The place and meaning of *computing* in a sound relationship of man, machines, and environment

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ABSTRACT

The following is a revised version of the text prepared by the author for his keynote speech at the opening session of the International Computer Music Conference 2013 (12.08.2013 Heath Ledger Theatre, State Theatre Centre, Perth, Western Australia). It bears on conceptual changes that have taken place, along the decades, in the shared notion of "computing" as relative to creative practices of sound- and music-making. In particular, the notion of computing is considered vis a vis the relationship, either implicity established or deliberately designed by practitioners, to the (necessarily hybrid) technological infrastructures of their work, as well as to the surrouding physical space where such practices take place. A path is outlined across subsequent connotations of computational tasks and the coupling (or decoupling) of computing resources to the physical environment: from "calculation", to "communication", to "media processing", to "embedded (or physical or tangible) interfaces". The author then illustrates features of a sound installation of his own, where a structural coupling is handled between the acoustics of a room environment and the equipment (the latter including simple computational resources, beside pro- and consumer-level electroaoustic tranducers). The example raises questions as to the potential complexity and richness of creative sound-making emerging when larger and larger sets of data streams - from different sources in the environment - are admitted to, and are coordinated as part of, the computing process. A comprehensive view of the "performance ecosystem" is needed to handle this strong integration of technological layers, and a practice-led account is needed to propertly situate the performer's (and listener's) body in such performative practices.

1. INTRODUCTION

Computing in general, and music computing in particular, are today going through a variety of changes and developments. I'd like to pick some of those that, in my view, are relevant for current sound-making creative practices, particularly in the light of the theme [set to the 2013 ICMC: "international developments in electroacoustics"]. My discussion moves from the very trivial observation that in fact one always needs analog electroacoustic equipment in order to turn digital signals into sound and viceversa. More generally, one always needs resources other than digital in order to make sense of what in the world can be computed - provided there is anything really computable in music-related activities (a problematic question, often debated years ago). However, today the particular manner in which digital technologies are sided by, and integrated in, different but overlapping technological layers, seems to be increasingly significant to practitioners. This is clear from live performance practices where computing devices do not represent something standing on its own, and are rather embedded in a larger "performance ecosystem" (Waters, 2011) where other technogical layers and agencies play an (equally?) important role, whether they are human agencies (performers), mechanical agencies (music instruments and various infrastructures), or devices ranging from basic analog gear to "software ecosystems"[1]. More in general, in this view what counts is the array of looser or tighter relations among the agencies involved in the performance process, as well as their relationship to the physical space where the performance takes place. Significantly, a practice-led account gets increasingly necessary to propertly situate the performer's (and listener's) body in such approaches on musical performance (Green, 2013).

One can ask, then, where does *computing* take place, in such circumstances? What is its place and role within the larger infrastructures that are anyway needed for any computer music to exist, and what is the role of the infrastructure components for any computing to actually take place? I think answers may largely vary depending on what we mean by "computing". Far from being a term of shared meaning, it has taken up different connotations in history.

2. EARLY CONNOTATIONS OF "COMPUTING"

Based on research in information theory and early cybernetics (first half of the 20th century), the computer has existed for decades mainly and foremost as a kind of refined and programmable "calculator", hosted in very peculiar installments mostly closed to the outside world, i.e. in the rather anodyne environment of mainframe computer centres. That was before and after the advent of

[1] The notion of "software ecosystem" has come to mean "networks of mutually coordinated software applications". While it lends itself well to software analysis issues (Lungu, 2009), it remains merely and loosely metaphoric and has raised criticism. Richard Stallman considers it an entirely faulty if dangerous metaphor, because it conveys the view that artifacts - such as human-made networks, and even computer-mediated communities (social networks) - can be as void of implications of "intentionality" and "ethics" as natural ecosystems are (http://www.gnu.org/philosophy/words-to-avoid.en.html).

"commercial computing", which historians date to the years 1945-1955 (Ceruzzi, 2003). In that context, computing was largely connoted in terms of academic research and science (not only in the hard sciences: the "electronic brain" metaphor was quickly adopted in psychology and social sciences). The only exchange between the number-crunching engines and the physical world was through the input/output channels necessary for instructing the machine to execute the requested tasks and for observing the end results of the execution. The transition from mainframe computers to "minicomputers" (1960s) and "personal computers" (late 1970s) preserved the connotation of advanced research and science, but was not without a gradual but substantial shift partly reflecting an ideology of non-academic research - or at least, research freed from investements in mainstream science. With "home computing" (early 1980s), a shift from "calculation" to "communication" became increasingly predominant, due to the ease in the production of documents and in other office-related work activities, beside entertainment tasks (computer games). The shift was complete (1990s) with the coming of age of massive telematic networks and the popularisation of the internet through the world-wide-web built on top of it. By way of its hidden number-crunching, the computer became for most of us a device for homework and personal communication, and eventually a terminal connecting to "social (digital) networks". In other words, it became the "communication terminal" that we have been familar with for the last two decades, and that today gets even more in its way with "cloud computing" and "big data".

New connotations came with more recent developments, though. One is a shift in which devices still called "computers" are less "communication terminals" and more "media management centers" or "media processors" (Manovich, 2001). What is so peculiar in the latter idea is the notion of a kind of overarching media, a generalized instance of hypermedia not aimed so much to tasks of "mediation" but to tasks of "re-mediation" - i.e. the mediation of other media, the processing and re-framing of contents produced in other media, either older or newer ones maybe designed specifically to be re-mediated. Given the overwhelming amount of large-scale applications addressing massive audiences and accessing massive contents ("big data"), I tend to agree with this post-modernistic account of the computer as enabling a reframing and a reenactment of contents belonging to separate media. However, and in contrast to the end-of-history view it is too quickly connected with, I think that we should not consider such a view as reflecting the only and ultimate connotation of what computers may represent for us, at least not until creative, visionary artists and engineers will preserve an attitude of critical thinking about not only what they do *with* their tools, but also about what they do *of* them (and that implies: of themselves artists and engineers). Contrary to a view that describes the current scenario as flattened exclusively on the software level (Manovich, 2013), I deem more relevant today a view of software and digital medias as integrated and rearranged across other technological layers and media that they cannot (re)mediate, and eventually strictly coupled with the physical space. A few years ago I read: "Now that computation's denial of physicality has gone as far as it can, it is time for the reclamation of [physical] space as a computation medium" (Greenwold, 2003).

3. CURRENT CONNOTATIONS AND RESEARCH DIRECTIONS

A relevant connoting potential, today, lays in computing devices known as "microcontrollers", representing increasingly important components of everyday objects and sites, allowing for computation units to get packed in small to smallest circuit boards, with i/o channels connecting to the physical world (sensors, actuators and other transducers reaching into the environment). Sometimes we hear talks of "pervasive computing" or (more interestingly) "physical computing" - usually meaning that aspects of the environment are sensed by computer interfaces and drive ongoing computations which in turn actuate changes in the environment. The dissemination of such computing units across artefacts and throughout the environment creates a network - or should we say a *meshwork?*[2] - of mutually affecting processes and agencies. We are used to hear about "tangible interfaces", or "physical interfaces", described as retaining and manipulating "referents" to real objects and spaces (Papadimatos, 2005), thus offering a sensory richness and a human significance higher than screen-based elements can have (Greenworld, 2003). Addressing the dynamics of "interaction" in contemporary digital music, Bown-Eldridge-McCormack (2009) speak of "behavioural objects".

Such developments are part of an ongoing trend that can be seen as positively disruptive of previously encoded limits of computing. The CEOs of large corporations are imposing the catchwork *the internet of things*, which confirms that the trend will be (is being) foraged to become a potentially massive market[3]. Not surprisingly, occasions of paradoxical triumphalism are not missing: as far as music making and acoustic communications are concerning, there is a risk to obscure more important cognitive and experiential phenomena involved in auditory experience and listening - I can't say whether it is "promise" or "threat" when a guru of physical computing

[2] According to anthropologist Tim Ingold, by insistingly speaking of "networks", we end up experiencing the world in terms of a grid of "interconnected points", although the lived experience of our multifaceted relationship to the world is, in his terms, more like "interwoven lines" (Ingold, 2011: 63 and 70). In other words, the "lines" (how we move from one point to another, how we walk between end-points) are more central in our dwelling in the world: a metaphor of finely-threaded lines - such as the "meshwork" - should be preferred.

[3] In these days [summer 2013], Intel corporation is making agreements with the Arduino microcontroller makers to release Galileo, a small-size "Arduino-friendly" board designed to lead innovative "embedded interactive" designs. The project is announced to accept the open-source attitude of Arduino ("we will learn from you", said the Intel chief executive to Arduino's father, Massimo Banzi, as they announced the collaboration; see http://www.wired.co.uk/news/archive/2013-10/03/intel-arduino-galileo). This move could also be seen as aimed to rival the popular Raspberry Pi, incidentally a microcontroller device currently popular among computer music research projects (see various contributions to the ICMC 2013).

shows us, in a popular cookbook, how to "create talking objects from anything" using "computers of all shapes and sizes" (Igoe, 2007). Will we survive a saturated acoustic semiosphere, where *anything* can *talk* to us? And more to the point: what do we make *of* "talking", along the way?

Among interesting creative efforts of "audio physical computing", I'd like to mention the work of Andrea Valle, whose real-time "acoustic computer music" is made "by computational means, but in which sounds are generated from acoustic bodies" (Valle, 2011). Some of his experimental projects present hybrid performance infrastructures, where acoustic or force feedback occurs across different technologies (Valle & Sanfilippo, 2013). In a different but related perspective, of relevance is research work undertaken under the umbrella-definition of "mechanical sound synthesis" (Berdahl-Smith-Niemeyer, 2008 and 2010). Of course, the latter perspective follows from elaborate physical modeling approaches, often targeted at "virtual" or "augmented reality" technologies. However, in such approaches I also see a potential for a stronger and more widely shared ecologically and physically ingrained awareness of what sound is and how we deal with it as human beings. In my personal view, questions and goals of "virtual reality" are today both scientifically and artistically less fruitful than a higher awareness of real-world, situated and embodied perception and action.

4. STRUCTURAL COUPLING AND POSITION RELATIVE TO THE ENVIRONMENT

Our admittedly too short survey, then, ends up with four subsequent - but often overlapping - connotations of computing: "calculation", "communication", "media processing", "embedded (or physical) interfaces". We can observe a *displacement* of computing devices as relative to the specific context where they are set to work. Of course, with the move from mainframe computer rooms to wearable microcontrollers, a lot has changed. But for the purposes of my discussion, let's keep to the following two points:

(1) *The potential complexity and richness in creative designs and projects increases as a larger and larger set of data streams (coming from different sources in the environment) is admitted to, and is coordinated to be part of, the computing process.* Digital computing is of course done in digital devices, according to no matter what algorithms and programming style, but the array of connections-to and dependencies-on non-digital signals and non-software events gets today so large as to make it difficult to consider these latter as mere "input data", as something "external" that gets fed into and independent number-crunching process. What we see, here, is a gradual approach to a style of computation that does not so much take an input *from* the environment as it is rather coupled *with* the environment. We can describe this process at a meta-level, as a "structural coupling" of so-called internal computations and so-called external physical conditions. In such a situation, computing becomes neither an entirely deterministic process, nor an indeterministic one, but a driving active part of a larger complex system. It yields less into "resultant" output data, and more into "emergent" patterns or behaviours.

(2) *As the relationship of the computing equipment and the surrounding environment changes, so does our position in the environment as relative to the computing equipment* (it happens not by chance that, more and more often, people using computers in their music performances prefer not to stand or sit before the computer screen, and to rather focus on other centers of attention and activities). In my admittedly too compact survey, "computer musicians" started by standing or sitting *inside* mainframe computer installments (figure 1), where all that occurred used to occur in the form of coded instructions coming and going across i/o channels (e.g. punch cards), accurately delivered in symbolic form by highly specialised personnel. We ended, first, by sitting *before* the computer - or its monitor screen (figure 2). And we ended, later on, by moving around the room and across the streets, with networked computing, microcontroller interfaces, "cloud computing", etc. (figure 3). In other words, musicians using computer resources moved literally from within an environment made of computer hardware parts (where computing literally *environs* us, surrounds and envelopes us) to an environment hosting one ore more computer stations, and finally to an environment where computing units spread all around, absorbed into at least some of the several things and surfaces making up the environment itself.

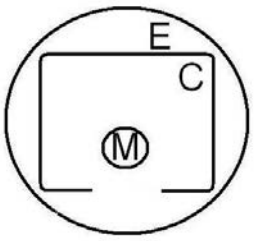

Figure 1. Here and below **E** stands for Environment, **C** for Computer, **M** for huMan being(s)

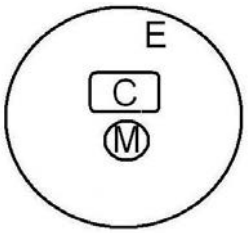

Figure 2.

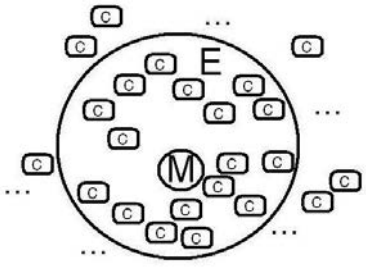

Figure 3.

Some words are necessary, at this point, concerning the notion of "environment", as I left it rather undetermined so far. Following the ecological and biological sciences, we should consider "environment" not the generic surrouding physical space, but a segment or selection of forces and agencies in that space which are meaningful to

the functionality of the system under consideration[4]. The environment is the particular section or niche in the physical world which "unfolds in relation" to the living beings inhabiting that niche (Ingold, 2011: 77).

Because human beings are able to shape their environment, they seem to be setting for themselves environments having calculative capabilities. On the other hand, what counts as "environment" for devices such as microcontrollers and computer interfaces is a set of few selected features or properties in the physical space (the "home" of "home computers", for example, is an "environment" to us, not to the computer, although clearly some functionalities expected of any "home" are necessary for a computer to work). By purposefully specifying the features in the physical space that are sensed and acted upon by our computer interfaces, we specify what counts as environment to these devices. By purposefully specifying the possible interactions between devices in the environment (figure 4), we are defining a potential "ecosystem", a web of interacting forces whose global behaviour is brought about by local exchanges of energy (sound) and information (environment traces taken on and carried by sound)[5].

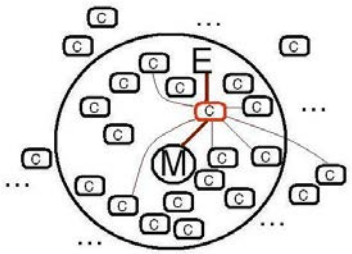

Figure 4.

That brings us in a position where, I think, we can better tackle questions posed at the beginning [of this talk]. However, before we go back there, I'd like to shortly illustrate a work of mine that probably reflect (albeit in a very personal manner) some of the issues we are dealing with.

5. AN EXAMPLE FROM MY OWN WORK

Condotte pubbliche (public conducts) is an "ecosystemic sound construction". As illustrated in figure 5, small microphones and common earpieces ("small speakers") are placed within two brass pipes (resonators), which firmly lay on two standard near-field speakers sitting on ground. A condenser microphone hangs from above. A piezo disc lays on the floor (if the floor surface is in wood).

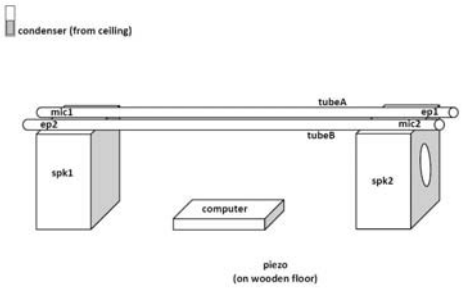

Figure 5. *Condotte Pubbliche.*
Schematics of technical the setup.

All trasducers are connected among them via an audio interface and signal processing software (figure 6). The whole design creates a multiple feedback delay network. The setup is fed with room noise or any other event of sound travelling through the room. Sounds are born of the local feedback conditions (inside the pipes and in the surrounding room) only based on the energy source of background noise. Simple processing methods were devised to dynamically adjust the gain level and to drive simple signal processing transformations based on properties of (or "information" about, if you prefer) the total sound in the room. This is made by real-time signal descriptors drive the signal processing algorithms, in a sort of adaptive and self-regulating manner. Because the room sound also includes - beside the background noise and all accidental sounds the visitors make - the sound delivered by the setup itself, in actuality no clear distincton can be made between the "system's own" voice and the ambience sound in the room. We have to speak of a larger unit that by definition includes the acoustic space in its process. The process dynamics will be affected by all sound-related components involved, not just by the computer processing: everything that can effectively generate, filter, and channel sound has some influence on the flow of emergent sonorities. I call the approach "ecosystemic" in the sense that my efforts as a composer and/or performer (as well as the efforts of other performers possibly involved) are necessarily directed to both the "system" (gathering of objects and functions) and its "oikos" (the host space), and more particularly to their permanent exchange and relationship - their "structural coupling". What is obtained is an unattended process in which *everything that counts as environment is connected to every other thing in the medium of sound only*. The task of composition becomes not so much one of "interactive composing", but one of "composing the interactions" (Di

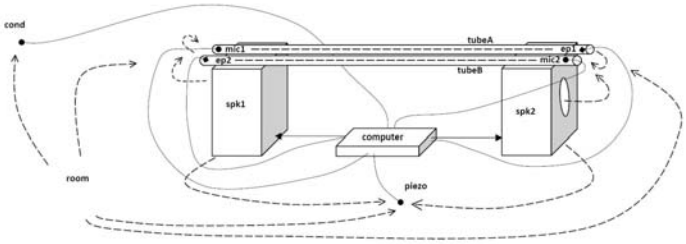

Figure 6. *Condotte Pubbliche.*
Schematics of acoustic connections (dashed lines) and the electroacoustic (bold lines) connections.

[4] This was made clear, even before Gibson's *ecological approach on perception* (Gibson, 1979), in pioneering research by Jacob von Uexkull in the 1930s, with his notion of *Umwelt* (1992).

[5] We usually conceptualize our bodily perception of the world as a matter of poking information in the environment (so we may turn it into a task of "information processing" - as in various styles of reductionistic cognitive science). However, what we call "information" is not *of* the environment: the environment does not exist prior to any "information", otherwise we could not define what counts as environment in the physical space. Information is our inferences build upon data gathered by sense descriptors (system terminals). In fact, "the environment contains no information; the environment is as it is" (von Foerster, 1972: 6).

Scipio, 2003; Anderson, 2005). In daily practice, the task involves designing and testing the specific technical infrastructure, crafting and checking the software in possibly realistic performance conditions, studying how the component parts affect each others, etc.

In principle, human performers are only an optional part of the performance process: the process should be able to unfold by regulating its own behaviour, non-supervised, like an autonomous (i.e. literally: self-organizing) systemic unity. Notice that, for this to happen, the system loops back onto itself *through* the environment: we can say that some kind of "autonomy" (systemic closure) can only be achieved thanks to a continuing openess and some degree of "heteronomy" (systemic openess). When human performers enter the loop structure, they either act on the electroacoustic setup and the computer, or contribute to the total sound in the performance space. In the latter case, they still act on the computer but only indirectly, through the room sound, while at the same time the room sound, hence the computer sound too, affect the performer's own actions. Hence, in actuality the computer acts onto itself through the performer. Or, if you prefer, the performer acts onto itself through the environment and the computer. It's a matter of where you start reading the process. In any case, performers will find themselves in a situation where they have to permanently negotiate their freedom of action with the global behaviour of the autonomous ecosystemic process.

Figure 7 is a close-up snapshot of the *Condotte pubbliche* installation. Here you see a dark blanket hiding the speakers and the computer equipment beneath. The function of the blanket, however, is also one of causing diffractions in the sound waves transferring from the two speakers into the pipes and the microphones sitting in the pipes. Everthing in the piece has a sound-related function.

This work was born as an installation project. However, I eventually devised ways to use it in performative contexts. Indeed, a performer can look for places or surfaces in the total infrastructure that lend themselves to be efficiently acted upon, searching the affordances that allow for possible gestures and for actions enabling her/him to enter the sonic process and to affect it, to some extent. That turns the "installation" into a kind of "instrument", or better a sound generating device that includes the environment as a part of it - the same environment where the performer acts as part of the sound generation process. The form of presentation becomes uncertain: is it *installation* or *performance*? Or is it an *instrument* that one can play with? This is a kind of ambiguity that, in past decades, has characterized the work of illustrious pioneers (a.o. Alvin Lucier and David Tudor, of course). Is the artistic content in the sound atmosphere the work creates, or is it in the process running? I tend to say it's in the process, but I will leave the question there.

In the opening night of a 2011 Berlin exhibit, Gianni Trovalusci, a flutist friend, enter the room and "perform the installation", acting close to the pipe ends or right against them, using either mouth or hands, exploring the sound behaviours - emergent behaviour that would have not been there, had the work been let to run on itself as an independent installation. When performers are involved in pieces such as this one, their role becomes a peculiar

Figure 7. Partial view of *Condotte Pubbliche* (Galerie Mario Mazzoli, Potzdamer Strasse, Berlin, March-May 2011).

one. As I was suggesting above, it becomes a question of taking part in a situation largely overriding ones' own specific, wanted actions. What a performer does, here, is not "interacting with a computer", and it is certainly not aiming to achive a specific "output sound". S/he is part of a whole network, made of mechanical, analog and digital components. Each component leaves its own trails behind, that might become audible or remain silent. In a sense, the performer becomes a part of what counts as environment to the technology: s/he represents another source of sound and of control, another agency, surely a particularly sensible and intelligent one, but also a fragile one. S/he cannot direct or lead, save by forcing the process to go adrift or to fix into a constant, invariable state of operations (that is the same as bringing the process to an end). Each move is captured in a continuous flow of mutually affecting events, in an "ecology of actions" (to use a definition by epistemologist Edgar Morin). That makes it difficult if not impossible to clearly foresee, or forehear, the consequences of actions taken. It makes it difficult to hear what is the very source of this or that sound event, as the particular causes of each event of sound may be so deeply spread across the history of previous and current sonic interactions to be completely blurred (a token of "distributed causation", as it seems). The performative experience becomes one of listening and taking action, as well as one of keeping and loosing control. In today's overly digitalized world, this taking and loosing of control is significant, in my mind at least, of issues of subjectivity and intersubjectivity, of identity and transformation, of self and non-self, issues that are the flesh and bones of our daily life. Yet, in the actual proceedings of the performance, such dynamics are not at all metaphorical: they are something happening in sound, in real-time, in real-space. The "instrument" and the environment change upon actions of the performers. Performers (and listeners as well) engage in understanding their presence and their action as relative to the presence and the actions of the autonomous process. What is there to be heard, with this kind of work, consists mostly of the audible traces left behind by the dynamical relationship of performer/equipment/room acoustics. In a way, that rede-

fines music as the audible emergent properties of the man/technology/environment recursive relationship.

6. Back to "computing" (conclusions)

What is the place of computing in *Condotte Pubbliche*? Precisely where computing is taking place, in similar works? Sure, we have a very important software component, executing (on a standard notebook) a variety of digital signal processing algorithms (implemented with Pure Data or Kyma). All that cannot be set aside nor replaced by other technologies. However, this software component alone can hardly account for the kind of sonorities and the long term articulation, either textural or gestural, emerging from the total ecosystemic process. It's rather the tight but dynamical interconnections of the component parts in the whole unit, that bring it forth. We have a small infrastructure of interlaced technological layers, each contributing to the entire process in its own way. For example, the earpieces (with their limited frequency and dynamics responses) and the pipes (with their specific acoustics) are surely responsible for characteristic spectral colorations. The nuances in dynamics also depend on the room size and the microphones sensitivity. Beside, to sonically exist, the piece needs a real space, possibly a room not meant to be just occupied, but to be inhabited, an area of entanglement of different process trails and different sound traces that might work as "environment" to the work. It needs the background noise, or any other acoustic perturbation in the room. In this regard, *Condotte Pubbliche* gets close to one of my *Audible Ecosystemics,* the 2005 live electronics solo performance *Background Noise Study* (Meric, 2008; Di Scipio, 2011)[6].

So, what is the place of computing resources in music-making practices where computer processing is coupled to the environment via overlapping, hybrid technical infrastructures? What is its role, once computational activities are heterogeneusly and heteronomically driven? I see a possible connection, here, to a much larger view once put forth by cybernetic pioneer Heinz von Foerster, who used to explain the Latin term "computare" as meaning "to consider or to contemplate things together" (von Foerster, 1973): computing is handling the mutual relationships. Today, with our ubiquitous microcontrollers and apps, computing is less "information processing" and more "coordinating agencies in their mutual exchanges (of energy and information)". I can easily admit that this is all very general and too broad. However, if I may dare referring to von Foerster, it's because, in the end, "composition" itself means "putting things together (Latin "componere", Greek "synthesis"). In current creative explorations where computing units are interfaced with non-digital devices in an overriding ecosystemic dynamics, computing can be said to take place across the tripolar, recursive relationship of equipment, environments, and human beings. The relationship is "recursive" in the sense that it consists in such a dense vector of mutual influences among component parts, that it's impossible to separate "input" and "output", "cause" and "effect". Here computing is no more the implementation of i/o functions, because all output is an input too (and viceversa): all effect is a cause too (and viceversa).

In the way I am using it here, the adjective "recursive" should also suggest that, at any time, the current system state is the achievement brought about throughout the *history* of all previous states, the trace of all past interactions among components: the ecosystem always operates in the here-and-now, but among the conditions to its current operations we should count the continuing exchanges with the environment, the outcome of the entire sequel of past exchanges and interactions. It a flux, in a line of events, not in a step-wise process (the software component of the work includes no symbolic representaton of time and time-related events). In that sense, once set on the run, the man-machine-environment relationship unfolds in time as a kind of *narrative* reflecting the actualization of past events in the configuration of the present. Beside, the emergence of what is heard, binds the potential of further emergent patterns, and submerges the possibility of what could have been. In that sense, the process may reveal orientations and directions.

In research interdisciplinary work, at the border between computer science, phylosophy and in post-computational cognitive science (Varela-Thompson-Rosch, 1991; Flores and Winograd, 1987), such a process is considered typical of living systems, i.e. systems whose activity is largely devoted to mantain and transform themselves by way of a permanent flow of exchanges with the segment of physical space that counts as environment. There, "computing" is equalled to "cognizing" (following earlier work by von Foerster and others), and becomes a question of lived stories feeding back and forth across and through layers of different physical substances - none of which is digital, except perhaps for the threshold logics of the single neuron!

If we regard music as audible phenomena emerging from man-machine-environment recursive relationships, then the place of computing is nowhere and everywhere along the trails and paths: music computing lays in the way things are connected and junctioned among them more than in what is connected and junctioned, in the lines more than in the nodes, in the way by which we set to reach into the environment.

Acknowledgments

Thanks to Cat Hope and her colleagues at Edith Cowan University, Perth, for their kind invitation to the ICMC 2013. Thanks to Scott Miller for early revision of the present text.

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[6] The DSP methods involved in the *Audible Ecosystemic* series of work (2002-2005) are more demanding and computationally expensive in comparison with *Condotte Pubbliche*. I have developed them on the Kyma workstation, which includes its own dedicated number-crunching hardware.

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