Towards an object grammar for electroacoustic music analysis and composition

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Background in electroacoustic music theory. Most of the works dealing with music analysis and computing have been interested in providing classical western music with tools and techniques for description and comprehension of the composing act (Lerdahl & Jackendoff, 1983) (Cope, 2001). But very little work has been done to specifically explore the aesthetic analysis and composition of electroacoustic and computer music in a theoretical perspective, whereas numerous examples can be found of articles describing new techniques regardless of the aesthetic and poietic implications.

Background in computing. The complexity in object-oriented programs lies in the relations between multiple entities rather than in the entities themselves, e.g. they focus on simulating the roles and the interactions of those entities rather than on their individual behaviour. With the help of design and modelling tools such as 'Design Patterns' (Alexander et al., 1977) (Gamma et al., 1995) or more recently 'model transformations' (Bézivin, 2001), software architects can work on complex abstract models while maintaining coherency between abstraction layers.

Aims. The composition of electroacoustic inherently deals with complexity. The introduction of the object-oriented paradigm in the computing world was meant to provide a solution to complex problems, difficult to solve by functional or logic programming. Object-Orientation focus on the relations between multiple entities rather than in the entities themselves, e.g. they focus on simulating the roles and the interactions of those entities rather than on their individual behaviour. While the object-oriented paradigm has been extensively used in the implementation of computer music software (e.g. *OpenMusic, SuperCollider*), rarely its theoretical component has been addressed as a mean to cast light on the musical structures used in computer music composition and analysis. With the help of design and modelling tools it is possible to work on complex abstract models while maintaining coherency between abstraction layers – what electroacoustic music composers themselves call 'objects' (Vaggione, 2001).

Main Contribution. Analysing electroacoustic music involves not only finding critical layouts of a musical piece, but also working out the syntactical elements and related grammar that are implicit in 'classical' music because of the use of a more or less common language, corollary of a (more or less) standardised graphical representation strategy. One can imagine the tension the analyst can find in an electroacoustic piece as very similar to the tension experienced between the graphical and the aural (i.e. performance) form of a classical music piece. We argue that it is possible to define specific methods for extracting meaningful inflexions in the musical discourse, permitting to create an ontology (in the computing sense) using an object-oriented approach to the musical structures, a grammar not depending on a given musical piece, and conceptually very close to the traditional score notation technique.

Implications. A working theory and technique for computer-assisted music analysis and composition requires excellent knowledge of both classical analysis techniques for music and particularly electroacoustic music, as well as expertise in state-of-the-art computing techniques, specifically in object-oriented programming. (Electroacoustic) music analysis would benefit greatly from using a semi-automated software to guide the user through defining meaningful structures, whereas computer music composition will be greatly improved by providing assistance for logical imbrication of musical structures, whether it will rely on databases or set of rules.

There exists a strong tendency in the computer music field to consider music production by software tools *per se*, without taking much attention at the results. Consequently, computer music research is focusing on creating new techniques, tools, evacuating the needs for the composers for higher-level paradigms, in which, without strictly speaking 'comprehension', tools acts as assistant. This frustration is clearly expressed in several studies and articles, notably (Nuhn, et al. 2002), (Budon, 2000), or (Risset, 1997), and most of the problems encountered by composers is one of "representation" - not only in the graphic sense. Of course, this situation is a result of the multiplicity of software tools for computer music, and its corollary, the possibility for composers to work at multiple levels of abstractions, of "time scales", in Vaggione's term.

It is interesting to see that a particular concept has been developed in computer science to solve the situation in which enormous amounts of information were involved. Instead of relying on algorithms (or flow-like data treatment), it was proposed to create higher-level abstractions, called "classes", which somehow modelled the behaviour and morphology of components of a problem, and objects deriving from these classes, possibly with minor changes. It should be stressed that a large part of the object-oriented literature is interested in "data modelling", quite different than the actual software implementation.

By combining selected music analysis principles and object-oriented theories, we aim to expose the basis for a more comprehensive approach of electroacoustic music composition and analysis. In the first section, we will describe what our methodology will consist in, then we will expose how having a well-defined object-oriented grammar can be used in electroacoustic music analysis and composition.

Methodology

Describing musical structures as *objects* (in the computing meaning), is a very difficult task. Traditional musicology considers musical structures as entities both *morphological* and *functional*, but not *behavioral*. As in electroacoustic music, the composition process is essentially based on *morphogenesis*, it is extremely difficult to draw a line between processes (used to create a structure) and its functional and morphological aspects (Vaggione, 2001).

Object-orientation as a method

Of course it is impossible to envisage the computer music field without object-oriented technology. However, if many software uses its technology and principles *internally*, it is interesting to note that few permits the user to work at abstract level with musical structures *integrated* as objects, and not merely *construed to* objects.
Basically, most object-oriented methods works the same way: defining the structural and functional aspects of the objects, defining the relations between objects and their natures, then "formalize" the ensemble in coherent terms (Meyer, 1997). Modern tools, such as *UML*, exemplify the use of *functional graphs* to describe in abstract terms an object-oriented answer to a problem - in a graphical representation style.

Musical structures and objects

Treating musical structures as objects may seem arbitrary. As we have stated in the introductory paragraph to this section, it is extremely difficult in electroacoustic music to dissociate structuring process (i.e. the composition act) and actual result (i.e. the sound or the musical phrase itself). As it is rarely possible to have access to the composer's code or original producing techniques (as pointed out in (Risset, 1997)), information on the structuring process can only be done by two methods: a) analysis/synthesis (time-consuming, and possibly not conclusive), or b) aural analysis. The latter solution has many advantages, but requires a good knowledge of the techniques used in synthesis, mixing, and general audio processing. However, "strict" aural analysis is impossible in this case, and our analysis method will have to rely on a collection of audio signal analysis.

The second problem is, naturally, that of the passage from the musical structures obtained to meaningful *objects*. Criterion such as amplitude, pitch, and timbre (spectrum) can provide morphological differentiation. Mapping these aspects in a logical manner is not an issue, as it is the "classical" approach to electroacoustic music analysis. The second property of objects is more difficult to adapt to sound analysis, as it deals with processes, by definition hidden to the analyst.

Introducing design patterns

Luckily, this problem has been central to the computer science field since the introduction of the concept of objects. The problem of *reusable architecture* (or software design) has been partially facilitated by using *design patterns*. The classical definition is given by (Alexander et al., 1977) : "Each pattern is a three-part rule, which expresses a relation between a certain context, a problem, and a solution." - at first sight, such a definition seems very difficult to apply to computer music. However, computer music analysis provides a context - a) the piece in itself, a problem - b) the aesthetic stake of it, and a solution – c) the poietic solution found by the composer to achieve b) in the context a). We purposely used the global level of the whole composition as context, to emphasize a natural property of design pattern, that of abstraction level independence: analysing a structure or a even a grain of sound can be made only by switching the context.

This leads to the abstraction level problem, which is widely discussed nowadays in computer science. A new approach has been recently formulated, that of *model transformation* (Peltier, Ziserman and Bézivin, 2000; Bézivin, 2001), which permits to use a single method for different abstraction levels – and their related representations. It involves finding a redundant method for representing a pattern, allowing multiple abstractions to be projected from it.

Electroacoustic music with objects

By working with composed musical objects in the sense we described, one will implicitly produce a particular grammar. Even if a clear definition of the grammar is still to be determined, several points are already set. We here explain what are the basic requirements to permit the formulation of such a grammar:

- *objects* in the grammar will have different *abstraction levels*, hence, they are not construed to a specific *time-domain*. This will probably result in different *representational strategies*,

- *objects* will have a *morphology* and a *behaviour* (by analogy with computer science),

- *objects* should be abstracted to *classes,*

- *patterns* must be used to distinguish between objects and their morphological components (in a crude sense, "solve" them).

This framework is relatively complex to put in place, and it requires an extreme attention, particularly in the case of analysis, to collect all necessary data not only at the "physical" level (i.e. the morphological characteristics of musical structures), but also to pay a significant attention in the way theses structures evolves *together* in time. Equipped with such information, a grammar and its related representation can be obtained.

The flexibility in terms of abstraction of the concepts of objects and patterns permits an equal ease in manipulating and relating poietics to aesthetics considerations. Such an analysis is beyond the scope of this article.

Conclusion

We discussed the various possibilities for defining an ontology for computer music, that can be useful both to composers and analysts. It is obvious that modern computer science techniques are to be employed, not only at the implementation level (as it is the case now), but are to be rooted into the way the musical structures are to be constructed or analyzed.

Modelling electroacoustic music with these tools and techniques can lead to very interesting results. We have been able to implement recently an embryonic software for composition (partly described in (Dahan, Brown and Eaglestone, 2003)), available at http://www.dcs.shef.ac.uk/~guy/mistres which uses some of the paradigms described above. One of the consequences is the time-abstraction, which means musical structures can be modelled without time scale.

Providing a new grammar for sound objects and musical structures may hence be useful to conceive electroacoustic in novel ways.

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