CREATIVITY, EDUCATION AND TECHNOLOGY.
METIS, AN INTERFACE FOR THE DYNAMIC EDUCATIONAL PARADIGM

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ABSTRACT

This paper focuses the topic of new interfaces from an educational point of view, under the light of the Dynamic Educational Paradigm. We analyze the experience of Metis, a Tangible User Interface created bt the NUME Group and presented at the last Festival of Science in Genova – Workshop “Orizzonti Sonori”.

1. THE DYNAMIC EDUCATIONAL PARADIGM

1.1 Static and dynamic educational paradigms

The difference between the Dynamic Educational Paradigm and the “static” one lies in the different configuration of the relationship binding the teacher, the boy and the knowledge. Whilst the static paradigm states that knowledge is a block of notions, estabilshed once and for all, the teacher doesn't have but verify the amount the boy has been able to memorize and output, the dynamic paradigm proposes a fluider concept of knowledge, as something that must interact with the boy's own culture (the static paradigm considers boys as tabula rasa: if they exhbit any kind of culture, it considers it as a low rank culture and works to eradicate it ny means of skeptical or derisive opinions). The aspect of the Dynamic Paradigm we are more interested in is that focusing the practise of creatvity as a fundamental step to introject and originally elaborate knowledge and transform notions into processes – whereas the static paradigm proposes the model of Masterworks and Classics as something it's better not to compete against. Our fundative statement is that “music can be an instrument of study, not only the simple study of an instrument”; since we think that languages and sounds of electronic and digital contemporarity are particularly suitable in such educational frame (as it happens for graphical and visual arts), the first issue we had to resolve was how to make sound synthesis, realtime elaboration and “concrete” sounds manipulation immediately available for boys without the need of mastering complex softwares and techniques[1].

1.2 Education and contemporary musical languages

As for graphics and painting, we believe that creative experiences with sound and music should be accessible to young students regardless of their musical skills. This is not the place to discuss the theme of contemporary music and education. Here we point up the necessity of an extension of aesthetic horizon beyond the edges of traditional musical pedagogy: the goal is to make any sound interesting as an aesthetic object and as a potential element of a musical construction.

2. WHY NEW INTERFACES?

The need of musical intefaces for education arises as soon as the exploration of different sounds and musical structures approaches the field of electronic music. Whereas traditional instruments (and the musical languages they traditionally convey) find their place in the music classroom, tools for production of synthetic sounds (or elaboration of existing ones) could hardly be used effectively by the music teacher in his classroom.

On the other hand, electronic keyboards and synthesizers controlled by means of MIDI devices, as far as sophisticated and rich of sound libraries, shouldn't be considered as something different from a traditional instrument, for several reasons. Though they're endowed with digital state-of-the-art technologies, their refer to the same musical universe as traditional instruments, never exceeding the boundaries of tonal music. (Unfortunately, forcing the twelve-tones frame of controllers – or at least changing its default sound parameters – requires too advanced skills to be useful in an educational context). We shouldn't lose sight of the cultural and linguistic side of the issue: if we want to make the sound a fertile field for creative exploration, it is crucial to go beyond the tonal horizon, not for an ideological stance. The tonal approach considers making music something radically different than making sound, being the latter simply a shapeless material for the former. From a dynamic point of view, there's no reason to exclude sound manipulation from the exploration of musical expression. In summary, we want

[1]For details about static and dynamic educational paradigm, see C. Delfrati, *Fondamenti di pedagogia musicale,* Torino, EDT 2008, pages 14-127.

all sounds for our palette, and we want suitable tools to manage them without being sound engineers.

We don't expect that every pupil become a new Risset or a new Chowning. In consonance with the dynamic educational paradigm, we expect that a creative approach to sounds and music could help the pupil to learn to observe, find solutions, express feelings, think and find his/her own paths.

3. BEYOND THE MOUSE

3.1 Pars destruens

A thorough analysis of didactic needs can produce substantial improvements in the design of software inrerface. However, they share a limit: the mediation of a "weak gesture" as that of moving the mouse on the screen as the only access to controls. (We call mouse actions a "weak gesture" because it is identical for radically different tasks and functions, so that it says nothing about what it is actually doing). If the interface is a simulation of a real action on some kind of hardware (e. g. a mixing console or a musical instrument or a flipper), this weakness can be partially balanced with the strength of the visual identity between real objects and the interface depicting them. In this case, the image on the screen of the laptop drives the mechanism of affordances. But what about tasks and processes with no counterpart in the real world? In this case, neither the inteface can rely on the experience of the user nor the system [mouse+ graphical interface] suggests behaviors for that specific task – unless a strong metaphor surrogates provides such suggestions. In a few words, it is not meaningful enough for a young boy exploring resources of sound. As far as such resources can be rich, the gestural key to access them is poor (mouse clicks and mouse dragging) and shared with procedures that have nothing to do with sound and music.

So are mouse and graphical interfaces no longer suitable tools for electronic music? Of course, our arguments should be placed in a dynamic-educational perspective. The cognitive, social and affective development of the young boy are the centre of the didactic action; sound and music are only instruments to achieve them.

3.2 Warning against magical sound boxes

If a mouse-based system is a sort of zero-degree of interfaces (after Barthes' definition), does it exist the best possible interface (for educational tasks)? Theoretically, we can select the ideal solution in a wide range of possibilities: wearable interfaces, exo-skeletons, visual interfaces, sensor-based insterfaces, motion capture systems and so on. In practice, there are two limits we have to deal with. The first is the limited budget. The second is less prosaic and concerns a risk intrinsic to too complex and fascinating toys. In fact, what we pursue is equilibrium between action and sonic counterpart. In an ideal condition, action and its sonic result build their sense reciprocally; moreover, after a necessary phase of random exploration, the user should become aware of the cause and effect relationship between his action and what he listens to so that he be able to foresee the result of a gesture before he makes it, and project structures and sequences knowing exactly what are the gestures he has to make to get them. If the interface is too complex, with dozens of sensors, if any intentional or unintentional gestures have an unpredictable sonic result, the user will act as a simple gear of a fascinating sound box without a projectual space, gliding from a creative to a re-creative paradigm. What we need is a tool by which the young user can always infer a connection between action and sound and thereby plan his own path

3.3 Pars construens

So, when we actually had to realize an interface for the workshop "Orizzonti sonori" [Sonic Horizons] (Genova, Festival della scienza, ed. 2010), we had two risks to avoid. The first was that we had already defined as the "magical sound box", an expensive toy with many hardware controls capable of producing impredictable sounds. On the opposite edge, there was the risk of making a general-purpose machine with generic controls, not very different from a sort of "augmented mouse" as to the theoretical issues it would have produced. We needed an interface capable to re-design itself in accordance with the requirements of any specific application. In addition, it had to allow collaborative experiences. That's why we finally opted for a visual interface, clearly distinguishing the hardware frame from its software library of applications.

3.4 Designing the applications library.

The design of the application library was crucial for our didactic goals. Indeed, the library should describe a sort of open path, exploring the different aspects of sound and music. Within the library, each application makes sense only in connection with the others. But what is the criterion by which we ought to classify the library and its sections? Starting from the simplest sound's structure up to musical complex structures we can set different levels of pertinence, as shown in the following table:

field (pertinence)	**Process (examples)**
sound	Synthesizing a single sound modifying it by varying one parameter on a simple sound generator (e.g. one oscillator or one filtered noise generator)
sound	Synthesizeng a single sound modifying it by varying multiple parameters on a simple sound generator.
timbre	Synthesizing a single sound with basic

	synthesis techniques (additive synthesis, filtering, modulation) varying one parameter
timbre	Synthesizing a single sound with basic synthesis techniques (additive synthesis, filtering, modulation) varying multiple-parameter
sound	Modifying a single existing sound by varying a single basic parameter (pitch, speed)
sound	Modifying a single existing sound by varying multiple basic parameters
timbre	Modifying a single existing sound by applying simple basic algorithms (modulations, filtering, delay-based processes)
composition	Synthesizing multiple sounds and modifying multiple existing sounds using one of the techniques described so far
composition	Synthesizing multiple sounds and modifying multiple existing sounds by combining the previous techniques.
composition	Composing simple structures by varying internal relative parameters (e.g. a pair of impulse trains varying their frequency and, consequently, the overall rhythm of the object,
composition	as above, but applying modification to timbres
composition	creating structures of structures
composition	combining all the previous levels

Table 1. Synthesis/elaboration applications typology

Though only the last levels are labelled with the word "composition", creative exploration can take place since the first level. As Gurevich, Stepleton and Marquez-Borbon demonstrate[1], personal style and creative strategies can appear even in contexts of extreme constraint. So, if the interface is sensitive enough to take trace of improvised movements, also a simple filter applied to a white noise can result in meaningful musical streams. Of course, we are not interested in teaching sound synthesis to young pupils. What we pursue is eliciting personal choice in exploring and composing

Along with the main path described in the table above, a wide range of "musical games" can be implemented for specific tasks:

orchestration applications (here we intend "orchesration" as assembly of multiple layers of existing sounds differing by timbre but omogeneous as to articulation; they can be traditional melodies as well as synthetic textures;
figure / ground applications (similar to the previous type, but using sonic objects with different rythnical and articulative features)
behavior-based composition applications (compositional structures take shape by setting and varying high-level parameters as density, register, articulation etc.)
aggregation / segregation applications (referred to Auditory Scene Analysis conceptual frame[2])
sonic landscape applications (something similar to a. and b. applications, but using sounds with strong semantic values)
musical games based on specific algorithms. Such applications, less suitable for educational tasks, are developed mostly for exhibits and demonstrations.

Table 2. Other applications typology, based on the description of the main process or model.

Such variety of tasks and paths couldn't be obtained but using a modular system. In turn, it couldn't be but a software system[3].

4. THE METIS INTERFACE

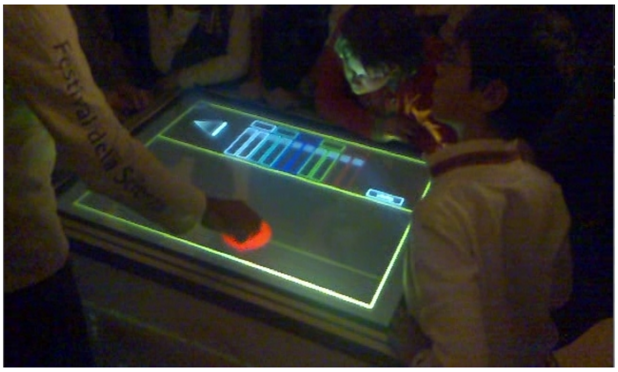

Figure 1. The Metis at the Orizzonti Sonori workshop.

4.1 Hardware and software specifications

Metis is a multi-touch with fiducial tracking device built within an aluminum box which measures 900mm width x 675mm length x 850mm height. The technology used is

[1]Michael Gurevich, Paul Stapleton and Adnan Marquez-Borbon, *Style and Constraint in Electronic Musical Instruments,* Proceedings of the 2010 Conference on New Interfaces for Musical Expression (NIME 2010), Sydney, Australia

[2]See A. S. Bregman, *Auditory Scene Analysis*, MIT Press, Cambridge MA, 1990

[3]The software solution must be considered, theoretically speaking, a second choice. The best tool would be a modular hardware controller – we could call it a meta-controller. Each should provide a user tutorial for assembling the desired interface for each application.

DSI (Diffused Surface Illumination) with retro-projection. The front panel is based on a 10mm diffusing plexiglas Endlighten layer lit by a 850nm infrared LED array and shot by a firewire camera equipped with wide-angle optics. For finger and fiducial tracking, Reactivision software has been used, while interface applications have been developed in Java within the MT4J (Multitouch for Java) framework. The communication among tracking, interface and sound synthesis applications has been based on TUIO-OSC protocol. All audio applications have been developed on MaxMSP platform. For testing applications the TUIO Simulator has been used until the hardware was completed. Metis has been accomplished in collaboration with the Conservatory "A. Casella" of L'Aquila – Dept. of Music and New Technologies.

4.2 Controls and actions

The MT4J framework provides several objects and multi-touch functions, as well as graphical shapes (lines, polygons) for the design of interface. We used:

Actions	**Mouse functions**: click and hold (simulating the double click); dragging.
	Resizing: applied to geometric shapes.
Controls	**Shapes:** resizable circles and hexagons with variable alpha; lines. They are usual icons to represent single objects (playing files or synthesis modules)
	Sliders and knobs: different layouts are available to distiguish functions. Used for parameters varying continuously.
	Toggles: on/off switches for activating/deactivating processess or enabling signal lines
	Popup menu: for selecting sound sources or route signals to labelled processes

Table 3. Actions and controls

4.3 Fiducials

The Reactivision tracking software (http://reactivision.sourceforge.net/) is well-known. It provides univocal optical recognizing of 256 shapes moving on the surface of the interface. This results in a great advantage for designing didactic application. First, manipulating solid objects is much more meaningful *in itself* for young boys than simply operating on the touch-screen. Though a system based exclusively on multi-touch function requires slightly different settings of the tracking parameters than a fiducial-based one, an integration between the two system is the most desirable for designing didactic applications. Second, being fiducials simple graphical labels to be applied on the flat surface sliding on the screen, the solid objects they are glued to can have any shape and dimension required by a specific application. The support we chose for labels with depicted fiducials is a disk of plexiglass with diameter of about 8cm and thickness of about 1cm.

Figure 2. Playing the Metis

4.4 Applications

Five applications have been developed for the workshop Orizzonti Sonori.

The first one (*Sonagli*) consists of a set of eight synthesis modules represented by as many fiducial-disks depicting the same icon. A ninth disk works as a controller for overall parameters of the synthesis modules. Each module consists of two impulse trains whose frequency (sub-audio) are inversely proportional and generate rythmical configurations. The impulses are filtered by a bandpass filter. Rotating disks changes the ratio between frequencies of the two impulses (the slower is the first, the fastest is the second, and vice-versa). The X position of the disk determines the position of the sound of the single module in the stereo front; the Y position sets the amount of frequency shifting applied to the output of the filter. Modules are activated by simply putting the disk on the Metis surface. The ninth disk sets the Q for all the resonant filters, hereby explaining the name of the application. (Changing the Q of all the filters at the same time sounds as if a set of rattles could change smothlessly the material they are made of, becoming castanets, bells, etc.). A second application (*Contrappunti*) consisted in a generator of four parts counterpoints by means of randomical sequences. The user can change the timbre (a simple FM algorithm), the modal scale from which notes are drawn out and the "species" of the counterpoint (actually, the variance of durations of each note in the binary suddivision-tree of the whole. The interface of *Sonagli* is visible in Figure 1.

A third application (*Frullatori*) applied speed variation and reverse to a file selected whitin a list of different sound sources (spoken and singing voices and instruments). After this first step of elaboration, controlled by means of a single fiducial-disk, five pairs of sliders on screen controlled the parameters of five complex algorithms.

The fourth application (*Melodie/Sfondi* [Melodies/Backrounds]) is a sample of what we have called either an “orchestration” application or a “figure / ground” one.

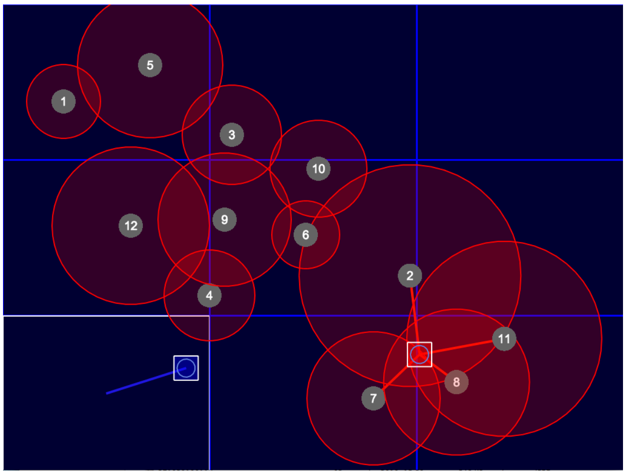

Figure 3. Melodie / Sfondi. The user interface

Each circle represents an instrument performing the same melody, perfectly synchronized with the others. Approaching the centre of a circle with the red cursor causes an increase of the level of the instrument it represents. Intersections of multiple circles result in a stratification of instrumental timbres whose levels depend on their position whitin each circle. Circles are movable and resizable. The nine rectangles represent a background. As for circles, the nearer is the cursor to the centre of the rectangle, the louder is its output. Putting the red cursor ouside any circle result in silence; likewise, putting the blue cursor on the intersection of vertical and horizontal lines mutes all backgrounds.

A last application (*Merli* [Blackbirds]) consisted of eight modules of analysis and resynthesis producing a sound very similar to the singing of blackbirds, with slight differences in settings of parameters. Each module was placed in a specific position of the stereo front. This application, whose interface was very similar to that of *Melodie/Sfondi,* can be considered as a simple musical game.

4.5 The Workshop “Orizzonti Sonori”

A few words should be spent to describe the workshop Orizzonti Sonori (Genova, Palazzo della Borsa, October 29^{th} – November 5^{th} 2010), where Metis has been presented for the first time. The workshop, organized by the CNR of Modena and the Physics Department of the University of Trento, was a didactic path through different exhibits, each one showing an experiment of acoustics (amongst others, a stroboscope, a waveguide, a vibrating surface revealing nodes at different frequencies by sprinkling sand on it etc.) . Metis was at the end of the path. The workshop has been visited by groups of pupils from 8 to 16 years old.

5. CONCLUSIONS

The next step is providing Metis of an appropriate library of applications, being the five described above just samples, for more, oriented to exhibits more than to real didactic paths. Moreover, some improvements are necessary to resolve the issue of the glare diffused on the surface caused by the projector. In the ideal “classroom” configuration, more Metis should be networked and interact.

Acknowledgments

Material and hardware of Metis were purchased with funds provided by the Conservatory “Alfredo Casella” of L'Aquila.