Analysis and Simulation of Convolution Reverb using City Tech’s New Auditorium

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Abstract:
In digital signal processing, convolution reverb can simulate the reverberation of a real acoustic space. The acoustics of different seating areas in an auditorium can vary from each other. To determine the reverberant characteristics of City Tech new building’s auditorium, impulse response (IR) signals are recorded in five key locations of the auditorium.

Directly recorded balloon burst is chosen as the source of impulse source. An omnidirectional and a cardioid microphone with flat frequency response curves are used to record IR signals to 24-bit monophonic wav files. Each IR signal, along with a vocal, is convoluted in MATLAB through both direct and fast convolution methods.

Method:
The impulse response (IR) was recorded of bursting of balloon in the City Tech New Academic Complex’s auditorium. Locations at the stage center, house front, house center, mezzanine, and balcony were selected to record. An omnidirectional microphone Earthworks M30 and a Schoeps CMC6 with MK2 cardioid capsule were used at the same time through a Sound Devices MixPre-3 audio interface to an Avid Pro Tools recording session.

The recorded IR samples were cut and exported from Pro Tools as monophonic, 24-bit, 48kHz, wav files. A dry vocal sample that had been recorded at an anechoic chamber, as the input signal, was imported to MATLAB to convolve with each IR signal. The MATLAB lowered the amplitude of each IR to 10%, zero-padded all signals, and provided two convolution methods: direct convolution and fast convolution. For fast convolution:

\[ \text{Output} = \text{ifft(fft(signal)*fft(IR))} \]

Each output signal was then normalized and saved as a monophonic, 32-bit floating, 48kHz, wav file, and a 2D plot that shows the amplitude by time.

Conclusion:
Fast convolution is faster than direct convolution method, especially when the original audio signal is long. Directly recorded impulse response, such as bursting of balloon, has the disadvantage of being susceptible to distortion, although the output signal’s bit depth was set to 32-bit floating. A more accurate impulse response of an auditorium can be recorded through a sine sweep method, which covers the whole audible frequency range and renders high-quality samples, but that method requires loudspeakers with highly precise reproduction of frequencies.

Reference:

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