Ironing In The Creases: Developing An Idiosyncratic Electro-mechanical Musical Instrument By Reinforcing Its Faults

Graham Dunning
London South Bank University
103 Borough Road, London, UK
dunningg@lsbu.ac.uk

ABSTRACT

This paper proposes an unusual approach to the development of a musical performance setup through an iterative process which seeks to enhance the errors, faults and shortcomings of the system rather than refine, improve or fine tune them. This particular instrument design approach works in parallel with a performance practice centered on live construction of new music, refinement of a groove and the creative process of troubleshooting.

In my practice I use an extended turntable system, developing new electro-mechanical interfaces between a record player and various other devices. The paper describes my approach to developing the Mechanical Techno project, using the system in live musicking contexts and making iterations of the setup. The aesthetic aims of the project are defined in order to highlight the types of mechanical and electronic errors and flaws which are important to its success.

Several specific examples are given by way of illustration, demonstrating how physical wobbles, imprecise triggering and out-of-sync mechanisms can lead to interesting and idiosyncratic elements in live performances and recorded compositions.

The approach is summarised as a process of 'ironing in the creases': recognising the system's problems and – counterintuitively – deliberately emphasising them.

Author Keywords

Making, instrument design, live performance, extended turntable, weirdness, failure, error

CCS Concepts

• **Applied computing → Sound and music computing**; Media arts; • **Applied computing → Sound and music computing**; Performing arts

1. INTRODUCTION

This paper presents an autoethnographic account of the process of developing a specific music-making system. Such practice research approaches are well established at NIME [6, 8, 42]. The paper does not intend to suggest universal principles for instrument design, but rather offer one possible approach, towards a specific aesthetic. The paper sets out a description of the aesthetic approach I take to my music as 'music that sounds a bit wrong', incorporating weirdness through extraneous noise and unpredictability. This is followed by a description of two alternative design strategies which have informed the process: Non-hylomorphic making and inconvenient design. My specific instrument design strategy is explained as iteration without refinement, or ironing in the creases: Examples from my ongoing project Mechanical Techno illustrate the approach.

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2. EXTENDED TURNTABLE SYSTEMS

Mechanical Techno is an extended turntable system I use to create slightly off-kilter dance music. The core of the setup is a standard DJ turntable onto which is built a tower of several modified vinyl records, separated by wooden cylinders. The layers of the tower create or trigger sound in many different ways including: A stylus that plays samples from records which have sections covered with adhesive plastic; an optical reflection sensor which sends control signals to an analogue oscillator; vertical pegs set into a record which flick sensors triggering a drum synth; rotating prisms interrupting a light source affecting an LDR; chaotic triggers generated from rolling ping-pong balls; mechanically activated acoustic percussion; textured records played with alternative styluses for various novel sound sources and control signals; tape heads playing collages of magnetic tape; and numerous others. [fig 1]. The system is by design modular so new interfaces and soundsources can be incorporated alongside existing ones, and multiple different interfaces are run simultaneously. The development of the system is open-ended allowing for ongoing development and new iterations.

The Mechanical Techno project utilises the turntable's innate capacity for producing cyclical rhythm. The project functions as an instrument, a sounding kinetic sculpture and a rotary sequencer, each of which have precedents.

The use of a turntable as an instrument can broadly be divided into two pathways, dependent on the method of interaction by the player, either as a direct sound manipulation instrument or as an automated playback instrument. A scratch turntablist approach exploits the tactile nature of the interface of a turntable, allowing for instant physical manipulation of sound through playback speed and direction, coupled with fast amplitude and tone control via the mixer. This approach is mirrored in experimental music, including by Christian Marclay [4], and Maria Chavez whose 2012 book catalogues a range of techniques [13]. More recently composer and performer Mariam Rezaei has used scratch techniques in avant garde contexts, manipulating material such as free jazz saxophone playing, experimental vocal recordings and harsh noise [39]. Katz' Groove Music explores the origins and development of hip-hop turntablism and technique, including discussion of the turntable as a musical instrument [24]. The criteria he suggests include the direct real-time manipulation of sound, a set of techniques specific to the instrument, and the reception by an audience of the sounds created as musical. With the focus on direct manipulation as a key component of what Katz describes as 'performative DJing', the definition excludes the musical capacity of the turntable's ability for continuous playback, which Katz acknowledges: "If the turntable suffers from an identity crisis, it's because it actually has two identities." [24]

Figure 1: Live performance (2023). Photo by Sophia Stefelle.

A mixing DJ approach to turntable use, prevalent in house and techno amongst other genres, takes advantage of this capacity for continuous playback and variable speed/pitch controls, allowing for records of different tempos to be blended seamlessly together, called beat matching. [11] Blends of an extended duration allow uninterrupted playback of the recorded material from two different records, collaged together. Some DJs will use locked grooves, either on pre-cut disks or by forcing the needle to skip back with stickers on the surface, utilising the turntable's innate capacity to create loops. Ritchie Hawtin's *Decks, EFX and 909* [21] couples this approach with external hardware to create dancefloor focused music. Working with turntables as a semi-automated system is an example of Mark J Butler's *Playing With Something That Runs*, [12] whereby the performer's focus is on re/combining sonic elements as opposed to creating each sound directly. The mixing approach to the turntable instrument still relies on the tactile interface, with hand movements used to make minor adjustments to the position and speed of the platter to keep the two rhythms synchronised. These types of systems can be considered a separate category, a distinct way of using a turntable as an instrument as automatic rather than directly performative. 'Automatic instruments challenge our thinking about traditional musical roles. The users of such instruments can be thought of as perceiver-performers while the creators are a kind of "maker-composer-producer-performer".' [23] There is considerable crossover between the two approaches to turntable-as-instrument, but the broad distinction is raised here in order to situate Mechanical Techno as a tactile automatic instrument, not as a performative instrument for executing individual sounds.

Turntables have been used extensively in sound art contexts. Otomo Yoshihide and Yasutomo Aoyama's 2008 installation *Without Records* features multiple turntables creating acoustic and amplified sounds through physical rotation, mechanical movement and friction: clicks, scrapes and rhythmical clattering. [51] Since 2007, Danish duo Vinyl Terror- and Horror's performances and studio work have created collages of noise and drone with a turntable tower, destroyed records and multiple tone arms. [50] Nam June Paik's 1963 work *Random Access* featured a skewered stack of records with a mobile tone arm, allowing listeners to select which audio to play back. [4] Ujino Muneteru's project *Ujino and the Rotators* uses a turntable as a mechanical sequencer, with pegs activating relays to power various home appliances and an electric guitar in an automated installation. [35] These examples are some which share sculptural or mechanical characteristics with Mechanical Techno and have influenced its development. While it draws on these projects, the intended outcome differs, as a playable, performable, programmable sequencer-instrument to create music in a live or recording context.

The fundamental working principle of the Mechanical Techno system is as a circular sequencer, which is implemented in various different ways. As such the system shares similarities with certain drum machines, hardware and software step sequencers and more recent turntable sequencers. The first commercially produced electronic drum machine, the Wurlitzer Sideman, used a rotating arm to create electrical contacts arranged in a circle. The user could select from ten preset patterns and change the speed of rotation. [28] Quintron's Drum Buddy shines a lamp through rotating pre-drilled cylinders, creating flickering lights which trigger synth sounds via photoelectric cells. The Drum Buddy is playable by rotation speed, individual controls for its four voices, and brightness of the light source. [40] Certain rotating sequencers have been developed and marketed more recently. The Playtronica Orbita uses colour detection to send MIDI signals from a custom built platter, with positionable coloured dots used to program sequences. [37] The ODM Malista System uses a standard DJ turntable with a fixed pickup arm and hall effect sensors, generating MIDI and triggering drum samples via a custom hardware device. [48]

While based on the same general concept - the use of a mechanically rotating circular sequencer to create musical patterns - the Mechanical

Techno system differs in several respects, notably: a reconfigurable modular approach with multiple different sensor types, sound sources, and physical interfaces that can be used simultaneously; an emphasis on real-time playability, pattern manipulation and live reconfiguration; and focus on the inherent errors, instability and unpredictable variation that the system can produce.

3. MUSIC THAT SOUNDS A BIT WRONG

The title Mechanical Techno was chosen for a short video clip shared online in 2014, documenting a very early experiment with the process. [33] All of the sequencing, soundmaking and triggering is dependent on the turntable's mechanical rotation, however much of the sound is electronically created or mediated, so 'electro-mechanical' would be a more accurate description. The machine's music is rhythmical, repetitive, usually in 4/4 time and between 122 and 144 BPM, so falls in the umbrella category of 'techno', though a stricter consideration of the characteristics of the genre might categorise it in various other dance music subgenres.

Aesthetically my intention is not to make typical electronic dance music. With my formative influences including noise and free improvisation as much as music of the 'hardcore continuum' [41] and beyond, my preference is for that which slips between genres or scuffs and perturbs their boundaries. I aim to make dance music which sounds 'a bit wrong' - where something sounds slightly off, unusual or unexpected, but not so unfamiliar it is unrecognisable. Brian Eno describes the noise and hiss in Lee Perry's dub productions as contributing an "ambience of weirdness". [17] Mark Fisher outlines a troubling of the familiar that can lead to newness: 'The sense of *wrongness* associated with the weird – the conviction *that this does not belong* – is often a sign that we are in the presence of something new.' [emphasis in original] [18]. I aim to embrace this sense of wrongness and the weird, through noise and hiss in both the design and the implementation of the technology.

Liveness can be tricky to define within electronic music performance, which can include various degrees of media playback and sounds which are not generated directly and in the moment (what Jensnius calls 'in time' or 'real time' performance [23]). At its best, live electronic music can be "an engaging and creative, yet blurry, territory of studio-based pre-production and improvisation that occurs live on stage." [44] The liveness of live electronic music can be difficult to convey to an audience. In comparison to musicians playing, for example string or percussion instruments, an electronic musician with a laptop or a table of small devices can be an uninspiring visual spectacle. Part of what is missing here is what Jensenius calls the 'action-sound coupling' [23] which facilitates the perception of the performance. 'The liveness of the performance is built around the idea of creating a "mediated immediacy." Audiences can accept significant disparities between what they see and hear if some of the music's core auditory elements are represented visually.' [23] My use of physical mechanical elements – sequencing, triggering and modulating sounds in a way which is imminently visible – has a direct action-sound coupling, making visible the processes which create the music. Inconsistencies and errors in music making can signal a real-time performance, something unrepeatable, even (or especially) in recordings. Any errors, misfires or slippages further reinforce this: mistakes add to the liveness, or indeed the liveliness of the machine.

Groove based music differs from linear pop music and western art music in its focus on repetition, rhythm and changing affect. Butler's unpacking of the use of rhythm in house and techno is concerned with the use of different temporalities and ambiguous layering of rhythms, as well as 'the way in which the rhythmic essence of music flows or unfolds.' [11] Katz's definition differs slightly, using the double meaning of the physical groove cut into the vinyl record and only an implied definition of dance music as having a groove through repetitive phrasing. [24] Danielsen describes the (pre-electronic music) process of 'finding the groove' through the example of a James Brown funk track. 'it would be better to call it optimisation than variation – optimisation of the different elements so that they become even more integrated and comfortable within the whole. This continuous optimization is often described as "locking" or "nailing the rhythm." It is not a carefully considered process, and it never really ends; instead, it goes on automatically, continuously, manifesting in the form of better or worse periods of interaction.' [15] My project applies some of the processes of performance-installation to a groove based dance music context, sculpting the sound by physically building the machine, working towards finding the groove. The machine makes a groove based on repetitive loops, but the repetitions are never perfectly identical.

Cutler identifies and criticises the unchanging repetition of recorded loops as lacking in character: 'Where biological systems are creative and unreliable – qualities which I believe are profoundly linked – mechanical or electronic systems are unerringly accurate, but mindless.' [14] His defence of human-played repetitive music revolves around the players' inconsistencies: 'There may be endless repetitions in aural cultures, but there can never be loops because, as long as human agency is involved, the same thing is always going to be different.' There are, of course, degrees of repetition within loop-based music, not all of which are 'unerringly accurate'. The inclusion of variation in loop-based music made without human players usually needs to be a conscious and deliberate process. Looping a single audio clip in a DAW *will* produce an identical reproduction on each cycle. Introducing variation – whether that's by overlaying additional sonic elements, randomisation presets, recording automation or using LFOs controlling parameters – are part of the producer's compositional choices in creating their desired outcome. Use of drum machines with analogue oscillators or their own unique microtiming characteristics, or 'machine based groove' [34], can introduce subtle variation to otherwise identical repetition, and hardware sequencers such as the Elektron Octatrack [36] or Arturia Beatstep Pro [1] include options for randomisation. Mechanical Techno, through its unreliability and fallibility, also creates loops which are consistently variable, creating a groove with more character than an unchanging, perfect repetition. The design of the system simply prevents identical repetition through its inability to be precise.

My sound, then, is a music of repetition and difference, rhythmical consistency and microtiming variations. Generating music that sounds 'a bit wrong' or as though it's about to break down and fall apart, is better served by an instrument system which itself cannot be fully relied upon.

4. NON-HYLOMORPHIC MAKING AND INCONVENIENT DESIGN

Tim Ingold has written to argue for a form of making which is based around working with materials towards a potentially unknown outcome: 'Contemporary discussions of art and technology continue to work on the assumption that making entails the imposition of form upon the material world, by an agent with a design in mind. Against this hylomorphic model of creation, I argue that the forms of things arise within fields of force and flows of material.' [22] A non-hylomorphic approach to making involves collecting together raw materials and working with them. The proposal of a final and fixed idea at the beginning of the process is not necessary. 'Rather than reading creativity "backwards", from a finished object to an initial intention in the mind of an agent, this entails reading it forwards, in an ongoing generative movement that is at once itinerant, improvisatory and rhythmic.' [22]

Within numerous fields of design, researchers have explored ways of creating without working towards a solution to a specific problem, including testing ideas known to be impractical. 'There is a small but growing body of work in HCI, which explicitly rejects the notion of design solutions and suggests various unworkable concepts as a means to advance discussion and better describe the problem space. Such work does not seek to criticize but rather explore partial, problematic, flawed, and sometimes plain silly ideas.' [5] At the Interaction Design Lab, University of Applied Sciences Potsdam, Tost et al developed one such approach. 'By combining iterative prototyping, anti-solutionist strategies, and tactics of critical and speculative design, we built a counter-approach to conventional design processes: Inconvenient Design.' [49] The approach 'is driven by the principles of absurdity, uselessness, ambiguity, exaggeration, estrangement or irony, as well as the inconvenient principles of provocation, irritation, user-unfriendliness, unpleasantness, discomfort, friction, limitations, and constraints.' [49] Dunne identifies similar concerns in the design of electronic objects, arguing the case for 'user-unfriendliness' through the design of 'post-optimal' devices: 'If user-friendliness characterizes the relationship between the user and the optimal object, user-unfriendliness then, a form of gentle provocation, could characterize the post-optimal object. This emphasis shifts from optimizing the fit between people and electronic objects through transparent communication, to providing aesthetic experiences through the electronic objects themselves.' [16]

In the field of musical instrument design, Bowers and Archer's 'infra-instruments' embody a parallel approach. [7] Their provocative 2005 paper highlights and sets itself in opposition to four trends in instrument design: 'Rich interactive capability', ' Detailed performance measurement', 'Engendering of complex music', and 'Expressivity and virtuosity.' The infra-instrument is designed in opposition to these tacit assumptions. Infra-instruments are 'devices of limited interactive potential, with little sensor enhancement, which engender simple musics with scarce opportunity for conventional virtuosity.' [7] Koutsomichalis' notion of 'rough-hewn' instruments is also relevant here, with the specific design choices in the fabrication of the instruments themselves providing unique sets of affordances and limitations. [27]

The continuing development of the Mechanical Techno system draws on these approaches. Technologies, components and sensors are considered as raw materials to explore and work from, often without a fixed goal aside from exploring their potential in the context of the system. Playfulness, extrapolating half-working ideas, and using components in incorrect or absurd ways contribute to the anti-solutionist approach. Evaluation of the outcomes of these experiments - and their potential musical application - is sometimes difficult due to their diverse nature, requiring consideration in the context of the desired musical aesthetic.

The problem of effective evaluation of new instruments was unpicked by Rodger et al, questioning the framings of instrument-as-device and musician-as user. [46] One of the pitfalls, they explain, is 'the implication that an instrument is a singular entity with a set of intended functional behaviours, known to the designer and employed by the user for the purpose of attaining some practical goal. Consequently, the success or failure of a device can be assessed by the extent to which it supports the attainment of these pre-determined goals.' My work aims to avoid this possible dead end, in alignment with the authors' suggested solution: 'We should jettison the idea of an instrument as an essentialised singular thing, but rather think of it as a constellation of processes (affordances) which may be shared with other instruments, and which may change over time.' [46]

Jensenius highlights the specific peculiarities of instruments as defining their character. 'People talk about the "character" of an instrument. To me, that boils down to its imperfections, whether in the look, the sound, or the touch.' [23] These idiosyncrasies are valuable characteristics and would be missing from an instrument improved with a focus on efficacy. With a non-hylomorphic design strategy, systems, techniques or materials are explored in order to uncover their affordances, properties and strengths which may in turn suggest suitable uses or feasible designs. Applying inconvenient design principles allows for critical evaluation of the assumptions which may intuitively seem to lead to a 'better' musical instrument. Specifically, this aligns with the aesthetic aims of the project, developing a system with a unique idiosyncratic character.

5. ITERATION BUT NOT REFINEMENT

As an ongoing and evolving project, Mechanical Techno benefits from active use in live and studio contexts. The process is a cycle: First designing and prototyping a new device, interface or sound source. Second, testing the prototype in the workshop, to a stage where it works reliably (not all prototypes make it through this stage), and making it portable enough for live use. The concert environment produces certain pressures, not least whether the interface is reliable enough to use in front of an audience. There may also be a change in function in using a device through a powerful soundsystem: issues with feedback, vibration or sensitivity can be tragically exposed when using large, loud subwoofers. In parallel, using a device in a home-studio recording context can highlight other more subtle inconsistencies and idiosyncrasies, as the environment allows for closer listening and more delicate usage. Finally, lessons learned from the workshop bench, the stage, and the recording studio are folded back into the next iteration.

My instinct through this iterative process is to work towards improvement, progress and refinement. If triggers are misfiring, beats sound sloppy, samples are inconsistent or pitches are unstable, my reaction is to fix them: make it work better, play tighter, be more consistent, do what I tell it to do. The key to my making process is acknowledging that the inconsistencies and errors are the fundamental aspect of what makes the music unique. This requires a conscious decision to hold back on improvements, slickness and perfection, and emphasise the aspects of the design which are unintuitive, difficult to use, unreliable or error-prone. Finding the balance between reliability and breakdown is the fundamental skill in this type of instrument design.

Knotts discusses an approach to live coding live performance in which there is a constant turnover of failure, reviewing and adjusting expectations and goals in order to keep moving forwards: Not iterating towards a fixed point, but accepting the failure of the initial conditions and working towards a new goal with the error built in. 'These kinds of failures introduce a level of indeterminacy, necessitating the following of unforeseen musical paths, constantly rethinking the next move. … Distinct timelines of physical and musical action in live coding means living with one's failures, sometimes for longer than one would like.' [26] Furthermore, this is a cyclical process: the new failures occur, and at each stage the goal is reset. 'The performer reacts to the output of the code they write by either refining or redefining the imagined musical goal state, and ultimately the trajectory of the performance.' The process of designing and developing a musical instrument works over a longer time frame, making it possible to stop and reflect. At every stage of iteration I choose whether to keep the errors in or take time to iron them out - the important point in this process is to acknowledge and emphasise them.

This can be seen as a deferral of problem solving. By not fixing the errors in the workshop, I can ensure that they occur in the next performance, delaying the act of troubleshooting to a point in time when I will be in front of an audience again, and folding in that process to become part of the performance. Morten Riis describes his performance role using his steam-powered mechanical musical instrument: 'machines have always been breaking down, and there has always been a physical mechanism that challenged the predetermined functionality of the machine. I must take the role of the repairman as much as the performer in order to safely guide this apparatus through a performance.' [45] With Mechanical Techno, I'm not necessarily repairing, but regulating the machine, encouraging it into a working state where it can function, but with the faults remaining. The repairman forces the machine to do its job properly - conversely I still have the option to give way to the machine, 'letting the instrument have its say'. [3] My role in performance is closer to that of 'the attendee' as described by Richards and Shaw in relation to performance-installation. ‘There are clear distinctions between attending to a sound and performing on an instrument. … attending to a sound infers that a sound or sound-making object has some kind of autonomy or agency, and performance happens at "arm’s length".’ [43] Another related performance role is that of catalyst, in the use of nonlinear feedback systems. Performing with feedback, Aufermann explains that 'the player’s function is that of a catalyst and not executive.' [2] Like such systems, the behaviour of Mechanical Techno is predictable to a degree but unexpected things can happen - these occurrences force a reaction during performance in order to maintain the coherence of the music. Honing, fine-tuning, and tweaking in most instrument design would happen in the workshop, before taking the instrument or machine on stage. These processes are present in my practice, but are deferred so that they happen during the performance: If the design of the machine was such that it worked perfectly every time, there would be little for me to correct, no tweaking for me to undertake in the performance space, and hence, no performance.

6. BUILDING A WONKY MACHINE

The following examples illustrate specific instances where 'improvement' has been tempered or restricted.

6.1 Wonky cylinders: rhythm variation

The cylinders which divide the layers of the tower are made of hardwood. In motion, the friction between each of the components affects the outcome. On initial use the wooden cylinders slipped against the labels of the records, causing loss of synchronisation. As such, they were painted with Plasti-Dip, a type of rubberised paint, to increase the friction. [fig 2]

Figure 2: Wooden cylinders with Plasti-Dip

Due to the tolerances in cutting, and manual application of the rubber paint, the faces of the cylinders are neither perfectly parallel nor perfectly flat. As such, there can be a small amount of lean introduced with each layer. If these minor inaccuracies add up, after five or six layers the tower can lean significantly. A relatively minor change in the alignment of the central spindle can lead to significant eccentric movement at the edge of the disk. [fig 3]

The record shown is programmed with eight pegs equally spaced around the disk. [fig 4] The piezo disk is connected to a drum module which outputs a bass drum sound each time a peg flicks the trigger. Fig 5 shows the variation in striking position at the trigger, the deviation caused by the wonky tower.

Figure 3: Tower with six layers

Figure 4: Record programmed with eight pegs

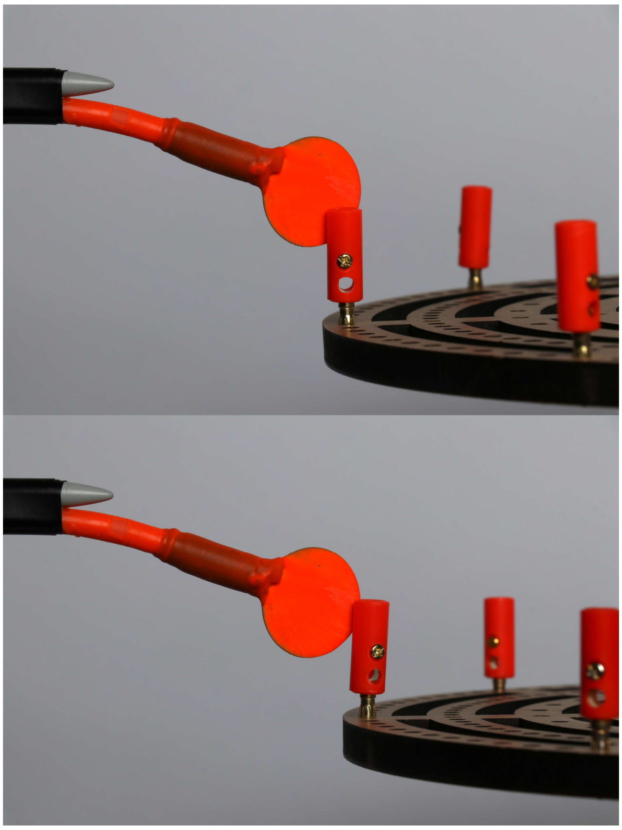

Figure 5: Variation in striking position at the trigger

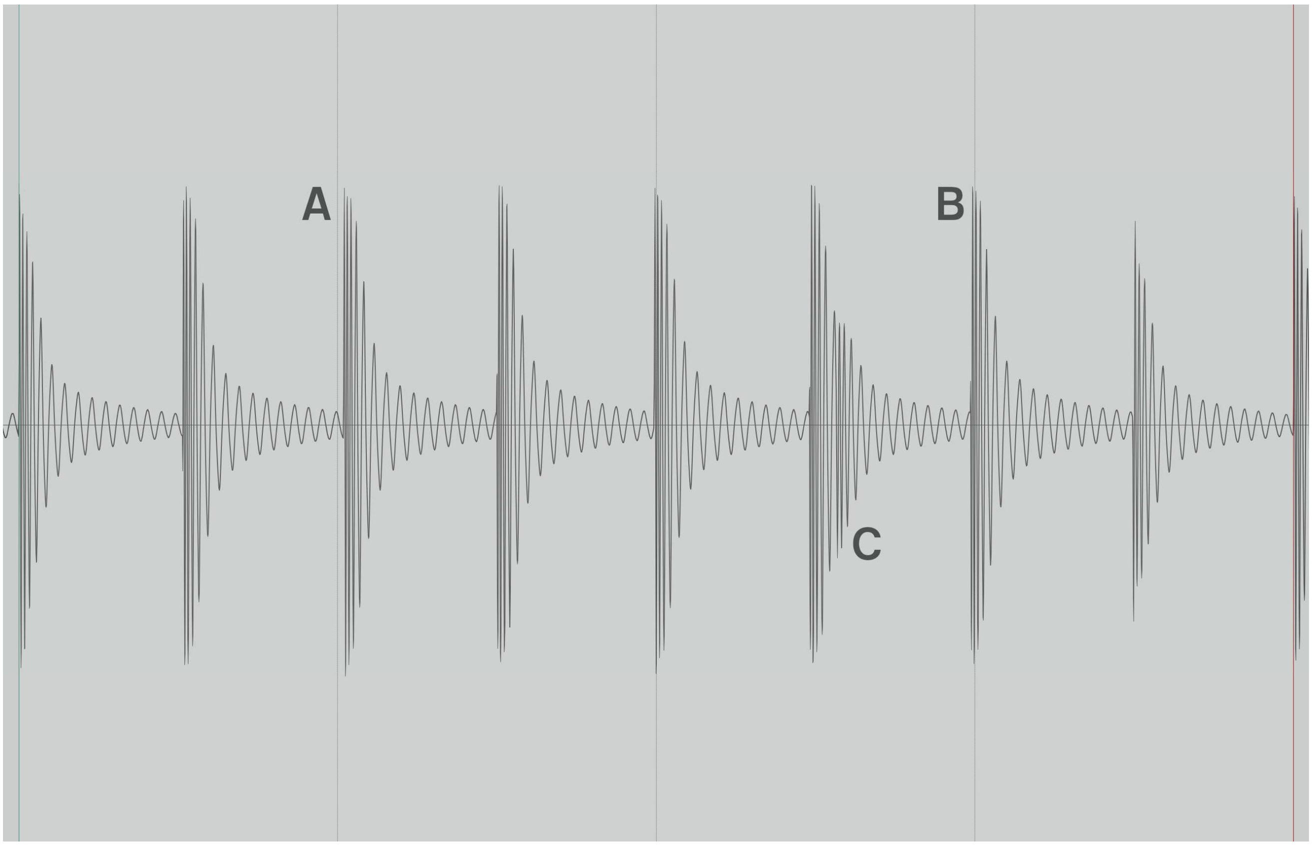

Figure 6: Waveform showing microtiming variations

The waveform [fig 6] shows the recorded output aligned with a DAW grid matching the turntable's speed, illustrating the deviation of the individual hits. At point A, the hit is significantly behind grid time. At point B, the drum hit is before the beat. By the end of the cycle the pattern is back on grid.

Additionally, point C shows a double-strike of the trigger, caused by the piezo disk scraping the peg. This happens irregularly due to other, less predictable wobble in the tower.

The current cylinders are the third iteration of this particular component of the setup. The wobbling of the tower is a valuable effect of this system, so in manufacturing the new cylinders I was aware not to be too precise. An alternative would have been to commission industrial fabrication of precise cylinders. Rubber sheet would have been more consistent in thickness than the lumpy Plasti-Dip paint. My choice of materials and self-fabrication ensured the tolerances would remain loose enough to provide the required wriggle room.

Figure 7: Modified records for sampling

6.2 Tone arm with loose string: random sample selection

The modified records are used as a physical form of sampling. Adhesive vinyl is stuck to the disk to cover over and blank-out parts of the existing groove. [fig 7] When the covered parts pass the stylus there is relative silence (with some surface noise). Passing any exposed disk the needle plays the sound already cut into the record. Due to the regular shapes of the stickers this results in rhythmical snippets of samples interspersed with silent sections.

Without use of the 'anti-skating' settings on a turntable, the tone-arm would move towards the centre of the record. My solution is to attach the tone-arm by a piece of string to a weight. [fig 8]

Figure 8: Tone arm with thread and anchor weight

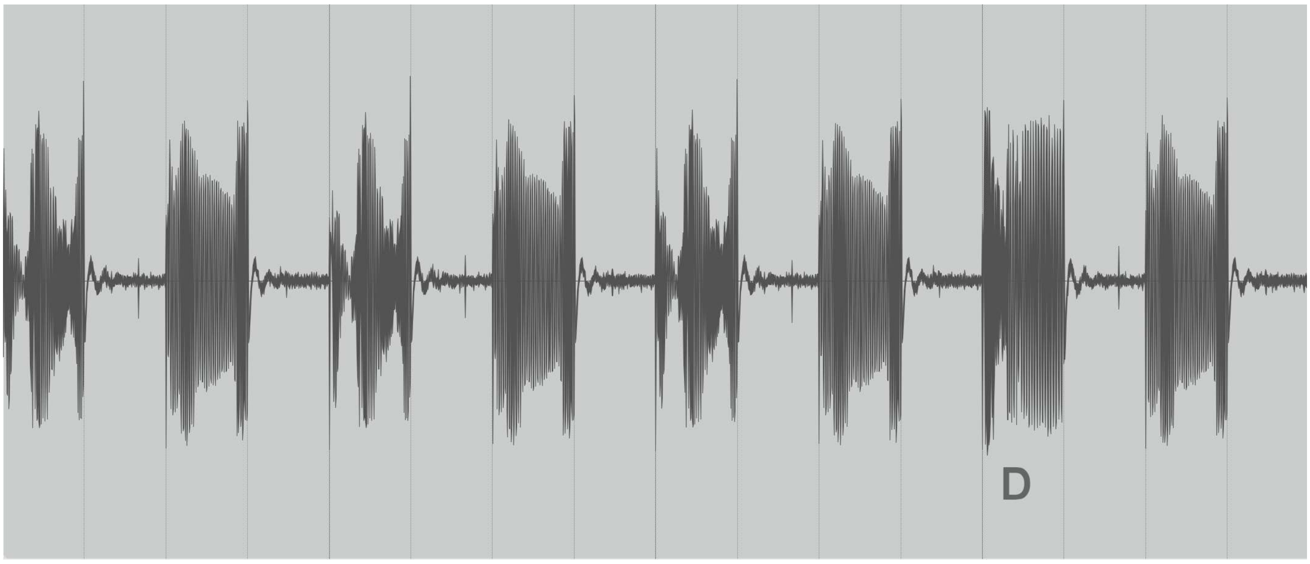

Figure 9: Waveform showing sample variation

The waveform in figure 9 is from four consecutive cycles of the record. For most of the time, the same pair of samples is played back. Despite the weight remaining in the same position, section D is a different sample - for this one cycle the needle skipped into a different groove. The use of a piece of thread rather than a rigid bar enables the tone arm to move. These jumps generally occur occasionally, but different factors can affect their likelihood. The amount of variation often changes depending on how many layers are on the tower, whether it is wobbling, vibration from sub bass, the stability of the table and the stage, and other physical factors.

6.3 Physical pitch bending: avoiding known scales or predictable pitches

Generating basslines and synth parts is through an optical reflection sensor sending gate signals to an analogue monosynth. The synth is fixed in an equal temperament tuning and there is no straightforward way to change this. Using the onboard sequencer, the method of changing notes becomes locked 'in the box' - it is no longer controlled by the turntable system or visible to the audience as caused by a physical mechanical process. My workaround to these two issues is a new interface for producing variable voltages, used to adjust the pitch of the oscillator. A fixed voltage source is fed through an outboard

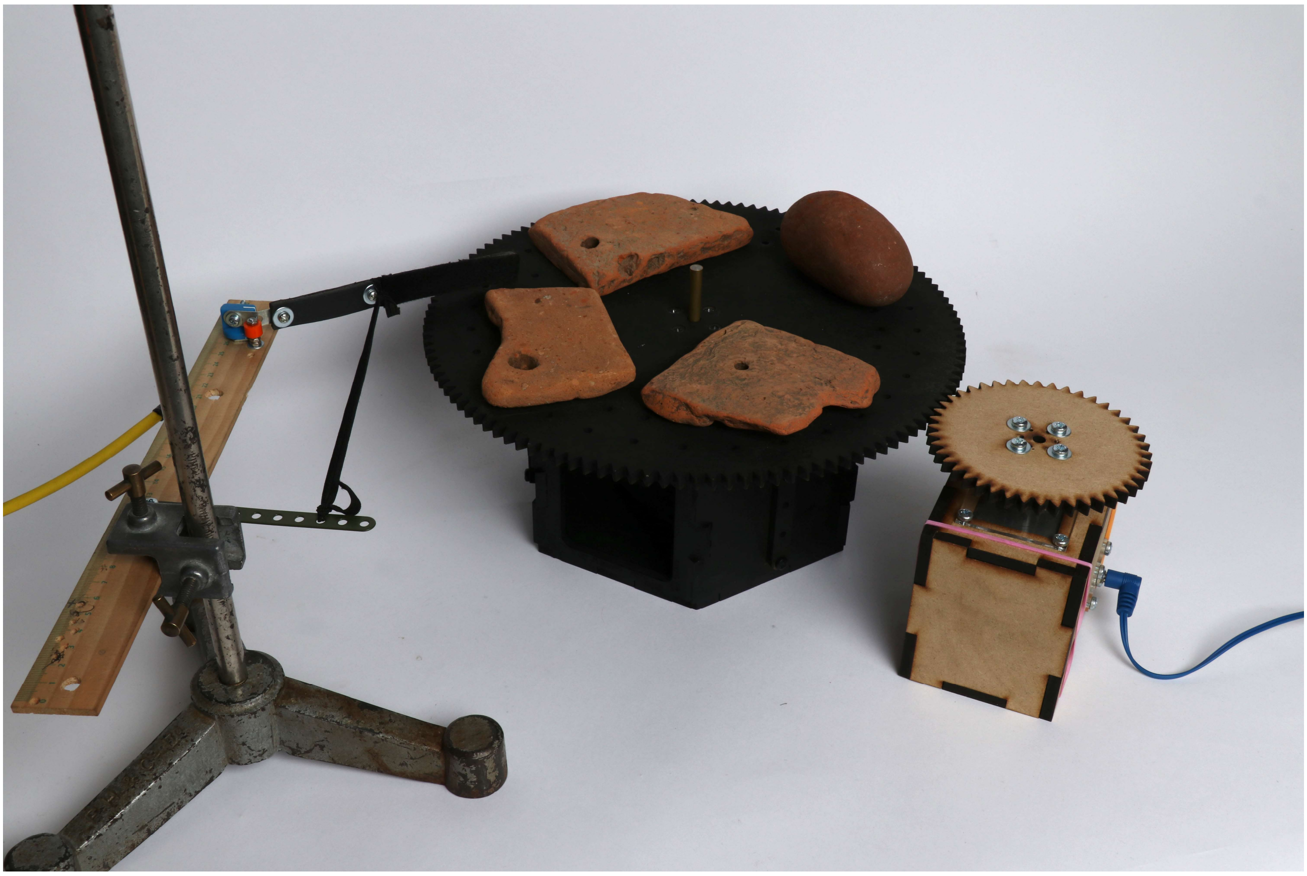

Figure 10: Slow turning platter and pitch control arm

potentiometer. An extended arm is attached to the control knob and positioned in such a way that it acts as a cam follower: any object placed on the turntable will push the arm and, using the potentiometer like the hinge of a gate, change the resistance in the circuit. Feeding this modulated voltage into the synth causes upwards pitch bends as the 'gate' opens, which fall back down as it closes, drawn inwards by a piece of elastic. Friction in the potentiometer reduces the speed at which the 'gate' closes physically causing the voltage to slew, so the pitch changes in a glissando.

The cam follower can be used on the same turntable as the sensor creating the gate signals, or a different tuntable moving at an unrelated speed. I have used a second, slow turning platter which varies from 2 to 12 RPM, not synchronised with the main turntable. At a slower speed, the pitch change of the oscillator can vary across several bars.

The photograph [fig 10] shows several brick tiles on the slow-platter affecting the oscillator pitch. The spectrogram [fig 11] illustrates the pitch change over a complete cycle.

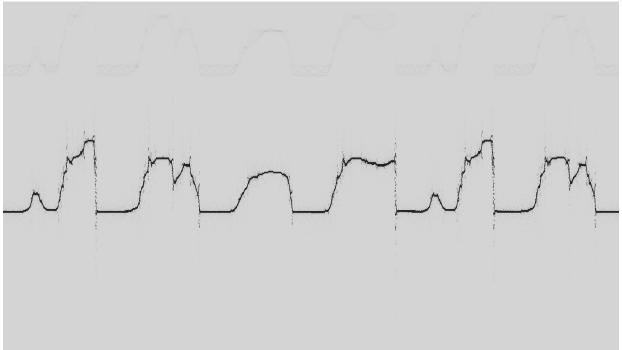

Figure 11: Spectrogram showing pitch change over time

Here, whilst the notes produced by the oscillator can be broadly tuned by ear, the precise pitches are controlled by a number of factors including the exact settings of several potentiometers; the distance and angle between the cam follower and the centre of the platter; and the shape, dimensions and positioning of each of the brick tiles. Furthermore, the tiles can slip and change position, further affecting the control signal over time. The physical repositioning of the objects as part of a performance changes the automation of different parameters over time, situating the device as a tactile, physical sequencer or LFO for different parameters. It would be possible to form precise segments of concentric circles in order to fix on stable frequencies, however this is another design choice I have rejected in favour of irregularly shaped found objects.

6.4 Out of sync secondary control mechanism: off-bar changes to patterns

When using a turntable as a sequencer, one of the limitations is that the bar length is always limited to one cycle. One workaround has been to incorporate the aforementioned slow-turning platter as a secondary control mechanism. The pattern disks which I use with the optical reflection sensor on the main turntable are designed to have several 'tracks' of patterns, formed into concentric circles, allowing for real-time pattern changes by switching the position of the optical tone-arm. Use of a cam follower on the slow platter and a connecting rod to the optical tone-arm allows for this position change to be automated. [fig 12] The disk in the photograph has four positions, connected segments of concentric circles which allow the cam follower to dwell or hold at a certain lateral position. These dwell positions correspond to the four 'tracks' of patterns on the optical disk. The arm cycles through the four patterns at a rate determined by the rotational speed of the slow-turning platter. Fig 13 shows the waveform of triggered synth sounds from 16 cycles of the main turntable, changing over time as the cam follower switches tracks.

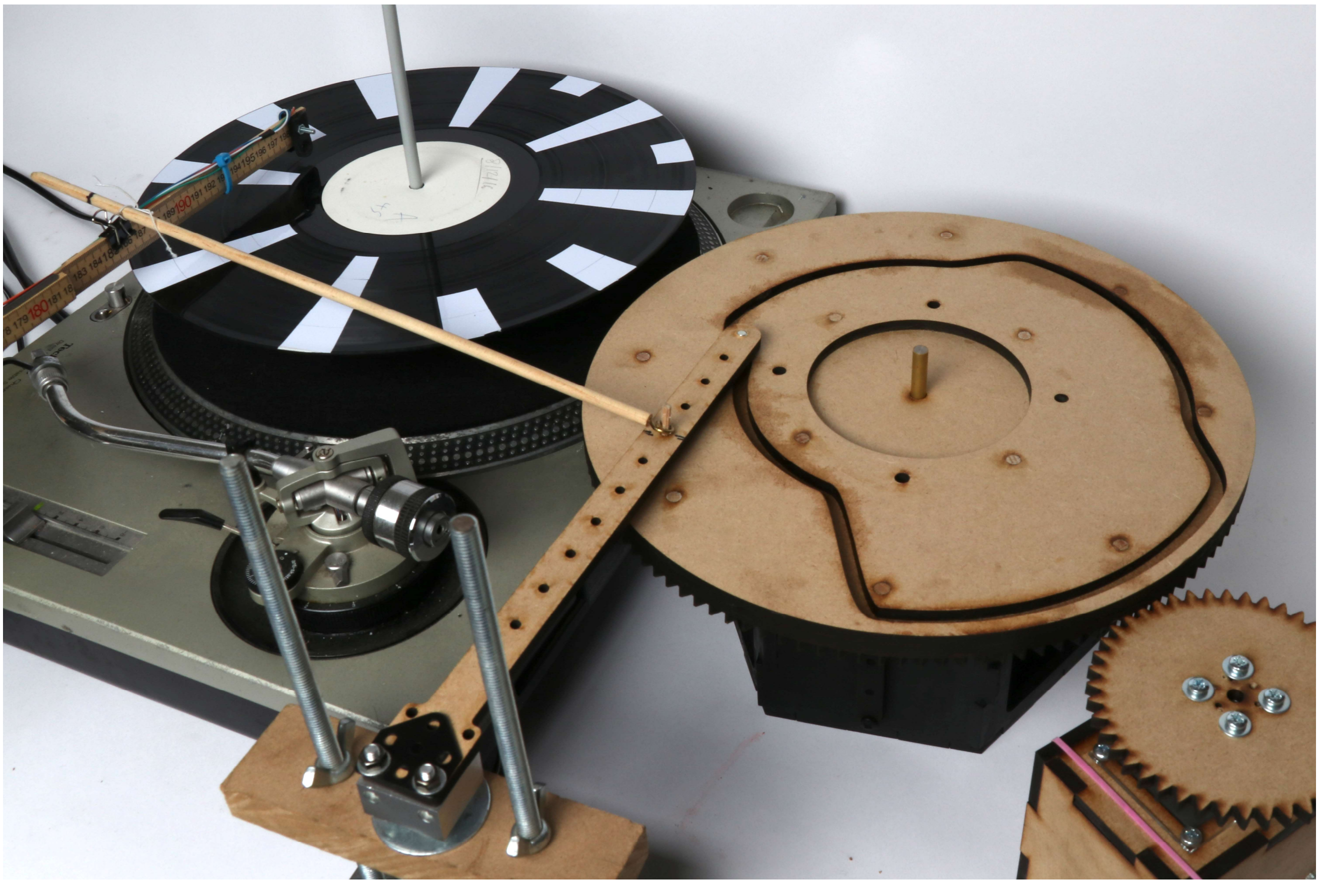

Figure 12: Cam follower track changing device

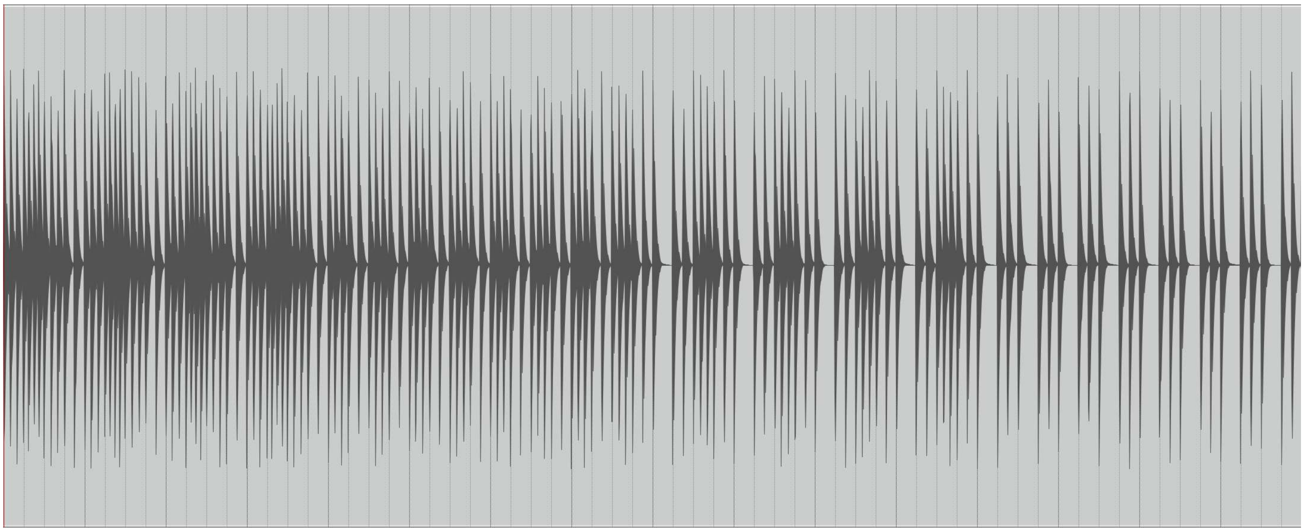

Figure 13: Change in triggered notes over time

In the current design, the speed of the platter is determined by a modulated control signal set by hand. There is no way to synchronise or lock the second platter to the rotation of the first. Whilst this is something which may be of interest - for example, changing optical track every 4 cycles resulting in on-bar pattern changes - the limitation provided by the current setup leads to different, and arguably more interesting, musical outcomes. Cleaning up the system would also potentially lock it down to the grid, making it more similar to a drum machine or DAW. (By chance when documenting the device for this paper, the slow platter speed was almost exactly 1/16th of the main turntable, perhaps a more conventional division than I aimed to illustrate here. This was entirely bad luck.)

7. DISCUSSION

Mechanical Techno is a system for both live performance and creating recorded compositions.

In a performance context it:

- has a distinct visual appearance which offers a strong sound-action coupling
- can generate a sense of fascination associated with mechanical devices (see [47])
- has a unique tactile sequencing interface affording an idiosyncratic performance style
- exposes fallibility in both its mechanisms and the performer's interactions contributing to a distinct sense of liveness

When used as a compositional tool the machine:

- affords a specific aesthetic which challenges some assumptions of electronic music as 'unerringly accurate' [14] and of the machine as 'time perfect, repetitious, logical, perfect, normative' [31].
- Uses its inherent instability a to signal a sense of liveness and liveliness, pointing to the unique character of the machine and its design
- Through its affordances and limitations encourages types of composition where the final outcome cannot be known at the outset, leading to a creative approach working in collaboration with materials and technologies

The use of multiple interfaces and lineage to previous turntable, sequencer and drum machine technologies can, as Bowers has written, contribute to a 'pedagogical potential' as one of the strengths of an ongoing project. [8] Masu, Morreale, and Jensenius discuss the importance of engaging with existing instruments, designs and technologies within the NIME discourse [32], and the use of the DJ turntable, a device with a long history of use and misuse, contributes to their suggestion for sustainability within design practice. While the project's formulation around a DJ turntable and use as a sequencer categorises it amongst numerous other designs which have appeared at NIME [25, 29, 38] and elsewhere, certain aspects of both the technological interfaces and approach to design and implementation distinguish the machine. The particular strategy of identifying weaknesses and capitalising upon them as desirable characteristics may have implications in other areas of research, such as the perception of liveness, skill or error in performance [10, 19, 20].

8. CONCLUSION

In this paper I have introduced the Mechanical Techno extended turntable project, outlined two broad historical approaches to the DJ turntable as instrument - as playable sound manipulation interface or as an automatic musical instrument - and given examples of other extended turntable systems from sound art and instrument design contexts. I demonstrated ways in which Mechanical Techno differs from other systems: modular reconfigurability; multiple simultaneous interfaces; emphasis on playability and live reconfiguration; focus on error and unpredictability. I described how the aesthetics of the musical output both derive from and guide the development of the system, defining key aspects of my aesthetics as: wrongness, weirdness, liveness, and sound-action coupling.

An aspect of the performance strategy was explored as groove music through performance installation, identifying various performance roles which share similarities with this as repairman, attendee and catalyst. I also described non-hylomorphic and anti-solutionist strategies, mentioning specific examples of their implementation in other disciplines, and these approaches' influence on the development of the machine: as a process of iteration but not refinement, or ironing in the creases. Specific examples from the development of the project were given to illustrate the approach.

The use of physical interfaces enables a tactile approach to performance and composition of electronic music, and one of the primary affordances of such interfaces is the messiness and propensity to slippages inherent in real world objects and things. I believe the approach illustrated - foregrounding the physical without aiming to smooth its rougher edges - has potential for further development in other hybrid systems.

9. ETHICS STATEMENT
There are no known ethical concerns to report.

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