Lecture 6: Reverberation and 3-D Sound

Introduction

Focus of this lecture was to give an overview of how reverberation behaves in real spaces, but also how it can be reproduced physically, using analog devices and algorithimically, respectively. I will provide a brief overview of topics and an implementation example of velvet noise based reverberation.

Reverb in Spaces

Sound that propagates through space can be separated into several categories, direct sound which refers to all the sound where delay is between 10 and 50 milliseconds, early reflections which are reflections from surfaces with a delay between 50 and 100 milliseconds and late reverberation which is everything audible afterwards. It is important to note that early reflections can clearly be distinguished from each other unlike the late reverberation where reflections blend together.

Artificial Reverberation

Physical Reverb

Physical reverbs refer to reverb effects achieved using physical spaces. This approach was especially important when early reverberation techniques were developed as at the time digital implementations were not possible. Physical reverb can be achieved using an echo chamber or by more effective techniques such as spring or plate reverb. Echo chambers are empty rooms with smooth walls to achieve as much reverb as possible. In order to record the reverb a loudspeaker is used to play the sound and a microphone records the reverberated output. Plate reverb uses a large sheet of metal onto which a vibration is passed using a transducer creating a reverberated sound as a result. Spring reverb functions in a similar manner, but instead of using large sheet of metal it uses springs which vibrate and reverberate the sound.

Analog Reverb

Reverb can be achieved using analog tape delay. Since we want to achieve an echo effect, by putting the delay time to very short we can do so. Another interesting type of analog delay is oil can delay. It uses a rotating disc in a can filled with special oil. There are also two wipers used to transfer the signal onto the disc, but also transfer the signal back into the amplifier. This type of delay produces an audio effect similar to vibrato.

Digital (Algorithmic) Reverb

Developments made in digital audio signal processing did not only allow us to transfer already existing analog and physical reverbs to a digital domain, but it also allowed us to create many more various methods of reverberation. First such algorithm was developed by Schroeder in 1962. It consisted of four comb filters with different delays placed in parallel followed by a cascade of several allpass comb filters to spread the impulse. Although this implementation worked, it suffered from higher frequencies decaying faster than low

frequencies. Moorer fixed this issue in 1979. by inserting a one-pole lowpass filter into the comb filter. This resulted in more naturally and less metallic sounding reverb.
Another way of producing reverb effect is using FDNs (Feedback Delay Networks). These are generalized comb filter structures which use a feedback matrix to vary the amount of delay. They consist of delay lines followed by gains or filters whose outputs are passed to the output of the network or back through the feedback matrix.
Lastly, I want to mention velvet noise reverb which is a type of noise based reverberation method. Characteristic that puts this approach apart from others is the fact that it is computationally efficient. This is due to the fact that unlike other noises, velvet noise is very sparse - it has a lot of 0 valued elements intertwined with -1 and 1 values. As a result, it is able to perform quickly while maintaining the audio quality comparable to other reverb effects. Implementation of this effect along with spectral analysis is shown as a part of the diary.