Digital Synthesis of Music

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1 Introduction

Digital music synthesis has been a topic of interest for decades, producing a vast array of methods and products. From the simple hardware synthesizers that play the ring tones of cellular phones to the complicated software systems providing background music to video games, to those used for creative expression by digital artists, music synthesis is ubiquitous. This document is concerned with exposing the reader to a selection of music synthesis techniques and embodiments, both hardware and software based, focusing on the synthesizers available to users of personal computers.

2 Typical Digital Music Synthesizers

In the personal computing world, music synthesis has historically been a function of dedicated circuitry, such as the Sound Interface Device chip on the famous Commodore 64 [1]. The music generated by these chips provides creative expression to users and accompaniment to video games. Though limited, these relatively simple synthesizer chips allow for the creation of recognizable and expressive music.

The Commodore SID and other chips of the era were soldered into the computer's main board. The expandability of the IBM PC coupled with its lack of on board music synthesis hardware created a market for competing solutions like the Yamaha YM3812 used on the Adlib and Soundblaster [2] and powerful wavetable chips like the Creative Labs EMU8000 [3].

As demonstrated by modern software synthesizers like ZynAddSubFX [4], the speed of modern computers is such that dedicated hardware is not even necessary to synthesize high quality music. Most of the techniques that have historically been the domain of dedicated hardware can now be implemented with sufficient speed in software.

3 Technology Behind Digital Music Synthesis

3.1 Primitive Square-Wave Systems

The simplest synthesizers provide a number of voices that can only use a square wave in addition to a "noise" channel. The frequency and amplitude of each of these voices can be controlled through registers. An example of this is the synthesizer that was included in the video processor of Commodore's VIC-20 [5], which provides three square wave voices and a noise channel for percussive effects. The advantage of this approach, and the reason it is still used in some embedded systems such as cellular telephone ringers is a lack of complexity. Digital systems already work in terms of square waves, allowing very simple digital signals to be used up to the final mixing stage.

3.2 FM Synthesis

Rich overtones can be created by modulating the frequency or phase of an output waveform at audio frequency. A popular implementation of this, the Yamaha YM3812 (OPL2) allows for nine voices. Each voice is made up of two oscillators that can be mixed by traditional addition or by phase modulation, allowing for a much wider variety of timbres than earlier methods [2].

3.3 Sample-Based (Wavetable) Synthesis

Sampling keyboards, like the Computer Music Melodian [6] and its successors, provided the technological incentive to create musical sounds based not on generated waveforms, but on prerecorded or created samples, perhaps of complex synthesized sounds, perhaps of real musical instruments. Hardware and software variations of this concept have been popular ever since. Soundtracker, originally released for the Amiga, is a typical software implementation of sample-based synthesis [7]. In Soundtracker, prerecorded samples of musical instruments are stored on the user's computer and played back at different speeds at the appropriate times. This is the most basic type of sample-based synthesis, and has inspired many work-alike clones and improvements.

3.4 Additive Synthesis

H. G. Alles, working at Bell Labs, pioneered a versatile synthesizer using what is now known as additive synthesis [8]. This device allowed the user to additively combine the output from multiple oscillators, choosing their base frequency and harmonics in the process. This, while not as flexible as wavetable synthesis, is less demanding on memory resources, because there is no need to store a time-domain sampled waveform, only the amplitudes of the harmonics.

3.5 Modular Software Synthesis

Modern software synthesizers, such as ZynAddSubFX [4], combine additive and sample-based synthesizers with a variety of filters, allowing the user greater flexibility in creating the types of musical sounds they want to hear. This represents the state of the art in music synthesis. All of the methods previously available become available in limitless combinations, enabling higly creative customization.

References

[1] Commodore Semiconductor Group, *6581 Sound Interface Device(SID)*, 1981.

[2] Yamaha, *YM3812 FM Operator Type-L-II(OPL-II).*

[3] D. Rossum, *AWE32/EMU8000 Programmer's Guide.* Creative Labs, 1994.

[4] "ZynAddSubFX Homepage." http://zynaddsubfx.sourceforge.net, 2007.

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[6] M. Vail, *Vintage Synthesizers.* Backbeat Books, 2000.

[7] "Retrospective - Karsten Obarski." www.textfiles.com/artscene/music/information/karstenobarski.html, Mar 1998.

[8] H. G. Alles, "An Inexpensive Digital Sound Synthesizer," *Computer Music Journal*, vol. 3, no. 3, 1979.