The University of Oxford

Engineering Science

4YP Project Report

- Using Machine Learning to Control Software Synthesisers -

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FINAL HONOUR SCHOOL OF ENG

UNIVERSITY OF OXFORD

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Abstract

Software Synthesisers (Soft-Synths) are computer applications which create sounds in response to musical input typically in the form of MIDI messages. They are widely used in a variety of musical contexts. Typical soft-synths have hundreds or thousands of parameters which control the sound generation algorithm, allowing the user to create sounds that suit their musical needs. This results in a high dimensional, non-linear search space which the user must navigate in order. Research indicates that humans are bad at navigating such interfaces with serial controls, and that there is a strong link between interface design and the level of creativity that the user with experience when using the interface.

This work describes a novel interface designed to help users control synthesisers in a quicker and more intuitive manner. It combines 3 interfaces together: a traditional ’knob and slider’ interface, a search space visualisation interface, and an iterative blending interface.

THIS ABSTRACT NEEDS A LOT MORE WORK, WILL WORK ON AFTER WRITING MORE OF THE REPORT

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Chapter 1

Introduction

1.1 Background Information

Software Synthesisers (Soft-Synths) are computer applications which create sounds in response to musical input typically in the form of MIDI messages. They are widely used in a variety of musical contexts. Typical soft-synths have hundreds or thousands of parameters which control the sound generation algorithm, allowing the user to create sounds that suit their musical needs. This results in a high dimensional, non-linear search space which the user must navigate in order. Research indicates that humans are bad at navigating such interfaces with serial controls, and that there is a strong link between interface design and the level of creativity that the user with experience when using the interface.
This work describes a novel interface designed to help users control synthesisers in a quicker and more intuitive manner. It combines 3 interfaces together: a traditional 'knob and slider' interface, a search space visualisation interface, and an iterative blending interface.

1.2 Aims of the project

Aim to ...

1.3 Methodology

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Several previous...

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Chapter 3

Description of Synthesiser and Image Processing Algorithms

3.1 Synthesiser Algorithm

3.1.1 Description

In order to develop the synthesiser controller, it was necessary to choose a synthesiser to work with. To remove some of the complexities of interfacing with many commercial synthesisers, a purpose built synth was made to make it as easy as possible to work with the interface, whilst being representative of typical soft-synths available. The programming language Supercollider was used to create a 6 operator Phase Modulation synthesiser, loosely based on the Yamaha DX7, a very famous synthesiser from the 1980s (CHECK DATE).

The synthesis algorithm is based around the FM7 UGen for Supercolldier [5], which implements 6 operators with independent amplitudes and frequencies, whose outputs can be used to modulate the phase of any of the operators. The implementation can be simply described by the following discrete time equation:

$$y_i[t+1] = a_i * sin(2\pi T f_i + \sum_{j=1}^{6} y_j[t] * m_{ij}) \tag{3.1}$$

T is the sampling interval, $y_i[t]$ is the output of operator i at time t, a_i and f_i are the amplitude and frequency of operator$i$ and m_{ij} is a scalar parameter determining the level of phase modulation from operator j to operator i. This is a very flexible sound generation algorithm which can create a large number of different sounds.

The full synthesiser architecture can be described as follows.

A MIDI Note ON message is received with a musical note number N and a velocity V. This triggers the sound generations process for this particular note. the note number N is converted into a base frequency F. The frequency of each operator is set using the equation $f_i = F * f_i^{coarse} * (1 + f_i^{fine})$. The coarse frequency parameter f_i^{coarse} for operator i can take discrete values $\{$0.5, 1, 2, 3, ...$\}$, allowing the operators to set to different harmonics of the base frequency. The fine frequency parameter f_i^{coarse} for operator i can take any value in the range [0,1], and is used to detune operators away from the perfect harmonic ratios. The base frequency F can be continually modulated by the MIDI PitchBend control, and by a vibrato envelope. The operators' amplitudes a_i are then continuously modulated by two low frequency oscillators (LFOs), and a modulation envelope. LFO A is a triangle wave oscillator with a frequency in the range [0,20Hz], amplitude in the range [0,1], and phase spread in the range [0,1], a parameter which allows the LFO's initial phase to be randomly varied. LFO B is a square wave oscillator with a frequency in the range [0,20Hz], amplitude in the range [0,1], and pulse width in the range [0,1]. The modulation envelope is an ADSR (Attack-Decay-Sustain-Release) style envelope generator, which is triggered by the MIDI Note ON message. This can be described by the equation $a_i[t] = 1 + LFO_a[t] * lfo_{a,i} + LFO_b[t] * lfo_{b,i}$

All of the synths parameters can be easily adjusted in real time, by sending messages through the Open Sound Control (OSC) protocol, a UDP based protocol for sending messages between applications.

3.1.2 Design choices and justification

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3.2 Image Processing Algorithm

3.2.1 Description

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3.2.2 Design choices and justification

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// Chapter 7

Conclusion

The interface proposed in this project has many benefits over a traditional synthesiser interface, as has been designed following design heuristics from the fields of Human Computer Interaction and Creative Cognition. Based on simulated user studies, the interface has at least as good performance as a traditional interface when carrying out search based tasks, and based on real user feedback it has many advantages in terms of creativity.

7.1 Further Work

The evaluation of this interface was only carried out on a single synthesiser, due to the projects time constraints. The interface has been designed to be as general purpose as possible, allowing it to control arbitrary synths over the OSC protocol, but due to a lack of standardisation between soft synths, and lack of implementation time, more work needs to be done to create a truly general purpose soft synth controller. As many soft-synths are in the VST format, making a version of the interface with acts as a VST host, and uses the parameter retrieval and preset storage functionality of VSTs is a good next goal if this project is continued in the future.

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