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A digital emulator of the photosonic instrument

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Abstract
In this paper we describe the digital emulation of a optical photosonic instrument. First we briefly describe the optical instrument which is the basis of this emulation. Then we give a musical description of the instrument implementation and its musical use and we conclude with the "duo" possibility of such an emulation.

Keywords
Photosonic synthesis, digital emulation, Max-Msp, gestural devices.

INTRODUCTION
We have implemented the photosonic synthesis in the Max-Msp real-time environment, and linked it to gesture devices. We will show in this paper how the original instrument is, how we emulate it, and how this emulator can be played and what are its capacities.

THE OPTICAL INSTRUMENT
This original instrument has been conceived by Jacques Dudon [6], and has been described extensively in [10] and with music in [5,7,8]. We will here only focus on aspects which are important for its digital emulation. The optical instrument can be represented (see Figure 1): a light (L) emits rays that go through an optical disk (D) and an optical filter (F). Some of these rays are summed up by a photocell (C), and the sound is produced by amplification of the electric current of the cell. No analog or digital synthesiser are inside the chain. The beauty of the sounds issued from this instrument come from two reasons: the disks themselves integrate complex and musical shapes, and define timbral space that can be explored, and the gesture of the two hands (one for the light and one for the filter) is ergonomic and gives the possibility of an expert gesture [3].

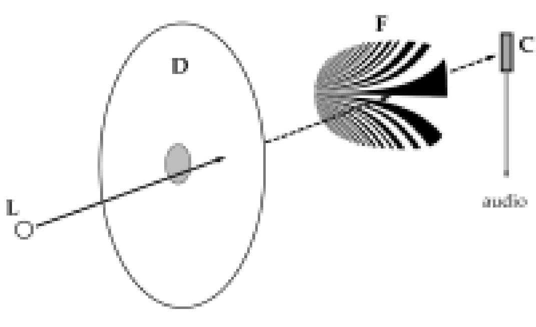

Figure 1. The photosonic optical instrument:

The photosonic disks
It is easy to build musical scales using the repetition of a waveform along different rings (see Figure 2). This enables the disks to reproduce any just intonation scale.

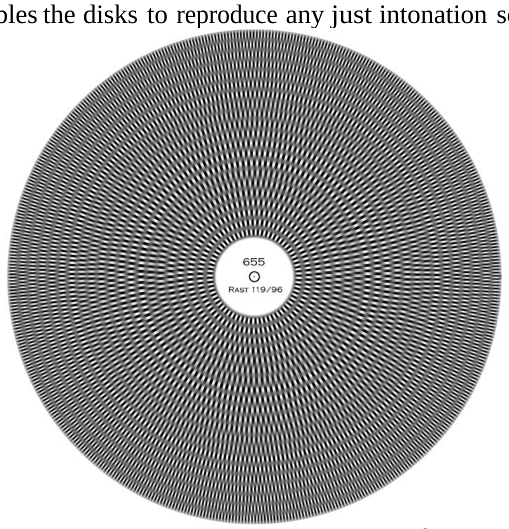

Figure 2. A disk with repetitive waveforms:

Modelling complex waveforms drawn on a disk (see Figure 3) is more difficult and has needed the writing of the WaveLoom program [1]. The research on these forms and graphical treatments are always perceptively related (differential tones, intermodulations, subharmonics, pseudoperiodic or fractal tones).
At the present day more than 900 have been devised by J. Dudon, and this still constitute only a small part of the possible musical material accessible to the optical disk technology.

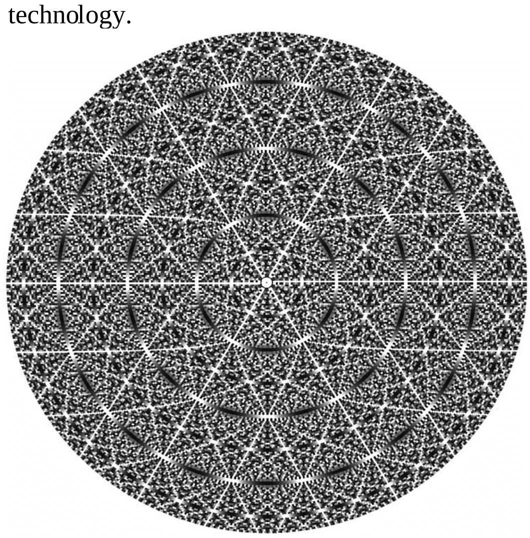

Figure 3. A disk resulting from graphical operation:

WaveLoom, a program to make disks

All this musical research has been rendered possible because of the implementation of a dedicated program, Waveloom [1], written and tested by Patrick Sanchez, which includes a language to build disks (as postscript files) with graphical operations musically sensible. This program is constantly enhanced as long as new operations are required for the make up of new disks.

the comb filter.

The optic filter (F) offers a very intuitive control of the coloration of sounds similar to overtone singing, along with attack, vibrato and chorus effects. This filter may integrate a square signal waveform, or other waveforms (see Figure 4).

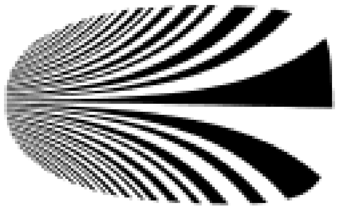

Figure 4. An optical comb filter

It brings smoothness in the interpretation and a great expressiveness to the material that is on the disk. The research carried at the Atelier d'Exploration Harmonique has especially focused on the intermeshing of the timbre aspect and intonation palette, because both of them are included in the harmonic texture of the disk [9].

THE EMULATOR

This "photosonic emulator" emulates the photosonic synthesis process that is intrinsic to the photosonic optical instrument previously described. This emulator has already been presented in an early stage in a non real time situation [2], so that we will focus here on the performance aspect more than the technical details.

The photosonic emulator instrument itself consists in a Macintosh computer with a Max-Msp patch dedicated to this emulation, on which a A4 oversize Wacom tablet is plugged with a pen and a mouse as input tools.

Figure 5. Playing the emulator virtual instrument

This emulator is part of the "Geste créatif en Informatique musicale" project [4].

The core of the synthesis process is in two parts:

- the disk emulator, which extracts information from the circular disk and mixes the sound of the different rings in a way similar to the action of the photocell in the optical instrument. This process is possible because the WaveLoom program that builds the disks themselves is able to produce a series of wave files corresponding to the rings. This mixing process is done according to a curve stored in a table which indicates the programmable influence of the neighbour rings (see Figure 6). A pre-filtering of the wave files is also carefully done to emulate the photocell bandwidth and to avoid aliasing due to the digital processing of the rings.

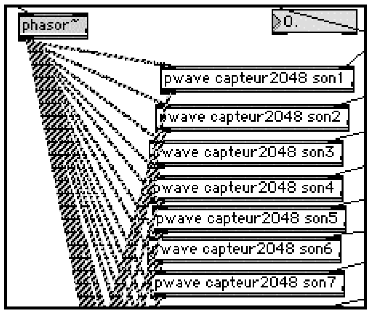

Figure 6. A part of the "light emulation" patch

- the graphical filter which passes in front of the cell in the optical instrument is emulated by a changeable digital filter. Recursive comb filters do not emulate well the Doppler shift and the attack transient (when abruptly placed) of the graphical filter, so a 256 point FIR implementation has been programmed where this filter is taken from an horizontal line of matrix (see Figure 7).

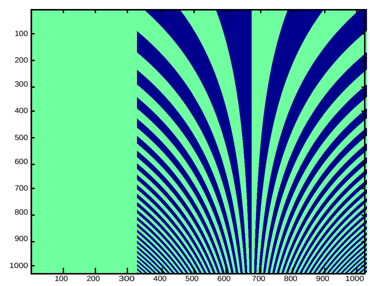

Figure 7. A matrix used by the digital comb filter

What is the control panel of the patch?

The control panel of this Max-Msp patch consists in six parameters (see Figure 8). Four of them are controlled by the graphic tablet devices:

- the x and y position of the graphic filter which is put between the light and the cell

- the x and z position of the light, which corresponds to a scanning of the disk with a "distance" parameter

Two of them are changeable on the patch:

- the speed of the disk which is usually fix but can be linked to any midi controller

- a "width factor" which indicates the stretching factor (or variance if it is a gaussian) of the curve describing the influence of respective rings.

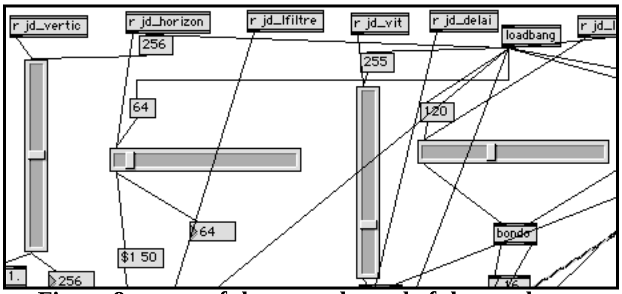

Figure 8. a part of the control panel of the emulator

PERFORMING WITH THE EMULATOR

The emulator is not only a research product, it is a musical instrument and one may ask different questions:

How to play on this digital instrument?

In our preferred implementation

-the disk memory directly comes from pre-filtered files corresponding to the different rings and is chosen at the beginning of a session.

- the "light gesture" emulation is produced by moving the mouse on the tablet inside the left and bottom part of the tablet (see Figure 9 for right-handed persons).

- the filter gesture emulation is produced by moving the stylus inside the right and top part of the tablet; the speed of the disk is directly chosen in the Max-Msp patch panel by moving a virtual potentiometer. An octaviation and double octaviation is produced when the lateral switch on the stylus is activated down or up (see Figure 8)

- the "width factor" is also adjusted by ear and controlled by a Max virtual potentiometer.

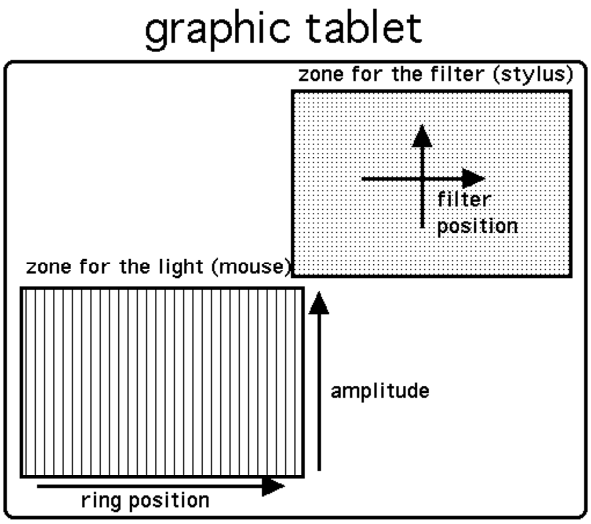

Figure 9. visual feedback of the ring and amplitude

During a performance the two hands are moving simultaneously (see Figure 10) with a sonic feeling similar to the one of the optical instrument. The basic gestures such as "moving the light" and "moving the filter" give the same sonic variations as the optical instrument, though it does not look for an exact reproduction of the initial sound : this digital instrument has its own sounding rendering linked to the digital generation of the sound, especially due to the digital filter.

Figure 10. the two hand situation with the emulator

The haptic feeling is however very different from the initial instrument: instead of moving a light in the air, we now have to browse a mouse on a surface and this brings sensation very near to the use of a "pied" in the natural instrument. Pointing with a stylus for the filter position is different to hold a graphic filter in hand in front of a cell, and is more as a "pencil situation", a fact strengthen by the use of the lateral button as an octaviation feature.

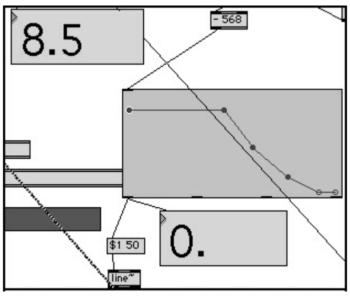

Figure 11. visual feedback of the ring and amplitude

The visual feedback (see Figure 11) on the screen can be of great help in the positioning of the light: a number is written (with two decimals) indicating the position and this gives an easy way to place the virtual light just in front of a virtual ring. The same is true for the distance of the light, where the indication of the amplitude is given. Though it would have been possible to draw a 2D simulation of the movement of the graphic filter on the screen,, a set of two potentiometers reflecting the coordinates has proved to be enough. This is due to the fact that the vertical and horizontal move of the filter give two different musical situations. The dissociation between the input (tablet) and the graphical return is a constant in many emulators. In a way we are conditioned by the "mouse effect" which dissociate the pointing from its representation.

What kind of music can the emulator play?

The emulation process uses the combination of an additive synthesis -the rings- and an subtractive feature - the filter-. The global situation of this instrument is that one is immediately surrounded by the sound; whatever the position of the mouse and the pen in their working zone, the sound is there, great, full, precise. As a matter of gesture, learning to move independently or simultaneously these two sensors (pen and mouse) brings the exploration of the sound material that is inscribed in the disk definition and the harmonic embellishment provided by the filter which is typical for this instrument. Combining these two gestures is strongly dependant upon the structure of the chosen disk : every disk appeals for different positions and movements. In one sense one can say that the real potential - that can be actualised or not- of the instrument comes from the research done on the disks. As an example the choice and ordering of the rings not only brings the melodic and harmonic materials but also the possible melodies and timbre melodies themselves.

So what about events? Are we confined, according to a taxonomy of gesture, in only modulation gestures rather than decision gestures (references in [4])? Yes and no; Yes because the instrument appeals for such gesture, it is really a theatrical situation of exploring a sonic space with two hands; but also no: as an example the octaviation switch on the pen immediately brings the apparition of notes, a fact that can be enhanced by the use of delay lines as an effect. In an other direction the use of a narrow "width factor) for the rings means that scanning the disk gives the feeling of the separation of the rings hence individual notes. Whatever function one superimposes on amplitude or other parameters also brings a pattern, a shape, and sequencers though not part of the emulation can be easily linked to the Max-Msp patch. Once again this depends upon the composer and/or performer attitude, many layers can go on top of the emulator itself or it can remain as a performance instrument.

Solo or duo?

The emulator can of course play solo. Sounds issued from this instrument can really mimic the original instrument; the pertinence of the structure of the disk is so strong that it builds an architecture of which the instrument , optical or digital, makes a customisation.

The musical combination of an optical and a digital emulator in a duo reveals some specific features of these two implementations: the haptic features of the optical instrument is really a must, the precision given by the digital version allows new ways of building musical ply situations. So musical play can explore not only imitation but also dialogues and contrasts.

CONCLUSION

The situation is still open concerning the respective possibilities of these two instruments: each of them improves every year due to the challenge of the musical situation, and of course even much more from the duo situation that will be shown in a performance at NIME.

These instruments are in the general line of bi-manual gestural control [11], and the emulator uses specific mapping strategies of a virtual instrument. We have depicted here a practical aspect linked to the performance, but the research behind is linked to many other possible developments or contexts [12].

ACKNOWLEDGEMENTS

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