

PHASE Project
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Human-Computer Interactions

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1 Presentation of the project

From the end of September to mid December 2004 (and during the days of sound design), a demonstration of *PHASE* will be presented in the children's gallery at the Pompidou centre, in the form of an interactive installation offering the public a musical game. Different from a video game the aim is not to animate the pixels on the screen but to play with the music and to incite a musical awareness. The pedagogical aspect is therefore important, children are also concerned by the system. The demonstration is not the only objective of *PHASE* since an important part of the project has been to experiment and research the use of the movement of the visual and sound haptic feedback with the aim of manipulating the music.

2 Playing the music with the help of an articulated arm with force feedback

PHASE is a *RIAM* project with several partners grouped together to realise a system of multimodal interactions with a view to manipulating the sound and the music:

- The CEA-List has carried out the haptic research,
- Haption has realised the haptic interface,
- Ondim has looked after the integration and visual realisation,
- Ircam has carried out research into sound and musical manipulations and defined the interaction metaphors.

CNAM-Cedric has been involved in the game scenario and its ergonomics.

The system realised by *PHASE* is a complex prototype:

- a computer (RTAI-Linux) manages the position sensor and the engine of the haptic arm (Virtuose),
- a computer (Windows XP) runs the engine for the physical interactions (CM-Labs Vortex) the engine for the scenario and the stereoscopic graphics rendering (Virtools) and centralises the communications via ethernet,
- a computer (MacOS X) which deals with generating sound and music (MAX/MSP),

- a fourth computer (MacOS X) which spatialises the sound on the audio rendering system (*Spat* Ircam on eight speakers).

Taking into account the different skills involved and in view of the technical difficulties, the research and realisation have been distributed into different modules, with two major concerns:

- what control is accessible to the user by his gesture?
- what musical play is possible?

Different approaches putting the various modalities together in different ways have created different realisations. Numerous interactive examples are available.

2.1 Gesture and the haptic feed-back

An abstract module of the gesture control has been realised for several reasons:

- Because of the complexity of the system it is important to be able to test the musical or sound behavior *with interactive gestures* without using the haptic system since it involves technically complicated realisations. For example we have used a Wacom tablet or a simple mouse for fast developments. The complete system is obviously necessary for the final adjustments and it has proved interesting to have validated certain concepts and realisations already by means of simulations.
- We have also been able to record certain gestures to replay (in order to experiment, regulate and validate sound dynamics behaviour) and to analyse them (outside their time of execution) with or without the haptic arm.

By haptic feedback, we mean tactile (the tactilo-kinesthetic sense) and force feedback (proprioceptive sense). This haptic feedback is very important to control the gesture. What feedback should be offered? We come to the problem of representation since it is necessary to define which sensation is being researched, which gesture expected and finally which access to the music. This point also concerns the visual and sound feedbacks for which the user also positions his action. Different paths have been explored.

In order for the user can have a certain expression to his gesture, the idea is to use the haptic as a guide, to reduce the constraints inherent to an instrument that requires a certain practice for its control. The learning process is also made easier by the scenario of the game.

2.2 Playing the music

Roland Cahen, the composer involved in the project has had a central role in the musical research.

Aware that our principal mode of interaction is the gesture, the instrumental game is a possibility, among others, to play the music. More generally we have searched which liberties could be left to the player in a given musical space. One can, for example, have access to the rhythm, timbre and tonality, etc. Different modes of playing (gestural and musical) have been identified:

- positioning oneself in the music

- browsing the music
- conducting the music
- playing the music like an instrument

There are different kinds of music to play (and re-play):

- Well-known music can be easily identified and it is then easy to find one temporal position, but the music is otherwise fixed and not adjustable;
- One can realise music that is adaptable for the expected manipulations;
- One can program music generators to interact on certain musical points in particular.

Different musical interactive tools have thus been realised:

- manipulating musical phrases, created specially, fixed and easy to transform;
- generating a staccato flow enabling numerous variation, programmed and interactive;

The use of musical structures close to notes requires a sound generator, like a MIDI sampler, with the possibilities and limitations of this type of sound synthesiser:

- a software sampler has been created *ad hoc*;
- fluidsynth with soundfonts has proved very efficient.

Work on the sound material – fixed or generated – has also been realised using the granular synthesis. This offers a privileged access to time allowing the system to replay the music in different ways:

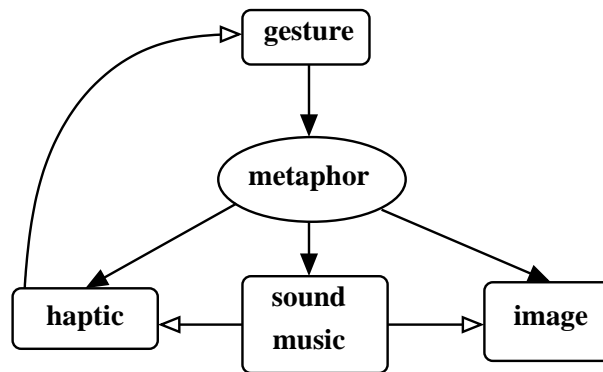
- one can control directly the temporal development if this is fixed in space;
- if the time evolves in its spatial representation, one controls a relative speed;
- and if one controls the evolution of time in a spatial representation, one can play by accelerating and slowing down.

Another approach consists in leaving a physical virtual world (or even constructing one) and trying to listen to it in different ways. It is tempting to exploit the different measures coming from the physical engine directly, particularly with the use of physical models synthesis. But it is not easy to avoid the risk of ending up with a metallic sound. The musical link between the different physical and sound objects still needs to be defined.

Whatever system of sound generation is used, it is always possible to take advantage of its different particularities, especially by diverting it, but it then becomes difficult to generalise the method. The following question remains: how to combine the problems of writing and playing sound and music, according to the dynamic controls one wishes?

2.3 The metaphor as a bond between the real world and the music

The gesture of a user exists in the real space universe (containing his hand), and is aimed at manipulating music. Various feedbacks (haptic, sound and visual) influence its gesture. Haptic in itself is a loop of direct feedback, since the gesture and the feedback are localised in the hand of the user. The *metaphor* ensures the coherence between the various modalities. It establishes the link between the real world – and the hand – and the musical virtual world.



The system presents different constraints:

- the gesture is performed within a spatial universe with temporal dynamics or not,
- a physics engine calculates the force feedback for the haptic device (the objects are defined by their form, mass and contact properties; they interact via forces),
- all the modalities must be coherent for the user.

According to the relations desired between the modalities and keeping in mind that the goal is to play music, one can define several metaphors, which lead to various realisations, more or less close to reality. We present several examples, which are combined in the game in order to enrich the interaction:

- the direct interaction resembles the sonification. It takes as a starting point the physical model and produces a significant immersion for the player because the modalities are close to those usually perceived in reality: the physical objects are sound sources. The interaction between the user and these objects are similar to play an instrumental.
- special zones of interaction: the physical world is just a musical pretext, for sound navigation for example, like a microphone moving in space for audio mixing.
- replay of a fixed music within a three-dimensional space, like the diamond inside a LP track: the musical course is then strongly related to the space course. According to whether the disc is spinning or not, one can conduct in various temporal modalities.

This last metaphor was particularly developed to be the very centre of the play.

3 The writing head and the playing head metaphor

The actors composing this metaphor are three, and they can produce an already significant amount of interactions:

- **the writing head** (*WH*): one hears and sees the *WH* which generates a music according to the actions of the player. This music is written along the space as a visual and haptic trace that the *WH* leaves behind it when it moves.
- **the playing head** (*PH*): the player handles the *PH*. When he places himself on the trace, he feels and hears the music, which he is replaying. The *PH* pursues the *WH*.
- **the trace** inside the track links the *PH* and the *WH* together. The *WH* writes the trace, which scrolls when the *PH* is inside. Thus, the movement of the *PH* is relative to the trace and the player controls indirectly the speed of the replayed music. To follow or to catch up *WH*, the player must follow the music thanks to the trace.

The choice of this metaphor was justified for several reasons:

- **analogy with the real world**: one can think of a LP whose track would be engraved (by the *WH*) and replayed by a diamond that can be hold in one's hand (the *PH*).
- **well-known game mode**: a race between the *WH* and the *PH*.
- **musical principle**: the principle of replay is close to the fugue, the canon or the counterpoint.
- **facility of gesture**: the trace is written inside a track which serves as a guide for the player.

The player must listen to the *WH* and play with it. This is a standard musical situation, except that the rhythm is not quantified: the relative speed of the two protagonists varies continuously.

It can then become difficult to distinguish the two musical actors, which is a musical issue in itself: for the system design, because one wants to help the game, but also for the player who must listen both to the other and to himself in order to position himself within the whole music.

4 Conclusion

The use of a haptic device to play the music raises many questions about the techniques employed, for scientific research and the music itself. During the *PHASE* project, hardware, software and methodological tools were developed, to allow the realisation of metaphors having a musical direction. These are now available.

The realisation of the game integrates various metaphors, proves the validity of such a device, as the large audience was enthusiastic, and opens up the way to many musical gestures.

PHASE is a big project and it is unfortunately not possible to cite everyone here. I would like to thank Ruth Shefton-Green for the english translation; the mistakes are mine.