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► **To cite this version:**

Paul Chable, Gilles Azzaro, Jean Mélou, Yvain Quéau, Axel Carlier, et al.. Macrogroove: A Sound 3D-sculpture Interactive Player. ACM International Conference on Multimedia (MM '19), Oct 2019, Nice, France. pp.1153-1154, 10.1145/3343031.3355709 . hal-02267053v2

**HAL Id: hal-02267053**

**<https://hal.science/hal-02267053v2>**

Submitted on 21 Aug 2019

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# Macrogroove

A Sound 3D-sculpture Interactive Player

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Figure 1: *Next Industrial Revolution*, a sculpture from Gilles Azzaro [1].

## ABSTRACT

*Macrogroove* is an interactive and playful multimedia system that allows the user to play a sound coded in the form of a 3D-sonagram. The user is invited to manually move a laser sheet over this “pseudo-relief”, in order to playback the original sound in real time.

## KEYWORDS

Sound, 3D-printing, 3D-sculpture, interactive player.

## 1 INTRODUCTION

Sculpting a sound in 3D is a long-standing dream of the French artist Gilles Azzaro [1]. While sound is a 1D-signal, which can thus be represented as a 2D-curve, its time-frequency representation, for example in the form of a *sonagram*, provides a 3D-model: one dimension for time, another one for frequency, and the last one for amplitude. This well-known 3D-representation of a sound signal is particularly suitable for 3D-printing. Thanks to some modifications,

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MM '19, October 21–25, 2019, Nice, France

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ACM ISBN 978-1-4503-6889-6/19/10.

<https://doi.org/10.1145/3343031.3355709>

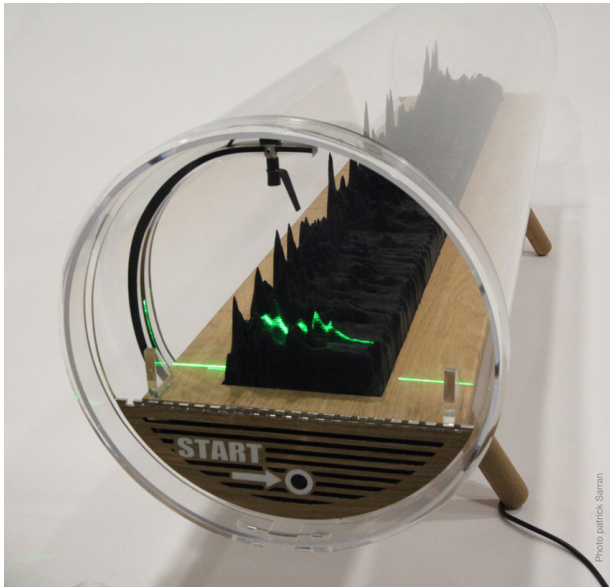
Gilles Azzaro knows how to transform this 3D-representation of a sound into a real artwork (see Figure 1).

## 2 3D-SONAGRAM READING

Another of Gilles Azzaro’s dreams is to read such a 3D-sonagram i.e., design a system able to turn the 3D-sonagram back into a sound. This would mimic the behavior of a diamond stylus reading the microscopic variations encoded in a vinyl disc, or *microgroove*. In the sought macroscopic version, a sensor moving along the time axis would analyze in real-time cross-sections of the relief, or *macrogroove*. Each section corresponds to an instantaneous spectrum of the signal (see Figure 2), therefore it seems possible to read a 3D-sonagram and playback a sound by inverting the time-frequency transform. However, many technical obstacles make this idea difficult to achieve. This is why Gilles Azzaro called on the REVA team at IRIT in Toulouse, who has expertise in both multimedia and 3D-reconstruction by artificial vision.

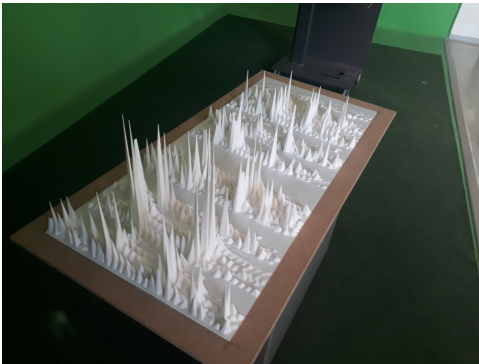
## 3 SIGNAL CODING

The first obstacle comes from the fact that the spectrum is not easily invertible. Indeed, the Fourier transform of a real signal (sound) is a complex spectrum. However, a 3D-representation can only encode part of this signal, for instance the amplitude. The phase is thus lost, which results in distortions in the reconstructed sound, as can be observed using the *Phono Paper* [2] app, which



**Figure 2: A laser sheet reveals an instantaneous spectrum.**

reads 2D graylevel sonagrams. It could seem more relevant to rely on the cosine transform, which is real if the signal is real. The problem with such a 3D-representation is that the peaks are very sharp, even using a logarithmic transform in  $z$  (see Figure 3). In addition to be less visually appealing, such sharp shapes would be difficult to accurately reconstruct in three dimensions using a depth sensor, which would result in noisy sound reconstructions. We therefore choose to keep the original version of Gilles Azzaro’s 3D-sonagrams, which code the complex module of the Fourier transform, and include some aesthetic modifications.



**Figure 3: Sound coding using the cosine transform.**

## 4 SOUND RESTITUTION

Two steps are required for sound restitution. First, we light the 3D-sonagram with a laser sheet, as shown in Figure 2, which in fact gives us a temporal reference, and second we scan its 3D-shape using a depth camera. At each iteration during playback, we get

the local depth values from the 3D-sculpture under the laser beam and from this information we determine the chunk of audio which needs to be played. An important peculiarity of this piece is that it is interactive and playful, since the user has the control on the playback: he gives the pace of lecture and can also decide on its direction (forward or backward).

## 5 CONCLUSION

At present, we only have a relatively rudimentary prototype of this multimedia system (see Figure 4). To better evaluate its relevance, a video accompanies this submission, where the sound is nothing more than a sentence in French: “Pas une personne ne chante comme une autre” (“Not one person sings like another”). The scrolling is done by manually moving the sonagram by hand, making it difficult to control the reading. In the final version, which will be presented at the exhibit, the movement will be controlled by means of a handwheel, hence much more precise. The playful aspect will therefore consist in trying to reproduce the original sound in the most faithful way possible, or on the contrary to deliberately distort it. Of course, any sound signal can be read: if accepted, our multimedia player will be presented in such a way that the user chooses a 3D-sonagram, like a vinyl disc, places it under the interactive playback system, and then “plays” it, as a barrel organ player would do.



**Figure 4: Prototype of our multimedia system.**

## REFERENCES

- [1] Gilles Azzaro. 2019. Homepage. <http://www.gillesazzaro.com>. Accessed: 2019-05-20.
- [2] Alexander Zolotov. Latest release - 1.6 (2018-03-10). PhonoPaper. <http://www.warmplace.ru/soft/phonopaper/>. Accessed: 2019-05-20.