Composing and Performing With and Within Feedback Systems

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BACHELOR THESIS

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University of Music and Performing Arts, Graz
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Computer Music Bachelor Degree Program

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June 2020

Declaration

I hereby declare and confirm that this thesis is entirely the result of my own original work. Where other sources of information have been used, they have been indicated as such and properly acknowledged. I further declare that this or similar work has not been submitted for credit elsewhere.

Graz, June 16, 2020

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Abstract

In this thesis I aim at outlining a model of computer music composition as inextricably intertwined with performance and intrinsically bound to the generative qualities of the machine. These qualities are prominent in some specific configurations, for instance in feedback systems. As will be discussed, they appear to be both the cause and the consequence of some specific properties: emergence, non-linearity, complexity and self-organization. My approach is based on the inclusion of these contingencies in the process of composition. As I shall demonstrate, two key elements in this model of computer music composition are the design of the interaction between human and machine, and the mutuality of this interaction, that is the bidirectionality of the exchange of information between the agents. I shall investigate the human, the machine and the bond between them, shaping a narrative along the lines of three key concepts, that are introduced in the very title: *composing and performing*, *with and within* and *feedback systems*.

1. Introduction

The aim of this thesis is to bridge the composing-performing dichotomy in favour of an approach based on the concomitance and interconnection between the two. To do so I will firstly define the two stages (composing, performing), in order to facilitate the understanding of the artistic process. This paves the way for a definition of the system as a synthetic organism, programmed by the artist, that contributes to the generation of the music.

As I will show, the role of the system is both that of being one of the agents, acting in the process of music composition, and the container, constituted by the environment, the composer-performer and the computer music system itself. Over the course of the thesis, the latter will come to take on a wider meaning than that of a musical instrument. The music, whose form and structures are shaped in real time by the interaction between the computer music system, the performer-composer and the environment, appears as a network of intersections between pre-composed relationships and improvised reactions. The role of the composer is that of setting up the system so that it facilitates the generation of emergent and unexpected sound material and form. This, I believe, suggests that the form of the music emerges from the interaction between the system and the performer, both embedded in the environment, rather than being previously conceived or fixed.

Within this framework, the agency of the components, which are interconnected and embodied in a single entity, obscures the hierarchical establishment of some upon the others, and blurs the distinction between them. The purpose is to avoid the enclosing one-directional impositions of some components on the others and allow interference, emergence, complexity and self-organization.
This usually takes place in the form of recursively exchanging structures, loops, which we may generally think of as feedback. Feedback, indeed, appears in multiple aspects of the composition and not only as the description of an audio signal processing structure.

2. Composing⇔Performing

In relation to my artistic practice, I will hereby try to define the steps that constituted my methodological approach to the conception of music. These can be grouped into two stages, composing and performing, which may be distinguished by analysing some specific aspects that appear to separate them. These two stages are undertaken, in this case, by the same person. The aspects, which present a certain degree of difference and can thus be helpful to distinguish the two parts, are:

- *range of action:* the amount of possibilities and freedom during that specific stage;
- *context and environment:* the space in which actions take place and its characteristics;
- *temporality and dynamism:* the former indicates the amount of time during which actions take place and the latter describes the number of actions and events over time. The two nouns are showing two different fields of action and analysis, however these are necessarily requiring one another and they are described as in relation to each other;

I will further discuss the above mentioned aspects in the following chapters, in relation to the respective act, composing or performing, which they affect.

Furthermore, the thesis proceeds by alluding to and describing the hybridisation and overlap of composing and performing. Although their distinction appears to be helpful to frame the role of the artists and their artistic practices, what proves to be a powerful driving force is the combination of these roles. This leads to a disturbance of these distinctions in order to merge them. Arguably, this partly happens because of the concomitant existence of the two within the same person (Pirrò, 2017). Moreover, they are not only executed by the same person, but, to some extent, they also share the time and the space in which they take place. In the end, it is practically impossible to separate them, because they are codependent. Using a mathematical metaphor for expressing their relationship, one could say that the two are multiplied together, not added to one another. If one of the two would become zero, the final result is zero, no matter how large the other one is.

2.1 Composing: Building a System

This stage is characterized by the focus on the development of the single components constituting a system. Furthermore, these are connected to one another and combined into a unitary body: the links and connections among the parts are also programmed and defined here. The system can be intended as a musical instrument with one peculiar difference from a traditional acoustic one: the computer instrument benefits from a potentially infinite energy source, thus overcoming its dependency from body gestures (Pirrò, 2017). This feature of electronic music instruments allows them to continuously oscillate, and at the same time tends to reduce the role of the musician to that of a controller, not supplying any energy.

The last, but not least important, role of the composer in this stage is that of mapping the performer’s actions onto the system. In order to achieve this result, the compositional act shifts its focus from building the instrument to assembling the appropriate *performance device:* the interface with which the instrument can be played (Chadabe, 1997).

In fact, in an acoustical instrument the performance device is a structural part of the instrument’s sound generating mechanism (Pirrò, 2017). Moreover, in terms of mechanical energy, the performer action cannot be detached from the resulting sound event which it will generate, because it is the source of the sound event itself. Thus, every instrumental gesture, applied on the instrument by transferring the energy from the performer through the performance device to the instrument itself, exists in itself: it is structurally afforded by the instrument and therefore determines the sound generated.

In the case of electronic music instruments, a gesture performed with an interface does not automatically produce any sound: the composer should link the interface to the sound generating mechanism, framing movements, gestures and actions, in order to give them a musical meaning. In this case, as opposed to the acoustic one, there is a complete separation between movement and sound. There is an additional need to transduce the mechanical energy of the performer into the electrical energy used by the electronic instrument. Thus, every gesture performed by the musician has an effect only in relation to the pre-programmed framework coded by the composer.

Ultimately, the aim of these steps in the *composition of processes*, is to build the features and properties of the system. Within this framework, to compose does not solely mean to generate the sound material, assemble it and give it a form. Rather, the concept of composition refers to the conditions through which the system gains generative qualities. The goal of the composers is to be able to code and allow a degree of unexpectedness and emergence into the system. In doing so, the composers try to distance themselves from the traditional utopian narrative of a composition that exists outside of time and of the contingencies of its realisation. They embrace the indeterminacy of the performance and, ultimately, of the world (Pirrò, 2017).

The composition of form and sound material happens at a later step, when the artist starts to interact with and within the system: this phase is further discussed in the next chapters.

2.2 Performing: Interacting With and Within the System

At this point sound events, music and form emerge. The performer, who, in this case, is the same person who also coded the system, starts to actively engage with it. The role of the performer is to acclimatize themselves within the boundaries of the system and with its generative potential. "Engage" in this context refers to the concept of <u>interaction</u>*: "the ability of a tool, usually digital, to be able to accept or sense input and adjust its state according to some internal rules"* (Pirrò 2017). For better understanding the performance practice, in the context of playing within the system and with its parts, it is historically interesting and still very meaningful to look at what Joel Chadabe writes, regarding his "interactive composition" process:

the performer […] shares control of the music with information that is automatically generated by the computer, and that information contains unpredictable elements to which the performer reacts while performing. The computer responds to the performer and the performer reacts to the computer, and the music takes its form through that mutually influential, interactive relationship (Chadabe 1984).

One keyword concept that emerges from this short text and is even explicitly used, is that of *mutuality*. It is not uncommon that, in the live electronics practice, the composer seems to favour the imposition of control structures, applied from the performer to the computer music system. Thus contributing towards a strong hierarchical separation of roles and fewer possibilities (or even no possibility at all) of inverting the direction of exchange of information. The relation between performer and computer music system is often thought of as a linear communication flow, an understanding that is deeply rooted in an instrumental perspective (Di Scipio, 2003). Thus, in the above mentioned unilateral communication, the computer music system's potential is constrained within a more functional framework, acting only as sound synthesis engine. On the contrary, in my artistic practice the generative character of the computer music system directly contributes to the emergence of the sound material and its form (more detailed information about the characteristics and the structures of the system can be found in chapter 3). It is actually the very unexpectedness of the generative contribution of the system, particularly prominent in feedback systems, which revitalizes and emphasizes the active role of the performer. The human is constantly facing the results of their gestures and compositional choices and, if they should raise the level of attention, this is not to better execute the score's instructions, but to achieve an organic aesthetic interaction with the system, enabling a meaningful human-machine collaboration.

As a result, *musicking*[1] gains some structural parts that are common to the practice of improvisation, where the musicians are usually required to formulate their reactions during time (sound production), according to what they hear (sound perception).

2.3 Narrowing the Gap between Composing and Performing

The present chapter is divided into two sub-chapters. The former exposes the differences shortly mentioned in chapter 1. *Composing⇔Performing*. which allow me to partially distinguish between the two roles; The latter aims at fostering the conception of an experimental approach to music composition, based on inclusion rather than exclusion. In this framework, the two parts are inseparable and often converging into junctions and intersections, as they coexist in times, spaces and in the person who interprets them.

2.3.1 Distinctions...

In order to trace and summarize the differences between the two stages, I am going to draw from the aspects outlined in chapter 1. *Composing⇔Performing*.

<u>*Range of action*</u> indicates the number of actions and events that the composer-performer can execute during the two stages (composing, performing).

- **Composing:** In the case of coding the computer music system, *range of action* refers to the composer's creativity. This, one may argue, is mainly limited by one's self-knowledge and skills, and by the technological means available. However, in my personal artistic practice, I have never encountered any issue that could be attributed to a lack in available technological means. Apart from these, while composing a computer music system, there are in principle no other limitations given than the ones chosen and applied by the composers

[1] For an explanation of the term, see https://www.google.com/url?q=https://en.wiktionary.org/wiki/musicking&sa=D&ust=1591881651314000&usg=AFQjCNEvln8o3ZNEtS_0vVvxZiMqOVd1eQ

themselves;

- **Performing:** Here, limitations are a crucial part of this stage and they are defined in advance. I conceive of performing as the ability to exploit the most productive interactions with the computer music system. The latter, as a consequence, develops the music together with the performer. The term refers to the ability of playing within the boundaries of the computer music system. The variety of gestures that one can use is finite and coded during the previous stage (composing). The richness of both the performance practice and the music emerges, on the one hand, from the careful assembling of gestures and, on the other hand, from the rapidness of the interaction with the generative system. Ultimately, performing means improvising with the computer music system, where the improvisation is inherently present in the interaction with the system, because of the contingencies and the indeterminacy which are pursued as structural compositional material.

<u>*Context and environment*</u> simply refers to the physical space in which composition and performance are taking place and the circumstances surrounding those particular moments.

- **Composing:** normally requires a calm situation, allowing the composer to concentrate on their work, more often alone. The physical space itself is not particularly relevant, as any place which can be considered appropriate can be used, and I shall not discuss it further here. It is more important, I believe, to understand that this moment is based on the idea of researching and experimenting in order to build the computer music system;

- **Performing:** it is mostly understood as exposing the act itself, and showing it to an audience. It is a moment of sharing that is more or less influenced by the environment, here conceived of as the physical space with its characteristics and the people who are part of it. The act is inextricably intertwined with the environment in which it takes place.

Temporality and dynamism indicate the time unit and the number of movements and events that take place in the same. Although these aspects describe different features, they are nevertheless considered as coupled. This allows one to define these features as in direct relation with each other.

- **Composing:** the composer extends and reiterates their actions on different time scales. The act of composing takes place during a long time span. According to this, the curve which describes the dynamism of the movements here is usually gentle and gradual. The activity takes hours of work per single session and events are spread along this long time line.

- **Performing:** events rapidly follow each other and the performer requires a high level of attention to catch, interpret and respond to the events and changes. Although the music does not necessarily appear fast, fragmented and hyperactive, it will in most cases be confined to a specific amount of time, usually a maximum of an hour. Decisions are taken in real time and often simultaneously reveal their consequences.

2.3.2 ...And Confluence

Now, once the aspects of differentiation are set and validated, it is possible to discuss and explore the network of interconnections which make the two stages blend into each other and feed one another. In general, it is clear to me that, throughout the entire process of completing a piece, the two stages are mostly co-existing, and the resulting piece only comes into being as the product of this symbiosis. The composers are no longer writing the piece, but rather initiating an experimental process of which they are considered an active part and their role is also to perform their own composition. The approach towards music composition and its experimental process aims at the inclusion of the resulting materials and emerging structures. Moreover, the musician performs a reiterated act of composing, taking aesthetic choices in front of the audience by interfering with the system and its dynamics in real time. Thus, enhancing the creative potential of the process through mutual interaction. Inclusion, rather than exclusion, proves to be a key aspect of generation of the music itself. As such, inclusion can also be understood as the act of unifying the two different stages of music realization through the same person. As John Cage claims:

Where attention […] becomes inclusive rather than exclusive - no question of making, in the sense of forming understandable structures, can arise (one is a tourist), and here the word "experimental" is apt, providing it is understood not as descriptive of an act to be later judged in terms of success and failure, but simply as an act the outcome of which is unknown (Cage, 1955).

This passage highlights the importance of inclusion as applied to the act of composing, while also giving a definition of the term "experimental", understood as an approach which is characterised by an openness to the contingencies of art making. I also relate to Daniele Pozzi's conception of a model for computer music composition and performance, where:

music is instantiated during performance on the basis of stored programs and performance and environmental information. The model is proposed on a view of music composition as an experimental activity, whose results are the consequence of the manifold interactions happening amongst the various agencies involved in its development. Music is understood as a dynamical complex of interacting situated embodied behaviours (Pozzi, 2019).

To conclude, by analysing the process of music generation and distinguishing the stages that constitute it, one can get a better understanding of the various functions of these stages. However, none of them is meaningfully capable of initiating the process without being entangled with the others. Entanglement is also present at other layers of the work, arising as a structural criterion in the development of the computer music system, which will be further discussed in the next chapters of the thesis.

3. With and Within

As I briefly mentioned, one of the constitutive sources of music creation is the relation between the human and the machine, represented here by the performer and the computer music system. However, the connection between the two appears even at other orders of magnitude. Three different degrees of relation are discussed in this chapter, which serves as an introduction to the last chapter, where the system will be described in detail. These three degrees of relation and their differentiation are measured against the degree of complexity and consequently emergent behaviour that they can potentially incur. Complexity and emergence are growing and increasing at each degree.

Another important aspect that is analysed at every degree is the amount of “mutuality” in the interaction among the parts. This portrays a decreasing level of imposition of control structures by the composer-performer and an increasing system’s agency. In this context, autonomy emerges from the strong interconnections among the parts.

3.1 Performer > System

“>” indicates the directionality and hierarchy of the control structures, from the composer-performer to the system, as well as the importance of the parts involved in the construction of the musical process and form. The first degree of interaction can be similarly defined as the relation between the musicians and their musical instrument, albeit the absence of feeding the instrument with bodily energy, as discussed in the previous chapters. The human is conceived of as the agent who alters and adjusts the parameters of the internal state of the system, in order to act on its output. The performers play the system, imposing their will, but they may structure their actions according to what they hear and listen to. This layer of interaction is based exclusively on the performer's decisions, and takes the form of a loop between the output sound and the composer-performer as an agent. However, this recursive element is strictly dependent on the performer and therefore optional. As Di Scipio notes, it does not matter in what complex mapping one redirects and translates the information of the performer to the system, because "[…] that is not essential to the underlying ontology: *agent acts, computer re-acts"* (Di Scipio, 2003). Moreover, as he claims "in a broader perspective, in this standard approach, *the sound-generating system is not itself able to directly cause any change or adjustment in the 'external conditions' set to its own process*" (Di Scipio, 2003).

I personally believe that one of the underlying reasons for constraining the computer's generative potential is the necessity of control. It seems to me that many composers tend towards these decisions in order to empower the human hierarchical establishment and control over the technological medium. Thus blocking its generative and emergent potential. Luc Döbereiner, in his article "Models of Constructed Sound: Nonstandard synthesis as an Aesthetic Perspective", presents a "perspective in which technology and its function are not accepted as pre-given or as immutable; not as merely a means for realizing a preconceived objective, but as something to be explored, to be determined, to be defined. The question is not so much which desires one can satisfy with a given technology, but rather which (old and new) desires emerge from it" (Döbereiner 2011).

3.2 Performer = System

"=" indicates an increased degree of interaction and mutuality between the two parts. At this level, the idea of a master slave relationship between human and machine is abandoned, and a hybridisation state is established. The parts become inseparable and incessantly cooperating and co-evolving to let the performance emerge (Sanfilippo, 2017). Within this framework, the system's agency can be seen as equally important to that of the performer. For the sake of clarity, one could similarly compare this interaction to the one that occurs in the relationship between two musicians: the two agents are both capable of interfering with their counterpart, prompting several actions and reactions with variable degrees of unexpectedness. This step determines the development of the system towards the possibility of interpreting inputs and upgrading it to a *self-observing* system, able to shape its internal state according to the external conditions (Di Scipio, 2003). In a feedback configuration, these conditions include a representation of the system's own traces. As a result, the complexity degree inevitably increases and a renegotiation of the agencies at play in the compositional act, understood as the organization of sound forms in time, takes place. The system contributes to a much larger extent to shape such sound forms, engaging with the performer in a generative interaction. However, while using the simile of the two musicians may help to better understand the quality of interaction that is being outlined, there are some consistent differences between humans and computers. Thus, the relation between two musicians and between performer and computer music system is inherently different. I will now try to trace some of these differences, as I encountered them in my artistic practice.

It is worth noting that, since I am reporting my take on this topic, the main point of view taken into account is that of the composer-performer, (a figure) who is internal to the process itself. The person is acting in the process and observing it with extended knowledge of its underlying implementations and structural interdependencies. As a matter of fact, the point of view may be drastically different if we consider, for example, the listener's stance.

The two main characteristics, which highlight difference in the relation between musician-musician and performer-computer music system, are:

- the system's dependency to the human (system is coded by the composer);
- the interpretation and elaboration of the inputs;

The former outlines a very peculiar characteristic of the system: the system depends on the composers, because it is coded and programmed in advance by them. Although this is quite obvious to me, I believe it is important to reiterate it, as it significantly determines other aspects of the system itself.

The latter depicts the way in which the human perceives and the machine interprets the inputs. One, out of many, ways to investigate this topic is to assume the human conception of the world as described in the embodiment theories, which draw upon *Phenomenology*. Other theories may follow different paths. It is not my aim here to go into a detailed discussion of these. However, for the sake of my argument, I will simply accept the theory which I felt more connected to my practice and to which I could relate more. According to the Stanford Encyclopedia of philosophy, phenomenology

... is the study of structures of consciousness as experienced from the first-person point of view. The central structure of an experience is its intentionality, its being directed toward something, as it is an experience of or about some object. An experience is directed toward an object by virtue of its content or meaning (which represents the object) together with appropriate enabling conditions (Smith, 2018).

Moreover, as detailed by Merleau-Ponty (Merleau-Ponty, 2002) and summarized by David Pirrò, a person does not simply undergo a passive perception of the stimuli. Instead, they perform an active process, which is similar to that of “breathing” or “procreating”. As a consequence, the sensations are emerging from the process of experiencing the world through active implications and movements (Pirrò, 2017).

On the one hand, sound events are interpreted by the performer with varying degrees of importance. Their importance is not necessarily connected to the magnitude of the events themselves, but rather to the meaning the performer attributes to them and the intensity with which they are experienced. On the other hand, computer music systems perform some analyses on the basis of reproducible, scientific and standardized interpretation of signals.

In order to further clarify the difference between computers and humans in the interpretation of sound events and their properties, I shall introduce the concept of temporality. In the case of human perception, temporality depends upon many variables. Arguably, humans don’t perceive time as a linear phenomenon, but rather in relation to sequences of events happening over a period of time. Furthermore, the way we perceive time varies according to the importance, the enjoyment or the overall experience we associate to these events. Thus, the perception of time is subjective and nonlinear. Similarly, in the performance framework, a sound event cannot be considered as dissociated from its context, but rather it is entangled to past events and future decisions, modelled by the musician. Events are bound to a human's subjective experience of them and this can significantly vary according to the context in which they take place.

Such a complex notion of time is complicated to implement in machines, and thus usually substituted by a numerical representation of time, by discretization and by sequentiality. However, it is important to keep in mind this difference between human and machine in collecting data, because the results of analyses output by the machine may appear very different to one's expectations, according to human perception of events.

3.3 System ∍ Performer, Computer Music System, Context

"∍" is used to indicate the last degree of complexity analysed in this thesis. In mathematics, this symbol means "containing". As applied here, it indicates that the system contains the elements: performer, computer music system, context.

In this framework, one is finally allowed to understand the *agents*, including the performer, as the elements operating within the system. This final step elevates the role of the system to that of a "container". The system is the "organism", which computes and generates the music work as a result of the continuous relations and dependencies in force within its structural boundaries among its smaller components.

In Di Scipio's work, these systems are named "*eco-systems*". They establish a "non-destructive interaction with the surrounding environment", that is regarded as an "*uneliminable component*". In these systems, the structure and development of the system itself, "*cannot exist (let alone be observed or modelled) except in its permanent contact with a medium*". Di Scipio's analysis proceeds by explaining their self-regulating principles, as it appears from the fact that "*their process reflects their own peculiar internal structure*". However as he claims "*they cannot be isolated from the external world, and cannot achieve their own autonomous function except in close conjunction with a source of information (or energy)*". Ultimately, "*to isolate them from the medium is to kill them*" (Di Scipio, 2003).

The above mentioned description of the eco-system is realised in Di Scipio's artistic practice as the inclusion of the sound environment, that is the sound-space in which the performance or installation takes place, as an agent in the compositional process. He also attributes a significant role to the "*noise"* and the "*ambience".* Room acoustics and space are the medium whereby the system spreads the sound results, but also the medium through which the system traces its own sound results and extracts information from the inputs.

Beside the use of the real environment, I would include the possibility of virtual environments or spaces. As a consequence, the meaning of "context" is apt to indicate, as suggested by Dario Sanfilippo, those "*closed systems which are coupled with themselves*". These particular recursive systems are also called close feedback systems: "*systems which provide the context that, circularly, affects their own state*" (Sanfilippo, 2017).

At this point we can address the system not only as an instrument to be played, or an agent to play with, but also as the network containing all the other agents and providing the context in which they interact and communicate. The musical piece emerges within the space and time provided by the system, in which the agents act upon the musical material at different layers, ranging from micro to macro, from shaping the processes which generate and synthesise the sounds, to modelling the form and concatenation of the sounds into musical structures.

4. Feedback Systems

“Feedback” is one of the possible system’s configurations that exhibits a peculiar level of emergence and in which the concepts of process, form, self-organization and complexity are entangled in a coherent way (Pozzi, 2019). Although an univocal and exhaustive definition of the term emergence doesn’t exist, its notion is related to that of complexity, the first defining the quality of unexpectedness of the results, the second defining the structural organization of the process. As noted by Dario Sanfilippo and Andrea Valle (Sanfilippo and Valle, 2013), emergence can refer to organizational levels (Lewels, 1879), to self organization (Varela, Thompson, and Rosch, 1991), to entropy variation (Kauffman, 1990), to non-linearity (Langton, 1990), exclusively to complexity (Cariani, 1991) or synergy (Corning, 2002). From a qualitative and holistic point of view, emergence is the formation of global properties stemming from the interactions of lower level components (Mitchell, 2006). In these cases, the synergy between the interacting components gives rise to an entity which is different from the sum of the parts (Corning, 1991).

Particularly relevant in feedback is the “economy” of the process itself: although it is an example of a simple behaviour, it leads to unexpected results through iteration and due to non-linearity. Therefore, it has to be described in the realm of complexity (Sanfilippo and Valle, 2013).

A basic definition of feedback takes into account the configuration of a system, provided with input and output, in which some kind of transformation occurs, where the output is connected (fed back) to the input after a delay (De Rosnay, 1997). “Economy” then describes how the system, given an initial impulse, is capable of self-alimenting, by means of iteration of the process (Sanfilippo and Valle, 2013).

One can distinguish between positive and negative feedback. These two options describe the relationship between input and output, where positive indicates a direct relation between the two, while negative an inverse relation. Thus, the concepts of positive and negative feedback can also be generalized as *causal relations* (Heylighen and Joslyn, 2001). The effects of positive feedback are cumulative and lead to divergent behaviour: on the one hand it produces indefinite expansion or explosion towards infinity, on the other hand it generates a total blocking of activities, converging to zero. Conversely, the negative feedback tends to stabilize the system: this leads to adaptive, or goal-seeking behaviour and the system oscillates around an ideal equilibrium that is never attained (De Rosnay, 1997). Often, working with feedback systems requires the employment of both, whose combination results in equilibrium and self-balancing dynamics.

A common characteristic of non-linearity is that causes of reduced size can have greater effects, and causes of greater size can have smaller effects. Feedback systems are typically nonlinear and characterized by their structural circular causality (Heylighen, 2001; Gershenson, 2007). In such configuration, the effects are also the causes (Heylighen, 2001), and there is a mutual relation between them (Sanfilippo and Valle, 2013).

Non-linearity describes the relationship among the components and the characterisation of their results, but it also implies a challenging and yet surprisingly fascinating procedure while interfacing with it in a performance context. In fact, the change of internal variables of a feedback process can result in very different behaviours and thus very different sound results. While in linear audio systems different kinds of sonic features are substantially unrelated, which gives the possibility to individually and independently control and adjust them, in feedback configurations these features are closely interrelated, meaning that a single adjustment may result into a modification of many other parts (Sanfilippo and Valle, 2013). This constellation drastically shifts the way music composition and performance is conceived of. As outlined in the previous chapters, the composers are no longer fixing the sound material and the form for every specific frame of time; they are instead planning the interdependencies among the system components which, as a byproduct, will result into the overall system dynamics and system interactions (Di Scipio, 2003). These, interfacing with their own context (because of the feedback configurations) and with the performer and/or other inputs, give birth to the music. Put in Agostino Di Scipio's words, it represents a move to *composing musical interaction* and a shift from creating wanted sounds towards *creating wanted interactions having audible traces* (Di Scipio, 2003).

Performing, on the other hand, implies taking risks and avoiding a controlling approach towards the material, to embrace the unexpectedness of the interactions' outcomes, and to search for the surprise element. Surprise should not be understood as an end in itself but as a form of perturbation, capable of provoking a movement of adaptation in the subject, an expansion of the field of experience that stimulates the emergence of alternative points of view and divergent approaches (Pozzi, 2019).

When working with feedback, one needs to search for its excitable regions, transitions and phases in which the material and the behaviour are musically meaningful and interesting. These are situated between the nothing and the infinite, the two poles to which feedback is easily attracted to. These are extremely relevant and rich when feedback is not framed or limited, albeit almost unusable, because the transitions happen faster than the time required to grasp and react to them, practically unfathomable. Hence the necessity of bounding its instability, with the inevitable loss of richness, to gain control over its reactions and dynamics.

In my experience, feedback systems offer the organicity and liveness which was otherwise missing while working with computer systems. I tried to direct the creative potential, initially within my hands, in the net of intersections emerging between human and machine. This is a step towards recognizing and raising the agency of algorithms and computer systems in the composition process, whose role should not be that of easing or executing my will, but rather interfere and challenge it, building a continuous confrontation and exchange of information between the system and myself.

5. Conclusions

In the above chapters, I have given an overview of a particular process of computer music composition. This was not aimed at suggesting a better or more efficient methodology for conceiving music, but rather as an argument supporting a less common approach, a different model of computer music composition.

The suggested model is based on inclusion and on experimental processes, which are not evaluated or judged on the basis of their results, or in terms of success or failure. The word "experimental" is simply used as descriptive of some processes whose results are contingent and unknown. The composers wanting to combine these in their work shall embrace and include this contingency.

The suggested model is strongly interrelated with performance. It shifts most of the potential of shaping the form and the material to the computer music system and to the act of performance, in this sense blurring the distinction between composer and performer.

The suggested model is apt to exploit the peculiarities of the machine and computer music itself. One of these, for instance, can be traced in the potentially infinite energy source and, as a consequence, in self-alimentation, largely employed in feedback systems.

The suggested model aims at emphasizing, rather than limiting, the generative character of the machine itself. One should not fear or submit to Technology, neither functionally employ it: it is no longer crucial which achievements one can obtain by using it, but rather which desires may emerge from it. For this reason the agency of the machines and their smaller internal structures are taken into consideration and embedded in the compositional-performative act.

In this model, most of the components are closely connected and continuously interfering and interacting with each other, within the boundaries of a "container" that takes the name of "system". The main purpose of the composition is to develop these interrelations and to exploit their dependencies. Ultimately, this is the very core of the model of computer music composition presented in this thesis. In my view, to compose means to model behaviours and relations, rather than acting directly upon the form and the material.

Emergence, non-linearity, complexity and self-organisation are the cornerstones of the proposed compositional model. These are not solely the result of careful research and programmatic implementations, but also the very consequences and artefacts encountered while engaging with generative processes and, more precisely, with feedback systems and recursive structures.

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