INTERACTIVE MUSIC SYSTEMS FOR EVERYONE: EXPLORING VISUAL FEEDBACK AS A WAY FOR CREATING MORE INTUITIVE, EFFICIENT AND LEARNABLE INSTRUMENTS

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ABSTRACT

New digital musical instruments designed for professional and trained musicians can be quite complex and challenging, offering as a counterpart a great amount of creative freedom and control possibilities to their players. On the other hand, instruments designed for amateur musicians or for audiences in interactive sound installations, tend to be quite simple, often trying to bring the illusion of control and interaction to their users, while still producing 'satisfactory' outputs. Logically, these two classes of instruments are often mutually exclusive. But wouldn't it be possible to design instruments that can appeal to both sectors? In this paper we will show, with two projects developed in our research group, how visual feedback can highly increase the intuitiveness of an interactive music system, making complex principles understandable.

1. INTRODUCTION

1.1. Music Instruments: Questions

What is a *good* music instrument? Are there instruments better than others? These are tricky questions. Obviously, some instruments are more powerful, flexible or versatile than others, but there are so many dimensions by which a musical instrument can be evaluated, that comparisons between most instruments do not make sense, unless we clearly specified the parameters involved in the evaluation. Parameters such as degrees of freedom of control, correlation between these controls, difficulty of use, apprenticeship and learning curve scalability,… are parameters that deal with the use of an instrument, that is with the relation between the instrument and its player. Sonic richness and variability, both at a macro level (e.g. dynamic range, tessitura…) and nuances at a micro level (e.g. pitch "resolution", portamento, vibrato and other modulation capabilities…), deal more directly with the output possibilities of the instrument.

Other measurable dimensions could be the instrument's temporal precision, its responsiveness, or its control reproducibility and variability. For example: how similar can two performances be? How predictable are the outputs of small control changes? Some instruments behave definitely less linear than others. How could we evaluate the potential expressiveness of an instrument? Can expressiveness only be studied from a cultural viewpoint or is there an absolute way to evaluate it? Would it possibly be, in that case, related to non-linearity?

1.2. Music Instruments: Possible Taxonomies

Too many dimensions and far too many questions to be seriously discussed within the scope of these pages. Many authors have addressed classifications and taxonomies, both for traditional and new music instruments, based on several of their properties. Joseph Paradiso's exhaustive classification of new electronic instruments [1] can hardly be surpassed, but his article is more written from the *techno-luthier*'s viewpoint that from the player´s or from the listener's one. Gabriele Boschi's instruments classification [2] (which considers both traditional and electronic instruments) is focused on the kind of control parameters instruments allow (quantity, discrete vs. continuous, etc.) and how they apply to sound (pitch, dynamics, spectral content, articulation, transition between notes, phrasing, rhythm, etc.). Many more instruments classifications and surveys could be added, although I do not know of any of them which systematically studies concepts such as playability or apprenticeship scalability, not even for traditional instruments[1].

[1] An essential selection of recent authors that have studied from different perspectives "how instruments are used", trying to infer from that "how they could be better designed", should at least include Perry Cook [3], Andy Hunt [4], Axel Mulder [5], Joel Ryan [6], Marcelo Wanderley [7] or David Wessel [8], among many others. The CD-ROM *Trends in Gestural Control of Music* [9] constitutes also a perfect introduction to this topic.

1.3. Music Instruments: Apprenticeship and Playability

Acoustic musical instruments as we know them now are the fruit of centuries or even millennia of evolution; they have settled into canonical forms. But that does not necessarily imply that these instruments should always excel at whatever parameter we evaluate. Let's consider the learning curve, for instance. Many traditional instruments are quite frustrating for the beginner. A violin, to mention only one, can hardly be taken as a toy (a piano could). Do not misunderstand me: I am not suggesting that the violin could be improved or that it should be made more toylike; the violin excels in many other dimensions (e.g. sound nuances) that are directly related with its initial difficulties. What I am affirming is that there is a lot to be studied from the perspectives of ergonomics and playability, and that this knowledge can only improve the design of new instruments. As Axel Mulder points, "we know how to make musical instruments that sound great, but can we make them easier to learn, better adapted to each individual's gestural expression preferences and movement capabilities?" [10].

At the opening of the NIME 2002 conference in Dublin, keynote speaker Tod Machover launched several questions of which I here retain two: "How do we create controls and interactions that feel *inevitable* to expert and amateur users?", "how do we create interactive situations that stimulate rather than placate, leading the participant beyond the surface and into thoughtful consideration of rich, expressive, meaningful experiences?". According to him, the last two decades have seen successful designs of controllers capable of virtuosity and subtlety, and also of controllers that "hook" novice users, but in this last case, very few systems have been nourishing as well, capable of encouraging deeper exploration and continued discovery and creativity [11].

2. INTUITIVE YET SOPHISTICATED MUSIC INSTRUMENTS

2.1. Professionals vs. Dilettantes

For the last years my main area of interest and research has focused around the possibilities for bringing new musical creative facilities to non-musicians, without degrading neither the music potentially producible, nor the users' interactive experiences and control possibilities [12].

New music instruments designed for trained musicians or for specific performers, can be quite complex and challenging indeed; as a counterpart they may offer a great amount of creative freedom and control possibilities to their players. On the other hand, instruments designed for amateur musicians or for public audiences in interactive sound installations, tend to be quite simple, trying in the best case, to bring the illusion of control and interaction to their users, while still producing "satisfactory" outputs. Logically, these two classes of instruments are often mutually exclusive. Musicians become easily bored with "popular" tools, while casual users get lost with sophisticated ones. But is this trend compulsory? Wouldn't it be possible to design instruments that can appeal to both sectors?

2.2. Playability and Efficiency of a Music Instrument

Let's write a simple equation (with quite fuzzy variables!) that will allow us to evaluate the playability *efficiency* of a music instrument according to the following ratio:

$$Efficiency = \frac{MusicalOutputComplexity}{InstrumentInputComplexity} \tag{1}$$

More complex instruments are usually capable of more complex music (e.g. the piano vs. the kazoo), but this equation is clearly misleading. What happens if we consider for example the CD player[2]? It is an instrument very simple to use, yet capable of all the imaginable music complexity. This tricky illusion is used indeed in many of the interactive sound installations which want to guarantee a complex musical output: they do not give to their interactors more than a couple of bits to play with. So let's modify our equation with an additional term that we will call *freedom*, vaguely dependent on the degrees of freedom accessible to the player, and the range of each of these degrees.

$$Efficiency = \frac{MusicalOutputComplexity \times PlayerFreedom}{InstrumentInputComplexity} \tag{2}$$

The goal is settled and it is an ambitious one: let us design and build instruments that can appeal to professional musicians as well as to complete novices; efficient instruments that like many traditional ones can offer a *low entry fee with no ceiling on virtuosity* [8]; systems in which basic principles of operation are easy to deduce, while, at the same time, sophisticated expressions are possible and mastery is progressively attainable.

3. THE FMOL VIRTUAL INSTRUMENT

3.1. Reintroducing FMOL

My first attempt at building interactive systems that tried to satisfy these conditions came with FMOL, a project I started in 1997 when the Catalan theatre group La Fura dels Baus proposed to me the conception and development of an Internet-based music composition system that could allow cybercomposers to participate in the creation of the music for La Fura's next show. FMOL has evolved since its debut and several articles have already been written ([12][14-17]). In this paper I want to focus only on the peculiar aspects brought by FMOL's

2 Meaning regular CD-players and regular discs! Not the manipulated ones like used by Yasunao Tone or Nicolas Collins [13].

unique user interface, which presents a closed feedback loop between the sound and the graphics: in FMOL, the same GUI works both as the input for sound control and as an output that intuitively displays all the sound and music activity.

3.2. FMOL Musical Output

With FMOL I wanted to introduce newcomers to experimental electronic music making. Therefore, for obvious availability reasons, the instrument had to be a mouse-driven software (it can still be freely downloaded at [18]). I also wanted to create a simple and complex tool all at once; a tool that would not dishearten hobbyist musicians, but would still be able to produce completely diverse music, allowing a rich and intricate control and offering various stages of training and different learning curves.

Both goals have been, in my opinion, quite well attained. During the two Internet calls for musical contributions for two of La Fura's shows (January-April 1998 for F@ust 3.0, and September-October 2000 for the opera DQ) more than 1,700 compositions were received in the database [19]. We know now that many of the participants had no prior contact with experimental electronic music and that a few were even composing or playing for the first time, but the final quality of the contributions (which can be heard online, as well as on the Fura dels Baus' F@ust 3.0-FMOL CD published in 1998 [20], and on the more recent CMJ 2002 companion CD [21]) was quite impressive.

Moreover, I have given several FMOL workshops usually with a mix of musicians and non-musicians, which usually end with public concerts. The intuitiveness acid test took place in March 2003 during a one-day workshop with 5 to 8-year old kids from Galicia (Spain), which ended with surprising collective improvisations!

It takes about half-hour to start having fun with the instrument, and several hours to acquire some confidence and produce controllable results. However, after five years of playing it, I am still learning it and do often discover hidden features. Because, and that is another important point, it happens that the instrument I originally designed as a freely available system for "experimental electronic music proselytism", turned to be my favorite instrument for live concerts. Since 1999, the FMOL Trio (Cristina Casanova and me on FMOL computers, plus Pelayo F. Arrizabalaga on saxophones/bass clarinet and turntables) performs free-form improvised electronic music and has produced several live CDs [22-25].

3.3. FMOL Visual Feedback

Arguably, visual feedback is not very important for playing traditional instruments, as the list of first rank blind musicians and instrumentalists may suggest. But traditional instruments usually bring other kinds of feedback, like haptic feedback [26-27], which is not so often present in digital instruments, at least in the "cheap" ones. So why not use at our advantage anything that could broaden the communication channel between the instrument and its player? I am convinced that in the case of FMOL, its unique visual feedback has been a fundamental component for its success as a powerful and at the same time intuitive and enjoyable instrument.

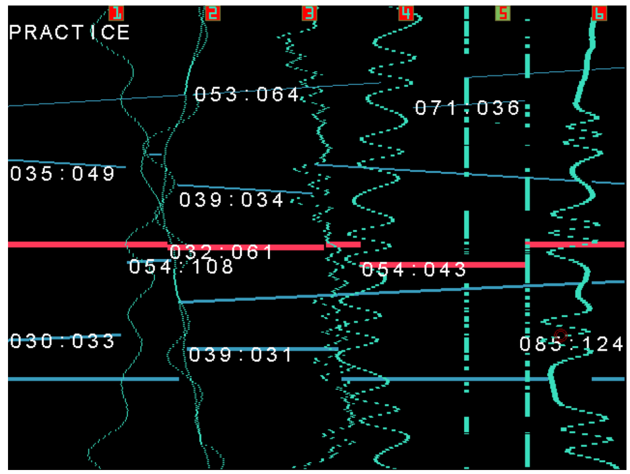

Figure 1: FMOL in action.

FMOL mouse-controlled GUI is so tightly related to the synthesis engine architecture, that almost every feature of the synthesizer is reflected in a symbolic, dynamic and non-technical way in the interface, that works both as an input devices (i.e. a controller) that can be picked and dragged with the mouse, and as an output device that gives dynamic visual feedback.

Mappings and detailed control mechanisms are explained better in [12]. The key point is that when multiple oscillators and sound generators are active, the resulting geometric "dance" tightly reflects the temporal activity and intensity of the piece and gives multidimensional cues to the player. Looking at a screen like figure 1 (which is taken from a quite dense FMOL fragment), the player can intuitively feel the loudness, frequency and timbrical content of every channel, the amount of different applied effects, and the activity of each of the 24 LFOs. Besides, as anything in the screen behaves simultaneously as an output and as an input, no indirection is needed to modify any of these parameters.

FMOL visual feedback has also proven to be a valuable addition in concerts, where two projectors connected to each of the computers are used, as it enables the audience to watch the music and how it is being constructed, giving the public a deeper understanding of the ongoing musical processes and adding new exciting elements to the show.

4. THE REACTABLE*

4.1. Mouse Limitations and New Intentions

Looking at the way people have used FMOL, and using it myself for improvisation in different contexts, raised ideas for new features and modifications. But I also felt that this control complexity could not be permanently increased: there are limits to what can be efficiently achieved in real-time by means of a mouse and a computer keyboard. These and other considerations took us to a completely new path, which should profit the knowledge gained during these years and bring it to a much more ambitious project.

The *reacTable** aims at the creation of a state-of-the-art interactive music instrument, which should be collaborative (off and on-line), intuitive (zero manual, zero instructions), sonically challenging and interesting, learnable, suitable for complete novices (in installations), suitable for advanced electronic musicians (in concerts) and totally controllable. The *reacTable** uses no mouse, no keyboard, no cables, no wearables. It allows a flexible number of users, and these will be able to enter or leave the instrument-installation without previous announcements. The technology involved should be, in one word, completely transparent [28].

4.2. Computer Vision and Tangible Objects

As the Tangible Media Group directed by Professor Hiroshi Ishii at the MIT Media Lab states, "People have developed sophisticated skills for sensing and manipulating our physical environments. However, most of these skills are not employed by traditional GUI…. The goal is to change the *painted bits* of GUIs to *tangible bits*, taking advantage of the richness of multimodal human senses and skills developed through our lifetime of interaction with the physical world." [29-30]. Several tangible systems have been constructed based on this philosophy. Some for musical applications, like *SmallFish* [31], the *Jam-O-Drum* [32-33], the *Musical Trinkets* [34], *Augmented Groove* [35] or the *Audiopad* [36], but we believe that no one attempts the level of integration, power and flexibility we propose: a table-based collaborative music instrument that uses computer vision and tangible user interfaces technologies, within a MAX-like architecture and scheduler, and with FMOL-inspired HCI models and visual feedback.

The *reacTable** is a musical instrument based on a round table, which has no sensors, no cables, no graphics or drawings. A video camera permanently analyses the surface of the table, tracking the hand movements over the table, and detecting the nature, position and orientation of the objects that are distributed on its surface, while a projector draws a dynamic and interactive interface on it. These objects are mostly passive and made out of plastic or wood of different shapes. Users interact with them by moving them, changing their orientation on the table plane or changing their faces (in the case of volumetric objects). More complex objects include (but are not limited to) flexible plastic tubes for continuous multiparametric control, little wooden dummy 1-octave keyboards, combs (for comb-filters), or other everyday objects. Figure 2 shows a *reacTable** scheme.

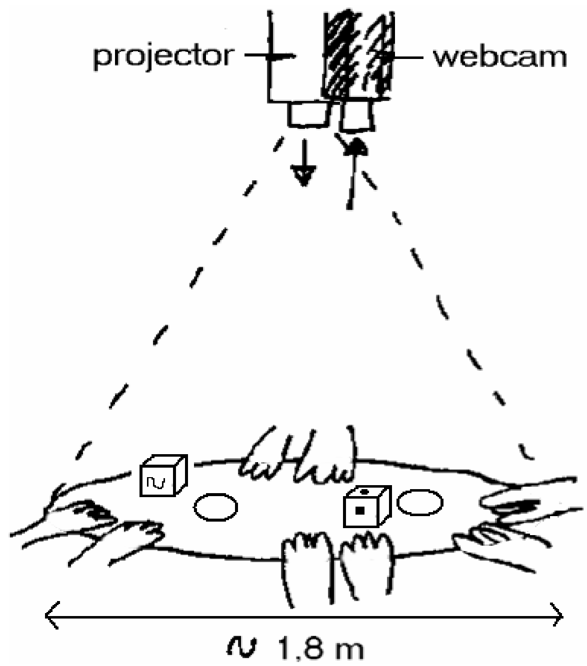

Figure 2. The *reacTable** simplified scheme.

4.3. Visuals

The projection follows the objects on the table wrapping them with auras or drawing figures on top of them, and covers also the whole table surface with dynamic and abstract elements that reflect all the system's activity, the objects' types and positions, and the relations between them all. The projection never shows buttons, sliders or widgets of any kind.

Like MAX and all of its cousins, the *reacTable** distinguishes between control and sound objects, and between control and sound connections. When a control flow is established between two objects, a thick straight line is drawn between them, showing by means of dynamic animations, the flux direction, its rate and its intensity. Visual feedback also guarantees that LFOs and other macrotemporal are perceived as blinking animations projected on top of the related objects, showing frequency and shape (e.g. square vs. sinusoidal).

While control flow lines are straight and simple, audio flow lines are *organic* and complex, as shown in figure 3 Their dynamic shapes show the macrotemporal audio variations (vibratos, tremolos, tempo and rhythms…) and their interior (colors, intensities…) depend on their spectral audio content. Users will also be able to control, modify or fork audio flows without using additional objects, but just by waving their hands, as if they were digging water channels in the beach sand.

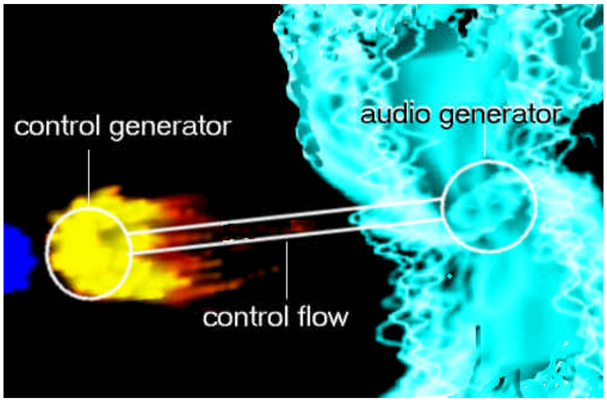

Figure 3. Control and audio flow simulation.

4.4. Avoid user's frustration at any cost

To avoid frustrations, a system does not necessarily have to be completely understandable, but it has to be coherent and responsible. Unlike MAX, the *reacTable** has to work "by default" and any gesture has to produce audible results. Here are some of its laws: objects are not active until they are touched; active objects have a dynamic visual *aura;* objects are interconnected by proximity; moving an object on the table can change the relations with the other objects.

Perry Cook, in an informal music controllers design decalogue, ironically points that "smart instruments are often not smart" [3]. Although we basically agree with him, we have come to the conclusion that a system like the *reacTable** must show some kind of intelligent behavior, suggesting for example interesting candidates for a given configuration by highlighting the appropriate objects (in a manner not to be confused with LFOs).

4.5. Future Work

The *reacTable** project has started in December 2002 coinciding with the foundation of the Interactivity Team within the Music Technology Group. We are currently working and researching all the main threads in parallel (computer vision and objects recognition, sound engine architecture, interactivity logic, sound visualization, etc.). Meanwhile we are designing the core and the integration of all its branches, and a virtual software-only version (shown in Figure 4) is already available. The *reacTable** is an ambitious project. Unlike many new designed instruments, its origin does not come from approaching its creation by exploring the possibilities of a specific technology, nor from the perspective of mimicking a known instrumental model. The *reacTable** comes from our experience designing instruments, making music with them, and listening and watching the way others have played them. Needless to say, we have deposited a great hope and expectation on it. We plan to have the first integrated by autumn 2003 and a first full working version by spring 2004.

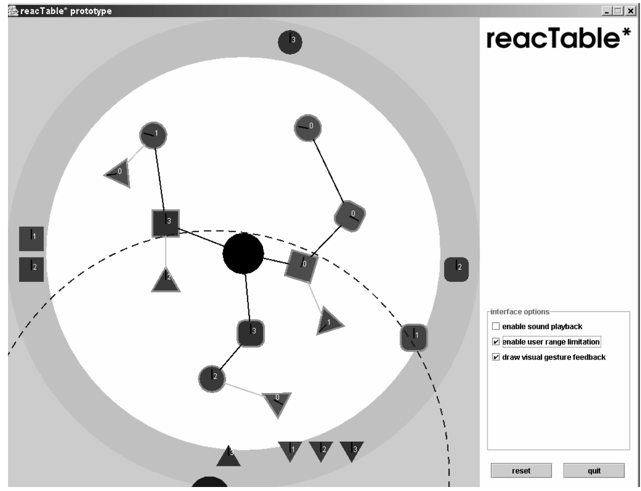

Figure 4. *reacTable** simulator snapshot

5. CONCLUSION

The field of new instruments and interactive music systems design seems to be lately in good shape. A yearly international conference (New Interfaces for Musical Expression, NIME [37]) is being held since 2001, a COST action (Con-Gas, for Gestured Controlled Audio Systems) has just started this year, and specialized journals are devoting more issues to this topic. Personal computers are already capable of complex real-time audio operations that demand for new interactive control interfaces. Yet the field is still in its infancy.

Not many recent electronic instruments have even attained the reduced popularity of the Theremin, created in 1920. The next public or standard electronic instruments after the Theremin may have not arrived yet. Or they have in fact (like the electric guitar and the turntable), but they are still not digital ones. Are we supposed to see a digital instrument standardization? Do we really need the new musical controller? Probably not. But on the other side, highly idiosyncratic instruments which are only used by their respective creators may not be the best sign or strategy for a serious evolution in this field.

New music instruments or controllers convey also new possibilities and paradigms to the act of making music. In this paper we have only scratched a few, like the chance to bring the joy of real-time music creation to non-trained musicians.

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