Software Synthesizers

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Abstract. The subject of study is showing the structure and principle work of software synthesizers with their types of synthesis. The synthesizer is a musical instrument from the group of electronic instruments. They generate sounds electronically, through additive and subtractive synthesis, frequency modulation, phase distortion or physical modeling synthesis. Synthesizers can imitate a piano, but can also sound like a flute, stringed or percussion instrument. Software synthesizers create sound by the mathematical processing of discreet values (algorithms). The first software synthesizers appeared in the middle of last century, but remained without practical application due the lack of computer power. Today, almost every home computer is able to audio synthesize in real time and the software is available to everyone interested. Software synthesizers can be run as a stand-alone program, and also as components (plugin modules) in other software.

Keywords: Audio Software, Sound Characteristics, Synthesizers.

1. SUBJECT OF STUDY

The subject of study are software synthesizers which are computer programs or plugins. The purpose of software synthesizers is to generate and modulate audio signals through which are created sounds, different in character. They work jointly with other digital audio workstations in the form of plugins, which can be in different formats like:

- VST (Virtual Studio Technology)
- RTAS (Real-Time Audio Suite)
- AAX (Avid Audio eXtension)
- DX (DirectX plugin) and others.

Software synthesizers can also be used as a separated standalone plugin. Their application is basically related to creating of computer music and sound design. Some of them resemble the flow pattern of hardware synthesizers, while others are made in their unique model with software type. Manufacturers of well-known brands are: Steingberg, NativeInstruments, Arturia, Tone2, reFX, XferRecords, Korg, Image-Line and others. An example of a software synthesizer is shown in Fig. 1:

Fig. 1 Software synthesizer

2. STRUCTURE, PRINCIPLES AND OPERATION OF SOFTWARE SYNTHESIZERS

The structure of software synthesizers consists of multiple components and parameters, which interact with each other and make up a complete system. Each one of these components and parameters are with different intended uses helping the functioning of the system.

Their structure consists of:

- Oscillator
- Filter tab
- ADSR envelope tab

- Low frequency oscillator tab LFO
- Unison tab
- Effects tab

2.1 Oscillator

The oscillator is main source for the reproduction of sound in the synthesizer. It generates a set of flickering signals with varied forms of waves. Some of the main forms of waves are (Fig. 2, Fig. 3, Fig. 4, Fig. 5):

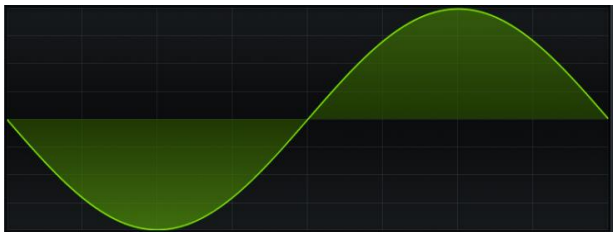

Fig. 2 Sine wave

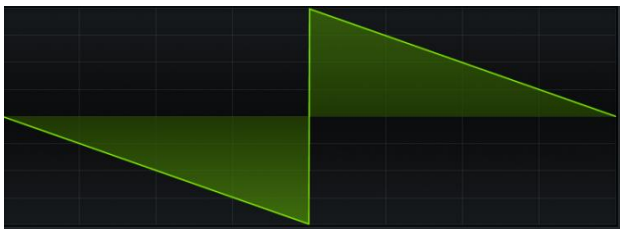

Fig. 3 Sawtooth wave

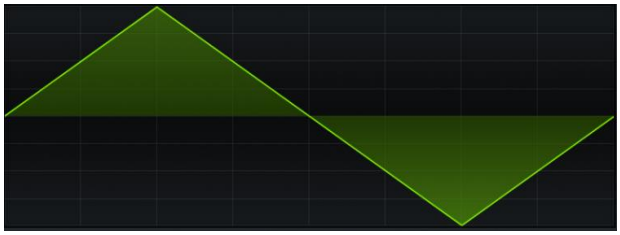

Fig. 4 Triangle wave

Fig. 5 Square wave

It creates these and other forms of waves which are a combination between two or more types forms as well waves with unique shapes.

Oscillators tabs can be two or more in number in one synthesizer. Each one of them generates vibrations. There is a possibility to create a Sub-oscillator generating vibrations with low bass frequencies.

The parameters of the oscillator are:

- *Volume (Level)* – It controls the amplitude level of the reproduced sound vibration.
- *Pan (Panning)* – This parameter serves for control over panoramic location of the sound.
- *Phase* – Through this parameter the wave can be shifted in time from the starting position of the sound vibration.
- *Invert* – The purpose of this function is to reverse the signal polarization that is to say to invert the positive polarity and make it negative and vice versa.
- *Octave* – This is a parameter of changing the pitch by one or more octaves up or down of sound vibration.
- *Fine Tune* – This is adjusting what frequency will be the pitch. By default it is on 440 Hz lower A.

An Oscillator is shown in Fig. 6:

Fig. 6 Oscillator

2.2 Filter Tab

Filters play an important role in synthesizers. Through them it is possible to change the frequency appearance of the generated sound. Use of this component changes a big part of the timbres sound. The change of timbre is the result of adding or withdrawal the harmonics in the frequency range of the sound signal.

- *Cut off* – This tool cuts off (Filters) a given frequency range by taking a given starting position from which the frequency removing begins.
- *Type of filtering* – There are three main filter types: low-frequency. They cut off high frequencies and passing the low band; high-frequency. They cut off the lows and passing the high band; band-

pass where they cut off partly low band and partly high band and pass the medium frequencies.

- *Resonance* – This controls how much the frequencies are to be amplified within their threshold of cut off. Their peak amplitude can, for example, be drastically amplified. In this way new innovative character of timbres sound may be established.

A filter tab is shown in Fig. 7:

Fig. 7 Filter tab

2.3 ADSR Envelope Tab

Modulating different parameters like amplitude level, filtering, pitch and others is carried out thanks to the ADSR envelope where the given parameter changes its value over time.

The abbreviation ADSR comes from:

- Attack;
- Decay;
- Sustain;
- Release

Attack envelope answers for that how fast the value of the given parameter is to increase from its minimum position to the maximum one.

Decay envelope begins at the moment of maximum value of the selected parameter for modulation, due to this it begins fading away for a determined amount of time, the reaching value lower from its maximum one.

The third envelope is Sustain. Its function is to keep an equally constant level while the key is continually pressed for an undetermined amount of time.

The fourth and final envelope is Release which specifies how fast to fade away the sound after the key was released.

The main use of these envelopes is to give dynamic and modifying character to the sound.

Fig. 8 shows ADSR envelope:

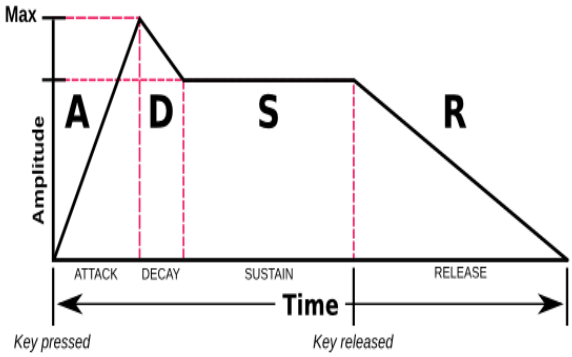

Fig. 8 ADSR envelope

2.4 Low Frequency Oscillator Tab LFO

In synthesizers, low frequency oscillation generation, which usually is under 20 Hz, creates rhythmically periodic impulses where the shape of the impulse varies in different forms. It is connected with and manages components and parameters from the synthesizer like amplitude, filter, pitch, sound panorama, resonance and many others effects like vibrato, tremolo, phasing. The low frequency oscillator consists of the following:

- *Rate (Speed)* controls the speed of the repeating cycles executed per unit time.
- *Sync* synchronizes the impulse to repeat over the same interval.
- *Wave (Shape)* determines what shape to be the generated impulse whether sinusoidal, saw shape, triangular, rectangular, square or random.
- *Offset controls* shifts in the phase impulse.
- *Gain control* amplifies the impulse level.
- *Mix (Amount)* balances how much quantity from the low frequency oscillation to be applied to the generated sound signal.

Fig. 9 shows a low frequency oscillator LFO:

Fig. 9 Low frequency oscillator

2.5 Unison Tab

In this tab performs multiplication of the generated sound two or more times. This group Unison from sounds creates harmony and transmits overburdened complex characteristic.

The Unison tab includes:

Unison order – Sets the number of the voices.

Detune (Pitch Thickness) – Serves for detuning between separated voices relative to each other. There is possibility to control the amount of detuning.

Spread (Pan) – Expands the panoramic distance of separated voices from each other.

Phase – Shifts and changes the starting position separately for each voice.

Fig. 10 shows a Unison tab:

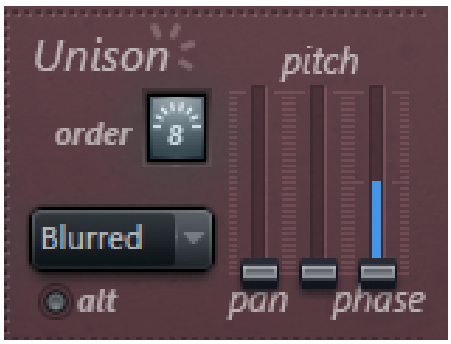

Fig. 10 Unison tab

2.6 Effects tab

In this tab are effects which can be added to the sound to improve the quality and changes its characteristics.

The effects are:

- Distortion;
- Compression;
- Equalization;
- Reverb;
- Chorus;
- Flanger;
- Phaser;
- Filter

Fig. 11 shows an effects tab:

Fig. 11 Effects tab

3. SOFTWARE SYNTHESIZER TYPES BASED ON THEIR SYNTHESIS METHOD

Several types of software synthesizers exist, each using different methods of synthesis, thanks to which they achieve distinguishable sounds for each type synthesizer. The main types of synthesizers and their methods are:

Additive Synthesizer – It use the Additive Synthesis method to create timbres, adding sinusoidal waves in one whole. This method is based on harmonics or disharmonic parts (frequencies) or overtones, each part is a sinusoidal wave on a different frequency with amplitude exalting and fading away over time. ADSR controls envelopes or low frequency modulation.

Harmonic additive synthesis is, in short, related with the concept of Fourier series which is the way to express the periodic function as an amount from sinusoidal functions equal to integers of common fundamental frequency.

Fig. 12 shows an additive software synthesizer:

Fig. 12 Additive software synthesizer

Subtractive Synthesizer – This type of synthesizer uses subtractive synthesis which is most closely related with analogue synthesizers. Many modern synthesizers and plugins imitate this synthesis. Analogue synthesizers are based on additive synthesis. Essentially this is related with taking over a source of a sound (oscillator) which is rich in sounds. It can take a single wave like sawtooth and, using a filter, remove some harmonics. Through ADSR (Attack, Decay, Sustain, Release) envelopes the sounds' shape can be formed. These types of synthesizers are built by Unison voices which are intended for reproducing a number voices at the same time.

Fig. 13 shows a subtractive synthesizer:

Fig. 13 Subtractive synthesizer

FM Synthesizer (Frequency modulation) – FM synthesis was one of the first digital methods for synthesis. The Yamaha DX7 introduced this synthesis for the first time. The way that FM synthesis works is that a single simple shape of wave is called a carrier (sine, sawtooth, square, triangle) which is modulating from another wave called modulator. As a result, it generates much more complicated shapes of waves. These waves are commonly known as operators. The FM synthesizer has many operators for shaping a sound to increasingly complicated waves. Among the main advantages of FM synthesizer is that it can reproduce waves with unprecedented complexity. Sound with ringing characters or characteristics that can be reproduce in much high level.

Fig. 14 shows an FM synthesizer:

Fig. 14 FM synthesizer

4. CONCLUSION

The goal of this research is to show the structure and working principle of software synthesizers and their types of synthesis.

Our research finds wide application in the music sphere.

REFERENCES

Friedman, S., 2014. Software Synthesizers. Packt Publishing, Birmingham, 286 pp.

Lalev, H.L. & Tsankov, T.S., 2009. Synthesis on computer systems of work of real time. *Proceedings of the International conference* 105-th anniversary of the birth of the pioneers of computing John Atanasoff and John von Neumann, Shumen (in Bulgarian).

Pease, S., 2009. Software Synthesizers The Comprehensive Guide. Cengage Learning, Boston.