UNFOLDING STONES: INTERACTIVE MUSIC DIALOGUING WITH DIGITAL IMMERSION AND AUGMENTED COGNITION

Jônatas Manzolli
Interdisciplinary Nucleus for Sound Studies (NICS)
Music Department
University of Campinas (UNICAMP)
www.nics.unicamp.br
e-mail: jonatas@nics.unicamp.br

ABSTRACT

Nowadays, new technologies emphasize interaction and novel music interfaces and alternative forms and modes of interactive media have been realized. The digital era is promoting interaction between audiovisuals, music and improvisation in virtual and mixed reality spaces. Have we *"stones"* in our hands - the computer technology? As the primitive man was stimulated by the images and sounds from the stones, we might be stimulated, by mixing the virtual and real worlds, to understand the integration of the brain and the body with such yet unpolished technological tools. This article presents a conceptual discussion articulating interactive music composition and computer creativity. It is also introduce the idea of using interactive media as laboratory to study creativity and to mediate the creation of artworks. We introduce previous interactive performances and *minDSounDS*, a performance to be presented at the Generative Art 2014 Conference.

INTRODUCTION

With the advent of new technologies that have emphasized interaction and novel music interfaces, alternative forms and modes of interactive media have been realized. These developments raise fundamental questions regarding the role of embodiment as well as the environment and interaction in live interactive composition focusing on our understanding of the man-machine interplay. In addition, it emphasizes a more situated and externalist view of performance and composition.

In parallel, music representations have evolved from symbolic notated pitches to expressions of the internal organization of sound. This can be observed in the extended instrumental techniques developed from the 1940's onwards up to the more recent compositional strategies that have emerged from the "new interfaces for musical expression". The dynamic organization of sound material in "real" time, however, adds new dimensions to musical information and to its symbolic representations.

In such époque, it is necessary to expand not only our familiarity with new technologies, but mainly to develop a critical and revitalized understanding revealed in new dialogues between Art and Science.

This article is organized as follows: first we present a conceptual discussion articulating interactive music composition and computer creativity, it is based on two recent chapters published in "*Language, Music and the Brain: A Mysterious Relationship*" [1][2]. Next we introduce the idea of using interactive media as laboratory to study creativity. It follows a philosophical point of view

based on the idea that acquiring knowledge from experience is an important evolutionary accomplishment. This observation leads the concepts of *Presence* [12] and Abduction from Charles S. Peirce [3]. To exemplify our perspective, previous artworks are presented, such as described in [5][6], and the article finishes with the description of minDSounDS, a performance to be presented at the Generative Art 2014 Conference.

THEORETICAL VIEW POINT

Sounds and images interact with the human cognitive system since the primitive man struck two rough and unpolished stones and he thought about mastering the power of Nature. Later these stones became polished tools and more sophisticated instruments were created. Nowadays, the digital era is promoting interaction between audio, visuals, images, musical composition and improvisation in virtual and mixed reality spaces. Have we again *"stones"* in our hands - the computer technology?

As the primitive man was stimulated by the images and sounds from the stones, we might be stimulated, by mixing the virtual and real worlds, to understand the integration of the Brain with sounds, images and music with such yet unpolished new computer and digital technological models and tools. As also the Greek composer Xenakis [7] envisioned:

> *"We shall thus be able to reascend to the fountain-head of the mental operations used in composition and attempt to extricate the general principles that are valid for all sorts of music. We shall not make a psycho-physiological study of perception, but shall simply try to understand clearly the phenomenon of hearing and the thought-processes involved when listening to music. In this way we hope to forge a tool for the better comprehension of the works of the past and for the construction of new music. […] We shall confine ourselves to following a path which may lead us to regions even more harmonious in the not too distant future (p. 155)".*

Ada Lovelace Lady Byron in documenting Babbage's analytical engine anticipated that the mechanized computational operations of this machine could enter domains that used to be the exclusive domain of human creativity:

> *"Again, it [the Analytical Engine] might act upon other things besides number, were objects found whose mutual fundamental relations could be expressed by those of the abstract science of operations... Supposing, for instance, that the fundamental relations of pitched sounds in the science of harmony and of musical composition were susceptible of such expression and adaptations, the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent." (Taylor's Scientific Memoirs 3)[8].*

Almost 170 years later such machines do exist and computer based music composition has reached high levels of sophistication. For instance, based on a prior analysis of harmonic relationships, hierarchical structure, and stylistic patterns of specific composition(s), Cope [9] has written algorithms to

generate plausible new pieces of music in the style of the composer behind the original pieces.

However, despite these advances there is no general theory of creativity that either explains creativity or can directly drive the construction of creative machines. Definitions of creativity mostly follow a Turing test like approach where the quality of a process or product is declared to be creative dependent on the subjective judgment by other humans of its novelty and value. The emerging field of computational creativity defines its goals explicitly along these lines see Colton [10].

Although these approaches could generate interesting applications its definition is not sufficient either as an explanation nor as a basis to build a transformative technology as the classic arguments of Searle against the use of the Turing test in Artificial Intelligence has shown Searle [11]: "*mimicry of surface features is not to be equated with emulation of the underlying generative processes*".

In this article we address the question of how we can advance our understanding of the interplay between computer intelligence and music creativity, by placing human experience in expressive and artistic contexts at the centre of the solution. So, our approach is to experiment with interaction in performance situations based on virtual sources, mostly in form of audiovisual materials, human gestures, real movements, register the behavioral outputs and bio-signals of humans.

Thus, extending this point of view in the direction of multimodal performances and interaction in mixed reality, our research intends to develop a program to: a) combine multimodalities using interactive media; b) produce digital immersion and augmented cognition; c) study human cognition and creativity using databases generated by computer music, computer graphics, sensory devices, bio-signals and motion caption.

INTERACTIVE MEDIA AS LABORATORY

In the use of the new interactive technologies, an interactive environment can function as a laboratory to explore computational models of cognitive processing, and interactive behavior. With the advent of new technologies that have emphasized interaction and novel interfaces, alternative forms and modes of interactive media have been realized, as described by Rowe and Winkler, [13][14].

For example, interactive music systems depend on a human user to control a stream of musical events, as in the early example of David Rockeby's Very Nervous System (1982–1991). This pioneering perspective on sound interactive media was developed to integrate musical performance with the human nervous system. Miranda and Wanderley [15] discuss the development and musical use of digital musical instruments (DMIs); that is, musical instruments comprised of a gestural controller used to control the parameters of a digital synthesis algorithm in real time, through predefined mapping strategies.

On the other hand body's perceptual, cognitive, motor and kinesthetic responses have to be reconfigured to the needs and constraints concerning action and perception in this new space and the interface can now be optimized to its user, as discussed by Coessens [16].

Thus we will deploy methodological efforts focusing on interactive media within mixed reality environment in order to study the constructions of meaningful relationship between agents and environmental stimuli in a virtual space. The assumption is that the interaction of an agent or group of agents with an immersive space, using interactive devices, indicates how these processes affect their behavior and the meaning that is constructed by them.

ANTICIPATION, DISCOVERY AND ABDUCTION

Acquiring knowledge from experience is an important evolutionary accomplishment, for it aids the organisms in predicting future outcomes of the always-shifting environment. In the sound domain, Anticipation seems to be a very prominent aspect of musical experience; listeners seek for relations in and of the antecedent sound events creating expectations as the possible consequents. Music expressivity and aesthetic pleasure or affects, important parts of artistic appreciation, are derived from the dynamics of expectations and their possible fulfillments in the unfolding of musical works, described by Huron [17].

On the other hand, concerning to the idea that there is logic in discovery processes, the work of the American philosopher Charles Sanders Peirce is paramount. Peirce's notion of Abduction (Peirce 1931-1958) is addressing the study of discovery in scientific knowledge that started to receive more attention in the 19th century.

Peirce described three types of reasoning: *Abduction, Induction and Deduction*. While induction and deduction are traditionally investigated thoroughly in philosophy, abduction seems to be less scrutinized, despite being one of the most important contributions of Peirce's Pragmatism. Basically, abduction is the kind of inference that generates explanatory hypotheses when anomalous facts are perceived. It is related to the presence of surprising or unexpected events. According to Peirce, the main activity of any mindful or cognitive system is the production of habits. Stable habits, in turn, constitute beliefs from which the reality is apprehended. From this perspective, a mental system could be understood as a dynamic network of stable habits (or beliefs) from which novelties and anomalies are detected as surprising events.

In previous article [4], we postulated that musical experience is not diverse from other kinds of cognitive experiences, thus employing similar reasoning those applied on daily life. Solving a very complex mathematical puzzle or doing the supermarket, or listening to music employs the same mental-logical operations available to acquire knowledge from experience. Our hypothesis is that artist, composers, performers and public generate and exchange expectations using these three kinds of reasoning understanding of the concept of meaning in a new (pragmatic) perspective.

TRAJECTORY OF INSTALLATIONS AND PERFORMANCES

In previous works, we had already developed artistic performances based on the perspective presented above: re(PER)curso (2007) and Multimodal Brain Orchestra (2009). In the first, the approach was to integrate algorithmic

composition with interactive narratives and scientific sonification and visualization. The structural pillars of that work were not a script or textual narrative, but how the concept of recursion could be used as a way of constructing meaning. Specifically, the interaction between two human agents that produced recurring changes in the physical world and an avatar in the virtual world, created a substrate for the emergence of meaning [5].

In the second study, we explored how the internal and external representations of the world could be joined together in a performance to create music, sounds and video, which can be also seen as a form of interactive narrative of a mixed reality [6].

These two works were preceded by the *RoBoser* project (1998) [18] and *ADA: intelligent space* (2002) [19], projects that were realized in real-world systems of multiple forms and functionalities. The RoBoser paradigm has been generalized from the musical domain to that of multimodal composition in the (Figure 1) exhibition as well the other two mentioned works, *Re(per)curso* (Figure 2) and *The Brain Orchestra* (Figure 3).
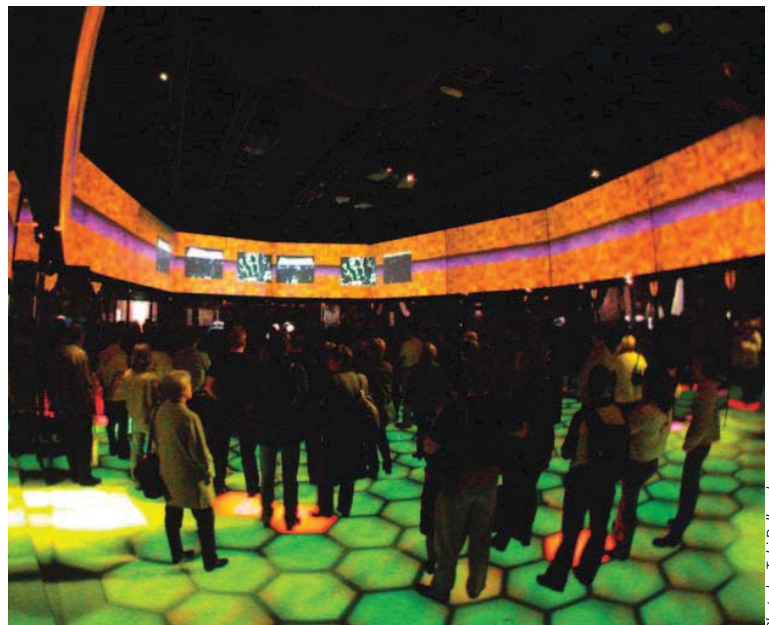

Photo by Tobi Delbruck

Figure 1: *The Ada main space (180 M^2) interacting with its visitors through interactive multi-modal compositions. The hexagonal floor tiles are pressure sensitive and display colored patterns dependent on Ada's behavior modes and on visitor interactions. The walls are made of semitransparent mirrors and allow visitors in the voyeur corridor to view what happens inside Ada. Above the mirrors a circular projection screen displays real-time animated graphics that, similar to the music, represent Ada's current behavior and emotional state. Ada was operation from May until October of 2002 and was visited by over 500.000 people.*

Figure 2: *The interactive performance re(PER)curso was presented in Barcelona in 2007 at the Museu d'Art Contemporani de Barcelona and in 2008 at the Art Futura festival at the Mercat de Les Flores. The performance explores the confluence of the physical and the virtual dimensions which underlie existence and experience, and it poses questions about the significance of artificial sentience and our ability to create and coexist with it.*

Figure 3: *The Brain Orchestra performance. The four Brain Orchestra members play virtual musical instruments through Brain Computer Interface - BCI - technology alone. The orchestra is conducted while also an emotional conductor, seated in the front right corner, is engaged who drives the affective content of a multi-modal composition by means of her physiological state.*

Table 1 presents a review of the concepts encapsulated by these works and also key ideas of minDSounDS (2014) that will be presented in its first run at the Generative Art Conference 2014.

Motivations
• *unfold performance in line with improvisation and audiovisuals.* • *create a live interactive composition system in which the physical space, light, sounds and images are integrated in a broad notion of musical instrument.* • *broaden exploration of the countless possibilities to correlate sounds, visual material and text.* • *understand music performance as re-creation and not merely reproduction of a work.*
Concepts
• *mixed reality performance as a performance environment* • *dynamic of creativity is correlated with semiotic operations* • *meaning driven by broken habits and abductive reasoning*
Interactive Performance
• *agents: human perfomers and avatars* • *interaction between trajectories build up from moviments and music improvisation* • *moviments and music improvisation interactive paradigm* • *improvisation and self-organization in the heart of the performance* • integrate performance trajectories to produce changes on Avatar's behavior

Table 1: *It features a review of the concepts presented above and also the key ideas of minDSounDS.*

PERFORMING MINDSOUNDS

minDSsounDs is based on the notion that the delivery of *Presence* is closely tied to an understanding of consciousness [12] and, in particular, of the interplay of implicit and explicit factors in the construction of human behaviour and artistic expression (as described in previous section). It is a performance where a group of musicians and machines dialogue in a network, there is a continuous exchange of information between these agents, and the emerging sounds and visuals are shaped by physical actions, movements, music improvisation and implicit signals captured by BCI.

Interactions between five musicians give rise to an artwork that uses interactive media in a multimodal performance (see figure 6). They come together to create a plot that plays with poetry, sound and visual textures, capture and analysis of movements and the use of BCI to control the movement of an Avatar in the virtual reality, audio and video in real time.

MinDSounDS speaks to the notion of "sound imaginary" and the idea of "mind the sounds". Its poetics describes creation and re-creation of meaning from the exchange of information among agents. It projects the building of a visual form based on sound manipulations within a network of exchanges between performers and computers (see figure 4). The composition uses sound material created from the Manzolli's poem "Apeiron[1]", originally in Portuguese, but presented in five languages during performance. The original poem is presented below in Portuguese and in a free translation to English (see Table 2)

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[1] Apeiron is a Greek expression describing a cosmological theory created by Anaximander in the 6th century BC.

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no mesmo momento a origem de todas as coisas fez-se nas partes uma das outras. árvore dos fragmentos peixes e luas dos grãos de areia e as sementes de todos nos outros. sonho do pensamento pensamento do movimento movimento do gesto gesto do som som da mudança mudança do sentimento sentimento da transformação. transmutam-se elementos e universo preenchem vazios cósmicos particionam direções do tempo plantam sementes todos os outros elementos. árvores voltam às cinzas grandes peixes às luas-grãos-de-areia matéria e conhecimento aos sonhos movimento ao gesto desejo ao prazer. o universo sustenta-se no encadeamento da conciliação.		at the same time the origin of all things made itself of each other's parts. tree of fragments fishes and moons of grains of sand and seeds of all in others. dream of thought thought of movement movement of gesture gesture of sound sound of change change of feeling feeling of transformation. transform themselves elements and universe filling cosmic voids partitioning directions of time planting seeds all the others elements. trees return to ashes big fishes to the moons-grains-of-sand matter and knowledge to dreams movement to gesture desire to pleasure. the universe sustains itself in the stream of conciliation.

Table 2: *Poem Apeiron, originally in Portuguese, used to produce an immersive chain of fragmented words in minDSounDS.*

The aim is to produce an immersive chain of sound information, a soundscape resonating various meanings and turning points. Thus, words are fragmented and (de)constructed with granular synthesis and these sounds are spatialized in real time using motion capture and interactive gestures.

Along with this process of integration between sound and movement, MinDSounDS dialogues with sound material generated by the flutist improvisation and gestural controls with the Wiimote interface. These elements are integrated to build a virtual representation of the interaction itself and the action between the five agents: the structure of movements and body construction of an Avatar is controlled by a BCI interface (see Figure 5).

All these elements are used to create a universe that can only be sustained by a chain of reconciling between actions and agents.

Figure 4: *Interaction with the Avatar. minDSounDS builds a visual form based on sound manipulations within a network of exchanges between performers and computers.*

minDSounDS concept follows this path: "*while an agent and a group of agents are interacting all multimodal signals produced by the agent(s) are shared in a network, captured and analyzed in real time and/or stored for future off-line manipulation, remotely or locally*. The concept is to create a live interactive composition system in which the physical space, light, sounds and images are integrated in a broad notion of musical instrument.

Figure 5: left: flute improvisation; right: the BCI interface *Interaction with the Avatar.*

Figure 6: *minDSounDS team. In left photo: Tiago Tavares, Clayton Mamedes, Gabriel Rimoldi e Vânia Pontes. In the right photo: Jônatas Manzolli and the Team at the electronic studio of NICS.*

Conclusion

We presented in this article the possibility of combing multimodalities and interactive media to unfold live performance in line with improvisation and audiovisuals such as re(PER)curso (2007) and the Multimodal Brain Orchestra (2009). As we understand music performance as re-creation and not merely reproduction of a work, we aim to enlarge the countless possibilities to correlate sounds, visual material and text in minDSounDS (2014). Thus we presented interactive performances aiming to create meaningful relationships between agents and explore their interactions using visualization and sonification. Further, for studying music cognition in its fullness and understand its processes of discovery and creativity, it is necessary to examine how the brain and body work together in the solution of such complex problem.

Many decisive steps in the processes of creativity and discovery rely on implicit factors rather than explicit ones. Our goal is to explore these factors to validate a mixed reality implicit and explicit Presence delivery system linked to expressive experience in artistic domains.

In short, these artworks illustrate that aesthetic experience can be, at least partially, obtained as emerging organization from the interaction between human users and an interactive system. Since our goal is to enhance creativity, this approach seems powerful and can lead to unexpected results (surprise is another form to describe information).

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