MACHINA INQUIETA – RESTAGING ASHBY'S HOMEOSTAT

Marco DOETTLINGER[1], **Arthur FLEXER**[2], **Patrik LECHNER**[1], and **Thomas GRILL**[1]

[1]**University of Music and Performing Arts Vienna**, Vienna, Austria
[2]**Johannes Kepler University Linz**, Linz, Austria

ABSTRACT

This paper presents *machina inquieta*, a digital feedback instrument conceptually inspired by W. Ross Ashby's Homeostat and its principle of ultrastability. *Machina inquieta* radicalizes cybernetic regulation by replacing equilibrium-seeking behavior with persistent multistability. The instrument consists of four interconnected digital synthesis units. Each unit forms a recurrent feedback loop combining sound synthesis, timbre-based self-analysis, and two multilayer perceptrons that map between a two-dimensional control interface and a multi-parameter synthesis space. When operating simultaneously, these models establish autonomous self-listening systems that continuously reorganize their own sonic states. A global coupling layer interconnects all units, creating a multi-agent ecology in which local perturbations propagate system-wide, including performer intra-actions. The system demonstrates how multistability can function as a core principle of contemporary musicianship. The project understands data creation within the framework of *Small-Data* strategies as an artistic practice and thus functions both as artistic resistance and as a speculative epistemology.

1. CONTEXTUALIZATION

Music emerges from the interaction of humans and sounding instruments within social, cultural and architectural contexts. Years of practice often foster close functional and affective relationships with acoustic instruments, recording equipment, synthesizers and software. These *resonant* relationships between human and non-human actors can take the form of kinship, negotiation, confrontation, or ritual. The multi-year project *Spirits in Complexity – Making kin with Experimental Music Systems*, launched in April 2024, investigates this question through a cooperation between the Artistic Research Center at mdw Vienna, the Institute of Computational Perception at JKU Linz, KTH Royal Institute of Technology Stockholm, and the Intelligent Instruments Lab at the University of Iceland. Following Donna Haraway [1], *making kin* denotes the formation of multi-species, non-biological, non-hierarchical relations enacted through shared practices and mutual responsiveness.

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1.1 Preliminary Work

In the preceding *Rotting Sounds* project, we conducted extensive artistic experiments with feedback systems [2–4]. The *Spirits in Complexity* project continues our research into *non-trivial* instruments and performance practice [5, 6], positioning artistic research as an exploration of dynamic multistability, where instrument, performer, and algorithm co-produce music as a continuously emergent phenomenon.

1.2 Feedback Musicianship

Audio feedback instruments still offer radical new ways of engaging with instrument design and musicianship. Since the early (cybernetic and) artistic attempts in the 1950s and later, techniques and artistic strategies of manipulating audio feedback behaviours have come to a variety of positions and insights until today, discussing nonlinear dynamical sonic behaviors [7–12]. Artists and researchers are still fascinated by the wildness and intrinsic dynamics of feedback processes, producing rich, unpredictable, and multistable sonic responses. Compelling musical outcomes emerge when the system's dynamic complexity is maximized without saturating feedback, enabling behaviors that cannot be fully anticipated or pre-programmed. Inspired by Ashby's Homeostat [13], we have designed a feedback instrument that explores multistable states not only via audio feedback, but using machine listening and machine learning feedback loops, exploring nonlinear mapping to produce sonic phenomena.

1.3 Ethical and Critical Data

Building on demystification of AI spheres or the AI complex (e.g., [14–16]) and the deconstructing of a "corporate regime of knowledge extractivism and epistemic colonialism," [17, p.40] the project treats data as a relational and material medium rather than a resource to be mined. We position apparatus-building, *Small-Data* generation, and data manufacturing as creative, manual and compositional acts, thereby challenging extractivist and colonial logics embedded in conventional computational infrastructures. Machine-performer intra-actions constitute phenomena that produce emergent and relational forms of expression (cf. [5]). *Small-Data* practices thus function as both artistic resistance and speculative epistemology, enabling new forms of musical understanding and expression.

Neo-colonialist practices have also been identified specifically in the use of AI technology for creating and producing music, where user data and existing music are often

used as a free and uncredited resource [18], connecting to earlier critique on treating data "as new oil" [19]. In a meta-study [20] of datasets presented at one of the premier conferences of the music information research field, it was shown that more than half of the datasets used or introduced were essentially scraped from the internet, almost always without seeking permission from musicians having created the data originally. Only about 15% of datasets involved musicians creating novel compositions or at least recording and performing existing compositions. It seems that in general human creative labor is obfuscated in music dataset creation. The often dubious provenance of data used to train AI music models of course has complex legal consequences [21]. In addition, just as digital-based instruments and software have been criticized as reproducing "more of the same" due to their reductive nature [22], modern AI music systems "are still unable to generate the full theoretical space of musical possibilities" because they are still affected by limiting, normalizing assumptions [23]. This reductionist effect has been lamented as cultural homogenization and depletion of artistic agency [24]. The custom design of synthesis, data generation and model training instead of using pre-trained AI music models stays clear of such legal and ethical qualms and can be seen as a deliberate decision to use "small data" [25] in order to gain full artistic and legal control. Data sovereignty is much more than the mere right to data protection; as an active artistic practice, it forms the necessary foundation for epistemic sovereignty. Data creation as a creative act also points critically at changes in the field of human labor. Low- and high-wage workers are just as involved as the users (unpaid workers) of these services, who are often unaware of their role. This is also indicated by the terms "produsage" or "produser" [26,27] as a new form of labour (unpaid and not perceived as such by the individuals).

By understanding data creation as a creative act, information is transformed from something factual and given into a conscious artifact: Those who determine the parameters of collection, the aesthetics of recording, and the logic of categorization themselves escape the algorithmic interpretive authority of global tech monopolies. An artistic appropriation of data generation makes it possible not only to manage knowledge, but also to think about it in a radically new and independent way.

2. ASHBY'S HOMEOSTAT

W. Ross Ashby (1903–1972), psychiatrist, biochemist, and pioneer of cybernetics, developed a thought provoking machine: the Homeostat. It was conceived as a concrete demonstration of adaptive regulation, of self organization and addressed a fundamental question: how can a system be both strictly state-determined and capable of adapting to environmental change [13]? The Homeostat models a form of machine agency grounded not in goal-directed optimization but in the maintenance of viability—an idea resonant with enactive accounts of adaptivity [28]. Completed in early 1948, the Homeostat consisted of four densely interconnected electro-mechanical units adapted (or better misappropriated) from Royal Air Force bomb-guidance components. Each unit contained a pivoting magnet whose angular deviation represented an essential variable that had to remain within viability bounds (appr. 45 degrees). These angular deviations functioned simultaneously as outputs and as state-defining variables. Through wires, commutators, water-filled potentiometers, and a uniselector mechanism, the units formed primary and secondary feedback loops. When a deviation exceeded its viability threshold, the system randomized its internal parameters, searching for a new configuration capable of restoring stability. This recursive reconfiguration instantiated what Ashby called ultrastability and exemplified his "law of requisite variety" [13, 29]: For a system (like a regulator, controller or organism) to effectively influence or respond to another system, it must have at least as much behavioral flexibility (variety) as the system it is trying to regulate. The device itself can be understood as practice based research, it is not merely illustrative but demonstrative: it embodies a concept in hardware. This materiality has inspired subsequent reinterpretations [30], as well as artistic/musical explorations of homeostasis in generative and adaptive digital systems [31–33].

2.1 From machina sopora to machina inquieta

Neurophysiologist William Grey Walter described the Homeostat as a machina sopora—a 'sleeping machine'—whose ideal function is to return to quiescence [34]. Sleep here signifies poised dormancy: a stable state ready to respond to perturbation. There are controversial interpretations of this characterization, Franchi [35] reads Walter's remark as potentially suggesting a passive conception of life as contingency-driven. Others reject this view [36], emphasizing that Ashby's Homeostat actively searches for viable states rather than merely lapsing into passivity. From our artistic research perspective, this tension is productive rather than contradictory. The machina sopora can be understood not as inert but as dynamically poised—its apparent 'sleep' is the visible trace of an invisible search process that has momentarily resolved. Without wanting to settle these conflicting positions, we restage the Homeostat as a *machina inquieta* ('restless machine') and radicalize Ashby's concept. Our work is based on Ashby's design, but incorporates nonlinearities that affect the instrument's adaptive capabilities. Our apparatus (digital synthesis instrument) does not seek quiescence; it persistently destabilizes, producing multistable sonic states. In contrast to Asby's original Homeostat, we integrate machine listening and machine learning feedback paths, to design an instrument that oscillates between attractors, exemplifying a novel practice recently termed *Multistable Musicianship* [37].

2.2 Composing the Apparatus as Epistemic Practice

Building on Karen Barad's notion of the apparatus as epistemic and generative [38], we treat instruments, synthesis algorithms, and data-generation pipelines not as passive objects but as active participants in the co-constitution of musical and sonic knowledge and artistic artefacts. In her agential realist framework, phenomena do not pre-exist

their measurement; they emerge through intra-action, a process in which distinct agencies arise through their entanglement rather than preceding it. From this perspective, we regard apparatuses as dynamic participants in the production of reality, material conditions involved in the data creation process when prototyping AI mediated or driven musical instruments are an evolving field of artistic research [39, 40].

Intra-actions with these apparatuses produce phenomena, where the material, performative, and computational aspects of sound-making are entangled. In this context, composition and synthesis converge: both share etymological roots—composition from Latin *componere* and synthesis from Greek *synthithenai*, meaning 'to put together'—yet the conventional distinction between the intellectual act of composition and the applied act of synthesis has been overcome [41]. Designing and operating feedback instruments, training *Small-Data* machine-learning models, generating inference-driven feedback instances, and exploring multistable sonic behaviors become acts of composition in themselves, where knowledge production, sonic experimentation, and ethical reflection are inseparable from the material apparatus.

"We [humans and non-humans] are entangled; we are processes of becoming; we are products of resistance to the conditions in which we find ourselves" [42, p.139]. Our apparatus, the *machina inquieta* does not simply illustrate entanglement, it enacts its dynamic, generative and poetic nature. By foregrounding the apparatus as both method and medium, musical creation becomes a relational, emergent, and performative practice, produced through the intra-actions of performer, instrument, and algorithm. Composition is no longer a static plan; it is entangled action, intra-actively realized in and with the apparatus.

3. REALIZATION

3.1 The Machina Inquieta

The *machina inquieta* digital instrument is conceptually inspired by W. Ross Ashby's Homeostat and adopts its fundamental structural principles. The system consists of four interconnected units, each implemented as an autonomous digital sound-synthesis instance. Mirroring the Homeostat's architecture, every unit contains an internal recurrent feedback path while simultaneously participating in a network of mutual interconnections with the other units. The project is realized in the SuperCollider environment [43], extended with a library for machine-learning functionality [44]. Each unit is defined through a shared synthesis recipe, forming the sonic basis of the prototype system [45].

The synthesis model for each unit is an adaptation of buffer-rewriting synthesis [46], augmented with a 1-train pulsar synthesis engine as excitation source, following the principles described by Roads [47]. The resulting digital instrument exposes 16 synthesis parameters, enabling a wide spectrum of sonic behaviors: from sparse or dense percussive textures to sustained, spectrally rich standing tones. The choice of synthesis technique is not conceptually prescriptive; rather, it serves demonstrative purposes. In principle, any synthesis method capable of sufficient temporal and spectral variability could fulfill this role. What is essential is not the specific synthesis method, but its capacity to generate diverse and multifaceted sonic outcomes.

3.2 Data Generation, Analysis and Mapping Strategies

In a subsequent data-generation phase, the authors explored the parameter space empirically. Through iterative listening, adjustment, and aesthetic evaluation, selected 16-dimensional parameter states were mapped onto positions within a two-dimensional control interface (an XY slider). This process—guided by listening and taste or musical-aesthetic judgement—constitutes a deliberate act of data manufacturing rather than indifferent data collection. Each saved data point thus consists of a complete 16-parameter synthesis configuration and a corresponding XY position. The artistically constructed data sets consist of only 36 data points for each unit, which were automatically arranged evenly across 6×6 XY positions (6 points from left to right in the 2D slider, with 6 points per row, all evenly spaced) to ensure an expressive and continuous control topography. It was intentional that this topography was not organized retrospectively according to its sonic qualities or properties. In a next step, these arrangements were automatically up-sampled (linearly from 6×6 to 50×50) to create two data sets for training the two Multilayer-Perceptrons (MLP) for regression, each with 2500 data points. Simultaneously, each generated sound instance (corresponding to a stored parameter state and XY position) was analyzed using Mel-Frequency Cepstral Coefficients (MFCCs). For each data point, a 0.25-second audio slice was captured, 13 MFCC coefficients (starting from the second coefficient) were extracted and a statistical mean was calculated. A first multilayer perceptron (MLP1) was trained on this input–output data-set: 'XY position $\rightarrow$ 16 synthesis parameters'. This model enables the performer (or system) to control the full 16-dimensional synthesis space via a two-dimensional interface. A second multilayer perceptron (MLP2) was trained on the inverse mapping: 'MFCC feature vector $\rightarrow$ XY position'. This second model allows the system to continuously analyze the currently synthesized sound and infer a projected XY position from its spectral features.

The entire process described in this section (data generation, mapping) is repeated four times, so that each unit produces different sonic outcomes and adaptive temporal behaviors, while using the same synthesis definition. In other words, each unit is based on its own unique dataset. This is another artistic or compositional decision, comparable to the way one instrument might be played or used in four different ways.

3.3 Recurrent Feedback Within a Unit

When both MLP models operate simultaneously, a closed feedback loop emerges. The unit synthesizes sound, ana-

lyzes its own output, predicts a new XY position, remaps this to synthesis parameters, and thereby alters its future sonic state.

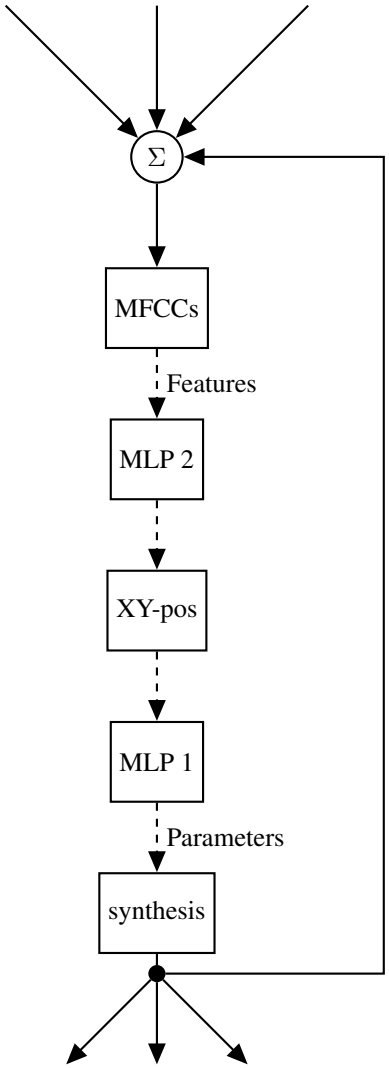


Figure 1. Structure of one unit u_i. Dashed lines indicate control rate data, bold lines indicate audio rate data.

In this configuration, each unit effectively plays, listens to, and reorganizes itself (Figure 1). Its behavior is not externally scripted but emerges from the recursive coupling between synthesis and analysis. One might expect one recurrent unit to form a stable equilibrium state here, but this is not the case. The reason for this lies in the artistic creation of the data sets: there are data points at different positions in the 2D field that are possibly characterized by similar timbre properties. In other words, during data set generation, no intentional effort was made to group similar sounds. In this way, the 2D representation of possible synthesis states should not be seen as a list of material possibilities, but rather as a compositional design.

3.4 Interconnection of Four Units

The complete instrument consists of four such units. Each unit contains its internal recurrent loop, but the system also introduces a global coupling layer. Audio outputs of the other three units plus the output of the respective unit are summed. This aggregated signal is then routed into the MFCC analysis stage of every unit. In other words: Each unit listens to itself and the total sound of the system and each unit adapts based on a shared digital environment (Figure 2). This creates a network topology in which every unit is self-referential (internal feedback) and every unit is environmentally coupled (global feedback). The result is a dynamically entangled system of four adaptive agents. Local adjustments propagate globally, and global changes perturb local states. The architecture thereby radicalizes Ashby's model: instead of stabilizing toward equilibrium, the system is configured to remain in motion—oscillating between attractors, reorganizing its parameter constellations, and exhibiting multistable sonic behaviors. In this sense, the digital instrument embodies the concept of *machina inquieta*: a restless apparatus whose structural condition is not quiescence but continuous reconfiguration.

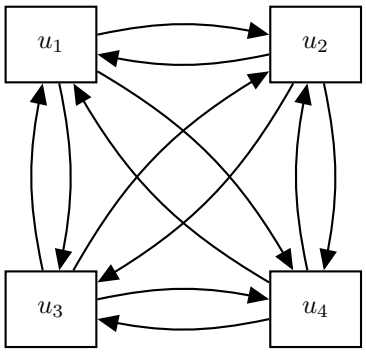


Figure 2. Fully connected four-unit system.

3.5 Intra-action via controller

Intra-action is implemented through four independent 360-degree non-homing joystick controllers (Figure 3), one assigned to each unit. This design is loosely inspired by W. Ross Ashby's Homeostat, whose protruding needles allowed physical perturbation of individual units: when touched, the system reacted. Similarly, engaging a joystick in the *machina inquieta* constitutes a deliberate disturbance of one (or more) agent(s) within the network. When a joystick is moved, the corresponding unit temporarily exits its autonomous feedback loop. Instead of allowing MLP2 to continuously infer the XY position from MFCC analysis, the joystick directly controls the two-dimensional parameter interface. In this state, the performer manually navigates the 2D control space, thereby playing the touched unit in a functional instrumental way. Once released, the unit re-enters its recurrent feedback process, resuming autonomous self-listening and adaptation. Importantly, while one unit is under direct performer control, the remaining units continue to operate within the global feedback ecology. They analyze not only their own output but also the performer-influenced global mix, adapting their internal states accordingly. The Intra-action thus establishes a dynamic balance between autonomy and perturbation. The

performer does not override the system as an external controller but intervenes as a situated agent within the multi-agent ecology—provoking reorganizations, redistributing attention across the network, and influencing emergent sonic and temporal musical structures through embodied disturbance.

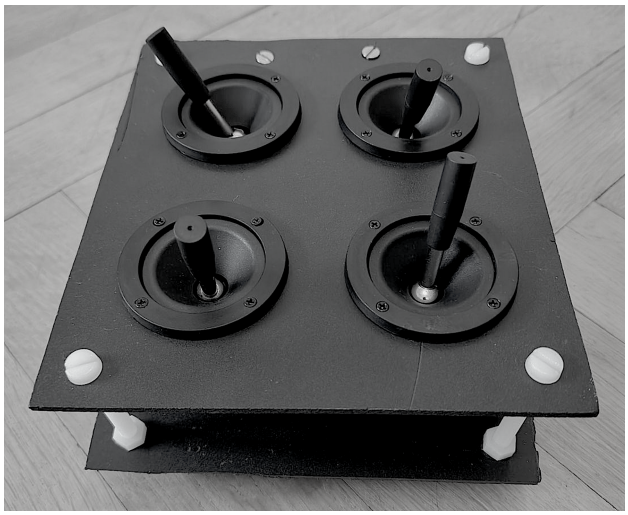


Figure 3. Joystick controller prototype to play the instrument

4. PERFORMER'S PERSPECTIVE

What follows is a first person account by Marco Doettlinger about playing the instrument:

When I engage with the machina inquieta*, I do not experience it as an instrument that I control, but as a system one can enter, already in motion. From the outset, it frames how I listen, how I act, and what I perceive as musically possible. My gestures do not necessarily translate into predictable outcomes; instead, they intervene in an ongoing process, shaping not only the sounds that emerge but also how I come to understand them.*

As I play, I find myself navigating rather than directing. The system responds to my actions, but not in a linear or fully transparent way. At times it amplifies a gesture, at others it resists or diverts it. This creates a condition of shared agency, where I am neither fully in control nor disengaged. Instead, I am continuously adjusting—listening to what the instrument is doing, and deciding whether to reinforce (at least trying to) or disrupt its behavior.

And one becomes particularly aware of the system's multistability through experience. This means that the instrument allows one to engage with it or, more generally, to develop a kinship relationship with it. Over time, I begin to recognize different behavioral regions—states with their own sonic identities and dynamics. Moving between these states is rarely smooth or intentional. Often, a minimal action shifts the system into a different regime, while more forceful interventions may have little effect. In these moments, my role becomes less about producing specific sounds and more about sensing when and how to act within an unstable and evolving field. Also, not all units are equally multi-stable (depending on the MLP models used); Unit u_4*, for example, is less 'restless'.*

Also, it must be said that each unit uses the same synthesis and only two fixed MLP models. The possible sonic states are therefore very limited—intentionally so. In a future iteration, it would certainly be interesting to expand on this principle by equipping each unit with more synthesis options and developing variable models that also change over time.

The temporal unfolding of the music emerges from intra-acting with it. I do not predefine its form; As a classically trained composer, that feels strange and very liberating. Sonic shapes develop through a continuous process of negotiation between my actions and the system's adaptation. There are moments where I attempt to stabilize a behavior, and others where I deliberately push it toward instability. Resistance becomes productive—it shapes phrasing, density, and transformation. Playing, in this sense, feels like working with the system rather than on it, what requires a particular mode of attention. I listen not for confirmation of intention, but for possibilities: where the system might go, what it affords, and where it becomes sensitive or agnostic to intervention. In this sense, playing is detached from mastering the instrument.

Media examples (excerpts) of the instrument can be found in [48].

5. CONCLUSION

This paper presents the *machina inquieta*, an instrument and an epistemic proposition: a performative system in which sound, data, and agency are continuously co-constituted through recursive feedback and intra-action. Building on the conceptual foundation of W. Ross Ashby's Homeostat, the project departs from a paradigm of stabilization and instead foregrounds persistent disequilibrium as a generative condition. In doing so, it reframes adaptive systems not as solely problem-solving mechanisms oriented toward equilibrium, but as dynamic ecologies that sustain musical richness through ongoing reconfiguration.

By integrating synthesis, machine listening, and machine learning into tightly coupled feedback loops, the system demonstrates how multistability can function as a core principle of contemporary musicianship. The resulting behaviors—unpredictable yet structured—challenge conventional distinctions between composer, performer, and instrument. Musical form is no longer pre-determined or solely human-authored, but emerges from the relational *interplay* between human gestures, algorithmic processes, and material constraints.

The project's emphasis on *Small-Data* practices further situates it within a critical discourse on AI and artistic production. By treating data as a crafted, situated, and aesthetic artifact rather than a resource, the research asserts both artistic and epistemic sovereignty. Conceptually, the *machina inquieta* aligns with Karen Barad's notion of apparatus as an active participant in the production of phenomena. The instrument does not represent musical ideas; it enacts them. Our thesis is that composition, synthesis, and performance collapse into a single entangled practice,

where knowledge arises through doing, listening, and intervening within a responsive system.

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