Posthuman Gesture

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ABSTRACT

This paper proposes the notion of *posthuman gesture* as a conceptual framework for approaching the increasingly complex notions of agency within digital instrumental system design and performance. *Posthuman gesture* is a synthesis of Barad's notion of posthuman performativity and current research of gesture in musical and digital instrument design contexts. An overview is provided of an approach to instrumental system design that took place in the context of a larger interactive dance work, followed by a discussion that applies the *posthuman gesture* framework to this example project.

CCS CONCEPTS

• **Applied computing~Performing arts** • **Applied computing~Sound and music computing** • Human-centered computing~Gestural input

KEYWORDS

instrumental system design, posthuman gesture, machine learning, concatenative synthesis, metaphor, agency

1 INTRODUCTION

It is increasingly difficult to conceptualize the structure and role of instrumental systems that are being developed for musical contexts due to the requirement of metaphors that are beyond those of the acoustic paradigm [12,4]. Digital technology has reconfigured the boundaries between traditional musical roles of composer, performer and instrument. Aspects of performance that used to be determined purely by material and/or socio-political influences are now "in the box", only bounded by the "fluid" nature of software. This reconfiguring of boundaries can be seen as a general trend as digital technology becomes increasingly ubiquitous, leading Berry [3] to declare that the digital is the unifying factor of the University. New emergent approaches to categorization [16] are required that consider "the multilayered structure of software, hardware, and network 'stacks' that arrange different technologies vertically within a modular, interdependent order" [6]. The problem with conceptualizing these systems is that the dominant acoustic metaphors do not account for how software provides a new distinct form of interaction between humans, a new cycle of development between software and developer, and how software itself can interact with other software [4].

In this paper, we focus on instrumental systems that are digital born [3] such as to directly engage these new distinct forms of interaction while highlighting the fracture between the physical human gesture and the resulting sonic morphology [22]. As gesture is understood to bypass the Cartesian divide between mind and body [13], this fracture can be understood to be all the more substantial in that it affects both the cerebral and corporeal intentionality that gestures propagate as both response and active contributor to the perception of the world [12]. This raises important questions as to how interaction design is augmenting our sensorimotor experience and thus the embodied grounding of the metaphorical structures that govern the way we think, act, and communicate [15]. A core issue is that interaction in such cases must be understood in terms of a shared human-machine agency: while the fracture creates a divide between human gesture and outcome, this is compensated by human intentionality, and the broader range of human influence, being fused with (potentially) opaque and automated/autonomous machine processes for which these trajectories can be amplified, muted or bifurcated. As a means of understanding such human-machine agency a conceptual system is required that accounts for the role of intentional human interaction, as well as notions of machine involvement that span performative (computational) understandings of technology [28,9], agency networks [7], machine learning/listening [31], and considerations of artificial intelligence [5]. This understanding of instrumental systems brings to the forefront the notion of agency: who or what is responsible for influencing the outcome?

Brown [7] uses the concept of "machine agency" to describe the range of influence that software can have over the generation of output during the context of performance[1]. The

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[1] In the context of the discussion raised in this paper, we can understand this range to encompass automation up to artificial intelligence which is a larger range than covered in [7].

author applies this framework to assessing the degree of agency existing between himself or the software. While this distinction between human and software is applied to the temporal arc of performance, it may be extended to how he, as the programmer, must prepare for the various performance contexts. What becomes clear is that when we focus purely on the context of performance, we can make the distinction between the human and the software in terms of who has more influence; yet, if we shift the perspective to include the larger temporal arc that includes the preparation for the performance, it becomes clear that there are added layers of influence by the performer-programmer, at least in terms of an increased influence on the outcome. This is further complicated through the recognition of the distributed nature of the influences from various human and non-human agents within digital networks [8].

Bown et al. [4] propose the notion of "behavioural object" to account for software's ability to act as musical and social forces in digital systems. "Behavioural" is meant to accommodate the more passive roles of software, such as a simple software synth, to more the active roles, such as live algorithms [5]. The distinction between musical and social forces is recognized in the description of different forms of agency: "performative agency" and "memetic agency". "Performative agency" parallels Brown's use of "machine agency" above in that it is used to describe software's influence in the context of a specific musical performance. "Memetic agency" describes software's ability to influence "the evolution of musical styles over historical time", pointing to the larger temporal arc that exists outside of the performance context. "Memetic agency" is grounded in Dawkins' theory of memes [4] and connects to temporally larger dynamic evolutionary systems "in which cultural forms such as music emerge". While it is not in the scope of this paper to explore instrumental systems across evolutionary temporal scales, it is important to note that marking the boundaries of the analytical frame for which we determine *when* a specific instrumental system came into being, as well as circumscribing the limits of where an instrumental system begins and ends is not a trivial endeavor and has consequences on the interpretations of its trajectories of influence, such as seen in the example provided above by [7]. Our conceptualization of instrumental systems is further problematized by digital technology's potential to be a tool, research object, expressive medium, and exploratory laboratory simultaneously [29]. Digital technology can be understood to be made up of sub-agencies concurrently creating a larger global assemblage and, as Brown [8] notes, it is increasingly difficult to trace the consequence of human intentionality through these instrumental systems. In order to account for these complexities, we propose the notion of *posthuman gesture*.

2 POSTHUMAN GESTURE

Our notion of *posthuman gesture* is grounded in the work of Barad [1,2]. Particularly influential are her conceptions of *posthuman performativity* and *apparatus* that are used to expand our ideas of agency and instrumentality respectively, while providing a general framework for understanding the de/re-stabilizing of boundaries that occur across various concurrent spatio-temporal scales. *Posthuman performativity* requires a rethinking of fundamental notions such as being, identity, matter, discourse, causality, dynamics, and agency [1]. While we are not able to cover all these terms and will just be able to touch upon Barad's ideas in this paper, we can approach *posthuman performativity* and *apparatus* through the relationships she draws between matter, dynamics, agency, and causality.

Physical matter is to be understood in a dynamical sense, having the ability to influence. Matter does not refer to a fixed substance, yet is a "stabilizing and destabilizing process of iterative intra-activity[2]." [2] This move from fixed objects to dynamical matter sets up the notion of performativity in terms of temporality such that the primary ontological units are phenomena, not "things" [1,2]. From this dynamical conception of matter, we are able to move to *posthuman performativity* with the understanding that all matter has agency, which Barad describes as such:

> "[a]gency is a matter of intra-acting; it is an enactment, not something that someone or something has. Agency cannot be designated as an attribute of subjects or objects (as they do not preexist as such). Agency is a matter of making iterative changes to particular practices through the dynamics of intra-activity (including enfoldings and other topological reconfigurings). Agency is about the possibilities and accountability entailed in reconfiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices." [1]

The breadth of agency covered in section 1 includes human, instrumental, and machinic, and points to their complex combinations and assemblages while allowing for new forms to emerge. This range can be understood to be a subsection of a broader *posthuman performative* interpretation. In this context, we shift away from the question of whether an object or thing has agency, to how specific assemblages of agencies have influence towards particular outcomes. This shift aligns with Barad's rethinking of causality that moves away from the local perception of a linear cause and effect to that which includes nonlinearity, affirming that "matter's dynamism is generative", and "[m]atter is a dynamic intra-active becoming that never sits still - an ongoing reconfiguring that exceeds any linear conception of dynamics in which effect follows cause end-on-end, and in which the global is a straightforward emanation outward of the local."[1] This understanding of causality has consequences for our notion of instrumentality and instrumental systems particularly in how we conceive them in holistic terms, how we understand the boundary that circumscribes the system to separate it from that which is "not the system".

Barad [1] develops the notion of *apparatus* that we can understand to be synonymous with "instrument" in its broader conception: the measuring apparatus, the reporting apparatus, the technical apparatus, and the conceptual apparatus. A central claim Barad is making is that phenomena (primary ontological units) do not exist in distinct opposition to each other but are in a constant flux of intra-action; and thus, there is a focus on the emergence of boundaries through "boundary-making" practices in relation to other apparatuses; that is, "apparatuses are not

[2] Intra-activity is used instead of interactivity as the later assumes the preexistence of objects that have discrete attributes while the former does not. "I introduce the term "intra-action" in recognition of their [entities] ontological inseparability, in contrast to the usual "interaction , "which relies on a metaphysics of individualism (in particular, the prior existence of separately determinate entities) . A phenomenon is a specific intra-action of an "object" and the "measuring agencies"; the object and the measuring agencies emerge from, rather than precede, the intra-action that produces them." [1]

mere static arrangements in the world, but rather apparatuses are dynamic (re)configurings of the world, specific agential practices/intra-actions/performances though which specific exclusionary boundaries are enacted"[2], and "[p]henomena are produced through specific causal intra-actions involving multiple apparatuses of bodily production."

We are introducing *posthuman gesture* as a way to navigate these complex assemblages of agencies and (re)configuration of boundaries. This is meant to extend the rich set of interpretations of gesture [14, 27, 12] to account for cyborgian and nonhuman influences. In part, this is a recognition that current practices already can be understood as posthuman as can be seen in the parallels of moving from representational models to performative ones as described by Sha [28]

Posthuman gesture can be understood in nested terms that can be articulated over various spatio-time scales. Leman has pointed out that gestures are multi-modal, referring to sound or movement, and multi-level as they may be deployed "in limited or more extended frames of space and time", while requiring a 3-tiered methodology that combines measurement, self-observation, and communication [17]. We are extending this notion of gesture to include the influence of *posthuman performativity* through the "space of agency" as described by Barad [1]. This perspective, particularly in the context of digital instrumental systems, allows us to extend the typology set out by Leman [17], with that outlined by Van Nort [30], with the goal of approaching the posthuman contexts through the lens of gesture. Furthermore, the dynamic understanding of matter aligns with the notion of matter profile [30], as "the time-varying aspects of all of the matter-related sound qualities", such as mass, harmonic timbre, motion, and grain. This can be understood as the dynamics of all sound descriptors that result from either human analysis or in combination with machine analysis techniques. *Matter profile* provides an example of the notion of intra-activity in the sense that an audio descriptor (such as spectral centroid) does not exist before the analysis technique that measures it.

Sha [27] describes his approach to gesture as one that "leans toward taking gesture as a dense and multivalent phenomenon whose boundaries we should not draw overly sharply at the outset of the analysis." This approach when translated into a posthuman context provides an indication of how various posthuman phenomena combine to create larger posthuman gestures with the understanding that there are no distinct boundaries to these gestures until an "agential cut" enacts a boundary resolution [1] or the less rigid perceptual "cut" [30] is made. *Posthuman gesture* provides a way of articulating the complex influence that is at times indeterminate of the accumulation of various agencies in specific contexts. This articulation occurs in part through the consistencies that are attributed to gesture as a notion of multimodal and multiscale influence, including its matter profile, across the breadth of its interpretations. It is within this framework that *posthuman gesture* can be understood as the *enactment of agency* in general that is perceived through its influence.

3 ELEMENTAL AGENCY

We now turn our attention to a collaborative interactive dance/media project that will serve to ground the discussion in a concrete example. Conceived and directed by the second author, *Elemental Agency* is a piece concerned with an emergent gestural language that manifests across movement, sound and light. Rather than sound/light articulating movement, or movement driving media, the approach builds outward from gestural metaphors as a point of shared intersection for these phenomena. The work draws upon the metaphorical constructs of Japanese Godai [18] and Indian Vaastu Shastra [23] philosophies of five elements: earth, water, wind, fire and void/space.

The director invited 13 graduate and advanced undergraduate students to collaborate on this project in a number of specified roles: six dancers from the York contemporary dance ensemble, three students focused on ceiling-mounted Kinect movement tracking and floor spotlight projection, and three students focused on sound/interaction design.

Working with conceptual metaphors drawn from these traditions, constraints are provided to the dancers in the form of a request to embody a given element as a collective – a texture of movement, rather than a singular human entity, that manifested a sense of non-human agency of a given element. The workshopping process also drew upon the director's experience of Deep Listening [21], which emphasizes a full-bodied approach to listening that focuses on awareness of attention and sensation of inner and outer worlds, incorporating self, other and environment. Integrating this framework and drawing upon writings from the cultural traditions of the elements, motivations related to five categories were articulated to the dancers and designers: *world, body, motion, emotion and enaction.* For example, developed metaphors included earth as stubbornness and resistance to change, wind as expansive, elusive and compassionate, fire as energetic and forceful, etc. Using machine learning methods and the Wekinator software [10], the sonic interaction designers sought to capture moments of gestural expression and fuse this with sounds that similarly embodied a given elemental quality/profile. Negotiation between art forms led to a collective choreography and sound design that emerged from the embodiment of the nonhuman elements and the mediation of the machine agents. Visual projections functioned as both lighting and enhancement of embodied experience in space, rather than screen-oriented media experience. Spotlights both enhanced elemental qualities as well as embodied behaviours that aligned with the constraints of the element metaphors: rigid tracking of movement within earth state, amorphous following within water state, tendency towards consumption in fire state, etc. An example moment of lighting and movement from earth state is depicted in figure 1.

Presenting gestural metaphors of the elements, abstracted out to the five categories, allowed for a shared point of reference for movement, sound and visual creators. Guided by directorial feedback, the workshopping process allowed dancers to develop a movement vocabulary that reflected their collective understanding of a given element. Mapping between movement and sound was a multi layered process that equally valued the transference from movement to sound as well as vice versa. Dancers presented movement ideas related to a given element, and both they and other participants vocalized their sonic understanding of this movement. At the same time, sonic meditation practices drawn from the Deep Listening literature allowed participants to reflect on their embodied reactions while listening to a sonic design idea proposed for a given element. Through this negotiation, an understanding was reached

between the dancer collective and the given sound designer for a given elemental section regarding potential relationships of movement and sonic gesture. At this point, machine learning (continuous neural networks) were employed to learn specific mappings between a given dancer, each wearing a Myo sensor armband, and an interactive sound instrument. The process was an improvisational coalescence of the workshopping process: dancer and sound designer would simultaneously perform a given movement/sound phrase, with the software learning a relationship between the two.

The arc of the larger movement/sound development process thus began from elemental metaphors, condensed by the director into categories related to inner/outer and self/world that applied equally to dancers and sound designers, and eventually coalesced into an emergent choreography for the dancers and an interactive sonic instrumental system for the sound designers, with continuous mappings emerging from improvisational co-articulations of the respective understandings of the elemental metaphors at play. Reacting to the emergence of the sections of wind, earth, fire and water, the director then created a larger structure that focused on a narrative that only emerged from these sessions. In order to reflect upon the nature of posthuman gesture as it arose within the development of this larger work, we focus on a specific section in which the first author was engaged in the sonic interaction design.

Figure 1: Moment from Earth section of Elemental Agency

4 FIRE

4.1 Fire in the context of Elemental Agency

The design of the instrumental system for the section devoted to *fire* inherited strategies and technical infrastructures from the larger context of Elemental Agency. This included six dancers equipped with the multi-sensor Myo armbands (www.thalmic.com) that transmitted data to software in MaxMSP, which conditioned the data to be sent to the machine learning software Wekinator, which in turn would transmit the data to the designed instruments for each section. The remainder of this section will focus on the creation of the sound design and the configuration of the instrumental system for the section *fire.*

4.2 Metaphorically informed design constraints

Drawing from the above-mentioned framework, qualities related to world, body, motion, emotion and enaction were derived. In the case of fire these included the metaphors: sunlight, lightning/electricity, metabolism, body heat, energetic, forceful, drive/passion, aggression, security, motivation, desire, and intention. The dancers workshopped their choreography around sets of movements and gestures that embodied various aspects of the metaphors. The sound design and configuration of the system emerged from the interpretation of these same metaphors, motivating three specific design goals. First, each dancer would have a unique sonic voice that could be clearly identified and would sustain interest being performed solo, yet when played all together would collectively fuse to create a perceived sonic whole. Thus, each dancer would have their own unique instantiation of a similarly-designed instrument. Secondly, each dancer would be able to reach a state of silence such that they are not only modifying sonic material but are able to embody sound creating gestures in that the sound is completely fused with their movement. This requirement presents the challenge of how to deal with the marking of a sound-generating gesture: when does the sound begin and when does it end without resorting to a manual triggering of the gesture (i.e. having someone turning it on and off) or a basic signal thresholding. Finally, the sound quality was to be influenced by the metaphors related to fire, yet were not to be recognizable as real-world sounds. In order to achieve these goals the strategy employed was to train the machine learning system Wekinator [10] towards the creation of a mapping model between the Myo armbands and the sound component of the performance system (section 4.3). The real-world constraint of having to develop the instrument both with and without dancers present motivated the authors to create a system that had sufficient gestural control of the sound generation both when sonic results were mapped to the dancers movements, as well as in situations that necessitated the designer to mimic the potential sonic outcome for the sound design process; as such, it was necessary to create an instrument that would be able to be performed during the sound design as well as the mapping design process.

4.3 Fire: system overview

The system can be broken down based on the functionality of its three basic software modules: sound generation, gesture input and data conditioning, and the mapping strategy (machine learning).

4.3.1 The Sound Module. The sound generation module of the instrumental system implements concatenative synthesis in MaxMSP utilizing CataRT [24,25]. A corpus of sound grains is generated by segmenting a collection of sampled audio into units that are analyzed for a variety of sound descriptors (pitch, loudness, brilliance, etc.). These sound descriptors are used to create a multi-dimensional space and synthesis occurs by choosing target values of sound descriptors within a reduced dimensional projection of this descriptor space, wherein the closest grain is chosen based on a weighted Euclidean distance. [26] CataRT also displays the units within the corpus spatially in two dimensions based on the choice of two sound descriptors. To synthesize the audio, one moves the cursor with a mouse/track pad through this 2-dimensional space.

Five unique sound corpuses were created/curated through an empirical approach. Various sound combinations were tested resulting in unique sound sets that can roughly be described with the categories of fire, storms, metal/rocks, thumps, and electricity. The electricity category provided the

broadest range of compelling sonic output, thus for aesthetic reasons two dancers shared this category. Concatenative synthesis provides the means to reanimate a trajectory of timbral morphology from a database of sound units allowing one to exploit the complex qualities found in the recording of real-world sounds or any audio sample. This reanimation removes the sound qualities from their inherent/captured temporality, yet, depending on grain size, the source of the sound file is often still recognizable. Aesthetically it was decided to have the sound morphology of the outcome be similar to fire, and "fire-like" but not necessarily to be heard by the audience as fire. Thus, SuperCollider was used to add audio effects to remove any lingering trace of the real-world connotations of the sound samples, as well as to emphasize the unique voice for each of the dancers. To control the synthesis for each CataRT corpus, an iPad was used in combination with Mira[3], specifically mira.multitouch. Mira allows the control of a Max/MSP patch on a mobile device, while mira.multitouch tracks 10+ fingers including x/y position, on/off, whether the finger is moving, pinch, rotation, swipe, and rotate among others. With this setup, it was possible to have six fingers, one for each dancer, mapped to five sound corpus and synthesis modules in CataRT (figure 2.) The x/y coordinates were scaled and mapped to the 2-dimensional space of the corpus, providing a means to mimic the potential sonic result of each dancer individually as well as collectively.

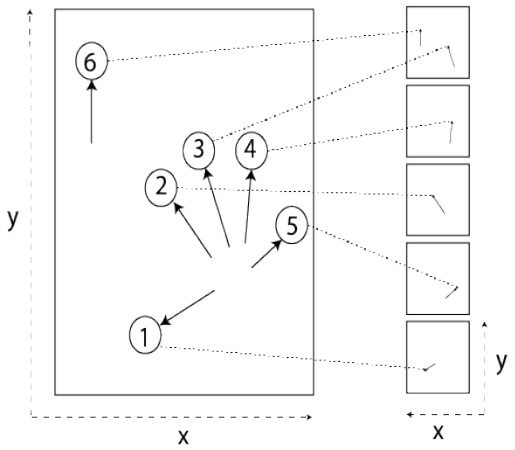

Figure 2: Showing the mapping configuration for six fingers on an iPad running mira.multitouch via maxMSP to five 2-dimensional representations of CataRT corpuses.

4.3.2 Choreography and Myos. The choreography was workshopped by the dancers and the director guided by the contextual metaphors for the section. This resulted in a structured improvisation that was based on a developed set of movement phrases. Each dancer was equipped with a multi-sensor Myo armband (https://www.myo.com/) worn on their right arm. It consists of eight electromyographic (EMG) sensors that measure muscle tension, a 3D accelerometer, 3D gyroscope, and 4D orientation in quaternions and communicates wirelessly over Bluetooth to proprietary software [20]. *myo for max*[4] was used to input the real-time streams of data into maxMSP where further software was developed to scale (if desired) the data and add appropriate OSC namespaces before being sent to other applications, particularly Wekinator. In order to work directly with data related to euclidean 3D representations, acceleration and gyroscope were used, in addition to EMG data to capture the subtle gestures of muscle tension variance.

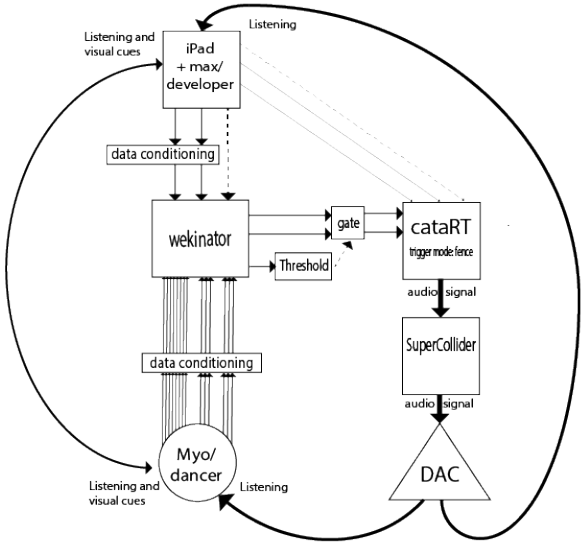

Figure 3: During the sound-design stage the iPad transmitted position data via MaxMSP's mira.multitouch to CataRT. See Figure 1. for the relationship between the iPad and CataRT. The dotted line represents the binary data of the on/off parameter. During Wekinator's training phase - the data received from the iPad (3 parameters) is used as the projected output based on input received from the Myo controller (14 parameters). During the running phase the iPad is no longer part of the system as the Myo data is interpreted by Wekinator's mapping model and sent to CataRT. Notice the threshold on the parameter out of Wekinator opening and closing the gate allowing the x/y data to pass to CataRT.

4.3.3 Machine Learning: Wekinator. Wekinator is an open-source machine learning software that allows for real-time creation and exploration of mappings using a supervised learning paradigm [10]. Within the context of *fire,* the use of Wekinator provided an efficient means to create complex mappings on the fly between the physical gestures (Myos) and the sonic output. Wekinator has three phases: recording, training, and running. During the recording phase, input (Myos) and output (iPad/ CataRT) data is recorded concurrently. For this phase, each dancer chose one gesture that they had been working on for *fire.* During the development of the instrument the author had developed a set of potential sonic gestures for the iPad that exploited the sonic diversity of each of the CataRT corpuses. For each dancer, as they presented their chosen movement the sonic gestures were auditioned. Once a chosen sonic gesture was agreed-upon by the dancer, sound designer (1st author), and the director (2nd author) the input (myo) and output (iPad/ CataRT) gestures were recorded into Wekinator. During the training phase, we utilized Wekinator's Neural Network method in order to learn a continuous mapping function to model the relationship between the input (Myo) and output (iPad/CataRT) data [11]. Then, during the running phase the input data is translated by the mapping function into the output data. In this case, we used fourteen data streams from each of the Myos that was translated into three data streams representing a single

finger from mira.multitouch, the x and y coordinates and on /off (i.e. contact or no contact) (see figure 3).

4.4 Reflections on fire: the instrumental system

The combination of CataRT, Myos, Wekinator, and an iPad (mira.multitouch) afforded particular solutions to creating (unique) mapping strategies between the physical gestures of each dancer to specific sonic output, that allowed meaningful embodied sound-generating gestures to occur for the dancers and be perceivable as such to the audience. The previous section provided an overview of how Wekinator streamlined the creation of the mapping functions. This resulted in specific physical gestures (Myos) having an expected sonic outcome, as well as a residual sonic space that could be explored gesturally during subsequent rehearsals, resulting in further sound-generating gestures. This residual sonic space is a result of Wekinator's mapping function handling streams of data that were not present during the training phase, that is, interpreting new gestures. *What became clear from this experience is that the physical sound-generating gestures that were used to create/discover/explore the sonic outcome through the combination of iPad and CataRT, by the sound designer, are not required to be the gestures used to perform the sonic outcome by the dancers; and, in fact do not require the same interface for expression.* This can be understood as a reconfiguration of the boundary that circumscribes the consistency between the "creation/discovery" gesture and the gesture of performance digital technology, due to the software that bridges the fracture between human physical gesture and outcome.

A challenge of working with sensors such as the Myo is segmenting the continuous streams of data into gestural units. In our case the physical-sonic gestures were to be perceived as sound-generating and thus marked by silence when there was no gestural movement by the dancers. An attempt at a simple solution would be to implement a threshold on one or more of the Myo parameters, thus acting as a mute button, or in slightly more sophisticated setups a gain control. Yet, this solution is bound to the position of the particular parameters in the mapping configuration and not to whether there is motion. A solution emerged as a consequence of training Wekinator with the iPad. The use of mira.multitouch for the iPad provides a sensorial interface that is binary (touch/no touch), one only need to cease making contact to assure a stationary state in the sound module. Yet with the Myos, contact is continuous and the sound-making gesture must be imposed onto the continuous stream of data. The solution to this issue was resolved by including the on/off parameter that resulted from the contact of a finger on the iPad in the training of Wekinator mapping function. The resulting output from Wekinator for this parameter was a float number between 0 and 1. The second step was to implement a threshold on the on/off parameter that controlled a gate for the x/y coordinates, a relatively simple implementation to guarantee a non-varying signal. This could be combined with the use of CataRT's trigger modes, which provide various options that determine the criteria for when the next selected grain is played. In this context, we were able to take advantage of the inherent gestural affordance of the *fence* mode, which remains silent by default if there are no changes within the input x/y coordinates. This resulted in the situation for which when the dancers were still there was silence, regardless of position. The dancers were able to respond to this in their choreography, resulting in an emerging form that was able highlight silence and the movement between single and collective voices.

5 DISCUSSION

Posthuman gesture provides a framework for approaching the increasingly complex notion of agency that emerges in the context of digital instrumental systems. This framework is grounded in Barad's notions of *posthuman performativity* and *apparatus* as a way to challenge traditional notions of instrumentality that are grounded in anthropocentric perspectives. Understanding all matter as dynamic with generative and nonlinear aspects shifts the question from whether a given phenomenon acts intentionally to that of how specific assemblages of phenomena act to influence outcomes in particular contexts. Drawing on the literature of contemporary research on gesture in musical contexts we extend the already wide breadth of this multi-modal, multi-scale methodological and analytical framework to include cyborgian, machinic, and non-human agencies; thus, broadening gesture and its associations to include the posthuman. This position extends the methodological and analytical framework of [30] whose approach to (digital) instrument design is "shaped by theories and views normally associated with the out-of-time electroacoustic tradition"; and, provides an understanding of gesture in terms of matter profile dynamics (see section 2) "that are either a result of, or which suggest human action" that is understood to be "embedded as a trace within a sound signal.. , and … recursively [may] be embedded within a mapping proper". From this position, we are able to extend the notion of human intentionality and action with the *posthuman performative* interpretation of agency, while broadening the notion of instrumental system with *apparatus*, providing a starting point for exploring the complex assemblage of processes that emerge. In so doing, *posthuman gesture* provides an open continuous framework between human, machine, and non-human forms of influence while accounting for the open-ended aspects of generative and non-linear processes.

Posthuman gesture in the context of this paper is meant to highlight an emergent (re)configuring of agential boundaries that is apparent within the literature of digital instrumental systems, and particularly with respect to human-machine agency. There may be a tendency to want to conceptualize *posthuman gesture* in a closed finite framework such as to understand it in its entirety, as a static form – this is to misunderstand its core tenants of dynamism, openness, and generativity across various spatio-temporal scales; yet, this by no means implies that stability and consistency are not also among its breadth of influence. It is merely that there is always at least a kernel of indeterminacy that must be accounted for. Particularly, in the context of digital instrumental systems it is precisely that which resists clear conceptualization for which the terms current formulation is best suited. In this light, we consider a few of the aspects of the instrumental system design and mapping training process that have *posthuman gestural* qualities.

A core design strategy revolved around the dancers being able to evoke sound-generating gestures. Utilizing supervised machine learning, gestures on the iPad were performed by the sound-designer and recorded concurrently with gestures performed with the Myos by the dancers (figure 3). This process was repeated 3-5 times with unique iPad/Myo gestural combinations. Wekinator then uses these recordings to

create a mapping model that sets output targets for the incoming data (Myos). Now, we imagine the dancer to perform a unique gesture that differs significantly from the ones training set. In this case, we can begin by conceptualizing the beginning of the trajectory of influence to align with the beginning of the dancer's gesture - in particular the discernible beginning of their movement, which enacts the notion of a sound-generating gesture. As the gesture is demarcated, the max patch broadcasts the conditioned Myo data-streams to Wekinator which remaps the 14 data-streams to 3 and then broadcasts this to CataRT. This data is then gated utilizing the on/off (touch/no touch) data stream as the gate's toggle to interpret x/y positions of CataRT's 2D interface to drive its synthesis module, which contains hundreds of audio segments based on 25 samples of various electrical sounds. The audio from CataRT is then processed by SuperCollider to add a final timbral colouring. The data conditioning module, Wekinator, CataRT (interface, corpus, synthesis module), and SuperCollider are all high-level interpretations of complex assemblages of influences. How are we to reconcile this sound-generating gesture with that of one that occurs in a purely acoustic context?

The chaining of these assemblages of influence creates the conditions for a sound-generating gesture to be perceived by both dancer and audience, yet the gesture in and of itself is not a sound-generating gesture as understood from an acoustic paradigm. The software nodes are all components in a chain that are bridging the fracture between human movement and sound, each containing an openness for potential indeterminate, generative, and non-linear process, unique to the digital contexts, to emerge via other assemblages of influence (including human). The force trajectory set out by a gesture in an acoustic paradigm is not sufficient as a metaphor for the trajectory of influence that can be traced from the physical gesture to the sonic result. While the metaphorical inference to a sound-generating gesture assures that there is a path that can be traced between human movement (Myo) and the resulting sound (DAC), there is *not* the closed conditions of acoustic contexts that constrain this path to only run from Myo to DAC, movement to sound. The perception of the human-sound connection emerges as an assemblage of agencies (influence trajectories), rather than marking a clear linear progression of cause and effect understood through the experience of momentum and transfer of energy[3]. The sound-generating gesture that traverses these assemblages is a special case, not the rule as we experience in acoustic performance contexts. This raises the question of how this embodied, dancerly gesture is understood to exist as part of a larger action-oriented ontology [17] or to suggest embodied metaphors [15]. This again points to the need to invoke the expanded notion of *posthuman gesture.*

This example is grounded in a specific case of a sound-generating gesture, yet as discussed, *posthuman gesture* does not prioritize the human position. Thus, we can approach the trajectory of influence from the starting point of the sound samples. If we allow ourselves to bracket out the conditions, locations and recording process, we must do so acknowledging that there is an indeterminacy in our influence trajectory. The samples are themselves assemblages of non-human and machinic agencies that point to *posthuman gestures.* The samples are analyzed and segmented by CataRT (which like Wekinator is a complex assemblage of processes not directly influenced by human action) and presented in a 2-dimensional space awaiting reanimation. With concatenative synthesis, the trajectory of influence becomes compounded quickly as thousands of sound grains are fused together in a complex weaving of spatio-temporal textures. This points towards automated processes that produce results that do not derive from human intention, and thus points towards *posthuman gesture.*

While *posthuman gesture* in some facets must always be approached from a reduced conceptualization it is important to emphasize that the sound-generating gesture, and sound sample examples must also be understood concurrently at the time of performance, which in our example is extended by the influence of the recorded iPad gestures and its own assemblage of influences, as well as the complex influence of the larger metaphorical constructs implemented in order to structure the emergence of "Elemental Agency".

6 CONCLUSIONS

This paper has introduced the notion of *posthuman gesture* as a synthesis of Barad's *posthuman performative* framework and current research on gesture in musical and digital instrument design contexts in order to account for the increasingly complex notions of agency in digital instrumental system contexts for which traditional boundaries between musical roles and notions of instruments are being destabilized and in some cases redefined. An overview of the design process for the section *fire* (from the piece Elemental Agency) was described, followed by a discussion of *posthuman gesture* in relation to this. This paper raises the point that there exists a complex relationship between posthumanism and gesture – one that is highly applicable to contemporary practices of interactive performance design and choreography/composition. There is, however, much more to be explored in this area going forward.

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