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Towards a hyper modular morphology

Abstract
This article proposes an alternate view on a collection of musical instruments that takes concepts like agency and polymorphism into consideration. A set of interrelated questions serves as a philosophical point of departure: How can autonomous sound generating entities of essential difference be integrated with each other in a composition? Will the use of a bi-directional feedback and control flow between the entities aid in viewing all agents in the ensemble as extensions to the others? In what way does it then matter whether the ensemble is comprised of a set of algorithmically controlled electronic devices or human musicians playing instruments? Can concepts from object oriented programming and the patching paradigm derived from modular synthesis help in bridging over these matters? The presented hypothesis is that by dealing with these questions we can eventually reach for a new kind of ensemble instrument and musical morphology in which both human and nonhuman agents are equals. A case study of the piece *Sinew0od* for Paetzold contrabass recorder and live electronics, composed by the author of this text, is also included.

1. Background

1.1 Introduction

In Western music traditional acoustic instruments and live electronics are usually considered as different species. The former can be thought of as the sum of certain aesthetic choices of *one* tradition of instrument builders *adhered to* by many performers. The latter is rather a sum of *several aesthetic traditions* chosen and *put together* by one performer. These ad hoc collections of sound producing devices, effects and controllers are often also tied to a very specific kind of performance situation or composition. When composers write mixed pieces it is also quite common to deal with electronics as something you *add* to the acoustic instruments. What will happen if we instead utilize a mindset where collections of different idioms and instrumental traditions could be merged together in compositions and performances and dealt with as equally capable sonic entities? If invisible patch cords connects instruments, concepts and musicians, making it possible to share data streams and control signals; could a new level of musical morphology be reached?

1.2 Idiomaticity, tradition and equilibrism

What is then idiomaticity in regard to live electronic instruments? Is it even possible to generalize or do we have to be satisfied with the respective idioms and aesthetics that different parts of the setup carry? Of course, these questions can be asked about any other ensemble of different instruments, e. g. a rock band, a symphony orchestra or even sub-sets thereof, like the percussion instrument group. There are, however, important differences in how we as composers and performers interface with the instruments in question. For instance, we cannot make use of traditional notation techniques to describe actions to perform on *unspecified* live electronics as we can on a violin. For the latter we can write things like *col legno battuto, sul pont., etc.* and be pretty sure that the musically intended function will be achieved. If we don't specify our live electronic instruments in detail or build them ourselves for a specific occasion or piece, we cannot trust the musical function as a result of an action. One common solution for this is either to provide a tailor-made instrument with the piece (as a Max patch or similar) or to specify musical or sonic functions instead of actions in the score, thus leaving the very definition of the instrument to the performer. Both those solutions are risky if the goal is to take advantage of someone's musicianship, virtuosity and experience of a specific instrument, since basically this requires a new instrument to be learned. Hence, this approach often leads to a simplification of the musician's role. Important structures and playing techniques become automated processes, built into the instrument, reducing the performer to less of an interpreter and more of an administrator of button presses and knob turns.

Yet another solution is to write for a specific musician and their existing instrument. As a consequence of this composers who works with live electronics often write themselves into the score. However, this approach could also be risky since the piece in question then depends on that performer. If the goal is to have it performed several times it might be difficult. The notion of the composer/performer is not new, but the increasing use of electronics has possibly lead to a revival. Henrik Frisk writes in his essay "Hell is full of musical amateurs, but so is heaven" (Frisk, 2017) about the disembodied listener as a result of the professionalization and division of labour between composers and performers. The fact that "the score became a product and a work independent of its sonic trace." (ibid), the consequences of equilibrist performers making successful careers in the recording industry and the commercialization of the interpretation has lead to this disembodiment. Listeners becomes consumers that do not have to engage physically in the music anymore. On the producer side many composer/performers create simplified instruments that becomes part of the score (or the product). These instruments are instead too closely connected to the intended sonic trace, allow no or very little deviation from a pre-defined path, and consequently become pointless from a musician's perspective. Perfectly adapted to personal advantages and shortcomings, such instruments effectively erase all traces of magic and elements of risk in the performance as well as possible embodiment.

There are several examples of live electronic performers who have walked the more traditional path, sticking to the same instrument as a solution to this problem. The idea of perfecting, practicing and basically treating the setup as self-contained and as if it were part of a long "luthier" tradition is strong here. But besides the obvious rewards of them being excellent musicians to their own and the audience's enjoyment, one can ask if this attitude actually pushes

the envelope. If the most idiomatic attribute encoded into the notion of live electronic instruments is its state of flux and inherent polymorphism, none of these approaches unlocks their potential.

1.3 Polymorphism

All musical instruments could possibly be considered as autonomous entities comprised of one or more *sound generating* or *sound processing* functions. These functions can be contained in one or several physical units or bodies. Those can be digital or analog and controlled by algorithms, automated or manual processes involving one or more physical or even virtual performers. All together, those constitute a collection of both human and non-human agents, or *actants,* as proposed in the *Actor Network Theory (ANT)* by Bruno Latour (Latour, 2005) and Michel Callon. All actants can be thought of as extensions to the others. Another way of describing this complex network is Christopher Small's term *Musicking:*

> "The act of musicking establishes in the place where it is happening a set of relationships, and it is in those relationships that the meaning of the act lies. They are to be found not only between those organized sounds which are conventionally thought of as being the stuff of musical meaning but also between the people who are taking part, in whatever capacity, in the performance; and they model, or stand as metaphor for, ideal relationships as the participants in the performance imagine them to be: relationships between person and person, between individual and society, between humanity and the natural world and even perhaps the supernatural world." (Small, 1998).

The inclusion of the instruments themselves in these relationships are obvious.

In object oriented programming languages (OOP), the concept of polymorphism means that different receiving objects could interpret the same method call in their own unique way. When musicians interpret a score in an ensemble, they could be thought of as responding to method calls invoked by a composer using notation as a proxy. Depending on what instrument that currently is in the hands of the interpreting musician and all the aforementioned relationships, different actions will be performed.

Within the field of computer music we have vast possibilities to design digital musical instruments (DMIs) that both could take advantage of, but also rearrange, such relations during performance. Using open environments like *PureData*[1], *Max*[2] and OOP languages like *SuperCollider*[3], we can define instruments that are truly modular and change state according to the performer's wish in an instant. Perhaps the most idiomatic way of actually *playing* a computer using this mindset is the live-coding paradigm. Utilizing only the built-in keyboard to alter code in real time the performer can create and redefine sonic entities as well as control structures at the same time. Within live-coding communities like TopLap[4] there is also a notion that by projecting the code being written and disclosing it to the audience, it will serve the same function as watching someone plucking the strings on a guitar[5]. The visualization of the previously obfuscated becomes a way to bridge over the distance between the composer, performer and the audience. Live-coding could also be thought as a way of solving the conflict between the rather essentialistic foundation that OOP stems from and the more idiomatic flux of live electronics discussed above. The human actant (i.e. the live-coder) adds a focus on *the space in between* the objects and how they change in relation to the others instead of being static entities with fixed attributes.

In staged art forms there is the concept of a *fourth wall* which denotes an invisible border that separates the performers (or even the artwork itself) from the audience. I will argue that different

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[1] https://puredata.info/

[2] https://cycling74.com/

[3] https://supercollider.github.io/

[4] https://toplap.org/

[5] The Toplap ManifestoDraft (https://toplap.org/wiki/ManifestoDraft, accessed 19-05-10)
"We demand:
- Give us access to the performer's mind, to the whole human instrument.
- Obscurantism is dangerous. Show us your screens.
- Programs are instruments that can change themselves
- The program is to be transcended - Artificial language is the way.
- Code should be seen as well as heard, underlying algorithms viewed as well as their visual outcome.
- Live coding is not about tools. Algorithms are thoughts. Chainsaws are tools. That's why algorithms are sometimes harder to notice than chainsaws.

We recognise continuums of interaction and profundity, but prefer:
- Insight into algorithms
- The skillful extemporisation of algorithm as an expressive/impressive display of mental dexterity
- No backup (minidisc, DVD, safety net computer)

We acknowledge that:
- It is not necessary for a lay audience to understand the code to appreciate it, much as it is not necessary to know how to play guitar in order to appreciate watching a guitar performance.
- Live coding may be accompanied by an impressive display of manual dexterity and the glorification of the typing interface.
- Performance involves continuums of interaction, covering perhaps the scope of controls with respect to the parameter space of the artwork, or gestural content, particularly directness of expressive detail. Whilst the traditional haptic rate timing deviations of expressivity in instrumental music are not approximated in code, why repeat the past? No doubt the writing of code and expression of thought will develop its own nuances and customs."

musical instruments and the traditions they carry have a tendency to create similar imagined walls even *within* ensembles. Good musicianship can certainly overcome this to some extent, but could we, by breaking these walls, make new musical and morphological expressions possible? Could this allow for a new kind of ensemble where a composer can work with seamless transitions from polymorphism to uniform response among the actants? This would perhaps require a change of attitudes among performers but could also benefit from the use of new technology that aids interaction, communication, visualization and expression within the ensemble. Could we develop a straightforward system and a toolkit that allows for a bi-directional feedback and control flow between different sonic entities? This would then include performers as well as the instruments themselves, utilizing a mindset where all agents in such an ensemble could be considered as extensions to the others. Existing extended instruments like *The extended clarinet* described by Normark et al. (Normark et al., 2016) as well as others that stems from the *hyperinstrument* tradition could indeed allow for further explorations and serve as a point of departure for realizing these concepts. To be able to fully deal with the notion of interacting modules in a composition and performance, it would also be necessary to explore how physical extensions to an instrument (e.g. sensors) differ from more abstract extensions like rules and attitudes for a performance. The use of motion sensors for capturing and sending gestural data together with other signal flows (the actual sound included) between agents appears to be a traversable path, since this builds further upon existing knowledge and traditions. Hence, we could aim for sustainable, yet musically flexible, extensions for both old and new instruments.

2. Context

2.1 Foundations

Historically, this aesthetically builds further upon the early ideas of composers like Edgard Varèse and Pierre Schaeffer. When Varèse wrote his manifesto *The Liberation of Sound* in 1936 he was frustrated by the fact that composers and musicians seemed to have forgotten that ”the raw material of music is sound” (Varèse, 1966) and that he still had to work with instruments and traditions that had not changed in two hundred years. He started to use the term *organized sound* to describe his music as a way to include sounds of any kind in his musical universe. The recording technology eventually lead to the idea of looking at the recorded sounds as objects that could be listened to without referring to its source. Pierre Schaeffer used the term *acousmatic music* to describe this approach to listening (Schaeffer, 1966). The word acousmatic originates from the Greek word *akousmatikoi* which means *the listeners*, and refers to the pupils of Pythagoras that were required to silently listen to his lectures presented from behind a veil. According to Schaeffer, the loudspeaker has the same effect as Pythagoras' veil in the sense that the sounds cause and origin remain unseen. In many ways this veil obfuscates many DMIs in a similar way. The performance aesthetics and traditions that surrounds conventional musical instruments might on the other hand work in the opposite direction. It can for example be very difficult to listen to a flute in an acousmatic manner. The chore here would then on one level be to find new ways of liberating sounds from their origin, organizing sonic entities and musical control structures and, with a non-referential mindset, make it possible to compose for arbitrary collections of such in a more generalized way. On another level we would also have to deal with different ways of making the intrinsic forces of this kind of composition / performance comprehensible, both for the participating musicians and the audience.

Technically, the modular designs stemming from pioneering synth builders like Donald Buchla and Robert Moog is related, but also modern visual programming environments and OOP languages like the previously mentioned.

2.2 Affordances and embodied knowledge

Using the analogy of the modular synthesizer seems reasonable as a starting point since it is an instrument that indeed recognizes the aforementioned attribute of polymorphism. When signal flows are re-patched during a performance on such an instrument, it is redefined to some extent. Hence, it also resembles live coding in the technological sense. Although in practice, the aesthetic and artistic outcome of a modular performance is often quite different from a live coding session. Psychologist James J. Gibson describes through his theory of affordances (Gibson, 1979) how

different tools affect what we do and how we do it. In this case the physicality of the modular and the abstractness of programming languages exerts different influences on our musicianship. How could then the metaphor of a *hyper modular system* to describe an ensemble help in finding new ways of making music? Musician and researcher Per Anders Nilsson uses the concepts *design time* and *play time* (Nilsson, 2014) to distinguish between creating possibilities for musicianship through designing DMIs and actually making use of their affordances. Nilsson's colleague Palle Dahlstedt states that "[t]he complete potential of a sound engine is traditionally available only at design time." (Dahlstedt, 2008) and has explored different strategies of randomness, evolutionary algorithms and dynamic controller mapping to "erase the line between sound editing and synthesizer performance, with an emphasis on free improvisation" (ibid). A key concept for the ensemble described in this article is to investigate possibilities of merging design time and play time into one embodied, performative realtime process for all musicians involved. Just like in a modular synthesizer where the patch and the composition can be inseparable, the goal would be to create *compositions that are also instruments* tied together in uncanny relationships.

Embodied and situated knowledge in relation to artistic practice in general and musical performance with and without electronics in particular have been extensively studied. To realize these concepts we could gain knowledge from and build further upon both theoretical and practice based works by researchers like Donna Haraway[6], Estelle Barrett, Barbara Bolt[7], Henrik Frisk, Stefan Östersjö[8], Juan Parra Cancino[9] and many others.

2.3 Hyperinstruments

One of the paradigms of live electronics in contemporary art music is the notion of hyperinstruments and offsprings thereof. This involves using electronics to extend the capabilities of traditional instruments and to make it possible for musicians to develop their sonic virtuosity even further, but also, as stated by composer and researcher Tod Machover, to give "unprecedented creative power to the musical amateur" (Machover, 1992). The original idea was to combine "machine-augmented instrumental technique, knowledge-based performance monitoring, and intelligent music structure generation" (Machover, 1986) to eventually redefine the means of musical expression. The strategies involved analyzing and collecting gestures and data from a musician and process through a computer to generate new musical structures (Machover, 1992). A lot of work in this area have been carried out at IRCAM[10] in Paris, resulting in advanced analysis algorithms and development of techniques such as score following and machine listening as well as pattern recognition and other AI systems.

While Machover's early work and ideas clearly build upon the available technology of that time, there are also several interesting current researchers in Europe that work in the spirit of hyperinstruments. In the paper that describes the aforementioned extended clarinet it is stated that their aim "is to augment the instrument with new possibilities and at the same time preserve the instrument's external complexity and only increase its internal complexity." (Normark et al., 2016). This approach allows for the professional performer to build further upon previous knowledge and the many hours of practice, since the original instrument still works as it used to. Also worth mentioning is Alex Nowitz's *Strophonion* (Nowitz, 2011 and 2019), originally developed[11] at the Studio for Electro-Instrumental Music – STEIM[12] in Amsterdam, and recently completely redesigned by Nowitz and Sukandar Kartadinata. It is a gestural controller that extends his voice performance in which Nowitz builds further upon STEIM founder Michel Waiswisz' famous instrument *The Hands*[13]. One of the initial goals with the *Strophonion* was that it should benefit from "virtuosity in playing the instrument, using the musician's fine-motoric, tactile and sensual skills, involving all five fingers to control and play the instrument" (Nowitz, 2011).

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[6] E.g. Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. Feminist Studies, Vol. 14, No. 3. (Autumn, 1988), pp. 575-599.

[7] E.g. Barrett, E. & Bolt, B. (red.) (2013). Carnal knowledge: towards a 'new materialism' through the arts. London: I.B. Tauris.

[8] E.g Östersjö, S. (2008). Shut up 'n' play!: negotiating the musical work. Diss. Lund: Lunds universitet, 2008. Malmö.

[9] E.g. Parra, J. (2014), Multiple Paths: Towards a Performance Practice in Computer Music. Diss. Leiden: Leiden University, 2014.

[10] https://www.ircam.fr/

[11] http://steim.org/projectblog/2012/01/02/alex-nowitz-the-strophonion-instrument-development-2010-2011/

[12] http://steim.org/

[13] http://www.crackle.org/TheHands.htm

Another interesting project is *The Throat III* (Unander-Scharin et al., 2013) developed as an artistic research project at KTH in Stockholm. It is ”a tool for opera-singers to dynamically disform, change and accompany their voices” (ibid) in the form of a glove with a set of sensors, wirelessly connected to a computer. A key figure in this project was composer / performer and DMI craftsman Ludvig Elblaus, whose recently published dissertation *Crafting Experience: Designing Digital Musical Instruments for Long-Term Use in Artistic Practice* (Elblaus, 2018) includes important findings, especially in regards to sustainability.

The hyperinstrument paradigm and related research is valuable here. It provides insight into how one can take advantage of previous instrumental knowledge and tradition in designing new instruments, protocols and proxies for musical communication. Furthermore, one can think of the autonomous sonic entities that a collection of instruments comprises as extending each other. Hence, the collection itself might be considered a hyperinstrument.

3. A case study: Sinew0od

The piece *Sinew0od*[14] (Petersson, 2008) for Paetzold contrabass recorder and live-electronics was commissioned by (the now closed down Swedish state foundation) Rikskonserter and written for recorder player Anna Petrini[15]. In this piece the instrument becomes part of a controlled feedback network that extends the instrument’s sonic possibilities. The player can interact with the feedback in various ways.

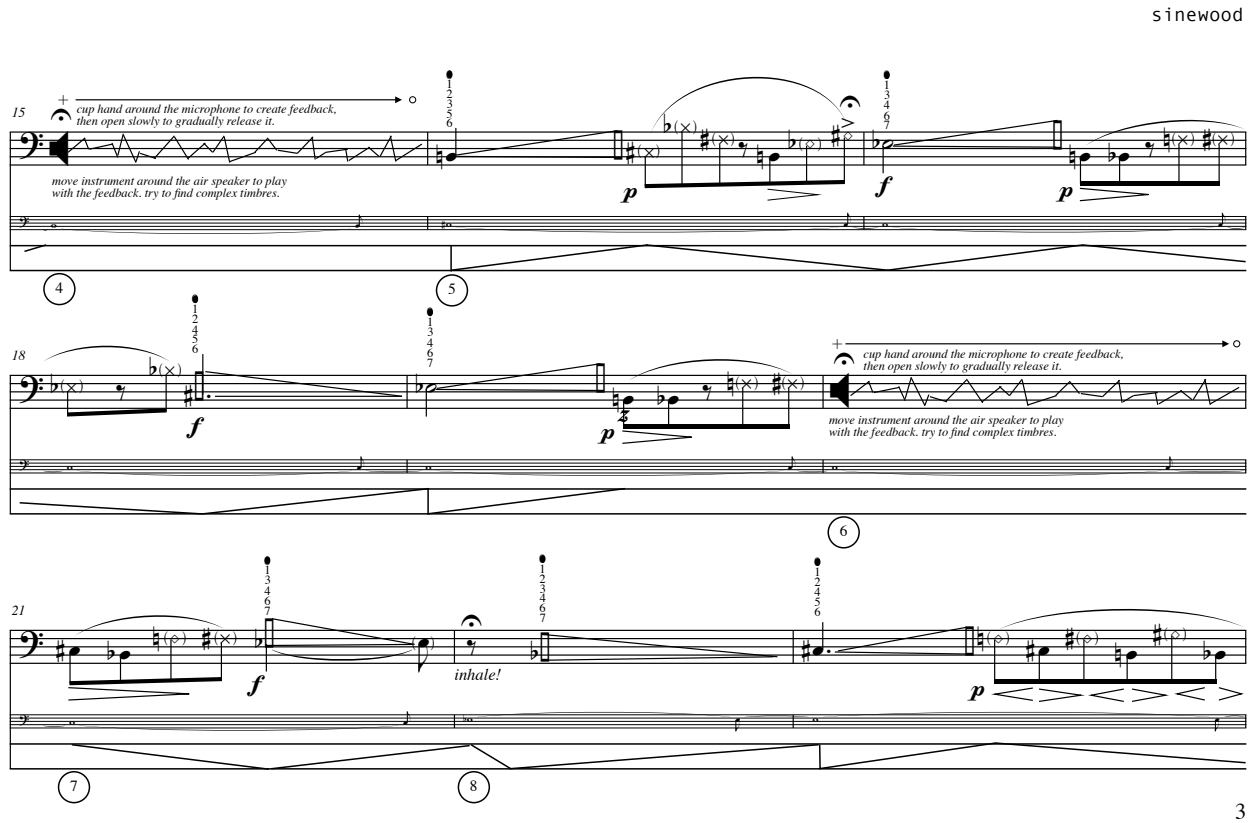


Fig. 1: page 3 from the score of *Sinew0od*

To create the network a microphone attached to the recorder is routed to two small, lo-fi speakers, one on a stand in front of the labium and the other attached to the instrument close to the floor. By turning up the volume of the microphone to the point where a continuous feedback is achieved, one can carefully tune the pitch and timbre to a ”root key note” utilizing the mixers equalizer. To further influence and modulate the frequency spectra of the feedback sound, a Max

[14] Petersson, M (2008). Sinew0od. Recording available on the album Crepusculo by Anna Petrin and here: https://soundcloud.com/emp/petersson-sinew0od/s-YMhY1

[15] http://www.annapetrini.com

patch with digitally produced timbres is used. The patch consists of frequency and amplitude modulated sine waves that also get wave shaped by the lo-fi quality of the small speakers when blended with the feedback. To control the the amount of influence the Max patch has on the feedback a stereo volume pedal is used. As the piece progress, the different pitches is sent to one or both of the speakers. A MIDI switch pedal that advances forward to the next note (in a pre-determined list of frequencies) also controls this routing. With each pedal press the intensity of a pre-recorded drone increases. This drone is also ring modulated by the microphone input.

symbols used:

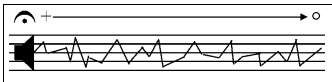
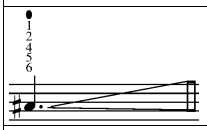
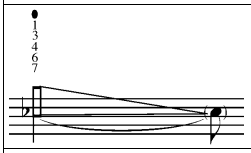
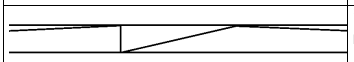
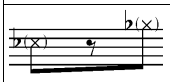
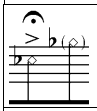
	cup hand around the microphone to create feedback. then slowly open to gradually release it. at the same time, move the instrument around the air speaker to play with the feedback. try to find complex timbres.
	start with the notated fingering, with (approximately) the written pitch and gradually transform it into a multiphonic sound. the duration is indicated by the first note. all similar events should be performed with vibrato. vary the speed dynamically "ad lib" to create beat frequencies.
	start with the notated fingering, with a multiphonic sound and gradually transform it into a single note of (approximately) the written pitch. all similar events should be performed with vibrato. vary the speed dynamically "ad lib" to create beat frequencies.
	press switch pedal. the index number should correspond to the number in the Max/MSP patch. note: index 1 is the [space] press that starts the piece.
	volume pedal curve. bottom is minimum volume (tilt backward), top is maximum (tilt forward). use these as guidelines. always interact with the feedback and strive to produce interesting sounds.
	the parenthesis indicates that the keys should be pressed silently (no clicks), to interact with the feedback by changeing the resonant frequency inside the instrument.
	an airy harmonic sound. in between the silently pressed keys and the normal notes.
	"flatterzunge" to produce a growling effect on the indicated pitch.
	all "normal" notes should be played with soft attack and decay. use an H-like articulation. it should preferably sound like a random wind suddenly growing strong enough to create a sound. this "wind" grows stronger and stronger throughout the piece, as the silent notes gradually transforms into sounding ones.

Fig. 2: playing techniques and notation used in Sinew0od.

A lot of interesting things were discovered while working with this piece. The complexity and unpredictable nature of analog feedback led to several unexpected findings. One of the most important is that, if the system is properly calibrated, the recorder player can radically alter the pitch of the feedback just by pressing the keys on the instrument without even blowing. The body of the instrument then becomes an active module of a larger system, capable of being the modulator of other modules as well as being modulated by them. While playing the instrument some notes gets choked by the feedback and others gets enhanced. Using the volume pedal to inject the governing force of the Max patch into the system, the player can compensate for this phenomena as well as cause others to occur. The position of the instrument relative to the small speakers also affects the whole system. By leaning the instrument towards or away from the air speaker small glissandos in the feedback can be achieved. The player can also cover the microphone to radically "transpose" the feedback and play on higher partials and resonances previously hidden in the system.

Thus can the piece *Sinew0od* serve as an elementary example of how to work with the concepts discussed in this article. In the finished work there are at least five significant agents (or modules) – each one of them could be thought of as autonomous entities by themselves, namely:

- the score (fig. 1 and fig. 2),
- the player,
- the Paetzold contrabass recorder,
- the feedback network,
- the Max patch.

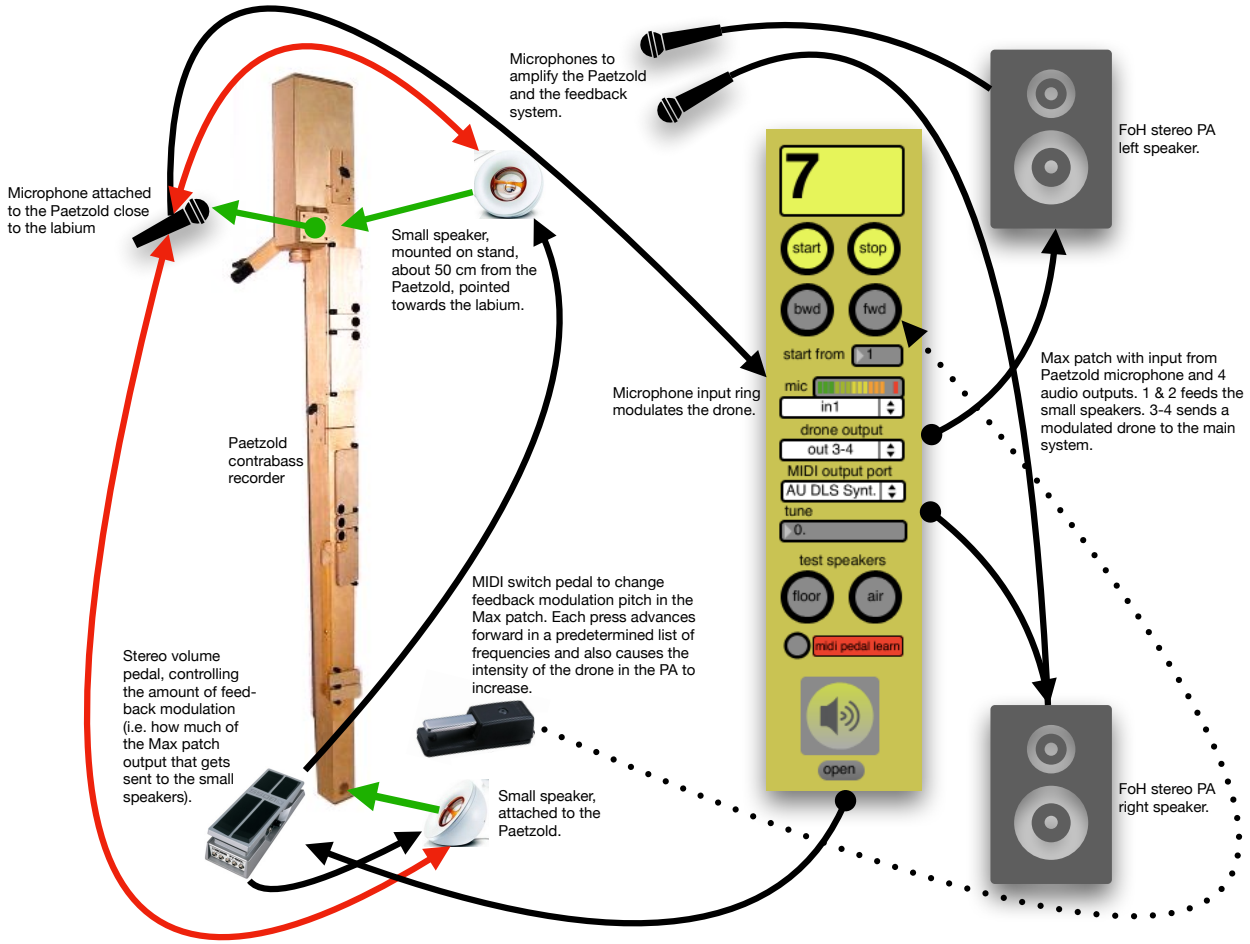


Fig. 3: Signal flow in the hyper modular system for *Sinew0od*.

Of course all of these modules could be subdivided and examined down to an atomic level, but for the sake of clarity in this example it is better to study the system at a higher abstraction level. What makes this piece happen are the concurrencies of the different modules connected to each other in the various ways described above and as illustrated in fig. 3. While the score serves as a proxy for the composition and as a mnemotechnical device for the player it affects the player, causing her to perform certain actions in a certain order, these actions also create disturbances in the feedback and the Max patch. In turn this affects the Paetzold's sound as well as how the coming actions will be performed by the player. All the modules are equally important to create this specific piece. Nothing is added to something specific but to the whole system. The modules and the patch cords (real and imaginary) between them makes up a new *hyper modular* instrument that is inseparable from the composition.

4. Conclusions

Henk Borgdorff writes in his article *The debate on research in the arts* that ”[a]rt practice – both the art object and the creative process – embodies situated, tacit knowledge that can be revealed and articulated by means of experimentation and interpretation.” (Borgdorff, 2006). He states that ”[r]esearchers employ experimental and hermeneutic methods that reveal and articulate the tacit knowledge that is situated and embodied in specific artworks and artistic processes.” (ibid.).

This essay suggests a new way of conceptualizing instruments in an ensemble as interconnected modules or sonic entities. Those are comprised by agents and part of a larger instrument that is indistinguishable from the composition performed. The hypothesis is that this needs to be dealt with as a new kind of instrument and furthermore that in utilizing such a mindset we could unlock new possibilities for composing for and performing with both human and non-human actants. Thor Magnusson says in his book *Sonic writing* that ”[t]he musical theory of each musical culture is written into the functional body of the instrument itself. The instrument is concretised music theory.” (Magnusson, 2019). To realize the *hyper modular ensemble instrument* described here it would be a good start to begin by building up a theoretical framework. It is probably necessary to adapt a lateral process, dealing with subject matter from different angles at the same time. Research on what different affordances means in practice for the performer and composer is needed. Different concepts drawn from the Actor Network Theory might also be useful. Phenomenological studies in relation to perception could help in deepen the understanding of embodied, situated and distributed cognition[16] and knowledge in regards to the human actants of the ensemble. Practice-led research of course means that the artistic practice itself might lead us into yet unknown territories, requiring unorthodox methods to be used. Although, we must not forget that the primary goal should be new musical experiences that at least tries to push the envelope.

[16] As explained by Smith and Conrey in the *Cambridge handbook to Situated Cognition* (Smith and Conrey 2009: 454-66)

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Links

- The PureData programming environment: https://puredata.info
- The Max programming environment: https://cycling74.com
- The SuperCollider programming language: http://supercollider.github.io
- Toplap live coding community: https://toplap.org/
- The Toplap manifesto draft: https://toplap.org/wiki/ManifestoDraft
- IRCAM: https://www.ircam.fr/
- STEIM: http://steim.org/
- Alex Nowitz' early version of The Stophonion: http://steim.org/projectblog/2012/01/02/alex-nowitz-the-strophonion-instrument-development-2010-2011/
- Michel Waiswisz' The Hands: http://www.crackle.org/TheHands.htm
- Anna Petrini's web page: http://www.annapetrini.com
- Petersson, M (2008). *Sinew0od*. Recording from the album *Crepusculo* by Anna Petrini: https://soundcloud.com/emp/petersson-sinew0od/s-YMhY1