Xth Sense: recoding visceral embodiment

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Abstract
This paper seek to weave a discourse around musical embodiment drawing on the idea of biological media in cultural studies, Information Technology (IT) and musical performance practice. The perspective outcomes of a widely diffused instrumentalization of biological signals can be as much seducing for a technologist as for an a musician; I focus my analysis on what can be lost in the process of encoding expressive, living matter into mere binary code. In order to evaluate this question in the frame of my own musical research, I introduce the Xth Sense (XS), a novel biophysical system which I'm developing and performing with since March 2011. Eventually, some perceptual and aesthetic benchmarks of the XS are assessed in the context of *Music for Flesh II*. This is the first of an on-going series of works that explore a new paradigm which I call *biophysical music:* the design of live sound performances that use a performer's muscle sounds to substantiate an authentic sonic vocabulary and uncharted sound forms.

Author Keywords
Embodiment, biomedia, interactive music, expressivity, muscle sounds.

ACM Classification Keywords
H.5.5. Information interfaces and presentation

Introduction

Ubiquitous, locative and biologically sensing technologies have flourished in the last decade, calling for a major shift in the foundations of Computer Music Interaction. What in the 80's and 90's was a concern about enhancing the capabilities of a computer that "removes you from your body" [11], slowly but diffusely evolved in a fascination for human ontological experience. As for Cultural Studies [6], the *affect* that embraces the body as a living organism is one of the latest subject of investigation in Computer Music. Biosensing devices are being used in an attempt to virtually portrait the processes behind human affect, so to envision unexplored musical strategies. The academic and artistic communities strive for informing the body and the mind with 'digital prosthesis' and augmented environments. The unparalleled heterogeneity of the body biological potentials, along with its inherent inadequacies, inspired artists and researchers to deploy the body as a biotechnological construct [2], a brain-computer interface [7], an electric spatial controller [10], and in the case of my own work, a self-enclosed musical instrument [4].
On the other hand, the advertisement and security industries are rapidly somatizing the utility of biodata. The Japanese IT giant NEC has tested digital walls that use a custom facial recognition system to gather information about passers-by and serve real time, physiologically and demographically targeted ads [8]. The United States Department of Homeland Security's Science & Technology Directorate is testing a program named FAST [3] that includes the use of sensor arrays to covertly conduct surveillance on individual not yet suspected of a crime. The system secretly observes and stores a diverse range of data among which "cardiovascular signals, pheromones, electrodermal activity, and respiratory measurements", so to describe the criminal potential of a subject and thus *pre-know* the advent of criminal activities [5].

The body technology

Machines can seamlessly infiltrate a body to trace electrical pulses and chemical reactions, muscle contractions and palpitations of the blood vessels. A low-level, organised yet unpredictable system is revealed; a networked order of integrated agents capable of learning, reasoning, reacting, interacting and overreacting in conjunction with other entities. In other words, the body is shown in its inherent form, an actual technology. Here the meaning of technology is intended as a complex, emergent system of rules and 'living' matter, rather than a situated, deterministic automaton. What makes the body technology profoundly different from others and particularly apt to be approached as a musical instrument is its distinctive and stunning expressivity.
The distinctive nature of a truly expressive computer musical instrument have been largely theorized. In [12] Tanaka refers to the characterization of expressivity by researchers such as Cadoz and Camurri in contrast with the intuitive approach of performers like Ryan, so to identify the key to full expressivity “not just in the effectiveness of communication, but in the sense of agency that the system gives back to the performer”. The relation between expressivity and agency is also asserted by Waters' [14] where he insists that “the constraints and constructs upon which music depends are... to be found... in the algorithms which operate in this particular piece of warm wet meat (i.e. the player)”. The capability of channeling articulate information with a single gaze, the dramatic force of a gesture propulsed by muscle tissue contractions, the

sympathetic rhythmic changes in the heartbeat when listening to someone else's palpitations, the meaningful modifications of brain wave cycles when drifting from relaxation to heightened mental activity; these are nothing but expressive notions of the affective agency of the body. Even though biological media have provided our community with a whole new world of sonic practices to experiment with, we have to remain aware that there is still much to learn and understand; the recoding of the complex patterns and unpredictable textures of human experience into a bundle of organized algorithms, is a rather difficult task, for it puts at stake the true meaning of human expressivity.

Recoding

Interactive music relies on a flowing exchange between a human performer and a computer. As Winkler puts it, “nothing is more interactive than a good conversation”; both parties are engaged, they both share ideas and respond to each other's inputs. A good conversation is usually open ended, yet bounded by an intangible frame of rules and cultural contingencies, that are shared by the participants. It is a delicate balance which can be achieved only by setting a “consistent context” that produces “a feeling of mutual understanding without being predictable” [15]. On the other hand, for Rokeby the computer is “objective and disinterested”, and therefore the interaction (e.g. experience) “should be intimate” [11]. Examples of Human-Computer Interfaces (HCI) that succeed in providing both a mutual context and an intimate experience can be found in the field of biomusic, or in its broader definition, the music generated by neural signals and other electrical impulses produced by the body. The Biomuse [7] is perhaps the best known HCI for biomusic. Thanks to the work of researchers such as Rosenboom [12], Knapp & Lusted [7] and Miranda [9], only to cite a few, biomusic HCI have opened up interesting prospects for the application of emotional mind states to computer music; however, if we consider the bodily interactivity of such instruments, we might notice how sometimes they may overlook the inherent performative qualities of the body. By relying exclusively on the mapping of electrical signals to control data, such tools may incur in what Thacker terms "the computerization of biology". Thacker's argument is crucial in this frame, for it brings to the forefront the assumption that "the biology is a technology" in itself; elaborating further, he describes how "the biological and the digital domains are no longer rendered ontologically distinct", but instead are inherent to each other: "the biological "informs" the digital, just as the digital "corporealizes" the biological" [13].

Biophysical music

Transposing Thacker's notion of biology to the macro-level, it can be argued that the whole body system is a technology; namely, a relentless sound technology: its muscular tissues, nerves and blood vessels produce sounds that retain a meaningful vocabulary of intimate interactions with the performer's neurological and kinetic behaviour. Drawing on this consideration, I advance the thesis that by injecting an understanding of the sonic expressivity of the physio-somatic body system into the computer “tiny playing fields of integrated circuits” [11] the mere computerized instrumentalization of the body can be extended, so to unveil an authentic paradigm of interactive performance; one that places emphasis on the body as a musical and dynamic technology in itself. Such model, which I term *biophysical music*, approaches the body of

What muscle sounds are?

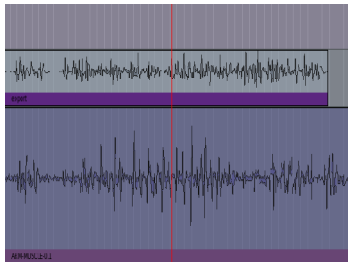

Figure 1. Muscle sounds captured with the Digital Audio Workstation Ardour2.

The mechanical signal which can be observed from the surface of a muscle when it is contracted is called a mechanomyogram (MMG) signal or muscle sound. It is mostly studied in prosthetics and biomedical engineering. At the onset of muscle contraction, significant changes in the muscle shape produce a large peak in the MMG. The oscillations of the muscle's fibres at the resonant frequency of the muscle generate subsequent vibrations causing complex sound waves to arise. The MMG is commonly known also as the phonomyogram, acoustic myogram, sound myogram or vibromyogram.

a performer not only as a controller or interface, but rather as a sound generating force.

The Xth Sense

The XS is a novel, interactive system for the biophysical generation and control of music [4]. It makes use of muscle sounds produced by a performer as both musical material and control data. Presently the XS consists of low-cost, wearable biosensors and a free and open Pure Data (Pd) based application for capture, analysis, real time processing and playback of human muscle sounds. The use of free technologies is an integral part of the research and Pd is my favourite development environment, for its flexibility and capabilities. Pd is a programming language for real time signal processing, and it is developed by a lively and inspiring community.

At the heart of the XS project stands a twofold motivation: to investigate the modalities by which a performer's intimate, corporeal agency can become digitally tangible; to develop a context of rules and algorithms which would enable computers to *sense* the varied nuances of the body potential, and affect the perceptual environment of the player by responding *artfully*.
The central principle underpinning the XS is not to 'interface' the human body with an interactive system, but rather to computationally extend the body inherent capabilities, so to shape an actual and complete musical instrument. Augmented musical instruments and physical computing techniques are generally based on the relation user>controller>system: a player interacts with a control interface, i.e. a physical controller or a sensor array, and modifies the results and or the rules of a computing system. Sometimes this approach can confine and perhaps drive the kinetic expression of a performer, leaving less room for physical energy and non-verbal communication. The XS attempts to transcend the paradigm of the user interface by creating sonic matter and control data directly from the performer's body. There is no mediation between body movements and music, for the raw musical material originates within the fibres of the body, and the sound manipulations are driven by the diverse amount of energy released by the performer. Major advantage of the design of sound and music with MMG audio signals is that of avoiding the uncanny perception of the sound being dissociated from the performer's gesture. The dissociation I point at not only refers to the visual feedback of the performer's actions being disjointed from the sonic experience, but it also, and most importantly, concerns a metaphorical level affecting the listener's interpretation of the sounds generated by the performer's somatic behavior [1].

Embodiment: MFII

Music for Flesh II (MFII)[1] is the first piece of an on-going series of musical performances for the Xth Sense. The work defines a temporary cognitive time-zone in which the physical space of the performance is augmented, stretched, enlightened, obscured, dominated by a real time reconstruction of the human body primal expressiveness. Body is no longer silent, and the embodied interaction which have been kept mute so far, acquires now a further textural layer. A tangible and profound degree of interpretation and representation can be at the same time intimately experienced by the performer, and audibly and visually externalized so to embrace the audience. By enabling a computer to sense and interact with the muscular sonic potential of human tissues, the XS approaches the biological body as a means for computational artistry.

[1] http://marcodonnarumma.com/works/music-for-flesh-ii

During the performance muscle movements and blood flow produce subcutaneous mechanical oscillations, which are nothing but low frequency sound waves. Two custom microphone sensors capture the sonic matter created by my limbs and send it to a computer. This develops an understanding of my kinetic behaviour by "listening" to the friction and palpitations of the flesh. The computer learns about the emergent physiology of my body by extracting discrete and continuous features from the MMG signal; then, it creatively process the sound of my muscular fibres, and eventually diffuse the resulting music through a variable array of loudspeakers. For instance, during the fourth 'movement' of the piece strong and wide contractions repeated for longer than 30 seconds prompt the computer to playback the muscle sound in its purest possible form: that of a deep, low frequency vibration; at the same (logical) time, the machine samples the initial muscle sound, and accordingly to the dynamic features of my physio-somatic behaviour recode the MMG audio sample through granular synthesis, delay lines and pitch transposition; eventually it steadily increases the loudness and density of the processed sound output until my body stands still once again and no sound is produced.[2] The neural and biological signals that drive my actions become analogous expressive matter, for they emerge as a tangible haunting soundscape. The border between physical and virtual body is blurred and dissolved; by harvesting pure kinetic energy from corporeal sounds, incarnated gesture and concrete vibrations, the piece actualizes before the audience eyes a visceral and cognitively challenging territory.

[2] A live recording of MFII that demonstrates this process far better than any textual description can be viewed on-line at http://vimeo.com/20889787

Mediation

The XS and MFII offer a novel and authentic contribution to the discourse on liveness and musical embodiment; however the ultimate challenge remains mediation. Mediation is inevitable when interfacing two different codes (e.g. the musical lexicon and the programming language), and as illustrated above, it is crucial to a discourse on the recoding of biological expressiveness into creative embodiment. A key to successful mediation is transparency. By establishing complex or compound mapping definitions [12] between biological information and algorithmic control data, it is feasible to obtain a good approximation of a determined, expected event of the body technology. Yet, the transcendental expressivity of our biological system can be lost in the dangerous and uncanny desert of monolithic circuits. Computers do not know how to duplicate expressiveness. Although they can 'learn', it is artists' and researchers' responsibility not to let the *affecting* meaningfulness of biological data vanish into the deceptive candor of its own utility.

Final thoughts

Today's paradigms of biomedia [13] and biotechnologies are mature enough to open up new perspectives on the motivation underpinning the connectivity between bodies and machines. In order to escape the mere instrumentalization of the body system, we need to question our practice at a subtler level than we ever did before. Ultimately, it is critical to explore limpid modalities to convert biological expressiveness into computational systems, for a deeper understanding of the endogenous affect of the body has the potential to better shape the socio-technological advance of the future.

Figure 2. Music for Flesh II, interactive music performance for enhanced body (Xth Sense). Live performance by the author at Inspace, Edinburgh, UK, May 2011. Courtesy of Mark Daniels.

Figure 3. The novel Xth Sense biophysical sensors. A low cost, wearable, free and open technology designed and developed by the author. Courtesy of Chris Scott.

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