Performing experimental music by physical simulation

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ABSTRACT

This paper presents ongoing work on methods dedicated to relations between composers and performers in the context of experimental music. The computer music community has over the last decade paid a strong interest on various kinds of gestural interfaces to control sound synthesis processes. The mapping between gesture and sound parameters has specially been investigated in order to design the most relevant schemes of sonic interaction. In fact, this relevance results in an aesthetic choice that encroaches on the process of composition. This work proposes to examine the relations between composers and performers in the context of the new interfaces for musical expression. It aims to define a theoretical and methodological framework clarifying these relations. In this project, this paper is the first experimental study about the use of physical models as *gestural maps* for the production of textural sounds.

Keywords

Simulation, Interaction, Sonic textures

1. INTRODUCTION

The relationship between action and sound is a critical point in the field of musical creation. The computer is an infinite source of sounds, but the lack of reference for the interactive control of the digital sound processes is always a problem for musical performances. While action and perception are strongly correlated by the energetic continuum with the traditional instruments, the sound process is often an abstract environment without a gestural reference. It is a problem in terms of performance since these relations have to insure expressivity, but it is also a problem for some composers whose instructions depend strongly on the sonic matter. Currently, two main strategies are followed when dealing with the real-time interaction with sound processes. The first one, referred as signal approach, uses mapping techniques to create artificial connexions between a gestural interface and parameters of sound synthesis [1, 5]. The second strategy, denoted as simulation approach, are based on physical models which simulates physical mechanisms producing the sound phenomenon. In that case, the physical parameters allows to recover natural relationships between gesture and sound production [6]. These two approaches are generally used separately or on the same layer of the sound process. The physical computation is also considered as a technique among others, and each approach keeps its limitations and advantages. However, the process of simulation and synthesis methods are really different. The development of physical model requires a paradigm shift, since the user must focus its intention on the object that could produce the desired sound. In the literature, this shift has the advantage of focusing attention on parameters of physical simulation that have a direct relationship with perceptual parameters [8][13]. Indeed, the physical parameters have two strong properties : they are really close to the model (easy to use) and have a strong perceptual significance (intuitive interaction).

A singular feature of the physical simulation in the context of creating music is that the physical model may give unexpected and undesired behaviors. This point is often defined as a significant limitation that is inappropriate for some composers working at the accuracy of the sample. However, the experimental composers do not usually care about the definition of temporal object whose elements, structure and interconnections are calculated and organized in advance. They prefer the idea of sketching the outlines of a situation in which sounds may occur, a process of generation (sound or otherwise), a field defined by rules of composition. Experimental composers have developed many methods to cause "actions whose outcome is unknown" (John Cage) [11]. This unknown may vary from a minimum of organization to a minimum of arbitrariness, with different connections between chance and choice, with different types of options and obligations.

This paper is based on a research intent about the conception of a new intermediate layer responding to the practice of experimental composers. It uses new methods of hierarchical cooperation between the signal approach and the simulation approach, where the physical layer is defined as a map of intentions initially sketched by the composer and finally experimented by the performers : *the gestural map* [3]. Physically-based virtual objects as an intermediate object-based mapping layer was thoroughly discussed by Mulder [9] or Hsu [4]. Also [7, 15, 12] have studied the physical simulation as a solution ensuring the coherence between interaction and audiovisual processes. Thus the *gestural map* seems to be a relevant candidate to support the intentions of composers. In order to validate this point, this study suggests also to observe the consequence of physical simulation in sound reception. The listener should perceive differences between experiments realized with two *gestural maps* and should identify similarities between different experiments realized with one *gestural map.* This is to assess whether the presence of a physical model upstream of the

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sound synthesis has observable consequences for the listener on his mental representation of the musical sequences.

2. METHODS AND MATERIALS

These first studies of sound identification focus on the sonic texture. Indeed, the manipulation of sonic texture accounts well time problems of a global composition with their micro and macro-temporal evolutions. The assumption is that the identification of musical sequences based on sonic texture addresses therefore the majority of the time discriminating criteria. As described below, the experiment consists in generating a base of sonic texture and asking to the subjects to identify their own musical production in the initial base.

2.1 Experimental protocol

Experiments are realized on 15 subjects with different profiles: instrumentalists, composers, audiophiles, and subjects without musical practice. The subjects were aged from 25 to 35 years and have no sensorimotor impairments. According the experimental protocol, the subjects have to manipulate a sonic texture created with the sound corpus of the piece *Koyaanisqatsi* by Philip Glass. Each subject explores with a mouse a 2D environment represented by a rectangle on the screen and perceived in real time the sound production through headphones. During each exploration, the sound production is recorded and normalized. After this operation, the user must immediately find the sound recording of his experience among nine other records. If there is hesitation between different records, he can answer with a list of 3 records in order of preference. The first exploration is performed without physical simulation between subject and sound synthesis. The subject discovers the environment by pointing successively each sonic grain represented by point clouds. His sound recording is added to the sound base and he must find his own sonic production. The second exploration is achieved with the mode of interaction based on fluid simulation. The subject explores the environment sound through the physical behavior of different fluids called A, B or C (see Table 2) . The recordings presented at the end of the exploration were also created with these different physical simulations, but without his knowledge his own sound recording is removed from the list of choice. Thus, the subject must choose among unknown records, but three of them were produced with the same fluid. So, the expected results are a significant choice of the sound recordings produced with the same fluid.

2.2 Materials

The framework supporting the *gestural map* is based on hierarchical cooperation between simulation and synthesis approaches. It consists in a software composed of a two concurrent processes described in the next parts : the particles simulation implemented on the *Processing* environment and the sound synthesis on the *Max5* environment. The local communication between these two processes is done through the udp protocol called *Open Sound Control*[1]. Developments are currently realized on a macbook pro with Intel Core 2 Duo (2,6 GHz) and 4 Go of DDR2 SDRAM where the co-processing is currently driven automatically by the operating system.

2.2.1 Particles simulation

This process is based on a library for solving real-time fluid dynamics simulations based on the following Navier-Stokes equations[2]. Given the current state of the velocity and a current set of forces, the Navier-Stokes equations precisely describe the evolution of a velocity field over time. In the context of analytic studies, the use of these equations strives for accuracy and thus consumes a large computation time. But this algorithm [16] has been developed to favor interactivity of the simulation in tuning the trade-off between accuracy and computing time. In order to command synthesis process with the particles, the velocity and the position of every moving points are sent at each simulation steps. The implementation of different *maps* requires tools to manage heterogeneous mediums. Yet the majority of fluid dynamics solvers considered homogeneous mediums. So the original solver has been modified to add dependencies to its physical parameters. The user can change independently the physical characteristics of the medium with coefficient of : forces, viscous diffusion, density, velocity. He can add as well other externals forces. Thus, the system can support a wide range of behavior, and the map can also be adapted to the wishes of composers. For now, the connection of this system with the sound process limits these experiments with 20 and 100 particles. This number is particularly adapted for these first experimentations, but the use of others computing solutions, as parallel computing, are planned in order to increase the number of particles.

2.2.2 Concatenative synthesis

The sound process of this study has been based on the concatenation of sounds. Precisely this experiment deals with CataRT from IRCAM researches. CataRT is a concatenative real-time sound synthesis system, which plays grains from a large corpus of segmented and descriptor-analyzed sounds according to proximity to a target position in the descriptor space. Our experiment has focused on the mapping between descriptor space of CataRT [14] (230 imported MPEG-7 signal, perceptual, spectral, and harmonic descriptors) and the physical properties of the particles system (Fig. 1). CataRT is developed on MaxMSP, thus this setup use even the system of communication based on Open Sound Control. In terms of performances, the global system allows to explore the corpus interactively through the simulation of particles without delay perception. Elementary experiments have been developed to illustrate the principle of *gestural map* emerging from the cooperation of CataRT analysis and the simulation of particle system. Figure (Fig. 1) described a mapping between *loudness* descriptor and *viscosity* property. Through this mapping, exploration of the map tend to the emergence of a sonic discussion between the explosion of high pitched textures and slow movement of low-pitched textures.[3]

3. EXPERIMENTAL RESULTS

The raw results of experiments are summarized in Tables 1 and 2. The tables contain a value 1 when the subject identifies his performance and value 0 when subjects choose a performance which is not his own. Without simulation layer, we observe two misidentifications for which the subject does not choice its performance. There is also four confusion for which the subject hesitates between his performance and the others. This result is not surprising since the direct control of CataRT system does not impose strong constraints to the production of sound. Each user have achieved a unique sound experience with great flexibility through singular events easily identifiable.

For the exploration mediated by the fluid, i.e. by a *gestural map*, no one detects the absence of his own sound

[1]See e.g. `http://opensoundcontrol.org/`.

[2]See e.g. `http://memo.tv/msafluid_for_processing`.

[3]`http://dl.dropbox.com/u/11924232/2.mov`

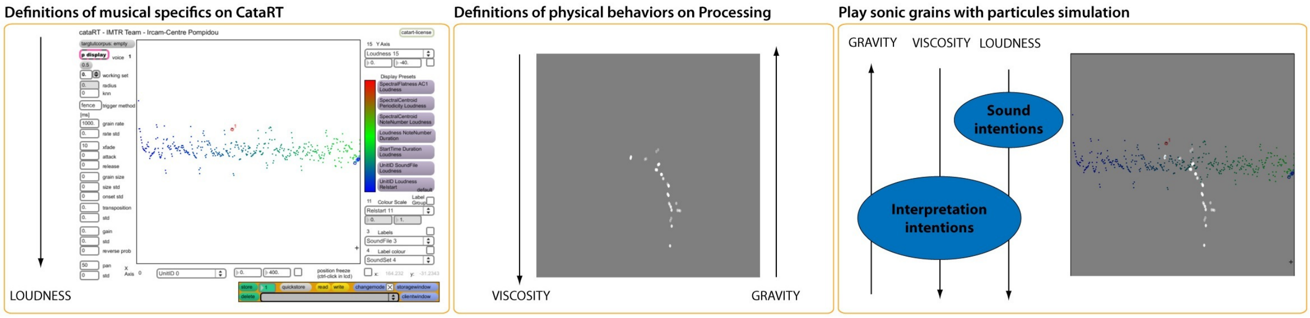

Figure 1: Elementary example with the cooperation of CataRT analysis and the simulation of particle system.

production among the available records. As expected, confusions are mainly observed among the sound produced with the same fluid. Indeed, the sound manipulation has a more limited field of possibilities. It is constrained by patterns of evolution easily spotted by users that increase the confusion between performance, or rather create a unity between the various interpretations of the same *map*. The results are satisfactory since a majority of subject choose a recording generated with the same *map*. It seems that we could identify categories emerging from the physical simulation at the origin of the sound. Despite these sonic constraints from the fluid, Figure 2 shows that the rate of identification errors are comparable to the experiment without fluid. In a sense, it means that the intrusion of this interaction layer does not disturb the singularity of musical performance. The system seems to provide a sufficient expressive freedom to create a singular interpretation.

Finally, the conclusions of this study are consistent with the motor theories of perception [2][10]. During his experience with the physical simulation, the subject seems to integrate, i.e. implicitly learn, physical behaviors of the environment. Thus this knowledge allows him to identify the prospective sound coming from this environment. This recalls the principle of internal simulation defined by the motor theories of perception in order to describe the sensorimotor learning. Indeed, the choice is intuitively sound recordings from the same *gestural map* without precise identification of similar musical sentence. This discriminatory power is therefore an effective way for the composer to imagine a sound aesthetic and forward it to the performer.

Subject	1st choice	2nd choice	3rd choice
1	1	*	*
2	1	*	*
3	0	*	*
4	1	*	*
5	1	0	0
6	1	0	*
7	0	*	*
8	1	*	*
9	1	*	*
10	1	*	*
11	1	*	*
12	1	*	*
13	1	*	*
14	1	0	*
15	1	*	*

Table 1: Results without fluid : ***1 means correctly identified, 0 means badly identified, * null***

Subject	Gestural Map	1st choice	2nd choice	3rd choice
1	A	1	1	0
2	A	1	*	*
3	A	0	1	0
4	A	1	1	0
5	A	1	*	*
6	B	1	1	*
7	B	0	*	*
8	B	0	*	*
9	B	1	1	*
10	B	1	1	*
11	C	1	*	*
12	C	1	*	*
13	C	1	1	*
14	C	1	0	*
15	C	1	*	*

Table 2: Results with fluid : ***1 means correctly identified, 0 means badly identified, * null***

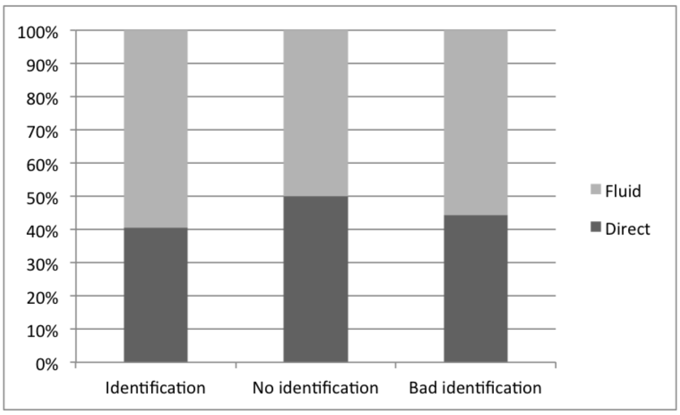

Figure 2: Comparison of identification task with and without fluid

4. PERSPECTIVES AND CONCLUSION

This contribution deals with solutions for sonic textures interaction, and suggests fluid simulation as layer between sound process and interacting system. This layer, called *gestural map*, provides a new way to manage and interact with sonic textures through physical behaviors. This first study has allowed to check that properties of fluid have perceptible influences on sound by creating sonic similarities among performances realized with the same fluid.

In most cases, real-time manipulations of sound processes are achieved by mapping between the gestural inputs and signal parameters. However, these methods require the instant handling of a significant number of parameters in order to converge towards compelling results. In the context of sonic texture, the efficient manipulation of signal parameters is still a challenge in interactive systems. This work deals with this challenge through a paradigm shift : from the signal approach to the physical approach. The framework of this study provides to use synthesis and simulation with a hierarchical relations. About the relevance of the interaction, dynamic behaviors of particles simulation quickly give landmarks to the user in his task, but they give also a consistence to the evolution of modalities. This work highlights the effectiveness of interaction metaphors inspired by the physical reality. From a cognitive point of view, the physical laws are a way to understand, learn and incorporate the virtual interaction.

In the relation between composers and performers, this shift may be disturbing, because it puts the musical intention on the design of sonic sources. But in the case of experimental music, the musical partitions are often guidelines for the performers. The musical evolution that led to this new type of creation process is close to this paradigm shift. In this context, the *gestural map* is a new medium to design these guidelines. It is not focused on the temporal position of each musical event, but on the dynamic of musical production. Through this *gestural map*, the composer gives the performer a finite number of possible tasks as the instructions of Lucier in his piece *Vespers*. Thus, *gestural map* simplifies exchange between composers and performers by moving the intention of the composer to the performer's gesture. The composers sketch the outline of a situation with physical constraints in the exploratory environment from which sounds may occur. It is both a means of forcing explicitly the performer and guide him towards the wish of the composer. Indeed, it is possible to implement *gestural maps* that excite strategically the curiosity of performers. The composer could design local difficulties in order to reach the performer by this singularity.

Gesture map based on heterogeneous fluid is therefore a real candidate for experimental score. But the establishment of such a writing and exchanging support around sonic textures is globally a significant advance for sonic design. The next evaluation will be about the ability of *gestural map* to be integrated into a creative process and to express intentions of designers. Indeed, composers must suggest, advise, pilot the interpretations of the performer with the construction of a *gestural map*. According to these previous experiments, some relationships as speed / pitch are common, but it appears that each user has its own gestural representations often derived from its own practical gestures during work or free time. After these first observations, experiments about relations between physical properties and sound descriptors have been started in order to enlarge knowledge about.

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6. REFERENCES

[1] D. Arfib, J. M. Couturier, L. Kessous, and V. Verfaille. Strategies of mapping between gesture data and synthesis model parameters using perceptual spaces. *Org. Sound*, 7:127–144, August 2002.

[2] J. Bertsh and C. Le Scanff. Paris : Presses universitaires de France, 1995.

[3] J. Castet. In *in Proc. of the Int. Conf. Interaction South America (ISA2011)*, 2011.

[4] W. Hsu. On movement and structure and abstraction in generative audiovisual improvisation. In A. R. Jensenius, A. Tveit, R. I. Godøy, and D. Overholt, editors, *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 417–420, Oslo, Norway, 2011.

[5] A. Hunt and M. M. Wanderley. Mapping performer parameters to synthesis engines. *Org. Sound*, 7:97–108, 2002.

[6] A. Luciani, J.-L. Florens, D. Couroussé, and J. Castet. Ergotic Sounds: A New Way to Improve Playability, Believability and Presence of Virtual Musical Instruments. *Journal of New Music Research*, 38(3):309–323, 2009.

[7] A. Luciani, S. O'Modhrain, C. Magnusson, J.-L. Florens, and D. Courousse. Perception of virtual multi-sensory objects: Some musings on the enactive approach. In *Cyberworlds, 2008 International Conference on*, pages 354 –360, sept. 2008.

[8] S. McAdams. Reconnaissance de sources et d'événements sonores. In *Penser les sons : Psychologie cognitive de l'audition*, pages 157–214. Presses Universitaires de France, Paris, 1994.

[9] A. G. E. Mulder and S. S. Fels. Sound sculpting: Performing with virtual musical sound sculpting : Performaing with virtual musical instruments. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, 1998.

[10] A. Noë. *Action in Perception*. The Mit Press, 2004.

[11] M. Nyman. *Experimental Music, Cage and beyond.* Editions Allia, 16, rue Charlemagne, Paris, 1999.

[12] D. Pirrò and G. Eckel. Physical modelling enabling enaction: an example. In A. R. Jensenius, A. Tveit, R. I. Godøy, and D. Overholt, editors, *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 461–464, Oslo, Norway, 2011.

[13] J.-C. Risset and D. Wessel. *Exploration of Timbre by Analysis Synthesis*, pages 113–169. San Diego, 1999.

[14] D. Schwarz, G. Beller, B. Verbrugghe, S. Britton, and I. C. Pompidou. Real-Time Corpus-Based Concatenative Synthesis with CataRT. In *in Proc. of the Int. Conf. on Digital Audio Effects (DAFx-06*, pages 279–282, 2006.

[15] S. Sinclair and M. M. Wanderley. A run-time programmable simulator to enable multi-modal interaction with rigid-body systems. *Interact. Comput.*, 21(1-2):54–63, Jan. 2009.

[16] J. Stam. Real-time fluid dynamics for games. In *Proceedings of the Game Developer Conference*, 2003.