Multi-Function Audio System Design

ECE 272/472 Audio Signal Processing
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Abstract

Every piece of audio has its own properties, like onsets, beats, amplitude, etc. These qualities can influence the feelings of the listener. This project is aimed to design a multi-function audio system based on MATLAB to visualize some properties of the input audio and make it possible for users to manipulate the audio with some interesting functions.

Objectives

Our system has a GUI that can realize three functions:

• Synchronized display of waveform and FFT spectrum

• LED simulation of onsets and the amplitude

• Reverberation simulation of different environments.

Theory

• The FFT spectrum is based on Fast Fourier Transform

$$X(k) = \sum_{n=0}^{N-1} x(n) \cdot e^{-j\left(\frac{2\pi}{N}\right)nk} \quad (k = 0,1,\dots,N-1)$$

• There are two ways to do the onsets detection, based on the energy and the spectral, separately. For the energy-based method, we use a window to take slices of the audio and choose the onsets by thresholding and peak-picking. For spectral-based method, we add an extra STFT after taking slices and choose the onsets following the same procedures as the former.

• The reverberation part is composed of four comb filters and two all-pass filters. The comb filters are used to create the room effects while the all-pass filters enhance the echo. With different parameters we can generate different reverberation effects.
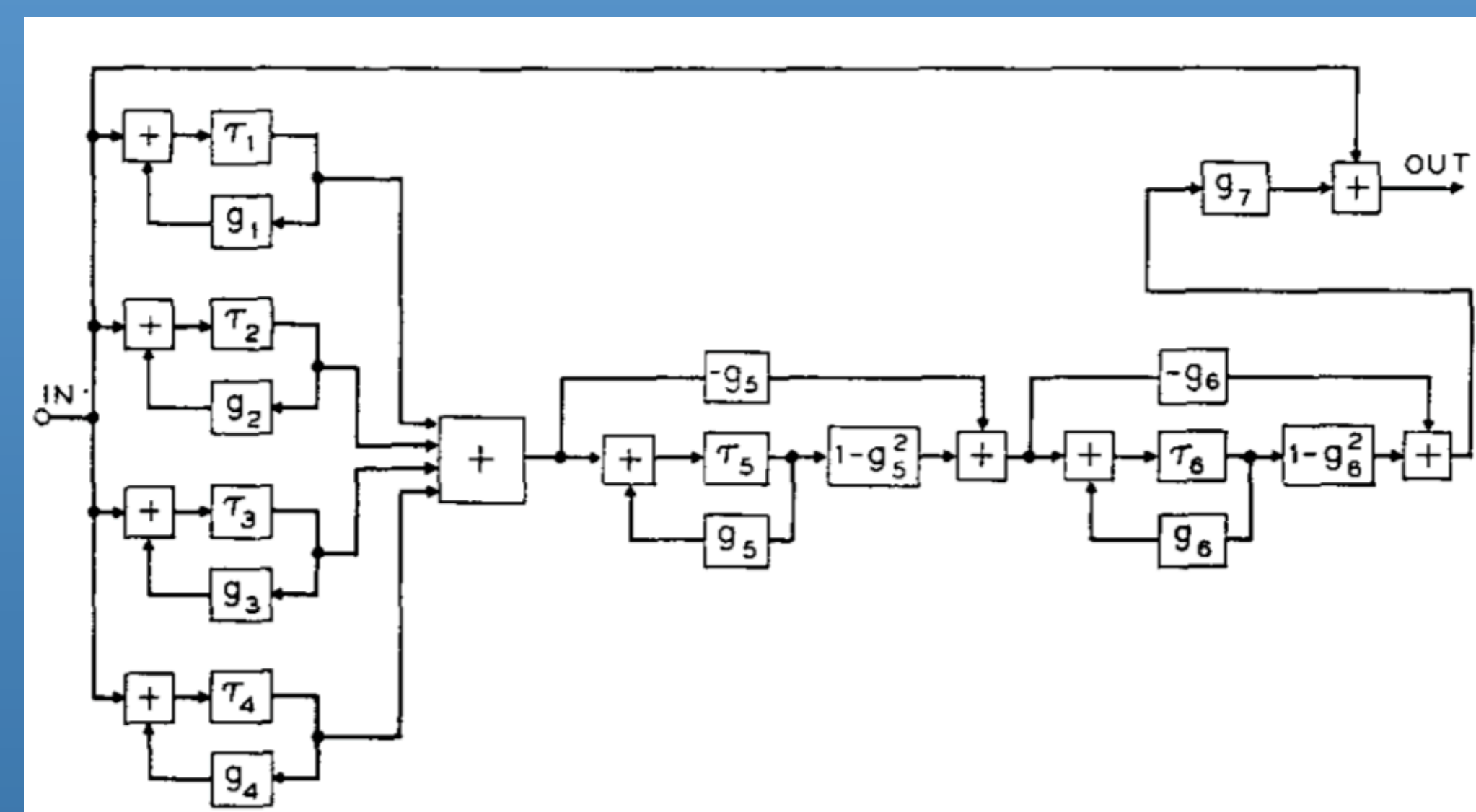

Block diagram of reverberator [1]

Method

• To synchronize the waveform and FFT spectrum with the audio, we plot the whole figures of waveform and the spectrum. Then we move the axis to show the corresponding part for current audio section.

• For LED simulation of onsets and amplitude, we set two images to show the qualities. We make first image spark at the onsets with the 'pause' function in MATLAB. The second image will change the color intensity to present the amplitude levels.

• For reverberation simulation, we calculate the T60, delays and gains for four kinds of rooms and apply the algorithm to achieve the echo effects.
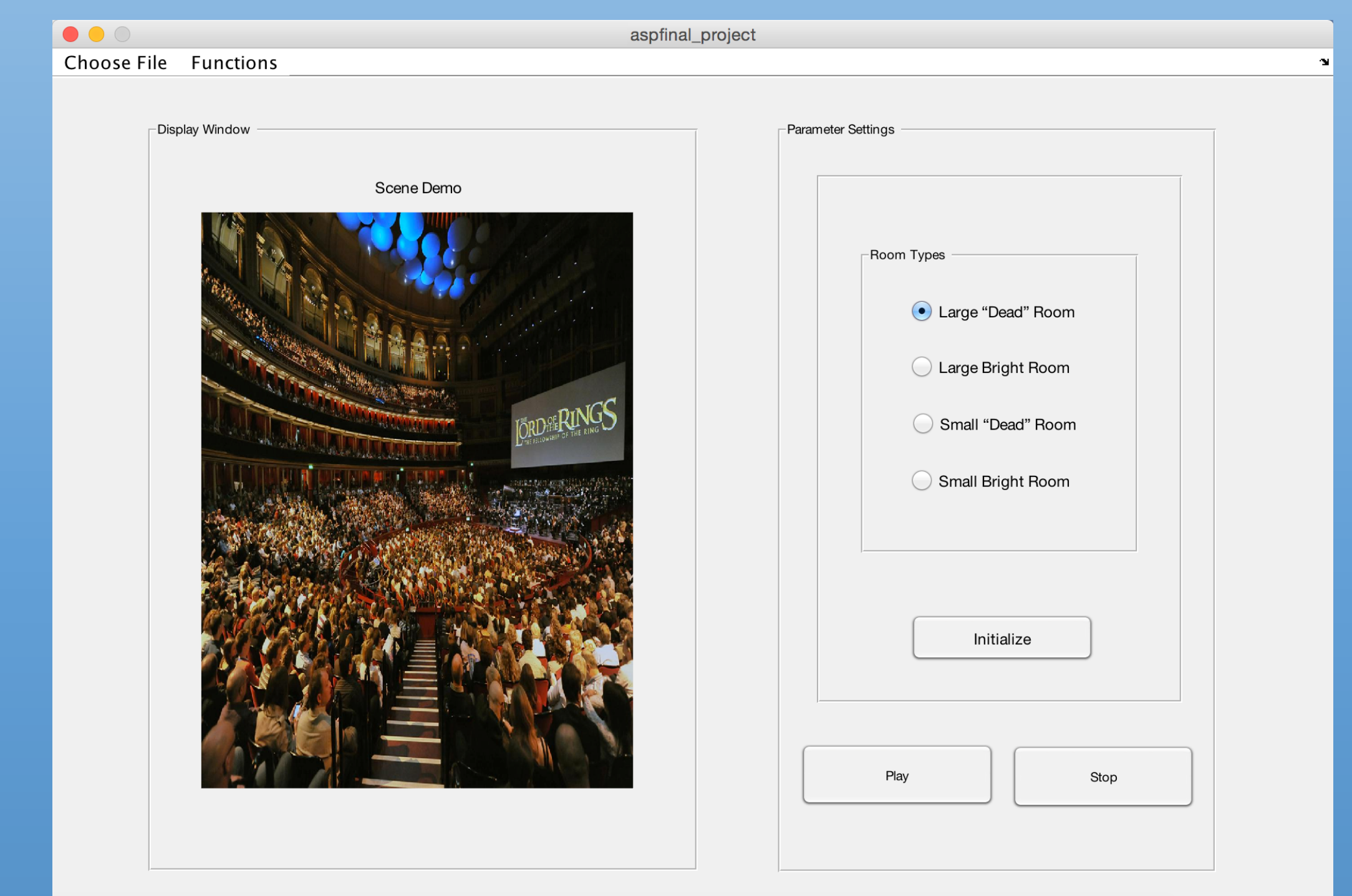
Results

• The GUI of our system is shown below
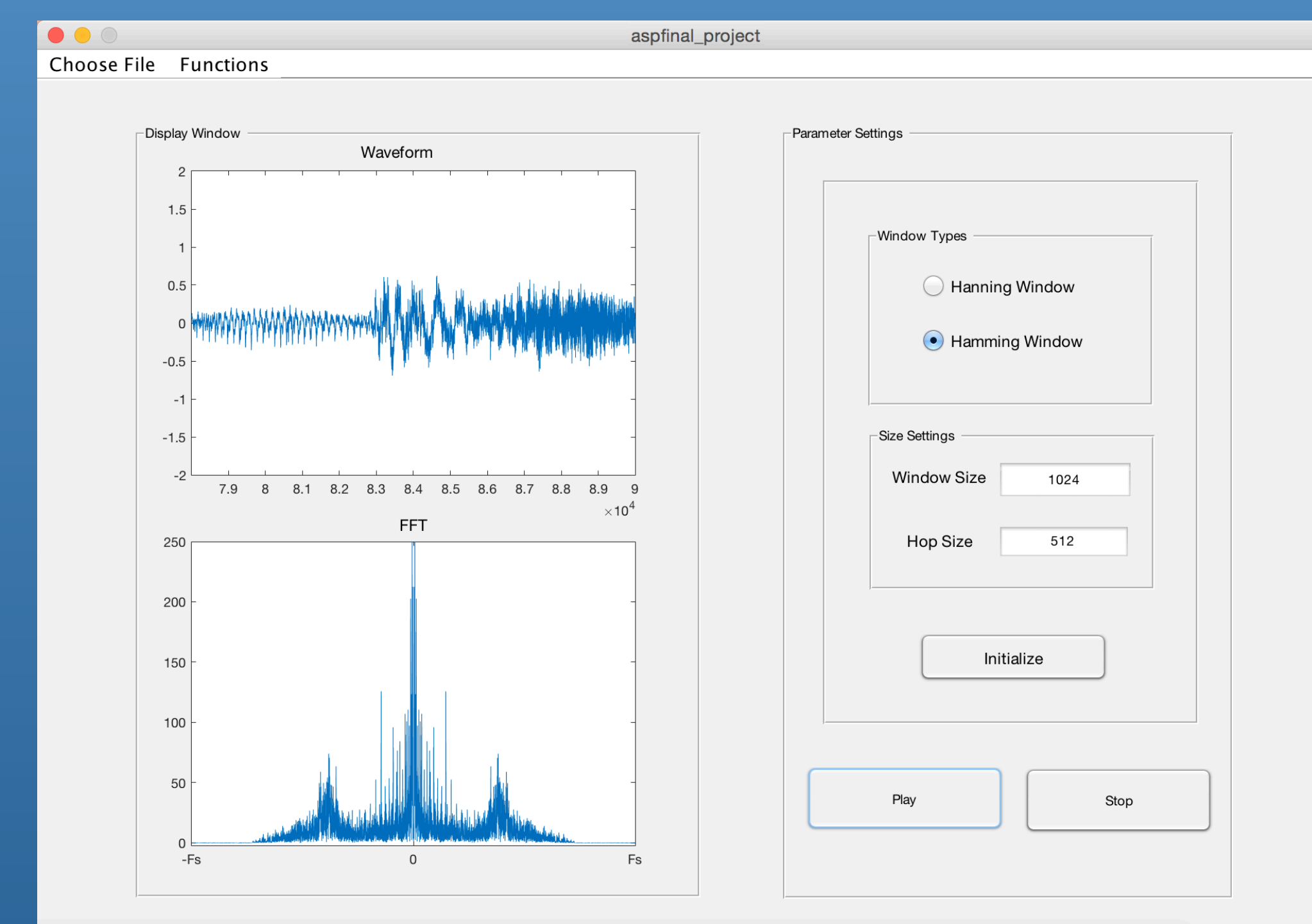
Waveform and FFT Spectrum Display
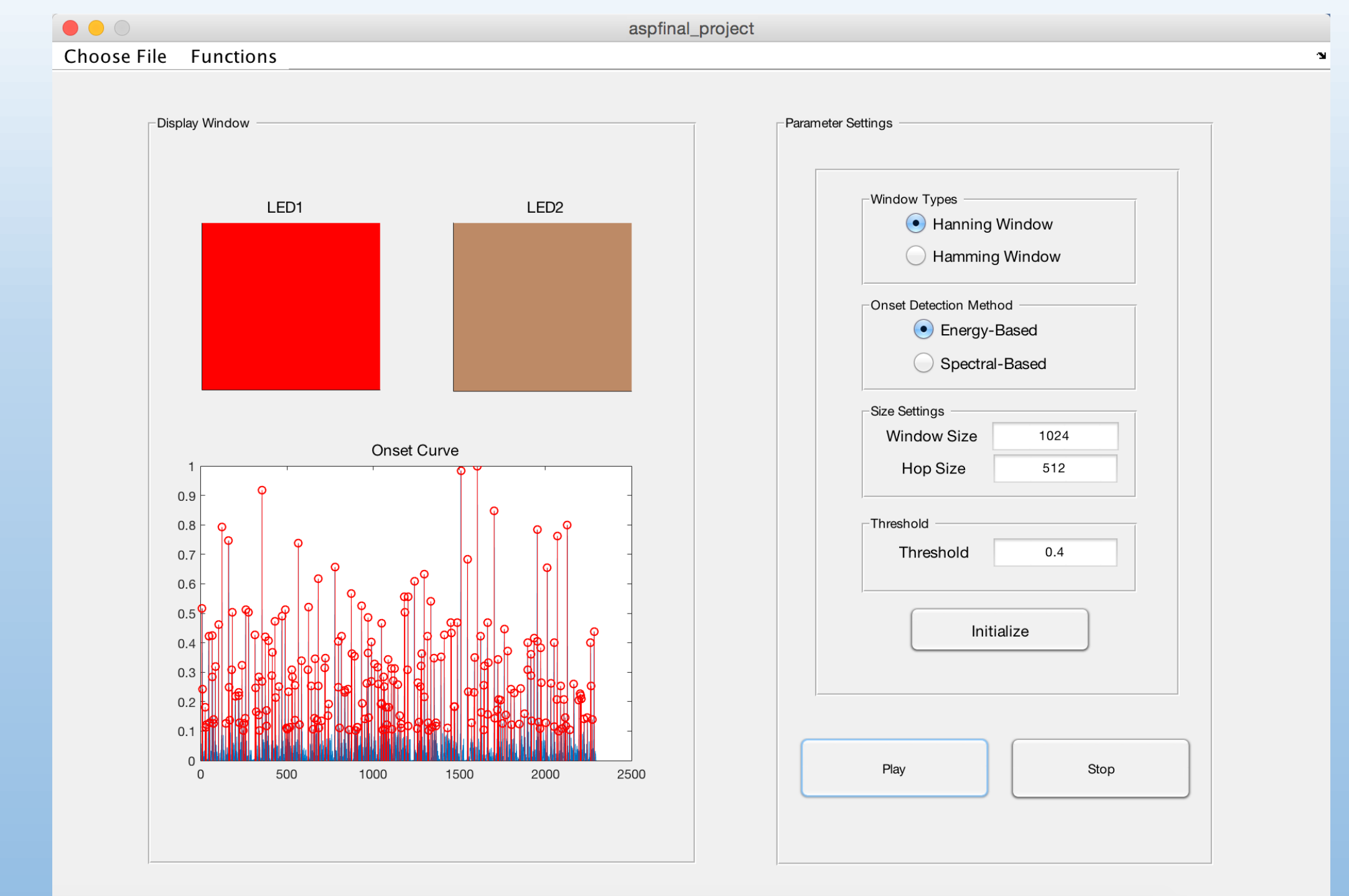
LED Simulation and Onsets Plot

Reverberation Simulation [2]

Future Works

• Real-time audio processing

• Onsets plot synchronization

Reference

[1] Schroeder, M. R. (1962). Natural sounding artificial reverberation. Journal of the Audio *Engineering Society*, *10*(3), 219-223.

[2] Picture source from the website: lotrresources.com/publicity.html.

[3] ECE 472 Assignments