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# Virtualization of real time audio processes : towards a musical notation of contemporary music.

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## Abstract

Contemporary musical production makes an heavy usage of digital artefacts, either hardware or software based. Since the middle of the 80es, an important issue has been recognized: the fast obsolescence of hardware and software products endanger seriously the future of this production. The question is not only to preserve the results, by recording them, but to preserve the ability to reperform the works live, as we do today for music of the last centuries.

We will present the methodology we develop in the ASTREE project for building knowledge in relation to musical works, and particularly for digital processes that are considered as specific music instruments. We will discuss the different issues in preservation of contemporary music, and show that one of the most prominent is the lack of formalized knowledge about the digital musical instruments, their notation, and their integration into musical score. We will present our efforts towards building an organology of real-time audio processes, and show that this can be the basis for an adequate musical notation and its integration in musical score.

Keywords : Music, Contemporary, Digital, Preservation

## 1. Introduction

### 1.1. A brief history

The first interactive works combining performers and realtime electronic modulation of their parts have appeared in the middle of the 80es. Electronic devices, either hardware or software, have been interfering with various musical configurations: the instrument-computer duet, for instance in Manoury's works (*Jupiter*, for flute and computer, 1987-1992 ; *En Echo*, for voice and computer, 1993-1994); the works for ensemble and live electronics, such as *Fragment de lune* (1985-1987) by Philippe Hurel; the works for soloists, ensemble and electronics, such as *Répons* (1981-1988) by Pierre Boulez.

After nearly 25 years of interactive works, institutions have become aware that this type of music is completely dependant on its hardware and software implementation. May the operating system or the processor evolve, the piece cannot be reperformed. This is for instance what nearly happened to *Diadèmes*, a work by composer Marc-André Dalbavie for alto solo, ensemble and electronics. First created in 1986 and honoured by the Ars Electronica Prize, the work was last performed in 1992. In december 2008, its american creation was planned, more than 22 years after its *premiere* in France. But the Yamaha TX 816 FM synthetizers previously used are no longer available, and the one still present at Ircam is nearly out of order. Moreover, composer Dalbavie has tried several software

emulators, but none of them was suitable according to him to replace the old hardware synthesizer.

In april 2008, Dalbavie and his musical assistant Serge Lemouton decided to choose another technique: they built a sampler. It is a kind of database of sounds produced by an instrument. The sounds have been recorded from the old TX 816 at various pitches and intensities. This solution enabled to reperform the piece having a kind of photography of the previous sounds. When no sound corresponding to a given pitch exists, the sampler is able to interpolate between existing files, to give the illusion the missing note exists.

One quickly understands the maintenance activity to be able to reperform a work is a never ending activity that should moreover respect a minimum of authenticity.

## **1.2. Aims of preservation**

Having in mind that the aim of preservation is to make possible new performances of the works, it becomes clearly not sufficient to preserve the outputs – audio or video recordings – even if these recordings are clearly part of the objects to be preserved.

At the very core of performance is the real-time process, often called “the patch” : it is software that takes data in input – directly from the performer, or from prerecorded data, audio or video, and process them before rendering the output on speakers or a display. The real-time process is the expression of the ideas of the composer regarding the use of digital material, it is then the main object to be preserved, in addition to the score (French composer Philippe Manoury often calls the digital material he is using a “Digital Orchestra”).

## **2. Risks and strategies**

### **2.1. The different strategies**

Active preservation of realtime interactive music involves various aspects and is based on various actions. The first step is the physical conservation of all elements necessary for the reperformance of the work: the score, the patches, the various instructions, etc. At Ircam, the Mustica server provides patch files and instructions of implementation for a selection of nearly 60 works.

Another possible strategy is emulation, definitely one of the most difficult. Bernardini and Vidolin [Bernardini 05] quote the example of Stockhausen’s *Oktophonie*, which requires an ATARI-1040 ST computer that no longer exists. There are Atari emulators running on other computers but nobody knows whether the Notator program used by Stockhausen will run on an emulator, though communities of users may give some help...

Migration is the most widespread activity to achieve reperformance. Many composers had their works transformed from one technical environment to another. All institutions in the field of electronic arts face migration necessities. At IRCAM, important pieces using Next computers were moved to Macintosh machines at the end of the 1990s.

Last but not least, virtualization means describing electronic modules using abstractions. At IRCAM, Andrew Gerzso has completed an important work aiming at finding representations as independent as possible from technical implementation for signal processing modules in *Anthèmes 2*, by Pierre Boulez, for violin and live electronics. The effects used in the piece have been added to the score as if they were instrumental parts. This is according to us the ultimate level of virtualization. It has also to be noticed that current musical notation (Common Western Musical Notation) is virtual, in the sense that it is independent from any implementation : we can play music written for any instrument on another instrument, the paradigms of notation being sufficiently abstract in order to achieve this goal.

## 2.2. The musical notation issue

The need to integrate new technology in the musical score has been recognized a long time ago [Assayag 97]. But, despite numerous tries, it seems that few systems have emerged. One can for instance examine the problem of notation for spatialization.

Spatialization of sound seems to be now a well-known domain, where numerous realizations have been made, and that offers a wide range of experiments. But there are few certainties, few theoretical studies and few references [Merlier 06].

Concepts and terms used are vague, not precisely defined, and their acceptations are different according to the point of view of the actor, depending on numerous factors [Merlier 06] :

- actions have different meanings according to the point of view : producer (an audio engineer...) or receiver (a listener)
- descriptors have different meanings according to the point of view envisioned : reality, image of the reality, or conceptualization of reality.

In this context, it becomes very difficult to envision a musical notation that takes into account all these different point of views, before having realized a unification, or merely a standardization of the domain, putting in relation the different points of view expressed.

Moreover, some tries to achieve notation of spatialization of the score becomes dependent on the physical implementation, like the following one that is dependent on a 5.1 system [Ellberger 06]:



Figure 1 : a notation of spatialization for a 5.1 system

## 2.3. The need of a rationalized approach

From the remarks exposed above, we recognized the need to build a common base about the digital musical instruments, from where we could extract and constitute the knowledge basis for a rationalized approach of the musical notation issue. This approach is the basis of the ASTREE project that is exposed below.

## 3. The ASTREE strategy

### 3.1. The ASTREE methodology

The ASTREE methodology is twofold:

First, existing processes have to be translated into a common language. Second, from that language, we will rebuild the original processes, or equivalent one, we will analyze them by applying data mining techniques, and we will also generate an automatic documentation.

The ASTREE methodology can be summarized in the following figure:

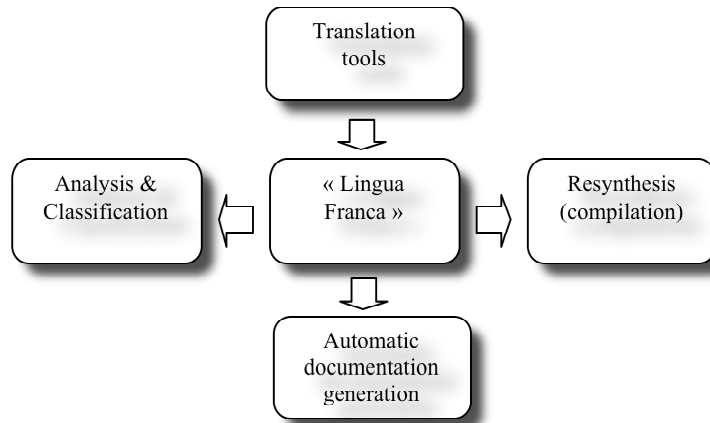


Figure 2 : the ASTREE methodology

### 3.2. Lingua Franca

At the very core of the methodology is a common language, a “Lingua Franca”, that should be completely independent from any hardware or software. Furthermore, this language should be sufficiently expressive to convey the meaning of current existing real-time processes, and at the same time very concise in order to be easily analyzed.

The FAUST language, developed in Grame since 2000 [Orlarey 02], is partially consistent with these requirements. It is a signal processing language, expressed as an algebra, that is aimed originally to process audio signals at a fixed rate, but is currently extended in order to become able to process vectors and matrices, with multi-rate capacities.

The FAUST language is sufficiently expressive for the expression of current objects in the domain of audio processing, at least for the synchronous part.

### 3.3. Translation

We develop tools for translating currently existing processes, built with current environments in use for contemporary music, for instance Max/MSP, but also for other environments like PureData (or even MatLab).

These translation tools are essential, not only for translation of existing material, but also for future material. Users, like composers or computer music designers that assist the composer in his task, are unlikely to use directly an algebraic language like the FAUST language. They will certainly continue using graphical programming environments like Max/MSP or PureData that let them free to experiment and build tools by successive refinements, rather than expressing tools in a language that imposes more or less a preliminary analysis and modeling.

### 3.4. Resynthesis

On top of this language, we can then add the ability to build processes, that in turn will become dependent on the machine, but that can be immediately compared to the original in terms of results: one can compare the output given by the newly implemented process the original output, as soon as the original process and its translation in the Lingua Franca are available.

The FAUST language can currently be translated in C++, and then compiled in a machine executable. We will also adapt the translation tool in order to work in the reverse order, and obtain Max/MSP or PureData implementations from the FAUST expression.

The purpose of this resynthesis is not only to be used in new performances, but, at the time of archiving processes, to prove that the FAUST expression of the process is sufficient.

We can prove it through two stages : first, by doing a reverse translation in the original language, we can prove that no information was lost in the process, and second, by doing a new implementation, and comparing outputs with the original, we can make an a priori evaluation of the authenticity of the translated process towards original.

### **3.5. Automatic documentation generation**

The code obtained as well as the source code can be analyzed in order to extract from there an automatic documentation. We can document input and output data, control parameters, extract comments and structures, and generate figures and mathematical expressions corresponding to the source.

### **3.6. Analysis and classification**

By applying data mining techniques to the data set obtained by applying translation tools to existing processes, we intend to start a process that will end in an organology of digital instruments. Not only the processes themselves will be analyzed, but also the annotations made by users, as well as the automatic documentation previously obtained, and particularly the control parameters, names of input and outputs data, and dependencies. The relationship to works, where processes are in use, and metadata (authorship...) could also be analysed.

## **4. Conclusion**

For preservation of digital material that is produced today, our approach is to use the tools that are available today, and particularly digital tools. To build a database is not sufficient, there is also the need of building knowledge out of it. To this end, we will use the most recent techniques in data mining and data analysis: neural networks, bayesian networks, or fuzzy logic. We will also validate the results obtained with these techniques by using statistical methodologies.

For building executable programs, we have to use the most recent techniques, for instance parallelism in order to get the best of multi-core processors. We have then to automatize the whole process, in order to save time and effort, including automatic generation of documentation, or automatic translation of objects from one expression to another one.

This does not exclude other approaches, and particularly those based on human reasoning and human activities. Our opinion is that our approach will give them some ways to explore, as well as a strong basis for experimentation and validation of new ideas.

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