Assignment 7: Audio Synthesis with Sine Waves

CS 4347: Sound and Music Computing

due Thursday 26 March 2015, 11:59 pm

NOTE: For inquiries on this assignment, please contact FANG Jiakun (a0123777@nus.edu.sg).

1. Additive synthesis

   Write a program that plays notes with these MIDI pitches:

   ```
   midis = [60, 62, 64, 65, 67, 69, 71, 72, 72, 0, 67, 0, 64, 0, 60]
   ```

   Hint: write a function which takes a MIDI number as input argument, and returns an array containing the synthesized sine waves. Use `numpy.concatenate()` to combine the notes together.

   - A "pitch" of 0 means a rest (also known as "silence", `numpy.zeros()`).
   - The fundamental frequency of each non-rest note `m` is:

     $$f_0 = 440 \cdot 2^{\frac{m-69}{12}}$$

   - Each note (including rests) should be 0.25 seconds long.
   - Use 16-bit samples and sampling rate of either 8000, 16000, or 32000 Hz.
   - Each note must use at least 4 sine waves with harmonic additive synthesis (frequencies are $n \cdot f_0$. You can choose your own n).
   - If any frequencies are aliased (due to going above the maximum frequency), you will lose a mark.
   - Save the audio to the file `notes.wav`.
     Hint: `scipy.io.wavfile.write()`
   - Create a spectrogram (window size 512, 50% overlap, blackman window, log-scale with constant of 10^{-10}) and save it to the file `spectrogram-notes.png`. The X-axis must be time, and the Y-axis must be frequency. You may display time in analysis frames, and frequency in bins (instead of converting to seconds and Hz).
     Hint: `pylab.imshow()`

2. ADSR Envelope

   Update your python program to apply an ADSR envelope to each note. You have the freedom to choose any ADSR envelope, but the resulting wav file should be audibly distinguishable from the one without envelope.

   - Save the audio to the file `notes-adsr.wav`.
   - Create a spectrogram and save it to the file `spectrogram-notes-adsr.png`.

3. Submit a zip file containing your program's source code (as a `.py` file), the `.wav` files, and the `.png` files to:

   `http://cs4347.smcnus.org`

- You may use anything in the python standard library, numpy (including pylab / matplotlib), and scipy libraries. No other libraries are permitted.

Grading scheme:
- **3/6 marks**: correct additive synthesis output (`.wav` and `.png`)
- **3/6 marks**: correct ADSR output (`.wav` and `.png`)