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Designing Virtual Instruments for Computer Music

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Abstract

This paper is about how to create virtual musical instruments. Virtual instruments have a wide variety of usages and vary from digitizing audio samples of real instruments and recreating brand new virtual instruments that do not exist. Virtual instruments help music composers to compose music more easily and quickly, they also provide composers with new ideas and concepts for traditional music composition. The biggest attraction of virtual instruments is that the sound produced is real. Today's software synths are in some ways superior to their analog counterparts. They produce an excellent quality of sound, are stable, and parameters are automatable in real time, such as the opening and closing of filters, the changing of envelope decay times, bending pitch, and so on. Virtual instruments are a global standard and their acceptance has strengthened with time. This paper describes the concept of music synthesis and explains the process of how to create a new instrument from a pre-recorded guitar.

Keywords: *Virtual instrument, MIDI, VST (Virtual Studio Technology), Modulation, Mapping, Phase shift, ADSR, Multi-sampling*

1. Introduction

MIDI is based on two major principles; universality and expandability. It was designed to handle a simple set of tasks. The initial idea was that when a composer played one MIDI synthesizer's keyboard and attached a cable from its MIDI out to another synth's MIDI in, the second synth would take the messages from the first synth, which included the notes to play, thus layering the sound of the two devices. In the early days of MIDI, most messages were note-on and off messages; each MIDI note-on includes a key velocity message which tells the receiving device how hard the key is being struck. Other performance data, such as pitch bends and modulation wheel moves, could be transmitted as MIDI data [1]. Timing synchronization between devices such as drum machines and sequencers was handled by MIDI clock messages.

Over the years, MIDI has been expanded to allow for more complex types of communication. MIDI remains popular for sequencing, live control of synths and samplers from master keyboards, and studio control. It is used for sending patch data from synth to storage device, and synchronization via MIDI time code.

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2. Digital music technology

2.1 Understanding music synthesis

As computer technology developed, MIDI bandwidth increased and is now capable of handling multitrack music performances. The original implementation called for 16 separate channels of music data, but today, 32 or more channels are common.

Music technology is closely related to computer technology. First was recording (MIDI and audio), then signal processing (including plug-ins), and finally, synthesis and sampling. Although computer-based synthesis and sampling is not new, many manufacturers such as Steinberg VST (Virtual Studio Technology), Native Instrument Kontakt, and Logic Pro ESX 24, have introduced a lot of virtual instruments.

A virtual instrument can act like a MIDI track with respect to recording and note editing, but is more like digital audio when it comes to plug-in processing, automation, and mixing.

The biggest attraction of virtual instruments is that the sound is real. Today's software synths are in some ways superior to the devices they wish to emulate. They produce an excellent quality of sound, are stable, and parameters are automatable in real time; such as the opening and closing of filters, the changing of envelope decay times, bending pitch, and so on. Virtual instruments are a global standard and their acceptance has strengthened with time [2].

MIDI and digital audio programs include a software mixer, which receives input from digital audio tracks. A virtual instrument models sound in software, and is equivalent to a digital audio track.

2.2 Guitar sample recording

Virtual instruments have several advantages over outboard gear; such as patch data being saved as part of the sequence which recalls all settings, patch cords exist only in software, load down the host processor, feel that the original, and low-cost compared to hardware.

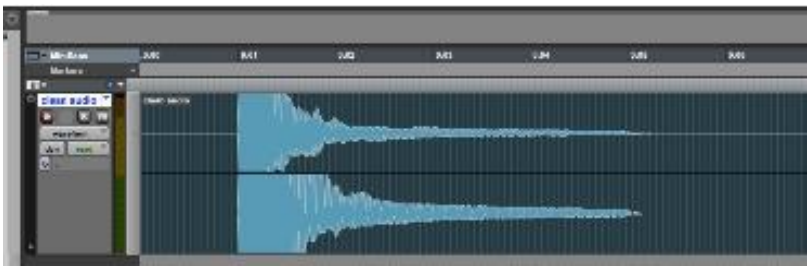

Figure 1. Guitar recording in Pro Tools

Developing MIDI (Musical Instrument Digital Interface) is expected to create a massive music industry. Early MIDI technology was just electrical combination, but nowadays, it is sound transformation by digital sampling from 0s and 1s. Music samplers and virtual instruments have marched in tremendous strides over the past few decades. These developments exceed the limits of analog synthesizers, which are sometimes impossible or inconvenient to edit, in addition, they create new sounds from the existing presets on analog synthesizers.

This paper introduces the ways to create a new pitch from an original sound source and change the tone color (timbre) from the original sound source. We recorded an E note from the guitar into Pro Tools via the Digidesign 002 audio interface.

2.3 Sound mapping and layering

We made the starting point of the guitar source as short as possible and also made sure that there was a natural fade out. There are several kinds of computer music software which can be used for mapping, such as Logic Pro ESX24, Steinberg Cubase Halion, and Native Instrument Kontakt. We have chosen Native Instrument Kontakt because the user interface is easy to see and sound editing is very detailed.

We dragged the pre-recorded guitar sound sample into Kontakt and put it on horizontally from C0 to C4 of the software keyboard in Kontakt.

Figure 2. Sound Source in mapping

Left and right (horizontally) represent pitch and up and down (vertically) represent the velocity layer. Using velocity to determine which instrument plays the sound involves selecting only those notes which have a velocity value above a specific value (half-way, 64, is a starting point) and allocating those notes to a different instrument.

Samplers can assign samples to two or more layers of the keyboard. For example, playing with a velocity from 0 to 64 might play one sample, while playing with a velocity from 65 to 127 would play a different one. Sometimes the distinction is not abrupt and samples can blend into each other as velocity changes [2].

Thus, the more velocity layers, the more natural it sounds. Also, an increase of velocity layers can provide users with the ability to operate very detailed techniques. We divided the velocity into 4 layers; 1 - 29, 30 -59, 60 - 94, and 95 - 127. A greater number of layers produce a better sound, but it imposes a heavy burden on computer capacity and memory.

Figure 3. Sound source layering

2.4 Sound modulation and envelope

Modulation is another type of modifier. Any parameter which can be voltage controlled is a potential means of modulation [3-4]. Although VCAs (Voltage Controlled Amplifier) are available from the front panels of many analog synthesizers, they are used inside to allow control voltages to act as modulators. There are many possible modulators, such as LFO, VCO mod, Filter Mod, PWM, and so on.

Figure 4. Modulation

A single sound source can be created for a variety of string pads by envelope and filters. The envelope is the overall shape of the volume of a sound. In an analog synthesizer, the volume of the sound output at any time is controlled by a VCA [5].

Envelopes are split into segments or parts. The time from silence to the initial loudest point is called the attack time, while the time for the envelope to decrease or decay to a steady value is called the decay time [6]. For instruments that can produce a continuous sound, such as an organ, the decay time is defined as the time for the sound to decay to the steady-state sustain level, whilst the time that it takes for the sound to decay to silence when it ends is called the release time.

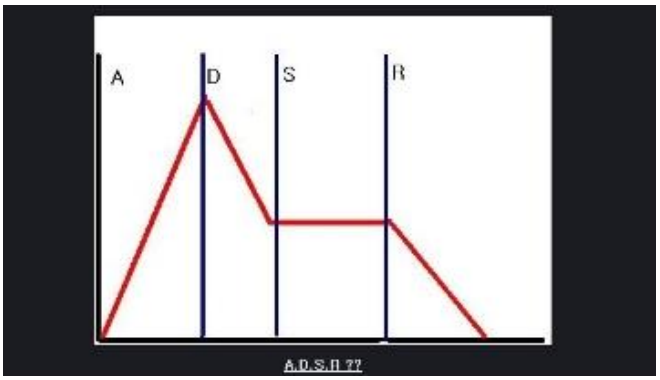

Figure 5. ADSR sound graph

2.4 Sound effects

User can add effects to the insert of Kontakt. Digital reverb, compared to outboard reverb, produces very clear sound, but uses a substantial amount of computer memory. Especially, reverb in Kontakt is designed to simplify the general function and takes minimum computer memory except reverberation.

In this paper, modulation and phase shift performed a role to change the original guitar sound to a specific digital sample. We adjusted the phaser for phase shift and the original guitar sound was changed to an electric violin sound. The main obstacle and point of consideration was how to adjust and twist the amount of feedback and phase on the phaser [7]. Phasers are variations on the chorus effect with a mixing of an undelayed audio signal with a delayed audio signal, but with feedback from the output to the input. Phasers use a phase shift circuit. In this case, cancellations occur when the delayed and undelayed audio signals are out of phase, and so a series of narrow cancelations are formed in the audio spectrum. As the phase shift or time delay is changed by an LFO.

Moreover, an arpeggiator enables a specific auto-arpeggio pattern depending on what pattern users program in Kontakt. Also, the arpeggiator provides more functions, such as a variety of rhythms and tempos.

Figure 6. Sound arpeggiator and phase shift

3. Conclusion

After the digital revolution, it is clear that selected virtual instruments take the position of real instruments. Virtual instruments have plenty of uses, from digitally restoring traditional instruments to creating new digital instruments. The advent of new virtual instruments enables music composers to produce music more creatively than the general music production methods which were relied on for years.

Also, multi-sampling must be considered. As we mentioned earlier, it can be used to provide changes in sound across the keyboard. It is used for instruments which have marked differences in their harmonic structure for high and low pitches [8]. Samples are taken of the source sound played at different pitches at the same sample rate. Multi-sample uses a large amount of memory, but provides the most accurate reproduction.

However, it must be considered that the virtual instruments are just music tools which help musicians to create music. No matter what, the creative music masterpiece is the musicians.

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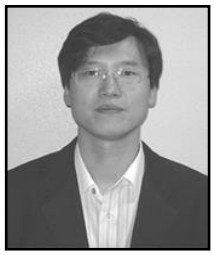

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