Creating Graphical Metaphors of Music with the Alma Environment

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Abstract

In this paper we present our research in the field of graphical metaphors of music structures and data and especially describe the Alma environment we have developed. The general idea is to split the image generation in two levels, including correspondences between musical objects and graphical elements and music to image counterpoint. We then describe the current Alma implementation. It is possible to vary the level of musical representation required. Moreover, going through three dimensional objects at the pace of music enables active links, either between the different voices of a piece or between different pieces. There are various possible applications for Alma, from music analysis to multimedia design or composition.

1. Starting from Chéreau's production of Wagner's *Rheingold*

In the video version of his famous Bayreuth production (1980) of « Das Rheingold » by Wagner, Patrice Chéreau experimented an interesting and original approach of filming the three orchestral interludes. Many other productions just show the stage curtain drawn and let the music play without any visual support.

On the contrary, Chéreau has chosen to stage these interludes. Each of them is split into three parts :

- the visible taking down of the set of the previous scene,
- a sequence dealing with a symbolic element of the narrative. For instance, in the interlude between the scenes II and III, as we listen to the famous rythm of the anvils, Chéreau proposes a vertical travelling along a metallic staircase.
- the visible assembly of the set of the next scene.

If we analyze this example in terms of adequacy between what we can see and what we listen to, we can find the following relationships :

- the shape of represented objects has sometimes to do with musical structural aspects (series of stairs related to the streaked anvil rythm).

- the material of represented objects has sometimes to do with the sound itself (metallic sound of the anvils related to the metallic stairs).
- there is a « choreography » staging the elements of the set when being taken down or assembled at precise moments in the music.
- relationships between images and music go beyond simple correspondences as in note-to-note counterpoint.

Let us see now how we can integrate the statements induced from this example in our own research approach.

2. Towards graphical metaphors of music

Our research in the field of graphical metaphors of music takes place in different frameworks :

- a research about new approaches of music analysis by the means of hypermedia applications, by giving the musicologist or the music listener the possibility of visualizing the structure of the work, the musical phrases as well as the different voices of a polyphony.

- a research about « musical open forms », it means multiple path pieces (Eco, 1962) : this deals with many aspects, not only aesthetic and related to music composition, but also with such problematics as building music programs and exploring music file databases such as MPEG3 file servers on the Web. The idea would then be : how can graphical representations of music help us to select pieces of music, not only one after the other but having musically coherent links between the ones selected ?

- a research about new kinds of operas named Virtual Interactive Operas (VIO), which are running on personal computers, and more generally applications in the field of multimedia design, by enabling the creation of « music architectures ».

To be able to propose an interesting environment to be used in these various contexts (analysis and creation) we need to state general principles that can be further refined in each particular case. The analysis of Chéreau's example has lead us to the following principles :

- there are two levels of comparison between music and images :
  - on the first basic level, correspondences between music and images are set, either dealing with symbolic representations of music (structures and data) or with its audio content, or even the difference between the score and the way it is played.
  - the second level has to do with playing in time. Whatever the images computed are, the way we go through them and show them is as important as them. This level has to do with the camera movements and the lights.

- the principles of correspondence between music and images should not be strict one-to-one counterpoint nor simple harmony. Contrary to what is generally stated by such movements as Visual Music, we claim there is no simple « harmony » between music and image either through the concept of waves as emphasized at the beginning of the century or more recently through digital format [Pellegrino 1983].

Our idea is to implement these principles on a personal computer, being able to handle music in quasi real-time to create graphical metaphors of music. This requires programs running between immediate computerized correspondence for instance just by analyzing the music spectrum and making automatic drawings from it and semi-automatic processing such as the ones used to generate cartoons including the specifications of the designers (for instance *Fantasia 2000* by Disney) or other installations such as the *Camera Musica* by Gerhard Eckel (Eckel 1997).

3. Principles of the Alma environment

3.1. Describing music

To achieve these results, we need music descriptions giving enough syntactic information. Our idea is that we have to go back to something very close to the score. The Alma system we have implemented therefore uses the GUIDO score representation (Hoos & al., 1998), to encode[1] as a text file a set of information that exist in the score, some of them being absent from such popular storage formats as MIDI. This mainly concerns :

- the chords, represented between braces. Thus **{C E G}** represents in GUIDO the C-E-G chord in the default octave. Whereas in the MIDI format, this chord would not be represented but split into three notes starting at the same date, GUIDO preserves the harmonic writing as specified by the composer, as it is a fundamental information. The chord is then no longer a list of three notes but a real object that is worth because of its intrinsic qualities as well as its relationships to the previous and the next objects.

- the musical phrases, associated to the **\slur** tag in GUIDO. This fundamental musical notation, partly inherited from the borrowing of baroque music from rhetoric, does not exist in MIDI.

- the piece structure, especially its linkings and loops. Whereas the MDI format does not deal with these aspects, the GUIDO format enables the specification of part of the piece structure by using such instructions as **\repeatBegin** ...**\repeatEnd** to enable varied re-entries. However the GUIDO format does not describe the relationships between the different entities, it is not possible to state that two parts of a piece are equal, neither can it find out any hierarchical structure. This would require either the help of a music analyst or the addition of specific software, or both. In the current development of Alma, no software

[1] the GUIDO representation uses a simple hierarchical system based on square brackets ([,]) and braces ({,}), combined to a set of tags to describe the different aspects of a score.

module is included, the user has to identify by himself the different parts of the piece, and indicate them using square brackets in a GUIDO editor. Thus, he acts as a music analyst manually annotating a score.

3.2. Adequacy principles

The first step in the elaboration of graphical metaphors of a GUIDO file consists in splitting it in significant units according selected discontinuities. It means choosing the concerned parameters and segmenting the piece into fragments where these parameters remain coherent. For instance, if one chooses the pitch as a parameter, the basic fragments can be the melodic motives indicated by the **\slur** tag.
Once the parameters are chosen and the segmentation achieved, the idea is to use functions between the set of musical parameters *M* and the set of graphical parameters *G*. There can be two types of functions :

- either functions from *M* to *G*, giving graphical objects and properties from values of musical parameters, it means *f : (musical parameter 1, 2, ...)* ➝ *(X, Y, Z, textures, lights, ...)*. For instance, we can relate the pitch to the X coordinate.

- or functions from $G \times M$ to *M*, it means *g : (X, Y, Z, musical parameters)* ➝ *musical parameter*. For instance we can imagine a sphere varying according to the tempo with such an equation as $X^2+Y^2+Z^2 = tempo^2$

3.3. Counterpoint principles

Counterpoint must be set on two levels :

- on the adequacy level detailed just below. We can imagine very simple models of counterpoint based on the principle of imitation. It means two possibilities :
  - transforming the graphical representation so that it is not the exact translation of the music object, using such musical processes as amplifying or reducing the ambitus, computing the *inversus* or the reverse sequence, etc.
  - delaying the graphical answer from the music input.

- on the level of camera movements that must not inevitably follow a linear progression in time.

4. Current Alma implementation

4.1. Developped tools

Up to now, we have developped in Alma a kernel of simple functions enabling the computing of graphical elements from musical parameters, it means only the first type of function described in the 3.2. paragraph. Simple counterpoint features are going to be included soon.

The Alma software is written in C/C++ for Macintosh (Power PC) and is based on the following software components :

- the MidiShare library for the temporal computing in MIDI and the wandering inside corridors, and to play music, before synchronization with an audio file,
- the Apple QuickDraw 3D library for the 3D graphical rendering,
- the Apple QuickTime library to enable animation cut.

Alma is integrated to a set of applications. It uses GUIDO files already created with a GUIDO editor from MIDI files, by manual annotation of music. Several kinds of files can be generated as outputs :

- 3DMF files storing the 3D generated objects. They can either be used in 3D modeling softwares or imported in Director to produce multimedia applications.

- synchronization files (text format) to use audio files instead of MIDI files. This synchronization can be achieved in Alma according to three levels corresponding to the three visualization levels detailed before (part, phrase, note), including all the more synchronization points as precision is required.

4.1. The corridor principle

We associate with each voice a corridor or 3D tunnel, with possibilities of various shapes. It means we have a function that simply tells that time corresponds to one dimension, for instance *Z*. The object that is created can either be statically browsed using zoom, translation and rotation functions or dynamically displayed at the tempo of music (which is played in MIDI using the Midishare environment), so that at any moment the user can observe the geometrical translation of selected music properties.

In the case of polyphonies, this principle leads us to have several corridors or tunnels, one for each voice. In the case of a dynamic display, the user chooses at the beginning the voice he/she wants to follow, but can turn off for other voices during the course, at the place where it is indicated by a road-sign. In the example of the figure 1, extracted from the Pamina/Papageno duo (number 7) in the *Magic Flute* by Mozart, two corridors are respectively associated with Pamina and Papagno, and indicated as panels that look like road-signs.

Figure 1. *Selecting a voice in the Pamina/Papageno duo extracted from the Magic Flute from Mozart*

In terms of music rendering in MIDI, the followed voice is underlined by an increased volume, the other ones being faded.

4.2. Links and navigation through music

One of our main topics is the creation of musical open forms designed for the listeners, no longer for the musicians. In the past, many open pieces have been written, among them some remarkable piano pieces like the *Troisième Sonate* by Pierre Boulez (1957), the *Klavierstück XI* by Karlheinz Stockhausen (1957), or the *Archipel IV* (1965-1971) by André Boucourechliev. But let us say that in these pieces the combinatory possibilities are rather designed for the player than for the listener, who does not even perceive them, since the different possible versions of the same piece are rarely played within the same concert.

This issue has to do with music selection, and music program setting. As in an open composition, we can imagine that the user can choose the next piece to come after the one currently played. If we play the A piece, should we play next B_1, B_2 or B_3 piece ? One can easily notice strong resemblances with hypertext principles : we are handling a kind of « hypermusic » space, since we seem to have information nodes, which are A, B_1, B_2, B_3 pieces and links which are $A \rightarrow B_1$, $A \rightarrow B_2$, and $A \rightarrow B_3$. But this is purely metaphoric, since links in music do not work at all as they do in hypertext. First of all, let us state that music, though being a language with its own syntax, has no other meaning than itself. This means there is no possibility that a music fragment should suggest by itself another fragment. This is the way music can surprize us, precisely by allowing the actualization of given contents to singular revelations. Contrary to hypertext, music links are here non semantic links. Let us say we can only appreciate the necessity of a musical link $A \rightarrow B$ after the experience of listening to A and B.

But the principle of the voice-to-corridor association leads to the creation of other kinds of links, since the different voices of the same polyphony can be split into different corridors, and we need links to navigate from one instrument to another. We would then have two kinds of links : either between voices in the same polyphony, that could be named as *intra-polyphonic*, or between fragments belonging to different polyphonies, named as *inter-polyphonic*. To achieve that, we added a **\link** tag to the GUIDO format. But it does not differentiate the kind of links, since it just specifies the musical phrase towards we want to go (in the future we plan to be able to specify such notions as the melodically closest phrase (for instance as it has been implemented by Melucci and Orio (Melucci & Orio, 1999)).

However, let us notice that though the **\link** belongs to the two kinds of links, their graphical representation is really different. An *intra-polyphonic* link is associated with an icon showing the instrument playing the voice the user wants to follow (see figure 2), but how can we represent an *inter-polyphonic* link ?

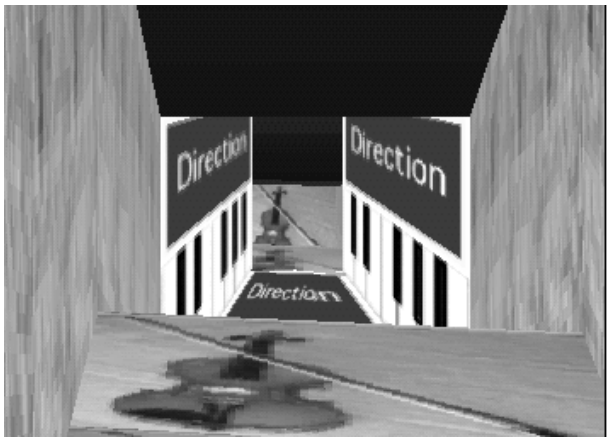

Figure 2. *An example of an intra-polyphonic link : in the « Spring »Sonata by Beethoven for violin and piano, the user follows the violon part (icon on the ground) and comes across a place where he/she can click on a piano icon (side walls) and then join the piano part*

We here face again the impossibility of music prescription : a music cannot indicate another one in an unique way, but the musical meaning is set afterwards (Boucourechliev, 1993); on the other hand, it is not possible to create an univocal icon of music. Two fragments played one after another will or will not make some music, it is impossible to predict it, this can only be observed afterwards. The only possible icon would be the one indicating that the current fragment is linked to another one, that the two together maybe make music. A reasonable representation of this phenomenon would maybe be an icon asking the question of the presence of music, maybe just a question mark.

4.3. The principle of variability of the observation level

In Alma three hierarchical levels of music can be represented :

- the sequences or the parts of a piece,
- its phrases or sub-phrases (Gervais, 1992),
- the notes.

Let us start by the elementary level, dealing with notes. One dimension in space either vertical or horizontal (left-right) is associated with pitches, so that it either builds the ground or the side walls of the corridors representing the various voices. The silences are represented by empty spaces. The pitches are associated either with slopes separating two successive notes or with steps, each step being associated with a note.

On the upper level, it means sub-phrases and phrases, the Alma program starts from note sets belonging to the same sub-phrase or phrase, to reduce it to two, three or four points, according to the following principle : the lowest pitch in the phrase is looked after; let *m* be that note; then the highest pitch is looked after in the same phrase; let *M* be that note. Let *a* and *b* respectively be the first and last notes in this phrase. We know that and come to several cases :

- either *m* and *M* belong to the [*a*, *b*] interval : it means in fact that *a* et *b* correspond to *m* and *M* (or *M* and *m*). In this case, the musical phrase will be represented by the [*a*, *b*] segment.
- either *m* belongs to the [*a*, *b*] interval and *M* does not belong to it : in this case, the musical phrase will be represented by the gathering of two segments : [*a*, *M*] and [*M*, *b*].
- either *M* belongs to the [*a*, *b*] interval and *m* does not belong to it : in this case the musical phrase is represented by the gathering of two segments : [*a*, *m*] and [*m*, *b*].
- either *m* nor *M* belong to the [*a*, *b*] interval : in this case, the musical phrase will be represented by the gathering of three segments : [*a*, *m*], [*m*, *M*] and [*M*, *b*] or [*a*, *M*], [*M*, *m*] and [*m*, *b*].

Though very simple, this approach gives rather good results on the perception level when dynamically displaying the 3D objects and playing music. However, it better fits rather continuous phrases as often in classical or romantic music that discontinuous phrases as in contemporary music.

Last but not least, concerning the top hierarchical level, dealing with sequences and parts, the representation is once more reduced; it can for instance be based on modulations instead of pitches, since we have added a **\modulto** tag to the GUIDO format. Concerning durations, average values are represented by less or more strias for each part, corresponding to the average flow of notes.

4.4. Other parameters in the representation

Perpendicularly to the selected dimension for pitches (either by default the vertical one or the left-right axis in the horizontal plan), other parameters are represented as the phrase curve, the vertical density, the modulations and/or the associated annotated harmonic events. Therefore, the corridor shape, its color or texture can correspond to any of these musical parameters.

It is planned in a further version to be able to handle global light sources for the scene and local sources for the beginning of musical phrases.

5. Applications

Except music analysis, we have used Alma in the field of opera for two very different projects :

- the first one is a virtual interactive opera, named *Virtualis*. In this framework, we have created a space to wander inside music interludes and have added to the musical links previously described textual links corresponding to keywords pronounced by the singer, and also « clickable » images as shown on the figure 3. The user can click on the words « de la voie » but also on the image of the Goddess.

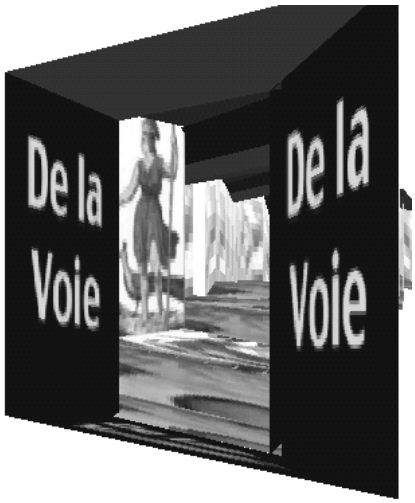

Figure 3. *Example of Alma use for the Virtualis CD-ROM opera*

- the second one is a projected set for « real » opera performances to take place next august in l'Ile d'Yeu (France). The opera is *Norma* by Bellini. The set will be dynamically modified according to music.

6. Conclusion

We have shown the metaphorization capacities of the Alma environment, that can interest music listeners, musicologists, multimedia designers, composers or even set designers. On a functionnal point of view, the software will be upgraded with modules enabling :

- the comparative analysis of the parts of a piece,
- the representation of analogies and differences between several pieces described in several GUIDO files.

On a technical point of view, an OpenGL version will be developed in the next monthes, taking advantage of the capacities of this standard library.

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