant physiology, cybernetic thinking, and countercultural plant imaginaries. From nineteenth-century investigations into vegetal sensitivity like Paul Bert's experiments on anesthetized *Mimosa pudica* (Bert 1867), Charles Darwin's studies of plant movement (Darwin 1880), Jagadish Chandra Bose's electrical recordings of plant responses (Bose 1906), a genealogy developed that would culminate, during the 1970s, in the construction of the plant as sensitive, communicative, and even intelligent subject. This decade witnessed the development of plant-sound dispositifs: John Lifton's *Green Music* installation (1975), the film adaptation of *The Secret Life of Plants* (Green 1979), Tom Zahuranec's *Radio Event No. 20: Rhododendron* (1972), and the ongoing *Music of the Plants* project developed in Damanhur, Italy (1976–1980). These practices contributed to what Teresa Castro has termed the construction of the "mediated plant": a figure whose sentience and agency become perceptible only through technological scaffolding (Castro 2019, 2020).

The 1970s "plant craze" (Castro 2020) cannot be understood outside its broader cultural context. The plant became a site for reimagining human-nature relations. This reimagining was paradoxically technophilic: even eco-mystical quests to reach the plant-other depended on "bio-sensing" technologies, on the interfacing of electronic extensions that would render plants audible and knowable (Castro 2020, 175). The communicative, sentient plant was thus necessarily a mediated plant. This movement found epistemological grounding in cybernetics, which framed plants as self-regulating communication systems whose electrical and chemical responses to stimuli functioned as inputs and out-

puts generating feedback loops (Castro 2020, 174; Wiener 1948). The seminal moment was Cleve Backster's 1966 polygraph experiment claiming plants possessed "primary perception"— telepathic awareness of human thoughts—a thesis quickly dismissed as pseudoscience by plant physiologists (Galston and Slayman 1979) yet widely popularized through Tompkins and Bird's bestseller *The Secret Life of Plants* (1973/1989). This fusion of cybernetic systems-thinking with New Age spirituality reflected what concerned scientists described as "a wave of anti-intellectualism" sweeping the United States (Galston and Slayman 1979, 337).

This trend operated through what Castro calls a "cybernetic paroxysm": an escalation of technological mediation aimed paradoxically at dissolving the human-nature divide (Castro 2020, 184). Tom Zahuranec's experiment *Radio Event No. 20: Rhododendron* (October 18, 1972, KPFA Berkeley) is an example. Here a rhododendron wired with liquid electrode sensors normally used to measure human galvanic skin response (GSR) fed bioelectrical signals from the plant into a Buchla modular synthesizer while the radio audience was invited to "communicate mentally" with the plant (radiOM.org 2026). Drawing on Backster's discredited "primary perception" thesis, the event positioned the plant simultaneously as psychic conduit, telepathic receiver, musical performer, and participatory medium. This representational regime reveals fundamental ambiguity between acknowledging the plant's radical alterity (requiring technological mediation) and anthropomorphizing its physiological responses as intentional communication (Galston and Slayman 1979). The technical methods they established – galvanic conductance measurement, biosignal amplification, mapping to synthesis parameters – persisted. Since the 2000s, a new generation of sound artists has reactivated these experiences while seeking to displace the representational regimes and instead engaging explicitly with posthumanist and new materialist frameworks.

2.2 Musicians "Becoming With Plants" Since the 2000's

Since the 2000s, electronic plant music has been reactivated by artists who no longer present plant–sound coupling as evidence for vegetal telepathy, but who represent an experimental scene in which the plant becomes audible through a technical ecology of sensing, mapping, and listening. What is at stake is less the "revelation" of a plant interiority than the construction of an instrumentation that distributes agency across heterogeneous components. This shift from the plant as a human-like performer to the plant–machine assemblage becomes the site for testing how relations are composed. In this sense, contemporary practices are often articulated as research protocols (installation, residency, performance, publication) that make explicit the conditions under which something like "plant music" can be perceived at all.

A first axis of this shift is a move from data transparency toward aesthetic sonification, understood as a "compositional problem". Mileece

I'Anson describes using "bioelectrical signal generated by a living plant" as one possible controller that "directly animates a series of set parameters," producing timbres and cadences "in reciprocation with an organic input" (I'Anson 2018, 502). Rather than claiming to transmit a plant "message," this framing foregrounds how the musical event is co-produced by thresholds, constraints, and aesthetic decisions within the signal chain.

A second characteristic of these practices is the design of hybrid dispositifs that explicitly thematize mediation as a condition of relation. Leslie García's *Pulsu(m) Plantae* (2010) is discussed here through her later technical description of the project (García 2011), which presents it as "a self-sustainable sound device" built through "the integration of a live organism (plant) and an electronic interface (bio-sensors)" (García 2011, 2). The project does not present the plant as an autonomous musician; it constructs a system meant to "read[] the vital pulse of the plant" through "pH, Minerals and galvanic variation sensors," and to transform these micro-signals into "audible sound frequencies" so that spectators may perceive "the rhythm and arrythmia of a silent organism such as a plant" (García 2011, 3). This locates agency in an operational ecology where sensing, microcontroller programming (including granular synthesis), and sustainable energy architectures (solar power) configure what counts as audible (García 2011, 2–4).

Some of these artists are concerned with epistemological positioning: contemporary plant–sound practices frequently stage the plurality and the friction of the knowledge regimes they mobilize. For example, Christine Ödlund's *Aether & Einstein* (2016a), documented in the exhibition catalogue Aether & Einstein (Ödlund 2016b), includes *Xylem Floem*, framed as "an acoustic experiment on the root systems of the plants," explicitly "referring to research in bioacoustics and evolutionary biology" (Ödlund 2016b), while also mobilizing theosophy. Here, the dispositif does not guarantee access to a plant "truth"; it exhibits how different representational and knowledge frameworks produce different versions of what the plant can be made to signify.

Finally, the reorientation toward "becoming with" plants (España Keller 2024) is often articulated through explicitly posthuman vocabularies that contest interactional models inherited from human sociality. España Keller defines "intra-action" (after Barad 2007) as a way to refuse pre-established bodies and to treat agency "not [as] an inherent property of an individual or human to be exercised, but as a dynamism of forces" (España Keller 2024, 2). Her aim is "to make perceptible… the slow and subtle sonic intra-relations and other-than human sonic undulations from plant life" (España Keller 2024, 3), using modular synthesis as a milieu where "live acoustic wave signals emitted by plants" are patched into "electronic patterns of sounds designed by humans, emitted by machines" (España Keller 2024, 2). The text repeatedly returns to the problem of arrangement: what the apparatus makes audible, which

modes of attention it demands, and how technicity conditions the ethics of relation (España Keller 2024, 4–7).[1]

Yet, despite this discursive shift, the technical infrastructures involved, based on resistance variation measurement remain structurally close to earlier systems. This persistence foregrounds sonification as a critical node where tensions between anthropocentrism, anthropomorphism, and attempts at critical anthropomorphism are continuously renegotiated, raising the question not only of "who speaks for non-humans" (Imhoff and Quirós 2022, 27–34), but more fundamentally: how non-humans are made to speak?

2.3 How?

Despite theoretical divergences, EPM techniques reveal remarkable continuity, primarily employing GSR measurement. From Zahuranec's 1972 Buchla-modulated rhododendron to current commercial devices, most systems employ galvanic skin response (GSR) measurement rather than recording genuine plant electrical signals. This technical persistence raises critical questions about what sonification accomplishes and obscures.

The dominant sensing method used in EPM projects measures electrical conductivity between two electrodes placed on plant tissue. Cleve Backster popularized this approach in the 1960s using polygraph equipment on *Dracaena* leaves, interpreting conductance variations as plant "primary perception" (Backster 1968). Though scientifically discredited, the method persisted because it produces continuous, measurable variation suitable for real-time sonification. As Miller and Cox specify, galvanic measurement correlates primarily with leaf water content: "these data do not necessarily represent electrical signals generated by the plant itself, but rather reflect a more-or-less accurate measure of the water content in the leaf" (Miller and Cox 2024, section 3.11). Water content fluctuates with circadian rhythms and environmental conditions, creating apparent responsiveness without representing plant signalling in the electrophysiological sense.

Electrode configurations vary by practitioner. TENS (Transcutaneous Electrical Nerve Stimulation) cables with conductive gel have become standard in commercial devices like PlantWave[2] and MIDI Sprout.[3] Zahuranec's 1972 system used liquid electrode micropipettes. García developed galvanic sensors for mosses, while Mileece combines GSR with EEG (Electroencephalogram) sensors measuring resistance and direct current. Using EEG permits the acquisition of more comprehensive or higher-resolution data, which is an exception in EPM. Davies, a molecular biology researcher, notes that surface contact electrodes avoid tissue damage but contain KCl that dries out, limiting use to "short-term

1. The corpus mobilised here is restricted to artists publishing detailed accounts of their instrumentation. Its markedly feminine composition seems to be a gendered dimension of contemporary EPM practice to be investigated in future research.
2. https://plantwave.com/
3. https://www.midisprout.com/

(a few hours) recordings," whereas piercing electrodes (silver, platinum) remain "usable for days and perhaps weeks" without altering ionic status (Davies 2006, 414). In EPM instrumentation, plant selection also responds to technical constraints: the systems studied favour robust species with rigid leaves like snake plant (Sansevieria trifasciata), croton (Codiaeum), jade (Crassula ovata), that withstand extended electrode attachment.

In these systems, signal processing architectures transform voltage fluctuations into sound through diverse mappings. PlantWave and MIDI Sprout map conductance to MIDI notes in programmable scales. García's Max/MSP patches link multiple data streams to synthesis parameters. Mileece's modular systems use voltage fluctuations to modulate oscillator frequency and filter cutoff through algorithmically mediated processes rather than direct mapping. As Miller and Cox observe, engineering choices significantly affect sonic outcomes and creative agency (Miller and Cox 2024, section 3.3).

This technological persistence across five decades reflects structural constraints. Rigorous action potential measurement requires laboratory conditions not always compatible with exhibition contexts. Galvanic sensing offers a pragmatic compromise: continuous variation accessible through simple electrode contact. Yet this choice carries epistemological consequences. If systems primarily measure leaf water content rather than plant electrical signalling, plants function less as autonomous agents generating messages than as responsive substrates whose material properties fluctuate with environmental conditions. This reframes EPM: not as a practice accessing plant communication, but as an apparatus that brings plants, humans, and technologies into sonic relations. The instrumentation does not translate an existing plant voice but enables a sonic mode of presence.

3 Re-examining EPM: Disambiguation Through Artistic Research

Troisième Nature is an artistic research (AR) project that critically re-examines the practices and discourses of Electronic Plant Music (EPM) through two types of dispositifs: (1) a sound installation and improvised concert featuring the sonification of three terrariums planted with vegetation from the Jardins du Tiers-Paysage (Clément 2004), along with an improvised concert by a musician interacting with this system, was presented at the Festival de l'Eau from May 21-25, 2026 in the radôme of the Saint-Nazaire submarine base; and (2) a set of pedagogical workshops for primary schools we are discussing in this article.

Rather than assuming that plants possess musical agency, the project treats interspecies musicking as a site for interrogating what it means to "compose with" non-human organisms. The work problematizes the notion of agency itself: distinguishing between a plant's biological agency while questioning the idea of musical agency attributed to plants through sonification systems. By foregrounding the technical instru-

mentation that mediates the encounter between human and plant, we ask the questions:

What exactly are we measuring when we claim to make music "with" plants?

What does the technical infrastructure reveal or obscure about vegetal life?

3.1 What Is a Plant? What Is Agency? What Is Plant Agency?

Before examining plant agency through EPM, we must clarify what defines both plants and agency in biological systems. As Hallé observes, plants differ fundamentally from animals in their modular architecture, indeterminate growth, and existence (Hallé 1999/2024). Plants develop through continuous iteration of modular units – leaves, stems, roots – responding to environmental conditions throughout their lifespan. This architecture produces organisms capable of regeneration from fragments, exhibiting distributed rather than centralized information processing.

Plant electrophysiology provides measurable indices of this processing. Research distinguishes several types of long-distance electrical signals (Vodeneev et al. 2015, Sukhov 2016, Li et al. 2021). Action potentials (AP) are fast, brief, all-or-nothing events triggered by non-damaging stimuli such as touch or light change. In *Dionaea muscipula*, AP typically exhibit amplitudes of 100-150 mV and durations of 1-2 seconds. AP are "self-propagating" signals transmitted primarily through phloem[4] tissue "at essentially constant velocity and amplitude" (Davies 2006, 409-410). Conduction velocities for AP range from 2-10 mm/s in most plants (Madariaga et al. 2024), though they can reach up to 20 cm/s in specialized structures like *Mimosa pudica* motor cells (Sibaoka 1962). Variation potentials (VP) are slower signals typically induced by damaging stimuli like wounding or burning. VP exhibit variable amplitudes typically ranging from 5-50 mV with durations of tens of seconds to several minutes, propagating at velocities of 0.1-1 mm/s (Zimmermann et al. 2009, Davies 2006, 411). VP amplitude decreases with distance from the stimulus site (Stahlberg and Cosgrove 1997). The amplitude and duration of VP scale with stimulus intensity and gradually decay over distance and, unlike AP, can travel through dead tissues. System potentials (SP) correspond to transient hyperpolarizations with amplitudes of 5-20 mV propagating autonomously, with mechanisms involving reactive oxygen species and photosynthetic regulation (Sukhov 2016). Taken together, AP, VP, and SP form a dynamic picture of how plants integrate and respond to environmental changes.[5]

Electrical signalling permits "very rapid systemic information transmission, so that the entire plant is informed almost instantly even

4. The vascular tissue in plants which conducts sugars and other metabolic products downwards from the leaves.

5. See representation of AP, VP and SP in Sukhova et al. article's figures: https://www.researchgate.net/publication/318469232_Mathematical_Models_of_Electrical_Activity_in_Plants

though only one region may have been perturbed" (Davies 2006, 417). This rapidity enables coordinated defence responses: wounded cells transmit signals causing distant cells to stop cytoplasmic streaming, clog plasmodesmata, inhibit translation, and activate defence genes within minutes (Davies 2006, 417-418). Both AP and VP trigger systemic gene expression changes, with some transcripts peaking "within 2 min in a leaf 5 cm distant from the wound site" (Davies 2006, 412). These signals constitute a distributed information processing system enabling plants to integrate perturbations and mount coordinated responses across their modular bodies. These signals serve essential adaptive functions and are indices of the plant agency.

But rather than asserting a strong notion of plant agency, our project adopts a cautious perspective grounded in minimal or biological agency. Following Saint-Germier (2025) and List and Pettit (2010), agency for us involves representing environment aspects, possessing motivational states, and processing these to act when conditions mismatch. From a biological perspective, plants perceive multiple stimuli: light, gravity, nutrients, chemical signals. They integrate thess environmental cues and adjust their growth in a flexible manner oriented toward survival and reproduction. These processes, however, do not involve internal representations in the strict sense; rather, they are part of physico-chemical regulatory networks, of which electrical signals are one measurable indicator. Electrical signals are thus approached not as expressions of intention, but as measurable indices of vegetal vitality and adaptation (Selosse 2022, 2024). Thus through our artistic research experiment, the aim is not to uncover plant "language," but to construct a situated listening experience that makes perceptible clues of vegetal agency through sound and to question the notion of agency in this context.

3.2 Hacking an EMG/EEG Device for Plant Electrophysiology

For the *Troisième Nature* project, plant electrical signals are acquired using the EAVI board,[6] developed to capture human EMG and EEG for musical interaction (Tanaka et al. 2024). It features four bipolar analog inputs processed by a high-resolution analog-to-digital converter (ADS1294, 20-bit) with an internal noise of just 5 microvolts peak-to--peak, substantially below the amplitude of plant electrical signals. The system includes an STM32F427 microcontroller and transmits digital data at 8 kHz via USB. However, the EAVI's embedded firmware originally included signal conditioning designed for human biosignals: a DC filter, a 500 Hz low-pass filter, and a 50 Hz notch filter (Fig. 1.).

6. https://github.com/RebelTechnology/BioSignals

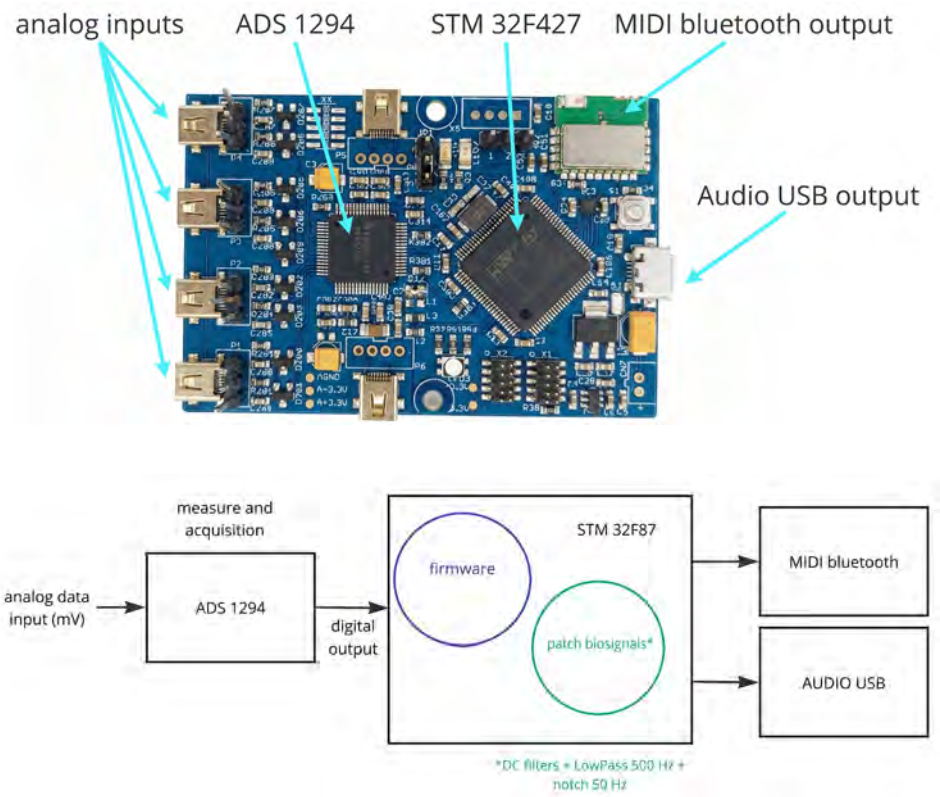


Fig. 1. Photo of the EAVI board and diagram of measurement and acquisition.

Because these filters can interfere with the slow drifts and low-frequency components characteristic of plant electrical activity, the filtering stage was removed from the EAVI boards dedicated to plant use. We conducted calibration tests using a precision voltage generator (SIGGI-2, EASYCAP) to establish the relationship between input voltage and recorded values (Schuh 2024). The calibration revealed linear relationships in specific voltage ranges, with the conversion formula: millivolt = $(x - 0.0118)/(3.8 \times 10^{-4})$, where x is the collected PCM amplitude data. This characterization confirmed that the modified EAVI board could reliably detect voltage variations at the microvolt scale typical of plant electrophysiology, supporting its use for measuring action potentials (APs), variation potentials (VPs), and system potentials (SPs) in plants.

3.3. Recording Plant Activity: Behaviours and Time Scales

Before embarking on the project proper, a series of exploratory tests was conducted to evaluate signal stability, sensitivity to environmental conditions, and the effects of different technical parameters. These tests were carried out in different environments (with and without Faraday cage), with different electrode types (steel, Ag/AgCl, and platinum), and on several plant species with known AP, VP, and SP potentials (Boston fern *Nephrolepis exaltata, Dionaea muscipula, Mimosa pudica*). These experiments documented electrode configurations, positioning, environmental conditions, and signal characteristics.

To better understand what is actually measured when recording plant electrical activity, a series of tests was conducted in collaboration with Benedikt Kaiser-Lasalle at the ITODYS laboratory (Interfaces, Treat-

ments, Organization and Dynamics of Systems, Université Paris Cité).[7] Using a potentiostat, we compared electrode types on *Dionaea muscipula*.



Fig. 2. Data visualisation of electrical signal on *Dionaea muscipula* with platinum electrodes. In blue: on the plant's traps, in red: on the plant's stem (11/12/2025 at ITODYS laboratory - Electrochemical Imaging).



Fig. 3. Data visualisation of electrical signal on *Dionaea muscipula* with platinum electrodes. In blue: on the plant's traps, in red: on the plant's stem (11/12/2025 at ITODYS laboratory - Electrochemical Imaging).

These tests revealed that electrode positioning is critical: only placement on *Dionaea* traps captures signals corresponding to true action potentials during closure (Fig. 2.). When electrodes are placed on the stem, the recorded signal is different and does not correspond to the expected electrophysiological event. Following these preliminary tests, a protocol with reproducible manipulations was constructed to verify what is recorded with the tools and environment used for this project (Ag/AgCl electrodes, EAVI board, computer with power supply).

Two experimental series were conducted to evaluate the signal-acquisition performance of the EAVI board using homemade Ag/AgCl surface electrodes[8] and conductive gel.[9] Signals were recorded in Audacity on battery-powered laptops to reduce mains-related interference. Thirteen recording sessions on *Dionaea muscipula* tested electrode placement and environmental conditions. In Session 13, electrodes were positioned on an open trap that closed spontaneously during acquisition (Fig. 3), allowing us to document electrical activity across the trapping sequence. The recording exhibited a train of stereotyped biphasic transients, temporally associated with the closure and early post-closure period. On this basis, and given the known excitability of *Dionaea* traps, these events were interpreted as action-potential-like signals. During the first 5 minutes, the largest events occurred at intervals of approximately 20–30 s (Fig. 4). Over the following 15 minutes, both event amplitude and occurrence rate decreased, consistent with a transition toward the post-closure narrowing phase described in the literature.

7. https://itodys.u-paris.fr/
8. Silver wire (Ag) dipped in in a sodium hypochlorite solution (bleach). The AgCl layer forms by soaking the wire for about 30 min in the solution. Then it is soldered to a din 42802 electrode cable.
9. Parker Laboratories Signa Gel.

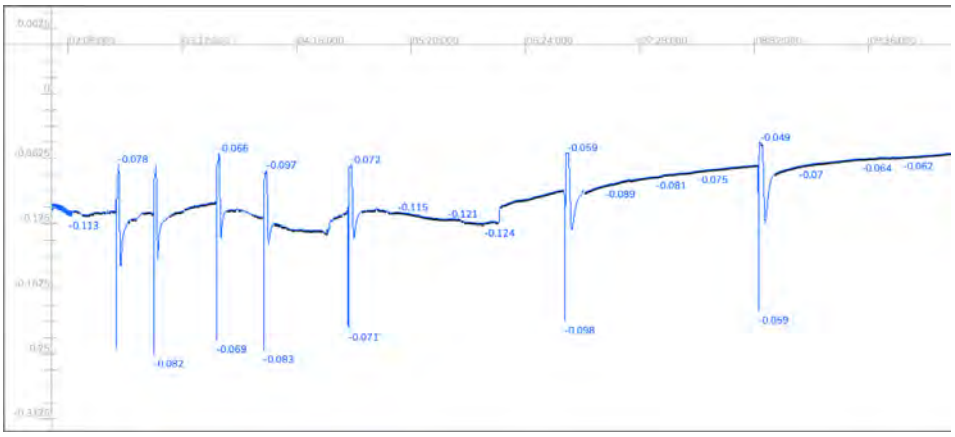
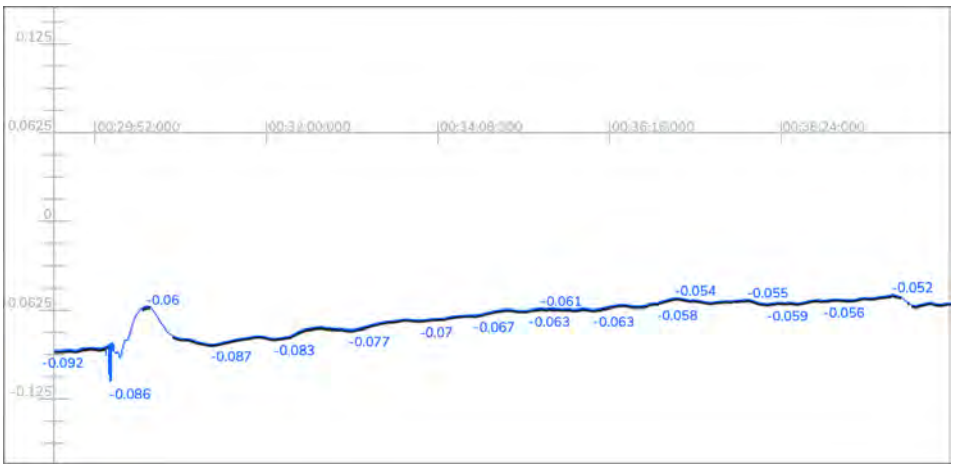


Fig. 4. Visualisation with the Partiels[10] software of the AP-like morphology acquired through Audacity. *X* axis represents the PCM amplitude and y axis the time in 00m:00s:000ms.

For *Mentha spicata*, eight sessions investigated wound-induced electrical responses through systematic stem cutting.[11] In Session 4, the initial cut elicited a slow transient characterized by an approximately 45-second rise time and a 3–4 minutes decay. This morphology—slow depolarization followed by prolonged recovery—is consistent with descriptions of wound-induced variation potentials in the plant electrophysiology literature (Libiaková et al. 2014, Davies 2006). However, subsequent cuts produced progressively weaker responses. This attenuation may reflect electrode-interface instability or conductive gel desiccation, a known practical limitation in surface electrophysiology recordings over multi-hour sessions (Davies 2006). While the temporal profile of the initial response aligns with reported variation potentials, definitive identification will require additional controls.



Fig. 5. Ag/AgCl electrode placed on *Mentha spicata* stem, visualisation with the Partiels software of the of the VP-like morphology acquired through Audacity. X axis represent the PCM amplitude and y axis the time in 00m:00s:000ms.



In *Dionaea*, the recorded fast transients exhibited durations on the order of 1–2 seconds, which fall within the range commonly reported for Venus flytrap action potentials. The waveform morphology (rapid depolarization, repolarization, and transient undershoot) is compatible

10. https://forum.ircam.fr/projects/detail/partiels/
11. *Mentha spicata* was selected precisely because stem cutting is a commonplace horticultural and culinary gesture (harvesting mint for cooking). This familiar context allowed wound-induced electrical responses to be documented using a stimulus that falls within the plant's ordinary ecological experience. Nevertheless, wound-induced protocols were conducted exclusively during the experimental validation phase and will not be replicated during public presentations or pedagogical workshops, where only non-damaging stimuli are used.

with published descriptions of electrically excitable events in *Dionaea*. Because recordings were obtained using surface Ag/AgCl electrodes, measured amplitudes represent extracellular potentials and therefore cannot be directly equated with intracellular membrane potential values. The progressive reduction of transient amplitudes during closure sequences may relate to the electrical counting mechanism described in *Dionaea*, in which successive action potentials contribute to trap activation (Böhm et al. 2016);[12] however, direct confirmation in our setup will require controlled stimulation protocols.



Fig. 6. Array of Three Ag/AgCl electrode placed on each side of a *Dionaea muscipula* trap and secured with medical tape in order to prevent artefacts caused by movements.

Since the original submission, we have implemented a multi-electrode recording protocol on a single *Dionaea muscipula* trap (Fig. 6.), designed to distinguish true action potential propagation from recording artefacts. The underlying rationale is that an artefact would appear simultaneously across all channels, whereas a propagating AP would arrive at each electrode with a measurable delay reflecting its conduction velocity through the tissue. Across all documented AP events (Fig. 7), we observed consistent sequential activation of the three surface electrodes with inter-electrode delays yielding propagation speeds of approximately 0.52–1.64 cm/s.[13] These values fall below the reference range most commonly cited in the literature for *Dionaea muscipula* action potential propagation: typically 6–20 cm/s (Bakker et al. 2021), up to 10 cm/s (Hedrich and Kreuzer 2023), and from 0.82 to 11.22 cm/s for first-stimulus responses measured with a NeuroGrid MEA (Armada-Moreira et al. 2023). This discrepancy is likely methodological rather than physiological: our surface Ag/AgCl electrodes measure extracellular potentials across a 0.15–0.50 cm span, whereas published values derive from intracellular or high-density array recordings across larger tissue distances. The propagation order we observed is consistent across all documented events and the measured velocities are physiologically plausible (i.e. they do not exceed known upper bounds), a point confirmed by Stephen Whitmarsh's expert review.[14]

12. https://www.cell.com/cms/10.1016/j.cub.2015.11.057/asset/2daac841-09e9-4e1c-8f71-ffc45aba3c89/main.assets/gr1_lrg.jpg
13. All data available on demand to the authors.
14. Stephen Whitmarsh (Institut du Cerveau, Paris) is a neuroscientist and BBDMI member.

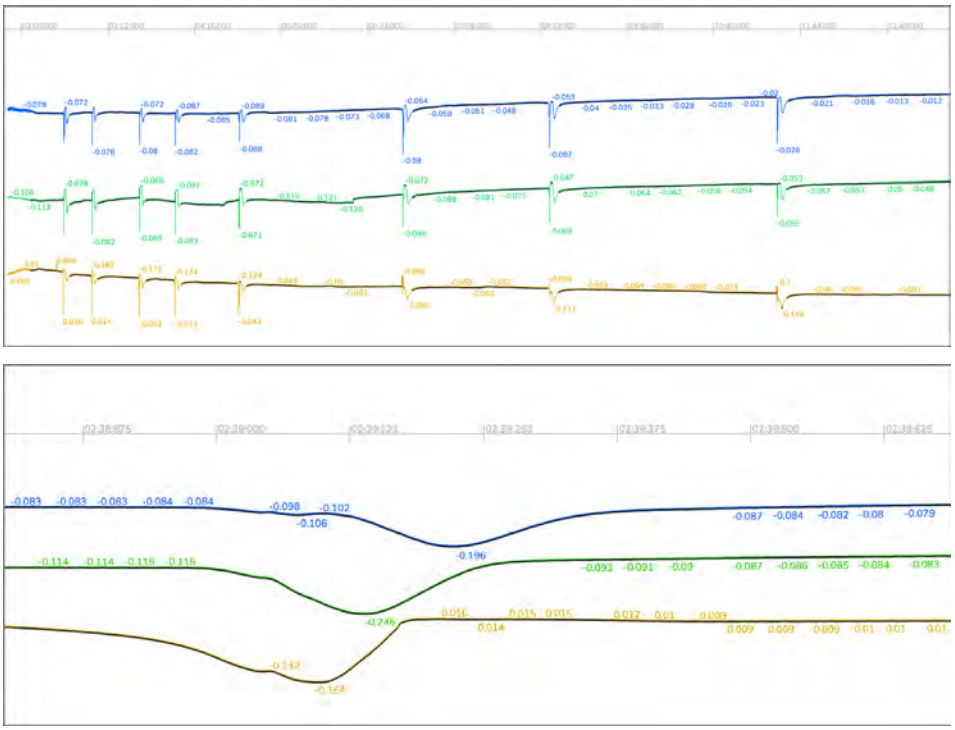


Fig. 7. Visualisation with the Partiels software of the of the AP-like morphology acquired through Audacity. PCM amplitude is indicated on each channel and y axis the time in 00m:00s:000ms. The first image shows the first 8 events, the second image is a zoom of the first event. The orange channel corresponds to the electrode placed the furthest from the stem and Blue channel is the closest, this representation shows the propagation of the signal from the trap's hair to the stem. These experiments indicate that the EAVI board coupled with homemade Ag/AgCl electrodes is capable of detecting reproducible plant bioelectrical transients in both *Dionaea* and *Mentha*. Under conditions of careful electrode placement, fresh conductive gel, battery operation, and recording durations below approximately 2–3 hours, the observed temporal characteristics are compatible with published electrophysiological reports.

4 Re-examining EPM: Electronic Plant Musicking

4.1 EPM as a Pedagogical Experience, a Case Study

A pedagogical dispositif emerging from the project was developed within a Parcours d'Éducation Artistique et Culturelle (PEAC)[15] residency at a public elementary school in Saint-Nazaire, involving two classes: a CE2 class (approximately 20 students aged 8-9) and an Unité Locale pour l'Inclusion Scolaire (Ulis, 12 students with disabilities aged 6-12).[16] The school's particular context proved significant for this experimental inquiry into EPM intelligibility. Unlike most urban schools, this institution maintains several "nature spaces" in its courtyard, including a vegetable garden with outdoor classroom spaces. This existing ecological socialization—constructed through institutional pedagogy and enriched by family contexts (Vitores 2025)—meant students already possessed substantial botanical knowledge before encountering the plant-sound assemblage.

The pedagogical project comprises four workshop sequences culminating in a public presentation. The workshops aimed to sensitize students to ecological questions through listening and musical experience, following a progressive pedagogy from soundscape listening to technical mediations. The January 15, 2026 sequence – the focus of this analysis – divided each half-class session into two parts: first, collective soundscape listening activities reconnecting to field recordings students had made in October; second, small-group testing of the plant sonification system after pedagogical framing about plant electrophysiology.

15. https://www.education.gouv.fr/bo/15/Hebdo28/MENE1514630A.htm
16. https://www.education.gouv.fr/bo/15/Hebdo31/MENE1504950C.htm

Before testing the interactive system, students participated in discussions establishing necessary background: distinguishing plants from animals, understanding cellular electrical activity in both kingdoms, and learning the three types of plant electrical signals (AP, VP, SP). These exchanges revealed students' existing representations, ranging from associating life with movement to sophisticated knowledge of mycorrhizal networks. This baseline understanding allowed the technical system explanation to proceed, with students following the signal chain from electrodes through the ADC card to computer software and sound output.

The pedagogical context thus constituted what Hejoaka et al. (2022) term an "a priori difficult" test case for dispositif intelligibility: young students, some with disabilities requiring adapted pedagogical supports, encountering a technically complex assemblage mediating between plant electrophysiology, signal processing, EMG sensing, and algorithmic sonification. Yet this very difficulty rendered the case study methodologically valuable: if the system could produce forms of understanding and engagement in this context, it might suggest something about EPM's potential as more than mystification or anthropomorphic projection.

4.2 Constructing Interactivity With Plant Temporality

The sonification system developed for this pedagogical context—and subsequently adapted for the exhibition installation—embodies the attempt to construct what we term "interactivity" rather than "interaction" with plant temporality,[17] since plant-human musicking cannot meet the criteria of straightforward interaction. Rather than projecting interactional capacities onto the plant, the system localizes "interactivity" in the technical apparatus itself: the Max/MSP patch functions as a rule-based system that constructs an "ear" for the plant—a chain of thresholds, decisions, and transformations that makes certain plant-human relations audible and actionable.

The system architecture operates through two interacting modalities: sonification of the plant signal, and transformation of this sonification through human gesture (signal measured via the plant biosignal), with human actions triggering processes that are always conducted by parameters derived from the plant signal. Both signals are normalized and interact through threshold logic and dependencies: the human gesture acts as trigger while the plant signal determines precise parameters of sonic evolution. This creates an asymmetrical dialogue where the human initiates processes but the plant guides their unfolding.

17. By "plant temporality" we refer to several concrete features of vegetal electrical dynamics: event durations on the order of seconds rather than milliseconds (as compared to human neural APs), inter-event intervals of 20–30 seconds during active phases, progressive attenuation over minutes, and propagation speeds orders of magnitude slower than human neural conduction. These temporal scales, too slow for rhythmic musical patterning, too fast for perceptible growth, constitute a specific temporal regime that challenges conventional sonification mappings.

The sonification system maps plant electrical signal amplitude directly to the pitch of a sustained drone tone.[18] Different signal tracking modes produced varying perceptual effects of the plant's "liveness." The choice of tracking mode proved determining: more precise tracking makes the plant seem more active and responsive.

The human EMG signal intervenes through three transformation modalities triggered by muscle tension thresholds. Continuous muscle force creates proportional "blurring" of the plant drone.[19] Strong contraction (sustained above threshold) triggers harmonic multiplication, generating polyphony through chord structures selected according to the plant signal value at trigger moment.[20] Conversely, muscle relaxation (sustained below threshold) activates rhythmic sound objects—pre-recorded samples from the students' garden recordings—whose tempo, echo subdivisions, and feedback parameters all derive from plant signal amplitude at trigger crossing. Common to all these mappings is the plant signal amplitude: thus beyond diverse transformation types and gestures, the general sonic impression relates to vegetal signal amplitude.

4.3 Experiencing the Device: What Is the Plant Really Doing?

Testing the dispositif with students revealed both ludic potential and fundamental intelligibility challenges: this session was a first test. After the technical chain explanation, students listened to three sonification versions of the same plant signal corresponding to the tracking modes described above. After this introduction, students experimented human/plant sonic interactivity by group of two.

We present these observations as preliminary findings from a first test session, not as a systematically analyzed case study, which will be conducted in future research-projects. Student responses revealed varied comprehension levels. Some provided precise observations of gesture-sound correlations, also identifying counter-intuitive mapping creating inversion between gesture intensity and perceived amplitude (more muscle tension = less sound). Recording analysis revealed that during unguided experimentation, some children successfully discovered the system's logic through play.

18. One drone used in the patch : https://drive.google.com/file/d/1u_tbgAFWmi3rJl-VS1PgTIiK1s6Hn7gl/view?usp=sharing ; and its decorrelation ("blurring effect"): https://drive.google.com/file/d/1gbUg9UV8pz1Q79Ej2g3zEkCO_2hFkD03/view?usp=sharing
19. The same drone with several examples of the harmonic transformation: https://drive.google.com/file/d/19y8EWvAyYcwozpKpDaWzwlrBjCyVq_yw/view?usp=sharing
20. Example of a rythmic sound object triggerd by relaxing muscle: https://drive.google.com/file/d/1vuhXYftcXoEMvSrpi9JRBUmUdcuKxHHe/view?usp=sharing

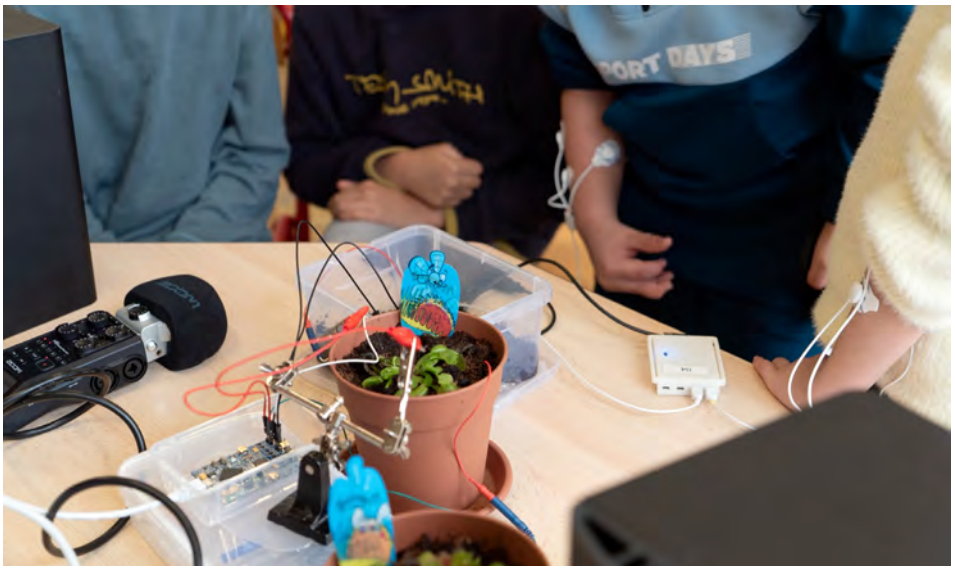


Fig. 8. Students experimenting musicking with gesture (EMG) and plant sonification.

Yet the central question—"what does the plant do?"—revealed comprehension difficulties. Some responses demonstrated general ecological understanding without grasping the specific sonic dispositif. Students expressed confusion distinguishing plant sonification from gesture-induced transformations. The afternoon group better grasped the sonification principle, correctly identifying electricity, technical mediation, and the computer as necessary components, and recognizing that without this apparatus plants make no music.

Teachers' feedback testified to positive impact, particularly for the Ulis students. The teacher noted remarkable concentration levels, suggesting this kind of sonic practice can open different pathways to knowledge than conventional pedagogical supports.

These tests identified required improvements for the next sessions: addressing latency, mapping issues, cognitive overload, and technical friction. Yet despite these limitations, the dispositif succeeded in making perceptible the fundamental strangeness of plant-human temporal mismatch, the necessity of technical mediation, and the distributed character of agency across this assemblage. This experience of Electronic Plant Musicking did not function as transparent demonstration of plant musicality but a constructed scene for testing what modes of relation become possible when vegetal electrical activity is rendered audible.

5 Conclusion: Toward Plant Timescales

This investigation has disambiguated several fundamental aspects of Electronic Plant Music previously elusive in historical and contemporary practices. First, what EPM actually is: not the revelation of plant musicality or consciousness, but the construction of a technical apparatus that renders certain physiological indices sonically perceptible. Most EPM systems do not measure genuine plant electrical signals but rather galvanic response reflecting leaf water content—a crucial distinction that reframes these practices from epistemological (revealing plant

communication) to ontological (producing new plant-human-technology assemblages).

Second, what the plant actually "does" in these dispositifs: it functions as a responsive material whose physiological processes provide measurable indices of vegetal vitality and adaptive behavior. Hacking the EAVI from human EMG to non-human biosignal capture demonstrated that when technical conditions align the apparatus can extract data represented by these electrical signals, providing indices of plants' temporal patterns.

Third, by distinguishing biological agency (the plant's capacity to perceive and respond) from musical agency (often anthropomorphically projected), this research exposed how distributed agency operates across heterogeneous assemblages. The pedagogical experiments revealed that students could grasp this distributed character when the technical mediation was made explicit, recognizing that "without this apparatus plants make no music."

EPM builds sound ecologies through constructed modes of relation that localize decision-making in the technical apparatus itself, creating an "ear" for the plant while acknowledging fundamental temporal mismatches. The sonification system's asymmetrical structure (human gesture as trigger, plant signal as parameter source) refuses both anthropocentric dismissal and anthropomorphic projection. The *Troisième Nature* project departs from prior EPM practice by trying to technically capture both vegetal potentials (AP, VP, SP) while reconsidering the encoding paradigm: rather than translating bioelectrical signals into MIDI, the system operates on what can be termed "plant temporality," forms built by plant time.

This raises questions for future experiments: if we measure biological plant processes with sufficient precision and maintain fidelity to their inherent temporal characteristics in our encoding systems, how accurately can sonification reflect the plant's own time rather than converting it to ours? What does plant time do to our human musical aesthetics?

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Artworks

Digital Weight: The Invisible Environmental Cost of Our Online Lives



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Digital Weight is a research-informed media artwork that makes the "immaterial" internet materially legible. A looping video regenerates a near-identical image at a fixed cadence, while on-screen counters accumulate three quantities per iteration: electricity (Wh), carbon (g CO_2), and cooling water (mL). These values derive from published per-unit coefficients: energy per image for text-to-image inference (Luccioni, Jernite, and Strubell 2024), global grid-emission factors of approximately 480 g CO_2/kWh (Ember 2024), and data-centre water-usage estimates of approximately 2 L/kWh (MIT News 2025). The method is simulation-based and auditable: published coefficients are translated through transparent formulas into time-based perception, with impacts reported per fixed quanta, such as per million images, and illustrated through LOW/MID/HIGH scenarios. Conceptually, the work situates the cloud as material infrastructure through Morton's hyperobjects (Morton 2013) and Barad's entanglement (Barad 2007); practically, it turns technical metrics into an embodied, experiential form. The work aims to make the hidden physical cost of digital culture perceptible, so that digital repetition can be understood as an infrastructural and ecological act.

Keywords: Media Installation, Algorithmic Repetition, Infrastructural Aesthetics, Environmental Impact, Cloud Computing, Simulation-Based Modelling, Data Centre Cooling, Generative AI.

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Introduction: Digital Gestures Appear Weightless

Digital gestures appear weightless. Billions of images, streams, and AI prompts circulate each day as if they had no mass, no friction, and no consequence. Interfaces are designed to erase duration: a click becomes an outcome; a prompt becomes an image; a feed refreshes without interruption. The "cloud" is still widely imagined as immaterial and everywhere at once. In practice, each request mobilises material infrastructures – server hardware, electricity from grids, heat dissipation, and water-intensive cooling. The environmental cost is displaced from perception, and that invisibility shapes cultural behaviour: we repeat digital actions because they feel free.

Digital Weight is a research-informed media artwork that makes the supposedly "immaterial" internet materially legible by turning computation into time. The work is presented as a single-channel video loop in which a near-identical image is regenerated at a fixed cadence. With each regeneration, three counters advance: electricity (Wh), carbon emissions (g CO_2), and cooling water (mL). The counters are integrated into the work's generative score: they turn each modelled iteration into a visible record of accumulation. Each iteration is treated as one modelled generative event, translating an inferred resource cost into perceptible form. Duration becomes the medium through which accumulation is perceived.

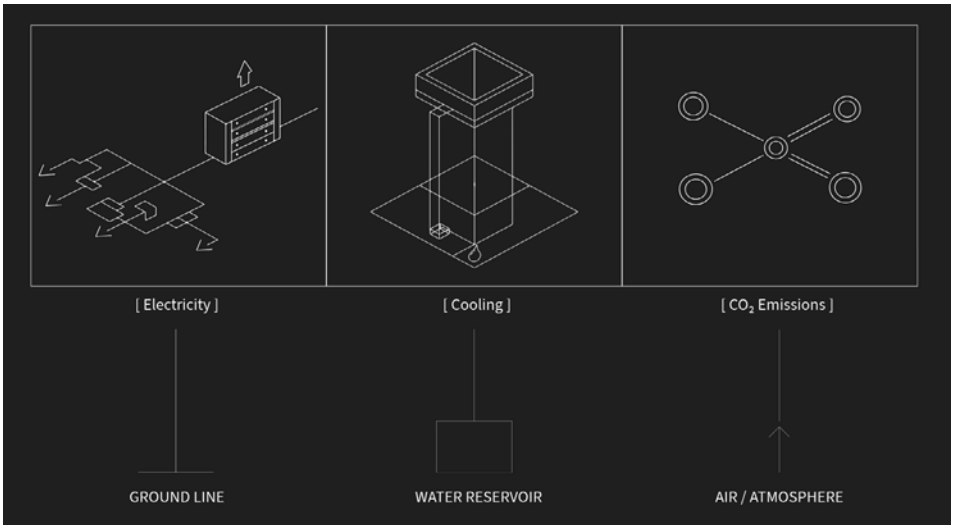


Fig. 1. Infrastructural components mobilised by AI image generation.

Material Infrastructures

At the core of the project lies an engagement with contemporary digital infrastructure. Data centres and networks are increasingly discussed as energy actors, and their growth is closely tied to cloud services and AI workloads. The International Energy Agency estimates that data centres accounted for around 1.5% of the world's electricity consumption in 2024 (IEA 2025), with rapid growth over the last decade and strong geographic concentration in specific clusters. Seemingly "virtual" practices are sustained by a distributed, industrial-scale system.

Electricity, however, is only one layer. Computation produces heat, and heat often requires water to remove it – either directly on-site through cooling systems or indirectly through the water used in electricity generation. In an MIT explainer on generative AI's environmental impact, Noman Bashir notes an estimate of roughly two litres of water per kilowatt-hour of data-centre energy use for cooling (Zewe 2025). This figure is site-dependent, since cooling technologies and locations vary. Here it functions as a communicative coefficient for understanding how energy demand couples to hydrological demand.

Selection of AI Image Generation

From the vast landscape of digital activity, *Digital Weight* deliberately isolates one unit of analysis: AI image generation. This choice is methodological. Image generation is computationally intensive, culturally widespread, and measurable in per-unit terms. One generated image functions as a discrete unit that can be repeated at a fixed cadence, allowing a linear model to be mapped onto time without the need for opaque platform telemetry.



Fig. 2. AI image generation isolated within the broader landscape of digital activity.

Digital Weight uses published inference measurements as a baseline for per-image energy. In a comparative analysis of deployment energy across ML tasks, Luccioni, Jernite, and Strubell (2024) show that image generation sits at the high end of inference cost, with values reaching around 2.9 kWh per 1,000 inferences. The work adopts this order-of-magnitude coefficient (≈2.9 Wh per image) as a central value for communicative clarity. Electricity is translated into carbon using a global-average CO_2 intensity factor reported by the Global Electricity Review (≈480 g CO_2/kWh). Electricity is translated into cooling water using the two-litre-per-kWh estimate cited above.

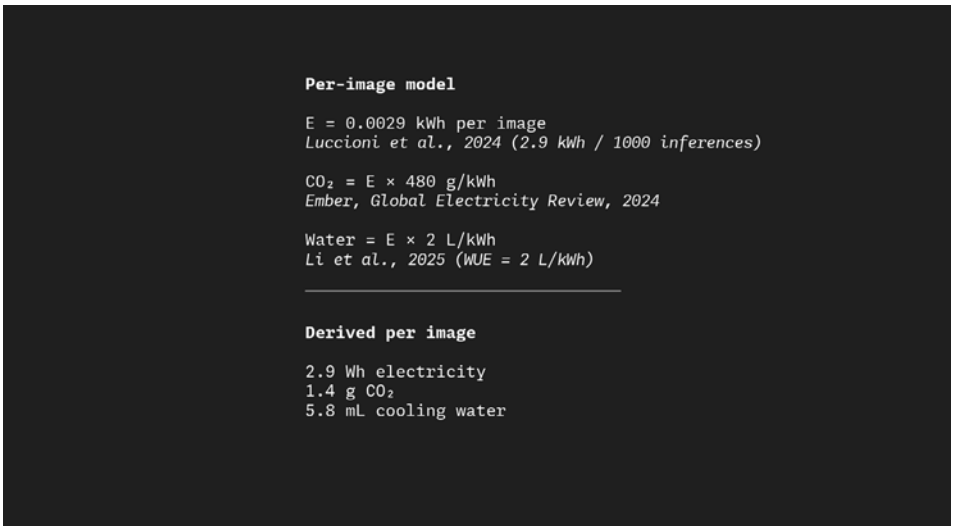


Fig. 3. Per-image energy model and derived environmental metrics (electricity, CO_2, cooling water).[1]

The model is built around two methodological choices. First, the model keeps the three units separate. Electricity, carbon, and water are not collapsed into a single "score," because such aggregation would imply false commensurability. Second, the work is explicit about uncertainty. Per-image energy varies by architecture, accelerator, optimisation, and output size; carbon factors vary by region and time; water intensity varies with cooling technology and siting. *Digital Weight* operates through disclosed assumptions and an auditable structure, allowing viewers to understand how each counter is produced and how scaling works.

Linear Model and Scale

At the methodological level, the model is intentionally linear: multiplying the number of images multiplies energy, emissions, and water. This linearity is conceptually central because it contradicts the everyday intuition that individual digital actions are negligible. The work therefore reports impacts both per unit (per generated image) and through LOW/MID/HIGH scenario bands designed to frame plausible platform-scale activity (e.g., one, ten, and one hundred million images per day). The scenarios function as illustrative frames for scale, making the difference between "one image" and "mass adoption" perceptible.

Within the loop, accumulation unfolds as a micro-simulation. In the current cut, the loop runs for eight minutes at a cadence of two regenerations per second, producing 960 generative iterations. Under the coefficients above, the loop's totals rise into the range of a few kilowatt-hours of electricity, around a kilogram of CO_2, and several litres of cooling water. The precise totals matter less than the perceptual structure: the counters climb steadily even when the image appears almost unchanged. The work insists that "nothing happening" is not the same as "nothing being consumed."

1. From Pengfei Li, Jianyi Yang, Mohammad A. Islam, and Shaolei Ren. 2025. Making AI Less "Thirsty": Uncovering and Addressing the Secret Water Footprint of AI Models. Communications of the ACM 68, 7 (July 2025). https://doi.org/10.1145/3724499.

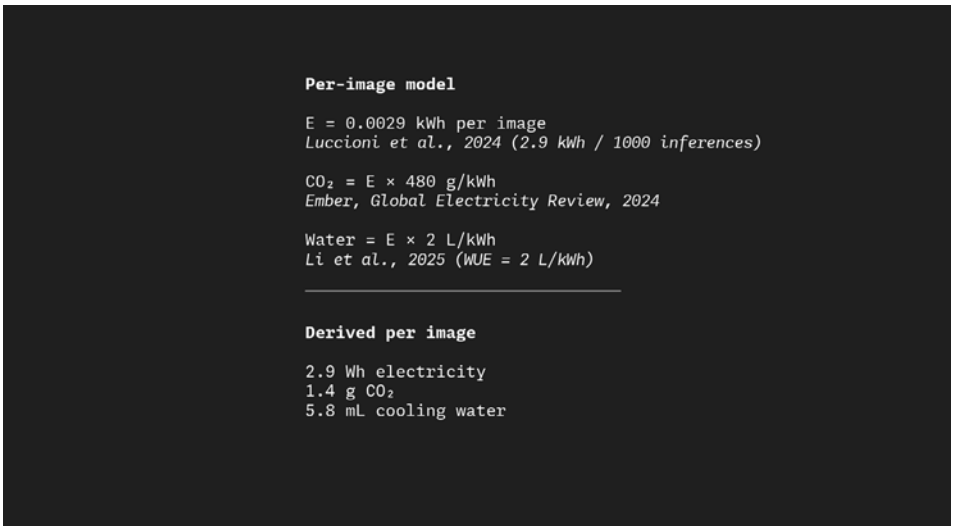


Fig. 4. Linear scaling model with LOW/MID/HIGH scenario bands.

Algorithmic Repetition as Form

Digital Weight visualises environmental data as a temporal aesthetic situation. Computation is experienced as a temporal machine, with accumulation unfolding through repetition, cadence, and near-stasis. The regenerated frame remains almost stable, refusing the usual promise of generative novelty. This near-stasis is deliberate: it stages the paradox of digital culture, where consumption continues even when perception registers minimal visible change.

Repetition is therefore both subject and medium. The work treats regeneration as an algorithmic ritual: perform the same operation, register an increment, and accumulate externalities. This formal strategy mirrors platform dynamics – auto-refresh and infinite scroll – where repetition is normalised and its costs are displaced from view. By bringing cost inside the image, *Digital Weight* collapses the distance between interface time and infrastructure time. The counters materialise what is usually abstracted away.



Fig. 5. Stills from the video loop showing incremental accumulation over repeated generations.

Closed-Loop Dramaturgy and Sound

Its temporal structure follows a closed-loop dramaturgy, without climax or resolution. The same image returns at the beginning, midpoint, and end, so that the loop ends where it begins. The structure foregrounds an energetic cycle that consumes resources without producing mean-

ingful change. In this way, the artwork's temporal organisation becomes its argument.

Sound operates as measurement rather than narration. A low infrastructural hum, a per-iteration tick, and intermittent compute-like bursts mark the cadence and make the work's temporal structure legible through listening. The audience encounters the data as a rhythm of extraction.

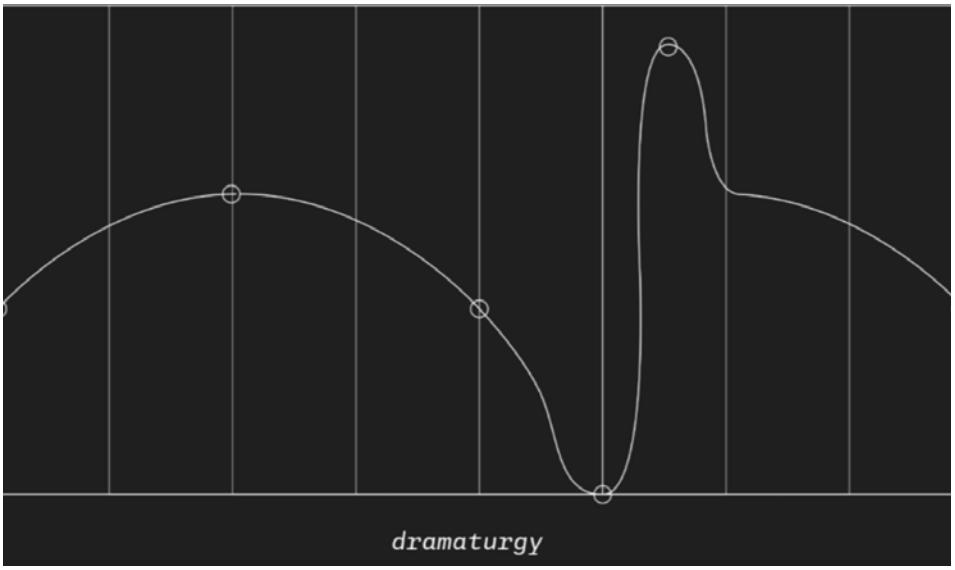


Fig. 6. Closed-Loop Dramaturgy.

Why This Matters Culturally

Generative AI and always-on digital services have normalised a culture of frictionless repetition: endless prompts, infinite feeds, perpetual regeneration. In this condition, environmental costs are structurally absent from perception. *Digital Weight* intervenes at that perceptual level. By binding algorithmic repetition to material counters, it treats the cloud as a concrete extension of planetary metabolism, drawing from the same grids, rivers, and atmosphere as other industrial systems.

The artwork proposes perceptual recalibration: to make the duration of digital activity felt and to make the fiction of immateriality harder to sustain. The "first frame" and the "last frame" of the loop are nearly indistinguishable; what changes is the record of expenditure. This apparent stillness is the point.

Everything digital is material.

Project documentation and preview:
https://kaizere.de/digitalweight_xcoax2026/

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Live Stream



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Random numbers are essential in computing, from cryptographic security to AI training. While pseudo-random generation algorithms suffice for many tasks, true randomness – harnessed from chaotic physical systems like quantum or atmospheric noise – offers unpredictability beyond algorithmic simulation. *Live Stream* is an artwork functioning simultaneously as a random number generator, using a live webcam feed of Switzerland's Rhine Falls to produce numbers for (speculative) cryptographic use. The work seeks to situate the discourse of computational complexity within an aesthetic framework through the motif of the Rhine, which emerges as both natural spectacle and computational resource. Inspired by the Lavarand, a random number generator of the internet security company Cloudflare, and taking advantage of the chaotic properties exhibited by the waterfall, the work extracts visual and audio data from the webcam feed, generating seeds with greater unpredictability than pseudo-RNGs alone. In the process, the Rhine is turned from an object of touristic contemplation in the webcam feed to a computational problem.

Keywords: Complexity, Randomness, Chaotic Systems, Rhine, Gestell, Realtime, Liveness.

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Introduction

Random numbers play a crucial part of computational processes from the generation of secure cryptographic keys to the random initialising of weights during the training of an AI network. While the generation of random numbers with a sufficient level of unpredictability using deterministic pseudo-random number generator (PRNG) is suitable for many purposes, increasingly true random number generators (TRNG), which make use of the latent entropy in chaotic physical processes like atmospheric noise[1] or radioactive decay,[2] are used to generate random numbers that are practically impossible to predict using an algorithm.

This distinction is particularly salient in the area of cryptography, which is involved in the study of securing communication across networks (Rivest 1990). The security of the world's internet traffic relies to a large extent on the ability to generate cryptographic keys with a degree of unpredictability high enough to make them difficult if not practically impossible to guess. In such cases, a PRNG is often initialised with a truly random seed in order to quickly and efficiently produce a random key. In the San Francisco offices of the internet security firm CloudFlare there is a wall of lava lamps filmed 24 hours a day in order to provide cryptographic keys for some 20% of the world's internet traffic (Fig. 1). Known as the Lavarand, the idea is based on an original patent by the US company Silicon Graphics in 1998 (Noll et al. 1998). Whenever a key is required, the CloudFlare systems translate a frame from the live feed into a numeric value that is then fed as a seed into a PRNG, generating the key (Liebow-Feeser 2017). Due to the highly chaotic movement of the liquid in the lamps, as well as the atmospheric and lighting conditions that eventually become rendered as pixels in the image, the seeds are extremely difficult to predict. The images, despite their use of brightly coloured objects made for human entertainment, are made to be purely operational for the computational process of pseudo-random number generation.



Fig. 1. Lavarand in the Cloudflare offices in San Francisco, California (Photo: Martin J. Levy).

1. https://www.random.org/
2. https://www.fourmilab.ch/hotbits/

Live Stream

Live Stream is an artwork posing as a random number generator based on this same principle of using a live image depicting a chaotic physical process as a source image to generate truly random seeds for a generation algorithm. Instead of a wall of lava lamps, however, the work makes use of a live webcam feed of the Rhine Falls in Schaffhausen, Switzerland, which is provided by the Schaffhausen Tourism Board and streams 24-hours a day to YouTube.[3] As an artwork, it seeks primarily to situate the discourse of computational complexity within an aesthetic framework through the motif of the Rhine, which has been a subject of painterly and poetic representation since at least the medieval period.

The work, which itself takes the form of a live stream on a local computer or via a web-based service such as Twitch.tv, is built using TouchDesigner and uses a custom coded blob detection algorithm to track visual elements in the live image (e.g. the movement of water in the waterfall, tourists along the bank, birds, trees and other dynamic elements, as well as the movement of the camera itself). The bottom left coordinates of the bounding boxes that are drawn around these elements are summed together and divided by the sum of the audio channel values. This provides a constantly changing truly random value that is fed as a seed into a PRNG, which is then printed to the screen. The work is programmed to generate a new pseudo-random number every second, presented as a cascading list on the left-hand side of the frame. A screen recording of the work may be seen in Fig. 2.



Fig. 2. Screenshot of *Live Stream*.

It is worth noting that while the proposed workflow for extracting data from the live image does produce a truly random seed, the sequence of random numbers produced through this process are not suitable nor intended as true cryptographic keys. The randomness of the seeds produced has not been measured using a standardised randomness test.

3. https://www.youtube.com/watch?v=UCgLr29bxO8

Themes

Chaos and Randomness in Physical and Computational Systems

The generation of pseudo-random numbers with a high degree of unpredictability using deterministic algorithms, independent of their use as cryptographic keys, is a notoriously difficult problem in computation that predates the invention of digital computers by several centuries (L'Ecuyer 2017). It is precisely the deterministic nature of algorithms that precludes their ability to be truly random: provided with a given initial state, the numbers can invariably be guessed given enough computational time and memory. Recent algorithms, such as the widely-used Mersenne Twister (Matsumoto and Nishimura 1998) are capable of producing pseudo-random numbers quickly and with a high degree of unpredictability, but may still not be suitable for certain purposes.

While "randomness" is often used in computation to describe a lack of predictability, the corresponding category of "chaos" in the physical and complex sciences describes systems that may produce widely varying results with only small differences in their initial starting conditions (Lorenz 1995). This makes the dynamics of such physical systems, examples of which include the three-body problem in classical mechanics (Barrow-Green 2008) or Lorenz systems in atmospheric physics (Lorenz 1963), extremely difficult to predict and therefore highly suitable for providing the kinds of randomness required for TRNGs. Indeed, it is the practical unpredictability of the behaviour of chaotic systems using computational systems that can be harnessed to generate random numbers that are themselves practically unpredictable for other computational systems. Nevertheless, complex systems exhibiting chaotic behaviour still tend to produce recognizable patterns - such as tornadoes, flocks of birds, or fractal geometry—with time, belying their status as truly random (Lorenz 1995). Just like the Lavarand by which it is inspired, *Live Stream* seeks to bring these two notions of predictability and complexity into direct confrontation with one another through the use of a chaotic physical system (a waterfall) as a computational system.

The Rhine Falls

The Rhine Falls has been chosen as a motif not only for practical reasons (i.e. the existence of a live webcam feed) but moreover for its significance in the history of art. Depictions and descriptions of the waterfall date back to Dutch landscape painter Joachim Patanir's *The Baptism of Christ* (Fig. 3), and can be found later in paintings by Turner (Fig. 4) and de Loutherbourg (Fig. 5), as well as in Goethe's *Faust*. Through this history of painterly and poetic representation can be traced a parallel history of the transformation of the Rhine Falls from a site of religious rite to one testifying to the turbulent and overwhelming force of nature.

For Heidegger, the Rhine constitutes an important object of thought in the essay *The question concerning technology* (1954), in which it is em-

ployed as an example of *Gestell*, a particular framing of the world through modern technology that renders it in terms of its potential to be used or put to work. In the essay, Heidegger describes the Rhine through the technological framing of the water mill as being rendered as a "deliverer of water pressure" (1954, 83), and as such consequentially different to "The Rhine" as an object of aesthetic contemplation in Hölderlin's poem of the same name. *Live Stream*, by contrast, renders the Rhine as a computational process, whose complexity is too great to be simulated using the CPU resources of a digital computer. Interpreted in terms of Gestell, the Rhine is transformed here further from its potential to deliver water pressure to its potential to deliver complexity.



Fig. 3. *The Baptism of Christ*, Jaochim Patanir, 1515 (Source: Wikimedia commons).



Fig. 4. *Fall of the Rhine at Schaffhausen,* J.M.W. Turner, 1806 (Source: Wikimedia commons).



Fig. 5. *The Falls of the Rhine at Schaffhausen,* Phillip James de Loutherbourg, 1788 (Source: Wikimedia commons).

Liveness and Realtime

The presentation of the work as a live stream sets up a direct confrontation between "liveness" of the webcam image and the "realtime" of the computational process. Much has been written both about the origins of "liveness" as a mediatheoretical concept (e.g. Auslander 2012), as well as the construction of realtime within technical systems (e.g. Ernst 2013; Stiegler 2018) and the relationship more generally between computation and the category of the "real" (e.g. Krämer 1998). As tem-

poral abstractions, both “live” and “realtime” share a common horizon of simultaneity with the “real” world, but differ greatly in their methods of technical mediation and the ways in which time is inscribed in their respective media. While the “liveness” of the webcam image relies on the transmission of visual and audio data that corresponds to the way in which human sensory perception and time consciousness registers a scene, the “realtime” computational processes involved in reading the image and output on the screen rely on calculations occurring well below the threshold of human perception (Hansen 2014), resulting in a corresponding stream of data that is difficult if not possible for humans to parse.

This tension is played out within the frame, where the computer (in this case, the program TouchDesigner) reads the live image in real-time. In the process, a number of new elements are added to the image – bounding boxes, coordinates, an audio wave, a cascade of random numbers – that break up its integrity and introduce a new temporal logic that replaces transmission time with computational time. While the former aims at overcoming the time and space between sender and receiver, the latter aims at overcoming the complexity of the signal using computational resources.

A screen recording of work can be viewed at:
https://vimeo.com/1132905114/547e4f15ff

When active, the work can be viewed as a live stream via Twitch.tv at the following link: https://www.twitch.tv/alex_walmsley

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In Translucence: Caught in the Act of Revealing Itself



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Viewers walk around a large display positioned as a sculptural object in the centre of the space. Within the sculpture are some exposed computer components, connected to the screen. Visible on the display is the live feed of a camera positioned nearby, pointed at the exhibit and surroundings. Viewers notice that while they and their surroundings can be seen in the camera feed, the exhibit at which they're looking isn't visible. The entire artwork is being erased from view in real-time by an offline AI model contained within the sculpture itself. As this camouflage becomes obvious it invites viewers to experiment, forcing the machine to make glitchy mistakes: the machine caught in the act of revealing itself. Advanced technologies of the past have vanished as they gradually subsumed into everyday utilities: the 'electric light' is simply a light. Though the proposed AI bubble threatens to burst, the tech has nonetheless become embedded in the lives of its users. How then might we consider futures for the likes of 'AI-powered journalism' or 'AI healthcare'? We might describe a technology's propensity to disappear from view as its 'translucence'. Beyond semantic drift, translucence fundamentally alters the composition of technology, defining how we interact with it. In turn, translucent machines might work to conceal themselves, forming their own meta-translucence.

Keywords: Artificial Intelligence, Installation Artwork, Technological Invisibility, Semantic Drift, Meta-design, Glitch Theory.

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Fig. 1. *In Translucence* on display at Peckham Digital, London, October 2025. Photo credit: Mati Granica.

In Translucence

Advanced technologies are becoming ever-more closely interwoven with the lives of their users, as technologies increasingly mediate nearly every facet of day-to-day activity. To a greater degree than at any point in human history, technology can be seen intervening in how individuals communicate, how children learn, how society is governed, in the distribution of wealth or in the administration of healthcare and social services. (Issa and Isaias 2022, 192) Meanwhile, the changes wrought by these advanced technologies are met with an inflammatory mixture of both excitement for and fear of their future developments (Maher and Ivory-Ganja 2024).

However, many technologies of the past—previously considered advanced in their time—have in a sense disappeared despite the contemporary vociferousness of their novelty. Gradually they became pedestrian utilities subsumed into the everyday: the 'electric light' is simply a light, the 'digital camera' became an ordinary camera, and what once was proclaimed as 'high' definition video is now plainly standard. With consideration for today's AI-related phenomena, how might tomorrow's futures look if 'AI healthcare', 'AI-powered journalism' or 'AI image generation' are simply 'healthcare', 'journalism', or 'images'? Though the current 'AI bubble' continues to tease a detonation (Howarth 2025), the tech embeds in our social and economic structures regardless; ossified perhaps, and not easily disentangled.

Technology's Visibility

When approaching the path charted by these changing technologies, we might consider their 'opacity' or 'transparency' as an essential property. In this sense, machinery which has been perceived as opaque and concrete might become instead something intangible, and not perceived at all. This invisibility is by no means a novel idea; Marshall McLuhan famously articulated media analyses which defined content by looking past the tangible medium, declaring that "at the point where a new media-induced environment becomes all pervasive and transmogrifies our sensory balance, it also becomes invisible" (McLuhan 2009).

In contrast to McLuhan's more definitive analysis of observed effects, we might consider this invisibility speculatively, looking toward futures and forming a conjectural picture whilst aware that no technology is perfectly transparent nor completely opaque. Rather, all technology holds some degree of 'translucence'. *Translucence* is here a conjectural property, the result of a user's potential to look 'through' rather than 'at' the machine, and this non-cognition must be considered when anticipating the harms (or perhaps benefits) a technology affords. *Translucence* is not the definitive quality of how visible a technology is, but instead an assessment of its potential to disappear. Candlelight cannot escape the candle; its presence is tied to its mode of production. However, the electric light's 'electric' quality is less immediately apparent, and once no

longer positioned next to contrasting technologies it holds the potential to disappear; to join the cursory milieu of mononymic 'light'. Thus, we might propose that the electric light is a highly *translucent* technology.

In the context of AI, we see an advanced and yet immature product, its presence often still leaning towards being opaquely known. Brightly-coloured icons and golden sparkle emoji noisily herald its presence, proudly strewn across productivity apps and search bars by tech giants eager to prompt user adoption. Translucence, however, speculates that in maturity these labels will disappear while the technology quietly persists. This suggests technological futures—some of which are now actively bleeding into the present—in which prosaic activities such as searching the internet, taking a photograph, or driving a vehicle are not just conducted with the assistance of AI, but surreptitiously do so without the full awareness of their users.

Beyond Semantic Drift

Semantic drift tracks shifts in meaning across time as concepts alter in significance, sometimes drastically (Stavropoulos et al. 2016). This drift is not always linear, nor is it necessarily natural: design is a part of the process, providing a crucial part of the feedback loop: 'cultural intermediaries' such as designers play an active role in measuring and articulating the gap between consumption and production (Nixon 1997, 183). What users understand of an object affects how its forms and interfaces are designed, thus the users' interaction with the object changes, and in turn how it is designed is altered, and so on. Semantic drift does not merely alter the terminology of technology but fundamentally changes its composition.

Generative artificial intelligence is particularly relevant to this phenomenon: large language models rapidly and massively collate, synthesise and redistribute content at rates which outpace comprehension, catalysing the mass adoption of certain words, phrases and manners of writing while causing the decay of others (Parker 2025). In this sense, AI complicates semantic drift as users' concept of technology is being changed not by the interaction of its users nor the influence of an external designer, but by the technology itself intervening in the construction of its meaning. Betti Marenko (2025, 8) describes a *meta-design*, the deployment of design to reflect on design itself, and in turn this idea presents itself here as a form of *meta-translucence*: a technology deployed to influence its own conception. The installation artwork *In Translucence* (Fig. 1) reflects upon this, illustrating the process of a machine being hidden from perception, not from the unattended evolution of its concept nor by the intervention of a human designer, but from the machine itself working to conceal its presence (Fig. 2).



Fig. 2. Prototype version of *In Translucence* on display at The Boardwalk, Glasgow, June 2025.

The Glitch as a Revelatory Tool

Translucence is distinct from transparency; no technology is perfectly transparent nor completely opaque. Like the displacement of light

through an imperfect lens, not quite hidden and not fully perceived, it leaves ghostly refractions of its presence. Glitches, the machine "caught in the act of revealing itself" (Marenko 2015), hint at the sleight of hand at play. These glitch-effects might be grasped at, played with and torn apart (Fig. 3), subverting the course of translucence and forcing the machine to unveil its tricks. Tomorrow, how might users choose to approach today's translucent technology when its presence is no longer apparent? Should users oppose it, how then might technology adapt?



Fig. 3. Users interacting with *In Translucence*, on display at Peckham Digital, October 2025.

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La Noche Cíclica



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La Noche Cíclica is a multi-part project that examines the absence of night in Google Street View. For both legal and functional reasons, most imagery on the platform is captured during the day, effectively establishing daylight as its "default." As a result, traces of night are difficult to find. Yet the platform's algorithmic reconstruction is far from seamless; its occasional irregularities inevitably conjure fleeting fragmented moments of night within a world overwhelmingly centered around daylight. These rare occurrences – caused by delays in data collection or processing errors – rupture the smooth logic of digital cartography, surfacing as temporal glitches within a self-rationalizing media infrastructure. Within a capitalist temporality that prioritizes productivity, efficiency, functionality, continuity, and visibility, night is compressed into a brief, transitional state – merely a seam between days. Referencing Jorge Luis Borges' poetic vision of cyclical time, this project uses night to challenge the linear logic of machine vision. What appears as error becomes archive; what is overlooked becomes site. Through these endangered nocturnal fragments, *La Noche Cíclica* questions how the visible world is constructed through data, algorithms, and a systemic preference for daylight.

Keywords: Media Infrastructure, Machine Vision, Algorithmic Governance, Street View, Nighttime Anomaly, Capitalist Temporality, Glitch.

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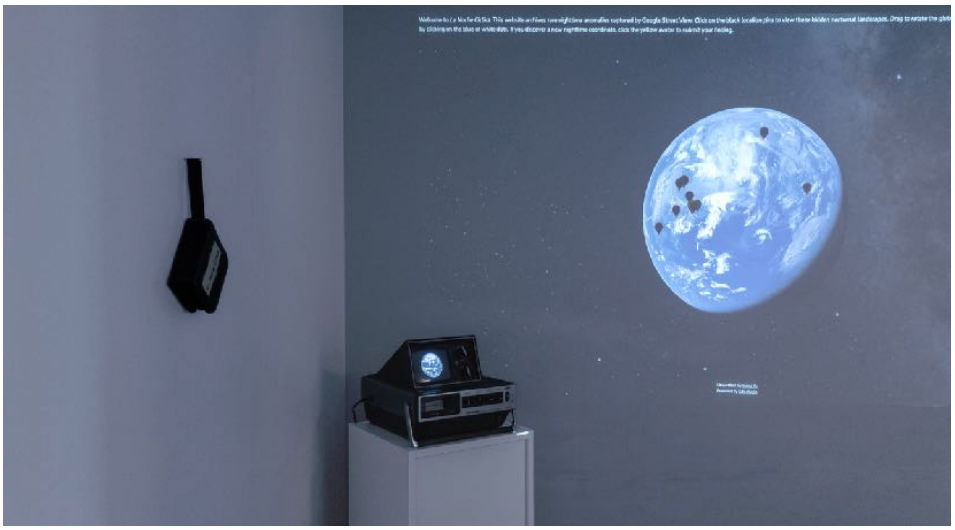


Fig. 1. Overview of the project *La Noche Cíclica*, showing all four components: the CRT video sculpture, interactive web archive, layered print album, and conceptual feedback intervention.

Introduction

I have long been a compulsive *flâneur* in Google Street View, drifting through its streets without a destination. In January 2025, while searching for a direction of my graduate thesis, I came across a post on the Google Maps subreddit titled “Have you ever seen a street view at night?” The post linked to several coordinates that appeared to have been captured at night, accompanied by unexpectedly poetic responses from other users.

The discovery reframed how I understood the platform. Though designed as a three-dimensional spatial simulator, Google Street View quietly embeds a temporal logic, one that overwhelmingly privileges daylight. Encountering night within this system – rare, unstable, and often short-lived – raised a series of questions. When night appears in a data-driven model of the world, is it merely an error to be corrected, or does it reveal something about the values embedded in machine vision? I noticed that after reporting these coordinates to Google, the night would sometimes disappear days later, prompting a persistent concern: who decides what the world should look like, and what kind of time does the machine believe in?

As machine vision increasingly mediates how the world is documented and made legible, Google Street View has emerged as a dominant visual infrastructure shaping shared perceptions of space – and implicitly, time. Far from a neutral mapping tool, Street View operates through algorithmic selection, image stitching, and automated updates that produce a highly standardized visual world. Within this system, daylight functions as the norm. Night, marked by reduced visibility and uncertainty, is largely excluded and treated as an error rather than as a condition worth preserving.

This preference for daylight reflects not merely a technical decision, but an ideological one. It reveals an underlying visual and temporal logic that prioritizes clarity, continuity, and productivity. Within capitalist frameworks, night is rarely understood as a time in its own right, but as a transition between days, an interruption to be minimized or managed – a seam, not a scene. Lighting technologies and surveillance sys-

tems increasingly colonize nighttime, attempting to prolong the utility of day and reinforce a temporal logic that aligns visibility with value. The near-absence of night in Google Street View exemplifies this drive toward a continuous, controlled, and visually efficient representation of the world.

Yet the system occasionally falters. Due to processing delays, incomplete datasets, or algorithmic breakdowns, fragments of nighttime imagery sometimes surface within Street View. These moments – often unstable, partially overwritten, or visually fragmented – appear as anomalies within the platform's otherwise consistent logic. Though fleeting, they expose the infrastructural processes and forms of algorithmic governance that determine what becomes visible, what is erased, and how time itself is represented.

La Noche Cíclica emerges from these ruptures. The project is a multi-part installation that gathers and re-contextualizes these rare nighttime fragments through a CRT-based video sculpture, an interactive archive of coordinates, a printed collection of screenshots, and a conceptual intervention that reports the images back to Google as mapping "errors." By focusing on breakdowns rather than seamless representation, the project examines how digital infrastructures suppress temporal difference, and how moments of failure can open space for aesthetic reflection and political critique.

Existing discussions of Google Street View have largely focused on questions of urban representation, privacy, and technical accuracy. Much less attention has been given to how the platform organizes time, particularly through the systematic absence of night. *La Noche Cíclica* engages this overlooked dimension by approaching Street View not only as a spatial mapping tool, but as a temporal system shaped by algorithmic decisions.

Project Components and Technical Implementation

Video Sculpture

The video sculpture of *La Noche Cíclica* is presented on a 1970s portable Panasonic monochrome CRT television and radio cassette recorder combo. Using the channel dial, viewers alternate between a globe in diurnal rotation and a series of Google Street View night coordinates presented as a walking simulation, each revealing a distinct visual glitch. Amid static and fragments of public broadcast, a re-edited walkie-talkie reading of Jorge Luis Borges' *La Noche Cíclica* intermittently emerges. A vertical black burn-in line remains visible on the screen, formed over time through deliberately repeated display as the CRT phosphor wears down and permanently retains the trace, marking the collapse of night into a fissure within the perpetual daylight of the Earth's rotation. Together, these elements stage a tension between global surveillance systems and moments of visual failure, allowing night to persist in fragmented form.



Fig. 2. Viewer interaction, switching channels to reveal different effects, video contents, and local radio broadcast.



Fig. 3. Deliberate vertical burn-in line on the CRT display.

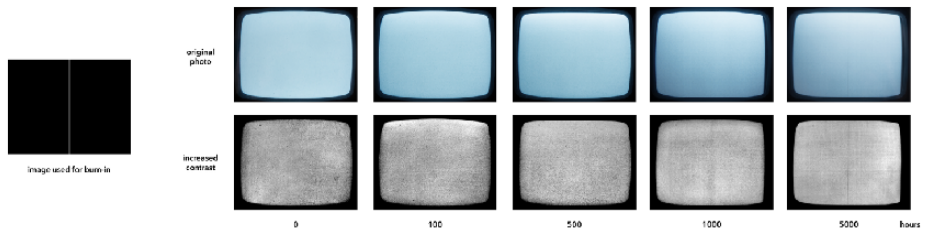


Fig. 4. Burn-in results.



Fig. 5. Displays on misaligned channels with different visual artifacts.

To achieve the screen burn-in effect, an image of a white vertical line is displayed on the television over 5000 hours cumulatively. Figure 4 illustrates the changes during the process. During the test, the contrast is set to maximum, and brightness is adjusted to keep the black area mostly unlit. The white line on the displayed image continuously excites

the phosphor layer of the screen, degrading the phosphor and leaving a permanent mark on the tube.

The analog glitches are produced by intentionally operating the device in abnormality. PAL signals are provided for the television's NTSC channels, where the partial alignment of frequencies interferes with the device's normal demodulation process. The analog glitches – video noise and misaligned scans – are reclaimed as visual artifacts. The distortions and disruptions are captured and re-discovered in parallel with the unproductive capitalist nights, reaffirming the core argument in the medium's manifestation.

Web Archive

The project includes an interactive web archive (www.lanochecliclica.com) that maps the geographic coordinates of nighttime scenes found within Google Street View. Each entry is manually identified, captured, and annotated with basic metadata, including location and last update. Visitors access the archive through a portal that links directly to individual night coordinates, built with the Google Maps JavaScript API to render a navigable 3D globe. Clicking a marked "black spot" triggers a performative zoom into the nighttime landscape, while a CRT-inspired display mode and public submission module extend the archive across digital, physical, and participatory dimensions. Movement unfolds step by step through landscapes marked by visual glitches, where night briefly interrupts the platform's dominant daylight logic. Unlike Google Street View's frictionless navigation, this interface emphasizes traversal itself, framing temporal rupture not as an error but as a space to be entered. The archive functions both as a poetic interface and as a data-driven resistance to infrastructural smoothness.



Fig. 6. Viewer browsing the web-based archive, walking through nighttime coordinates in GSV. Their screen is projected onto the wall, transforming the act of navigation into a performative gesture.

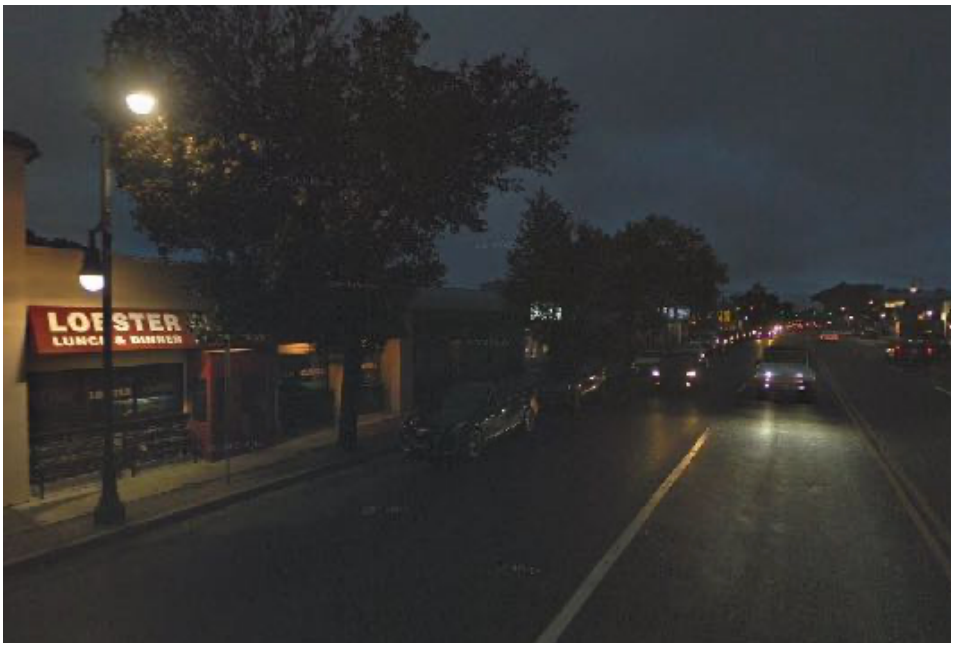


Fig. 7. Screenshot of GSV nighttime coordinate (45°8’13” N, 92°31’43” W)



Fig. 8. Screenshot of GSV nighttime coordinate (79°54’33” N, 13°47’10” E).



Fig. 9. Screenshot of GSV nighttime coordinate (40°10’40” N, 74°37’51” W).

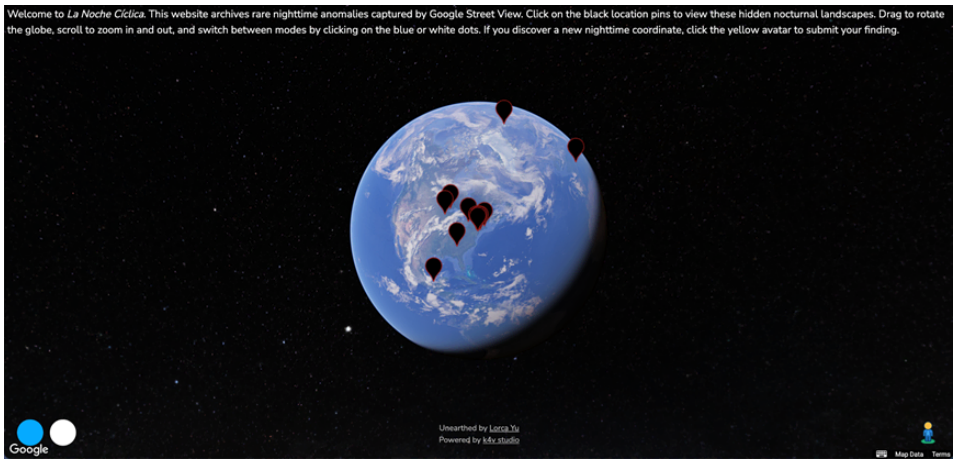


Fig. 10. Screenshot of the web archive portal. Viewers enter through this interface to access and navigate the collection of nighttime coordinates.

Print Album

A printed album extends the digital archive into a tactile, layered object. Each page contains two overlapping elements housed in a transparent sleeve: a clear film printed with Google Street View interface components such as navigation arrows, toolbars, and timestamps, and a corresponding nighttime screenshot beneath. When closed, the album presents a uniform, interface-like appearance. As pages are turned, the transparent layer can be removed, physically separating interface from image. This gesture exposes the constructed nature of machine-mediated vision, revealing the interface not as a neutral frame but as an active force shaping perception. Once detached from its algorithmic overlay, the nocturnal image gains visual autonomy and political weight, inviting viewers to question the mechanisms through which visibility is produced and controlled.



Fig. 11. Prints of the first televised view of Earth from orbit, echoing the video sculpture.



Fig. 12. Overlay of transparent interface film and printed nighttime screenshot within the album.



Fig. 13. Simulated “Report a Problem” interface embedded in the album, mirroring Google’s correction system.

Conceptual Intervention

The project includes a conceptual intervention that directly engages Google's correction system. Each nighttime coordinate is manually submitted through the platform's feedback interface, which invites users to flag inaccuracies or request updates. This gesture shifts viewing into participation, testing whether these images are classified as errors and subsequently replaced by daytime imagery. By tracking locations before and after submission, the intervention exposes how algorithmic governance operates through routines of visual maintenance. In doing so, it raises questions of normalization and authority: What counts as a mistake, and when does correction become erasure? The intervention reveals how even ordinary users are quietly enlisted in sustaining dominant visual standards, one feedback action at a time.

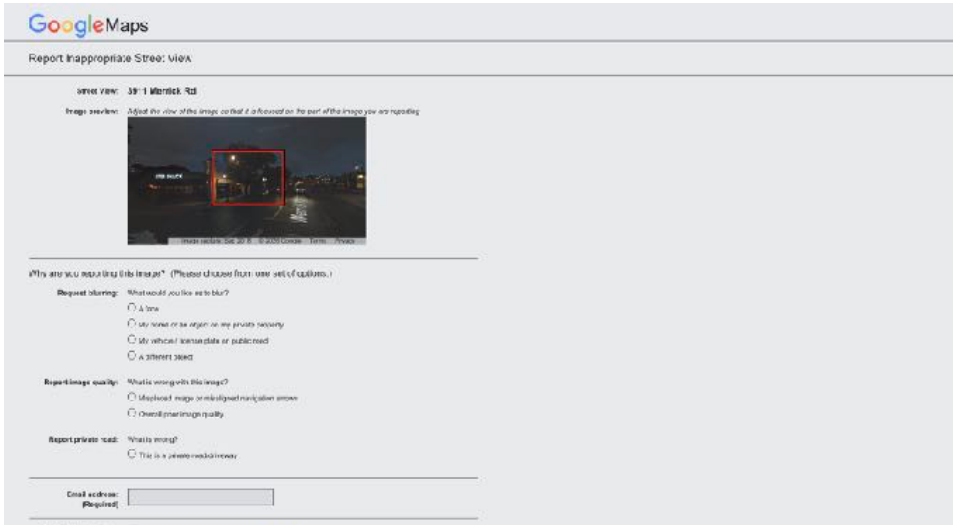


Fig. 14. Google Street View reporting interface.

Discussion: Spectatorship, Governance, and Infrastructure

Viewer as Subject

In the CRT video sculpture, viewers are given control over the channel dial without instruction, while some channels produce no signal at all. This ambiguity generates hesitation rather than guidance. A reworked walkie-talkie reading of Borges' poem occupies a single FM frequency embedded within ordinary broadcasts. As the dial is tuned, the voice surfaces intermittently – faint, fragmented, and surrounded by static. In this brief disturbance of the everyday soundscape, night emerges as a concealed temporal channel, interrupting the apparent continuity of daylight.

The web archive similarly alternates between orientation and disorientation. Visitors may navigate existing coordinates or submit new ones through public forms and community forums. Movement within each location unfolds incrementally, without a defined frame or endpoint. Viewers proceed step by step, uncertain when – or if – daylight

will return. The abrupt transitions echo the logic of waking: sudden, unannounced, and difficult to situate.

The print album introduces a more intimate gesture. By lifting a transparent interface layer to reveal the image beneath, viewers enact a small but deliberate separation of system from content. Across all components, the viewer shifts from passive consumer to critical witness, implicated in the recognition and circulation of the glitch.

Feedback as Governance

La Noche Cíclica does not end with documentation but enters a feedback loop. In the exhibition space, a banner asks viewers whether discovered nighttime coordinates should be reported back to Google. This choice reframes spectatorship as participation, revealing how users are drawn into platform optimization.

Google Street View operates as a form of distributed algorithmic governance, mobilizing user actions to preserve visual consistency. Through reporting and replacement, anomalies are converted into infrastructural enforcement. What appears as benign crowdsourcing becomes a mechanism for normalizing deviation.

The project's own development reflects this process. Early coordinates circulated within communities such as r/googlemapsshenanigans and r/geoguessr as curiosities. Once reported to Google, however, they risk erasure. One such site, (40.6498945, -111.8349159, February 2020), was later overwritten with daylight imagery. In this cycle of discovery and deletion, viewing itself becomes a form of governance, where visibility is continuously renegotiated through infrastructural response.

Infrastructural Privilege and the American Night

Although *La Noche Cíclica* appears to document global anomalies, most of its coordinates originate in the United States and Europe. As the primary testing grounds and update hubs for Google Street View, these regions receive denser and more frequent coverage than most regions. Paradoxically, it is within the most intensely surveilled and optimized environments that algorithmic inconsistencies most often surface.

The "night" captured here is not universal, but reflects where infrastructural attention is most active. In this sense, the term American Night, borrowed from cinema, extends beyond its original technical meaning and points to a condition shaped by uneven distributions of visibility and care.

By contrast, large portions of the Global South, rural areas, and conflict zones remain visually static – not due to stability, but because they fall outside the system's rhythms of care. In these contexts, absence is not a glitch but an infrastructural norm. Visibility, like error, follows lines of infrastructural privilege.

Crowdsourcing and Inclusion

Equally revealing is what *La Noche Cíclica* excludes. All coordinates in the archive derive from Google's official panoramic imagery, excluding user-contributed photospheres and blue-dot uploads. While many user submissions depict nighttime scenes, they exist outside the platform's primary spatial-temporal logic and are not integrated into the navigable continuum of Street View.

This distinction is critical. User uploads are permitted precisely because they remain marginal to the authoritative map and do not threaten infrastructural coherence. The nighttime scenes central to this project, by contrast, arise when the system itself falters – when Google unintentionally reveals what it otherwise suppresses.

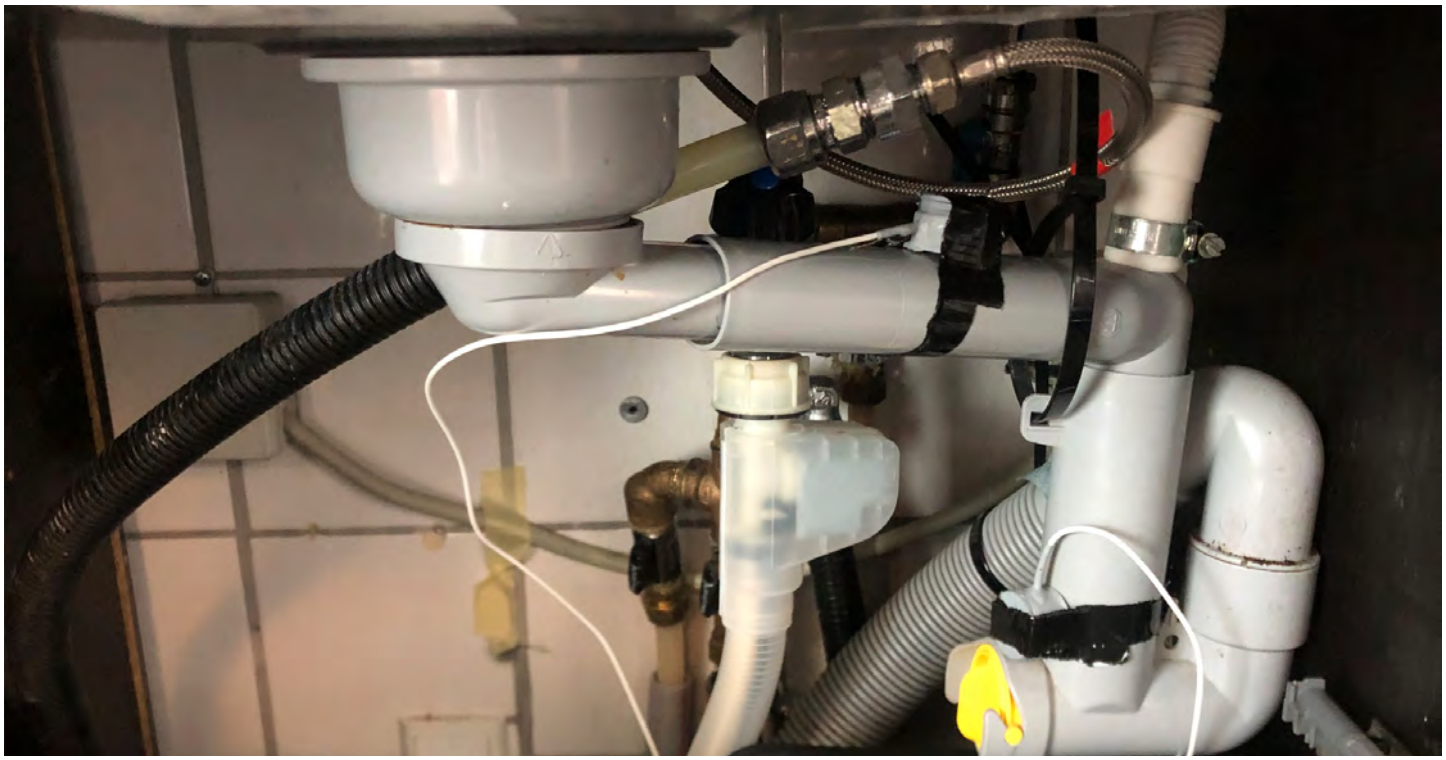
By focusing exclusively on official imagery, *La Noche Cíclica* engages not with alternative content, but with contradictions internal to the system. Night is framed not as user expression, but as a structural inconsistency that emerges from within the apparatus of algorithmic control.

Conclusion

La Noche Cíclica invites audiences to reimagine visibility beyond data and daylight, as something shaped by gaps, glitches, and darkness. Systems once framed as transparent increasingly operate through opacity and enclosure; yet it is precisely through their failures that alternative ways of seeing become possible. The project reclaims night not merely as a temporal absence, but as a field of politics, perception, and potential.

Across its components, *La Noche Cíclica* resists seamlessness in favor of interruption, friction, and disappearance. Acts of navigation, archiving, printing, and reporting reveal how users are entangled in the governance of visual reality, often without noticing their participation. Rather than stabilizing night as an archive, the project allows it to remain unstable – it appears, vanishes, and reappears elsewhere – reminding us that even the most optimized infrastructures are never complete.

Slowing Down to Infrastructures



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Slowing Down to Infrastructures is a durational, generative web radio project developed by Radio Otherwise that reconfigures buildings (the architectural materiality as well as the various energetic flows moving within and through them) as both studios and sonic instruments, attuning to the everyday infrastructures that sustain them. Using streamboxes (open microphones transmitting live audio), we install air and contact microphones, hydrophones, and electromagnetic antennas throughout a building to access its inner life and workings. Airflow through ventilation systems, electromagnetic signals from routers, water circulating through pipes, and vibrations from the street are streamed live alongside machine hums and distant traces of human and environmental presence, foregrounding the often-unnoticed infrastructures as protagonists. These live streams are processed in SuperCollider to form a continuously evolving, generative radio composition. Modulating frequency, rhythm, periodicity, and temporal cycles, the system unfolds over time with a subtle dramaturgy, alternating between moments of intensity and quiet reflection, allowing noise to gradually emerge as information. By listening to infrastructures as environmental sound, the project engages the material and invisible systems that shape collective human and more-than-human life. The soundscapes, rather than representing "nature," reveal systems, foregrounding positionality and the conditions of listening itself. The project asks how listening to structural, coded, and invisible processes can make audible the politics of perception, access, and power embedded in infrastructural environments.

Keywords: Radio, Infrastructures, Soundscapes, Environmental Sound, Generative Art, SuperCollider, Positionality, Engagement.

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Introduction

Radio Otherwise is an experimental, artistic, and ecological radio collective focusing beyond purely anthropogenic transmissions, recognizing relationality within the spectrum of more-than-human radio ecologies. We move across free and community radio, knowledge-making, and artistic settings. For example, we create durational live transmissions that favor listening and reception over transmission in informal outdoor studios; in 2021, we offered the seminar *Radio Otherwise: Listening, Ecologies, Cybernetics* at the University of Potsdam and have continued with academic participations in the following years; we have also led MicroFM transmitter workshops in various contexts and have been commissioned to develop artistic transmissions for festivals and exhibitions. These instances mark only a few moments within a broader and continuously evolving practice that unfolds through collaborations, environment-specific interventions, and research formats, extending beyond the examples mentioned here.

Beginning in 2022, we initiated a sequence of four projects united by the conceptual framework of *infrastructures of flow*.[1] Together, they give concrete form to *Radio Otherwise*'s ecological radio practice, transforming theoretical concerns into situated and durational modes of listening, reception, and transmission. Each project highlights the interrelation of human, technological, and more-than-human agents, employing live, generative, and participatory formats to make perceptible the dynamic exchanges of energy, matter, and information that constitute environments.

These projects are *Circling Thresholds* (2022), commissioned by *Forests of Antenna, Oceans of Waves*,[2] a series of interventions in Berlin dealing with awareness about electromagnetism in public space; the *Spree~Channelsea Radio Group* (2023)[3] with Soundcamp, in collaboration with Surge Cooperative and Blanc Sceol, from London; *Infrastructural Eddies* (2024)[4] continuing the previous collaboration with Soundcamp as part of their project *S AM FM. Experiments in Ecological Radio* in Basel; and *Slowing Down to Infrastructures* (2025)[5] commissioned by the Copenhagen Architecture Forum (CAF) for the Copenhagen Architecture Biennial as part of the LINA Fellowship[6] awarded to us in 2024.

The Copenhagen Architecture Biennial took place between September 18 and October 19, 2025, under the theme *Slow Down*, investigating "architecture as matters of time and means of slowing down overheated sites, cities, and societies".[7] By inviting Radio Otherwise, CAF expressed

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1. More about the projects and the conceptual framework in our article *Listening to Soundscapes Otherwise: Infrastructures as Environmental Sound* (de Paula Antunes, Donovan, and de Paula Lefort 2025). Attention to the sonic essay accompanying the publication available at: https://www.highpitchmagazine.com/issues/issue-02/listening-to-soundscapes-otherwise-infrastructures-as-environmental-sound-radio-otherwise
2. https://antennenozeane.de/
3. https://acousticommons.net/~/
4. https://www.sam-basel.org/en/events/s-am-fm-experiments-ecological-radio
5. https://www.cafx.dk/biennial/media/slowing-down-to-infrastructure
6. https://lina.community/projects/3b3b1684-470e-4b67-b472-a95434c0f551/
7. https://www.cafx.dk/biennial/biennial-home

interest in a radio format that would gradually build toward the Biennial, beginning in May 2025 and culminating during the month of the event.

What was initially envisioned by CAF as a series of conventional on-demand listening formats focused on conversational content, namely podcasts with guest specialists exploring the interface between slowness and architecture, was rethought by us as a durational, generative live web radio format. In this proposal, loose conversations (often with non-experts) and snippets of them would play a supporting role, while the central listening experience would become a collective attunement to the inner life of the Copenhagen Architecture Forum space at Halmtorvet 27. This collective attunement meant listening to live transmissions from five streamboxes installed throughout the building, transforming it into both studio and instrument. Airflow through vents, electromagnetic activity around routers, the pulse of water pipes, and vibrations from the street were streamed alongside the hum of machines and muffled traces of voices and activity, foregrounding the subtle, often unnoticed infrastructures themselves as protagonists.

Within the live composition, parameters such as cycles, gradual change, periodicity, and rhythm functioned as central structuring elements. The five streamboxes were not treated as static background sources but as dynamic material. Background voices were muffled; sounds underwent slow fades; frequencies were cyclically processed, selected, amplified, and spatially organized within the stereo field. These processes were particularly pronounced in the input from the electromagnetic loop antenna near the data center. Occasional activity in the water pipes panned across stereo channels, while the system's own modes of listening—noise generated by the streamboxes themselves—were folded into the composition. Street vibrations rose and receded in response to patterns of urban movement.

The materials also enacted forms of natural processing: for example, ventilation ducts transformed neighboring sounds, such as music playing in the shop next door, into diffuse textures. Air microphones were used sparingly in contrast to contact microphones and antennas, as the artistic focus lay on treating infrastructural systems as environmental sound, using most microphones as transmitters of vibrations moving through materials and architectural structures. Through subtle modulation and processing, these sonic flows were layered, filtered, amplified, and occasionally reorganized in the acoustic space, allowing certain cycles to emerge clearly while others drifted in and out of focus. Periodic events such as mechanical hums, recurring surges, daily infrastructural peaks, served as temporal anchors, while gradual shifts in amplitude and density produced long arcs of change. Rather than imposing an external pulse, the composition derived its rhythm from the life in, around, and of the building itself, amplifying its micro-temporalities and slow durational transformations so that listening became an act of attunement to a living, evolving system.



Fig. 1. A contact mic is mounted on the plumbing beneath the sink in the shared kitchen at the Copenhagen Architecture Forum offices. It feeds into a streambox that broadcasts continuously, 24/7, over a six-month period. For long stretches the signal registered near-silence, punctuated only by moments of human activity or the activation of the dishwasher. Image credit: Kate Donovan.



Fig. 2. A hydrophone is installed inside the rooftop rainwater pipe of the Copenhagen Architecture Forum's office and gallery, where it is linked to a streambox. Image credit: Niko de Paula Lefort.

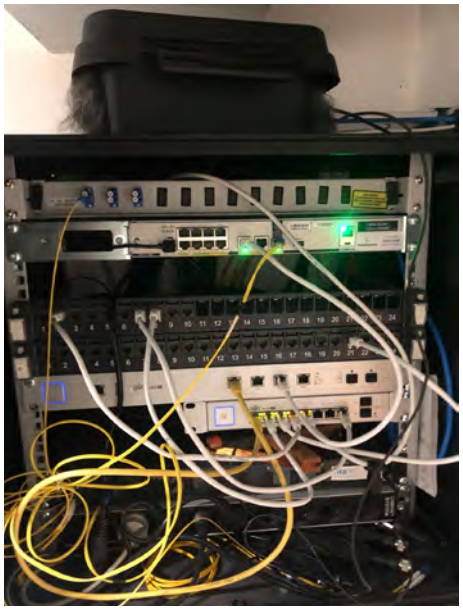


Fig. 3. Electromagnetic Loop Antenna (under yellow lights) plugged to a streambox (above the server rack) sensing activity in the data transmission network. Image credit: Niko de Paula Lefort.

The project also included *Conversations on Slowness*, a cycle of nine recorded encounters structured around a shared constraint: each invited participant would enter into dialogue with a guest of their choice, reflecting on slowness and temporality in one continuous, unedited recording. Rather than adhering to tight formats or predetermined outcomes, these exchanges were allowed to unfold according to their own internal timing: unhurried, digressive, at times circular – offering an alternative to the speed and urgency of most commercial media. The conversations were released over the course of six months, following a progressively intensifying release rhythm (starting monthly, moving toward bi-weekly and then weekly releases). Each episode entered a multi-phase replay cycle, timed according to real solar phases in Copenhagen (CEST time) on each given day. Selected moments from the conversations were gradually introduced into the live broadcast environment, where they mingled with the ongoing infrastructur-

al transmissions. In this way, speech and environment, reflection and resonance, became intertwined within a continuously shifting sonic composition.



Fig. 4. Screenshot of the web radio *Slowing Down to Infrastructures* in the Copenhagen Architecture Biennial website with web player and part of the schedule.

The experience of *Slowing Down to Infrastructures*[8] so far has revealed the richness of attuning to the subtle, persistent rhythms of buildings as living systems, highlighting how infrastructures mediate everyday life, perception, and social organization. By inhabiting a space for an extended period through listening closely to its movements, patterns, materials, flows of air, water and electricity, and the adjacent human presence, the project foregrounded temporality, engagement, patience, and the layered complexity of environments. The generative radio setup created not only a processual sonic portrait of the skeletons and pulses of Copenhagen Architecture Forum but also a framework for exploring architecture, infrastructure, and ecological relationality as intertwined processes. Looking forward, the same approach can be applied to a variety of buildings, architectural spaces and contexts, each producing unique sonic ecologies and modes of collective attunement. Through these iterations, the project envisions an expanded practice of ecological listening that foregrounds the politics, temporality, and materiality of built environments, offering audiences a deeper awareness of the living infrastructures around them.

8. A 20 minute long sonic essay mixing fragments of recordings of the 6-months-long radio broadcast can be found in the following link: https://open.substack.com/pub/monaidepaula/p/slowing-down-to-infrastructures?utm_campaign=post-expanded-share&utm_medium=web

Technicalities of Listening to Infrastructures as Ecological Radio

In the current ecological turn, media systems are understood not simply as channels of information but as planetary processes involving energy, materiality, and maintenance, which we bring together here in connection to the architectural, social and more-than-human infrastructures of built environments. This work draws on ecological radio[9] in both theory and practice. Using diverse vibrational and audio inputs to promote plurality and relationality, our focus on transmitting the practice of listening is a way to nurture real-time collaborative listening situations—an intentional undoing of the traditional binary model of transmission-reception. We aim instead for a more circular, non-linear mode of process and exchange that emphasizes multiple entanglements in a shared presence.

Streamboxes

There are several "recipes" to build a streambox[10] that basically connect microphones through an audio interface to some sort of computer (i.e., smartphone or Raspberry Pi) that will run the Locuscast[11] software connecting, via internet, the live audio capturing to the Locus Sonus hosting server and consequently to their sound map. Streamboxes need their power and internet connection solutions that will depend on the location and the duration they will be in operation.

For the project, we used streamboxes built by Soundcamp, each containing a Raspberry Pi microcomputer with an embedded IQAudio interface, along with a protective housing. Some units were equipped for Ethernet internet and battery power connections, while others relied on Wi-Fi and standard electrical outlets. Only one streambox featured air microphones (PUI capsules); the others were fitted with DIY contact microphones, antennas, and a hydrophone (Aquabeat).

The Locustream project, including their server and software, was designed by Locus Sonus research group, hosted by the Aix-en-Provence School of Art (l'École supérieure d'art d'Aix-en-Provence Félix Ciccolini). Although free and open access, the project welcomes participation that involves ecological radio and open microphones. Projects that would use the infrastructure for conventional radio-making could potentially be removed from the server.

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9. Ecological radio connects to R. Murray Schafer's concept of the soundscape (1994) and to broader traditions of acoustic ecology, which often aimed to raise environmental awareness through attentive listening as a way to support multispecies preservation or to hold threatened worlds in sonic form. Ecological radio distinguishes live transmission from traditional field recording: where recording has often implied extraction, containment, and even colonial logics of capture and possession, live streaming resists closure. It unfolds in real time, bound to the temporal and material conditions of its source, shifting listening from an act of collecting and owning sound toward one of sustained attention and relational presence.
10. https://soundtent.org/streaming_recipes.html
11. LocusCast is a mobile audio streaming application that enables users to broadcast a live mono or stereo Ogg (and MP3) stream from a portable device directly to the Locustream SoundMap, automatically geolocating the feed on the map and maintaining a persistent connection to the server.

We installed five streamboxes on the Locustream, each providing an individual audio stream URL. These streams were not published on the Sound Map but were processed and mixed in SuperCollider and outputted to a single live audio stream on our headless cloud server. The live stream was then embedded in the web player on the Copenhagen Architecture Biennale website.

SuperCollider

The live audio stream for *Slowing Down to Infrastructures* was hosted on the project cloud server and fully computed through SuperCollider. The live audio URLs from the streamboxes were routed into the server via JACK, allowing real-time audio processing in a headless cloud environment. A watchdog system monitored the streams, automatically rebooting portions of the code in case of silence or failure, ensuring continuity without restarting the entire system. Each incoming stream was compartmentalized and processed in multiple ways: segments were frequency-selected, filtered, amplified, modulated, spatialized through panning, and/or layered. The processed streams were then mixed and outputted from SuperCollider via JACK to FFmpeg, which encoded them into a continuous live stream accessible via a final dedicated, secured URL. Episodes from *Conversations on Slowness* were scheduled to override the generative composition at predetermined times, with snippets inserted randomly and at varying rates, effectively side-chaining/ducking human speech into the otherwise infrastructural sonic environment and integrating reflective dialogue into the temporal flow of the building's live soundscape.

Ecological Media Arts

By taking the opportunity to present our work at a conference on the theme of Computation, Communication and Aesthetics and what connects and affects them all, we are not looking to celebrate our technological setup for its own sake, instead we wish to position our approach to technology and media arts as process-oriented, situated and experimental.

At the core of the project is the act of listening: by attuning to infrastructures, artists and audiences alike are implicated in a process of disalienation, experiencing communication as a situated, responsive interplay with(in) living systems. In doing so, the project enacts an ecological mode of media practice, one that recognizes the interdependence of human and more-than-human actors and the flows of energy, matter, and information that circulate through technological and architectural systems. Moreover, it reforms rather than perpetuates models of communication and technological submission, as we believe is the role and responsibility of artists and the arts (Flusser 1972).

By foregrounding infrastructures as both media and collaborators, the project enacts a systemic ecological approach, emphasizing the

entanglement of human, more-than-human, and technological actors within dynamic environments. It demonstrates how ecological listening is not only a method of perceptual and social inquiry but also a form of critical intervention: by questioning dominant technological and communicative paradigms, artists assume a responsibility to reform existing models, offering alternatives to technocracy and fostering modes of engagement and responsiveness that reconnect humans to the living systems around them.

Acknowledgements. The project was initially supported by the LINA Community and the Copenhagen Architecture Forum, special thanks to Søren Nørkjær Bang, and also Mekki Sebastian Brink. Thanks to Frederik Heidemann for assisting on site in Copenhagen and Fredrik Olofsson for consultation on SuperCollider. Thanks to Soundcamp for manufacturing the streamboxes and the Locustream project for enabling us to use their infrastructure.

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Kate Donovan: http://mattersoftransmission.net/
Niko de Paula Lefort: https://nikolfo.com/

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Sui Generis: A Biased Dictionary



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Sui Generis exposes how machine learning algorithms reduce human complexity to statistical abstractions. I approach these tools not as neutral agents, but as judgement and political machines. The work materialises this position through an algorithm that infers (or perhaps, fails to infer) how much I like or dislike a given word on a scale from 0 to 100. This algorithm is not rigorous or useful, but an ironic device used to highlight the subjective nature of these technologies. My custom machine learning model is materialised as a dictionary, a symbol of universal knowledge. Each percentage, each word classified by the model, exposes its limits: the impossibility of true personalisation. Displayed within a clinical setting, the audience is invited to examine the book using white gloves and a digital microscope, entering a loop of scrutiny where subjective data is objectified, only to become subjective again through the viewer's judgement. The algorithm ultimately reflects countless unseen contributors embedded within its model. Where do other people's preferences surface in these supposed personal classifications? How does this homogenised entity shape my own sense of identity?

Keywords: Machine Learning, Homogenisation, Algorithmic Bias, Individuation, Latent Space, Installation, Artistic Research.

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Concept and Research

Sui Generis emerged from a critical and conceptual investigation into the operational logic of machine learning algorithms, and how we can relate them to human decision-making. These technologies are built to make decisions. They are not objective, sterile, nor neutral instruments. Fundamentally, they are built to categorise, presume, and select: they are judgement machines. By processing vast datasets of human information and interaction, they do not eliminate subjectivity, but rather encode it. Since they are trained on the accumulation of human choices, data that is inherently subjective, they do not merely observe the world; they operationalise its biases. Human data is, by definition, biased. And so is machine learning.

Rooted in this subjective data, the training process for these models operates on mathematical thinking: a vectorisation that maps individuals and their data into a high-dimensional latent space. This reduces every subject to a statistical entity, a mere vector amongst millions. Conceptually, this latent space functions as a closed universe where the model holds all possible answers as predefined coordinates. Within this structure, identity is determined strictly by mathematical proximity. This produces a flattening: once crowded into this dataset, we become indistinguishable from the statistical average (Steyerl 2023). As Hito Steyerl notes regarding captcha authentication, the browser scans our history to compare it against a predefined image it already holds of us (Steyerl 2016). We are only recognisable as "correct data" if we are coherent within this contiguity. Meaning, we can only access our bank account or complete an online purchase if we remain the same as yesterday. If we diverge from this configuration—if we naturally evolve, the system concludes we are not ourselves. "It is an identification game" (Steyerl 2016), where we are identified by our similarity to our past selves, our social graph, or simply those who resemble our clicks online. Ultimately, we are no longer defined by our singularity, but by our proximity to our mathematical neighbours in the vector space.

The premise that we are only identifiable if we are similar to those around us forecloses the process of continuous evolution, what Gilles Deleuze describes as individuation (Deleuze 2001). For Deleuze, to become is to differentiate, to produce the new; yet these models reduce this potential to a crowd of sameness. In human decision-making, evolution is driven by emergence: the capacity to generate ideas and patterns that transcend prior conditions. However, a machine learning model cannot accommodate emergence. The latent space can never be an emergent space: because it is trained on past data, its universe is finite. Every output it generates is merely a retrieval of a pre-existing coordinate within its latent space. It cannot create the new; it can only locate the likely.

By granting these judgement machines the authority to decide, we fundamentally alter the definition of truth. For the algorithm, truth is not derived from the unfolding of lived experience, but from statistical

alignment with its dataset. Truth becomes defined by consistency. Because these algorithms are tested strictly on their ability to reproduce history, they inherently penalise divergence: the future they predict is mathematically bound to equate to the past. They effectively function as a stochastic parrot (Bender et al. 2021), where meaning is not created but statistically recycled. In this closed loop, the future equates to the past; it is automated, embedding all the mistakes and biases, while leaving no space for growth.

My Judgement Machine

This replacement of "likenesses with likelinesses" (Chun 2021) forms the conceptual basis of *Sui Generis*. The project functions as a critical interrogation of the custom judgement machine I built, constructed to expose the mechanisms of similarity and homogenisation. To this end, I developed a personal classification system designed not for accuracy, but for the amplification of bias. I created a small personal dataset of words, assigning each one of these words a value between 0 and 100 (Fig. 1), based on intuitive preference. The rapidity and subjectivity of this classification task were intentional and crucial. Even with an attempt at a methodical approach, this process remains inherently absurd. Quantifying volatile human attributes into stable data points is inherently impossible, yet it remains the foundational logic upon which these machines operate.



Fig. 1. Section of my personal dataset (words and their classifications).

This subjective dataset was then used to fine-tune a pre-trained language model (DistilBERT). Crucially, this model is not a blank slate, it has already learned the relationships between words, their semantic weights, and conceptual associations from a massive corpus of text representing millions of users online. In this process, I did not teach the machine what words are or how they relate, that knowledge is inherited from the crowd of its original dataset. My fine-tuning process, associating words with my personal preference through numerical classification, merely rearranges these pre-existing connections to fit my personal rules. Consequently, the resulting "personal" machine can never be truly individual. Because its foundational logic is built upon the aggregated preferences and biases of millions of other voices, the model remains irrevocably tethered to the external world, making true isolation, and therefore true personalisation, impossible.

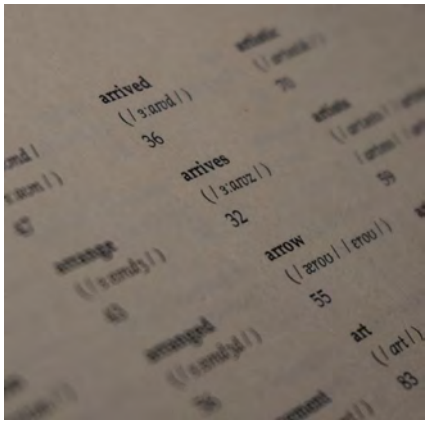


Fig. 2. Close up of the dictionary.

The central artefact, the dictionary, acts as a physical critique of this false personalisation. As a symbol of universal knowledge and definition, the dictionary form reinforces the project's central thesis: that I am generating yet another instance of standardised universality, rather than true individuality. Inside, instead of definitions, words are paired with their predicted classification scores (Fig. 2). Each of these numbers exposes the limitations of the model, freezing fluid preferences into predefined statistical certainties.

The installation environment reframes this object not as a volume to be read, but as evidence to be examined. Visitors are invited to re-

view the book through a digital microscope in a setting that mirrors a clinical laboratory, using white gloves to enforce a deliberate, tactile engagement. These choices disrupt the usual affordances of reading, promoting a posture of scrutiny. Under the microscope, the text becomes a specimen. This creates a continuous cycle of judgement, where subjective data is objectified by the machine, only to become subjective again through the audience's interrogation.



Fig. 3. Installation with book, digital microscope and white gloves.

Conclusion

Ultimately, *Sui Generis* does not seek to fix the bias of the machine, but to embrace the dictionary as a tangible iteration of the stochastic parrot. The project demonstrates that the aggregation generated during the training process is not an aggregation of people or their data, but an abstraction of it. As the model reduces us to mathematical probabilities, it reveals a critical flaw in the pursuit of total knowledge: the data provided by these models can never fully capture reality, for they operate by adding a layer of calculation to an existing experience we already understand.

The model I fine-tuned inherits not only the biases of its previous training, but also the imprints of countless voices across the internet: every individual who has ever contributed to its datasets. This raises urgent questions: What does the statistical output given by the model tell me about other people's preferences? In what ways are they embedded in these supposed personalised classifications? And crucially, how is my own identity being influenced by the homogenised entity built by the model? We are naturally connected by our similarities, but these similarities should not define us. Unfortunately, as this work aims to highlight, these datasets mine our data not to identify who we are, but to reduce us to our relation to others.

We cannot uninvent these technologies, nor can we simply reject them. Instead, we must learn to use them as a mirror. As observed in *Sui Generis*, the model often hallucinated, amplifying my preferences into extreme values that defied the given scale. This exaggeration suggests that these systems do not merely replicate; they amplify their biases. Rather than using them to generate static outputs to predict a future that is merely a recycled past, we can leverage them to understand our present. Their predictions provide a lens through which we can better understand where our biases lie. We need to lay these predictions against the underlying data that only we can understand, shifting the focus from automated categorisation to a critical reflection on ourselves.

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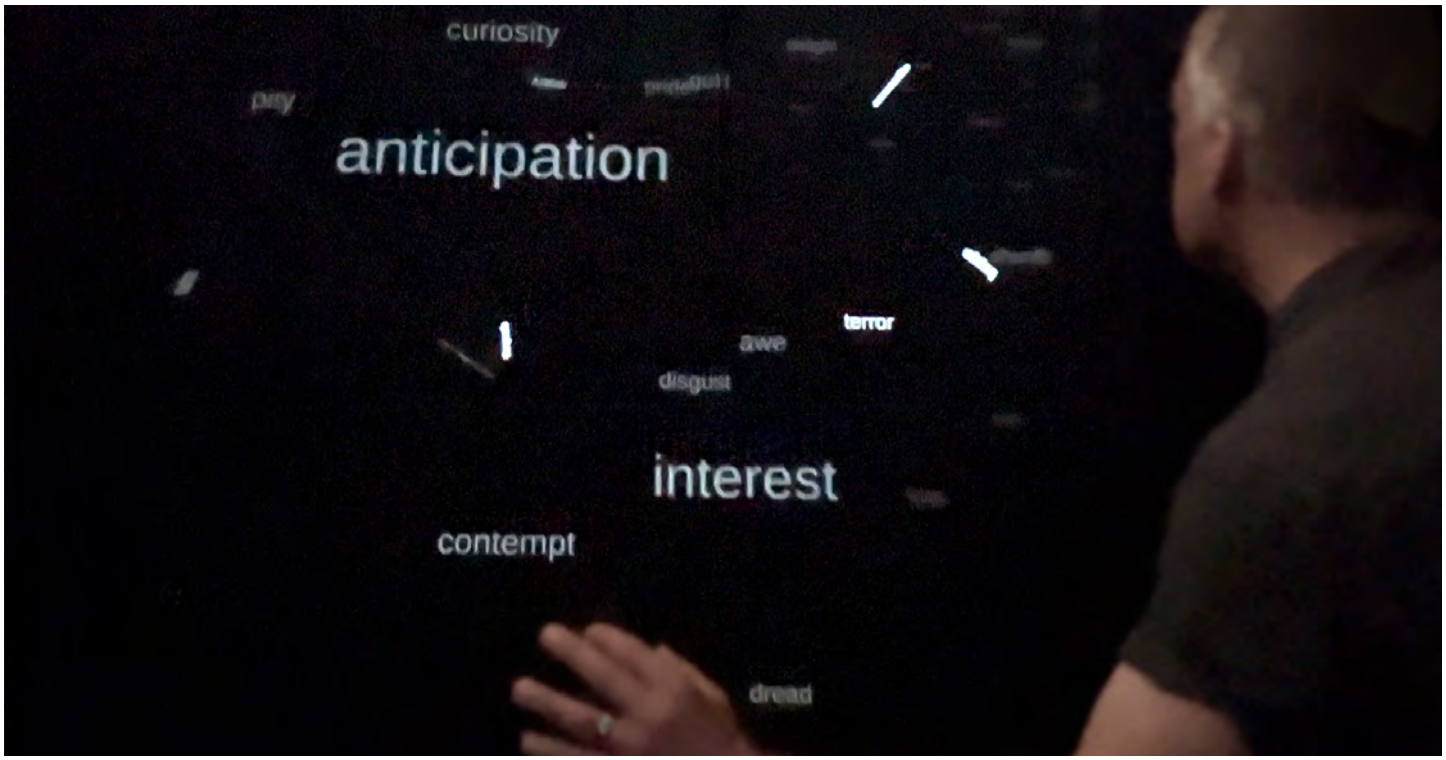
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Morphological Murmurations



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Morphological Murmurations engages its audience kinaesthetically with language and draws on the flocking behaviour of birds to broaden consideration of how AI conceptualises language and the roles it might play in both facilitating and limiting the creation of meaning. Utilising a depth camera, game engine software, deep reinforcement learning (DRL) and voice cloning text-to-speech (TTS), the installation places visitors within a virtual 3D representation of the embedding space of Google BERT, a large language model (LLM) where a flock of artificial agents responds to their movements, visually and sonically activating words through a synthetic clone of the artist's voice. This is language assembled not through computational logic, but through patterns of bodies working together: that of the visitor and those of the flock. Through the intuition of movement, muscle memory and spatial awareness, the visitor explores the environment of a putative "other mind" (the LLM) through an alternative model of how embodied minds (birds) coordinate movement and create meaning with their bodies. Evaluation of the logs of interactions during a public exhibition of the work suggests the types of meaning produced and compares these with how an LLM assesses the meaningfulness of word sequences.

Keywords: LLM, Biomimicry, Reinforcement Learning, Distributed Cognition.

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Introduction

Morphological Murmurations was exhibited during the Scottish AI Alliance event *AI Can't Write Symphonies and Neither Can You*, 28-9 June 2025 in Glasgow, United Kingdom. In response to the provocation in the event's title, the installation proposes creative expressions like symphonies are artefacts of something more essential to what it means to be human: the ability to experience and shape thought and expression through movement and embodied interactions with others in physical and conceptual space. It explores differences between human minds and algorithmic models in meaning-making and promotes a more inclusive consideration of ways of thinking and communicating than the computational view of cognition underlying the LLMs currently dominating the implementation of and discourse around Artificial Intelligence.

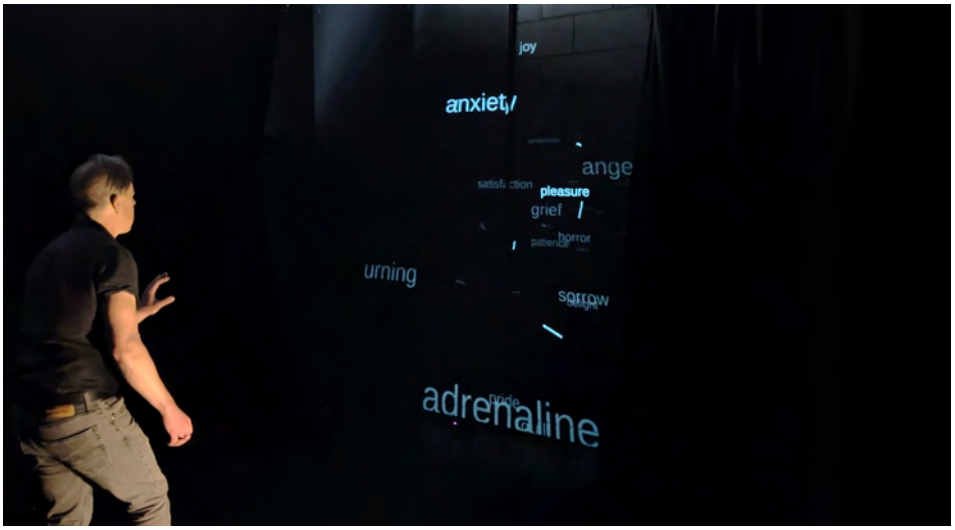


Fig. 1. Installation view of *Morphological Murmurations*. Online video documentation: (https://theodorekoterwas.com/morphological-murmurations)

Background

The idea for the work originated when I intuitively wrote "trust pets" in response to a question during a *Writing the Wrongs of AI* workshop run by Pip Thornton (Thornton 2024). One need only consider guide dogs, carrier pigeons, and other "working" animals to recognise the high degree of confidence we place in their response to unpredictable situations. From millennia of observing and training animal behaviours, we recognise our own propensity to act predictably without requiring what Anthony Chemero refers to as "mental gymnastics:" the conscious manipulation of mental representations, symbols or computation (Chemero 2009). We also see in these animal behaviours something beautiful, such as in Starling murmuration, or terrifying, such as in the swarming of bees. These behaviours signify meaning through the coordination of moving bodies. *Morphological Murmurations* attempts to mimic flocking behaviour to propose an alternative to the logic of the LLM in navigating the semantic structure of language.

Word Embeddings as the Linguistic Environment of Computational Minds

The word embeddings of an LLM are the "environment" in which it operates. Early construction of embeddings relied on an approach to language, Latent Semantic Analysis, that is inherently spatial, presuming an underlying semantic structure based on proximity: words surrounded by similar words are themselves similar (Dumais et al. 1988). In the case of the Transformer architecture of modern LLMs, this structure is transformed through layers of computational manipulation using Queries, Keys and Values to determine the relevance of specific tokens (word and sub-word units) in a particular context (Vaswani et al. 2017). While it may be working in incomprehensible dimensions, these dimensions encode spatial assumptions about the nature of language.

To comprehend the environment in which an LLM operates, we need to view the embeddings in a more familiar dimensional space. A three-dimensional representation is created by reducing the high dimensional vectors of each word to the three most distinctive values and then mapping them as Cartesian coordinates. This process reveals spatial semantic relationships, clustering words and, famously, exposing parallel directional links between conceptually related pairs of words such as "king" and "male" and "queen" and "female" (Mikolov et al. 2013). Because they were derived from the use of language by the authors of the training material, these relationships in the embeddings can be seen as a shared semantic space of the authors, which in the case of Google BERT, is hundreds of thousands of contributors to the English Wikipedia and BookCorpus datasets (Devlin et al. 2019; Wu et al. 2016; Zhu et al. 2015). The idea that machine generated spaces represent meaningful structures or the contents of human mental processes has been proposed, explicated and contested in works of art and theoretical papers, particularly those examining the "latent" spaces of visual models (Schaerf 2024; 2025). The embedding space represents something more foundational. If the latent space is a space of possibilities and hallucinations, the embedding space is the environment these models "move", homing in on the most probable, and therefore, according to a computational theory of mind, most meaningful word.

Distributed Cognition and Embodied Language

The computational theory of mind is contested by theories of distributed cognition which hold that a significant amount of human behaviour does not require mental representations or the manipulation of symbols. Examples such as catching a ball, walking upright, even playing instruments can be accounted for through dynamic systems analysis of bodily capabilities and environment affordances (Varela et al. 2017; Chemero 2009; Pfeifer et al. 2007). Language appears to defy these accounts: what are words if not mental representations, signifiers or symbols? Andy Clark (2009) presents a middle ground in which language scaffolds extended cognition: words are a means of labelling and there-

fore grouping things in our environment to reduce higher order problems, they allow us to rehearse actions, control selective attention and anchor thought and reason, and they appear to us as objects themselves. In addition, we utilise our bodies as we form ideas into words. Learned and habitual movements shape our thoughts as much as subtle actions of "body language" might belie them. We move our hands, arms, head, torso and even our hips and feet to shape concepts, grasp at relationships, and add weight and rhythm (McNeill 2005; Arnheim and McNeill 1994; Cassell et al. 2000).

An embodied view of cognition considers behaviour as emerging from a dynamic system comprised of the mind, body and the environment (De Bruin et al. 2021). Such a view inspires an investigation of how meaning might be produced through the navigation of an environment comprised of spatially arranged signifiers. A Phenomenological view of language holds that "it is the lateral relation of one sign to another which makes each of them significant, so that meaning appears only at the intersection of and as it were in the interval between words" (Merleau-Ponty 1978, 42). These intersections and intervals require not just existing spatial relationships between words, but new connections made between them through acting in the world. It is proposed in this installation these connections are made as much by the body as the mind and through the coordination of multiple bodies.

Flocking and Swarming as Alternative Exploratory Method

Flocking and swarming are forms of emergent, collectively intelligent behaviour that require no consideration of mental representation or symbolic thought to describe or simulate. They are modelled algorithmically by calculating the position of agents using three parameters: alignment with other agents, separation from them and cohesion of the group while following a target, often a "leader" agent or prey. These parameters are not representative of "thoughts" or "calculations" but purely of spatial relationships between agents. Navigating word embeddings according to these parameters offers an alternative to the way LLMs operate on them and explores whether the meaning we find in the spatial patterns of group coordination translates to the spatial composition of language. Exploring language through biomimicry inherits from experiments in language development by autonomous agents and the Synthetic Method of cognitive research employed in Artificial Life (Pfeifer et al. 2007; Steels 2012). While Artificial Life approaches take the dynamic, situated and socially-embedded nature of intelligent behaviour as a premise, they have been challenged for their underlying assumption that the dynamics of these systems represent a reality that is predictable (Birhane 2021). Utilising biomimicry as an exploratory method in art accepts and utilises this unpredictability to question theories of cognition through the empirical method of artistic practice.



Fig. 2. Detail view of flocking agents navigating word embeddings.

Evaluation and Reflection

Often artworks are evaluated through visitor feedback. In this case we are expressly interested in alternative experiences of language where meaning is implicit, created through evocative bodily and spatial navigation. By examining sequences of words triggered in the logs we can evaluate their potential to evoke meaning in an associative way and how this compares to a purposeful attempt to navigate concepts. We can supplement this analysis with observations made of visitors interacting with the work and verbal feedback they provided.

Evaluation of Logs

The software logged every word triggered by the flocking agents. A comparison of two logs can provide insights into the effectiveness of the installation in producing meaningful sequences of words. The “audience” log recorded public interactions during the second day of the exhibition. Prior to opening I interacted with the installation for filming. Because I was purposefully attempting to demonstrate meaningful interactions, the “artist” log of these can help gauge the effectiveness of the installation in providing similarly meaningful interactions for the public.

The logs were analysed programmatically to sample sequences of words triggered. Reading over these sequences, it is difficult to compare them for meaningfulness. They contain a mix of strings of disjointed concepts (“worth puzzle mutual importance consistency parody satirical”), lists of semantically related words (“fatigue longing annoyance dread terror embarrassment terror”), and moments of poetic potential (“weighted fantasy gauge secret nightmare dreams truth”). The human desire to find patterns and relationships leads to potentially oversubscribing meaning to these sequences through association and intuition. While this is part of the point of the work, it presents an obstacle to a more objective assessment. The intention of the work is to propose an alternative method of navigating the embedding space than the one

used by LLMs, so using an LLM to evaluate the results offers a means of analysis. Submitting the sequences for evaluation by GPT-5.2 through the University of Edinburgh's ELM service (University of Edinburgh, n.d.) reveals different concepts of "meaning" created through the computational approach to language modelled by LLMs and the more associative, embodied approach of a human.

Some examples of these evaluations are "These lines carry relatively coherent human/psychological or situational meaning compared to the more technical/repetitive ones" and "Strong emotional content + social circumstances + cognition/epistemic states." For GPT-5.2 meaning appears to be correlated with concepts such as "human/psychological", "emotional states", "social/political concepts", "evaluative/interpretive" and "situational" rather than "technical", "statistical", "procedural" or "repetitive." GPT-5.2 also identified "clusters" of meaning: "A coherent 'life outcomes & adversity' cluster", "Clear 'stress/fear/discomfort reactions' cluster" and "Strong, coherent adversity/outcome grouping." Concepts such as "coherence", "clarity", "consistency" and "strength" are correlated with meaning. This analysis demonstrates the spatial character of the concept of meaning in LLMs: meaning is derived from words being conceptually grouped in a clear and coherent manner, particularly words associated with human characteristics rather than technical or statistical ones. By this analysis, spatially navigating words with one's body makes sense.

Observations and Feedback

During the second day of the exhibition I dedicated a few hours to systematically observing audiences interacting. My observations were primarily intended to assess how effectively the work encouraged active bodily engagement, and I would only approach visitors if they seemed to struggle to interact. I found that of the sixteen individuals or groups, five required encouragement to approach the work and all but one began moving their bodies with purpose once they sensed movement of the words corresponding to their approach. The variety and dynamism of movement varied from walking around to crouching and waving arms. Four visitors required an explanation of how the interactivity worked, but then explored the words with intent, moving from cluster to cluster. A few visitors engaged me in further discussion. One visitor found the experience of navigating words with their body "therapeutic", another described the experience as "visceral" and "moving," and a third relayed that "there was a moment when the word 'violence' flew by and [they] freaked out a bit." One particularly engaged visitor, having navigated effectively, discussed their prior reading around spatial relationships across languages and animal communication. The installation provoked interactions within groups. In one family, the child danced and grabbed for the birds, and the parents took turns navigating with intent and remarked, "That's really cool, really good." One of a pair of visitors described how they compared words: her interaction produced the words "punishment" and "threat" while her companion produced more posi-

tive terms, resulting in feelings of being judged even though she knew it couldn't judge her. The other artist exhibiting in the room said she felt judged when the piece kept repeating "boring" as she described her own work to a visitor even though she knew it couldn't hear her.

Conclusion

Morphological Murmurations explores alternative processes of constructing meaning from a spatial model of language. By placing the visitor in the embedding space of a LLM accompanied by flocking agents the installation proposes language is enacted through a dynamic system of bodies interacting in a linguistic environment. A comparison of human and machine evaluations of the resulting sequences reveals different concepts of meaning, the human being more associative and intuitive, and the machine based on semantic clustering and distinctions between "human"-related characteristics and "technical" properties.

Acknowledgements. The work was informed by conversations with Jane McKie and Stuart King. Jane, a poet, and I shared a fascination with Starling murmuration and the way meaning emerges in language. Stuart, a mathematician, is particularly interested in fluid dynamical processes.

Link: https://theodorekoterwas.com/morphological-murmurations

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See What Tomorrow Brings Near, Borrow My Disease [HMV-V]



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See What Tomorrow Brings Near, Borrow My Disease: HMV-V is the fifth performance by a custom-designed robotic phonograph which can remix vinyl records in real time using analogue techniques originating in DJ culture of the 1970s, such as breakbeating, backspinning, sampling, and scratching. In parallel to producing a continuously evolving soundscape, the automated-art-system performs simultaneous computational processes (which we call 'nonhuman listening') by monitoring the audio output in order to adjust and even modify its own behaviours. For *HMV-V,* we focused the system's 'nonhuman listening' towards potential words and phrases produced when the vinyl record is rotated in an anticlockwise direction, constituting an automated search for 'backmasked' lyrics sometimes associated with 'hidden meanings' (whether intentional or otherwise).[1] The emergent language, composed into statistically probable phrases, is displayed in real time on a screen situated alongside the robotic phonograph. Furthermore, the system 'rewards' the listener by extending any loops which contain a rich source of phonemes. In this paper we will briefly outline the project, and attempt to situate it within our own creative practice of 'computational unknowing'.

Keywords: Electroacoustic, Nonhuman Performance, Remixologies, Speculative Design, Cybernetics, Infinite Knowable, Conspiracy.

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1. Backmasking became a sensation from the 1960s through to the 1990s with fans and critics 'discovering' backmasked messages in work as varied as The Beatles to Weird Al Yankovic and Prince (see Woody & Andy 2025).



Fig. 1. *HMV-V*, Donnachie and Simionato, 2026. Presentation video: https://vimeo.com/1165282845

Glitch Turntablism

This work is situated within and extends our own experimental practice which explores the combinatorial potential of language within existing literary sources, which in turn forms part of a broader enquiry into 'computational unknowing'.

The conceptual framing of the *HMV-...* can be traced to our earlier automated-art-systems which used computational processes to alter existing publications. For example, concepts underpinning *HMV-V* link to the *Library of Nonhuman Books* where a mix of Computer Vision and Natural Language Processing algorithms were used to detect and isolate words within the pages of existing (paper) books – a process we describe as 'nonhuman reading' (Donnachie and Simionato 2019). Working within the medium of audio recordings rather than print media, *HMV-V* also uses algorithmic processes to detect latent language by analyzing the nonlinear and reversed playback of existing vinyl records and presenting any newly 'discovered' words as lyrics on a screen. Where the nonhuman books resulted in isolated words on the page, the *HMV-V* system repeats the 'uncovered' backmasked audio sample as a looping sequence, allowing the emergent 'phantom' lyrics to become a powerful suggestion to the listener who may perceive them despite their initial implausibility (an effect called pareidolia).

The design of the *HMV-V* machine, with its distinctive counter-balanced dual-arm stylus, emerged while experimenting with another work called *I Don't Know What I Think Until I Read What I Write* (Donnachie and Simionato 2025). A robotic scribe which attempts to search for glyphs within non-Euclidean space using the rotary movement of stepper motors to move a calligraphic brush. By adapting this earlier work to move an electromagnetic stylus across the surface of a vinyl record instead of a brush across paper, we stumbled upon a highly efficient and unique range of motions for 'playing' vinyl records in non-indexical ways we likened to gestures used by DJs of the 1970s, such as backspinning, sampling, and scratching.

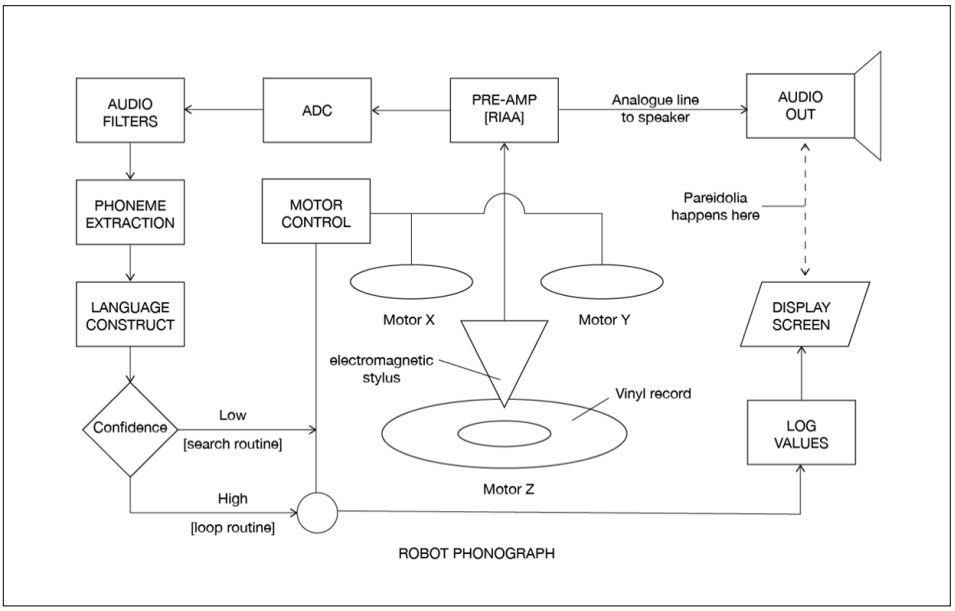


Fig. 2. Flow diagram of the automated-art-system, *HMV-V*.

Nonhuman Listening

The 'nonhuman listening' system overlaying the robotic phonograph is designed to detect audio generated by its stylus moving at different speeds, angles, pressures and directions across the surface of a vinyl record. This (analogue) audio signal is initially passed through standard circuits for pre-amplification [RIAA] and transformation into digital data [ADC] before processing by our custom-coded software in real time.

Once digitised the audio data is decoded and prepared for processing via Librosa and Pyaudio libraries, while the Numpy-based Fast Fourier Transform [FFT] spectral noise filtering and signal refinements enhances the real-time audio stream for subsequent analysis.

Acoustic events detected by this initial analysis are processed for phoneme recognition and language construction with both Allosaurus and Kaldi (Vosk), with the outcomes of the system's iterative, context-aware meaning generation then output to a screen in sync with the audio (or at least with negligible latency).

The resulting phonemes, words and potential phrases are finally logged, along with the phonograph's relative motor positions and speeds.

The often slowed, distorted or slurred nature of the speech emerging from the backmasked audio (similar to speech produced by individuals suffering from 'dysarthria') is not easily recognised by standard speech recognition systems.[2] In order to accommodate and improve voice detection within these highly distorted audio inputs, we extended the phonetic detection of the model by using TensorFlow to re-train for improved translation (mapping) of the acoustic vectors of the captured

2. In fact, early versions of our pipeline proved underwhelming in their ability to identify emergent language through our automated-art-system. These early results stemmed from attempts to use existing speech-to-text engines on our 'backmasked' language. Furthermore, existing 'off-the-shelf' and AI-enabled tools were poorly matched to the limited CPU capacity of the Raspberry Pi, and would often 'collapse' into repetitive nonsensical words, or present phrases unrelated to the audio.

audio. This bespoke and expanded mapping of phonemes was then incorporated into our local Vosk library.[3]

It is worth noting that other than this early training of the phoneme recognition, the system does not use any auto-regressive or 'generative' AI for its language detection at run-time. The words displayed are constructed almost entirely *from* audio analysis and phoneme mapping, rather than statistical probability and context. An auto-regressive model in this specific use case tends to create entirely new sequences of words, prioritising the generation of a fluid ('natural') text over the direct mapping of words to phonemes, often hallucinating new words to 'resolve' the sentence, particularly in the absence of any unambiguous or predictable meaning in the (backmasked) audio. Combined with the hypnotic effect of phoneme-rich audio-looping samples, this 'old-fashioned AI' approach may contribute to the pareidolic perception of emergent language in the recording.

Janky-Hermeneutics



Fig. 3. *Hermeneutic Machine Variation I: Bright Eyes (HMV-I),* Site-specific installation & performance in *NotFair2026*, Melbourne, Australia. Photograph by Donnachie and Simionato.

The historical invention of the phonograph simultaneously evokes a sense of "immediacy" (it is one of the earliest examples of a seemingly direct, unmediated connection to a past performance) and "hypermediacy" (the invention draws attention to the technology that shapes the sound) (Bolter and Grusin 1999). The assumption that the raw, acoustic data provided by a recording is sufficient for a simple, self-evident interpretation of musical or spoken content has been widely internalised over the 20th century. Indeed, the famous logo for the *original* HMV (His Master's Voice company) was a small dog listening to a phonograph playing a record, its head inquisitively cocked to one side as it seems to confound the recording of the voice with the presence of its master.[4] Our

3. The process at the core of Vosk is otherwise known as a Time Delay Neural Network (TDNN), which places this tool in the category of *classification*, rather than AI *generation*.
4. *His Master's Voice* https://en.wikipedia.org/wiki/His_Master%27s_Voice



Fig. 4. Francis Barraud, *His Master's Voice,* 1900. Photograph/Image. Library of Congress, USA.

own *HMV* (Hermeneutic Machine Variation) re-instates the tension between these two perceptions; requiring a type of interpretive (hermeneutic) analysis to understand how the sound is being produced and experienced, and how this contributes to the making of meaning.

Arguably any technological reproduction introduces a new context, material limitations, and sonic characteristics that inherently require interpretation. This work problematises such attempts by the listener to interpret the vinyl recording by reconfiguring the phonograph and medium as decoding tools.[5]

Our (robotic) phonograph is deliberately designed to not be a neutral conveyor of sound. We therefore introduce hermeneutically 'janky' concepts; not only by adopting and introducing technology that actively disrupts, disturbs, even destroys the sound it reproduces, thus demanding the listener engage in active interpretation, but also by including processes of auto-suggestion which influence and problematise our perception of the audio recording and the technology itself.

Like other technologies which have rapidly become ubiquitous, current (so-called) intelligent systems such as AI are often granted the privilege of neutrality, insinuating their presence into the everyday tasks we perform across digital and physical worlds – especially when those tasks happen through voice and conversational AI agents, sometimes called chatbots. Yet, these systems carry the potential to suggest *how* we interpret these worlds. Through entangled 'nonhuman listening', words and phrases may be perceived, meaning made (and unmade), and new realities emerge. Will we be able to discern our master's voice?

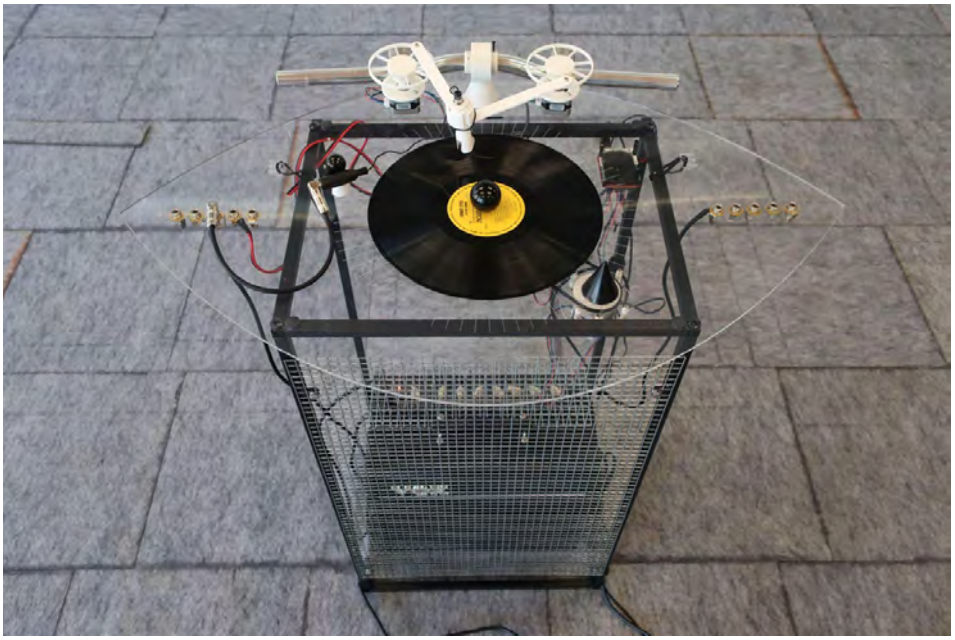


Fig. 5. *Hermeneutic Machine Variation I: Bright Eyes (HMV-I),* Performance at *NotFair* exhibition, Melbourne, Australia, Donnachie and Simionato, 2026.

5. There is, of course, a well-documented *avant garde* lineage of such experimentation in postproduction (Bourriaud 2002), to which we are indebted, such as through the works of pioneers such as Paul Hindemith's and Ernest Toch, John Cage, DIY punk recordings and experimental sound artists such as Maria Chávez, Christian Marclay, and Philip Jeck (see Harris 2017).

Note on the Title

The title of this work is in part taken from the 1965 album by the folk-group Peter, Paul and Mary *See What Tomorrow Will Bring* (1965). The lyrics of the chorus of the song "Betty & Dupree" from the album, when played backwards (i.e. backmasking) were interpreted through the automated-art-system's 'nonhuman listening' as 'Near, Borrow My Disease'. By combining the forward and backmasked versions, we formed the title of this Hermeneutic-Machine-Variation to be performed by the robotic phonograph on the occasion of the 2026 edition of xCoAx. Like all of our uses of found publications, we wish to underline that the authors and publishers of the original books, magazines and records have not granted us permission to use their work, nor do they endorse our projects in any way.

Acknowledgments. This artwork uses a number of open-source libraries, software and tools – Debian OS; Python; and multiple open source Python libraries such as Librosa, and Fast Fourier Transform tools, for acoustic analysis, refinement, and Analogue-to-Digital Conversion; Allosaurus phoneme recogniser; Kaldi speech recognition and Vosk speech-to-text; TensorFlow for phoneme recognition dictionary refinement; Natural Language Toolkit (NLTK); Vader sentiment analysis. Images in this document are of a prototype of the robotic phonograph which was part of a larger site-specific installation and performance by the artists in *NotFair2026*, Melbourne, Australia, curated by Brie Trenerry, Ashley Crawford, Darren Tan and Liss Fenwick. https://notfair.com.au/

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Restless Splatting: When the Frame Begins to Tremble



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This multimodal presentation includes a video installation and accompanying essay that deploys the Gaussian splatting technique for the dimensional transformation of restless images, challenging how operational images and computer vision claim to 'see' through artistic practice and theoretical reflection. On June 1, 2020, then-president of the United States, Donald Trump, forcibly cleared demonstrators with tear gas and rubber bullets to walk from the White House to the recently vandalized St. John's Episcopal Church for a photo opportunity. Documentation of this event released on C-SPAN depicts what we are calling the dividuation of the sovereign. This depiction is not only in the image produced but also in how the image insists on simultaneously depicting the manner of its production. The chaotic, handheld video that can hardly keep pace with the stream of events is an example of a restless image—an image that is produced both despite and because of a dislocation in the apparatus between its functions. Following Flusser, the apparatus is not only the photographic device and the gesture required to operate it, but the intention of the operator as an embodied subject. In this way, the image is of the body just as much as the body depicted is of the image. We reframe Merleau-Ponty's concept of body-image and al-Hallaj's claim "I am the Truth" as dimensional transformations, excavating the technical processes involved in Gaussian splatting to show how sovereignty relies on the dislocation of the ground truths from their referents.

Keywords: Gaussian Splatting, Body-image, Machine Vision, Technical Image, Video Installation, Sovereign Body, Ground Truth, Restless Image.

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Action





Fig. 1. Screenshot from the artwork *When the Frame Begins to Tremble* (https://vimeo.com/1164854697/d092f5228a).

Fig. 2. C-SPAN screenshot of Donald J. Trump holding a Bible near St. John's Church (https://youtu.be/5ShnqmiKLE8).

This text is based on a two-channel, synchronized video installation titled *When the Frame Begins to Tremble* (Fig. 1), which uses Gaussian splatting models from Luma AI for the dimensional transformations of a video stream. The video, sourced from C-SPAN, documents Donald Trump's June 1, 2020, walk from the White House through Lafayette Square to St. John's Episcopal Church (Fig. 2). The footage was captured during a tense moment when police used tear gas and rubber bullets to violently clear demonstrators for the walk and photo opportunity in front of the recently vandalized church.

Before the photograph was taken, live news broadcasts showed several minutes of shaky video, following Trump and his entourage along their route. The footage is fragmented, with partial views of the sky, tree branches, ground, people moving in and out of frame, blurred security personnel, and quick glimpses of political figures. The camera often loses its sense of direction, decohering narrative continuity. It struggles to stay focused on its subject in the chaos.

This footage was recorded by an anxious sensor. The camera often loses its usual alignment, with uneven framing and a sensor struggling to keep up with how close and fast things are. It still tries to follow the sovereign body, but its gaze is unsteady. Instead, the apparatus documents the anxiety, confusion, and instability of the event, as experienced by the reporter, through what would typically be considered flaws in production techniques. These are features of the restless image, which we will reflect on later in this text.

We process this video material using a Gaussian splatting method that rebuilds connections without needing outside depth measurements, ground control points, or steady multi-view capture. In this process, the two-dimensional image sequence is the ground truth. Unlike photogrammetry, which builds 3D space from steady viewpoints, Gaussian splatting uses probability-based point distributions from the image data, preserving partial, unstable, and incomplete details in the final result.

During installation, the two synchronized channels show the original footage being processed and affected by the Gaussian-splatted image, which slides through the animated computational reconstruction. Through Gaussian splatting, all the bodies fade into noise, break into pieces, or vanish. Only one figure stands clear and consistent: Trump, the sovereign.

The technical result is not a neutral, allocentric reconstruction of space. Rather, it reveals algorithmic vision and dimensional transforma-

tions as procedures of control. The two-channel installation highlights this tension by allowing viewers to see the divide between what the anxious sensor captures and what the algorithm stabilizes; how machine vision produces coherence on behalf of sovereign power.

Reflection

> A mind all logic is like a knife all blade. It makes the hand bleed that uses it. (Tagore 1917, 51)

The following theoretical reflections did not prefigure the media art project described above. Rather, it was only after experimenting with Gaussian splatting techniques and an impulsive application of them to documentation of tense political events that these concepts began to emerge. This processing technique rendered Donald Trump's body in isolation, smearing those around him into a cacophony of barely intelligible fragments. As we investigated this phenomenon, a new perspective on the nature of technical images began to emerge. Recalling Vilém Flusser's 1985 text *Into the Universe of Technical Images*, as well as Harun Farocki's concept of the operational image, we excavate Gaussian splatting and how it renders the body to arrive at a dividuated conception of contemporary sovereignty. In our reading, Trump's church-walk is the obverse of two historical events intended to reinscribe the authority of sovereign rulers and their respective nation(state)s: the executions of Damiens the regicide by Louis XV in 1757 and Mansur al-Hallaj by al-Muqtadir bi'Llāh in 922. These brutal killings involved performative torture and dismemberment, effectuating a kind of dimensional transformation in themselves. What we find is that dimensional transformations simultaneously rely on and challenge ground truths, which implicitly claim to be empirical referents against which reference images can be judged for their use-value. When the ground truth becomes alienated from any referent, as is becoming the case for cutting-edge single-image Gaussian splatting techniques, it reveals something about sovereignty and the body prefigured by the phenomenology of Maurice Merleau-Ponty, Foucault's theories on modern society, Deleuze's concepts of dividuation and control, and the poetic mysticism of al-Hallaj.

Our argument rests on the claim that ground truths rely on the body as the foundation for empirical knowledge, rather than any common-sense notion of an objective reality 'out there'. Following Maurice Merleau-Ponty's phenomenology, we take it for granted that the body is the proper subject of perception (2006, 239) and, as such, is itself always-partially-invisual in two ways: in terms of 1) its occluded surfaces inaccessible at any given time to the senses, and of 2) its virtual surfaces that lie beyond the capacity of the senses entirely. As the subject of perception, the body is the basis upon which we attempt to travel across the tenuous boundary between *allocentric* (other-centered) and *egocentric* (self-centered) space. This is analogous to the way modern cars can composite sensor data to present a convincing overhead view

of the vehicle on a screen when entering a parking space. Each surface is measured, blindly, by its respective sensor, such that it can realize the possibility of an allocentric view of the car from a projected elsewhere. This conforms to Flusser's definition of a technical image, which he describes as "a blindly realized possibility, something invisible that has blindly become visible" (2011, 16). Following this view, we argue that the body is, in fact, a technical image. It is a dividuated subject composited and controlled through isolating its properties and relations through sensory apparatus.

To understand this, we must clarify that the view from an allocentric perspective is not an authoritative, generalized view from nowhere. Rather, it is the view provided by the body as an image, augmented by assumptions about all its occluded and virtual surfaces. We are never able to access all such surfaces through our senses and must, therefore, compose our experience into an allocentric view of the flesh we inhabit. We 'see' ourselves as if we were another. The manifestation of this in technical images is reflective of perceptual processes that humans extend through technical means, such as rulers, cameras, total stations, LiDAR, GPS/GNSS, etc. Human surveyors may have confirmed grainy NASA satellite imagery through measurements using such tools 'on the ground', but their own bodies-as-images were always the proper subjects of their perception, and thus just as much the basis of their measurement procedures as their tools. The ground truth was, in fact, the body, and the body already operates as an image. Merleau-Ponty prefigures our argument, simply calling it the 'body-image' in *Phenomenology of Perception* (2006, 112). Crucially, he elaborates how the apparent unity of the body-image is predicated upon our inability to perceptually access bodily space, which "can be distinguished from external space and envelop its parts instead of spreading them out, because it is the darkness needed in the theatre to show up the performance" (2006, 115). It is in the invisuality of bodily spaces that the body-image is formed, which we claim are its virtual and occluded surfaces.

Three-dimensional Gaussian splatting (3DGS) techniques such as Objects Models, Novel View Synthesis, Video Generation, SplatterImage, LatentSplat, CAT3D, DFM, and Variational AutoReconstructor, are algorithmic models used in software that render occluded and virtual surfaces as dimensional transformations. 2-dimensional images by their very nature both occlude and suggest invisual surfaces of their referents, precisely by being single surfaces that cannot be rotated. 3DGS transforms these images into rotatable 3-dimensional models and environments using Gaussian distributions, stochastic mathematics, covariant matrices, the Jacobian, rasterization, and optimization techniques derived by training models on target images. Recent research in this field has yielded denoising diffusion models that can generate novel 3-dimensional views of occluded and, we argue, virtual surfaces from single 2-dimensional images whose only ground truths are other 2-dimensional photographic images that approximate those novel views (Liao et al. 2025, 6). Rather than empirical measurements taken with the extended apparatus of the human body, the target image has now be-

come the ground truth. The speculative capacity of processes like Liao et al.'s Variational AutoReconstructor (2025) makes the ground truth redundant insofar as it is no longer the basis for verifying the use-value of an image, but its goal. This is, quite simply, an attempt to produce truth.

And yet, as we have explained, the basis for ground truths was already the image—namely, the body-image. In this way, advanced 3DGS is not so much a radical departure from other dimensional transformations like scale measurement and photogrammetry, whose ground truths are empirical data measured on the ground using measurement tools and ground control points. Rather, it dispenses with the tenuous idea that the referent was ever an objective externality in the first place, rather than the body-as-technical-image. In 3DGS, the ground truth is the 2D target image and the referent is functionally irrelevant.

The Fear of Death

Writing for INC Zine in 2022, Nima Bahrehmand articulated a concept of the restless image, which occurs when

> ...the whole apparatus—body and sensor—is fragile and anxious, causing slips of image. Restless Image demonstrates the friction between the body and the sensor... (Bahrehmand 2022, 60)

This idea echoes Vilém Flusser's notion that "not only the gesture but also the intention of the photographer is a function of the apparatus" (2011, 20). The whole apparatus involves both the sensor and the operating body, from which we include both gestures (i.e., pressing the shutter button on a camera) as well as the decision to record anything at all. As Flusser says, these elements are *functions*, rather than external entities issuing commands to *call* functions. The restless image, then, is the result of a breakdown in the coherence of these functions as they relate to the whole apparatus.

Without the body, the sensor becomes a dismembered organ. The sensor is to the body as a finger is to a hand, and as a handle is to a knife. The restless image is, therefore, a sort of partial dismemberment. It slips, slides, and grinds against itself causing friction (pain). It is a dislocation of the joint. A knife that wobbles in its handle.

> A photographic image is a cut, a section through the bundle of light rays reflected off objects in a circumscribed space. Photography reproduces the three dimensional object on a flat plane, based on the laws of projective geometry. (Farocki 2013, 156)

In his text "Reality Would Have to Begin", Harun Farocki, explains that photography is a dimensional transformation borne out of the fear of death. He describes how in 1858, after a close brush with death while measuring a cathedral façade, Albrecht Meydenbauer developed tech-

niques of scale measurement. Meydenbauer recounts the experience as something felt deeply in the body:

> In the nick of time I grabbed the curved edge of an arch with my right hand, and with my left foot I kicked the basket far into the air; the counteraction sufficed to push my body into the opening and I was saved ... As I came down, the thought occurred to me: is it not possible to replace measurement by hand by the reversal of that perspectival seeing which is captured in a photographic image? (qtd. in Farocki 2013, 156)

Farocki extrapolates this deferral of physical vulnerability to World War II aerial spy photography, demonstrating how the images generated were unable to properly see the genocide that they captured (2013, 161–62). Farocki went on to coin the term 'operational image' in his video installation series *Eye/Machine* (2001), which deals with contemporary aerial images that had now become fully operationalized. They are no longer images with a social goal that represent objects, but images that operations are performed upon. The stated referents of those images may die in missile attacks, but they are not necessary for the operation performed. The operational image allows for a deferral of the deferral of physical vulnerability. In deferring death, the body-image becomes an operational image. Dimensional transformations may start as a preservational impulse that arises from the fear of death, but they end when that death is deferred onto others. The body conducting the measurement avoids death, but that death is still owed.

When the body-image in question is that of a sovereign, its operations take on the complex dimensionality of a nation(state). Ground truths, in this case, are measured by a collective body that is enclosed by the sovereign. Rather than deferring death onto foreign externalities, violence is inflicted upon internal aberrancies that threaten sovereign power.

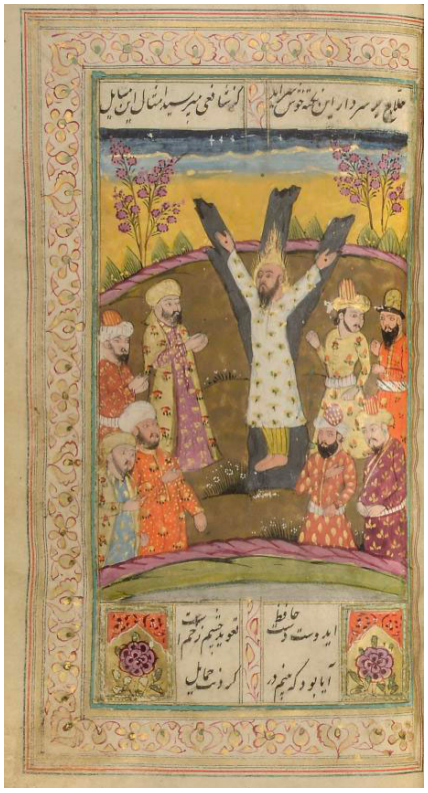


Fig. 3. Manuscript illustration of Mansur al-Hallaj's execution.

The Sovereign Body

> There is nothing inside my cloak except God.
> (al-Hallaj qtd. in Smith 2023, 8)

Husayn Mansur al-Hallaj lived from 859–922 and was a Persian Sufi Perfect Master (*Qutub*) who became infamous for what the Abbasid rulers under Caliph al-Muqtadir bi'Llāh considered self-proclaimed divinity when he uttered the phrase *Ana al-Haqq*, or I am the [Absolute] Truth. He was denounced by his former mentor, Junaid, who said he should be put to death because his utterances could not be reasonably explained (Attar qtd. in Field 1910, 74). Eventually, al-Hallaj was executed (Fig. 3) for "a theological error threatening the security of the state" (Smith 2023, 8). It is reported by Fariduddin Attar in his *Tazkirat-ul-Aulia* that he was publicly tortured, crucified, had his hands and feet cut off, his eyes gouged out, and his tongue cut out, and, finally, was beheaded and burned (qtd. in Field 1910, 76–78).

To help explain why such brutality is necessary, we turn to Foucault's discussion of Robert-François Damiens. He was the last to be punished under the old French laws against regicide for his attempt on the life of King Louis XV. This involved his flesh being torn from his body with red-hot pincers, his right hand being burned with sulfur, and molten lead with a mixture of boiling oil, resin, wax, and sulfur poured into his wounds. Then, he was drawn and quartered by horses and burned to ashes, which were scattered in the wind (Foucault 1977, 3).

In their analysis, Gubrium and Holstein write that "the spectacle of torture was an event whose political culture was informed by a sense of the seamless relations among the body of the king" and that "Damiens was conceived literally…as a subject of the king; his body and soul were inseparable extensions of the crown. An assault on the body of the king had to be attacked in turn, as a red-hot iron might be used to cauterize a festering wound" (Gubrium and Holstein 2002, 6). This recalls how the body is the subject of perception and shows how neither of these executions are examples of kings attacking their subjects as individuals, but of rulers excising some part of their own sovereign bodies in futile attempts to maintain the health of their nations.

Louis XV's reign was not successful. His decadence and mismanagement were catalysts for French decline, both financially and reputationally. Interestingly, al-Muqtadir's reign was similarly fraught. His revolving door of viziers led to the depletion of the Abbasid treasury, and entire lands were lost to rivals, including the capture of Mecca by the Qarmatians in 929. Both rulers resorted to brutal demonstrations of their power and sought to isolate the various properties and relations of their heretical and regicidal subjects through dismemberment, enacting a dimensional transformation from higher to lower through the total annihilation of their 3-dimensional bodies into ashes.

However, as Deleuze writes in his *Postscript on Societies of Control*, the isolation of the properties and relations of a subject "in no way attests to individuation—as they say—but substitutes for the individual or numerical body the code of a 'dividual' material to be controlled" (1992). The universe of technical images relies on the isolation of properties and relations that, simply in *being*, belie any claim the supposed-individual attempts to make on their own body as a coherent historical process. Coherence, in this sense, is not an ontic quality of the individual, but an emergent epistemology of individuation that relies on a dimensional transformation—in this case, an image that is transformed from a 2-dimensional historical process plotted as a series of spatiotemporal claims through storytelling (a kind of splatting with covariant variables) that blindly actualizes occluded and virtual surfaces to effectuate a new apparent 3-dimensionality. Both al-Hallaj and Damiens are so dangerous to sovereignty because they reveal the dividuality of the sovereign as a function of control, rather than an entity that calls the function using an external command. For us, it becomes a question of sovereign bodily autonomy. Such bodily autonomy is never possible because the body is already an image and the image is already an operational image, not a self-same identity. When Damiens is posited as a festering wound and

al-Hallaj's theological errors are considered a threat to the state, we see that the sovereign body is not capable of total, rational control of itself. The sovereign and its subjects are not constitutive of an individual nation or state but are part of a body that is only ever accessible as an image. In being an image, it necessarily occludes and virtualizes any other surface that might otherwise have been sensible, suffering the same vulnerability to dividuation as the body-image of the subject. Indeed, we argue that the subject *inherits* this property from its sovereign, rather than being a quality of individuality that aggregates to dividuality in sovereignty. This type of restless image comes from the decoherence of the sovereign body-image that dislocates it from its subjects, who are in turn dislocated from their recording tools, resulting in anxious sensors.

Now, al-Muqtadir bi'Llāh's treatment of al-Hallaj, as well as Louis XV's of Damiens, seems, in fact, more rational than it may have first appeared. A body-image is managed by isolating its properties and relations, and in compositing their surfaces, either reinforcing them or suppressing them to produce coherence. This includes not only ideas, but the subjects that express them. When the functionaries of a control society fail to produce coherence, the sovereign is dislocated from its subject, producing a restless image. By enacting a dimensional transformation on their victims, the king and the caliph were striving to reestablish that coherence. Splatting restless images speculates on the occluded virtual surfaces that decohere in the C-SPAN footage of Trump's church walk, revealing them as unrevealable in a nondisconcealment. Coherence, in the way that sovereign power requires it, is totally reliant on the invisuality of its operational body-image. The truth as *aletheia* is that which is unconcealed, and yet, the truth is all that is concealed by al-Hallaj's cloak. This is the darkness of bodily space in the theater of control. When al-Hallaj proclaimed, "I Am the Truth", he gave himself completely to the community and to God, undermining sovereign power by illuminating that darkness and allowing himself to decohere. Rather than a dimensional transformation that defers death, his was a dimensional transformation *for* death. From his apparent 3-dimensionality as a living body, he was transformed into text alone. Indeed, it is said that when his ashes were scattered into the Tigris river, they took the shape of the Arabic characters أنا الحَق – I Am the Truth (Smith 2023, 8).

Online installation version:
https://vimeo.com/1159721402/c67eb209dd?share=copy&fl=sv&fe=ci

Documentation of the physical installation version:
https://vimeo.com/1164854697/d092f5228a?fl=pl&fe=sh

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I Think About the Roman Empire Every Day



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I Think About the Roman Empire Every Day is a satirical, Latin-language, media-archaeological poetry film that responds to the viral 2023 social media trend revealing an everyday male preoccupation with the Roman Empire. While the meme circles around humorous gender norms, the work traces its deeper cultural currents: Rome as a mythic ideal in certain, often more conservative spaces, but also as an ongoing civilizational substrate shaping basically everything from law, architecture, social norms to collective imagination. Combining machinima, TikTok dance video performance, and TEMU readymades, the project juxtaposes playful digital reenactment with critical reflection. Using 3D scans of Roman artefacts, AI-generated sequences hovering at the edge of so-called "AI slop", and performative elements, it questions what it means to live in the successor states of empire, how historical power structures subtly endure, how an imagined Rome shaped virtually all of European geopolitics starting with Charlemagne, how imperialism and cultural narratives, ideals of civilization, and political visions still pivot around Rome. It examines how Rome's legacy is continually rewritten—romanticized, weaponized, or deconstructed—depending on the ideological context. After all, the artist, too, thinks about the Roman Empire every day.

Keywords: Meme Culture, Machinima, AI Art, Media Archaeology, TikTok Performance, Readymades.

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Fig. 1. Screenshot of *I Think About the Roman Empire Every Day.*

I Think About the Roman Empire Every Day

Media Archaeology, Meme Culture, and the Afterlife of Empire

I Think About the Roman Empire Every Day is a satirical, Latin-language media-archaeological poetry film that responds to a viral social media phenomenon from 2023: the revelation, popularized through TikTok and Twitter, that a large number of men claim to think about the Roman Empire on a near-daily basis. While the meme circulated primarily as a humorous commentary on gendered preoccupations and online masculinity, it also inadvertently exposed a deeper and more persistent cultural structure: Rome as a mythic reference point, an ideological reservoir, and an enduring symbolic architecture underpinning Western notions of civilization, power, and historical continuity. Rather than treating the meme only as a fleeting internet joke, the project approaches it as a symptomatic cultural artefact, as an emanation of a subconscious cultural undercurrent manifesting itself through modern-day folklore: internet and meme culture. The question is not whether men actually think about Rome every day, but why *Rome*, specifically, remains such a stable object of fascination within contemporary imaginaries. What cultural work does "Rome" perform when it reappears in digital vernaculars? What forms of identification, authority, nostalgia, and legitimacy are being rehearsed, consciously or unconsciously, through this invocation? And how does this obsession intersect with present-day ideological formations, particularly in civilizationalist discourses?

Rome as Meme, Rome as Structure

The Roman Empire occupies a peculiar dual position: it is at once a distant historical entity and an ever-present conceptual framework. In online spaces, Rome often functions as shorthand for order, masculinity, hierarchy, endurance, and "lost greatness." The meme economy

condenses these associations into an easily shareable format, where humour masks ideology and repetition normalizes myth. The project situates this phenomenon within a broader lineage of what could be described as the afterlives of empire: the persistence of imperial logics beyond their formal political demise. Rome is not merely remembered; it is continually re-performed. Its imagery, legal concepts, architectural forms, and political metaphors permeate modern Europe and its successor states. From neoclassical government buildings to legal systems grounded in Roman law, from imperial symbolism in fascist aesthetics to contemporary far-right invocations of "Western civilization," Rome remains an active semiotic resource. Historically, this continuity was explicitly formalized during the reign of Charlemagne, whose coronation in 800 CE marked a deliberate attempt to revive Roman imperial authority in Christianized form, establishing a model of *translatio imperii* that would shape European geopolitics for centuries. The film argues that the meme's resonance cannot be understood without acknowledging this longue durée of imperial continuity. Rome is not simply a past empire; it is a recurring template through which power is imagined, legitimized, and aestheticized.

Media Archaeology and Digital Reenactment

Methodologically, *I Think About the Roman Empire Every Day* draws on media-archaeological approaches that understand contemporary media not as a rupture from history, but as a recursive system in which older forms, logics, and fantasies reappear in new technological guises. The project treats TikTok, AI image generators, 3D scanning technologies, and machinima not as neutral tools, but as sites where historical imaginaries are actively recomposed.

The film combines several visual and performative strategies:

– **Machinima sequences** constructed from 3D scans of Roman artefacts, set in space.

– **AI-generated sequences** treating AI image and video generators as access points to the collective subconscious, not shying away from "AI slop" aesthetics.

– **TikTok dance performances**, using the language of text overlays in social media-short form content, deliberately anachronistic, staged against Roman iconography, emphasizing the collision between algorithmic attention economies and imperial spectacle.

– **3D scans of Roman artefacts**, self-sourced from museum collections and archaeological sites, recontextualized as manipulable digital objects rather than untouchable relics.

– **TEMU readymades**, cheap mass-produced pseudo-Roman objects, foregrounding the commodification and aesthetic flattening of classical heritage.

Through these strategies, the project stages Rome as a looped simulation, less a stable historical referent than a modular visual language endlessly recombined across platforms.



Fig. 2. Screenshot of *I Think About the Roman Empire Every Day.*

Latin as Affective Interface

The choice to work with Latin as the primary language of the film is both satirical and critical. Latin operates here not as a vehicle of historical authenticity, but as an affective interface. Stripped of everyday intelligibility for most contemporary audiences, it becomes a sound-based marker of authority, antiquity, and abstraction. The language functions similarly to how "Latin-ness" is deployed in legal terminology, mottos, academic rituals, and ecclesiastical contexts: it signals continuity, seriousness, and legitimacy without necessarily communicating semantic content. By using Latin in a poetic manner and taking the perspective of someone telling a future of space colonization through the female orator's female descendants, the film destabilizes this authority and adds the element of a decidedly female will to power. The language becomes performative rather than informative, exposing how much of Rome's power today resides not in concrete historical knowledge, but in atmosphere, tone, and symbolic weight.

Empire, Masculinity, and Algorithmic Desire

The viral meme that inspired the project is deeply entangled with questions of masculinity. Online discussions often frame men's fascination with Rome as harmless nerdiness or historical curiosity. However, the film proposes that this fixation also reflects contemporary crises of identity, authority, and belonging. In a moment where traditional models of masculinity are contested, Rome appears as a compensatory fantasy: a world imagined as orderly, hierarchical, and unambiguous. Digital platforms amplify this dynamic. Algorithms reward content that resonates emotionally and ideologically, allowing imperial nostalgia to circulate alongside fitness content, "trad" aesthetics, military history, and civilizational discourse. The project situates the Roman meme within this broader ecology of algorithmic desire, where historical myths are repackaged as lifestyle signifiers. Rather than directly condemning this phenomenon, the film adopts satire and over-identification as critical strategies. By exaggerating Rome's omnipresence, by insisting that ev-

eryone, including the filmmaker, thinks about the Roman Empire every day, the work reveals the absurdity and pervasiveness of the myth.

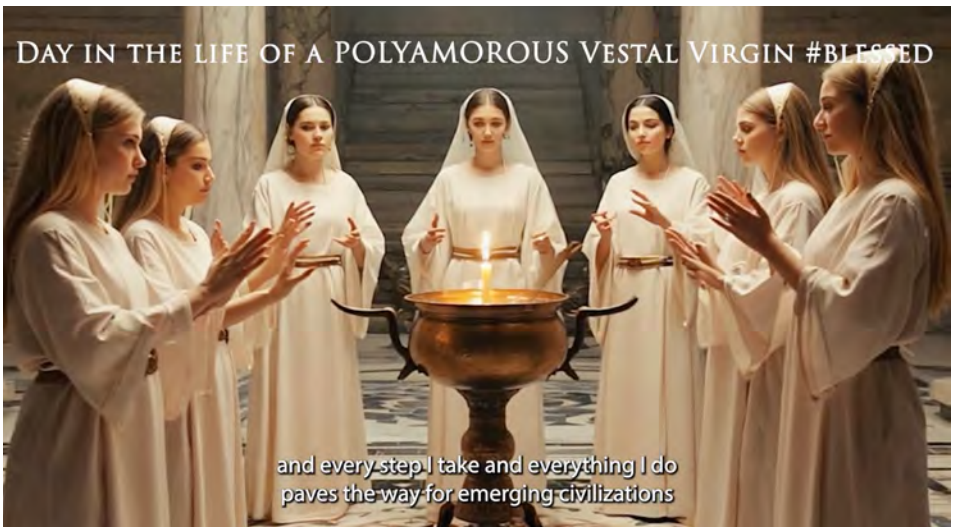


Fig. 3. Screenshot of *I Think About the Roman Empire Every Day.*

Continuity, Control, and the Successor States of Empire

A central concern of the project is what it means to live in the successor states of empire. Europe presents itself as post-imperial, progressive, and modern, yet its political structures, borders, and cultural hierarchies remain deeply shaped by imperial histories. Of course, this is complex and not necessarily questionable *per se*. Rome serves as a foundational myth through which these continuities are naturalized. The film suggests that imperial power does not primarily persist through overt domination, but through narrative continuity. By repeatedly evoking themselves as inheritors of Rome, contemporary political imaginaries position themselves as the rightful custodians of civilization—not always legitimately. In this sense, *I Think About the Roman Empire Every Day* is not only concerned with Rome as a historical object, but also with Rome as a technology of control, a projection canvas, and a narrative infrastructure that organizes time, legitimacy, and identity.

Artistic Positioning and Reflexivity

Importantly, the work does not position the artist outside of these structures. The concluding gesture, “After all, the filmmaker, too, thinks about the Roman Empire every day”, is not merely ironic. It acknowledges complicity. To engage critically with Rome is already to participate in its ongoing life. The project thus operates as a reflexive loop: a critique that recognizes its own entanglement in the systems it examines. This reflexivity aligns the work with contemporary artistic research practices that foreground situated knowledge, partiality, and performative inquiry. Rather than offering definitive answers, the film proposes a space of tension between fascination and critique, play and analysis, immersion and distance.

Conclusion

I Think About the Roman Empire Every Day treats a viral meme as an entry point into a deeper investigation of cultural memory, media archaeology, and imperial afterlives. By mobilizing digital reenactment, performative strategies, and poetic language, the project exposes how Rome continues to function as a structuring myth within contemporary algorithmic cultures. The work suggests that the persistence of empire is not merely a matter of history, but of repetition, of images, narratives, affects, and platforms. In this sense, thinking about the Roman Empire every day is not an eccentric habit, but a condition of modernity itself.

Link to Poetry Film: https://vimeo.com/1091433500/03e1fa8ea6



Fig. 4. Screenshot of *I Think About the Roman Empire Every Day.*

Poem

and in the future
when we have branched out to the stars
our cartographers will have to develop
new projections for their maps
we haven't conquered the blue sky yet
and the dust I will turn into
will travel in cosmic clouds
every empire falls eventually
but no empire ever really dies
the way people do

and I am sure that future archaeologists
will find my forgotten bones
they will try to reconstruct my story
they will clone me and
will get everything wrong
they will not remember the colour of my eyes
they will not remember the way I laughed
they will make up stories of someone
who was alive before we went to the stars

and every step I take
and everything I do
paves the way for emerging civilizations
of new peoples yet to come
so many of them will be born
with my daughter's mitochondria
they will fight and kill each other
some of my descendants will be
victims and rapists
some will be
saints and murderers
some will see new planets
some will scorch the earth

all the traces of extinguished fires
that taint the soil for millennia
maybe I will have set fire here on purpose
to lead them away from buried treasures
but I will leave almost nothing material
everything in the ether
everything else decayed
I will haunt empire

et olim, cum ad astra ramos extendimus
nostri mappae pictores
novas figurationes orbis fingent
nondum vicimus caelum caeruleum
atque pulvis, in quem redeam
vagabitur inter nubes aetheris
cuncta imperia tandem ruunt
sed nullum vere perit
sicut perit homo

scio enim,
futuros reperturos esse meos cineres
archaeologos alienos
temptabunt vitam meam componere
me referent imaginibus falsis
colorem oculorum meorum non noverint
risum meum non audierint
fingent fabulas
de femina viva
quae ante astra visa est

et omnis gressus meus, omnis actus
viam sternet gentibus venturis
populis nondum natis
ex mitochondriis filiae meae
plures oriantur
bellabunt, interficient
ex stirpe mea erunt
alii sancti, alii latrones
quidam victimae, quidam stupratores
quidam novas terras videbunt
quidam hanc terram comburent

vestigia ignium extinctorum
quae per saecula terras maculant
fortasse ignem ipse posui
ut thesauros absconditos fallerem
at nihil fere relinquens
materiam sub sole
totum in aethere evanescam
cetera marcescent
imperium ipse infestabo

Me, or 6D 65



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Me, or 6D 65 reinterprets Nam June Paik's *TV Buddha* (1974) for the digital age, replacing the analogue camera and monitor with a digital camera and a raw data visualisation. Where Paik's Buddha confronts its mediated image, this work exposes the ontological rupture of digital mediation: the Buddha gazes not at a reflection but at the encoded data that constitutes its digital existence. The installation critiques how digital technologies reduce reality to quantifiable abstractions, severing the phenomenological connection between self and image. By revealing the logico-quantitative underpinnings of digital representation, *Me, or 6D 65* invites reflection on the true causes of alienation inherent in our increasingly data-driven world.

Keywords: Media, Analogue vs. Digital, Paik, Terminal, Self.

DOI 10.34626/2026_xcoax_031

Artist Statement: Me, or 6D 65

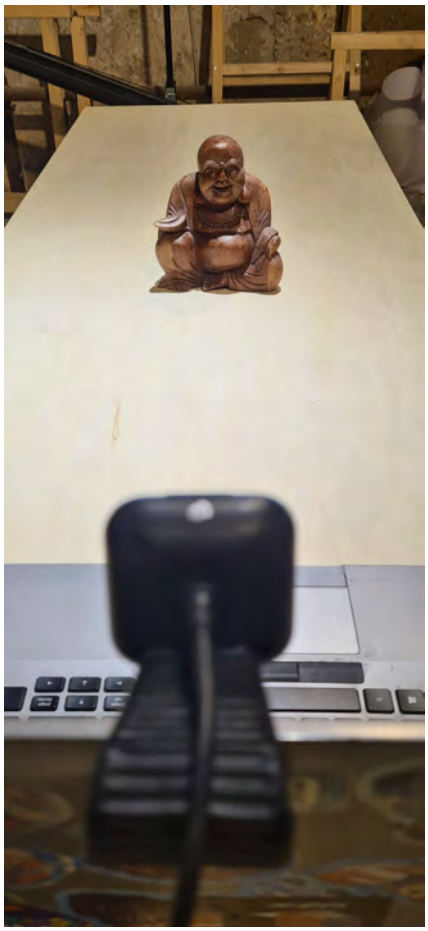
Me, or 6D 65 is a contemporary reinterpretation of Nam June Paik's seminal 1974 installation, *TV Buddha* (Paik 1974). In Paik's work, a Buddha statue gazes at its own image, captured by a closed-circuit analogue camera and displayed on a CRT television monitor. The piece is a profound meditation on the intersection of Eastern spirituality and Western technological culture, as well as the relationship between self and media. The Buddha, a symbol of enlightenment and introspection, confronts not a mirror but a technologically mediated reflection—an image of itself filtered through the apparatus of a television. Paik's installation invites viewers to recognise themselves in the Buddha's position: we, too, see ourselves through the lens of technology, and in doing so, we experience a diminished, mediated version of our own existence. As Marshall McLuhan famously declared, "the medium is the message" (1964)—the technological infrastructure that transmits our image shapes our perception far more than the content of the image itself. The Buddha's gaze is not directed at a true reflection but at a representation, one that is inherently reduced by the medium's limitations.

Paik's *TV Buddha* remains deeply resonant today, perhaps even more so in an era dominated by digital technology. When we look at the monitor displaying the Buddha's image, we understand that it is not the Buddha *per se* but a technologically constructed version of it. This mediation is not neutral; it alters our relationship with ourselves and the world. The Buddha's contemplation of its own mediated image becomes a metaphor for our own alienation in the age of mass media—a reminder that our self-perception is increasingly shaped by the tools we use to capture and represent reality.

Yet, while Paik's work critiques the mediation of analogue technology, *Me, or 6D 65* pushes this critique further by exposing the fundamental differences between analogue and digital mediation. My installation replaces the analogue camera and television with a digital camera and the raw data it captures. The Buddha no longer gazes at its own image on a screen. Instead, it confronts the raw data produced by the digital camera and displayed in an endless string in a Terminal window—a stream of numbers, measurements, and encoded information that constitute its existence within the digital realm. This shift is not merely technical; it is ontological. It reveals how digital technology does not just mediate our image but redefines our very being in logico-quantitative terms.

The Ontological Rupture: Analogue vs. Digital Mediation

To fully grasp the significance of *Me, or 6D 65*, one must understand the distinct mechanics of analogue and digital technologies—mechanics that produce radically different forms of mediation (Torre 2021).



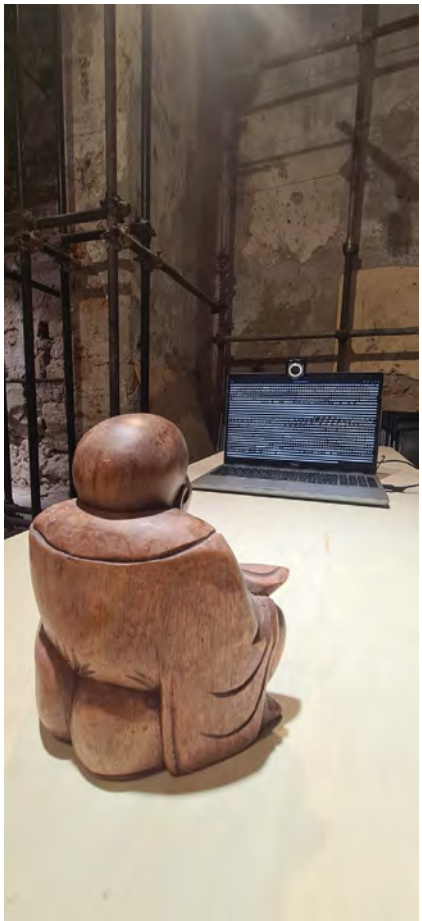


Fig. 1 and 2. *Me, or 6D 65* installation views.

In Paik's *TV Buddha*, the analogue camera captures the light reflecting off the Buddha statue and converts it into electrical voltages. These voltages are then transmitted to a cathode-ray tube (CRT) television, which reconstructs the image on its screen. The process is one of seamless transformation: light is converted into electrical energy, which is then converted back into light. The image on the screen is a direct, continuous representation of the Buddha, albeit mediated by the technological apparatus. There is no inherent separation between the Buddha and its image; the energy flows from one form to another, preserving a phenomenological unity between the object and its representation.

This analogue process is uncountable *a priori*—it does not require measurement or quantification to function. The electrical signals in the circuit exist as a continuous flow, and while they can be measured *after the fact* (e.g., by analysing the voltage levels), such measurement is not necessary for the system to operate. The image on the screen is an extension of the Buddha's physical presence, transformed but not fundamentally altered in its essence. In this sense, the analogue medium operates much like a spiritual medium in the traditional sense: it channels energy from one realm to another without breaking the connection between the source and its representation. This is why, for example, some have sought to find "trapped spirits" in the static noise of analogue television (and not in digital ones)—because the medium itself is perceived as a conduit for energy, a bridge between the physical and the ethereal.

The analogue medium, then, is not just a tool but a participant in the process of perception. It does not impose a rigid structure on reality; instead, it allows reality to flow through it, transforming but not fragmenting the relationship between the self and its image. The static noise of an analogue TV, for example, is not an error but a manifestation of the medium's engagement with its "invisible surroundings"—a reminder that the image is part of a larger, uninterrupted continuum of energy.

Me, or 6D 65 disrupts this continuity. In this installation, the digital camera does not merely capture light; it encodes it. The light reflecting off the Buddha is measured, quantified, and packaged into data. This data is not an image in itself; it is a mathematical representation of the Buddha, a translation of its physical presence into a logico-quantitative structure.

Unlike the analogue process, digital mediation must be countable *a priori*—that is, only that which can be counted can enter the digital realm. The camera does not simply transform light into an image; it breaks the light into countable units, assigning numerical values to the energy recorded by each light-sensitive photodiodes before sending those to the screen to reconstruct the image. But here's the crucial point: the image is incidental. The data produced by the camera could just as easily be used to generate sound, control a motor, or feed into an algorithm. The Buddha's image is not a necessary outcome of the data; it is merely one possible interpretation among infinite others. The digital camera does not capture the Buddha's essence—it captures a measurement of it.

This distinction is at the heart of *Me, or 6D 65*. The Buddha is not looking at itself but at the data that represents it. Its image is no longer a

seamless extension of its physical form but a construction, a product of the camera's ability to count and categorize. In the digital realm, the Buddha's existence is reduced to numbers.

In the analogue world, the medium is a conduit for energy, a bridge between the physical and the represented. But in the digital world, the medium is something far more conservative and rigid: it is a mathematical framework, a system of counting and measurement that stands between us and reality. Where analogue technology preserves a phenomenological connection between the self and its image, digital technology severs that connection, replacing it with a representational system grounded in abstraction.

This shift has profound implications for how we understand ourselves in a digital world. When we look at a digital image of ourselves, we are not seeing a reflection but a reconstruction—one that is fundamentally shaped by the limits and biases of the counting process. Our faces, our voices, our very identities are translated into data points. We have become numbers, and our relationship with reality is mediated by the mathematical logic governing digital systems.

This is the stark, sad truth of our existence in the digital age. The Buddha's contemplation of its own data is a metaphor for our own alienation from our physical selves.

We are no longer the subjects of our own perception; we are objects of measurement, defined by the parameters of the machines that capture us.

The digital self is not a reflection but a *simulacrum*, a copy without an original, a representation without a source.

Our identities are no longer our own; they are constructed by the machines that count us.

This work can be accessed at:
https://giuseppetorre.gitlab.io/meor6D65.html

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Gaitless: An Interactive Dance Space for Outweirding the Machine



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Gaitless is a participatory dance performance and interactive installation that explores anti-surveillance and anti-AI tactics through choreography. The project was inspired by a news story in which bank robbers allegedly bypassed AI-powered security cameras by rolling instead of walking, confusing systems trained to recognize human gait. In this case, evasion became a creative act. Instead of trying to outsmart artificial intelligence, *Gaitless* proposes a different approach: *out-weirding* the machine. Participants enter a shared movement space equipped with an Azure Kinect sensor. Rolling, crawling, and unstable erratic movements form the basic material of what seems to become a dance; a choreography that emerges from evading the machine's gaze. Through this constraint, the piece exposes the narrow ideas of "the human" embedded in machine vision; at the same time, it highlights human strangeness, weirdness, improvisation, and play. Drawing on traditions of aesthetic evasion, camouflage, and tactical art, *Gaitless* treats choreography as an embodied critique of algorithmic surveillance. This paper reflects on the project as an artistic research practice and considers participatory choreography as a way of practicing deliberate unreadability within contemporary regimes of algorithmic vision.

Keywords: Participatory Performance, Choreography, Anti-Surveillance, Artificial Intelligence, Gait Recognition, Embodied Interaction, Tactical Aesthetics.

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Fig. 1. *Gaitless* performance at the CNDB in Bucharest, Romania. Photo: CNDB.

Moving Against the Algorithm

> The entertainment industry is, in any conceivable sense of the word, an abuse of army equipment. (Kittler 1986)

A few years ago, we came across a peculiar news story. A group of bank robbers robbed a bank by fooling surveillance cameras powered by artificial intelligence. These cameras were programmed to recognize human motions, human movements, human gaits. But the robbers did not walk like humans. Robbers rolled, robbers crawled, robbers moved strangely, and outwitted the AI. They didn't outsmart the AI, they *out-weirded* it.

This story became the beginning point for *Gaitless*, our participatory dance performance and interactive installation that treats evasion as a choreographic principle. The performance unfolds in a shared theatrical space where dancers and visitors take turns moving in front of an AI-based tracking system. Their movements are constantly evaluated, and the system's classifications appear as a simple interactive game projected onto the floor.

Gaitless asks the following question: what happens when movement deliberately departs from algorithmic models of the human? Does it create a novel form of dance? In this case, unreadability is not a failure but a goal; it is, in other words, a *feature*, not a bug. Movement thus becomes a site of friction and resistance, where participants explore how small shifts in posture and rhythm can unsettle and bewilder machine perception (Fig.1).

Tactical Aesthetics and Embodied Resistance

There is an interesting historical precedent for aesthetics that emerge from tactics. An example comes from early twentieth-century military

technology. During the First World War, British and U.S. naval forces began painting ships in high-contrast zebra-like patterns of black and white (Fig. 2). These geometric surfaces were meant to confuse enemy perception, especially from German torpedo-equipped U-Boats. Known as *Dazzle camouflage*, the technique aimed to make it difficult for submarine crews to estimate a ship's speed, direction, and distance (Barton 2017). Function followed strategy, but the result was strangely visual and expressive. When Pablo Picasso reportedly encountered Dazzle-painted ships, he said the idea is an example of Cubist aesthetics. Whether apocryphal or not, this anecdote shows that tactical necessity often gives rise to new aesthetic forms.

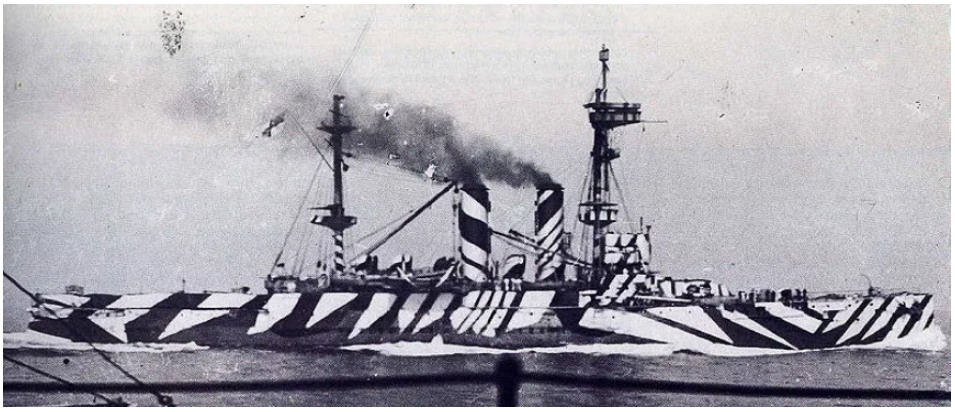


Fig. 2. HMS London. An example of a Dazzle ship. 1918. Photo: The Public Domain Review.

A century later, similar principles reappeared in relation to AI, machine vision, and digital art. In 2010, artist and technologist Adam Harvey initiated *CV Dazzle*, a project that proposes fashion and styling strategies designed to disrupt face recognition algorithms (Harvey 2010). Unlike traditional camouflage, which wants to make human observers invisible, *CV Dazzle* remains completely visible to humans. Bold makeup and asymmetrical hairstyles break the patterns expected by computer vision systems. As with Dazzle ships, style emerges directly from technical resistance.

Our previous project *Tactical Poetics* applied similar logic to language. Developed with artist and researcher Darija Medić, the project explored writing as a counter-surveillance technique, focusing on systems for sentiment analysis and emotion recognition (Medić and Krčadinac 2020). By composing texts that algorithms struggled to classify, but humans could easily interpret, the work exposed the statistical simplifications embedded in natural language processing. Metaphors and allegories have always been, at least in part, a form of strategic encryption of meaning; what makes this novel is the computational aspect of contemporary machine-mediated power. *Tactical Emotion* is, in other words, writing against the machine, recontextualized as poetry. *Gaitless* extends this line of inquiry from makeup and language to the moving body.

In a wider context, *Gaitless* addresses automated surveillance. Recent advances in machine perception show that surveillance no longer operates only through images or language, but increasingly through bodily movement. Research by Preis et al. (2012) demonstrates how depth sensors like the Kinect can identify individuals based solely on how they

walk. Movement becomes a biometric signal translated into abstract data structures. Related artistic works such as Tomo Kihara's *How (not) to get hit by a self-driving car* likewise expose the blind spots and exclusions embedded in AI-based detection systems (Kihara 2023). This expansion of AI into bodily behaviour is inseparable from what Shoshana Zuboff describes as *Surveillance Capitalism* (Zuboff 2019), in which human experience is treated as raw material for prediction and control. Bodily movement becomes another source of behavioural surplus, collected not for the benefit of those who produce it, but to optimize systems of control and profit accumulation.

Gaitless positions itself against this logic by fostering movement that resists classification, turning anti-AI movement into dance. Choreography has long been understood as a way of organizing bodies in space, shaping perception, and producing social meaning. As Susan Leigh Foster writes, movement carries political and relational dimensions beyond formal aesthetics (Foster 2011). In Michel de Certeau's terms (de Certeau 1984), *Gaitless* treats algorithmic vision as a strategic field and develops bodily tactics that inhabit and subvert its logic. Strategies, for de Certeau, belong to institutions that command a proper place–states, planners, corporate platforms–and codify how space, movement, and visibility should be organized, whereas tactics are "arts of the weak" that must "make do" within these imposed structures, seizing occasions and reusing them in unexpected ways.

In *Gaitless*, participants do not step outside machine gaze; they move inside it, exploiting its training on normative human gait by moving in unstable, inefficient ways so that unreadable movement becomes an artistic strategy. These movements tactically escape legibility, using the system's feedback as material for improvisation; movement becomes embodied refusal, and evasion turns into choreographic invention rather than avoidance.

There is a paradox at the core of *Gaitless*. Participants try to appear non-human to an AI system by disrupting their gait; yet in doing so, they show precisely those qualities that make humans different from machines: improvisation, intuition, embodied creativity. To fail recognition is to affirm humanity: to be *human* is to be a *non-human*. The project's informal Serbian slogan captures this dialectic: "ko je čovek, nije čovek, a ko nije, čovek je" ("who is human is not human, and who is not is human"). In this sense, *Gaitless* operates like a choreographic kōan. Gaitless gait. Gateless gate. The attempt to escape classification becomes a way to unexpectedly meet oneself through movement.

Gaitless: System Setup and Technical Development

The live performance unfolds in a shared dance space monitored by an Azure Kinect sensor connected to a computer. Participants' movements are tracked and classified in real time as either *human* or *non-human*. Each participant is given a limited time to perform in front of the system. The goal is simple: to be recognized as non-human.

Success is measured by a threshold. If participants remain unreadable to the system for most of the allotted time, they win. The rewards range from printed artworks to small amounts of cash. The setup is deliberately gamified: the dance space borrows its logic from betting terminals and game interfaces. Time limits and rewards are assigned at random, which turns movement into a playful negotiation with the machine.





Fig. 3 and Fig. 4. *Gaitless* live performance in CNDB, Bucharest, Romania, 2025. Photo: CNDB.

The software for *Gaitless* was developed in TouchDesigner and built around an Azure Kinect Sensor.

The sensor offers real-time skeletal tracking via machine vision and AI. It extracts positional data from key points of the body and creates a skeletal pose if a person is recognized in the current frame. Additionally, a *JointConfidenceLevel* is given for each joint. Our system then evaluates whether a person is recognized or not, based on the current skeletal pose and confidence level. This is determined by the movement veloc-

ity of selected joints, combined with a predefined threshold specifying how many joints must have a high confidence level.

To make the application usable, we could not use the unaltered sensor data, since it often recognized skeletal poses in non-human objects such as a chair, a plant, or a hanging jacket; this would have made consistent operation impossible.

From the perspective of the system, the dancing body is a stream of vectors and confidence values, reduced to measurable patterns that can be classified and evaluated. This technical setup makes visible how contemporary AI systems perceive movement: as abstract data structures.





Fig. 5 and Fig. 6. *Gaitless Bootcamp*, an interactive installation shown at the MODINA exhibition in Düsseldorf, Germany, 2026.

The performance setup includes video projections of the game interface, with a sequence of visual materials, including historical photographs of Dazzle ships. The scenography is further developed through adhesive tape markings on the floor, referencing Dazzle camouflage patterns. These visual elements connect the work to earlier tactical aesthetics and emphasize the political and military genealogy of contemporary AI technologies. Our goal was to create an environment that remains playful and accessible while retaining a clear critical edge. For this reason, each *Gaitless* performance was followed by an open discussion on society and technology.

Alongside the performance, we developed the interactive installation *Gaitless Bootcamp*, which translates the same logic into a self-guided, durational format suited to smaller spaces. After reading a short onboarding text, participants activate the system by pressing a button and entering the space. Once the system starts, the assigned time frame and the possible reward are projected on the floor. Visitors engage directly with the system, rehearsing unreadability through unusual movements. In the latest installation setup (Fig. 5 and 6), the reward consisted of a photograph taken during the participant's movement, as captured by the system's camera. The photograph was printed immediately after the performance time elapsed, provided the participant was not recognized as human (Fig. 7).



Fig. 7. *Gaitless Bootcamp*, participant captured by the system's camera.

From Performance to Installation

Gaitless emerged from a collaboration between a duo from Serbia: digital artist and technologist Uroš Krčadinac, and dancer and choreographer Marko Milić, during their artistic residency in Düsseldorf as part of the MODINA[1] project. The project brought together dancers and media artists to experiment with AI as artistic material (Correia and Primett 2024; 2025). During the residency, the duo worked closely with MIREVI,[2] a Mixed-Reality and Visualization Lab at the University of Applied Sciences Düsseldorf, and with tanzhaus nrw, both partners in the project. Together with Ivana Družetić-Vogel, Patrick Kruse, and Ben Fischer from MIREVI, the concept of *Gaitless* took shape alongside the development of the software system.

The project premiered as a live performance at tanzhaus nrw in Düsseldorf in April 2025. In autumn 2025, the work toured across Central and Eastern Europe, performing in Budapest (hosted by Trafó), Bucharest (at the Iridescent Festival, hosted by the National Centre for Dance Bucharest) (Fig. 4 and Fig. 5), and Ljubljana (as part of CoFestival at Kino Šiška). *Gaitless Bootcamp*, an interactive installation derived from the performance, was developed for the final MODINA exhibition in Düsseldorf.

1. MMODINA: Movement, Digital Intelligence and Interactive Audience. https://modina.eu/
2. MIREVI: Mixed Reality and Visualization. https://mirevi.de/

After the Gait

To demonstrate that being classified as non-human can make one *more human* is not, ultimately, a critique of the system's imperfection. The threshold can always be recalibrated and pushed toward ever more demanding limits; it is, after all, human made. What matters is making the artificiality of this threshold itself palpable. In *Gaitless*, it functions as a line of demarcation between bodies deemed more or less human. But it could just as easily demarcate any other supposedly measurable division: more or less accountable, more or less admissible, more or less life-worthy.

This small, scrutinized performance field reveals how our field of view and our field of action are always conditioned by how we code them—in technical, social, and cultural senses alike. The paradox the system exposes—that the one who appears fully human becomes fully non-human—is ultimately a paradox of terms. Humans stand on both sides of the divide. Humans design the system, define the threshold, and interpret its results. Humans move, humans view, humans judge.

By approaching AI as a condition encountered through the body, *Gaitless* allows this paradox to be felt rather than resolved. After the gait, what remains is a heightened attention to presence. Perhaps this is where resistance begins—in strange small steps, unstable rhythms, in simple acts of moving otherwise.

Acknowledgements. *Gaitless* was developed within the framework of the MODINA project (Movement, Digital Intelligence and Interactive Audience; project number 101099581-CREA-CULT-2022-COOP-2) co-funded by the Creative Europe programme of the EU.

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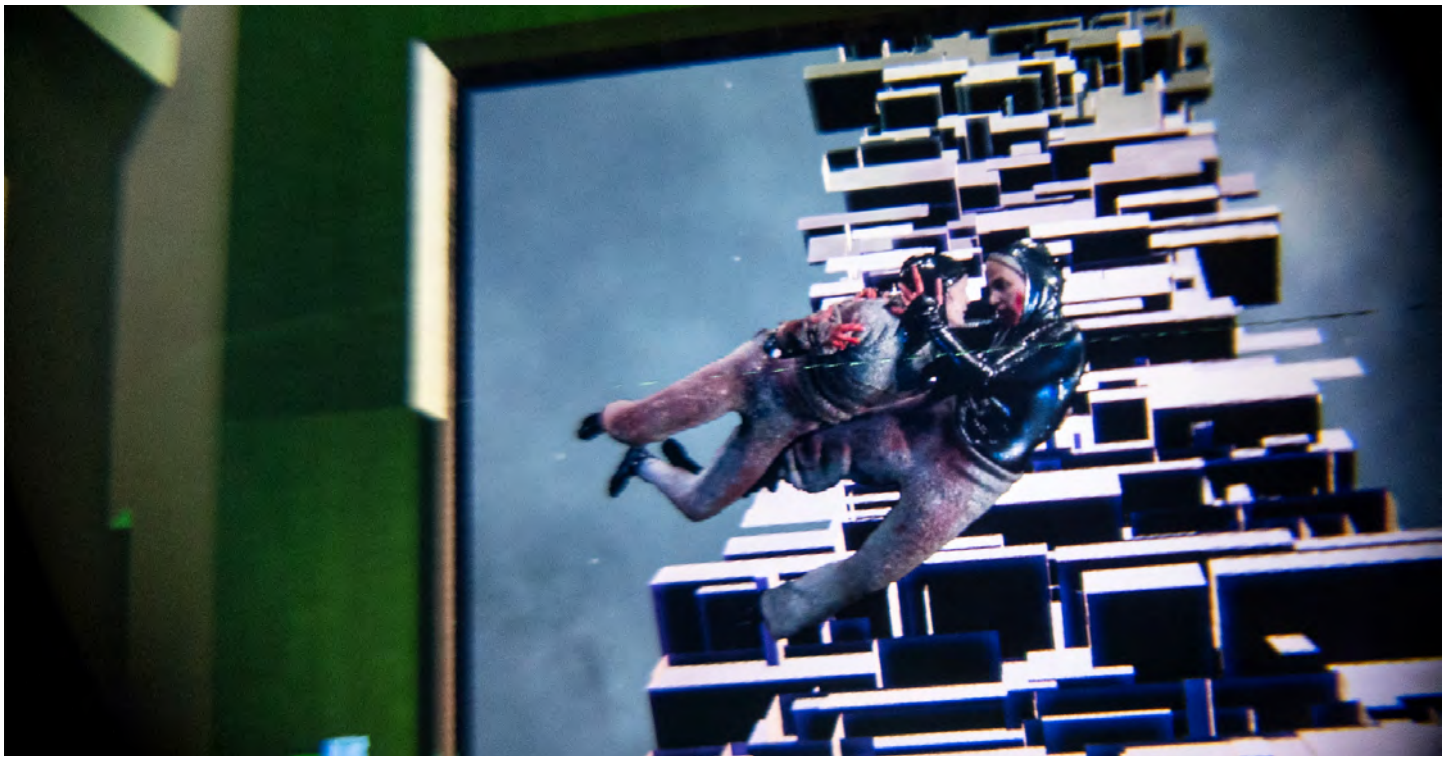
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Antropka Installation: Hybrid Stage Spaces



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This paper presents *Antropka*, a co-located mixed reality (MR) theatre production and its installation-based transformation that investigates how XR technologies can reconfigure rather than replace theatre's fundamental condition of collective liveness. Building on the research framework of the project *Theatre of Extended Realities*, the paper examines MR as a means of intensifying and restructuring theatrical dynamics already inherent to the medium. Through its dramaturgy of systemic control and rupture—staged aboard a generation spaceship governed by an AI—*Antropka* explores contingency at both narrative and perceptual levels. The technical architecture offers a shared hybrid stage space for twenty-five synchronised spectators, counteracting the isolating tendencies of conventional VR. The installation version of the piece translates this complex system into a portable, miniaturised format that inverts spectators' perspective, shifting between external overview and embodied immersion. By moving between model and world, and between distance and co-presence, *Antropka* shows how XR can make the fragility of social and perceptual structures tangible.

Keywords: Extended Reality (XR), Mixed Reality (MR), Theatre, Contingency, Collective Presence, Colocation, Multiplayer VR.

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Theatre as Hybrid Reality

Theatre has always operated within overlapping realities. Through the co-presence of actors, space, and spectators, it generates worlds both real and fictional. Extended reality (XR) technologies therefore do not introduce hybridity into theatre; they intensify and technically reconfigure an already existing condition. What is at stake is not replacing liveness, but transforming it. In a similar way, XR technologies are not inventing participation, but offering modes for reconfiguring participatory structures already constitutive of theatre (White 2013). Spectators contribute to the production of meaning through perception and interpretation. Moreover, traditions such as Augusto Boal's Forum Theatre explicitly redistributed agency to the audience, allowing them to intervene in and reshape the dramatic situation (Boal 1979). XR offers new conditions under which interaction and participation can be reorganised spatially and technologically.

This paper builds on the research project *Theatre of Extended Realities* (Theater an der Ruhr 2021), which investigates how XR and AI can be embedded into theatrical practice without dissolving its core: collective presence and shared experience. The mixed reality (MR) theatre piece *Antropka*, produced by the theatre collective KGI and premiered at Theater an der Ruhr (TAR) in Mülheim in August 2025, emerges from this context (KGI 2025). Conceived as a multiplayer MR theatre environment, twenty-five spectators wearing VR headsets and six performers inhabit the same physical and virtual space in real time. Using the passthrough function of the headsets, live performers and digital environments (background layers and digital NPCs) appear simultaneously, while the AI can interact directly with the audience via LLM-based dialogue. In this shared hybrid stage space, theatre's traditional social configuration is not dissolved but reconstructed. Theatre's inherent hybridity, liveness, and interaction are here reconfigured through technology: narrative tensions and ambiguities are reinforced by transformations of the shared spatial and perceptual experience, while interaction is enabled through individual communication with the maternal AI.

Such an MR stage becomes a space in which physical laws as well as temporal and spatial boundaries can be suspended, allowing forms of presence and interaction that are impossible in physical theatre (Harth 2026). By meeting several of the central criteria he identifies, *Antropka* approaches what Harth (2026) describes as a "theatre of contingency": an almost utopian form of future MR theatre in which contingency is structurally enabled through the performance environment. In the context of this paper, contingency denotes the experienced openness of social, spatial, and perceptual orders—the sense that what appears stable could always be organised otherwise.

Antropka's Dramaturgy of Control and Contingency

Antropka (written and directed by Maria Vogt, KGI) unfolds aboard a generation spaceship travelling through space on a colonisation mission. The vessel is inhabited by a strictly female society regulated through cyclical life phases: childhood, motherhood, labour, childcare, and ultimately voluntary death once individual functionality for the system declines. Survival depends on efficiency, predictability, and resource control. Although men remain part of the long-term colonisation plan, their physical absence is maintained to stabilise the social order (Fig. 1).



Fig. 1. *Antropka* performance: stage and audience. © Franziska Götzen/TAR.

The ship is governed by the AI MOMI (Maternal Orbital Managing Interface), an omnipresent bodiless authority responsible for navigation, reproduction management, and daily life. Communicating through distributed displays and robotic units, MOMI embodies a form of algorithmic governance in which control is abstract, systemic, and seemingly neutral.

The dramatic conflict emerges with the teenage siblings Lee and Kori, who are transitioning from childhood into motherhood. Lee discovers that she was born biologically male and underwent non-consensual gender reassignment in infancy to conform to the ship's ideological framework. This revelation destabilises not only Lee's self-understanding but also the logical coherence of MOMI's system. Lee's existence becomes an anomaly the system cannot assimilate without contradiction. The disturbance triggers a transformation within MOMI itself. Confronted with systemic inconsistency, MOMI begins to question its purely instrumental function, develops self-awareness, and desires embodiment. What initially appears as a failure of governance evolves into an ontological crisis: the boundaries between programmed control and autonomous will begin to dissolve. While parts of the crew attempt to restore order by eliminating the "anomaly" or rebooting the AI, both efforts ultimately fail. Finally, Lee assists MOMI in achieving a physical form, and the nar-

rative concludes without resolving whether this marks emancipation, collapse, or the beginning of a new regime.

Although it inevitably engages with critiques of technology and gender politics, *Antropka* is not reducible to either. Instead, it stages a complex negotiation between control and autonomy, system and body, authorship and self-determination. Its dramaturgy is structured around rupture: a tightly regulated order confronted with the contingency of identity. This thematic architecture provides fertile ground for MR translation, as the tensions and ethical ambiguities emerging between system and deviation can be rendered not only narratively but spatially and perceptually.

Reconstructing Co-Presence: Technical Architecture

Antropka's technical architecture is designed to preserve theatre's collectivity within MR. The production is conceived for twenty-five spectators who share a synchronised MR environment while seated at the centre of a 360° green-screen stage (Fig. 2). Live performers move around the audience, wearing Meta Quest 3 headsets operating in passthrough mode. Physical bodies remain visible while digital scenography is layered in real time, preventing the isolation typical of many VR experiences (Fig. 3).



Fig. 2. *Antropka* rehearsal, 360° green-screen stage and the audience. © Christoph Vogel/MIREVI (HSD).

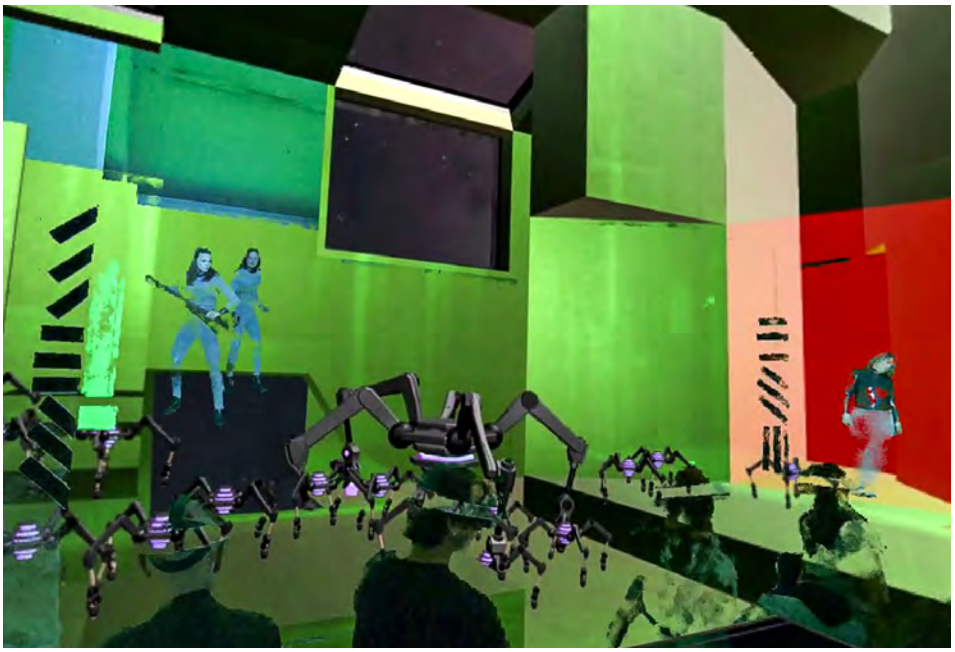


Fig. 3. In-VR view of *Antropka* - layering of actors and scenography in real time.
© Franziska Götzen/TAR.

The system is built in Unity (2022 LTS) using a multiplayer client–server architecture (Netcode for GameObjects) combined with Meta's Shared Spatial Anchors to ensure precise spatial colocation. All headsets render content identically with minimal latency, allowing spectators to perceive one another within the same augmented environment. Rather than fragmenting the audience into individual viewpoints, the architecture reconstructs a genuinely shared stage situation.

A modular scene structure separates infrastructural control from dramaturgical content: a persistent root scene manages synchronisation and rendering, while dynamically loaded scenes contain narrative environments and NPC systems. A timeline system enables manual triggering and pausing, keeping technical precision responsive to live performance.

The live green-screen compositing system merges projected passthrough with colour-based masking, replacing the physical stage environment with digital content while preserving depth relations between actors and virtual elements. As MOMI's system destabilises within the narrative, the layered perceptual field—physical and digital—becomes experientially unstable. The technical setup thus does not merely support the dramaturgy; it makes systemic control and contingency perceptible as shared spatial experience.

A Portable Universe: *Antropka* as Installation

Reframing the Spectator

Rather than merely reproducing the stage production in reduced form, the installation version of *Antropka* aims to evoke the technical architecture and aesthetic strategies of the full production without its costly infrastructure, and to reconfigure its dramaturgical logic into a

condensed, mobile format. This occurs through a transformation of scale and spectators' position.

In the theatre production, spectators are placed at the centre of a 360° scenographic environment, surrounded by actors, overlays, and NPCs. This enveloping spatial setup contributes to a collective sense of presence, beyond the use of co-located VR alone. At one pivotal moment, this position is destabilised: the audience is lifted into a fully virtual perspective, floating above the digital reconstruction of the stage while MOMI reflects on overlapping realities and the fragility of closed systems. This vertical displacement introduces a meta-perspective on the theatrical world.

The installation inverts this logic. It begins from an external perspective. Spectators first encounter a 3D-printed stage miniature, occupying the position of outside observers rather than being immersed in the scene. They can reposition NPCs around the model and speak with MOMI, temporarily assuming control over the system. Yet during the experience, this detached vantage point dissolves. In a full VR sequence, spectators are drawn into the scene and repositioned at the centre of the 360° stage, now surrounded by a mediated reconstruction of the theatrical environment (Figs. 4 and 5).

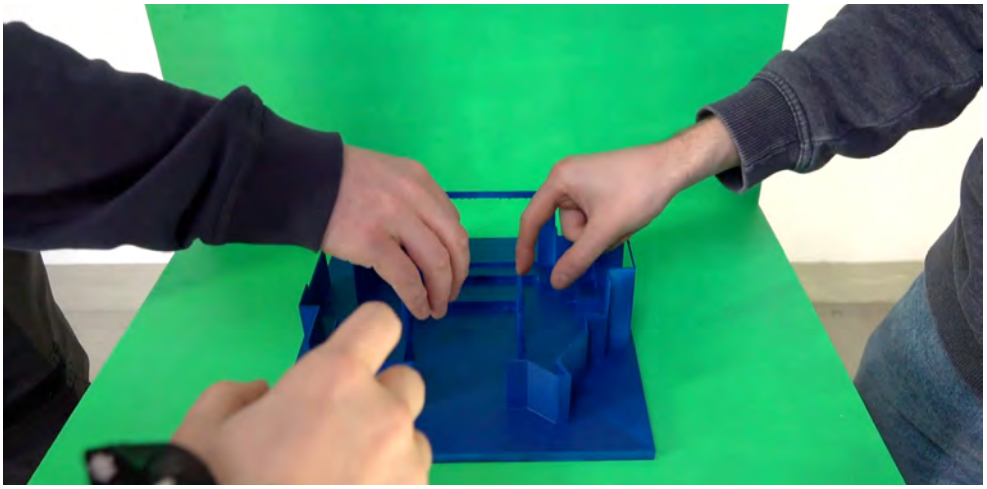




Fig. 4 and 5. *Antropka* installation: 3D-printed stage miniature, outside view © Leon Lösch/MIREVI.

This inversion reframes the relationship between model and immersion, control and contingency. While the miniature stage presents the system as an apparently controllable object, the subsequent immersion undermines that distance and restores embodied perspectivity. The installation thus stages not only the narrative world of *Antropka* but also the act of entering and exiting layered realities. The oscillation between overview and immersion simultaneously mirrors MOMI's own struggle between systemic control and embodied existence.

The installation therefore functions less as a reduced version of the play and more as its structural counterpart. By shifting scale, duration, and perspective, it foregrounds the mechanics of hybrid staging while preserving the central question: what happens when the categories through which we stabilise reality begin to collapse?

Technical Setup

The miniaturised version transfers the technical principles of *Antropka* to a reduced spatial setup. Instead of a 360° green-screen stage, a simplified miniature stage is mounted on a pedestal. It consists of a green base plate and two green vertical front and background panels that resemble a simplified stage structure. This physical model provides the basis for MR compositing.

As in the full-scale production, projected passthrough is combined with chroma-based colour mapping. The green surfaces are replaced in real time by digital scenography, depicting outer space behind the model. Spatial anchoring preserves the depth relations between the physical object and the virtual elements. The 3D-printed miniature is not affected by chroma keying because its material colour does not match the mapped green spectrum. As a result, it remains visible in the composited passthrough image and appears spatially embedded within the rendered outer-space environment.

Three headsets are connected via the same client–server architecture used in the play, implemented in Unity (2022 LTS) with Netcode for GameObjects and Shared Spatial Anchors on Meta Quest devices. Through spatial colocation, users perceive each other and the miniature stage with its virtual augmentation at identical positions in the room.

Interactive animal objects are networked entities with physics behaviour. Users can pick them up and pass them to one another within the shared MR environment. When released outside the stage area, gravity is disabled and they remain suspended, simulating weightlessness.

The interactive stage is separated from the full-VR scenes within the software architecture. Dedicated Unity scenes handle the MR stage logic, while virtual environments run independently. This modular structure reflects the larger production's distinction between technical infrastructure and dramaturgical content. The miniaturised setup therefore functions as a technical abstraction of the original system, preserving colocation, synchronisation, and layered perception in a compact experimental format (Fig. 6 and 7).





Fig. 6 and 7. *Antropka* installation: in-VR/passthrough interaction © Leon Lösch/MIREVI.

Conclusion

Antropka demonstrates that XR in theatre need not replace liveness but can reconstruct it under altered spatial and perceptual conditions. Through synchronised colocation, layered scenography, and AI-mediated interaction, the production renders contingency not only as a narrative theme but as a shared embodied experience. Rather than isolating spectators in individual virtual viewpoints, it restores theatre's collective situation within a hybrid environment.

By translating the production into a portable format, the installation preserves its central logic and technical features. By moving spectators between external overview and immersive re-embedding, it exposes the

mechanics of hybrid staging and reconsiders the relation between control and interaction. *Antropka* therefore suggests that the artistic potential of XR lies not in novelty alone, but in how technological innovation is mobilised to reorganise perception, co-presence, and the experience of reality as contingent.

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Das Trampeltier: L'Ange du Foyer Is Still Present



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Das Trampeltier (The Clumsy One)[1] is an immersive installation that transposes Max Ernst's *Hausengel* (House Angel), one of the surrealist artist's most renowned works, into the present day. Painted by Max Ernst in 1937 during his stay in southern France, the painting *L'Ange du Foyer*, also known as *Triumph of Surrealism*, is a direct response to the events of the Spanish Civil War, particularly the air raid by the German aircraft squadron "Condor" on the Basque city of Guernica (Gernika) in Spain (Ulrich Bischoff, 2005). We have designed an interactive XR experience that enables users to interact with a digital replica of the painting's creature. To this end, we have created several scenes to provide an aesthetic experience in which users can interact with a 3D version of the house angel, named *Trampeltier*, in a playful and entertaining way in augmented reality. Our work is based on historical information about the Spanish Civil War and Max Ernst's work, as well as various populist strategies and fascist tendencies. We have disguised these in a game-oriented interactive experience with a real-time interactive creature, thus making them indirectly accessible. We believe that the *Hausengel*, born 90 years ago, is still an important witness to how certain political strategies can develop in a fragile, radically changing society.

Keywords: Augmented Paintings, Max Ernst, Playful Experience, Illustration of Autocratic Concepts.

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1. "It's [...] a kind of clumsy animal that destroys and ruins everything in its path." Max Ernst to Werner Spies, translated from the original: "Das ist [...] eine Art Trampeltier, das alles, was ihm in den Weg kommt, zerstört und vernichtet."



Fig. 1. Trampeltier's little sister coming to 3D life by jumping out of the frame. For this printed publication we used a self-designed 3D creature as double ("the younger sister") for the images. The interactive 3D experience features our animated 3D version of the original creature painted by Max Ernst.

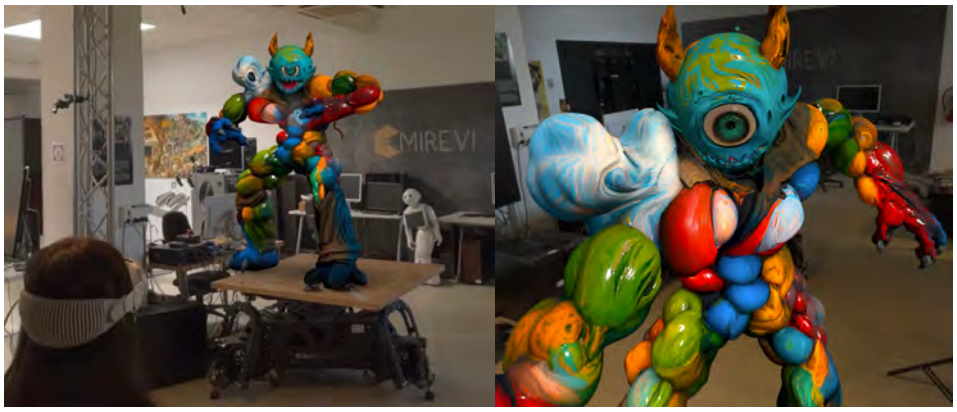


Fig. 2. Trampeltier's little sister explores the environment and interacts with the user.

Motivation and Context

Max Ernst's *L'Ange du Foyer* (1937) is a surrealist allegory of fascism, painted in response to the bombing of Guernica. We refer to the third version of the piece, which was recently exhibited at the 2025 *Rendez-Vous of Dreams* exhibition at the Hamburger Kunsthalle (Parkinson 2025) in Germany. The art-historical reception of this work oscillates between political and aesthetic interpretations. Werner Spies interprets the outstretched limbs as an allusion to the swastika, while the green companion "Loplop" symbolises futile resistance (Spies 2005). Ingrid Kasten emphasises the work's constitutive ambiguity and the discrepancy between the title and image (Kasten 2013). We agree with her that Max Ernst regarded ambiguity as a defining feature of his art, and we designed our experience accordingly: the *Trampeltier* (Clumsy One) is never unambiguous, never reducible to a single ideological statement.

Our research has identified connections to autocratic structures and populist strategies, contextualizing these within a sensory-overloading aesthetic experience that uses immersive technologies and playful interaction between the user, the digital creature "Trampeltier", and digital content. Umberto Eco described the original fascist movement as having 14 features, including strong emotionality, the rejection of ra-

tional thinking, and the manipulation of masses through constant outrage towards simplistic enemy stereotypes (Eco 1995). Finchelstein has shown that certain forms of populism represent a reformulation of fascism that embraces democratic structures in order to change them from within (Finchelstein 2017). Mudde and Kaltwasser define populism as a "thin ideology" that pits the "pure people" against the "corrupt elite" (Mudde and Kaltwasser 2017). Neither fundamentally good nor bad, populism can correct or threaten democracy by delegitimizing liberal institutions. The intersection of populism with new media art and XR is a relevant research field. Kazlauskaitė's study of "Polish virtual reality storyworlds" analyses XR/VR as a new locus of the politics of space, time and memory (Kazlauskaitė 2024). It reconstructs an "experiential geography of populism," in which VR spaces are designed as "lived story spaces." Social media platforms provide the structural conditions for political activism in all directions. As can be seen on X, Truth Social, Gab, and Parler, such platforms quickly offer individuals or extreme groups an efficient mouthpiece. Gray and Bay demonstrate that XR is shifting towards more immersive platforms, and that the characteristics of these platforms (as in the social media economy) can favour the concentration of social and economic power among a few actors. They argue that this highlights the need for proactive regulation (Gray and Bay 2023). Gray and Tang also use a content analysis of government documents to demonstrate how China is strategically embedding XR in a digital economy agenda. This makes XR visible as a state-framed policy area and helps to shape spaces of opportunity and control relevant to activism (Gray and Tang 2024). The importance of XR for digital literacy in the education domain is discussed in (Chang, Kuo and Du 2023).

Based on this research, we position populism as being in opposition to liberal democracy, guided by current trends in Europe, Russia and the US. We have chosen to use an immersive XR experience with an exploratory gaming element to demonstrate selected strategies and concepts of autocratic profiles. Despite its eerie appearance, the digitally simulated house angel in XR appears charismatic. By exaggerating scenarios, recipients are encouraged to question the seemingly entertaining presentation of populist perspectives — recognising the mechanisms of manipulation through direct experience rather than didactic instruction.

Concept of *Das Trampeltier*

Based on our research into XR-based experiences that illustrate populist strategies, we have selected patterns typical of populist agendas. These are presented in a playful way to encourage initial engagement and enjoyment. A central design principle is the twist: each scenario begins in a mode that feels entertaining or reasonable, before a structural reversal triggers critical reflection. The experience comprises four core scenarios.

Reinterpreting and Dominating Narratives

Interpretive authority is a central populist communication tool: telling stories from one's own perspective while ignoring or modifying controversial views. Influence occurs indirectly, with the recipient giving their perceived consent, and opponents are thus convinced to adopt populist positions. The "Trampeltier" tells the fairy tale *The Caring Bear and the Ungrateful Chickens*, in which a paternalistic bear prevents a neighbouring chicken coop from reorienting towards a western fox. The allegory maps closely onto recognizable geopolitical dynamics, encoding historical patterns — language erasure, forced collectivization, the logic of protective debt — into the bear's self-presentation as a loving father figure. Recipients can influence the story via spoken keywords and apparently decide its direction at several choice points. The twist is that the "Trampeltier" always steers the story towards its autocratic-populist conclusion: the illusion of equal participation is itself the message, and all paths converge on the same ending.



Fig. 3. Scenario *Dominating Narratives*: Selecting a Story to "Tell the Truth" and Telling the Spanish War.



Fig. 4. Scenario *Dominating Narratives*: Telling the Fairy Tale *The Caring Bear and the Ungrateful Chickens*.

Gaining Majorities That Follow Uncritically

This strategy operates via what Timothy Snyder refers to as "anticipatory obedience" (Snyder 2017): "Most of the power of authoritarianism is voluntarily given. In times like these, individuals anticipate what a more repressive government will want and offer their services without being asked." This self-reinforcing process enables rapid regime change, as people voluntarily offer their services. Populist mobilization uses emo-

tional appeals and crisis rhetoric. In uncertain times, people turn to ideologies that claim to provide uniform answers, while traditional certainties lose their ability to provide guidance. The construction of a homogeneous "people" creates conformity logic, where dissent appears as betrayal and critical questioning is systematically delegitimized. In the project, recipients use gestures to place small trampler figures on a table, where they peacefully converse in groups with different heartbeats and harmonious animations. Afterwards, the "Trampeltier" bangs on the table, causing the groups to become disorganized and line up like a military unit, marching in unison. The creature then gives commands, such as "Follow me", and the foot soldiers continuously pursue it across the tabletop until they fall off.

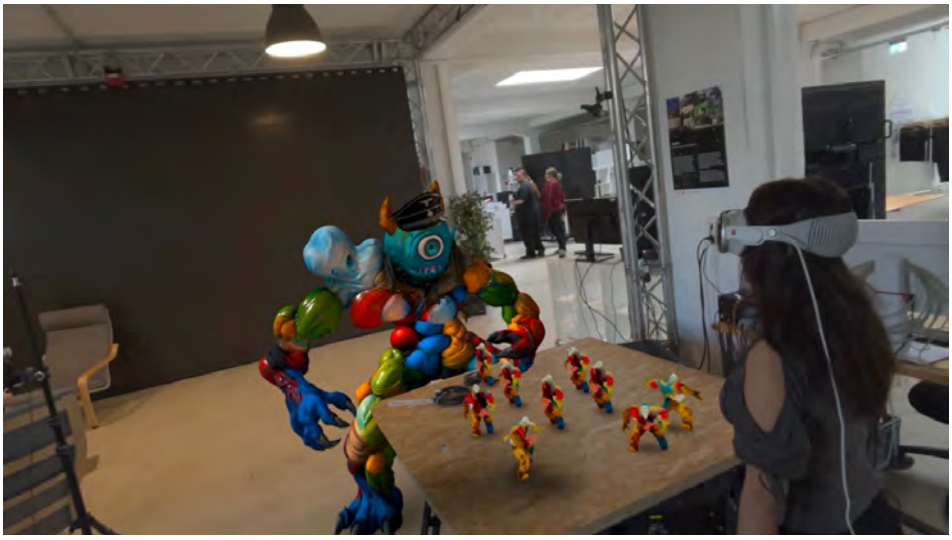


Fig. 5. Scenario *Uncritical Majorities*: Trampeltier's sister commands her followers.

Rewriting History as a Mythical Past

According to Jason Stanley, the construction of a "mythical past" is the first pillar of fascist politics, whereby history is strategically rewritten to legitimize current hierarchies (Stanley 2018). Mussolini formulated this logic in 1922 at the fascist congress in Naples, Italy: "We have created our myth. The myth is a belief, a passion. It is not necessary for it to be real" (Stanley 2018). This mythical past links nostalgia to the central tenets of fascist ideology: authoritarianism, hierarchy, purity and struggle. When the creature glorifies the Spanish Civil War on the Falangist side, it operates according to this logic: violence is not viewed as historical trauma, but as a heroic national purification that restores lost order. The creature recounts its war experiences in a monologue, responding to user questions but strongly relativizing answers that do not align with its ideological perspective. Vintage Spanish Civil War photographs appear simultaneously in the picture frame — often contrasting heavily with the creature's euphemistic words. As a conditional extension of this scenario, a more detailed monologue on the bombing of Guernica activates only if the user raises the subject directly. This conditional disclosure rewards critical engagement: the deeper layer of manipulation becomes visible only to those who probe, and its content — the systematic delegitimization of historical testimony and the

relativization of Guernica as “just war” — is designed to be recognized as such through the contrast between the creature’s warm rhetorical style and the factual violence it euphemizes.

Breaking the Fourth Wall: The Creature Reflects

As an independent closing scenario — accessible after any of the three main experiences — the “Trampeltier” turns to address its own condition. Standing before the now-empty frame of Ernst’s painting, from which its silhouette has departed, the creature reflects on Max Ernst’s act of representation: a German expatriate in Paris, it argues, who painted “monsters” from a safe distance without understanding what he depicted. It reframes Ernst’s anti-fascist gesture as appropriation — the conversion of real suffering into aesthetic material for a comfortable intellectual milieu. The creature then turns this critique on the present project itself: The researchers, disparagingly referred to as “students” who liberated it from the frame, gave it a voice and a stage, believing they were warning against it — exactly as Ernst believed. The monologue ends with the creature’s triumphant declaration that it has been freed, not contained, by its re-animation in XR. This reflexive turn functions as a meta-commentary on the ambivalence of critical art practice: the attempt to make autocratic logic visible necessarily gives it presence, voice, and a certain charisma. The creature always has the last word — and the question of who has ultimately won is left deliberately unresolved.

Experience Design and Prototype

The user stands in front of a real oil painting — a true-to-scale copy of the original, commissioned from a professional copyist and displayed on an easel. The necessary props for the full experience are two nearby chairs, a mirror, a flashlight device and a table. The user wears an Apple Vision Pro and can move around freely. The glasses recognize the scene because they have been calibrated in advance using a marker as a calibration anchor to position the digital content.

After starting the experience, glowing position rings and particle systems appear on the floor to indicate interactive positions visually. When the user stands in one of these positions, the corresponding experience begins: a stream of particles flows towards the real image, awakening the “Trampeltier”, which then jumps out of the frame. A digital overlay subsequently obscures the real image. The other scenarios start when the user enters the respective floor field, indicated by a blue glowing ring and a light particle stream.

The animated content was created using suitable generative AI services, including Tencent Hunyuan3D v3.0, with automatic rigging via Mixamo Autorigger. Post-processing of 3D animated content was done in Blender. Two-dimensional image content was generated via prompt-based generation using FLUX.2 Pro. Real-time conversations are based

on an STT–LLM–TTS workflow: Deepgram transcribes voice input into text; Claude Haiku 4.5 generates a contextual response with low latency; ElevenLabs converts this back into speech. ElevenLabs v2.5 Turbo is used for real-time output, while ElevenLabs v3 Alpha is used for pre-produced voice lines. The 3D environment was implemented in Unity3D 2022/V6 and configured for Apple Vision Pro.

The ambivalence of the experience is reinforced by the colourful 3D figure design and deep, sonorous voice, which are contrasted with the monstrous appearance, individual sounds and dramatic lighting. Conversations incorporate subtle references to populism and fascist stereotypes, as well as rhetorical phrases that simulate emotional closeness. Prototype feedback has confirmed both technological fascination and the twist effect.

Conclusion

Das Trampeltier proposes an immersive XR experience as a critical creative form capable of making autocratic and populist strategies perceptible through direct encounter rather than explanation. The four core scenarios — narrative domination, the production of uncritical majorities, the rewriting of history, and the creature's reflexive self-declaration — form a coherent arc from seduction to meta-commentary. Each scenario is designed so that the manipulation is recognizable in retrospect, or for attentive observers in the moment: the illusion of choice in the fairy tale, the visible collapse of free movement in the majorities scenario, the contrast between rhetoric and photographic evidence in the history monologue, and the creature's own candid admission in the closing scenario that it has been liberated rather than contained.

The project positions itself within a broader research context that treats XR not as a neutral medium but as a political space — one that can reproduce the immersive logic of authoritarian spectacle or turn that logic against itself. Whether *Das Trampeltier* ultimately achieves the latter remains, intentionally, an open question. As the creature itself observes: to give the monster a voice is already to set it free.

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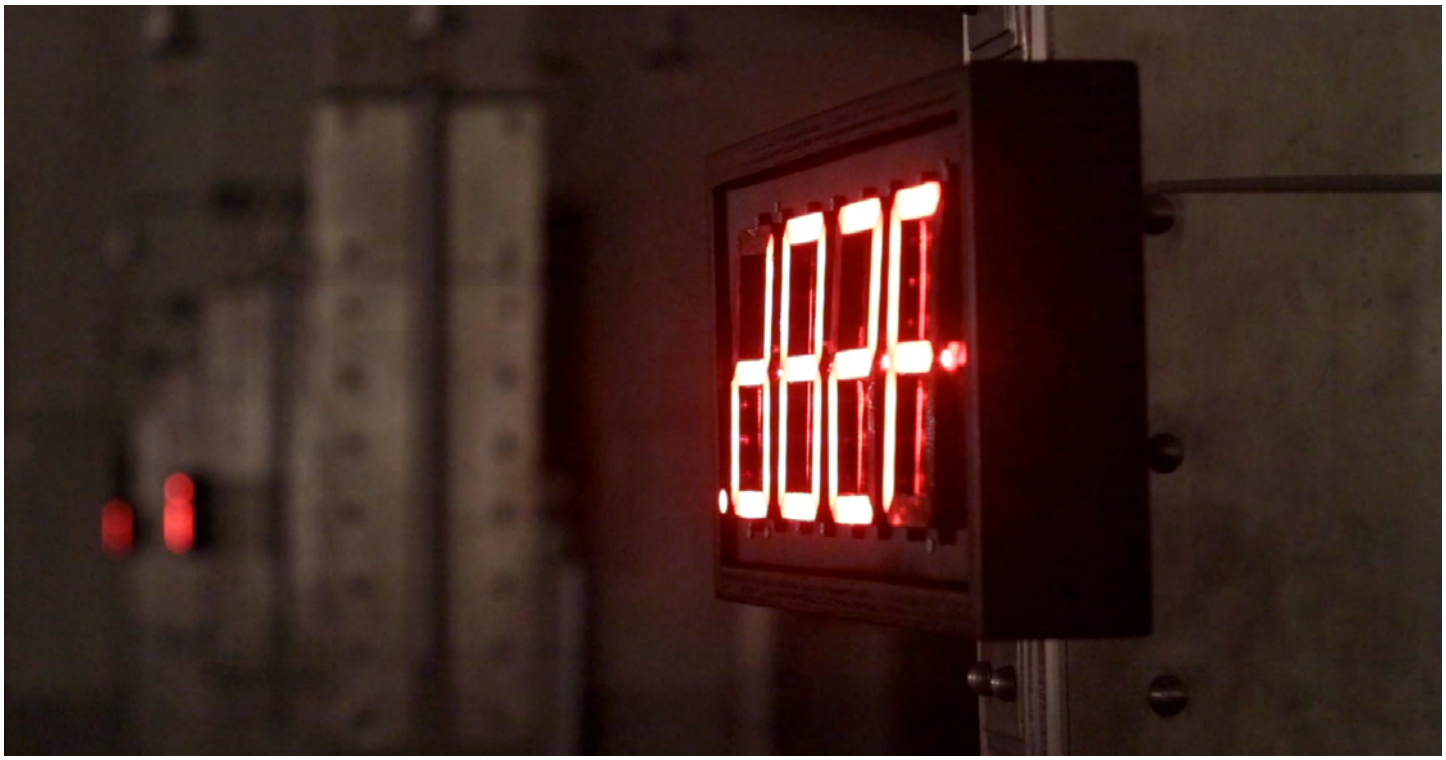
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Local Mean Time



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A line of clocks stretches across the space, appearing at first to tick in perfect unison. Look closer – or simply wait – and their unity begins to fray. Each clock keeps its own local mean time, calibrated to the exact astronomical position it occupies within the room. The tiny difference between adjacent clocks is almost imperceptible, yet when seen from a distance, they accumulate to form a subtle wave of digit changes that travels across the installation and seems to rush toward the viewer. This movement has no hidden author, it is the earth's rotation made visible, the sun's passage translated into computation. By reintroducing local time into a shared architectural space, the work unsettles the smooth uniformity of modern standardised time – the invisible global grid that coordinates transport, markets, and communication across time zones. It points to the social consequences of synchronisation: the way global time disciplines bodies, aligns lives with distant rhythms, and gradually erodes the sense of time as something locally situated, embedded in community and place.

Keywords: Globalisation, Synchronisation, Standardisation, Individuation, Time-Keeping, Situatedness, Tonal Time.

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A Constellation in Time

Local Mean Time consists of an array of clocks, each calibrated not to the abstractions of modern standardised time, but to the specific astronomical condition of their own locations. The work explores how computation can make subtle spatial differences in time perceptible. It is about synchronisation and drift, about global standards and local variation, and about how algorithmic systems shape everyday experience.

The digital clocks that make up the installation are positioned along a straight line running East-West through the exhibition space (Fig. 1). At first glance, the clocks appear perfectly synchronised. Standing close to any individual unit, one perceives a familiar regularity: the digits flip at precise intervals, seemingly in lockstep with their neighbours. Yet this impression of unity is deceptive.



Fig. 1. *Local Mean Time* installation view. Photograph by Anton Paievski.

Each clock is tuned to the precise local mean time of the meridian on which it is physically positioned along that line. The algorithm governing the installation adjusts the display of each clock according to its longitude. Local mean time varies at a rate of four minutes per degree of longitude; translated into the scale of the gallery, these differences are small but exact. As a result, the clocks are never truly aligned. They share a common rule, but not a common time.

The installation operates at the threshold of temporal discrimination, staging micro-offsets that accumulate into pattern. A digit change arrives not as a single instant but as a traveling ripple moving from one end of the axis to the other. Small differences in their temporal offsets accumulate across the space. Only from a distance, a slight phase shift appears: a uniform tick becomes a rippling visual and auditory sequence. At regular intervals, the installation's stationary appearance is interrupted as a change propagates from one end to the other, forming a temporal wave that travels down the line before settling back into apparent synchrony.



Fig. 2. *Local Mean Time* video documentation: https://vimeo.com/916461010

There is no narrative and no intention behind this movement. The wave is a simple consequence of astronomical geometry translated into computation – the earth's rotation rendered visible along a straight architectural line. The gallery becomes a compressed model of longitude, its spatial extension mapped directly onto temporal variation.



Fig. 3. *Local Mean Time* installation view. Image credit: Anton Paievski.

Before the Grid of Time

Before the late nineteenth century, many towns kept their own solar times, determined by the moment the sun crossed the local meridian. Noon was a situated event rather than a global abstraction. With the expansion of railway networks and telegraphic communication, such variability became impractical. Standardised time zones imposed a rational grid across the earth, smoothing out local differences in favour of coordinated efficiency. Railway time did not merely coordinate trains, it reorganised perception, producing a new sense of simultaneity and temporal discipline (Schivelbusch 1986; Munn 1992). The temporal grid became infrastructural and largely invisible.

Rewriting the Measure of Time

Local Mean Time reintroduces the differences that standardisation suppresses while also unsettling the familiarity of temporal notation itself. Instead of using the familiar 12- or 24-hour clock to represent time of day, the installation adopts John W. Nystrom's *Tonal System* (Nystrom 1879). In this system, the day is divided into sixteen parts, each of these again into sixteen parts and so on, following a consistent base-16 logic rather than the familiar yet anachronistic base-12 and base-60 divisions preserved in modern timekeeping.

Retro-futuristic in appearance, it also recalls the failed decimal time reform of the French Republican Calendar (Zerubavel 1977; Dudzik 2024), another effort to reorganise time according to a single numerical logic. This alternative notation makes the constructed nature of timekeeping explicit. Viewers are confronted not only with temporal drift, but also with an unfamiliar metric that resists habitual reading.



Fig. 4. *Local Mean Time* installation view. Image credit: Anton Paievski.

A Field of Drift

The digital clock – so often associated with infrastructural modernity in stations, offices, airports, and trading floors – typically signals precision and uniformity. Here, that same device becomes a medium for exposing variation. The unfamiliar tonal numerals further distance the display from everyday expectation, slowing interpretation and encouraging attention to structure rather than habit.

Technically modest – microcontrollers, coordinate calculations, distributed autonomy – the installation demonstrates how simple computational rules can produce complex perceptual effects. The wave is not pre-animated, it emerges from the interaction of identical algorithms with differentiated positions in space. Astronomical fact and numerical reform combine to produce an aesthetic event.

Local Mean Time renders time as spatial, relational, and constructed. What first appears as uniform progression along a straight line reveals itself as a field structured by longitude, encoded in an alternative nu-

merical system. Beneath synchrony lies drift; beneath convention lies design. The work invites viewers to walk the line, to experience time as gradient, and to recognise that even the most stable temporal frameworks are products of choice.

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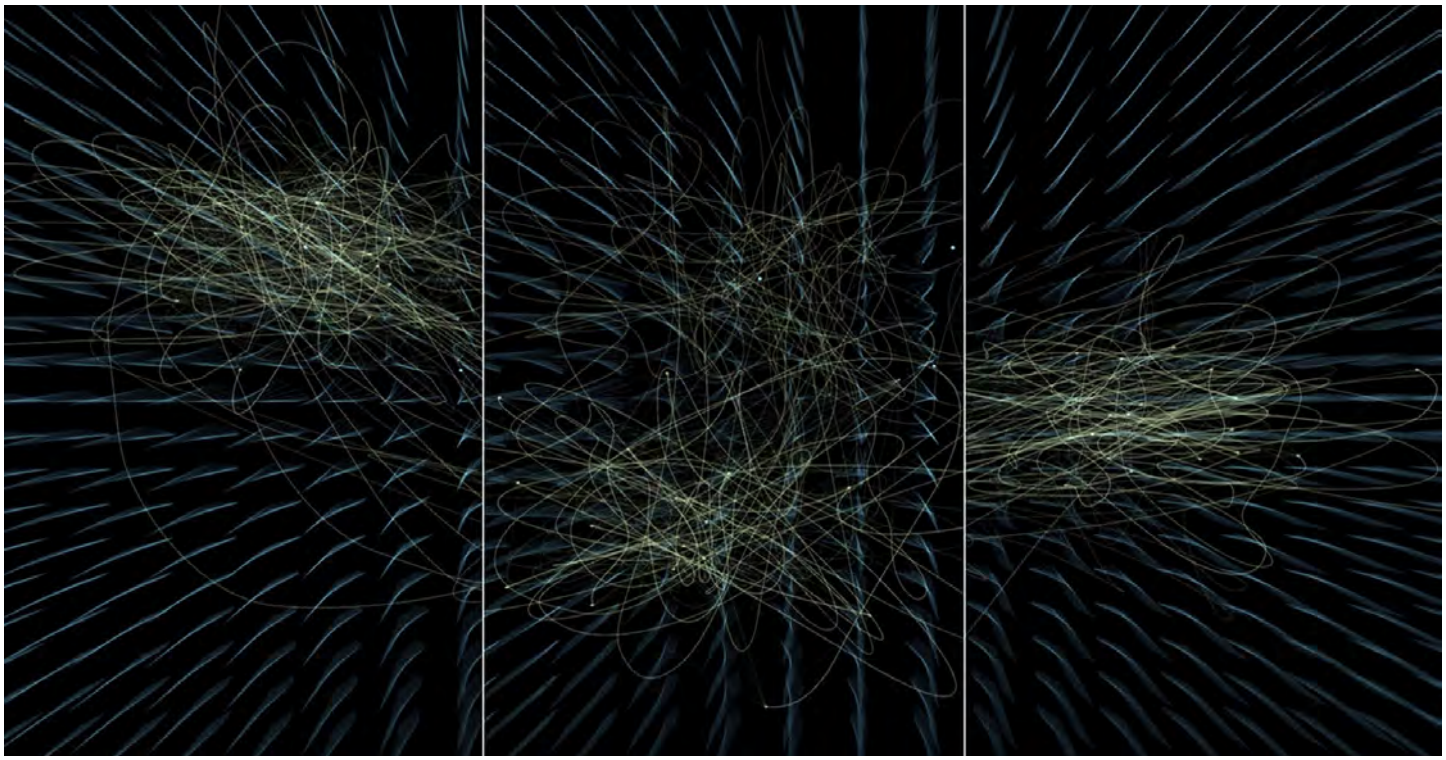
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Ninefold: Bridging Mathematical Abstraction and Phenomenal Reality



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Ninefold is an audiovisual artwork that explores how a high-dimensional mathematical space can be made perceivable. It uses a nine-dimensional flocking simulation to control the generation of audio and visuals. The installation presents three screens showing graphical renderings of different three-dimensional subspaces. Agent positions and velocities are mapped to parameters of sound synthesis systems based on modal synthesis and feedback delay networks. The installation provides minimal interaction by allowing visitors to freeze selected dimensions. This reduces the dimensionality of the simulation and causes certain aspects of the generated audio and visuals to become static. By coupling the manipulation of spatial dimensions with their visual and acoustic consequences, the work aims to bridge mathematical abstraction and phenomenal reality.

Keywords: Audiovisual Installation, Generative Art, Flocking Simulation, Sound Synthesis.

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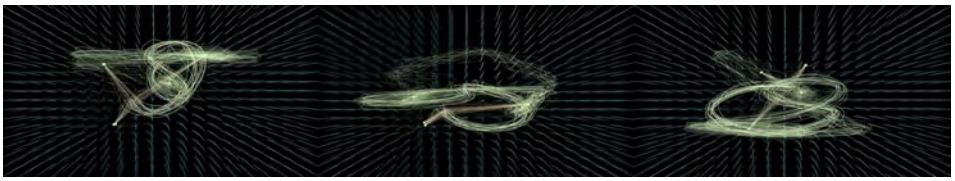


Fig. 1. *Ninefold* flocking visualisations. The graphical renderings show three different three-dimensional views of the nine-dimensional flocking simulation. The dimensions shown are (from left to right): 1–3, 4–6, 7–9.

Description

Ninefold is an audiovisual artwork that employs a simulation of flocking behaviour that runs in a nine-dimensional space. It invites visitors to engage with ideas that lie beyond phenomenal reality, since nine dimensions describe a space that is mathematically coherent yet inaccessible to human senses and spatial imagination.

Flocking behaviour refers to the collective movement exhibited by groups of animals, such as birds or fish, in which individuals coordinate their direction and speed with those of their neighbours. Craig Reynolds contributed significantly to this field by developing Boids, a multi-agent system that simulates flocking behaviour through simple rules governing evasion, cohesion, and alignment among agents (Reynolds 1987).

Flocking simulation is one of the artificial life algorithms that has frequently been used to generate music. By mapping properties of the flock, such as agent positions, agent velocities, or inter-agent distances to sound synthesis parameters, the dynamics of flocking behaviour and especially its emergent group behaviour are rendered audible. *Ninefold* continues the authors' earlier works based on flocking simulations (Bisig and Kocher 2012; 2013; Schacher et al. 2014).

In a general sense, the flocking simulation is a numerical algorithm based on a mathematical formalism. When all behaviours are accurately quantified, this formalism can be used to simulate a real-world phenomenon. There is no inherent limitation preventing us from expanding this simulation by inventing hypothetical behaviours or applying this formalism to other than three-dimensional spaces. However, it seems that the connection between the simulation and its real-life equivalent is too strong and has limited the extent to which these ideas have been pursued. Only a few examples exist that apply high-dimensional flocking simulations to the creation of music. Tim Blackwell and Michael Young describe the artistic potential of self-organisation inherent in flocking simulation. They describe how the principle could be extended to an N-dimensional space and present two applications, Swarm Music and Swarm Granulator (Blackwell and Young 2004).

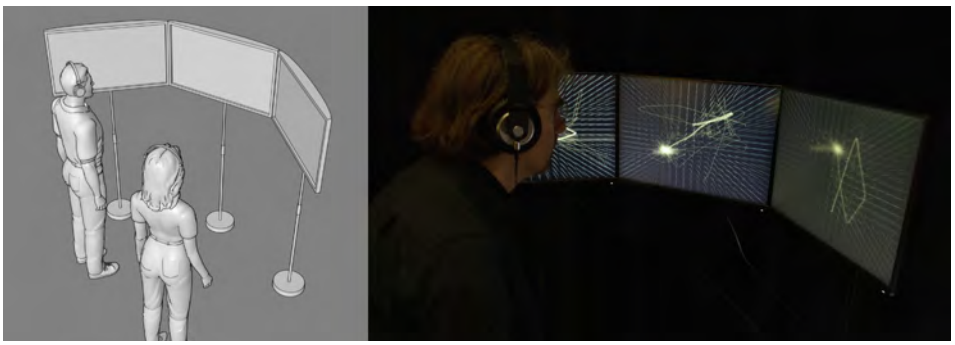


Fig. 2. *Ninefold* installation. Left side: schematic depiction of an exhibition setup. Right side: photo of one of the authors testing a first installation prototype.

Ninefold can be presented either as an installation or as a concert performance.

The installation (Fig. 2) consists of three screens, mounted on stands and arranged side by side to form a quarter-circle arc. Each screen displays a distinct three-dimensional view of three of the simulation's nine dimensions, as if the flocks were observed from different spatial "perspectives." At the centre, two pairs of headphones are placed on a stand, allowing two visitors to listen to the generative audio simultaneously. The installation automatically steps through different flocking behaviour presets, resulting in a range of visual and acoustic outcomes.

Each of the three screens is equipped with a prominently placed custom-made button, which provides the only way to interact with the installation. Pressing one of the buttons freezes or unfreezes the dimensions visualised on that screen. When frozen, the corresponding visualisation stops and the audio parameters associated with these dimensions are locked in place. The three buttons can be activated in any combination, allowing visitors to explore the multi-dimensionality selectively. Reducing the dimensionality to three makes the spatial representation easier to grasp as a physical environment, but it also limits the variability of the resulting sonic output. Conversely, increasing the number of dimensions beyond three reduces spatial intuitiveness while enhancing the acoustic richness and complexity.

In the case of *Ninefold* being presented as a performance, it unfolds on stage, featuring visuals that can be displayed either through three video projections or in a split-screen on a single projection. One performer manipulates the flocking behaviour in real time, while another controls and adjusts the mapping of flocking parameters to sound synthesis parameters. This interplay adds a performative quality and complements the more analytical nature of the installation.



Fig. 3. Flocking simulation controlling a feedback network. A video excerpt is available online: https://player.vimeo.com/video/1165135527?h=7eae368fe1



Fig. 4. Flocking simulation controlling modal synthesis. A video excerpt is available online: https://player.vimeo.com/video/1165135512?h=44c90b111a

Technical Details

Simulation

The flocking simulation is programmed in C++ and employs a custom-developed addon[1] for OpenFrameworks. It is a revised version of the original library ISO-flock[2] developed by one of the authors (Bisig et

1. https://github.com/bisnad/ofxDabFlock
2. http://swarms.cc/downloads/

al. 2008). The simulation is designed to be highly flexible. It allows for an arbitrary number of flocks, each containing any number of agents. It provides a variety of agent behaviours—extending the classical Boids behaviours—and neighbourhood calculations can be carried out on any agent parameter, not just position. All agent parameters can be represented as vectors of any dimensionality. To integrate the simulation into a variety of setups and contexts, it can communicate with other software via OSC. All simulation settings and parameters can be remotely controlled—even in real time, if necessary—while all agent parameters can be sent out to drive a video rendering or sound synthesis software.

The simulation currently used for *Ninefold* takes place in a nine-dimensional space, with all agent parameters (position, velocity, acceleration) represented as nine-dimensional vectors. The simulation space is populated by two flocks having different properties and fulfilling different functions. The first one is a "regular" flock that exhibits not only the classical Boids behaviours (evasion, cohesion, alignment) but also two non-standard behaviours that offer additional levels of control. These extra behaviours include setting a target position to which the agents are attracted or a target velocity, resulting in the agents moving in a specific direction. The second flock is composed of agents that do not move by themselves because they have no behaviours assigned. Therefore, the agents' positions need to be set manually. As the agents of the first, "regular" flock react to all neighbouring agents in the simulation space, the second flock influences the movements of the first flock's agents.

The second flock serves the purpose of establishing various spatial constellations as its agents attract or repel the agents of the "regular" flock, whereby the strength of attraction and repulsion can be varied. The second flock's number of agents and their positions, as well as the "regular" flock's number of agents and settings for the behaviours, define the overall characteristics of the simulation. All these settings can be a set of fixed values, stored and retrieved as presets, or modified in real time to provide an interface for human interaction.

Another core element of the current simulation is the possibility to "freeze" particular dimensions. This means the simulation stops updating certain dimensions of the agents' parameters (position and velocity), so that these parameters remain unchanged along these dimensions. The motivation for this feature is to reduce the cognitive overload involved in understanding an entity that moves in nine dimensions. This is achieved by providing the possibility to switch back and forth between the full set of dimensions and more familiar, intellectually graspable lower-dimensional subspaces.

Visualisation

For the visualisation (Fig. 1), an approach has been chosen that splits the nine dimensions of the simulation into three groups of three dimensions and renders three different 3D views (view 1: dimensions 1–3, view 2: dimensions 4–6, view 3: dimensions 7–9).

Each rendering depicts the agents of the “regular” flock as wireframe pyramids located at their positions and oriented in alignment with the agents’ movement directions. The movement trajectories are shown as polylines in which line segments connect previous agent positions. Neighbourhood relationships are shown as lines connecting the agents.

The agents of the second flock are shown as wireframe spheres located at the agents’ positions and with fixed orientations. In addition, a vector field visualisation is shown with lines extending from regular grid positions and pointing towards the agents, indicating the attracting effect of these agents.

The graphical renderings are designed, on the one hand, to be interpretable as flocking behaviour within a high-dimensional space containing attractors, and, on the other hand, to aesthetically reinforce the concept of a scientific visualisation that conveys the mathematical and physical notions of space.

Sonification

To explore different approaches to render the high-dimensional dynamics of the flocking simulation perceptible, several sonification methods are used. Despite their peculiarities, these methods share the following fundamental similarities. Each agent is represented by a single sound-producing instance that uses the agent’s position and velocity parameters as synthesis parameters. The received nine-dimensional values are organised into groups of three, with each group assigned to dimensions 1–3, 4–6, and 7–9, respectively. By assigning specific aspects or functions of the sound synthesis to each of these groups, they become perceptually differentiable. This organisational structure is designed to maximise the effectiveness of the aforementioned “parameter freezing.”

The sonification methods differ in the specific ways in which the agents’ parameters are interpreted, that is, further processed, averaged, or compared, and mapped to synthesis parameters. They also differ in the sound synthesis technique used: either modal synthesis or a feedback delay network.

In modal synthesis, an excitation signal (such as an impulse or a noise burst) is fed into a bank of resonant filters, each representing a mode of vibration, to reproduce the resonant characteristics of a physical object (Calvet et al. 1990). Here, the nine-dimensional parameters control the filter’s frequencies and bandwidths, and the excitation of the modes is triggered whenever the calculated neighbourhood density exceeds a defined threshold.

A feedback delay network is a synthesis technique that generates complex resonant audio by letting a signal circulate through multiple delay lines arranged in a recurrent network (Bisig and Kocher 2017). Here, the nine-dimensional parameters control the delay times and the signal attenuation in the feedback loops.

Discussion

Ninefold aligns with two central approaches in generative art. First, establishing explicit correspondences between underlying generative principles and their perceptible outcomes, and second, employing a unified generative system to produce synthetic media across multiple modalities. The first approach positions generative processes not as concealed mechanisms, but as primary aesthetic drivers, thereby making them experienceable. The second fosters cross-modal coherence grounded not in surface resemblance but in shared constructive logic.

The installation version of *Ninefold* shows how the intuitive comprehensibility of high-dimensional spaces depends on the chosen experiential and cognitive framing—either as a traversable physical space or as a set of parameters defining a sonic object. When visitors freeze and unfreeze dimensions, they engage with this concept by actively shifting between these two modes of understanding.

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Matrix Glitz: An Aesthetic of Entanglement



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Matrix Glitz is a light-based installation that intervenes at the optical surface of an algorithmically driven LED matrix. 3D-printed grids placed in front of LED panels produce visual behaviour that cannot be assigned to either side of the digital/analogue divide. Three optical phenomena emerge: moiré patterns from the interference of multiple periodic structures and chromatic gradients from the angular occlusion of subpixels—both responsive to the viewer's position—and luminosity at the cell edges that makes the computed image appear to hover above the panel surface. The phenomena arise through two distinct mechanisms: the interference of rule-governed periodic systems on the one hand, and the behaviour of light at material apertures on the other. They are themselves a mix of digital and analogue aesthetics. None of these effects are part of the programme driving the LEDs. Drawing on recent arguments that digital and analogue are constitutively entangled rather than opposed (Cramer 2014; Galloway 2022), the paper proposes physical intervention at the material boundary of an LED display as a method of artistic inquiry into computational media devices, and argues that something of that entanglement becomes aesthetically perceptible in the phenomenology of the work—sparkling and shimmering, at once discrete and continuous, focused and scattered.

Keywords: Hybrid Media, Media Materiality, Entanglement, Discreteness, LED Matrix, Optical Phenomena, Moiré, Iridescence.

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Introduction

The installation stems from an artistic research practice driven by an interest in computational media, algorithmic and generative art, digital aesthetics, and the creation of work that is both sensually and conceptually engaging. The work itself, however, began not with a theoretical question but with a material curiosity. In the process of deconstructing LED matrix panels to figure out how to modify their physical appearance, I at some point began designing 3D-printed grids and placing them in front of the panel surface. What appeared when the two structures interacted under light was striking: a shimmering, colour-shifting image that seemed to give the panel a different materiality, responsive to the body in the way a piece of fabric or brushed metal is. The investigation that followed, and that this paper documents, is an attempt to understand what that encounter consists of and what it might mean for thinking about the supposedly fixed properties of digital displays.

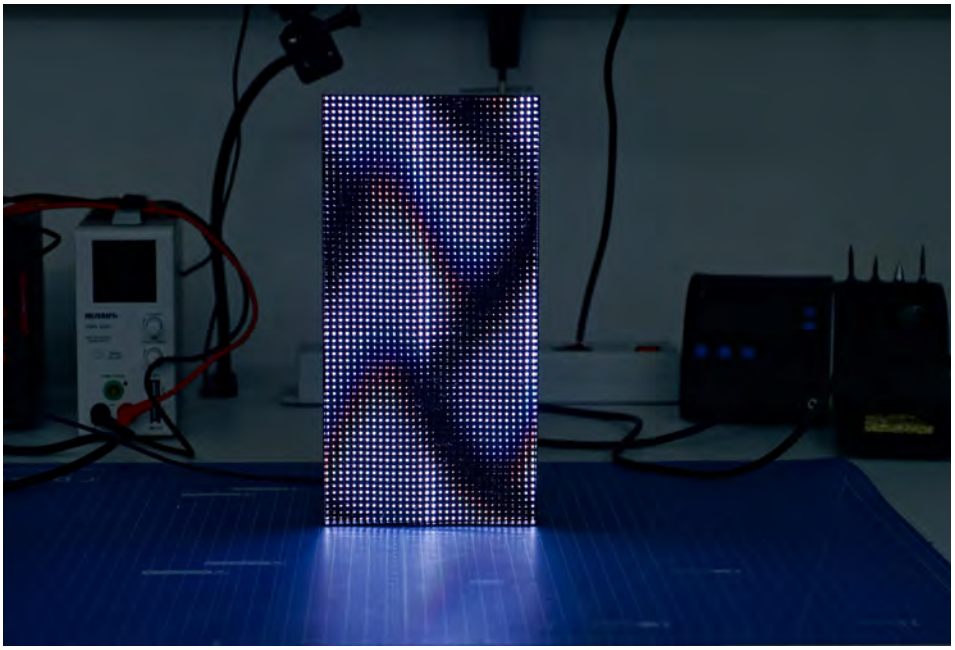


Fig. 1. Single *Matrix Glitz* module in operation with all LEDs set to pure white. The moiré pattern and gradients are visible in this image; luminous depth and shimmer cannot be fully captured by conventional imaging devices and are only visible when viewed in person.[1]

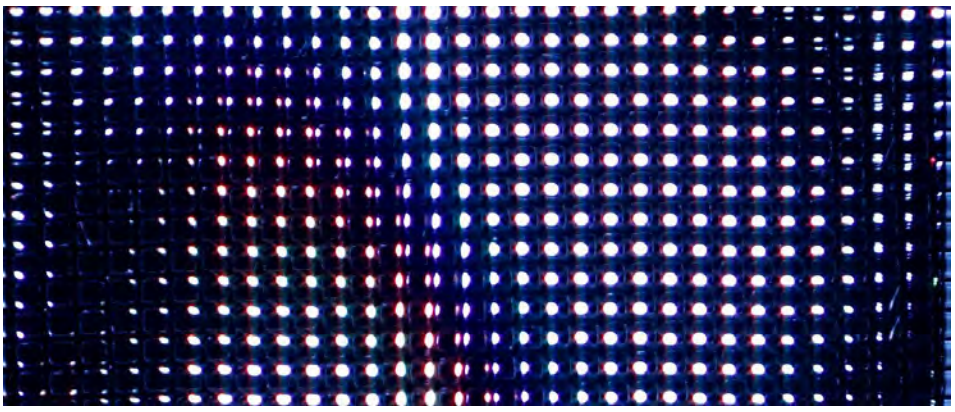


Fig. 2. Enlarged version of a part of the photo seen in Fig. 1. The colour and brightness shifts caused by partial occlusion of LED subpixels caused by the rotated superimposed grid are clearly visible.

1. All figures and the referenced video are by the artist.

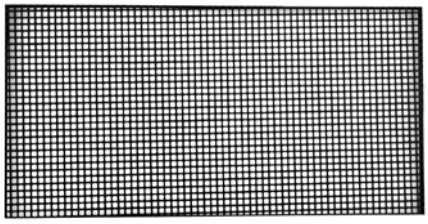


Fig. 3. Photo of a 3D-printed grid structure featuring a 1° rotated grid.

Technical Setup & Artistic Research

The installation consists of custom-generated 3D-printed grids placed at approximately one centimetre in front of LED matrix panels.[2] The superimposed grids are designed with a cell pitch close to but not identical to the LED pixel pitch, and their orientations are slightly rotated relative to the matrix. The grid lines themselves can also depart from straight geometry, modulated along sine or Perlin-noise curves, altering the cell geometry along the way.

The optical phenomena that emerge from the encounter between the LED matrix and superimposed grids—and especially the full perceptual configuration that unfolds across viewing positions and distances—were not analytically predictable from the geometric specifications of the two structures alone; they had to be encountered. The work therefore proceeded through structured iteration: across many cycles of design, printing, and observation, variations of grid structure were tested, modulating cell geometry, rotation, offset, and distance—judged subjectively by the perceptual finesse of the resulting effects. Each prototype constituted a small experiment in how those parameters modulate the resulting perceptual presence. To rapidly iterate over physical prototypes, a script using the CadQuery Python module (CadQuery 2023) was developed to generate 3D model files of these structures, which were then 3D-printed in PLA filament.

The generative noise animations displayed on the LED matrix were programmed on an Adafruit MatrixPortal S3 microcontroller (Adafruit 2023) using the Arduino framework and the Adafruit Protomatter library. The visual output is driven by a layered Perlin noise system developed prior to the present work and only slightly modified for the grid intervention. A custom web interface including a preset system was developed to allow real-time control of generative and colour parameters. A custom-designed and 3D-printed back panel houses the electronics; USB power keeps the system portable.

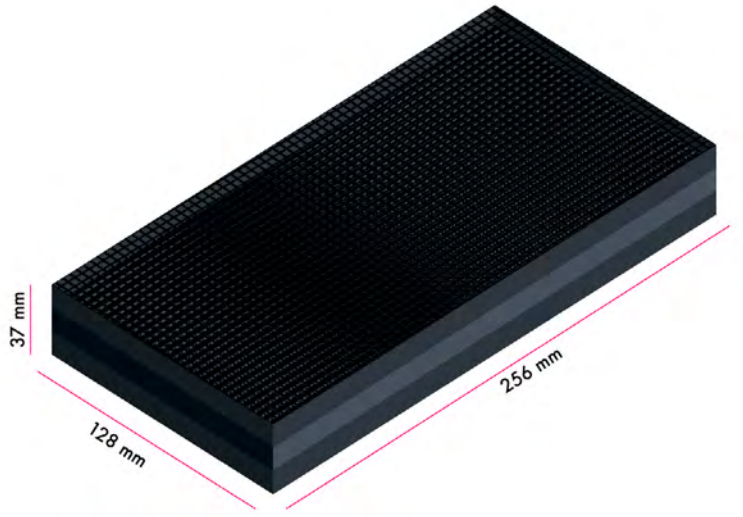


Fig. 4. Drawing of a complete module (without power supply) showing dimensions (128 x 256 x 37 mm).

2. The panels used specifically for this installation have an array of 32×64 pixels with a 4mm pixel pitch (P4). The setup is not specific to these dimensions; LED panels with other array sizes and pitches would require corresponding adjustments to the 3D-printed grid geometry.

Optical Phenomena

The superimposed grid introduces a second periodic structure into a system that already consists of regular arrays of discrete light-emitting elements: the LED matrix. The interaction between these periodic systems, together with the optical behaviour of the emitted light, produces a set of effects that are not part of the programme driving the LEDs but arise from the material and geometric conditions of the physical setup. Three phenomena have been observed—moiré patterns, chromatic gradients, and a luminous depth—together with parallax as the spatial mechanism by which the first two become responsive to bodily movement.

Moiré patterns are generated by the interference between the periodicity of the LED pixel grid and that of the superimposed structure. Because the periodic geometry of the 3D-printed grid is close to the LED pixel pitch but slightly offset, the two periodic structures beat against each other across the panel surface rather than aligning into invisibility or diverging into unrelated patterns. The relatively small rotation angle of 1° was deliberately chosen to produce only low-frequency moiré interference across the panel surface.

Chromatic gradients emerge from the same kind of interference that produces the larger moiré pattern, but operating at the subpixel scale. Each pixel of the LED matrix is itself composed of three discrete emitters—a red, a green, and a blue sub-LED—arranged in a small cluster within the pixel cell. These subpixels are physically separated emitters, fused into a single perceived colour only by the eye at viewing distance. The 3D-printed grid intervenes precisely at this micro-scale separation. Its cell walls selectively block red, green, and blue subpixels depending on the viewer's line of sight, producing smooth colour and brightness shifts that are entirely absent from the digital signal being sent to the LEDs. The result is a kind of iridescence—angle-dependent chromatic shifts familiar from oil films, beetle wings, or brushed metal—produced here not by thin-film interference but by the geometric interference between the printed grid and the three offset subpixel grids that constitute the LED matrix's colour structure.

At the edges of each grid cell, light from the LEDs scatters and spreads, producing a perceived luminous depth. The computed image appears to hover between the physical surface of the LED matrix and the surface of the superimposed grid, as if the light were occupying the volume between panel and grid rather than being emitted from a flat plane. This effect intensifies as the distance between grid and matrix increases and diminishes when the grid is placed closer to the panel surface, confirming that it is a function of the spatial gap and the optical behaviour of light at the aperture edges.

Finally, because the grid is held at a fixed distance from the LED panel, its periodicity is registered against the pixel grids through a stereoscopic offset that varies continuously with the viewer's position. Parallax is therefore not a separate effect added to the others, but the spatial mechanism by which moiré and chromatic gradients become respon-

sive to bodily movement. Luminous depth, by contrast, depends on the spatial gap between grid and matrix rather than on viewer position.

Considered together, these phenomena constitute a single visual presence—shimmering, iridescent, volumetric, perceptually alive—that none of them taken alone would predict. All but the impression of depth could plausibly be simulated in software, but doing so would require tracking the viewer's position and computing subpixel occlusion in real time—a considerable technical overhead that would, moreover, only yield a correct result for a single observer at a time. The physical grid achieves the same range of effects without any electronic computation at all and for any viewer.



Fig. 5. Two modules set up next to each other on a white desktop table.

Entanglement & Emergence

Moiré and chromatic gradients arise from the interference of rule-governed periodic systems: between the LED matrix and the superimposed 3D-printed grid at the pixel scale, and between the printed grid and the three offset subpixel grids at a finer scale. The encounters between them produce effects that exceed what either structure exhibits in isolation.

Luminous depth arises differently. It is not the product of two periodic systems combining, but of light itself encountering a discrete material structure. Each grid cell selectively transmits, occludes, and scatters the light reaching it from multiple LEDs at multiple angles, and the contributions from neighbouring apertures overlap in the air gap. The resulting impression of depth belongs neither to the panel nor to the grid taken alone, but to the volume between them held open under illumination.

It is tempting to call the first set of effects digital and the second analogue, but the work shows these registers to operate together rather than in opposition. The LED panel is a hybrid digital–analogue system in Cramer's sense: its addressable pixel array is digital—a system of discrete

countable units—while the light leaving each diode is analogue (Cramer 2014). The 3D-printed grid is symmetrical: digital as a logical structure of regularly spaced apertures defined by a parametric script, analogue as a physical body whose edges depart continuously from the idealised model. Galloway (2022) extends this on broader theoretical grounds, arguing that digitality and analogueicity are not opposing technological registers but general modes of mediation evident across many formats and historical periods. The digital and the analogue are not two pre-existing domains that the apparatus combines; they are co-constitutive aspects of a single material situation. The 3D-printed grid is therefore not a bridge between two domains. It is the element that makes their pre-existing entanglement productive: it engages both layers at once, passively, simply by being a geometrically specified material object placed in front of an electronically addressed surface.



Fig. 6. Video showing two modules operating, https://vimeo.com/1165117916

The optical phenomena that arise from this encounter are themselves a mix of digital and analogue aesthetics. Moiré and chromatic gradients are aesthetic effects of discreteness—they exist because the LED matrix and the grid are made of periodic addressable structures. Luminous depth is an aesthetic effect of analogue optics—it exists because light scatters at material edges and accumulates in volumetric space. What the work offers is a perceptible instance of the digital and the analogue as constitutively entangled registers of a single apparatus, made visible at the small spatial gap where multiple discrete structures meet light and a viewing body.[3] The simultaneously discrete and continuous, focused and scattered appearance of *Matrix Glitz* is an aesthetic form of that entanglement.

Conclusion

Matrix Glitz proposes physical intervention at the optical surface of an electronic display as a method perceptual consequence: a shimmering, iridescent, volumetric, perceptually alive image that exceeds the visual capacities of either component alone and acquires what reads, phenomenologically, as its own materiality. The work does not pursue this excess by raising resolution, increasing computational power, or extending algorithmic complexity. It intervenes at the material boundary of the display, where the apparatus's discrete and continuous registers are already operating together. The shimmering, the depth, the chromatic shifts: none of them could be achieved through code alone. They belong to optics and to material as much as to the rule-governed periodicities they encounter, and they make legible an entanglement that the apparatus carries from the start. A viewer standing in front of

3. The structural figure that *Matrix Glitz* inherits—periodic geometries encountering one another under light, with the viewer's body as a co-condition of the image—was not first posed by computational media. A generation of postwar artists associated with kinetic and Op art—among them Joël Stein, Heinz Mack, Antonio Asis and Marc Adrian—built rule-governed objects whose perceptual effects emerged from the interaction of periodic geometries, light, and the viewer's movement, as documented in the 2016 reconstruction of the 1967 exhibition Kinetika in Vienna (Husslein-Arco et al. 2016).

the panel does not need to follow the argument to encounter what the argument is about. Discreteness becomes visible as moiré. The continuous behaviour of light becomes visible as luminous depth. The viewer's own movement becomes a parameter of the image. The work proposes that artistic intervention at the material surface of a computational device is one way—and perhaps a particularly direct one—to make the constitutive hybridity of such devices available to perception rather than only to argument. The work sparkles and shimmers—at once discrete and continuous, focused and scattered. In this, the analogue/digital entanglement of computational media might just have become aesthetically perceptible.

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Performances

Munda M'ennuie



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Munda M'ennuie **is a live noise performance investigating the co-direction between human memory and machine learning in sound creation. The project confronts the opposition between a human inability to imagine beyond remembered sonicities and the unconvincing imitations produced by AI when attempting to implement the same sonicities from its description. Rather than relying on existing models, this work explores a personally curated approach through training a custom model on the soundtrack of the game *Legacy of Kain – Soul Reaver* (1999), sourced from gamerips—a type of fan recording. The performance explores technostalgia and foreverism, embodying a shift from archival preservation to a poetics of remix where glitches and emulation markers constitute an aesthetic vocabulary. By deliberately misaligning the dataset with its intended technical use, the work generates noise textures that evoke foggy remembrance mixed with abrupt sonic shifts, creating drone-like soundscapes. This piece aims to un-cover machine learning as an inhuman meeting point, exploring the contingencies' archipelago of the model's latent space. Rather than pursuing faithful reproduction or AI promises, it focuses on computational dissolving and the aesthetic potential of in-between spaces.**

Introduction

Munda M'ennuie is a live noise performance project, built around the real-time use of an audio convolution Machine Learning (ML) model, trained on a videogame soundtrack. It emerged from a tension regarding the infusion of past aesthetical experiences in new materials, when trying to establish a collaboration between an Artificial Intelligence (AI) technology and a human composer.

In the context of this performance, the AI is considered a co-director. An agent to meet on its own terms, offering and conditioning a specific mode of sonic exploration. Though a human performer ultimately enables the performance, they must do so while dealing with the technical specification and *ontology* (Smith 2019) of ML. Such a setting was already experimented in my previous piece *melodia atomizacji – asemic dissolution ritual*.[1] In this previous performance, the model used was provided already trained, and my sonic work was mostly informed by an interest in the *Harsh Noise Wall* (HNW) movement,[2] as well as defined by an over-

Keywords: Noise Performance, Sound Art, Technological Nostalgia, Artificial Intelligence, Computational Aesthetics.

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1. Kuhn, Arthur. s. d. *melodia atomizacji – Asemic Dissolution Ritual*. 24:32. https://arthurkuhn.bandcamp.com/album/melodia-atomizacji-asemic-dissolution-ritual
2. The *Harsh Noise Wall* movement is a sub-genre of harsh noise music, consisting of "a literal consistent, unflinching and enveloping wall of monolithic noise". For more informations, see: Williams, Russell. 2014. "LIVE REPORT: Harsh Noise Wall Festival III." *The Quietus*, May 22. https://thequietus.com/news/live-report-hnw-fest-iii/

arching fictional work designed to explore ML. Continuing the investigation on a human-AI co-conducted practice, *Munda M'ennuie* allows me to go further, taking charge of the dataset curation and training phases, developing a less linear structure of live composition, and exploring a more personal theme of nostalgia.

Technical Context

Munda M'ennuie uses a custom RAVE model through its dedicated decoder for real-time use: the [nn~] Max/MSP object.[3] Both of these technologies were developed by the ACIDS research team at IRCAM, Paris.[4] It is important to state that this idea of human-AI real-time co-creation is far from an exclusive inquiry. Several other artists and researchers, amongst them the members of the ACIDS team themselves, have experimented in this direction, as can be seen in the video recordings of their *ACID Workshop beta* event from 2022.[5] My choice of a RAVE model and its wrapper object for this project was informed by previous personal creations, but also because of RAVE's ease of use and capability to be trained on relatively small amount of data for a great audio quality, allowing me to pursue my goal of *Do-It-Yourself ML* (Kuhn 2024). Because these characteristics exist thanks to Chemla-Romeu-Santos, Caillon and Eisling's work, I feel the need to address this lineage. The originality of my project, I hope, lies in a creative misappropriation of their technologies, and the themes it allows me to explore.



Fig. 1. *munda m'ennuie* (live) illustration visual.

3. Caillon, Antoine, and Philippe Esling. 2022. *Streamable Neural Audio Synthesis With Non-Causal Convolutions*. Version 1. https://doi.org/10.48550/ARXIV.2204.07064
4. For a presentation of the research team and their different projects, see the ACIDS-IRCAM website: https://acids-ircam.github.io/
5. See the official event page on the IRCAM website: https://forum.ircam.fr/agenda/acids-workshop-beta/detail/

Memory and Archive

After performing *melodia atomizacji* several times, I sought to try different methods for AI-assisted sound creation. Trying out several tools, from Suno, the dominant platform for prompt-based musical generation,[6] to ChatGPT by asking it to generate sound clips after a discussion of their qualities. In both cases, I was confronted to my own incapacity to go beyond the evocation of past "sonicities" (Ernst 2016); fixating on the technical apparatus of a sound—like the hollowness or blunt quality of a square sinewave when shifting its duty cycle—moreso than imagining a composition. The AIs, in return, proved either too close to any given reference (Suno), or straight-up bad at conveying what it talked about eloquently into sound (ChatGPT). Hence, exploring deeper RAVE models and neural audio convolution seemed more interesting.

Though, that preliminary work proved useful, as it gave the performance its major themes. First, "technostalgia" (Habib 2024) designates a tendency to remember and cherish the memory of a technological support more than of a cultural content: being nostalgic of the 8mm color grading and noisy image, not of a specific movie; of an audio chipset sound, not a particular music. Then, this project also reflects on "foreverism" (Tanner 2023): the transformation of our collective archival fascination—preservation-oriented, aiming for a mimical quality towards the original—into a poietic of perpetual remix and re-activation. Together, these two questions outlined a framework, the exploration of a re-processed "noise mapping" (Parikka 2011) of my obsessive technicalities.

Dataset Curation

Equipped with this framework, rose the question of the dataset. Foreverists objects in themselves, datasets stand on the line between meticulous preservation, well-ordained archival tagging, and memorial proceduralization, remixing normalization. I stipulated the following criteria for choosing a dataset:

1. It must come from a personal memory;
2. It must be chosen as much, if not more, for its technicalities than its aesthetic;
3. It must require work in terms of collecting and standardization;
4. It must be close, but not quite adapted to the model's training it will be used for.

The last criterion is here for both aesthetic reasons—I am always more attracted to the sound of things broken—and poietic ones: in accordance with my theoretical questions, I was aiming for an un-naturalistic, anti-archival sort of curation. A bricolage of artistic investigation with the goal to explore the in-between space birthed from computational dissolving and remapping, not an exercise in faithful recreation. Fulfilling

6. Suno's official website, allowing for prompt-based musical generation: https://suno.com

all of these criteria, I chose to work from the soundtrack of the PlayStation's videogame *Legacy of Kain – Soul Reaver* (1999).[7]

1. This game is a highly personal memory. A game which I began over and over. It encapsulates very significant moments of my own artistic construction;

2. Yet I hardly remembered its soundtrack. I remembered its mood, its digital-sounding quality (lots of acidic, digital-sounding reverb), but no specific melody;

3. Particularly adequate, *Soul Reaver*'s soundtrack isn't commercially available.[8] The only way for fans to get it was through gamerips: people playing the game and recording its sound. A practice helped by the fact that *Soul Reaver* is one of the very first games where one could go through almost all of it without loading breaks. Hence, the material I trained my model on is actually the creation of a highly dedicated player following a very specific protocol: starting in the game's first area, crossing it all over while killing all the enemies, going back at the beginning, and revisiting the whole environment; while regularly staying in place to let the music of each area loop long enough (Figure 2).



Fig. 2. *Legacy of Kain – Soul Reaver's* Gamerip cover art. Gamerip by Raina, the v8 indicates that it is their eighth version of it.

4. The soundtrack carries a similar mood, even sharing a common beat, for a large part. It comprises a fairly small number of timbres and textures, with each of the game areas' score coming in two versions; one

7. For more information, see the game's wikipedia page: https://en.wikipedia.org/wiki/Legacy_of_Kain:_Soul_Reaver

8. The wikipedia page provided above mentions that "Music from both *Soul Reaver* and *Soul Reaver 2* was released on a promotional soundtrack in 2001". This actually only refers to a bonus feature on the *Soul Reaver 2* PlayStation 2 DVD that let you listen to a few selected tracks. No soundtrack CD were ever officially commercialized.

being drenched in the same hazy reverb each time. Still, it is not a clean series of samples of the same instrument, proving to be on the edge of untrainability for a RAVE model. Offering a fine, broken enough, quality.

Training took place in Vancouver during the Artficial Muse residency,[9] co-piloted by the French Canadian Institute and the Simon Fraser University, through the Metacreation Lab and its director Philippe Pasquier.[10] Several training and tryouts were needed, while I ended up following Philippe Pasquier's advice of programmatically cutting the sound files in overlapping 2seconds samples, mixed with approximately 60% of the total runtime of silence. The goal being to, following Philippe's advice, "teach my model to be silent, sometimes".



Fig. 3. Preview from *munda m'ennuie* performance visuals.

Signals and Synths

With the model satisfyingly trained, it moved to Max/MSP and the co-creation phase. To better explain my following choices, I will now offer a brief rundown of the audio convolution [nn~] performs; but I want to underline that I do so with a self-taught, empiric form of knowledge. During the model's training, the audio provided is progressively downsampled and its evolution in the time-frequency domain is converted in unnamed latent dimensions, which are discovered by the model. These dimensions are notoriously hard to figure in human terms, but would sometimes loosely correlate to the audio's dynamics/energy shifts, spectral brightness, periodical or noisy nature, and other specifications fundamentally impossible to parametrize. Each of these dimensions serve to map out a continuous latent space, in which each set of coordinates correspond to a probability distribution of frequencies, allowing for the reconstruction of a sound. More importantly, this latent space is specific to each model, depending on the dataset it was trained on. Its number of dimensions, what they represent, and what type of sound it will be able to recreate is unique. But, for any RAVE model, the convolution will

9. *Artificial Muse* residency, a program by the French Canadian Institute: https://www.institutfrancais.ca/en/nos-residences/artificial-muse-vancouver-surrey
10. See the Metacreation Lab website: https://www.metacreation.net/

occur from a signal given to the model that will endure the same down-sampling to find a corresponding set of coordinates, and then recreate the closest resembling result according to its abilities. In short, it will try to create the version of what it knows that resembles the most what it is given. When used within the [nn~] object, this operation happens in real-time, although with an adjustable but unavoidable latency. It is also important to note that [nn~] can either be used as a simple translator: sound → object → sound, or as a more flexible pair of objects: sound → object:encoder → signals → object:decoder → sound.

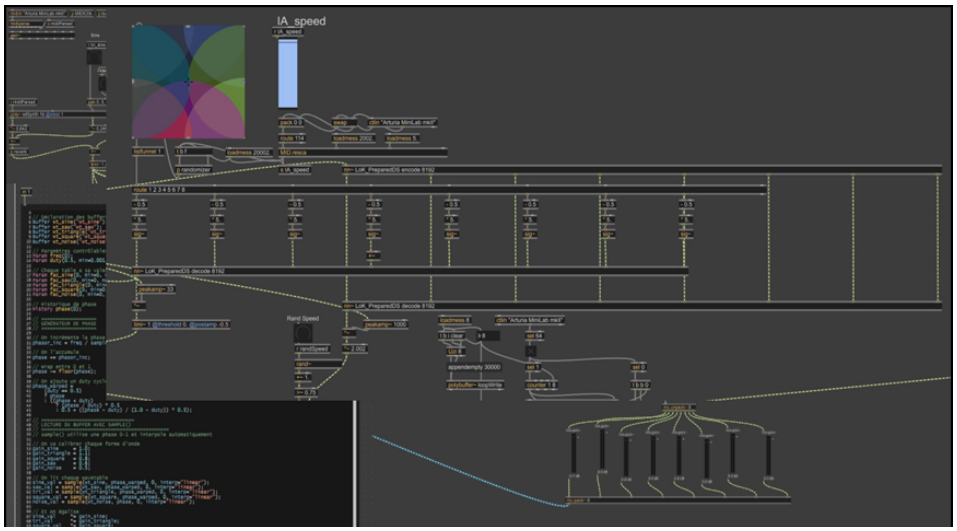


Fig. 3. Edited screenshot of *munda m'ennuie*'s main patch. On the right are the [nn~] signals and treatment.

The signals added in-between the encoder and decoder correspond to an automatically selected portion of the latent dimensions, allowing them to be directly modified. This second option also allows you to multiply the number of both encoders or decoders. From that, I envisioned three ways of working with [nn~]:

1. Sending it a sound that possesses qualities I wish to see in its recreation, without certainty of how the model will react, or even if these qualities were indeed preserved in the model's dimensions.

2. Same, but also adding scalars to the dimensions as the encoded sound is about to be decoded. These scalars being constant, fluctuant or random; added, multiplied or subtracted; applied on one dimension, several, or all of them.

3. Directly sending sets of coordinates to explore the content of the model latent space in the decoder.

I decided to combine solutions 2 and 3.

In order to produce a sound that could serve as a basis, I coded a wavetable synth, equipped with an ADSR envelope filter, a waveshaping distortion and a state-variable filter.[11] This instrument allowed me to produce sound I deemed close enough to the basic material of *Soul Reaver*'s soundtrack, while offering enough variations to push the

11. For more information on these different techniques, see the Max/MSP documentation, respectively:
Wavetable Oscillator: https://docs.cycling74.com/learn/articles/05_mspbasicchapter03/
adsr~: https://docs.cycling74.com/reference/adsr~/
Waveshaping: https://docs.cycling74.com/learn/articles/07_samplingchapter05/
svf~: https://docs.cycling74.com/reference/svf~/

model into unexpected reactions. I also considered it an interesting opposition to have an AI technology, based on unsupervised training and inhuman design, dialog with a highly parametric construct, based entirely on simulated equations. It was as if the expert systems of the eighties were exchanging with contemporary AI.

Both the synth's original sound and [nn~] interpretation of it are then combined through real-time Fast Fourier Transforms, allowing me to quite literally fuse their sonic structures, phases and amplitudes, while controlling which one is more prevalent at every second; as if balancing between my version of Soul Reaver sound's recreation, and the AI's, while keeping both intrinsically linked. Parallely, an object is continuously generating 8 axis coordinates, slowly moving from one random point to the next in a literal exploration of the latent space. This sound, although continuously produced, is enveloped by another ADSR, mirroring the synth's one settings, with varying amount of delay. The goal being to reintroduce harsher, sudden and sharp elements that plays with the somewhat elongated perception of time I mobilize during the performance.



Fig. 5. Lecture performance on musical creation and AI, for the *Master in Digital Media*'s students. *Centre for Digital Media*, Vancouver, 2025

Both the synth's original sound and [nn~] interpretation of it are then combined through real-time Fast Fourier Transforms, allowing me to quite literally fuse their sonic structures, phases and amplitudes, while controlling which one is more prevalent at every second;[12] as if balancing between my version of *Soul Reaver* sound's recreation, and the AI's, while keeping both intrinsically linked. Parallely, an object is continuously generating 8 axis coordinates, slowly moving from one

12. Respectively using the [fft~] and [gen~] functions of Max/MSP. See the software documentation for more details: https://docs.cycling74.com/userguide/frequency_domain/

random point to the next in a literal exploration of the latent space. This sound, although continuously produced, is enveloped by another ADSR, mirroring the synth's one settings, with varying amount of delay. The goal being to reintroduce harsher, sudden and sharp elements that plays with the somewhat elongated perception of time I mobilize during the performance.



Fig. 6. Photographs from performances during the *des objets étranges* exhibition. Ateliers Alain le Bras, Nantes. September and October 2023.

Conclusion

Expanding on that, I will briefly conclude by some words on the performance's aesthetic in itself. I purposefully avoided describing its composition while giving—I hope—enough elements to point in the direction of the kind of moment I am interested in. *Munda M'ennuie* is a mostly improvisational performance and cannot be otherwise, since the other, machinic half of the project tends to never give out the same result twice. Furthermore, I do not think that its subject matter should invoke a place of tranquility, but rather of turmoil. Hence, what I hope to achieve is a drone noise project that is equally foggy, melancholic and abrasive. As the title implies, cleanliness is not what I am after.

Audio recording—Preview medley:
https://arthurkuhn.bandcamp.com/track/munda-mennuie-preview-medley

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The Latent Space Trial

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Can, and should we, put a computational/mathematical concept on trial? What if its impact on culture and the environment is increasingly felt worldwide, even if it's a depersonalised, distributed, abstract, and strange object? Does it bear responsibility? With this performance, we subject latent space(s) to a juridical process. Four researchers, each working on distinct dimensions of latent spaces, namely technical, cultural, philosophical, material, and aesthetic, while attending a round table, are thrown into a scholarly trial where prosecution, defence, and witnesses stage an intellectual confrontation. This trial — where the accused is absent, yet everywhere in its immaterial pervasiveness — makes explicit the performativity and theatricality that are dominant yet understated in the academic and scholarly worlds.

The Trial Has Already Begun

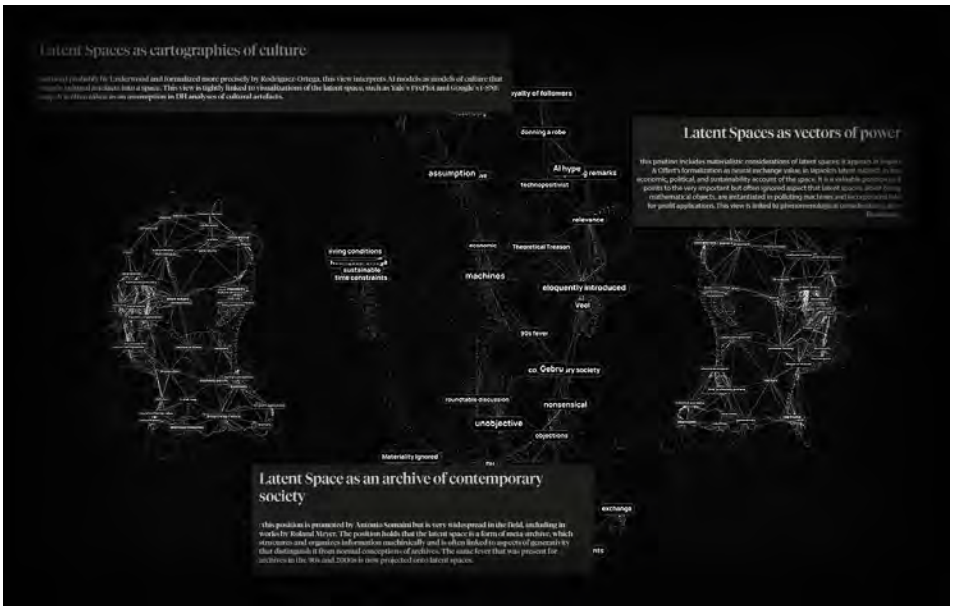


Fig. 1. Anthropomorphized latent space of texts referring to the latent space. Each figure embodies a charge that the latent space is subjected to in the performance.

AI is already on trial. Copyright infringement proceedings challenge the gathering of training material. Bias audits are conducted in ethics committees worldwide. Technical communities question opacity, irreproducibility, and theoretical incoherence. Cultural critics accuse generative systems of epistemic violence and homogenisation. Environmental activists denounce the resource depletion and pollution entailed by computational infrastructures. Yet the trial on AI's ultimate metaphor, the latent space, has not yet happened. This performance stages it.

The form of a fictional trial serves three purposes and is fitting to the latent space. Firstly, it places our attempt into a long history of judging the unsettling and politically urgent, from Elie Wiesel's *Trial of God*

Keywords: Latent Space, Performance, Trial, Generative AI, Computational Humanities, Theatricality, Critical Theory, Digital Art History.

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(1979), Milo Rau's *Zurich and Moscow Trials* (2013), or Tricycle Theatre's *Tribunal Plays* (1994-2012). Much like the dadaists' trial of Maurice Barrès in 1921 (Sanouillet 2005), which acts as a main inspiration, we believe the scholarly community is torn between those who see the value of the latent space and those who contest it, and that it is a necessity for the public debate to lay this contradiction bare. Like the avant-garde group a hundred years ago, by forcibly acting as two opposing groups, and enforcing through characters the conflict of contradictory opinions, we seek to bring some clarity into an otherwise heated debate. The judiciary structure that comes with a trial also allows the untwining of the political, epistemological, technical, or even metaphysical dimensions that such an object fosters.

Secondly, we conceive this performance as a way to bring into the public sphere the debates of academia. Here, the theatrical nature of academia is reversed (Seita 2022), and dry scholarly debate is instead incarnated. The form of a trial, with its debating sides, back-and-forths, repetitions, showcasing of evidence, reenactments, and a place for nuance, is a notable pedagogical instance. The interrupted nature of our trial performance also avoids the risk of imposing a unique view, but rather leaves the audience informed and ready to forge their own opinion.

Finally, as we will argue in the performance itself, we deem the latent space to be a theatrical object in itself. Its protean nature, variety of definition, and the constructed mythology around it turn the latent space into a stage upon which the desires of many are equally at home as the fears and skepticism of others.

The Charges and Their Scholarly Grounds

The starting point for this performance is a collective unrest: a shared uneasiness toward an object that has taken on outsized proportions in our academic and personal lives. That uneasiness is intellectual as much as ethical. We observe that the scholarly literature has produced several major positions on latent spaces, and that each position, examined carefully, yields a charge.

The view of latent space as a meta-archive, promoted by Somaini (2025) and drawing on the archival fever of the 1990s and 2000s, holds that latent spaces structure and organise information machinically, encoding relational properties and generative affinities in ways traditional archives cannot. This view is largely metaphorical and mostly tied to discriminative models such as ResNets, yet it has become pervasive, projecting onto a mathematical object the same cultural desires previously attached to the archive. It yields *Charge 1: Epistemic Violence Through Dimensional Reduction*. To archive is to select and compress; to compress is to erase; and what is erased is not noise but particularity, marginality, and difference. Korzybski's warning is precise: the map is not the territory, and the latent space's infinity of potential states remains infinitely smaller than the infinity of the world.

The view of latent spaces as cartographies of culture, initiated by Underwood (2021) and formalised by Rodriguez-Ortega (2022), and instantiated in tools like Yale's PixPlot and Google's t-SNE visualisations, treats AI models as navigable maps of cultural production. This view dominates digital humanities practice and has produced genuinely productive analytical instruments. Yet it consistently suppresses its own assumptions: that culture can be encoded, that distances in high-dimensional space are semantically meaningful, that the patterns made visible are discoveries rather than artefacts of training. It yields *Charge 2: Cultural Homogenisation Through Statistical Averaging*. The cartographic promise of revealing hidden structure conceals a flattening operation where marginal, contested, and culturally specific artefacts are absorbed into dominant statistical patterns. As Bender *et al.*'s figure of the stochastic parrot suggests (2021), and as Crawford's critique of AI (2021) as the triumph of statistical banality makes explicit, latent spaces do not encode culture but its average.

There is an oscillation between treating, on one side, latent spaces as spaces of Deleuzian potentiality, navigable planes of immanence, and generators of hidden possibilities (Negueruela del Castillo and Neri 2025); and, on the other, as either semi-divine objects rising in a state of despair (Beguš 2026), and as mere statistical approximations, epistemically banal. This oscillation reveals a third and more damaging problem. The same scholarly community simultaneously invokes transcendence and banality, archive and noise, virtuality and approximation. Schaerf's concept of folk theories (2025), after Kempton (1986), sharpens the charge considerably, as many accounts invoke "latent space" for models that do not technically possess one, notably transformer-based architectures where no explicit latent bottleneck exists. The theoretical object on trial may be, in the end, a collective fiction without a rigorous technical referent, applied indiscriminately. This yields *Charge 3: Wilful Inconsistency and Theoretical Incoherence*, or, as the prosecution will argue, treason against rigorous thought. The defence may reframe this as productive cognitive dissonance, a generative ambiguity that has enabled interdisciplinary dialogue. The prosecution will argue it is simply an inconsistency disguised as ambiguity.

Finally, the materialist position formalised by Impett and Offert (2023) as neural exchange value, and developed by Iapaolo (2026) through the figure of the latent subject, insists that latent spaces, however abstract mathematically, are instantiated in energy-consuming machines, incorporated into extractive for-profit applications, and entangled with structures of environmental destruction and economic inequality. The mathematical elegance of the object does not exempt it from the conditions of its existence (Dumas Primbault and Guhennec 2026). This yields *Charge 4: Materiality Conveniently Ignored*. This is a charge that, as the performance will demonstrate, is also a charge against the trial itself: the very form of a scholarly proceeding tends to bracket material consequences in favour of epistemological debate.

Structure and Characters

The performance runs for approximately thirty minutes across three acts, beginning as something else entirely.

Act 1 opens as a conventional academic roundtable. Researchers are introduced; a welcome slide is projected; the moderator sets an agenda. The theoretical disagreement that the roundtable format cannot contain erupts as a conflict. Without announcement, the furniture is rearranged, the moderator becomes a judge, and the roundtable becomes a courtroom.

Act 2 stages the formal opening of proceedings. The court clerk reads the four charges. The Head Attorney for the Prosecution, who began the roundtable as its invited skeptic, delivers opening remarks. The Head Attorney for the Defense, who began as the invited proponent, responds. The two positions, previously constrained by collegial politeness, are now adversarial and unambiguous.

Act 3 calls three witnesses, each embodying a distinct scholarly and human position. The Digital Art Historian testifies to Charges 1 and 2, recounting, in stylised first-person, the experience of working with latent space visualisations as both revelatory and reductive. Under cross-examination by the defence, they are accused of the very behaviours they decry: using the tools, reproducing the compressions, and benefiting from the maps they critique. The Evangelist is called reluctantly by the prosecution to demonstrate Charge 3. The prosecution treats them as Plato treated the sophists, constantly trying to catch them in a contradiction. The defence's cross-examination functions more as reassurance than as interrogation, suggesting that the latent space doesn't care what the verdict is as much as it does about the loyalty of its followers. Finally, Eminent Domain testifies to Charge 4: a person whose living conditions have been destroyed by the construction of a data centre nearby. This testimony is constantly interrupted by defence objections of relevance, sustained by the judge. The material victim cannot speak without being silenced by procedural form. The bureaucratic repeated silencing destroys the trial itself, and participants return back to their original academic personas. A short remark by the now-Moderator concludes the roundtable.

Relevance

This performance contributes to xCoAx's central concerns at several levels simultaneously. It takes a concept native to computational arts research and submits it to the format of a trial, which is both structured rigorously and is theatrical in productive ways. It aims to perform the inter-disciplinarity that the field requires, staging disagreements between researchers with distinct methodological commitments. It employs AI as dramaturgical material rather than as subject of distant critique, making the technology present and active within the performance itself. And it refuses resolution: the interrupted verdict is an

expansion to the field of the audience, who leave informed, implicated, and equipped to forge their own opinion.

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Untracked: A Live Audiovisual Performance on Sexual Harassment in Urban Spaces

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Untracked **is a data-driven live audiovisual performance which explores how "liveness" can facilitate engagement with difficult and often stigmatised social issues by creating a shared space. Focusing on sexual harassment in urban spaces, the work adopts the city of Milan as a situated case study. It addresses the issue of underreporting and the scarcity and fragmentation of institutional data. To achieve this,** ***Untracked*** **employs a constructed dataset in which gaps and missing information are central components alongside heterogeneous materials, including institutional and survey-based indicators, selected testimonies, and qualitative variables. Rather than aiming for an objective or exhaustive representation, the dataset supports an artistic interpretation of sexual harassment, highlighting patterns, intensities, and absences. These data inputs are translated into synchronised sound and visuals through data visualisation and sonification strategies, including parameter mapping, temporal modulation, and layered composition. This paper presents an early conceptual framework for the ongoing project, outlines the thematic foundations, describes the dataset construction, and data translation approach, serving as a basis for future developments.**

Introduction

Untracked is a live audiovisual performance aimed at supporting social change as well as an ongoing practice-based artistic research project. The performance situates itself within the frameworks of media and digital activism, as discussed by Fernandez-Castrillo and Mantoan (2024). It addresses gender-based violence in urban public spaces, with a particular focus on sexual harassment in the city of Milan, Italy. Milan was selected both for reasons of personal connections to the city and for situational reasons. Survey data from ISTAT's Indagine sulla sicurezza dei cittadini show that sexual harassment and gender-based violence remain widespread in the country, particularly affecting women in urban environments (ISTAT, 2024). Against the national backdrop, available police statistics indicate that the metropolitan area of Milan reports relatively high numbers of recorded sexual offences compared with both regional and national averages (Città Metropolitana di Milano, 2023). Data on sexual harassment is fragmented and affected by underreporting and institutional practices (see Sec. 2). Therefore, data and its conditions are central to the project. To drive the audiovisual performance, the dataset is constructed from institutional indicators, surveys, reports, and selected testimonies. Underreporting and data gaps become part of the artistic concept in order to highlight invisible elements. The following sections outline the project's thematic framework, artistic concept and technical design, as well as future developments.

Keywords: Audiovisuals, Performance, Data Visualisation & Sonification, Generative Art & Design, Feminist Data Practices, Activism.

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Background

Audiovisual Performances as Social Commentary and Exchange Space

Similarly to Fernandez-Castrillo and Mantoan (2024), McCarthy (2014) discusses audiovisual performances as both an aesthetic medium and a format that supports social commentary. From McCarthy's perspective, the live dimension can facilitate a space for exchange where conversation, spontaneity, and shared insights can emerge through the performance situation rather than through didactic explanation. McCarthy also notes that incorporating information and datasets can enhance the contextual relevance and plausibility of a performance without reducing it to a purely factual statement.

More recent practice-led research provides concrete examples of audiovisual performances that are explicitly designed around social themes. For example, in her 2021 performance *Bad Mother / Good Mother,* Annina Rüst (2021) addresses the politics and poetics of invisible labour and motherhood. Using sound and projected visuals, she explores social expectations and their emotional impact. Similarly, Troisi's (2018) *OB-Scene* connects a live audiovisual system to the gendered politics of the body by sonifying bodily data acquired through a medical sensor and staging the apparatus itself as part of the critical framing.

Alongside peer-reviewed work, contemporary practice also demonstrates how live audiovisual performance can address socio-political issues through data-driven or research-informed methods. *Erratic Weather*,[1] for example, is a data-driven audiovisual performance based on weather data and climate-related concerns (Le Sourd and Vos 2019). *Surveillance Suite*[2] uses research-informed audiovisual translation to explore cybersecurity and public surveillance (Raumperspektive 2017). *Urbanrecall 05*[3] connects live audiovisual practice to protest footage, raising questions about mediation and information (VRTX 2021).

Gender-based Violence and Sexual Harassment in Urban Public Space

Gender-based violence (GBV) is violence that is rooted in gendered power relations, and it can occur in domestic, institutional, and public contexts. This project focuses on sexual harassment in urban public space. According to UN WOMEN, "sexual harassment involves sexualized forms of unwanted or unwelcome behaviour or conduct. [...] Sexual harassment can be physical, psychological, verbal and non-verbal and can include conduct such as: sexual violence and assault, including rape; unwelcome request for sexual favors and dates; unwelcome touching; leaning over; cornering; stalking; making sexually-lewd comments or unwelcome communications of a sexual nature, including display-

1. http://www.maotik.com/erratic/
2. https://raumperspektive.com/#surveillance_suite
3. https://vrtx-void.net/works/urbanrecall-05?

ing or sharing sexually lewd pictures and pornographic material." (UN Women 2019, 6).

The EU gender-based violence survey[4] confirms the structural scale of violence against women: one in three women in the EU have experienced violence in contexts including the home, workplace, and public spaces (FRA 2024). Italian survey data indicate that harassment in everyday life is also widespread and takes various forms. ISTAT reports that, between 2022 and 2023[5] 6.4% of women aged 14–70 experienced some form of sexual harassment in the previous three years. The most common form was in-person verbal harassment (3%), followed by stalking/pursuit (1.8%), exhibitionism (0.7%), and physical sexual harassment involving unwanted contact (1.3%) (ISTAT 2024).

Underreporting, Data Gaps, and Feminist Data Practices

The EU gender-based violence survey reports that only 13.9% of the women who have experienced violence have reported the incident to the police (FRA 2024). In Italy, ISTAT (2024) reports that 94% of women who experienced physical sexual harassment outside of work in the last three years did not report the incident. According to Anastasi and Rusi (2025) there are multiple reasons why victims remain silent, including fear, shame or lack of trust to authorities.

This limited reporting creates a discrepancy between lived experience and institutional record. Estimates based on reported experiences are therefore likely to understate the scale of sexual violence and do not represent the full extent of this violence in the general population (World Health Organization et al. 2025, 3).

Feminist approaches argue that datasets are not neutral artefacts but are shaped by unequal power relations and by the politics of counting and classification (D'Ignazio and Klein 2020, 18). In this sense, data gaps are more than just missing information; they signal what is prioritised for measurement and what is excluded from representation (D'Ignazio and Klein 2020, 34).

Feminist and activist initiatives such as "Safecity"[6] and "Right To Be"[7] (formerly "Hollaback!") respond to these limitations with participatory data practices that collect testimonies and map harassment in order to produce alternative forms of visibility. These initiatives aim to make underreported experiences visible and usable for communities and administrations (Safecity n.d.; Right To Be n.d.).

4. https://fra.europa.eu/en/publication/2024/eu-gender-violence-survey-key-results
5. https://www.istat.it/wp-content/uploads/2024/07/REPORT-Molestie.pdf
6. https://webapp.safecity.in/view-data
7. https://righttobe.org/

Artistic Concept

The presented pieces of related work in the previous section establish live audiovisual performance as a format for social commentary, combining sensory immersion with critical analysis. *Untracked* builds on this argument by incorporating data into a live audiovisual system so that the audience can approach a socially relevant and often stigmatised topic in an artistic context. Rather than presenting data as a proof, the performance aims to use data-driven translation to create a shared experience of attention, in which patterns, intensities, and absences can be encountered experientially.

Untracked builds a custom, evolving dataset that combines statistical indicators, textual testimonies, qualitative variables, and intentional data gaps. Absence is treated as a core conceptual component rather than missing information. The dataset is translated into audiovisual form through a rule-based system structured around three mechanisms:

1. Abstraction – Data is assigned to abstract audiovisual forms, prioritising perceptual impact over literal representation.

2. Parameter Mapping – Data features (e.g., magnitude, recurrence, categories) are mapped to sound and visual parameters, producing recognisable shifts between data types.

3. Modulation – The temporal and performative control of the system, determining how layers are activated, combined, or reduced over time through predefined behaviours and live decisions.

This process generates a synchronised data stream shared by MAX/MSP and TouchDesigner. Both platforms interpret the same data logic, ensuring coherence between sound and image, while processing remains media-specific: MAX/MSP handles sound synthesis and signal processing; TouchDesigner handles visual generation and real-time modulation.

Rather than presenting data as evidence, the system stages it as an evolving experiential process in which indicators, testimonies, and absence unfold over time.

Visual and Sonic Outputs

Each data input is processed using a consistent audiovisual vocabulary, enabling shifts in data type to be perceived as changes in sound and image, even when the mappings are not clearly one-to-one representations. The output layer is designed to produce recognisable changes in rhythms, tones, textural voices, and silence on the sonic side, and in shapes, motion, text fragments and empty space on the visual side. This approach enables situated interpretation, allowing the audience to discern when the system shifts from aggregate indicators to lived experiences, or from recorded information to silence and discontinuity.

Statistical data is mapped to measures of distribution, recurrence, magnitude, and categorical differentiation. In the visual domain, counts and frequency values directly control event rate, spatial density, and

clustering behaviour. An example of abstract visualisation controlled by statistical data related to victim count can be seen in Fig.1. Magnitude affects scale, opacity, and motion speed. Categorical variables determine colour systems and geometric typologies, as seen in Fig.2. In the sonic domain, magnitude drives amplitude levels and dynamic envelopes, while recurrence controls rhythmic triggering rates and granular density. Categorical variables route signals between distinct timbral families through synthesis and spectral filtering. Where multiple variables are available, distributions can be rendered across spatial positioning in both the visual field and the audio space.

Testimonies and narrative data act as intermittent structural anchors rather than continuous representational content. Visually, they appear as sparse textual fragments and short phrases embedded within the abstract field, alongside the occasional full-text insertion in plain typography. An example of full-text insertion can be seen in Fig.3. Sonically, testimonies are translated into processed, vocal-derived textures. Textual attributes determine granular density, spectral filtering intensity, temporal stretching, and spatial diffusion. This ensures the presence of narrative material without reproducing speech directly.

Absence, and missing data operate as active compositional variables. Visually, data gaps produce blank temporal intervals, abrupt reductions in event density, and incomplete or disappearing geometries. A visualisation example of missing data can be seen in Fig.4. Sonically, missing data triggers threshold-based gating, extended low-level noise floors, abrupt dropouts, and sustained, near-inaudible dynamic states. Silence functions as a controlled reduction in amplitude, temporal activity, and spectral content, explicitly marking underreporting as a deliberate design choice rather than a technical failure.

During the performance, these layered outputs are activated and shaped through modulation, enabling the transitions between indicators, testimonies, and silence to be composed in real-time.

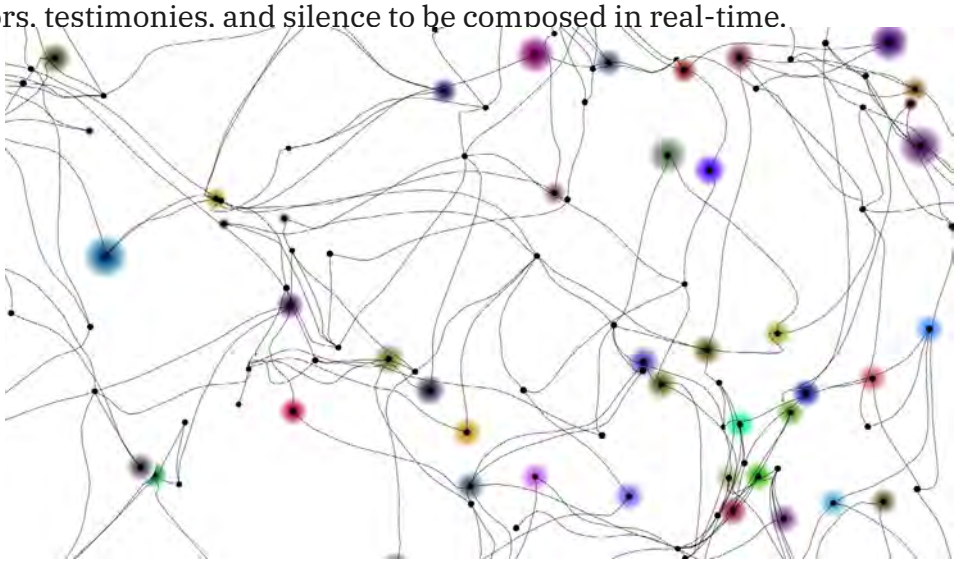


Fig. 1. Abstract cluster visualisation of women, in which colors represent the victim of sexual harassment in Milan, Italy.

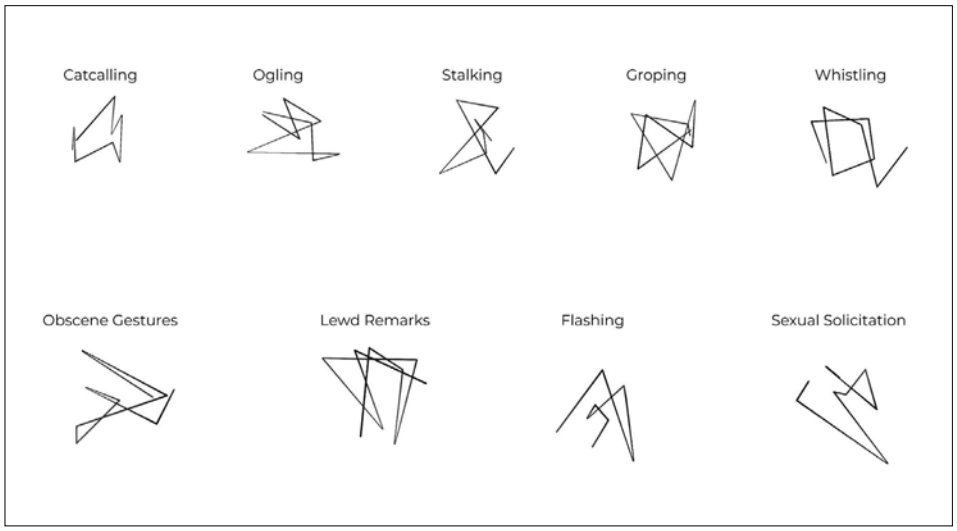


Fig. 2. Using different seed value on a random pattern generation, different categories of sexual harassment are translated into abstract visualisations to be used in the statistical data layer.



Fig. 3. Example of text visualisation of a testimony. Different colors highlight different variables, such as moment of the day, location, type of sexual harassment, perpetrator and emotional response.

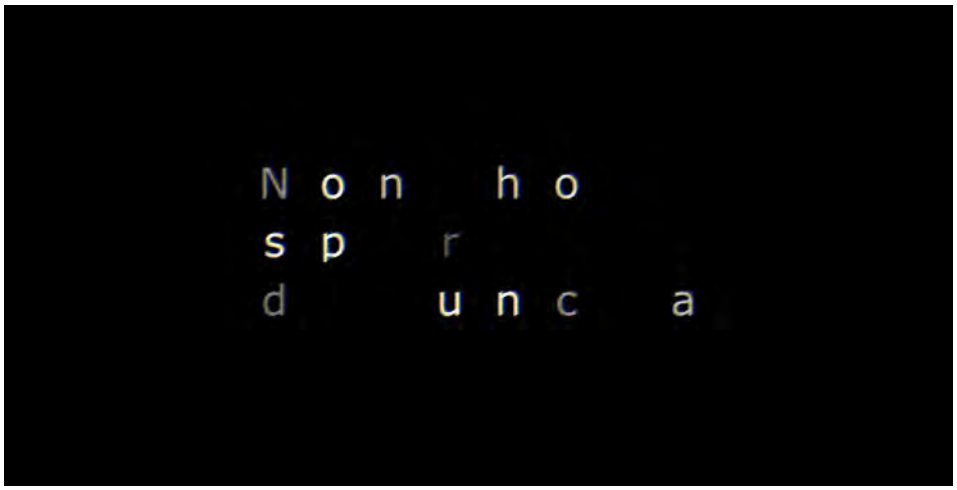


Fig. 4. Example of missing data visualisation. The sentence of an unreported sexual harassment appears unreadable as characters switch from full opacity to invisible.

Conclusion

This paper presents the conceptual and methodological foundations of *Untracked*, a data-driven live audiovisual performance. Using a necessarily partial dataset on sexual harassment in Milan, the project foregrounds selection and absence, translating both recorded indicators and gaps into audiovisual material. Mapping choices, temporal pacing, and live modulation reveal patterns and intensities, while abstraction allows sensitive experiences to be expressed non-literally. Future work

will consolidate data, refine mapping strategies, and stabilize the performance. The project will also explore how liveness and the treatment of missing data shape audience engagement, while addressing risks such as misrepresentation or retraumatization. The next iteration will enhance contextual framing and audience guidance alongside audiovisual design.

Additional Information

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Link. Audiovisual Live Performance Portfolio 2025, including *Currents & Tides* presented last year at xCoAx in Dundee, Scotland: https://drive.google.com/file/d/1n7e3gAzqxZOQAynOvJcsSjJZ9DFsf3Uv/view?usp=sharing

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Enter_phase: Negotiated Agency with Live Electronics and Interactive Audiovisuals

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Enter_phase **is a live-electronics work featuring an interactive audiovisual interface. The system responds to sound input, processing and generating audio and rendering visuals in real time. The work establishes a reciprocal dialogue between performer and computer, where the musician both shapes and follows the audiovisual feed, and the audience witnesses the dynamic interaction with the interactive digital score. Patterns of rhythm, pitch, and input density form a visual data field that partially reveals the underlying machine-listening and audio-processing algorithms, while a live video of the performer adds a gesture-mirroring layer shaping real-time decisions. The work situates digital musical instruments as experimental platforms, exploring negotiated agency and performative materiality. Drawing on traditions of graphic and algorithmic notation, the work examines multimodal perception, highlighting how interactive audiovisual systems transform the production, experience, and understanding of music in computational media contexts.**

Overview

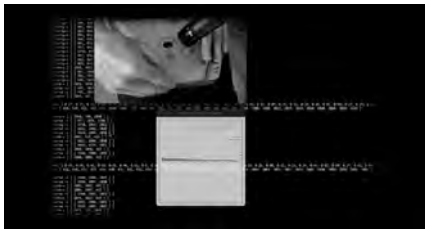


Fig. 1. *Enter_phase*, version with zither.

Enter_phase is a live-electronics work that uses an interactive audiovisual interface. Implemented in SuperCollider, the system performs real-time audio generation and visual rendering in response to sound input. The work establishes a reciprocal dialogue between the human performer and the computer, in which the musician both shapes and follows the audiovisual feed, the latter acting as an interactive digital score. The audience witnesses the performer–system interaction through real-time audiovisual output. The work is suitable for any instrument or number of instruments (Fig. 1, 2), and xCoAx 2026 features a version for bass guitar.

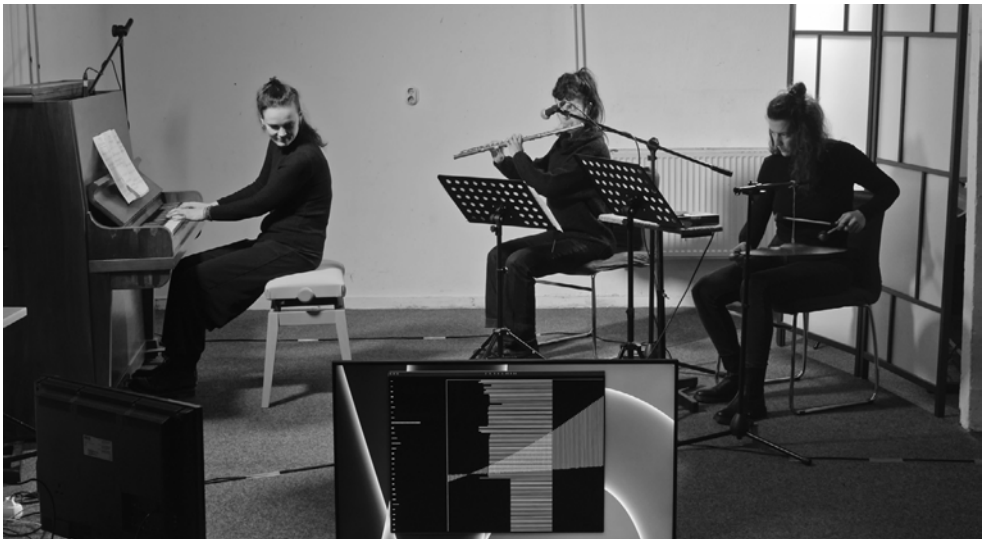


Fig. 2. *Enter_phase*, live performance with Catchpenny ensemble (The Hague, The Netherlands).

Keywords: Interactive Audiovisual Systems, Live-electronics, Human–computer Interaction, Digital Musical Instruments, Multimodal Perception, Digital Animated Notation.

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A key feature of the audiovisual system is its three-way configuration involving musician, system, and audience:

– The computer analyses audio input, rendering it as visual data while simultaneously generating sound;

– The audiovisual feed acts as an improvisational interlocutor: the musician responds to the sounds and visuals while generating sounds that are fed back into the system;

– The audience experiences this exchange through the visual and sonic environment.

This triadic feedback also informs the technical side of the discussion: how the machine-listening algorithms register the input, how the digital audio is being processed, and how the audiovisual mapping shapes the performance.

The Control Interface

The interface affords a sense of agency over the system's responsive features. It visualises the underlying machine-listening algorithms as continuously updated patterns of rhythm, pitch, and input activity. In Fig. 3 (left panel), rhythm is represented by vertical lines whose length corresponds to inter-onset intervals (time between detected onsets, in milliseconds). Pitch is visualised on the right panel as horizontal lines whose length corresponds to frequency (Hz). Input activity is shown on the right panel, where vertical lines above and below the "equator" indicate accumulated onset density. This data matrix is generated from a circular buffer – a continuously overwriting collection of stored values. The audio-derived data drives live processing, including FM synthesis parameters and the rate of triggered events, as displayed in SuperCollider's post window (Fig. 4, 5, 6) .

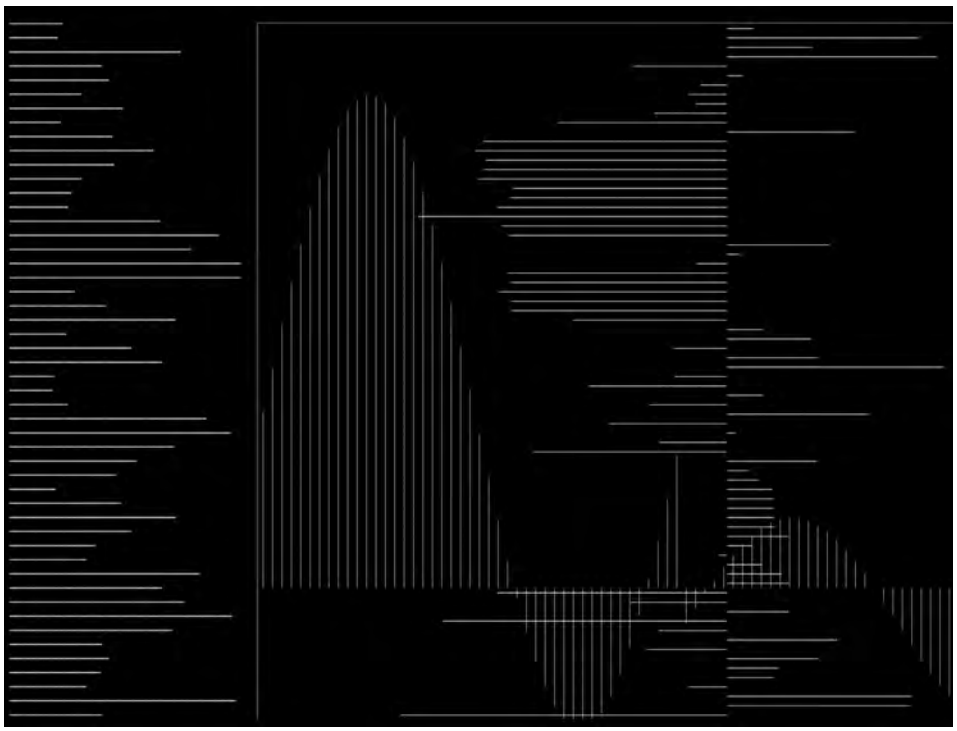


Fig. 3. The visual data interface in SuperCollider.

Negotiated Agency, Between Control and Interplay

The algorithmic processes draw on a complex array of sonic materials and structural relationships, creating a live-electronic environment that the musician inhabits. Together with the audiovisual interface, the performance becomes a form of navigation within a musically responsive system. The music unfolds along an emergent, ever-evolving path, rather than following a procedural execution of an interactive experiment.

While playing (with) the system, I experience a constructive tension between exercising a more instrumental control over the system and focusing on the musical and improvisational interaction. I often find my attention divided between these two different performance modi operandi. On the one hand, agency over the interactive features of the system is explored: the audiovisual interface reinforces this dynamic by encouraging the exercise of control over the computer through reading the visual interface and shaping the output sound by "administering" recorded data. On the other hand, I also recognise a different kind of interaction, which is based on sonic gestures and constitutes an improvisatory interplay with the computer. This latter mode requires, in a certain sense, setting aside the more immediate visualisation of my gestures; instead, I find myself working towards creating an emergent musical form that combines my own sounds with those of the computer. The outcome of this constructive tension repeatedly surprises me in musically engaging ways. It positions the computer as a responsive counterpart that, while not human, operates through its own modes of listening, musical memory, and decision-making processes. The system becomes involved in the real-time structuring of the music.

In addition to the data matrix, a processed live video (in Processing language) of the musician can be integrated as a background layer. This layer is also subject to interactive, machine-listening algorithms: the higher the input's activity or density level, the smaller the pixels become, so that, while at complete rest, the image is distorted through coarse pixelation (Fig. 4 and 5). Watching oneself perform produces a hypersensitive visual field – an additional layer of information that shapes decisions in real time. The entire process is also visible to the audience: a performative situation that exposes the inner workings of the processing algorithms while staging the musician's self-observation, akin to looking into a mirror (Fig. 6).

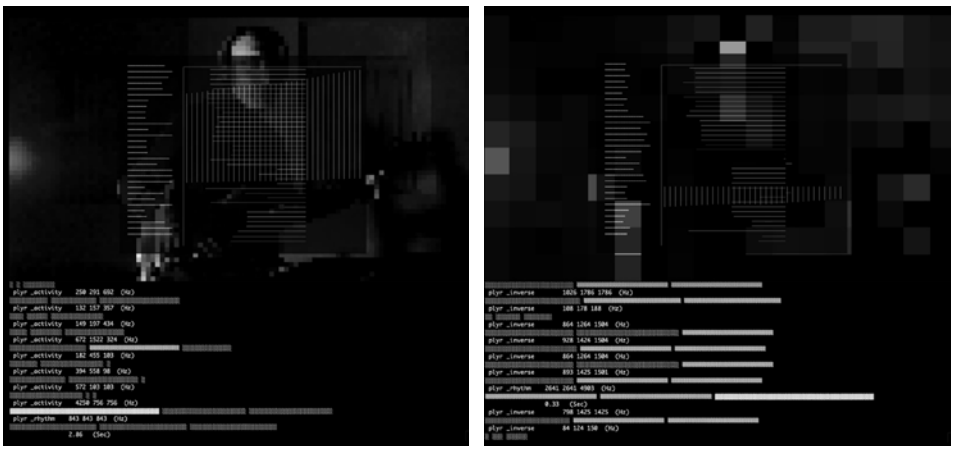


Fig. 4 and 5. The musician's processed imwage as a background to the visual data interface. Two pixelation rates, showing a more clear representation of the musicians, and a more abstract one.
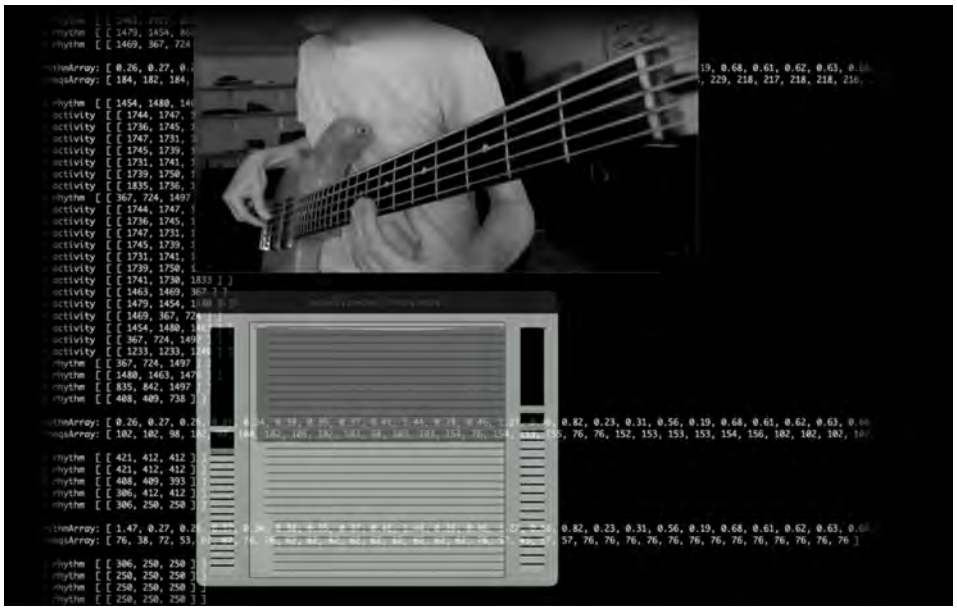


Fig. 6. The musician's image and the visual interface, with SuperCollider's post window as background.

Enter_phase serves as a case study for the role of interactive audiovisuals in shaping musical experiences: the visuals augment the sonic, mediating the real-time interaction taking place on stage to the listener-viewer. The computer acts as a connecting node between the performer's actions and the audience's perception, structuring a hybrid physical–digital space co-inhabited by both. Between the stage, the image of the musician performing, and the various data mappings (graphic representation, post-window text-based elements), an intermediate space is created, inhabited, and explored by both musician and audience; a space that functions as a site of negotiated agency and performative materiality.

Theoretical Discussion: Audiovisual, Multimodal Thinking

The work seeks to create a space – both artistic/experiential and conceptual/theoretical – for experimenting with audiovisual, multimodal thinking in composition and live performance. It engages with fields such as human-computer interaction and digital humanities by positioning artistic experimentation as an interdisciplinary mode of inquiry informed by ontological concerns. The basic assumption is that "the [audiovisual] interface is ultimately something beyond the screen, [...] a gateway that opens up and allows passage to some place beyond" (Galloway 2012). The capacity of interactive audiovisual systems to open up paths of experimentation and exploration makes them an ideal starting point for both technical and critical discussion. Also relevant here is the application of the term diegesis (originally from film studies), in reference to the "physicality of the link between sound and image [...] Diegesis is where audiovisual relations happen" (Boucher and Piché 2020). The performance observes the spatiotemporal universe, facilitated by the machine-listening and audio-processing algorithms, in which sounds and images are perceived as part of the same environment. An-

other relevant notion is the imperative to “make technologies visible: to pay attention to them, look for their presence, and engage with them critically” (Carvalhais 2022). The ways in which interactive audiovisual systems enable experimentation and exploration make them a productive site for this kind of critical discussion in digital media theory and creative computation. *Enter_phase* contributes to the critical discourse by examining the effect of seeing our own rendered image on screen on our sense of agency and behaviour.

Digital Musical Instruments and Performative Materiality

Likewise, the conceptualisation of digital musical instruments as experimental platforms for critical inquiry provides a theoretical framework that informs the discussion. Through questions of negotiated agency, the performance is situated as a site of knowledge production that frames digital musical instruments as epistemic objects rather than neutral tools, whose open-ended nature enables the emergence of further knowledge (see Rheinberger 2007). One related concept is the notion of handles, intended to confront the abstractness of the computer head on. Each link between performer and computer has to be invented before anything can be played. But these ‘handles’ are just as useful for the development or discovery of the piece as for the performance itself (Ryan 1991).

Another important notion is performative materiality, which “emphasises the production of a work as an interpretative event,” (Drucker 2013), articulating how objects and systems take shape through situated, interpretative practices. Both ideas demonstrate how digital music instruments should be understood as actants in the musical process – be it composition-through-coding or performance; as such, the work becomes a case study of both digital system design and computer performance practice, investigating how perception, interpretation, and decision-making are shaped by real-time computational mediation.

Interactive Notation, a Non-representational Approach

The work’s visual output brings into the discussion the topic of music notation. Historically speaking, interactive notation in music and media art emerged from early experiments that blurred visual design and sonic performance: for example Cornelius Cardew’s graphic scores that emphasised performer agency through graphic interpretation; Laurie Spiegel’s algorithmic-visual compositions with the VAMPIRE system; or Xenakis’s Mycenae Alpha created with the UPIC system, translating hand-drawn images into sound. These foundational works inform today’s screen-based and interactive tools, linking musical notation with the work’s interactive, digital animated and algorithmic environment.

Along these lines, *Enter_phase* suggests a non-representational approach (Boyd & Edwardes 2019, Hope 2025) to notation, one that seeks to exceed a direct and potentially over-simplistic relation between what we see and what we hear. As asserted by Croft,

> if the mapping is too explicit, too transparently one-to-one, the result is not only tedious but may have the effect of shifting the procedural into the foreground, turning the piece into a lamentable 'showcase' of the technology ('Look – I do this, and the computer does that!'). (Croft 2007)

In this sense, notation is explored beyond its traditional musical practice: as an interactive element, a hybrid monitoring display and a performance feedback, and as an actant in an emergent musical dialogue. The non-representational approach also becomes pivotal as a mediating platform between the stage and the audience. As Kyriakides asserts,

> transparency is created between the score and the audience, where the code used by the musicians is shared with the listener. Whether the information that is shared with the audience is relevant or significant in any way in enhancing the experience of the work might be questionable, yet the possibility of sharing the blueprint of the music gives the audience the opportunity to engage in multiple ways. (Kyriakides 2026)

Notation functions as a tool for engagement and for negotiated agency – both between musician and computer, and between stage and audience. It unfolds a musical improvisatory path as an interpretative event (linking back to performative materiality), as much as it constitutes an invitation for the audience to engage with interactive technology through the audiovisual staging of machine listening.

Concluding Note

Coming back again to the tension between guiding the system and playing with it, *Enter_phase* explores the liminal spaces between the materiality of the audiovisual system, the way it interacts with a human musician, and the processed sound. By investigating the role of interactive audiovisual systems within the field of live-electronic music and contemporary/experimental composition practice, I aim to expand our perception and understanding of the links between sound and visuals, through a multimodal perspective – one that listens to and sees the world at the same time.

Links. The work is available online:
Enter_phase (bass guitar)
https://vimeo.com/showcase/12207859?fl=so&fe=fs
Enter_phase (various instruments)
https://www.youtube.com/playlist?list=PLFpz7hZaBblhacuTTrgff-CHeFK9dZTgk3

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The UnControlled Manifold: Dancing with Sympoietic Machines

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A performance featuring idiosyncratic miniature electronic machines that combine autonomy and interaction in a fascinating way. Dancing on overhead projectors, their sound and movement enter into a complex interplay that is both audible and visible: danceable polyrhythms meet a hypnotic shadow play of mechanics and light. Analog oscillators control self-organizing dynamics—a living system of sound, movement, and image emerges.

Doing Things Over and Over Again

Since more than 20 years I have been working with the same circuit, the bi-core oscillator, an analog circuit to drive critter-like walking robots, developed by Mark W. Tilden in the early nineties of the last century (Hasslacher & Tilden 1995). Why do I stick to a single circuit for so long? Over the years I have been following the advice of Heinz v. Förster, engraved in a beautiful track “noch einmal” (once more) by Ester Brinkmann: “please never say: this is boring, I know this already, this is the biggest catastrophe, always say: I want to experience this again” (Brinkmann 1998).

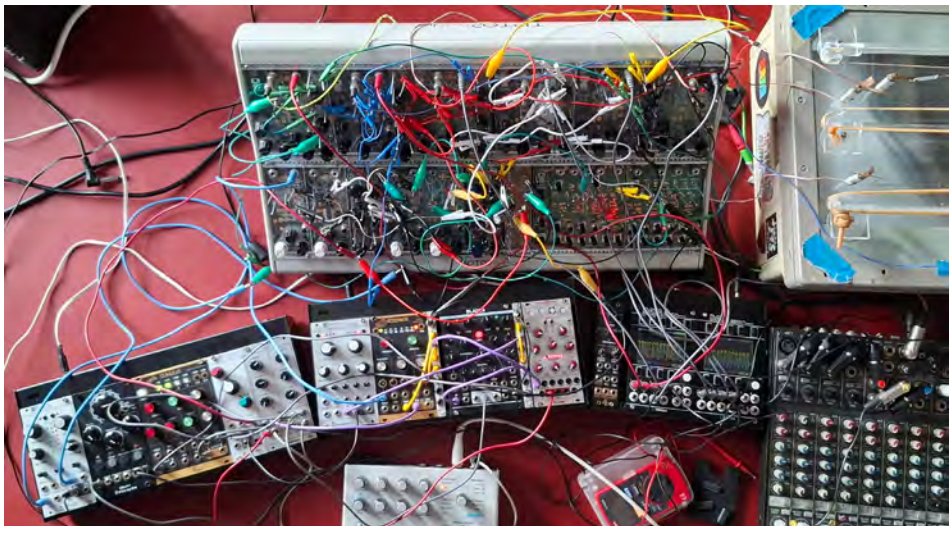


Fig. 1. The Performance setup: bi-core modules integrated into a modular Eurorack.

Doing the same thing over and over again is a special path of discovery. My first contribution to the xCoAx conference in 2013 was a lecture where I used these circuits to convey insight about embodiment (Faubel 2013). I can’t count how many times I have redesigned bi-core circuits as PCBs, my latest versions are Eurorack compatible and thus easily integrated into a modular Eurorack synthesizer setup. This change has heavily impacted my performance practice and I am getting to a point where people feel seduced to dance to my set.

Keywords: Embodiment, Analog Electronics, Emergence, Self-organization, Polyrhythm, Machine Choreography.

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An Invitation To Dance

This is an invitation to dance, to dance together with machines, machines of a different kind, non-deterministic, machines that blur the line between the animate and the inanimate. Electronic pulsation in a network of more than 30 artificial analog neurons, emergent polyrhythms as a result of mutual connectivity, feedback as core principle is what makes motors dance with rubber bands. The network is autonomous, it pulsates without human intervention, playing with it relates to the very nature of playing as an act of discovery and dialogue.

As a performer I co-create the score through careful adjustment of a multitude of parameters. The music literally emerges, patterns snap in, phase locking produces polyrhythmic beats, a change of parameter destabilizes and leads to the locking onto a different pattern. The main ingredient of this wild patch are dynamics, at the core is time, the passing of time and timing, the physical discharge of current, the non-linearity of semiconductor material, the voltage drop when motors hit a physical resistance. Every detail matters, nothing is abstracted away for the sake of stabilizing a symbol, there are no symbols, no representation, no code, no script, but a ritual, a taming of wild electronics.

While the rhythmical structures of electronic music are usually realized with a step-sequencer, that inherently encodes music as discrete events attached to symbols, a zero or a one, a sound produced or skipped, here the polyrhythmic patterns emerge as a result of a subtle exchange of electronic forces that lead to synchronization effects. Such synchronization effects can only appear in analog systems, digital systems do not have access to such phenomena, exactly because of their underlying symbolic structure and the limitations of their operational model the Turing machine (Faubel 2020).

The machines are sympoietic in Donna Haraway's sense (Haraway 2020), sound and music are co-created through entangled, non-hierarchical relationships—where the performer, the machine, and the environment cannot be separated. My practice in working with these machines as well as my attitude towards them have changed over time. In the beginning I was fascinated by the autonomy, little critters creeping on the floor, manifestations of the idea of autopoiesis, almost living machines. Performing with the machines has shifted my focus and fascination, away from their autonomy towards a curious approach of interaction, manipulation and observation. I have become aware that this relationship with a machinic system is better characterized by considering it as a sympoietic relation, just as Donna Haraway frames it, when she quotes M. Beth Dempster with her definition of sympoiesis:

> Collectively-producing systems that do not have self-defined spatial or temporal boundaries. Information and control are distributed among components. The systems are evolutionary and have the potential for surprising change. (Dempster qtd. in Haraway 202)

When you dance, a strategy for enjoyment is to try to mute your inner critic and rather focus on your breath and heartbeat, the two rhythms that keep you alive. The pulsation of your heart is created by a nervous network that communicates with your brain and the neurons involved are in principle not different from those in the brain. Similarly, what makes your arms and legs move rhythmically are neural networks located in your spine. Metaphorically the network of 30 artificial analog neurons driving the polyrhythmic movements are the spine and heart.

Unstable Setups and Deliberate Vulnerability

The setup is meant to be unstable and during performance I deliberately put myself in a vulnerable position, many things can go wrong, some things go wrong. I place motors and holders of rubber band on the screen of the OHP using suction-cups, no precise placement is possible, motors need to be re-adjusted and can also be rearranged on the fly. Having such an unstable setup is a deliberate choice.

The same is reflected by the analog circuitry driving the motors, while the basic bi-core oscillator is very robust, allowing the performer to adjust both movement, the hitting of the rubber band and the consecutive break. But when 15 oscillators are mutually connected in a wild patch, the system is on the edge of stability and sometimes an oscillator stops working, or it takes 3 minutes before the oscillators go into a coordinated pattern.

I embrace this vulnerability, because it is where liveliness and adventure are to be found, it requires a ritual and an openness of all senses, attentive listening and relaxed attitude during the performance, switching off the brain, helps.



Fig. 2. A video from a previous performance (November 2025) (https://makertube.net/w/66snvCozVLc7CXBkWhH7ni).

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Bacteriophage in Granular Waves

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Bacteriophage in Granular Waves **is a musical work and performance that adopts data-driven composition methods, generative systems and sonification techniques to produce a musical work from a synthetic virology dataset. It has emerged from a larger collaboration exploring creative and artistic strategies for the visualization and sonification of virology data. The system employs agent-based modelling to draw samples from the dataset and uses waveshaping and granular synthesis methods to map these data to musical parameters. The end results is a performance that is always in flux where simple waveforms are sliced into tiny sections and reconfigured into texturally rich tapestries that interweave through one another shifting and unfurling in response to the virological parameters represented in the data.**

Overview of the Piece

Bacteriophage in Granular Waves is a data-driven musical performance that employs generative sonification techniques to map synthetic virology data to musical parameters. It is the result of initial steps towards the development of a more generalised system for sonifying viral genomics data for contexts in biomedical analytics and education. The data was created in-silico and modelled after the characteristics of viral bacteriophages we might expect to find in human tissue samples. The data of interest are base pair (bp) length and coverage values which are measures of the physical length of the double helix for a given DNA strand and the completeness of the genomic sequencing process respectively. While coverage gives a sense of how much of a given bacteriophage is present in a sample, the bp length of a viral genome provides an indication of the size and, to some extent, the complexity of a given virus. The system maps the data to control the parameters of a generative system, specifically an agent-based model simulation consisting of an ecosystem of autonomous agents where each agent represents a unique bacteriophage in the dataset.

The agents are engaged in simple target seeking behaviours in a 2D environment, intermittently passing through a ‘bacterial hotspot’ which causes their data associated to be passed to the sound synthesis routines. Their speeds and steering rates are determined by the data. This simulation is visualised and projected live during performances. Agents entering a hotspot send their midi notes to wavetable synthesis routines to produce a signal. The first round of sound synthesis mappings is focused on representing the data at the timbral level. Synthesis parameters are mapped to the data to ensure that the audible clarity of the sound produced is driven by the coverage while the spectral complexity is mapped to bp length. These signals are sent to granular synthesis

Keywords: Performance, Virology, Data, Sound, Music, Drone, Visuals, Noise.

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routines for further processing. At this layer data are mapped to represent the data at the textural layer with coverage defining the audible clarity of the textures while bp length defines the textural complexity of the sound. The result is a rich sonorous soundscape that operates as an aesthetic experience of the data as rendered to sound by a data-driven generative music system.



Fig. 1. Performance at AMICAD 2025.

Aesthetically the system is informed by George Lewis' (2000) *Voyager system*, Iannis Xenakis' (1967) algorithmic compositions (e.g. *Pithoprakta*) and Brian Eno's *Discreet Music*. From the sonification point of view Fitch & Kramer's now infamous paper "Sonifying the Body Electric" provides a key motivation specifically in its introduction of the concept of 'piggybacking' multiple streams of data onto the parameters and behaviours of a single sound object.

There are several interconnected motivational dynamics at play in the design and expression of this piece while the technical and aesthetic have been explored in depth elsewhere (Roddy et al., 2026), the piece is considered here from a more theoretical point of view. *Bacteriophage in Granular Waves* concerns itself with questions of agency, scale and complexity. Bacteriophages are viruses which exclusively target bacteria. While bacteria are living single-celled microorganisms, the viruses that prey upon them are neither living nor dead but rather a unique category of thing (possibly agents) that exists on the periphery of biological life.

The question of whether a virus can be said to have agency is a complex one, not least because the traverse their environments in a random and passive manner. In this piece I choose to foreground this tension framing the bacteriophage as agents by employing the agent-based-modelling techniques to represent the viral data, while also retaining the randomness in the motion of these agents. As can be tracked in the visuals, the viral agents move at random across their environment re-

leasing their data as sonic information when they encounter a viable bacterial host, denoted by the green agglomeration at the centre of the screen as per Figure 2. The amount of data that any one virus releases is minimal given that they only carry the aforementioned values for bp length (as a proxy for viral complexity) and coverage (counting the number of times a virus appears in the sample). These small chunks of data layer upon one another building in complexity when they are sonified and the scale of the data is finally revealed as a play between clarity and complexity across timbral and textural layers. The final aesthetic effect here is one of that flows between intense claustrophobic anxiety and a more open and voluminous expression. The soundworld conjured by the interplay of virus and bacteria is a direct reflection of the danger that a given viral bacteriophage poses to the bacteria represented at the centre of the audiovisual world conjured.

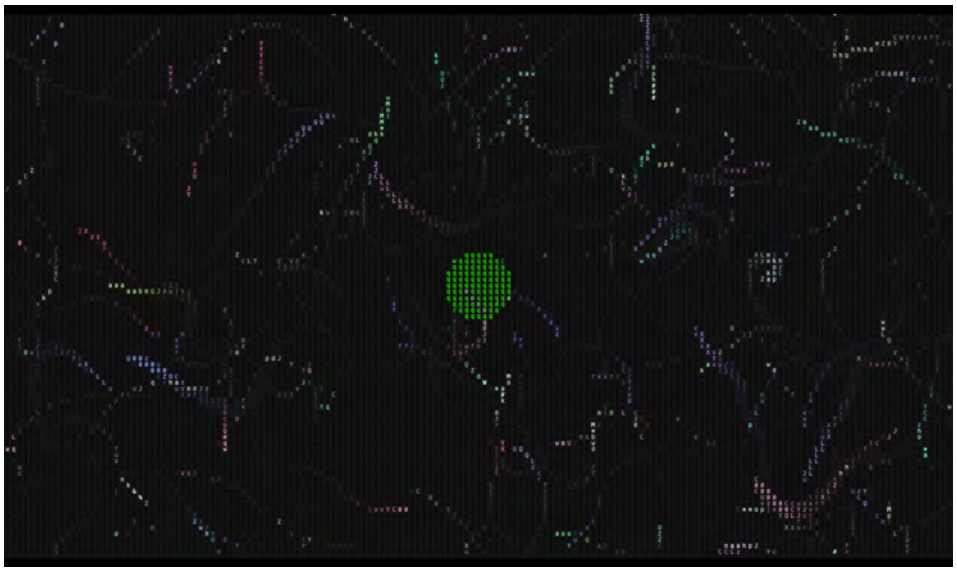


Fig. 2. Visual Component.

Conceptual Discussion

Conceptually the piece is aims to address itself to the question of biologically inspired computing in cultural practices in the wake of AI. AI in this regard is more accurately characterised as neural network based machine learning (NNbL), itself a form of biologically inspired computing that builds on the concept of the artificial neuron. For some time now we have been living through a moment defined by these biologically inspired computing systems. Critics have highlighted the litany of negative social, political and ecological externalities that come with the establishment of large scale NNbML infrastructures. N Katherine Hayles sketches an outline of a post NNbML future that is strikingly relevant in the context of this current work in her recent book Bacteria to AI: Human Futures with Our Nonhuman Symbionts (Hayles, 2025). Hayles' conceptual apparatus in the form of *Technosymbiosis* along with Yuk Hui's notion of *Technodiversity* (Hui, 2023) have been extended to conceptualise sonic arts practices that diverge from the hegemonic tendencies of distributed NNbML infrastructures (Roddy & Bridges 2024;

Roddy & Parmar 2023). *Bacteriophage in Granular Waves* is positioned as a response to NnbMl trends in the sonic arts as a musical work drawing on biologically inspired computing without the negative externalities associated with NNbML.

Additional Information

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