Computer Music: Task 1 (Sound Synthesizer with GUI)

Flexi Synth Report

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‘Flexi Synth’

Synthesizer overview:

‘Flexi Synth’ is a synthesizer, which uses a combination of additive, subtractive and frequency modulation synthesis. Modern day software synthesizers such as Waves ‘Element’ inspired its look and popular analogue synthesizers like Yamaha’s DX7 inspired its functionality. This report will outline the theory behind these techniques of sound manipulation, provide a thorough account of how I realised the solution within my synthesizer “Flexi Synth” and evaluate the overall functionality of the synth.

Aims proposed; make the synth as flexible as possible i.e. allow enough parameter control that users can create a vast sonic palette, design a simple and clear GUI that is accessible for all users and offer the ability to save and load favored sounds.

Realization of Synthesis:

1. Additive Synthesis:

The foundation of ‘flexi synth’ begins with additive synthesis.

Additive synthesis is a synthesis technique derived from the Fourier theorem. Mathematically, the Fourier theorem states that a periodic function can be formulated as a sum of sine waves. [1] Contextually meaning when we combine (sum together) two or more waveforms the result is a waveform of higher complexity. I chose this for my synthesizer in the hope of achieving rich sounds from the offset and since it’s historically a very common feature amongst popular synthesizers it means most users will be very familiar with this synthesis technique.

This was realized by creating two oscillators whereby each can choose between three different wave types, 1 Sine 2 Sawtooth 3 Square. This allows for exploration of the complex waveforms created when adding together the same wave types or choosing to add together different wave types.

2. Subtractive Synthesis:

Although having a combination of different wave types provided a wide range of sounds, I wasn’t completely satisfied with the output and more commonly than not found that some frequencies after summing periodic waveforms produced unwanted tones. Subtractive synthesis offers a comfortable solution for these problems, as it is a technique whereby a complex wave is taken as the source and a filter is applied to reduce unwanted harmonic content.

Therefore this application was implemented within my design, providing choice between a resonant low-pass or high-pass filter. The low-pass filter allows us to cutoff frequencies above a specified threshold and let frequencies below this threshold to pass through. Logically the high pass filter is vice versa, frequencies below a certain threshold are cutoff and those above are allowed to pass. This greater control over harmonic content allows for unwanted tones or harshness created by additive synthesis to be contained and reduced, getting us closer to our desired output. In addition the resonant filter enables us to manipulate the formant of the sound.

3. Frequency Modulation:

In order to achieve my initial aim of making the synthesizer as flexible as possible, a third synthesis manipulation technique was added, which since its inception has become one of the most popular techniques to date – FM synthesis.

"In FM, the instantaneous frequency of a carrier wave is varied according to a modulating wave, such that the rate at which the carrier varies is the frequency of the modulating wave, or modulating frequency".

- Chowning 1973 [2]

Chownings's modulation synthesis was applied to three parameters; pitch of oscillator one, pitch of oscillator two and the cutoff frequency of the filter. These three parameters can be seen as the individual carrier frequencies, the LFO 1 and 2 rates are the modulating waves and the mod frequency dials within the matrix represent the modulating frequency.

The synthesizer uses the basic principles of FM synthesis but we use the LFO rates to control the rate at which we move between the range of the carrier frequency and the modulating frequency. This implementation within a matrix means we can choose the parameters we wish to control to great extent. With three source menus and three destination menus we can modulate either LFO to a choice of three parameters. The build of three menus (as inspired by Waves 'Element' see figure 1) means we can have up to three parameters being modulated simultaneously, and the ability to choose the wave type of the LFOs gives yet more depth to the shape of the sound.

Fig.1 Waves 'Element' Software Synthesizer [3] (see mod matrix)

4. Envelope and Effects:

In addition to my synthesis creation and manipulations, I included the use of an ADSR envelope (figure 2) to control the timbre of the sound over time. The ADSR envelope allows for hard striking metallic sounds with a fast attack or swelling string sounds with a slow attack and slow release time. The slower the attack the longer it takes for the sound to reach its desired amplitude level, the decay controls the time it takes for amplitude to drop to desire sustain level where the amplitude is kept constant until it stops and release adds the tail off sound i.e. how long it takes to finally reach an amplitude of 0 from the sustain level. Reverb effects were applied to give spatialization to the sound and to add more depth.

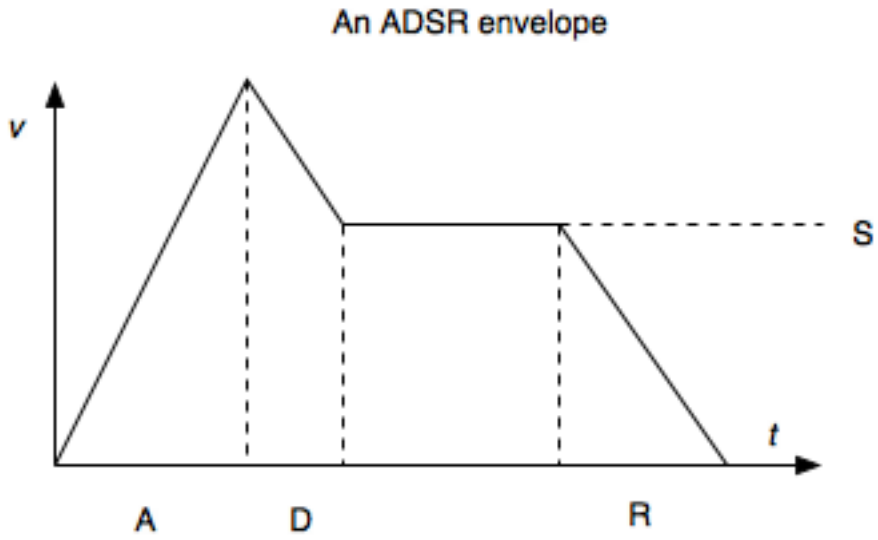

Fig.2 ADSR Envelope [4]

Execution of concept: (Bringing the Synth to life with the GUI)

Once synthesis had been finalized, the GUI of which we manipulate the synth with was made. As stated in my proposed aims the main goal of the GUI was to be as clear and simple to use as possible. To achieve this I made sure the main elements such as the oscillators and play/stop button were the most spaced and placed from left to right. All items colour coded and fonts universally mapped.

The main focus I tried to showcase through the GUI was to gradually move progressively more advanced in terms of parameter control when we move across the screen. This allows beginners to easily get involved with creating additive synthesis quickly and gives further advanced users deep control over their sound. It was of prime importance to make this synth as ergonomically efficient as possible. The inclusion of the preset buttons means it's quickly for users to return to factory settings and the ability to write their creations to disk.

Evaluation and outcomes:

The creation of Flexi Synth proved that the proposed aims I set out to achieve could become a reality and I feel that the execution of this synthesizer throughout the creation of its synthesis to its realization in the GUI was an overall success. In terms of effects, there is definitely room for expansion to using delays, chorus by using the space I have laid out already in the GUI.

The matrix modulation proved to be the toughest challenge of all the build. As it takes into account a vast number of conditions that although works within the synth, there are certain possibilities it hasn't accounted for which can throw it off. I hope to improve on this in the future with a deeper controllable synth whereby every parameter available to the user can be controlled and modulated by any other. Pointing in the direction of how a software application such as Native Instruments Massive [5] makes use of drag and drop capabilities to put this theory into practice.

Flexi Synth Final Outcome

References

1 Nick Collins and Julio d'Escriván, *Cambridge Companion to Electronic Music,* © Cambridge University Press (2007), Chapter 11 "Computer generation and manipulation of sounds", Page 204.

2 John M. Chowning, *The Synthesis of Complex Audio Spectra by means of Frequency Modulation,* © Stanford Artificial Intelligence Laboratory, Stanford, California
Available online:
https://ccrma.stanford.edu/sites/default/files/user/jc/fmsynthesispaperfinal_1.pdf
(Accessed March 14, 2013)

3 Waves, *Element*, Image Accessed Online
Available online: http://www.waves.com/content.aspx?id=12081#image
(Accessed March 14, 2013)

4 ADSR Envelope Image
Available Online:
http://folk.uio.no/andrely/synth/images/ADSR%20envelope.png
(Accessed March 14, 2013)

5 Native Instruments, *Massive,*
http://www.native-instruments.com/en/products/komplete/synths-samplers/massive/