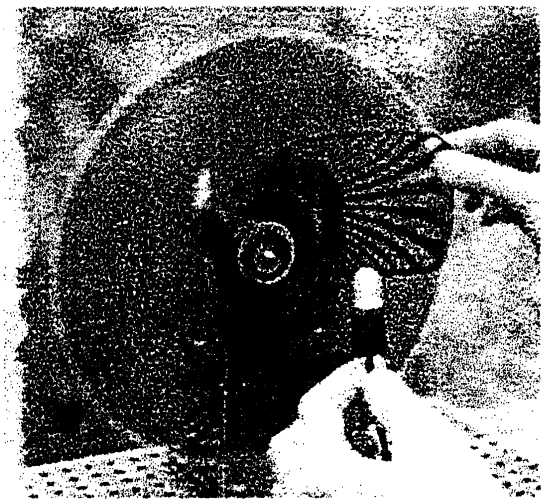
A DIGITAL VERSION OF THE PHOTOSONIC INSTRUMENT

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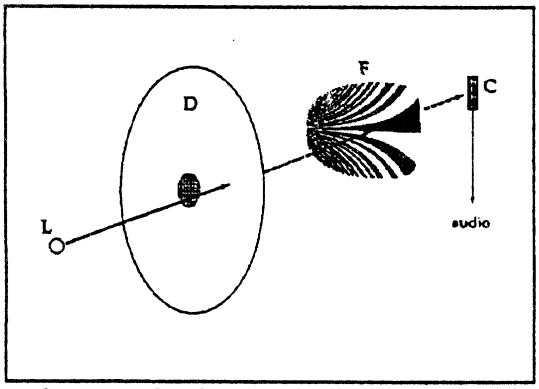
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ABSTRACT

The photosonic instrument has proved to be a analog synthesiser with good sound, scales and music. Its computer simulation (especially in real time) aims at a better knowledge of its characteristics, and is by itself a new instrument.



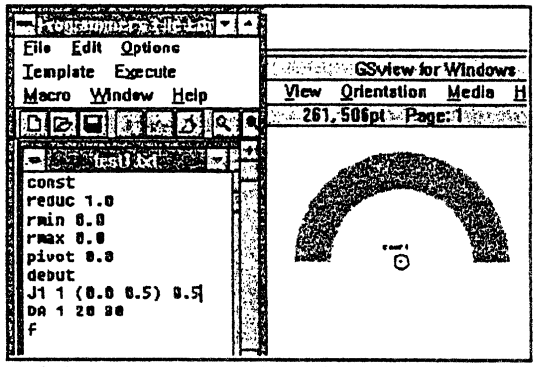
1. The photosonic instrument is an analog musical instrument invented by Jacques Dudon in the eighties. Its basic implementation consists in a moving source of light directed toward a solar cell. In between the source of light and the photocell we put a rotating disk on which waveforms are drawn in circular rings.



the principle of the photosonic instrument

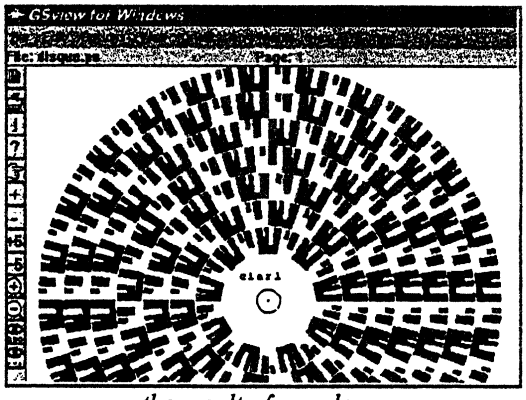
The sound is directly coming from the induced current of this cell. A very important device is a graphical "comb filter" which is a graphical mask that can be put and moved around on the trajectory of the beam light between the disk and the cell. We could at first think about this instrument as a beam of light which scans the disk but the cell by itself is a surface so a really integrating process takes place between rings of the disk.

2. More than 500 disks have been produced by the "Atelier d'Exploration Harmonique" . The first samples were hand cut but then two versions of a software helped the design and drawing of disks on transparent sheets. Till the 90s it used a plotter and then a standard postscript printer. A graphical language has been developed to build waveforms that are radially spread as rings on photosonic disks.



a disk programmed in "waveloom" (P.Sanchez)

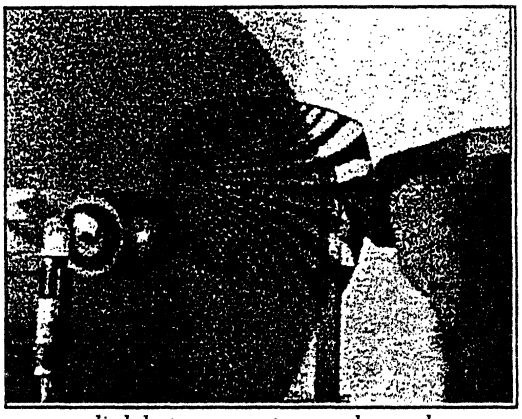
Just intonation scales are of course a must with these disks but also studies have been made on specific timbres (formant structures, difference tones, subharmonics). Though the sound is periodic (at the frequency of rotation of the disk) fractal and noisy sounds have been made.



the result of waveloom

3. this instrument can be complexified (multiple rotating disks, graphical sequencer, automatic moving lights, a.s.o.) but even in its basic implementation it uses the two hands : the left one holds the light source in a 3D space and the right one the interference filter between the disk and the photocell (so it is mostly a 2D movement). This instrument is very precise : depending upon the shapes that are drawn on the disks a palette of possible sounds is given and the musical gesture really depends on the choice of this palette.

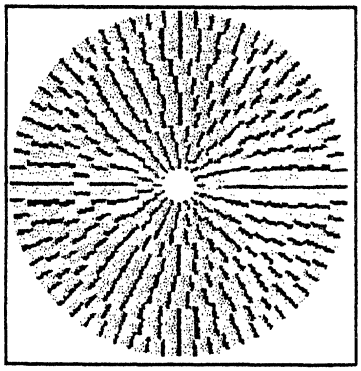
4. The idea behind the simulation of this instrument in the form of an electronic digital instrument is very much oriented to the gesture control : here we have an analog instrument which has a direct one-to-one relationship between the positions of the light and filter and the resulting sound, according to the chosen disk.



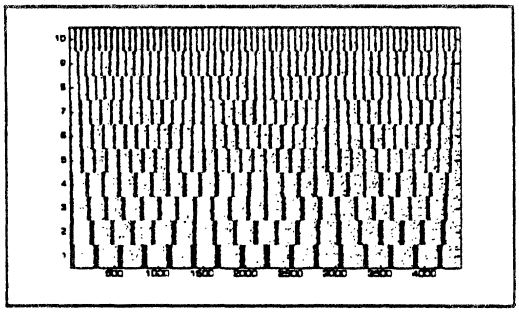
link between gesture and sound

5. The first step is to understand what is the relation between the light position and the sound. The filter brings a very strong coloration which is inherent to its structure and position but only sculpts the sound that would otherwise occur. The photocell is a surface cell so we can think of the cell as integrating the different intensities that arrives from the beams that touch its surface. This has proved to be true : if rings are somewhat thin, there is a blend between them, depending upon the position of the light. This filter action of the cell is dependent on the position of the light (the radius in the original instrument) because the projection of the shadow is not the same according to the position of the light. There is also a cut-off frequency of the cell by itself.

6. a Matlab implementation has been made to simulate the process : the disk can be assimilated to a 2D image, which can be thought as warped (or looped) in the time domain.



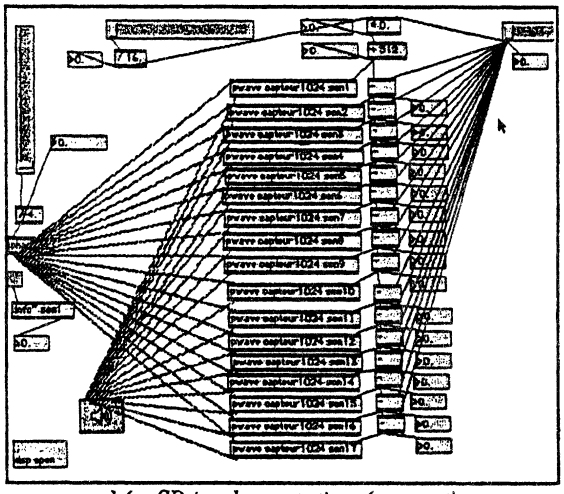
the original disk



its matrix version

The effect of the surface of the cell - or other stated the non-focus of the light beam - can be approximated by a 2D filter on this image. This 2D filter can be separated in two 1D filters : one in the time domain, and one in the vertical selection domain. The first one simulate the blend between rings, the second one the fact that the cell has a certain physical high.

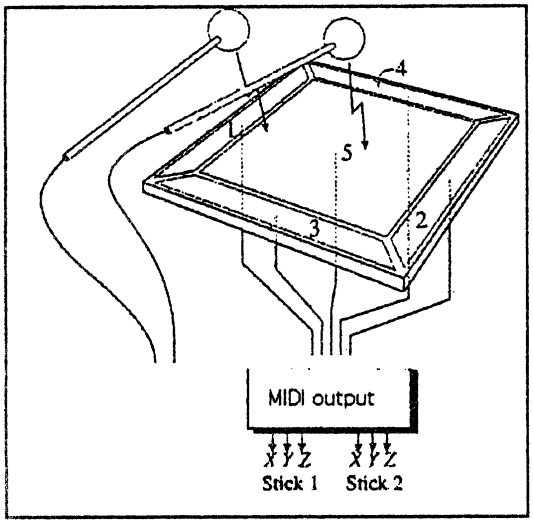
In the basic matlab implementation, we give a disk description which builds a matrix symbolising the disk, and a x(t) function which describes the displacement of the light in the horizontal dimension. This curve is rendered vertically in a matrix where each column represents the blending of different rings. The process uses loops and multiplication of matrixes.



a MaxSP implementation (excerpt)

7. A MSP implementation of the basic instrument has been done on a MacIntosh . Different rings are installed as files and loaded in looped oscillators. These files take in account the cut-off frequency of the cell so that what is loaded is in fact already transformed by the filtering corresponding to the temporal action of the cell.. the amplitude of these oscillators are variable and will depend upon gestural controls. These amplitudes are calculated by a table look up in table giving the 'ring blending' effect, and has two parameters : the radius where the light is played, and the focus of the spot. One slider controls the fundamental frequency of the

sampling of the waves, simulating the rotation of the disk. Two other simulate the horizontal placement of the light and its distance from the disc. A comb filter is then added to modify the sound according to its filtering function.



a radio baton control

8. The Radio-Baton is a device which tracks the motions of the tips of 2 batons in a 3 dimensional space._ The main components of the system are 2 batons, and a base unit called the ``antenna." It has been deviced by Max Mathews and we have a MIDI version at CNRS in Marseille. It has been linked to the photosonic simulator in order to provide a gestural control. The first baton simulates the light, and the second one the placement of the filter.

9 Concerning sound results, first of all one must say that there is a family resemblance between the "true" version and its digital clone, but the secrets of the initial instrument are well kept.

- The original instrument has idiosyncrasies that are hard to match: the flutter of the rotation, the imprecision of the printing, but also more specific terms : the photocell being by itself an ensemble of sensors has a filtering function which is not only a lowpass filter. Saturation and hysteresis can occur in the cell that are not easy to match. The gesture uis also very neat. The positioning of the light is very precise : ring can be as small as 3 mm and the hand is able to adjust the position so far. The graphical comb filter is very intuitive and not only it filters but can give rise to dynamics attacks and release due to its edges when it comes in the field of the sensor.

- the digital instrument is a perfectly pitched instrument, and just intonation scales sound just like they have to do. The sound is digitally clean and it can use disks that are the digital copies of the former ones. The control with a "radio baton" is very handful for experiments but other 3D sensors could be used. The musician is a little bit lost by the absence of visual feed-back. The comb filter still needs to be improved to match its initial characteristics. In general This first implementation proves to widen a large field of new experimentation. But also this instrument is very powerful in itself : "disks" can be stored and changed instantaneously, rotatin speeds can be synchronised very easily, and it is a very good basis for a study on gesture mapping. The "vocabulary of gesture" is an important step for these instrumetns to be used for composed music.

10. conclusion :this study has proved to be very helpful to understand some of the characteristics of the original instrument, and also allows to start a new research on timbre mapping respective to gesture.

REFERENCES

"CD : Lumières audibles", by J. Dudon, éditions "les Mondes harmoniques", available for 20$ including postage from the Atelier d'Exploration Harmonique, les Camaïls, 83340 Le Thoronet, (tel : +33 (0)4 94 73 87 78)

"synthèse photosonique", 1990, byJ. Dudon & D. Arfib, in *1er congrès français d'acoustique*, les éditions de physique, Lyon

"les harmoniques lumineuses de Jacques Dudon", 1993, by B. Dubreuil, in *Musicworks, n° 55* , Toronto (with a CD)

"waveloom, logiciel d'aide à la création de disques photosoniques" ,1996, by D. Arfib & J. Dudon, in *3emes journées d'Informatique musicale, actes du colloque*, Cahiers du GREYC, université de Caen.

"Jacques Dudon, music of water and light", 1996, by Bart Hopkin, in *Gravikords, whirlies & pyrophones*, Ellipsis Arts editions , New York (with a CD)

"cohérence différentielle : une nouvelle approche de la consonance", by J. Dudon, in *Actes des JIM'98*, CNRS-LMA, Marseille

"the photosonic disk", 1999, by J. Dudon, in *Experimental musical instruments*, vol 14, #4 (with audio cassette) PO Box 784 Nicasio, CA 94946 USA

The radio baton image has been taken from: http://wwwccrma.stanford.edu/CCRMA/Courses/252/sensors/sensors.html