Introducing Composed Instruments, Technical and Musicological Implications

Norbert Schnell and Marc Battier
IRCAM
1, place Igor Stravinsky
Paris, France
{Norbert.Schnell, Marc.Battier}@ircam.fr

Abstract

In this paper, we develop the concept of "composed instruments". We will look at this idea from two perspectives: the design of computer systems in the context of live performed music and musicological considerations. A historical context is developed. Examples will be drawn from recent compositions. Finally basic concepts from computer science will be examined for their relation ship to this concept.

Keywords

Instruments, musicology, composed instrument, Theremin, Martenot, interaction, streams, MAX.

INTRODUCTION

Musicians performing with electronic devices have been a major turning point in the practice of music for over a century. When computers became available for music performance, the question of turning a general-purpose machine into a music packed device became sensitive. In particular, developing interfaces and specially-designed peripherals for music composing and performance led a very active and increasingly large community of researchers and artists to develop solutions.

A metaphor which is easily employed for a wide range of artistic performances with computers is that of the musical instrument. The term of the *composed* instrument underlines the fact that computer systems used in musical performance carry as much the notion of an instrument as that of a score, in the sense of determining various aspects of a musical work. This paper will merely designate which metaphors and concepts are implicit or explicit in the creation and performance of music using computers. We are at the onset of a larger research and we think that allying musicology and engineering will be fruitful. We would like to present the hypotheses and intention of our research.

Composed instruments in the XXth Century

The concept of composed instrument became possible when musical instruments became dematerialised. In other words, with electronic technology, it was possible to conceive a sound producing device independently from its gestural interface. As an example, the thereminvox (Russia, 1920), well known for its unique gestural interface in which performers move their hands in front of antennas, thus having no physical contact with the instrument, uses the same sound-producing technology as the ondes Martenot (France, 1928), namely the *heterodyne effect*. Yet, both Leon Termen and Maurice Martenot developed quite different modes of playing. As a result, the theremin became of landmark for film music (notably Hitchcok's) in which its ability to produce portamenti and glissandi was widely used for effects, while a substantial number of more conventional pieces were written for the ondes. Although this instrument is perfectly able to produce glissandi too, it was its chromatic keyboard and its timbre variety, thanks to a number of specialized loudspeakers which attracted composers.

A composed instrument is one in which several conditions must be met. One of them is that the two main components of a musical instrument, the sound producing part and the gestural performance part, are decoupled, or isolated one from another. In a composed instrument, gesture is linked to sound production in a non-direct, oftentimes non-obvious fashion. This is quite clear for digital devices. The two electronic instruments from the first half of the 20th century show that, in some ways, this is also true for analog instruments. Electronic synthesizers, dating from the 1952 - 1955 RCA synthesizer Mark I or the 1965 Buchla, Moog and Synket synthesizers, are perfect examples of the decoupling. While the Moog and the Synket machines had organ keyboards - and the Synket actually had a stack of three small monophonic keyboards - Donald Buchla developed other ways of generating control voltages to manually and automatically control its Electronic Music box [1].

Electronic Music Studios: an Electronic Environment

The advent of Electronic music studios in musical history offer a transition in the development of composed instruments. Although considered an instrument only by a few, the Electronic music studio helped create the sense that composers were, if they chose to do so, able to create their own working environment. This began to be clear when, in 1951, the first electronic music studio was conceived from scratch at the WDR Radio of Cologne (Germany) to enable the composition of electronic music sounds. Based on the conception of physicist Werner Meyer-Eppler, the Cologne studio was organised around the control of synthesis resources, albeit limited in scope and power [2]. Briefly, the concept of studios evolved up to the 1955 design of the Phonology studio in Milan by Luciano Berio and Bruno Maderna, With nine oscillators, various filters and other sophisticated equipment [3][4], the presence of a technician/musician and of a scientist who helped design and build specific processing devices, the studio was the best equipped in the world at that time. Composers, then, were required to adopt a low profile and accept the "conditions and limits" of the technical environment, and his or her work was to be mediated by a technician[5]. In this case, the composer was considered unable to "compose an instrument" from the overwhelming technical environment of the studio. Nevertheless, one should not take this official studio rule too seriously, and musical analysis of various pieces coming out of this studio during the late 1950s show that, on the contrary, degrees of liberty were quickly explored by in-house and visiting composers, as shown in pieces by Berio (*Tema, Visage*), Pousseur (*Scambi*), Cage (*Fontana Mix*), and others. In the same period, Pierre Boulez defined in his manner another goal for electronic music studios: "Electroacoustic means, which are offered to us by current technology, should be integrated with a generalized musical vocabulary" [6].

In 1984, the Italian composer Luigi Nono made a striking statement about the evolution of the electronic music studio at that time. For him, electronic music studios are "new instruments which need to be studied over time (also to avoid falling into the trap of using small commonplace ways), to learn and study again and again, to explore other possibilities, different from the ones usually chosen and given, other musical thoughts, other infinite spaces..." [7].

Furthermore, almost 20 years later, when Berio became involved in the direction of the new electroacoustic department of IRCAM, he took an opposite route and declared "We now try to conceive and formulate widely open ideas and devices, in which researchers and musicians may project themselves and be able to familiarize themselves." [8]. Probably thanks to the then new computer music means which began to appear, such as the very first digital synthesizers, it was at last perfectly natural for composers to "compose" their instrument.

Instrument, Machine, Representation

Although the concept of composed instrument is recent, the brief considerations above attempt to show that it can, within a musicological context, be applied to the history and practice of electronic music. Historically, the invention of electronic instruments followed industrial research and development. Radio technique was on the forefront of technology in the 1910s and 1920s, and it is from it that the thereminvox and the ondes Martenot were made possible. In many ways, this transition phase for musical instruments is related to the industrial revolution in which the technique of the individual tool was replaced by the machine, for which man is merely an *operator*. A machine is built around a mechanism which encodes the *representation* of a task. Although in music a task can take many forms and may be applied to various phases of the making ad performing of a piece, musical systems can be seen from three different perspectives.

Three categories can be defined to help understand the complex nature of electronic instruments [9]:

- musical instrument,
- machine,
- representation.

As a musical instrument, it should enable the performer enough degrees of liberty to explore personal and original ways of playing with it.

As a machine, it is under the control of complex computational and algorithmic layers.

The representation integrates the two first categories. Composers use the representational nature of the system to define events, write scores and specify the computational and algorithmic layers while performers can apply gestural controls and adjust parameters [10].

A composed instrument can be seen as the result of an implementation of these three categories.

Musicological Analysis and Composed Instruments

The musicological analysis of electronic music is confronted with works composed of a variety of heterogonous structures and processes having different representations. In general the notion of a musical instrument is interweaven with that of the musical work. We believe that the composed instrument can be a helpful concept for musicological analysis in this context.

Examples of such analyses will be drawn from recent pieces realized at IRCAM: by Philippe Manoury, *Jupiter* (1987) for MIDI flute and real-time processor, and *En écho* (1993-1994) for voice and real-time processor; by Brice Pauset, *Perspectivae Syntagma I* (1997) for piano and processing; by Jonathan Harvey, *Advaya* (1994) for cello and electronic set-up; and, by Yan Maresz, *Metallics* (1994-1995) for trumpet and live electronics.

In the first examples, a passage of Jupiter by Philippe Manoury show the effect of processing a short flute moment with harmonizers and reverberation.

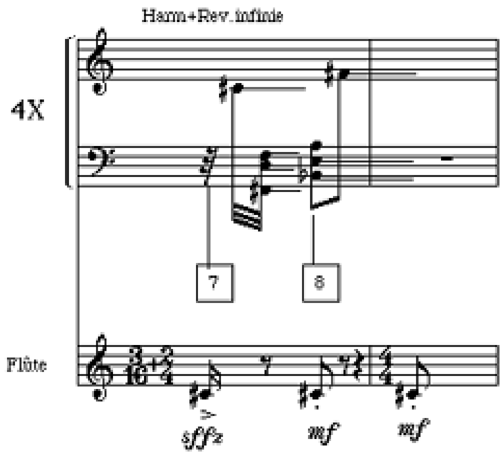

Figure 1. Extract from *Jupiter* by P. Manoury

The approach taken by the composer can be seen as an electronic counterpoint permitted by a precise notation of time, duration and pitches which are interpreted by the machine in interaction with the performer.

The next example, from *Metallics* by Yan Maresz, uses a similar set-up. However, the notation and the result are quite different. It is as if the composer had chosen to create another environment, although, technically, the electronic processing used in the former example and in this one are comparable. In the score excerpt given in figure 2, the live instrument appears on top staff.

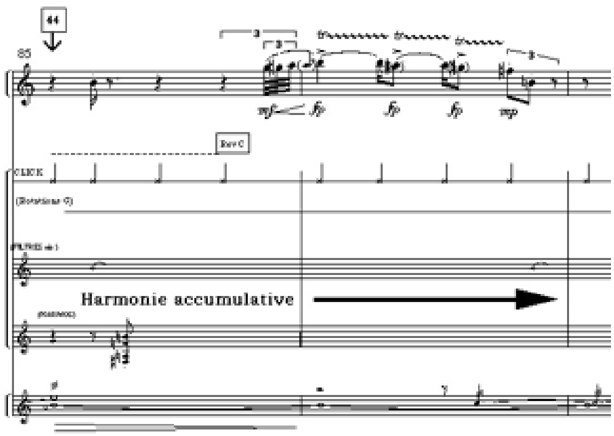

Figure 2. Extract from *Metallics* by Y. Maresz

Metaphors

With some simplification, the act of composing could be described as the determination of a musical work and the performance as its execution. In order to reintroduce the freedom of the performer to this image, a concrete work could be associated to a position in a continuous space between the perfectly determined (and identically reproducible) execution of a composition and totally freely improvised music.

A similar distinction can be found for the interaction between the performer and a composed instrument. The extreme points here can be illustrated by two examples:

- a performer pushing a button triggering the execution of a precomposed work;
- a performer controlling every smallest detail of the performance similar to playing a violin.

In the former case, the music is entirely determined by the computer system. In the latter case, it is in the hands of the performer (whether they improvise or act according to an additional score is not the important here, apart from the possibility that the score could be generated by the computer system during the performance). The composed instrument "lives" in the space spanned by these extreme points.

Interpreting the attitude of the performer of a composed instrument with the help of categories from the traditional way music is created leads to various metaphors such as that of *playing* a musical instrument, *conducting* an orchestra, *playing together* (ensemble) with a machine, acting as a *one-man band* [11], and so on. Each of these metaphors implies certain expectations towards the computer system and requires different techniques of its design. The metaphor of playing a musical instrument implies that the computer system behaves like a musical instrument. The final system may even be compared to traditional musical instruments regarding the quality of the interaction with the player.

Further metaphors can be found directly in the domain of engineering such as *executing*, *navigating* (for example in timbre spaces or other virtual spaces) [12], or *mixing* in the sense of a DJ's work [13].

Streams, Objects and Functions

What are composed instruments composed of? Computer science provides us with various data structures, models of computation, and families of programming languages. These multiple approaches allow us to structure the resources of a computer system in various ways with different results in terms of their expressiveness and efficiency. Some of these techniques are developed for the modelling and simulation of real-world systems, while others provide powerful tools for a wide range of mathematical and logical problems. From the engineering point of view composed instruments appear to be composed of very different elements such as data structures, algorithms and procedures, functions and mappings, as well as configuration settings.

The composed instrument approaches the requirements of real-time simulation and control systems. The problematic concerning the of the design of such computer systems and their software is handled in domains such as *discrete event* and *data flow systems*. In the following we will briefly present three perspectives on the composed instrument using three elementary computer science concepts: streams, objects, and functions. The aim is to work out inspiring concepts for the design of such instruments as an artist's (composers) domain, which can interface with corresponding domains of computer science.

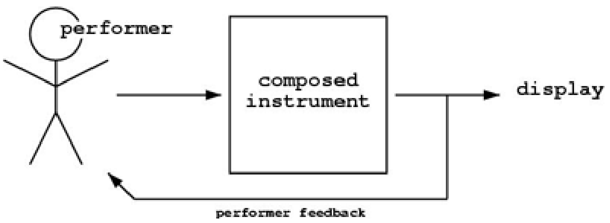

Figure 3. The performer and the composed instrument

The figure from above can be easily interpreted with the notion of *streams*. The performers gestures are input to the computer system in form of streams. The system processes these streams and outputs streams back to the performer and the audience via the display devices. For many applications the computer system can be seen as composed of processing modules passing streams between them. For a first approach the composition of the instrument from different modules can be seen as static.

Streams are always unidirectional flowing from the systems input to the system output and from the output of one module into the input of another. Many software tools such as Max [14] in the musical domain or Ptolemy [15] in the more general domain of modelling and simulation allow to represent and manipulate these modules (actors) and the connections between them in a graphical programming environment.

Since these streams are unidirectional, the interaction of the performer with the composed instrument needs at least a couple of streams. From this point of view *interaction* must be seen as defined by the processing of the systems input streams producing its output streams.

An important distinction for streams is whether they are composed of discrete events or constitute a continuous flow of (homogeneous) data. Even if the semantic of the information carried by different streams can be quite different and in for a given case closer to one or another domain such as discrete events or data flow, four categories can be commonly defined for their processing: *transformation*, *analysis*, *synthesis*, and *memorization*. A composed instrument can be seen as composed of streams running through processing modules of these four categories.

The components fitting the case of *transformation* modules are those which receive one or multiple streams at their inputs and output streams of the same type and semantic at their output. For example this can be a pitch transposed audio signal or stream of MIDI notes.

Modules of the type *analysis*, in the contrary, will output streams of a different semantic than their input streams. The streams output are the result of a parameter extraction of the input streams. While the type of an output stream of an analysis module can be the same as that of the input (e.g. an audio signal) the semantic is surely different (e.g. the continuous pitch or mean value of the input signal). An analysis module can be used to change the representation of a stream from one domain to another.

It is easy to create an example which shows the difficulty to clearly distinguish the notion of transformation from those of analysis. After all it will be always the semantic one associates to a given stream and processing module which counts. And the categories defined here can be helpful tools for the design of composed instruments only in this sense.

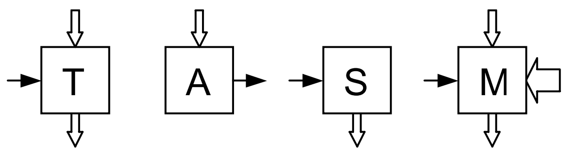

Figure 4. Stream processing modules

Synthesis represents the inverse case of analysis. Modules of this category are the origin of streams produced using a parametrization given by the inputs of the synthesis module. An interesting possibility is given by an analysis/resynthesis approach to transformation. The actual transformation is applied to the stream between the analysis and the synthesis in a different domain to that of the input stream.

In theory the input and output streams of the computer system are considered as infinite and without persistence. Nevertheless the *memorization* of sub-sequences and their (re-)composition is an evident ingredient of many composed instruments. Even if a subsequence still strongly related to the notion of streams its actual nature is those of an *object* manipulated by the performer.

Without changing its appearance the image above can be interpreted as a performer manipulating an object, the instrument, and consequently the instrument composed of dynamically muting objects. The performer acts on the state of the instrument, which is continuously displayed at the output. As done above for the processing of streams we can assign the actions performed on objects to different semantic categories such as *creation* (and destruction), *mutation*, *interpretation* (or execution), etc.

Typical classes of *passive* objects are notes, chords, entire musical sequences, video sequences, audio files (samples), tree structures and such. An audio or video file player as well as an "actor synthesizing melodies depending on a tree structure of chords and probabilities" are examples of *active* objects. Some metaphors mentioned above more easily match this object oriented approach than others. For example an instrument providing the possibilities to work like DJ does, with multiple record players and disks, is easier to describe in terms of objects and their functions than in terms of streams.

A third perspective on the performer/instrument situation is given by the functional approach. Here the overall image could be interpreted as an instrument defining the output of the instrument as a mutable function of the performers input and the instrument itself composed of functional entities. Even if functional approaches in the context of real-time systems are less explored than those mentioned above they become particularly interesting for the definition of more complex relationships between the performer and the instrument using algorithms for example based on machine learning, recognition or constraints.

It has been shown that different approaches such as data flow, object oriented and functional programming can be seen as equivalent in the sense that a program expressed with the means of one approach can be translated to another. The major question to be ask in this context is those about the relationship of a certain approach or model or paradigm to the artistic idea of the designer of a composed instrument. Which model fits best a certain artistic idea of composition and performance and which artistic idea can be inspired by a certain approach?

In this sense an authoring environment for composed instruments has to integrate multiple models of computation and programming paradigms in correspondence to a variety of different interfaces for expressive musical performance.

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