“GMU” - An Integrated Microsound Synthesis System

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Abstract. The GMEM (National Center for Musical Creation) has created an integrated microsound synthesis system called GMU (“GMEM Microsound Universe”) inside the Max/MSP environment. GMU works in real time and its center is made of a few microsound synthesis objects (written in C at GMEM). Around these objects, we have elaborated sophisticated sound control strategies, with high-level interactive access inputs. They can be deterministics or stochastics. The whole system offers many connections with tools for Composition Aided by Computers (written in Common Lisp and Java) and tools for sound analysis. Before describing our system and its applications, we will show how the synthesis and transformations of microsound have already been significant in music nowadays.

1 Introduction

Sound synthesis made by computers to create music has undergone very important developments in the late sixties and seventies. Our knowledge about the nature of sound has vastly improved during this period

At the end of the late sixties, Max Mathews had already enounced the essential of the sound synthesis techniques known today [4]. Jean-Claude Risset described the way to synthesize most musical instrument sounds [8].

At the end of the late seventies, Xavier Rodet proved that it was possible to produce singing voice synthesis by using a computer. He found out that the main difficulty is to develop parameter control convincing rules. In that, synthesis parameters must be interconnected [12].

During the late nineties, sampling expanded a lot, reducing the use of sound synthesis in music. Actually, the development of microcomputers and home studios has promoted the use of traditional sounds (with the General Midi standard). This has slowed down research of new sounds.

Recently, a lot of people have become more and more interested in new sounds. Some open environments, like Max/MSP, let the user construct his own synthesis tools. He needs to do programming, which is sometimes tricky, because he has to take into account many constraints related to “real time” processing. Other environments, like Csound, belonging to Max Mathews “Music N” programs, are used to program instruments which can produce sound “out of time”. The user can concentrate only on producing sound, without the real time constraints.

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2 Microsound Synthesis

What we decided to do is consider sound as a particle process rather than as a wave process.

This is not a new idea but generally it is not used in the main classical sound synthesis techniques in which harmonic analysis is the cornerstone. Gabor was obviously the first to have defined the notion of "sonic quanta", which is a very short sine wave [3].

Then Xenakis has developed a new composition theory in which he takes grains as the basic constituent elements. He proposed to create complex sounds with random distributions of thousands of grains, that he called a "cloud".

> "All sound, even all continuous sonic variation, is conceived as an assemblage of a large number of elementary grains adequately disposed in time?. In fact within human limits, using all sorts of manipulations with these grain clusters, we can hope to produce not only the sounds of classical instruments and elastics bodies, and those sounds generally preferred in concrete music, but also sonic perturbations with evolutions, unparalleled and unimaginable until now. The basis of the timbre structures and transformations will have nothing in common with what has been known until now" [16]

He proposed different stochastic laws about the control of the parameters of grains. This allows one to get closer to the natural sounds without having to specify the time evolution of each grain.

Since the end of the seventies, Curtis Roads has built different programs to generate artificial sound grains. He tried to create a granular sound system, with some controls of the sound parameters, allowing optimal sound quality and the best flexibility for a musical use. While studying the shapes of the amplitude envelopes of the grains, he has proposed a good compromise for these shapes: he uses Gauss functions for attack and release, and a small steady state in the middle [9].

In the late eighties, Barry Truax was interested in synthesis techniques that would allow him to create sounds similar to environmental sounds. He achieved one of the first and most powerful granular sound synthesis real time system (PODX on a PDP11 computer) [14].

In 1994, I worked with the composer Manuel Rocha. He made many pieces using only granular sound synthesis. For him I created many tools inside "PatchWork", the Ircam algorithmic composition program, for the control of granular sound synthesis made with Csound [6].

Later on, Manuel Rocha built, with the computer programmer Gerhard Eckel, the GIST "Granular Synthesis Tool Kit" system on the Ircam Musical Workstation. This system generalized the synthesis sound technique of the FOF ("Fonctions d'Ondes Formantiques", used for singing voice sound synthesis) for the micro-fragmentation of sampled sounds [1, 11].

3 The GMU Project

Considering these different concepts, we have decided at Gmem to create our own microsound synthesis tools and to put them into a more general integrated compositional system for control.

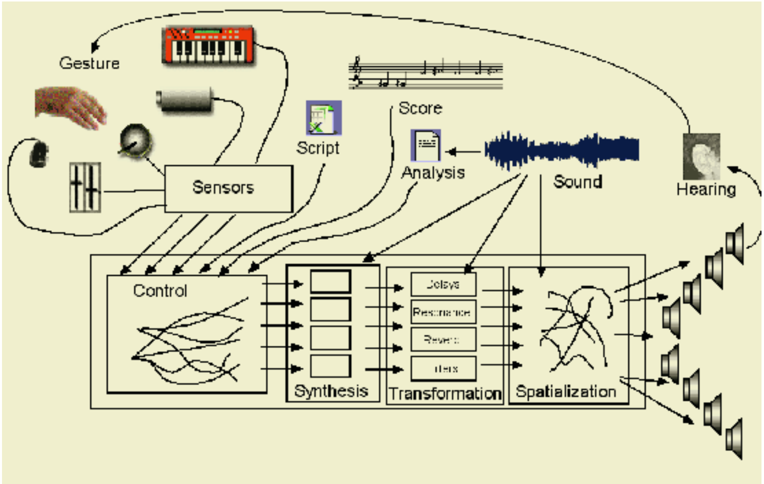

Fig. 1. The GMU microsound synthesis system.

This system has to take into account the different steps and methods involved in the compositional process. At the same time, we propose powerful sound synthesis generator units, a multi-speaker holophonic system and models and tools for the parameter control.

This system can be used for real time interactive applications on Max/MSP platform and for non real time applications on Csound. In this text, we will discuss only the Max/MSP version.

4 Generator Units

The base of our environment is made of several microsound generator units (grain makers) programmed by Loic Kessous (PhD student - Paris VIII University) and myself. These units create polyphonic streams made of grains with which waveforms and amplitude envelopes can be of several types.

The Envelope. Three types of grains envelopes are available:

- linear envelopes made of three straight lines of variable relative durations,
- gaussian envelopes,
- envelopes with a sinusoidal attack, a sinusoidal decay and a steady state.

The linear envelope contains some discontinuities making the sound aggressive and rough, especially in asynchronous streams. It can be used to produce streams where grains overlap and then can generate continuous partials (providing that phases are respected).

The gaussian envelope is very soft but most of the time it doesn't contain enough sound signal. It is useful with high-density clouds.

Lastly, the third envelope, which can be found in the FOF synthesis, is a very good compromise to create many types of sounds. It contains both a steady state and soft attack and decay.

The Waveform. Three situations have been considered:

- the waveform is artificially synthesized,
- the waveform is taken inside a memory stored sound,
- the waveform is taken from a live play sound.

In the first case, we can use a sine waveform but it is possible to use many waveforms stored in tables. It is possible to apply non-linear distortions to a sine wave (frequency modulation or another technique) too. Now, only the sine waveform is available in our real time system.

In the second case, the grains are taken from recorded sounds that can be instrumental, environmental or others sounds. The microsound synthesis can then resynthesize the original sound if the grains are played in the right order and if some criterions are respected. The grains can be played with different speeds and different rates so we can create transpositions or duration variations of the original sound. It allows the user to observe the sound as if through a microscope. Barry Truax has sometimes realized sound stretches with a factor of 100.

Other Parameters. Considering one type of envelope and one given waveform, a grain is characterised by the following parameters: its duration (typically from 10 to 50 ms), the transposition (or the frequency), the attack and decay's lengths, the position in the sampled sound where we take the grain (for sampled waveforms only) and the output direction. Inside a grain, the parameters don't change.

Start Times. The different grains are triggered by an audio signal. One grain is triggered when the audio signal goes from negative values to positive values (zero crossing).

If we use a sine waveform to trigger the grains, we obtain periodic triggering.

Several grain makers can be used at the same time and be triggered in a synchronous manner (with the same audio signal) or asynchronous. A synchronous triggering can produce harmonic sounds. This is the technique used, for example, for a singing voice synthesis. Asynchronous triggering can produce complex textures. The timbre of these sounds depends on the way we change parameter values.

The synthesis needs to produce streams composed of thousands of grains each second. The grain makers that we use have to produce up to one hundred grains simultaneously.

"Grain makers" have a lot of outputs. Panoramic parameter tells us which output will be given to each grain. The grains are sent to resonators and reverberations that contribute to the timbre of the sound.

5 Control of the Parameters

A grain maker can be controlled directly by sending values to it. These values can be produced by stored messages or by a gesture input device.

At a higher level, some functions have been programmed to deliver stochastic values (Brownian movement) between a minimum value and a maximum value.

For sound production to varies in time, the ranges can be modified dynamically. A graphical editor allows the user to draw curves describing the evolution of each parameter in relation with time.

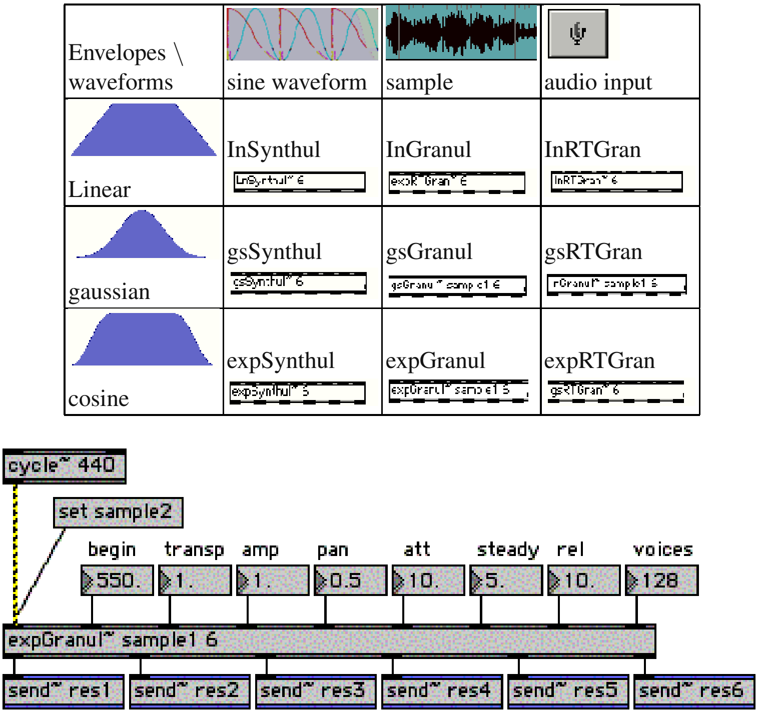

Fig. 2. The expGranul obejct with its synthesis parameters. Separated outputs is triggered with a sine signal.

Finally, connections were made by Jean-François Oliver (ATIAM DEA student) and myself with programs for algorithmic composition (Holo-Edit from Gmem or Open-Music from Ircam), which makes it possible to develope the evolution of the various parameters with graphics, music notation, sound analysis or many algorithms,

Some tools were realized in Max/MSP/Jitter to graphically represent the parameters of grains. They were made with the Open-GL graphical libraries. They help to control results of the synthesis. In future applications, they could be used to build artistic illustrations of sound.

6 Applications

Our main goal is to produce tools for musical applications. We wish to remain connected with musical production and to adapt our tools to artistic demand.

The first musical experiences I made with microsound synthesis were with Manuel Rocha ("Transiciones de fase": 1995) and Jean-Baptiste Barrière ("Le Messager": 1996) with the GIST synthesizer on the Ircam Musical Workstation.

In Marseille, during the festival "Les Musiques-2002", we used our system for the piece by Eric Abecassis "Straps" for the real time granulation of acoustic instruments played live.

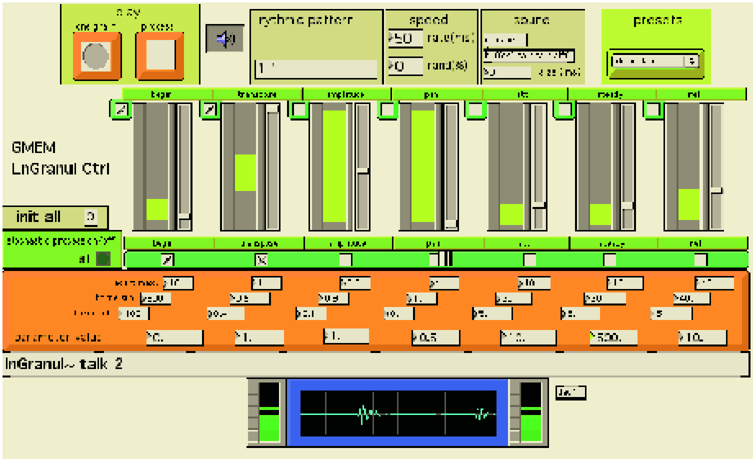

Fig. 3. Max patch with sliders used for control of range inside which the parameters for grains synthesis are calculated.

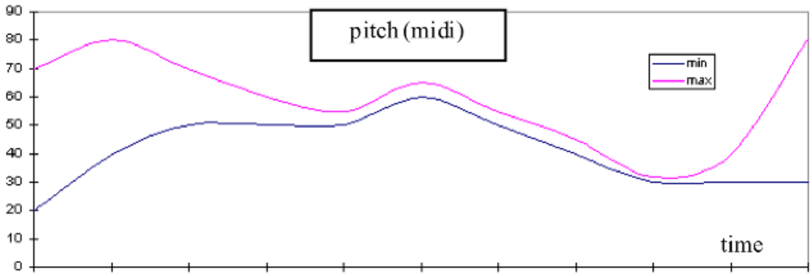

Fig. 4. Graphical description of the variations of pitch of grains.

At Gmem, composers have always been attracted to environmental sounds more than to harmonic sounds. Their main tool is the microphone as a first step and then signal manipulations inside a studio. Granular sound synthesis techniques interest them more and more because they have the advantages of both synthesis and sound processing. Primarly, these tools are built for fulfill their needs.

7 Perspectives

We are certain that synthesis technology is promising. Contrary to the widespread opinion observed in the late nineties, we think that all possibilities available with sound synthesis have not yet been explored. Sound synthesis is a very new field in music, especially with the exploration of micro-time domain, at a scale lower than perception. Microacoustic phenomena has been badly understood as yet. We must explore this domain and develop new tools and new expertises.

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