Master Thesis Proposal v1.03

Algorithmic Composition with Virtual Instrument in Matlab and Possible Application on FPGA

The task is initially to create a Matlab code that create its own composition and play it with a virtual instrument, which is also created in Matlab. After the successful implementation in Matlab, second part will start. In the second part, the aim is to implement the same designs into FPGA in order to have a stand-alone music player that can create and play its own music.

To carry out the thesis knowledge from different domains needs to be merged. Algorithm knowledge from computer engineering, composition knowledge from music, HDL knowledge from electronics, signal knowledge from communications and psychoacoustics knowledge will be used. DAT091, DAT110, SSY120, SSY130 and VTA160 are the courses I have taken about covering some of the fields above. The project is to be carried out in Chalmers University of Technology.

Virtual instruments summon either sounds from databases or the sounds created by mathematical models. The databases are created by recording various instruments even orchestras while the other virtual instruments are created by shaping signals in order achieve new sounds or replicate the known ones. Main stream development tools include software development kits such as Steinberg VST SDK (C++) or programming languages like Max/MSP, Pure Data or Csound.

For algorithmic composition, genetic algorithms, Markov chains and serialism can be used to create the backbone of the music, while the creativity part will be implemented through randomness. Randomness can be implemented by pseudo-random methods, flicker noise, radioactive decay or ADC noise. The aim is to simulate the creative process of a human mind, where inspiration is mixed with hard work. Some of these techniques are implemented in software, yet no dedicated hardware in integrated circuit level has been spotted in the preliminary search. More information on algorithmic composition can be found in Appendix A.

The thesis aims to enhance my knowledge on the field music technology, where I plan to continue my carrier on. Successful results can be published on Special Interest Group on Graphics and Interactive Techniques (SIGGRAPH) or The Acoustical Society of America (ASA).

Supervisor

Rough Initial Time Plan

Weeks 1-2	Literature Study
Weeks 3-6	Implementation of Algorithmic Composition in Matlab
Weeks 7-8	Implementation of Virtual Instrument in Matlab
Weeks 9-11	Implementation of Algorithmic Composition on FPGA
Weeks 12-15	Implementation of Virtual Instrument on FPGA
Weeks 16-18	Safety Time

Appendix A

An Introduction to Computer Based Algorithmic Composition

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Abstract

This paper gives an introduction to algorithmic composition via computers. A brief history on algorithmic composition is followed by the main algorithms used. Eventually the paper talks about some issues regarding the ownership of the music produced by automated composers.

1. Introduction

An algorithm is a step-by-step solution to a problem where the number of steps is finite, thus algorithmic composition is using a systematic method for composing music. Even though, algorithmic composition is sometimes taken as electronic music, not every algorithmic composition is electronic. The algorithm can be done with pen and paper. Clarence Barlow argues that he can reach the same music without a computer while using the same algorithms [1].

Algorithmic composition, even though is a relatively new name, have long been a point of interest. Ancient Greek philosophers such as Pythagoras, Ptolemy and Plato have mentioned the formalism and the mathematical rules that lie beneath the music. [2] Even, Plato calls the music created by the movements of the planets "the music of the spheres". Later, in Middle Ages, algorithmic composition could be seen in canonical songs [3] where the composer was only creating a piece of melody and the rest of the song was derived from the core. In the 18^{th} century, some composers including Mozart and Haydn used algorithmic techniques to create a game where the music is composed by dice or just saying random numbers. [4] Works of John Cage include algorithmic composition where movements of a chess play are used for composing.

However, it seemed inevitable to use computers for composing**.** The earliest example of computers used for composing, dates back to 1957 with the Illiac Suite [5]. Today, different types of algorithms are used for composing. Mainstream algorithms include rule based algorithms, grammar based algorithms, stochastic processes, Markov chains, chaotic algorithms, genetic algorithms and algorithms based on artificial intelligence. Some composition systems also include sound synthesis thus they can play the output composition.

2. Rule Based Algorithms

With rule-based compositions, certain rules are used for forming up a composition. These rules are generally generated by investigating important works, and they are constructed such that the rules also define what will come next. Examples include Ebcioglu's CHORAL, which composes chorals, where the more than 350 rules are derived from works J. S. Bach [6]**.**

One criticism [7] of rule-based algorithm is that, since the composer, either a human or a computer, is limited by well-defined rules, the output music is not something that is exceedingly new. Thus, even though rule-based algorithms produce correct sounding music, they do not introduce compositions that have not been heard before. On the other hand, the tedious work of extracting rules increases the understanding of the dynamics of composition.

In this method, the composer's main job is collecting or extracting rules for the program, while the output music carries resemblance to the pieces, which the rules are extracted from.

3. Grammar Based Algorithms

Formal grammars are one of the main topics in computer science and linguistics, where the initial aim is to formalize the spoken languages and the programming languages. Grammar based composition takes music as a language than analyses and formalizes music. L-systems are also used as grammar based composition [1, 8]

4. Stochastic Algorithms

Stochastic processes include probabilistic methods, as purely random choosing making up the simplest form. Introducing weights and selection that is more intelligent increase the quality of the compositions.

The weighing functions can be generated by investigating compositions; later these statistics can be used for building a new composition. Markov chains are also used widely for composing. A Markov chain holds the probabilistic information in which a certain state can be followed by other states. Xenakis is among the pioneers in the use of stochastic processes for composition [9]. On the hand, even though randomness can be achieved many ways, random functions in software are pseudorandom, meaning that they are generated from deterministic processes such as the clock of the processor. Yet, complete random values can also be achieved using various noise sources in electronics such as radioactive decay, flicker noise, 1/f noise [10] or ADC offset. Those techniques are also preferred in cryptology and security for their more randomness.

5. Chaotic Algorithms

The research in irregularity, non-linearity in nature has given birth to chaos theory. Use of chaos theory in music has two main applications. While small scale applications mean sound synthesis, large scale applications mean composition. Fractals, which are equations that can output equations that are similar to the parent functions, are used as the main tools for computation. In addition, one must not forget that chaos is not random. Instead, it is non-linear. Thus, the output composition is unexpected, but has a general pattern. One interesting point is that since chaotic systems are highly sensitive to initial point as explained by the butterfly effect, the result of an algorithm or a program might change due to anything such as using another computer [11].

6. Artificial Intelligence Based Algorithms

The main advantage of systems with artificial intelligence is their ability to learn. The system, Experiments in Musical Intelligence (EMI) consists a database of rules like the rule based algorithms, yet the system also has the capability to create a database by itself [12]. Methods based on artificial intelligence have been applied on composition, improvisation and performance-based systems in jazz [13].

7. Genetic Algorithms

With genetic algorithms, systems with evolution capability have been designed. Evolutionary algorithms are inspired after biology and biological concepts such as mutation, evolution and natural selection [14] and the algorithms search for optimum solutions. However, in the area of art in addition to optimum solutions other interesting solutions that result in satisfying aesthetics are also searched [15].

Composing with genetic algorithms requires also an entity in which selection methods are defined. The composed music parts either survive or die with respect to the selection following a Darwinist fashion. In some cases, three entities are developed for algorithmic composition where one entity composes,

another gives feedback and the last one evolves the composition [16, 17, 18, 19, 20].

7. Who Owns the Music?

An interesting question that arises with algorithmic composition is who owns the created score [21]. Is the person who designed the algorithm owns the music or the person who used the algorithm and presented the output? The initial answer might be the person who has written the algorithm, yet the importance of realizing art should not be disregarded.

Another topic of discussion arises with the interaction of the system with the user. Some systems require input and feedback from the user, while some systems do not use inputs and systems; on the other hand, some uses input and feedback yet do not interact with the user instead, interact with other parts of the system. Thus, arguments can be made about the artificial conscious' right for the ownership of the scores composed.

8. Conclusion

Algorithmic composition is an interesting interdisciplinary field, which mixes music, mathematics, physics, electronics, computer science and psychology. The aim of algorithmic composition is not only recreate the creativity of a composer but also understand and exceed it in order to reach new genres of music or unimagined types of compositions.

On the other hand, the future trend in algorithmic composition seems to lie in hybrid solutions with an ability to listen and understand. Where the listening or understanding is mainly implemented by evolving algorithms such as genetic algorithms or artificial intelligence [15, 17, 22, 23].

9. References

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