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Conducting the in-between: improvisation and intersubjective engagement in soundpainted electro-acoustic ensemble performance

Doug Van Nort

School of the Arts, Media, Performance & Design, York University, Toronto, ON, Canada

ABSTRACT

This paper examines an approach to ensemble performance, guided by a form of improvised conducting that functions both as communication with musicians and an embodied interface for transforming the ensemble sound. The framework for analysis draws upon the concepts of distributed creativity, its intersection with a listening-centric approach to meaning creation and an embodied cognitive stance on the development of semantic identifiers in music/movement practice. In the described project, tensions are negotiated between acoustic and electronic sources, and between bottom-up structured improvisation and top-down guidance via Soundpainting conducting. These continuums are amplified and explored through another layer of shared articulation, as machine learning has been applied to recognition of the composer/conductors gestures as well as to continuous mapping of conductor movement to sound transformations. These techniques allow for an intersubjective engagement between all members of the ensemble, wherein sound and movement gestures are co-constructed.

1. Introduction

This article discusses improvisational creativity as it manifests in collective musical performance in digitally mediated contexts. Of particular concern is an examination of shared agency in collective electro-acoustic improvisation (EAI) in which performers co-construct the larger musical form through the sharing of signals, in a context in which both human and machine agents mediate the direction of attention and performative response. I will present a project that merges shared-signal EAI practice with a human performer utilizing the Soundpainting conducting language, as well as a machine performer that applies machine learning to the task of gesture recognition and the mapping of

conductor movement to ensemble sound transformations. The larger critical implications surrounding shared agency and individual vs. collective performance dynamics that result from this approach will be discussed.

With respect to frameworks for discussing this work, many authors have explored the conversational and interactional dynamics of group improvisation (e.g. Monson 2009). Of particular relevance, Sawyer has gone on to expand this examination to various forms of improvised group activity, focusing on the conditions and dynamics of *distributed creativity* (Sawyer 2003; Sawyer and DeZutter 2009), applying principles of distributed cognition (Hutchins 1995) towards understanding creativity in contexts when

decision-making and performative agency is distributed amongst members of a group. Much of the focus has centred around the conditions that allow for collective creativity to manifest as an emergent property of group interaction. Conditions that have been noted by Sawyer et al. as key structural contributors to this quality of emergence include not having an a priori predictable outcome, or having equal contributional potential amongst members of the group. Meanwhile, in the context of solo approaches to EAI, Bowers (2002) articulates the presence of a shared and performative exploration of our collective human relationship to machines in the context of live EAI performance, placing emphasis on the sociological dimension of technological contingency. The author examines the role of technology in music performance both for its potential to augment performer action and its ability to represent futility and enhance disconnection from human intentionality. Van Nort (2016) integrates these conceptual threads by examining the intersection of non-hierarchical approaches and collectivist mindset in group improvisation with technological mediation, in this dual role as amplifier and distancing mechanism. He points to 'emergent practices' in EAI, articulating these as a distributed approach to compositional structure and 'shared sonic gestural actions as they propagate through shared signals in the moment of performance', applying them to case studies including the ensembles AMM and the HUB. In each of these scholarly projects, there is emphasis placed on emergent intentionality that manifests as a result of the specific contingencies of performative engagement, both human and technological, and how these interactions unfold over time. In the context of interaction design, Keller and Lazzarini (2017) note that distributed approaches are absent from the dominant discourses surrounding digital instrument and interaction design. They argue for an ecologically grounded approach that moves away from anthropocentric constructions of instrument/composition/interaction, identifying their approach as 'ubiquitous music'.

This article builds upon the work of these scholars, regarding the case study as an approach to composing constraints and potentials for interactional activity in the context of collective improvisation. It is an approach that begins from the position that listening is an embodied (Leman 2010) act, and that this may become distributed by virtue of the performance context. It can be easily argued that, to some extent, all modes of collective improvisation engender an approach to distributed listening, in the sense that players must closely attune to the larger sound field in order to find their own intentional sonic gestures as well as identify the intention of the group-sound. Meanwhile, in contemporary collective digital improvisation practices, listening is often enacted across a web of agents involving humans, instruments, machines and algorithmic processes. Working within this particular performance form, I thus propose that rather than focus on the causality of instrumental gesture paradigms, we may regard both movement and sonic gestures as dynamic elements of a larger topology of attention and mutual influence which provides an alternative design path in the course of designing scenarios (systems, compositions, etc.) for collective digital improvisation. The particular scenario presented here allows for a given movement vocabulary that shifts between explicit conducting of human performer activity and continuous modification of their sound output, thereby blurring the lines between symbolic communication of directed goals and a free and open co-construction of a shared sound world. The machine agent listens for, and responds to, conductor movement in order to present different instrumental conditions that influence the mapping of conductor movement to instrumentalists' sound transformation.

Traditionally, the paradigm of conducting is focused on a hierarchical organizational structure and a singular, centralizing force. Through a concern with shaping timing, dynamics and macro-qualities of a given performance group,

a conducted ensemble would seem to sit in opposition to a shared-signal EAI context that more naturally aligns with the distributed and ecological viewpoint that I invoke here. Through the *Intersubjective Soundings* project, I seek to present an approach that shifts the boundary conditions of the traditional conductor paradigm, highlighting a spectrum of autonomy and agency that can exist across all human performers (instrumental and Soundpainter). At one extreme, the distributed experience of shared-signal EAI allows for productive moments of getting 'lost' in one another's sound world, while the inclusion of Soundpainting-based conducting invites a reflexive consideration of musical meaning at the other. Designing a situation that shifts between these scenarios in performance, the project leverages machine agency so that these modes are not only mirrored in the movement of the conducting language and in the sound worlds of the performers, but in the responsive decisions of this underlying system that all human performers must equally listen for and react to.

In order to help articulate these two distinct experiences of performance within the project, we will refer to two distinct theoretical viewpoints. The first is Sawyer's semiotic approach to improvisation, applicable to discussing meaning arising from (movement or sonic) gestures in performance. The second is Husserl's notion of intersubjectivity, helpful in articulating the experience of shared-signal approaches within EAI. Informed by these, we will discuss Soundpainting in general before finally discussing the conception of Soundpainting as an interface in the design of the system for recognition and processing. This will lead us to an approach that places distributed listening and co-construction of sonic meaning as fundamental design principles.

2. Conditions for improvisationality

In his Semiotics of Improvisation, Sawyer (1996) articulates a spectrum between *ritualized*

and *improvisational* performance. The former is akin to composition, but is generalized to cultural traditions in which written notational forms may not exist, yet implicit or explicit rules may be established through patterns of practice and possibly verbal communication. The goal of his work is to move away from the structural analyses that are more amenable to compositional objects, towards a semiotic approach that considers the meaning that arises within the performance context. In positing ritualization and improvisation as two points on a multidimensional continuum for a given performance form, he defined nine *contrast dimensions* that follow the ritualized vs. improvisational spectrum. There are five that are particularly relevant to this discussion:

(1) Ossification vs. revivalism

The former refers to the process of habituation, beginning to constrain the possible interpretations and meanings of the semantic content of a ritual, tending towards meanings arising purely within formal structure. The latter is a condition when the new semantic content of the ritual becomes salient, and formal structures are deconstructed.

(2) Low vs. high creative involvement

This speaks to the degree of agency the individual performer has, and the extent to which they can assert their own personality within the ritual context.

(3) Indexically reflective vs. entailing

Drawing on the semiotic constructs of Peirce (1932), the former refers to the situation when the activities of a ritual serve to point to possible contextually meaningful outcomes of future actions of an individual, thereby constraining possible audience interpretations of an outcome. The latter refers to the situation in

which multiple competing trajectories emanate from and influence multiple performers.

(4) Large vs. small ready-mades

'Ready-mades' refers here to pre-existing learned units that an individual performer can draw on and any audience familiar with the ritual will understand it has having semantic relevance to the specificities of that ritual. The greater the degree of improvisationality, the less ready-mades that are available to the individual performer.

(5) Resistant vs. receptive to novelty

The degree of openness that the given ritual context allows for in defining new meanings in the flow of the performance.

Insofar as it does not generally organize its musical ideas relative to traditional notions of melody, rhythm and harmony, I would argue that EAI as a form of improvised performance engagement veers even further from structural signifiers of musical meaning than note-oriented forms of musical improvisation such as jazz. As such this semiotic framework may prove more useful than a purely structural analysis in reflecting on the conditions, results or structuring of an EAI encounter. Beyond the 'sound-oriented' nature of EAI, the material conditions of composition and instrument—and the boundary between these two—are far more fluid and often less codified than in many forms of musical improvisation. That is, the nature of 'instrument', the source and cause of a sound, and the qualities within the sound field that a listener can 'hold onto' as carrier of meaning (Landy 1994) are all malleable aspects of the larger musical invention of a given performance context, and as such are called into question. Speaking to the above contrast dimensions, EAI in general thus provides a situation in which revivalism (meaning not reliant on formal structures) is high, as is personal creative involvement. Nothing prevents the EAI

form in general from being indexically entailing, meaning that multiple trajectories of meaning can be taken up by audience and performer alike, while the definition of new meanings and 'ready-mades' are not constrained by the ritual form itself, but rather by other contextual elements (knowledge of a 'scene', certain personalities within it, etc.). Introducing Soundpainting conducting to this context, however, provides an explicit set of semiotic referents (hand/movement gestures) that constrain possible interpretations by performer and audience alike, moving towards a more ritualized performance form in general.

3. Soundpainting, extensions and ensemble EAI

The conducting language of Soundpainting, developed by Walter Thompson (2009) has been taken up for use globally by improvising ensembles across music, theatre and dance. The language has a syntactical structure focused around *who* should play, *what/how* they should play and *when* they should play/stop. A typical interaction is comprised of the sequence who, what/how and when. For example: a 'group 1' gesture may be followed by a sequence of what/how gestures whose collective meaning might be 'play sustained long tones with rough noise in a mid-high register, following the style of group 2' and finally be followed by an 'enter slowly beginning right now' gesture. At first glance this would seem to be a slight opening up of from standard western classical conducting traditions to include more sound descriptions—related to shape, timbre, texture and stylistic quality. At this level of interpretation, and in relation to Sawyer's framework, the hierarchical nature of conducting does move the ensemble context somewhat more towards ritualization, particularly along the dimensions of creative involvement and indexical reflectivity. At the same time, there are structures built into the language that play with the performer-conductor agency as a

performative dimension, such as the 'who (wants..)' gesture, which asks performers if they would like to subscribe to a given direction and take part in this or not. Further, there exist a number of gestures in which continuous conductor action is directly reinforced, interpreted or reacted to by members of the ensemble, such as 'sliders' for volume, density or register that performers continuously modulate in relationship to Soundpainter movement. This mode of Soundpainting presents a fusing of conductor/interpreter roles, in this moment reducing the dimensions of choice for both parties and leading to the visible and audible co-construction of embodied performance meaning. Shifting further away from traditional performer-conductor binaries, the Soundpainter may invoke a 'shapeline' gesture, which asks members to freely define their own interpretive mapping of meaning to complex movements, placing the ensemble in a privileged position to construct and reinforce sonic-kinetic meaning that is being defined within the flow of the performance. In this sense, while the very act of introducing Soundpainting moves the performance context in the direction of ritualization insofar as there are fixed signifiers of 'correct' performance activity, the position on the ritualization-improvisation spectrum is largely contingent on the modalities of interpretive or proscriptive signs that arise within a given performance.

Drawing on my own long-standing experience of EAI in which I capture signals from acoustic partners (Van Nort 2010), I have modified the Soundpainting vocabulary for ensemble context in order to engage with the unique situation of machine mediation, particularly the ability to play with representations as a performative element through capturing, transforming and re-injecting content as well as the ability for performers to co-modulate one another's signals in a very concrete and direct fashion. In terms of the conducting language, new gestures that amplify this include 'record/play', which asks performers to loop their

memory of a sequence of gestures and 'memory-process', which asks one to perform the memory of another performer's previous output by introducing sounds that match their recollection of this.

4. Shared signals and intersubjectivity

As one of his major strands of inquiry, Husserl articulated his concept of intersubjectivity—a transcendent state, condition and process through which a subject encounters an alien body, intuiting qualities of the world through the shared perception of self and other. This view provides an important lens through which to apply to the improvising ensemble, leading for the potential for what Husserl referred to as a 'functional community of perception' (Husserl 2013). As noted by Costello (2012),

> … another way to point out the mutual overlaying and awakening that occur within the encounter is to point to an operative, perceptual co-functioning … Persons co-perceive one another, and together (in mutual co-perception) they co-perceive the world as one world and their correlated perceptions as one act of perceiving.

The implications of this state of being are that the community perceives the same things in the world, that they do so in similar ways and that a given performer experiences 'his or her own separate acts of perceiving as implicated in (or as directed by) the other's' (Costello 2012). If we maintain an embodied view on musical meaning formation (Leman 2010), then we may extend this manner of thinking to a co-perceived gesturality in both sound and movement. As discussed in Van Nort (2016), the experience of the context of sharing signal paths in ensemble EAI settings leads to a need for this co-perception to function as a kind of distributed listening in which players much closely attune to the larger sound field in order to find their own intentional sonic gestures as well as identify the intention of the

group-sound. In other words, the Husserlian condition for a 'community of perception' and intersubjective engagement explicitly merges action and perception in a very direct and material fashion. While Sawyer's framework provides a means to examine EAI practices through a reception-oriented lens of examining emergent meaning in collective improvisation, this perspective of Husserlian phenomenology provides a means by which to consider the shifting subject positions of performers, in the moment of performance, within an EAI ensemble. I propose that these two views, one 'outside in' and the other 'inside out', act as duals of one another and that by considering both we may gain a more holistic view of distributed agency within EAI practices in general, and in the *Intersubjective Soundings* project in particular.

5. Intersubjective soundings

This section introduces the design and conceptual underpinnings for a project that integrates two MYO armbands, shared-signal sound processing of an electro-acoustic ensemble and gestural recognition of Soundpainting-style conducting. In the project, the Soundpainter shifts modes between guiding performers, collaborating through movement/sound improvisation, and explicitly processing the sonic output of performers through their movements. These shifting modes of interaction require all performers to become attentive to the tensions between acoustic and electronic sources, between their origination point (instrumentalist vs. Soundpainter) and between bottom-up structured improvisation and top-down guiding via conducting. These continuums are amplified and explored through another layer of shared articulation, as machine learning is applied to recognition of the composer/conductors gestures, with symbolic recognition opening up channels of electronic processing and discrete states of potential sound transformation, . The underlying machine learning system is also trained on continuous mappings between

conducted motion and sonic transformations, allowing the Soundpainter to perform these transformations through their (now free and unconstrained) movements, continuously co-shaping the output with a given performer. The presence of these two distinct modes of machine mediation creates a tension between the symbology of conducted instruction and that of continuously co-constructed sound, with the Soundpainter and performer sharing signals and intentional resonance in performance.

Intersubjective Soundings narrows in on this collective experience as a compositional parameter, allowing for moments of getting 'lost' in one another's sound world and gestural intentions, while needing to pull back to the symbology of soundpainting-based conducting. The work therefore traverses the spectrum of embodied listening-in-the-moment at one extreme, and a reflexive consideration of musical meaning at the other, with both of these modes being mirrored in the movement of the conducting language. This project has been developed in the context of the Electro-Acoustic Orchestra (EAO) at York University, a mixed electronic/acoustic ensemble that is comprised of a combination of students and Toronto-area professional musicians.

5.1. Soundpainting as interface

The project derives its lexicon of gestures from the Soundpainting vocabulary, along with adaptations that are more suited to the EAO ensemble in regard to the sonic palette and the unique instrumental and attentional challenges of synthesizer and laptop performers.

Consider the aforementioned example in which the Soundpainter indicates 'group 1, play sustained long tones with rough noise in a mid-high register, following the style of group 2, enter slowly beginning right now'. In such a situation, the Soundpainter acts as a centralized organizing force. In Thompson's own words, 'You are the one composing—creating

the piece in the moment utilizing Soundpainting gestures to indicate very specific and detailed instructions to be performed' (Thompson 2009). I would argue that this is applicable to such a moment within a given performance. At the same time, the level of specificity can vary dramatically. For example, the Soundpainter can ask 'who wants to play pointillistically right now? … and go'. Such a scenario might set the qualitative context, and importantly the 'when', but hands important elements of choice back over to the ensemble. Taking this further, the Soundpainter may simply sign 'whole group, improvise … and go'. As its name suggests, the 'improvise' gesture quite simply opens up a space for an improviser to play freely. Finally, moving along this spectrum of autonomy, the Soundpainter might ask 'who wants to improvise?', maintaining only the 'when' as their own artistic choice in the matter. Considering this spectrum of potential engagement, the Soundpainter clearly does maintain a central role at the minimum with respect to the shaping of form through determining activity over time, including who is or is not involved. Within this reality, there is quite a fluid engagement and shifting the level of agency with respect to performer choice of playing-or-not, and the level of specific pitch-range, timbral, rhythmic and stylistic quality. In this way, this performance context will never be as 'flat' with respect to the hierarchy of interaction as that of a completely free collective improvisation. At the same time, in the context of shared-signal EAI practices, for example, the Evan Parker Electro-Acoustic Ensemble (Lake 2004), this 'flatness' is also removed by virtue of the topology of mutual influence that is made possible by the ensemble's larger signal-sharing system configuration. A given acoustic performer might maintain a high degree of influence if an electronicist requires their input in order to play, while said electronicist might maintain the ability to completely transform or overshadow the output of an acoustic performer through their sound processing actions. The Soundpainting context does centralize a great deal by fixing the Soundpainter as a privileged source of 'who/when' decisions, yet this context does import much of the fluidity of negotiation found in shared-signal EAI. Rather than topology of signal paths, it is the unfolding of both the Soundpainting actions and the concomitant decisions of the entire ensemble that act as strong determinants of this. While a many-to-one topology invariably exists on some level in the Soundpainted ensemble, requests for relational playing between groups introduces important additional layers—heterogeneous networks—of listening and attentional dynamics within the group. Performers at times must listen and 'process' certain of their fellow ensemble members along a variety of sonic and musical dimensions. This sometimes happens in multi-stage chains, with actions of both groups being implicated in one another's sound worlds—a networked situation that bears similarity to shared-signal EAI contexts.

This shift becomes evident in the move from the aforementioned symbolic Soundpainting gestures to the usage of continuous gestural actions that allow for shared modifications of the ensemble. For example, the aforementioned 'sliders' that ask a given player or sub-group to vary their dynamic, pitch, density, etc. in direct relation to the spatial location of the gesture, such as the 'density fader' being enacted in Figure 1. Taking this further, the 'shapeline' gesture effectively asks the ensemble to create their own mapping of conductor action to sonic parameters, and to maintain this throughout the period that their gesture is active. In this mode of engagement, a deeply intertwined and collective movement-sound improvisation takes place: the ensemble must arrive at their own individual and group response to conductor movement, while the Soundpainter must negotiate and learn this set of relationships as both human-centred agents react to, as much as a guide, the other.

Inspired by these parallels between my past history with shared-signal EAI and a year spent soundpainting the EAO, I was motivated

Figure 1. Continuous modification of density via Soundpainting.

to augment the 'space between' us as performers through explicit machine recognition of gesture and resultant processing of performers in the *intersubjective soundings* project.

5.2. Machine mediation of soundpainting

The symbolic gestures of Soundpainting provide a clear set of actions that are well suited to the application of machine learning-based gesture recognition, very much in the spirit of sign-language recognition applications

Table 1. Set of *who* gestures that are trained on Wekinator for discrete classification.

Gesture	Description
Who (wants …)	'Who wants to play (something)?'
Group	Addressing group $X = 1,2,3,4,5$
Whole group	All players
Rest of group	Precisely who was just *not* addressed a moment ago
Acoustic	All acoustic instrumentalists
Electronic	All electronic instrumentalists

(Cooper, Holt, and Bowden 2011). Meanwhile the continuous movements, in particular shapeline, provide an opportunity to learn continuous mappings between movement and sound processing, very much in the spirit of interactive dance or free-hand interactive music systems (Godøy and Leman 2010). The underlying recognition system applies both techniques in order to inject a layer of machine agency between the conductor and ensemble.

5.2.1. Symbolic gesture recognition

The project focuses on categorical recognition of discrete gestures from the aforementioned categories of *who, what/how* and *when*. *Who* gesture recognition is achieved through an application of the Wekinator system (Fiebrink 2017), using a combination of its ability for supervised training of continuous gestures and discrete categories. Table 1 lists *who* gestures which are trained together as a group.

These gestures are trained using continuous recognition via dynamic time warping, trained on the 10 IMU position/speed/orientation values from 2 MYO armbands worn by the Soundpainter on their forearms. A threshold is set for the continuous recognition output that acts as a confidence measure and triggers system activity. It was found that this method allowed the Soundpainter to feel more natural in enacting *who* gestures without feeling the need to conduct 'into' the recognition system quite as much. The recognition of a given *who* allows for sub-group-specific processing to be activated and prepared for impending signals, as described in the following section. Additionally, the recognition of the 'Group X' gesture activates a second Wekinator module, which is trained on the eight-channel electromyogram output of the dominant hand MYO band, using a support vector machine classifier (and adaptive median filter pre-processing). This second system is tasked with recognizing the signing of a given group number using one to five fingers of the dominant hand of the Soundpainter.

If the machine agent recognizes the presence of a *who* gesture, a second layer of recognition of *how/what* gestures becomes active, potentially allowing for specific sub-types of processing to be prepared. This allows the Soundpainter to nonlinearly move between states of sonic transformation that need not be predetermined. The machine learning system is trained on a few gesture groupings which are brought together both for their distinct movement quality (for the pragmatic purpose of clean gesture recognition) but also because of their existence on opposite ends of a

Table 2. Set of *how/what* gestures that are trained on Wekinator for discrete classification.

Gesture	Description
Pointillism	Textural cloud of discrete sounds
Long tone	Sustained sound
Noise	Absence of discernible pitch centre or clear partials
Tone	Sound comprised of only pitched content
Rough	Spectrally or temporally unstable/dissonant/harsh
Smooth	Spectrally or temporally stable/consonant

spectrum of sonic quality. For example, the first trained set of *how/what* gestures, and still one of the most fundamentally important, is shown in Table 2. This set of gestures is trained in Wekinator on a dynamic time warping classifier, using both the electromyogram and IMU data from the MYO armbands. This set does not entirely come from the Soundpainting language, and includes concepts and gestures adapted to the specific context of the EAO.

These gestures describe a matrix of possibilities: for example, the Soundpainter might ask for rough noise pointillism. In terms of system design, the solution to this is to run a parallel gesture recognizer that listens for a special *with* gesture. If this is recognized, then the *how/what* recognizer turns back on to listen for further signed qualifiers.

5.2.3. Continuous and anticipatory mappings of activity

A very special two-gesture recognizer that is active during a *how/what* context is shapeline. The system listens for the enaction or the cancelling of the shapeline mode. If shapeline is enacted, one of a number of continuous mappings from MYO to sound processing, trained using the Wekinator's neural network, is engaged. Who this acts upon is switched depending on the *who* context, and the specific mapping that is in play can either be invoked by signing *how/what* gestures, or by explicit selection (foot switch) by the Soundpainter.

With respect to *when* gestures, the Wekinator system is used to listen for the anticipatory *pre-gesture* of a go/stop gesture. If the recognized gesture is for a slow and gradual entry/exit, the dynamic time warping output is used to anticipate the moment when the gesture is finalized. This turns on an RMS-based level monitor that asks the processing system to be mindful of when a given player is truly in or out of the mix, based on activity in their signal output. If a sudden hard go/stop pre-gesture is recognized this activates an onset detector listening to the IMU armband data, which is

used to anticipate the moment of the ictus for these sudden-action gestures. These gesture recognition systems are able to function well in both series and parallel precisely because of the syntactical structure of Soundpainting. In addition to these sets of *who, how/what, with, shapeline* and *when* gestures, there are a few key modifier gestures that exist outside of the Soundpainting communication/co-creation framework, and are described in the next section.

5.3. Expanding the expanded orchestra

The output of the machine learning system is used to initiate discrete state changes in an underlying sound processing system, as well as provide a continuous mapping from the conductor's MYO armbands to the control parameters of the said processing system. This system can take audio input from all members of the ensemble (which varies from ten to twenty people), and is designed to act as a mediating layer that amplifies and responds to the interactional qualities already present within a Soundpainting-centred structured improvisation context. As such, the design of the granular, spectral re-synthesis, modulation-synthesis and convolution modules are created in consideration of the musical framework and language presented by Soundpainting. This means that sound processing modules are tailored to groups 1–5, and are designed with discrete states that are amenable to long tone vs. pointillistic, noisy vs. tonal and rough vs. smooth playing, among others. In certain cases this means switching between processing types entirely, selecting the processing method that fits the sonic gestural needs of the moment and in so doing follows an interaction design approach that integrates what Paine (2002) has called 'dynamic morphology' through this dynamic-switching approach to software modules that map the processing type to the aesthetic and interactional demands of the moment.

Importantly, processing types are also chosen to act as a dual of potential ensemble action,

allowing for interactions between ensemble and Soundpainter to be enacted purely in the realm of movement/sound gestural interaction (with no processing), or to be 'transferred' into the realm of shared-signal processing. Two key ways that this occurs are through spectral/temporal freezing and record/playback. Within Soundpainting there exists a gesture called *stab-freeze*, which first primes a given group through an open-hand gesture, and then enacts the freeze moment (through a fist-in-hand motion), which might manifest as a short repeated fragment or a continuous freezing of the sound that is being played at the moment of the gesture. Within this project, a second freeze gesture has been added which is enacted by the Soundpainter holding out their arm to the side and making a fist. Depending on the active processing module, this will either loop a short grain of the last content played or enact a phase vocoder-based spectral freeze. These two-gesture actions then become duals of one another, with both conductor and ensemble knowing through the given priming gesture whether the human or the machine system are being engaged as the active agent of change within the system. Similarly, the *record/play* gesture asks the ensemble to segment and loop their memory of a sequence of Soundpainting gestures, playing back their own interpretations on loop. In this project, the electromyogram data are used to recognize hand waving (in/out) gestures that are used to start and stop the looping of MYO data output. In so doing, the Soundpainter is asking the machine agent to record and playback its understanding of a gesture sequence, which may be mapped into continuous control of sound processing. In either looped context, human or machine agent, the performer/system can modify their own engagement within the loop through interactions with the Soundpainter. The shifting interactions between human ensemble and mediating machine agent can further play out over time, through the use of *memory* gestures which ask the ensemble to

remember and recall content, used in tandem with gestures that address the explicit machine memory which manifests through capture and playback of a performer's sound.

It is through traversing these dual human/machine modes of interaction, symbolic Soundpainting recognition and shapeline continuous co-shaping that the ensemble becomes most deeply entangled and the need for collective listening becomes most amplified. The topology of signal, data and attentional connectivity is shown in Figure 2, reflecting relations between ensemble, Soundpainter and machine-mediating agents. In this figure, we see the ensemble, Soundpainter and machine mediation all residing within a sound field, each agent in this ecosystem capable of sounding. The human performers each listen within this field while the machine system listens for conducted movements, both symbolic and continuous. While there is a directedness exemplified by the 'communicate' vector from conductor to ensemble, there are also potentials for relational listening/sounding and co-construction of meaning,
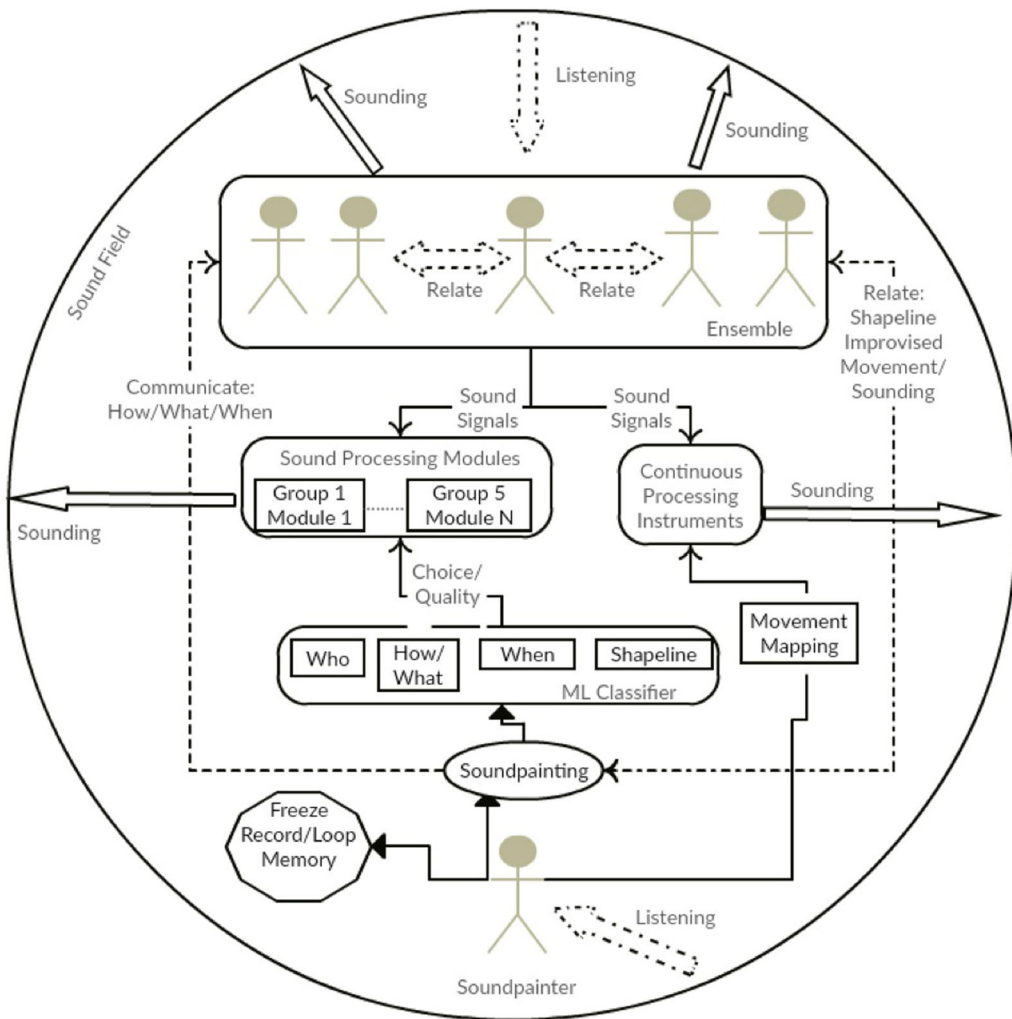
Figure 2. Diagram showing explicit (sound/data signals) and implicit (listening/sounding) relationships between ensemble and Soundpainter, and the mediating role of machine agents in intersubjective soundings.

such as when *shapeline* is invoked. In this context, ensemble and conductor seek to find moments of intentional resonance in order to collectively shape the sound field, with a machine-mediating layer that responds to both movement and sound between them. Notice also that the gestures freeze, record/loop and memory exist outside of the Soundpainting universe. This underscores the fact that the group can communicate through the symbolic expressions of Soundpainting, via the continuous co-creations of shapeline, or by expressing a set of gestures that explicitly exist outside of the Soundpainting universe, expressing to both ensemble and machine agents that a conscious shift in attention between the two is occurring.

6. Discussion

The Intersubjective Soundings project defines a field of potential interactions between all performers, with many specific and directed manifestations possible. The first public realization that emerged from this work was premiered in a concert at the Movement and Computing (MOCO) event at Goldsmiths, University of London. In this piece, the sense of 'listening across' that occurs between instrumental performer and conductor/performer was further heightened through the introduction of a telematic connection between sites. I believe that the need to discover intentionality and authorial voice within this project in general invites distributed listening in that performers' soundings become a search for resonance and co-modulation with fellow players. The act of sounding then functions as listening-in-search, as a gesture towards understanding how instrumentalists, Soundpainter and machine agents are themselves listening. This 'functional community of perception' (in the Husserlian sense) is akin to many experiences of telepresence, 'listening through the firewall' (Mills and Beilharz 2012) towards discovering the senses of agency present in the human and material conditions of another place. As such, the telematic context—while not required by any means—is a natural fit for this project and will continue to be an important site of performance explorations going forward.

As its name suggests, this project presents an intersubjective encounter between improvisers—both conductor and instrumentalists—as well as between the state and output of the computational agents and all human performers. It conditions a functional community of perception in which shifting attentions move from listening to comprehending dynamic symbolic instruction. This dynamics of attention merges with a need to construct an understanding of what the machine agent will respond to—both for self, other players as well as for the conductor. The spectrum of agency and degree of hierarchical interaction is challenged by the confluence of shared signals, Soundpainting and machine recognition that modifies and reacts to these, respectively. The ensemble might find themselves engaging in long stretches of shapeline-based co-construction of sonic gestural output that invites one to close eyes and get 'lost' in the sound field, yet at any moment shifting towards the searching for unfolding gestural actions that have very specific symbolic meanings. The Soundpainter too must engage in the search, listening for resonance with sound processing as well as with machine agent recognition. In reference to Sawyer's framework, I submit that the instabilities built into the system necessarily invite a *higher degree of creative involvement from all performers* than might purely be felt in acoustic Soundpainting-conducted works in several key ways. This includes the instabilities of the machine learning layer and presence of noisy data such as found with electromyogram signals, which may be sensitive to bluetooth dropouts, low batteries, etc. As such both the instrumentalists and Soundpainter are placed at a distance, with actions becoming probing mechanism towards an understanding of this mediating layer. There is a clear *indexical*

reflexivity present in the work in that performers must learn and anticipate gesture as well as resultant processing, which itself is one of the clearest senses of piece-ness that arises. Through repeated performances of a specific manifestation of the work, a given performer could develop a larger set of *ready-mades* in anticipation for the resonances of the system. At the same time, these resonant channels of processing are contingent on the effective machine recognition of gesture, the agency of the Soundpainter and also the *way* in which the gestures unfold. In this way, the semiotic referents found in the conducting language can serve to reveal or obscure the otherwise hidden complexities of the computational system. That these are being discursively refined explicitly as a performative element during the course of performance makes the revelation (or not) of the machine an explicit performative and compositional parameter. Through a resistance to repeatability by both the MYO sensing and machine agents, an added layer of *receptivity to novelty* can be found in the larger human/machine ecosystem.

7. Conclusion

Throughout the history of electro-acoustic music, artists and scholars have been concerned with ways of understanding intent, meaning and form through cultural and perceptual channels that did not focus on the score-object (Emmerson 1986). In the context of collective EAI in general, I argue, examining emergent forms through the lens of distributed creativity is a fruitful pathway towards understanding a set of larger values and outcomes that are not reducible to material and instrumental aspects or any one performer. In the case of shared-signal EAI contexts, intersubjective encounters are built into the ensemble-as-system, but are only understood through a listening and reception-oriented approach to uncovering intent. Inserting computational processes into this performance topology introduces another agential force that must be uncovered through an improvisational and discursive process of listening and sounding. Meanwhile, conducting would seem to stand in as a hierarchical and top-down counterexample par excellence in this case. However, I have presented a project wherein the combined symbolic and continuous affordances of the Soundpainting language are enacted within an ecosystem of shared signals and machine agents that mediate sound and conducting movement. Speaking from the 'inside out' perspective of the performer, this dynamic alteration can manifest in intersubjective encounters wherein the discovery of influence is productively entangled with expressing, as well as listening for, musical meaning that crosses between sound and movement. The *Intersubjective Soundings* piece offered a means to compose for such a community of perception by explicating the machine processes as symbolic conditions for performance as well as performative revealings of the distributed state of sonic activity. Examining this context from the 'outside in', Sawyer's semiotic conditions for improvisationality are a useful framework to reflect upon the fixedness of such a performance context by examining the agency of performers in the system from their place within the improvising collective. Through engaging with these multiple perspectives of human and machine agents, and shifting instrumental conditions, the work discussed in this article thus aligns with a growing trend towards distributed and ecosystemic views on interaction design in general and on improvisation in particular. Examining the social and interactional potentials through the lens of intersubjectivity and distributed listening provides an alternate view to that provided by purely structural assessments of a given performance context and can help to situate the influences of human, machine and the many layers of shared resonance found between them.

Disclosure statement

Notes on contributors

Doug Van Nort is an artist, researcher, composer and improviser. Van Nort is currently Canada Research Chair in Digital Performance and an Assistant Professor at York University, cross-appointed between the departments of Computational Arts and Music. At York he has founded the DisPerSion (DIStributed PERformance and Sensorial immerSION) Lab, dedicated to explorations in the distributed agency, improvisation and technologically mediated performance.

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