

## LIVE-ELECTRONICS ALGORITHMS IN THE MULTIMEDIA WORK "SWIM SWAN"

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### ABSTRACT

*Swim Swan* is a multimedia work for clarinet, live electronics and computer graphics. The principles underlying the work are exposed and a set of sound-processing and synthesis algorithms that are used in this work are described. The issue of the control of the computer by the clarinet is emphasized. The artistic issues of such a work are addressed.

### 1. INTRODUCTION

*Swim Swan* is a multimedia work for clarinet, live electronics and computer graphics [1].

#### 1.1. The reasons for live electronics

In general, the term "live electronics" means that electronic music is performed along with musical performers on stage. Electronic music has developed in the 50's. In that time the most frequently used devices and methods were ring modulators, oscillators or manipulations on the magnetic tape. The sound material was either based on sound synthesis or concrete sounds. These methods, that were new at that time, have broadened the scope of music through the introduction of new sounds and of new musical ways of thinking. Numerous musical works conceived according to these principles have entered the repertoire of contemporary music [2, 3].

The composers were very interested in these new methods but, on the other hand, the possibilities to perform the pieces were limited to those of the tape recorders and of the loudspeakers. In such a situation, the music comes from a loudspeaker, is not performed by a musician and all performances are similar which is somehow disturbing for the music listener. In order to prevent this situation, the composer may prefer to have performers on stage. They have to deal with the issues that are specific to their musical instrument as well as with those of the live-electronics equipment. This is not an easy task but it offers new means of expression and it enlivens as well the musical performance.

We will now address the work *Swim Swan* more specifically which comprises three components: a clarinet, a computer-music as well as a computer-graphics system. All three components are interrelated and the system should be considered as a single entity but we will concentrate here on the live-electronics issues. Instead of giving a formal presentation of the musical elements, we will rather give a set of examples and explain excerpts of the work which are by themselves autonomous cells. They will appear at

several locations throughout the piece, each time with a slightly differing appearance.

Please fancy an abstract space where strange events happen, driven by an absurd logic. Do not imagine here boring or horrible scenes but consider rather the drawings from Max Escher or the wonderland of Alice. She experiences strange situations and meets fabulous creatures in this wonderland where both the logic of the real and of the imaginary worlds superimpose with seamless transitions from the one to the other. The piece *Swim Swan* has been inspired by such a model. The clarinet is placed in an imaginary world where fiction and reality gather, forming a strange mixture. The clarinet, as an acoustical musical instrument, stands for the real world whereas the sounds originating from the computer represent the imaginary world.

Relating both worlds seamlessly in order to create an absurd but plausible identity is the challenge of this work. In other words, the intent was to create a sound world where the relation between the clarinet and the computer is intimate and complex, building a musical identity.

#### 1.2. Algorithms

The focus of this paper is the relation between the clarinet and the various algorithms that are used throughout the work. The acoustical features of the clarinet sounds control the sound-processing or synthesis algorithms. The details of the implementation won't be described here because they can be found elsewhere [4, 5, 6]. Each algorithm is illustrated by a musical excerpt where it can be clearly identified. In the course of the work, several algorithms will be put to work simultaneously to serve the musical purpose of the composer.

### 2. ALGORITHMS

The capabilities of the clarinet are extended in *Swim Swan* by various means.

- Sample processing
  - Triggering samples of various musical instruments or individual words of a single phrase
  - Control of the replay speed of these samples
  - Wording of a tongue twister.

- Sound synthesis
  - Control of a narrow-band noise generator
  - Control of a set of chaotic generations processes
  - Control of a set of non linear processes.
- Clarinet-sound processing
  - Vocoder
  - Delay loops.

In order to control these algorithms with the clarinet, a pair of feature-extraction algorithms are used. The first is an amplitude follower computing a moving average of the squared input signal [4], the second a pitch follower available in the Max/FTS environment [5].

The clarinet signal is needed both for the control issues and as input to the processing algorithms. However, each of these applications have specific requirements as to the quality of the input signal. The sound processing algorithms require a high audio quality, hence a studio microphone is used. On the other hand, the control algorithms need signals that are well calibrated and free of environmental noise. The amplitude and the pitch should be accurately correlated to that of the clarinet but the audio quality itself is not an issue. For this application a probe microphone is preferred. It is inserted close to the mouthpiece of the clarinet.

Whether the performer is practising, rehearsing or playing in concert, he/she will exhibit differing loudness ranges. This can be an issue when the sound-synthesis or sound-processing algorithms are sensitive to definite levels. Pre-processing the probe-microphone signal by a compressor-limiter will help cope with the large amplitude differences experienced between rehearsal and concert.

**Clarinet loudness - Variable speed replay:** As well as the clarinet can vary the loudness of its sounds, the computer can produce variations on its sounds (Fig. 1).

**Clarinet pitch - Sample selection:** As well as the clarinet can utter different sounds, the computer can produce different words (Fig. 1).

**Clarinet loudness - Narrow-band noise generation:** The timbre of the clarinet can be enriched or perturbed by computer sounds that follow and adapt to the clarinet sounds. In the chosen example, a narrow-band noise comes along with the clarinet (Fig. 2).

**Clarinet pitch - Narrow-band noise generation:** The synthetic sounds can also be influenced by the pitch of the clarinet (Fig. 2).

**Chaotic generation process:** As well as the clarinet is autonomous in the real world, some processes, e.g. a chaotic process, can be autonomous in the virtual world (Fig. 3).

**Non linear processes:** Whereas the clarinet cannot duplicate itself, the computer can easily drive several processes simultaneously. Three non-linear processes are activated according to the pitch of the clarinet. A time-management system, controlled by the pitch of the clarinet, triggers the processes (Fig. 4).

**Delay loops:** A means of duplicating the clarinet is to make use of the computer memory. Some excerpts of the clarinet melody are stored and replayed with some delay, all at once or with delays and iterations (Fig. 5).

**Vocoder:** The ability of the clarinet to vary its timbre is rather limited but the computer can help it produce timbre variations that are intimately related to those of the natural clarinet, e.g. with a channel vocoder (Fig. 6).

**Clarinet pitch - Sample triggering:** The previous computer-generated sounds were related to the timbre of the clarinet but

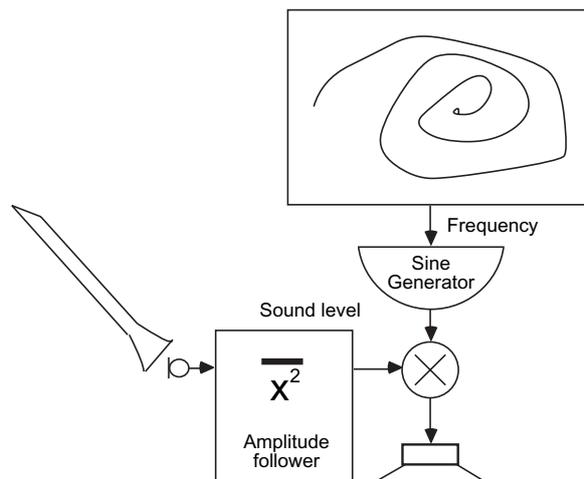


Figure 3: A chaotic process process is defined by a recursive formula the output of which is used to tune an oscillator. The amplitude of the synthetic sounds depends on that of the clarinet. While the chaotic process has an autonomous existence within the computer, the performer has command on its presence to the public or not.

sounds of different origin can also be controlled by the clarinet such as those from a double bass, a xylophone or a piano (Fig. 7).

**Clarinet pitch - Wording:** One says that the instrument player lets sing its clarinet when he can enliven its sounds. Thanks to the computer, the clarinet can even sing the individual words of a tongue twister. This can be achieved by letting the pitch of the clarinet trigger sampled sung words. The relationship between clarinet and sung words is defined in the score (Fig. 8).

### 3. CONCLUSIONS

#### 3.1. From the artistic idea towards its realization

The artistic idea is an abstraction that can be barely described. In some manner, the artist tries to realize this idea but the result is usually different from the abstraction that was thought of. This is due to the fact that idea and realization cannot be put at the same level of thinking. Once the result of a process is heard, it influences the idea and it implies a modification of the realization. In this manner, the artistic work gets formed under a mutual interaction between artistic idea and technology (Fig. 9).

The graphical part of *Swim Swan* is based on methods similar to those of the musical part. A few notes trigger various graphical objects. Some chaotic objects as well as Mandelbrot sets are active. The color depends on the pitch and on the loudness of the clarinet.

#### 3.2. Between engineering and composition

The work *Swim Swan* has required the collaboration between an artist and an engineer. The communication between two persons that have different knowledge fields is difficult because identical words may have very different meanings but the communication can be greatly improved when the words can be illustrated by sounds. Algorithms are often more effectively described by sounds than by words. The discussion at the level of the auditory result

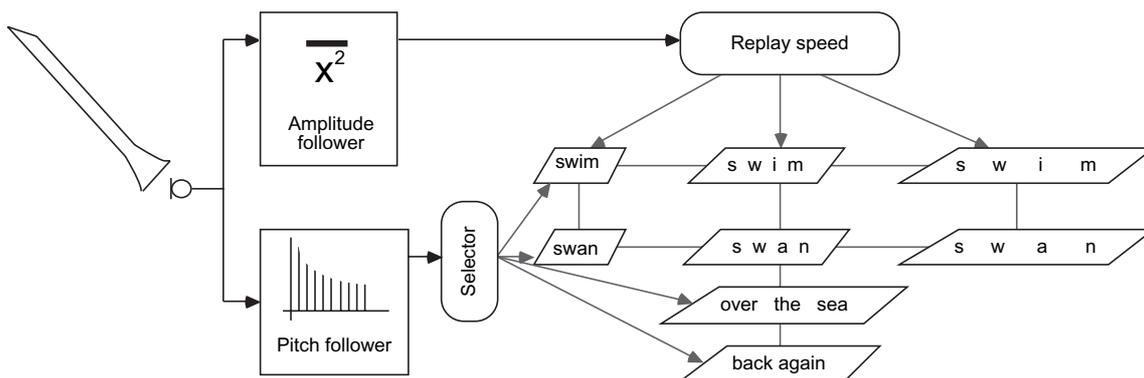


Figure 1: The amplitude of the clarinet sound controls the variable speed replay of speech samples - The computer plays a speech sample out of a predefined set. It decides which sample to play according to the pitch of the clarinet.

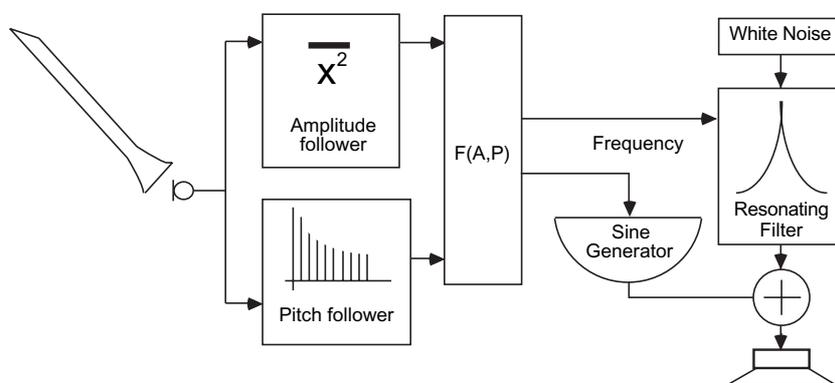


Figure 2: The tuning of the noise source depends on the loudness of the clarinet. The louder the clarinet, the lower the pitch of the accompanying noise - The relationships between pitch, loudness and synthesis parameters are determined according to composition rules.

helps indeed define and improve the artistic and technical frameworks.

### 3.3. Works to follow

Due to the high complexity of the computer system that was required in 1993 for the performance of the piece, it could be performed only a few times after its creation. If the live-electronics and computer-graphics parts of *Swim Swan* were ported onto an up-to-date computer system, it would be compact enough for a clarinet player to practise at home and to perform concerts on its own. However, the principles and methods that were derived while composing *Swim Swan* were put at work in following works such as *Die Gabe des Lapislazuli* [7] which is implemented on a system that can be set up more easily. Another follow-on project is the multimedia opera *den ungeborenen Göttern* [8, 9]. In this work, the interaction between musician and computer is not limited to the auditory domain but has been extended to the visual domain.

### 3.4. Beyond the limits of a human performer

The composer and the musical performer are always striving to reach and go beyond the limits of the capabilities of their mind, of their expressive means and of the instruments that they employ. The live-electronics system is a way of extending the capabilities

of the clarinet as an acoustical musical instrument, of the human performer as far as the control and expressive capabilities are concerned as well as the horizon of the composer who can deal with an additional level of abstraction within the imaginary world. The composer and the performer need the computer to realize their predefined project whereas the capabilities of the computer system enables new ways of thought and of action for them through a kind of retroactive loop. Although the clarinet player drives the computer, it has to listen to its response in order to adjust its play. This situation is pretty much similar to that of the various players in an orchestra who have to coordinate their play. Hence the combination composer / performer / computer-system should be considered a single man-machine system.

## 4. ACKNOWLEDGMENTS

*Swim Swan* was commissioned by ZKM - Center for Art and Media, Karlsruhe. It was created during MultiMediale 3, ZKM, 1993. The work reported in this paper was done as Pierre Dutilleux was employed by ZKM.

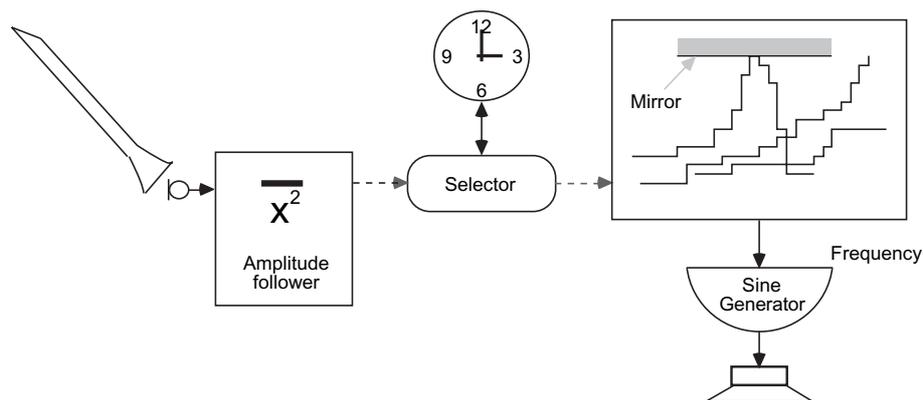


Figure 4: Three non-linear processes are activated according to the pitch of the clarinet. A time-management system, controlled by the pitch of the clarinet, triggers the processes.

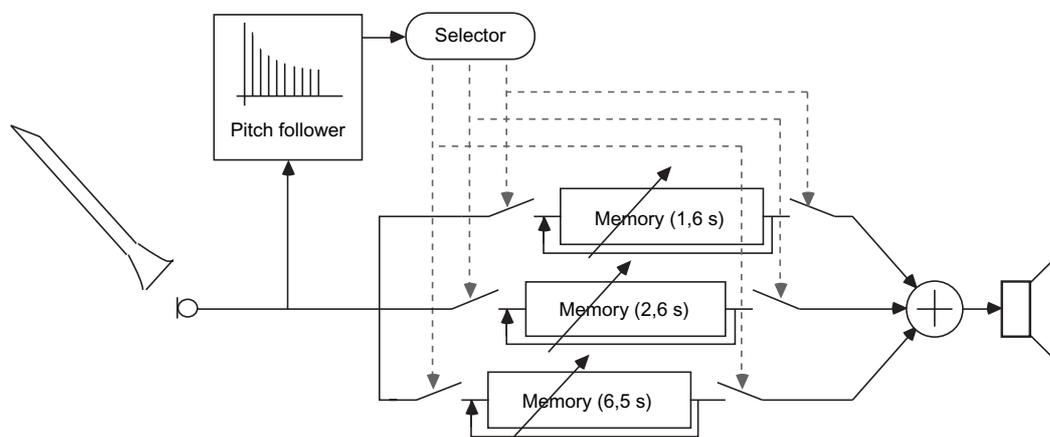


Figure 5: Three computer memory buffers are used to store copies of the clarinet sound. The clarinet pitch controls the time when the samples are stored and the times when they are replayed.

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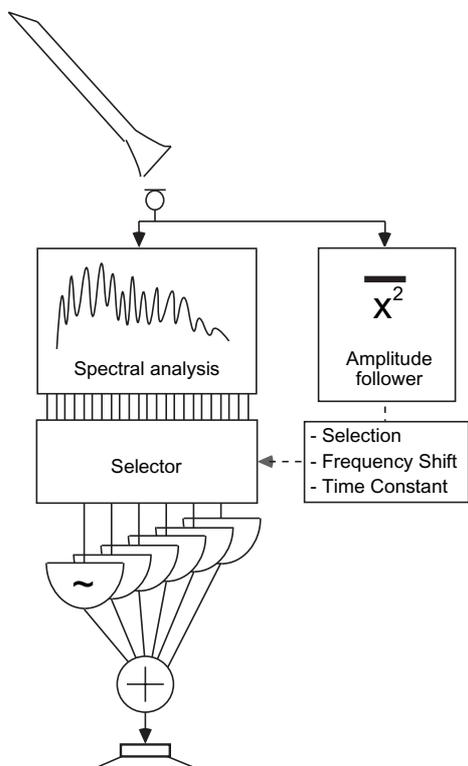


Figure 6: The clarinet sounds are modified by a channel vocoder. Only a subset of the data produced by the analysis is used in order to control a synthesis oscillator bank. The pitch of the clarinet controls the set of analysis data that is used for the synthesis.

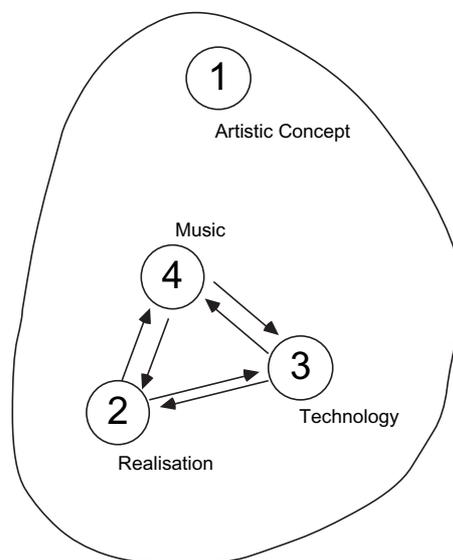


Figure 9: The realisation of the artistic idea is influenced by the possibilities offered by the technology and by the ability of the composer as well as of the performer to integrate them.

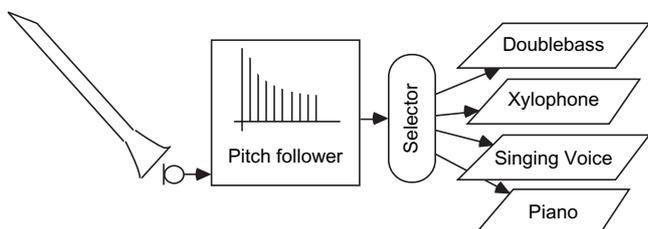


Figure 7: The pitch of the clarinet triggers the replay of the sampled sounds.

The figure shows a handwritten musical score for a clarinet. At the top left, there is a control flow diagram and a MIDI data table. The diagram shows a 'clarinet' input to a 'mic' block, which feeds into a 'freq.' block, then an 'amp.' block, and finally an 'audio out' block. A 'Tere + b' block also receives input from the 'audio out' block. The MIDI table lists MIDI numbers (72, 76, 79, 74, 69, 71, 77, 59, 83, 81, 88, 76, 77, 69, 79, 85, 87) and their corresponding actions (e.g., 'swan swim', 'over the sea', 'back again', 'well', 'swim', 'contrabass-sounds', 'woody-sound', 'sing-ing-voice', 'piano-sounds', 'add. synth.').

The score itself consists of two staves of music. The top staff is labeled 'Clari.' and the bottom staff is labeled 'Ciar.'. The music is written in treble clef with a key signature of one sharp (F#). The tempo is marked as quarter note = 44. The score includes various dynamics such as *pp*, *mf*, *mp*, and *p*. There are also markings for 'fail-safe' and 'STEP 14'. The score is annotated with circled numbers 17, 18, and 19, which correspond to specific MIDI events in the table.

Figure 8: The pitch of the clarinet triggers sampled sung words. Excerpt from the score showing the relations between clarinet notes and computer actions.