Music Synthesis

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IMPORTANT

To submit your assignment for this lab, you must upload a SINGLE ZIP file which includes this completed PDF answer sheet with the required answers/screenshots and your two .wav files (see Section 4).

Note: Each box is worth 1pt.

2. Build some chords and listen

- *Write down your last line of code from get freq.*

```
f =  middle_A_freq * (semitone_mult ^ semitone_jump);
```

- *What is the frequency of key number 9?*

207.6523 Hz

- *Write down the line of code inside the for loop in get chord wave.*

```
X = X + get_wave(notes{i,1}, notes{i,2}, duration, fs);
```

3. Visualize frequency of recorded and synthesized sounds

- *What* differences *do you notice between the time domain plots of the real and synthesized signals?*

For the MATLAB time domain plot, the amplitude of the synthesized audio signal does not increase/decrease with time, but rather remain constant*. This essentially means that the strength of the synthesized signal will remain consistent across the testing window. On the other hand,* ***changes in amplitude of the real music signal can be clearly identified****. Referring to the ADSR simulation model, the Attack and Release stages of the real signal are especially apparent. This damping trend signifies that the audio signal will fade with time.*

- *What* similarities *do you notice between the frequency domain plots of the real and synthesized signals?*

The frequency domain plots of the real and synthesized signals share similar major frequency signals. *Through Fourier Transform, a music chord signal can be separated into its main compositions. For example, from the synthesized C chord frequency domain plot, 3 major spikes can be identified at approximately 260Hz, 330Hz, and 390Hz. This observation is enhanced by the common music knowledge, that a C chord is composed of multiple music notes (C at 261.63 Hz, E at 329.628 Hz, and G at 391.995 Hz). Similarly, the real piano chord also has three major components in the frequency range of 250Hz-500Hz.*

- *What* differences *do you notice between the frequency domain plots?*

  The magnitudes of the real piano signals vary while their main frequencies are not exactly aligning with those frequencies predicted by music theory. *On the other hands,* ***the major frequencies of the synthesized signal can be clearly identified, and no noises appears on the synthesized frequency domain plot.*** *This is because more noises are introduced during the signal production process. Potential influence factors for real piano signal include noises created by piano key pressing, out of tune playing due to loosen strings, external noises that were accidentally recorded, etc.*

- *What does the spectrogram have in common with your frequency domain C chord plot?*

  Both spectrogram and the frequency domain C chord plot shows strong composition signals at approximately 260Hz, 330Hz, and 390Hz. *In brief, the spectrogram is a combination of time domain plot as well as frequency plot, as it reflects the strength of the composition signals along with time developments. When following x-axis, the red focus line of the chord signal shows where the main frequencies lines (the dominant frequencies that have the greatest strengths according to the righthand-side color legend), just like a frequency plot. Following the y-axis, the changes in the composition frequencies can be observed. However, as only one C chord is graphed in the spectrograph, the amplitudes as well as main composition of this specific music signal remain unchanged (confirmed in the time domain plot), which means the horizontal position of the red focus stays fixed throughout the time span.*

4. Synthesize a song

- *Write down your second argument in the call to get chord wave inside get song wave.*

  `Z = [Z, get chord wave( song{i,1} , beat length * song{i,2} ,fs)];`

- *Include the spectrogram plot for your song and attach it to this document*

  Similar to the previous spectrogram, the main frequencies for each chord can still be clearly identified in each beat (when strumming happens but chords remain unchanged). For the synthesized song shown in the following graph, the duration of one beat is 3 seconds; meanwhile, the spectrogram uses a Hamming window such that y is divided into eight segments (such that 24/8 = 3 seconds for each y interval) with no overlapping samples. As the beat duration aligns with the window setting, for each 3-second time interval, the exact signal frequency compositions can be identified. For example, a C chord is used from 0-3s and then an A minor chord kicks in. As the C major chord and the A minor chord differ by one note, where a low G note is substituted into a low A note, only one main frequency composition varies (changed from approximately 196Hz to 220Hz). Also, due to the ADSR simulation adaptation of the generated model, the yellow frequency line appears to be less focused (more spread-out and less powerful) when compared with the synthesized C chord shown in figure 3 in handout.