

## I547: Audio Music Processing Homework 2

The first two problems of this assignment will be a little easier for those having some musical knowledge, though especially valuable (and still accessible) for those who don't. Feel free to ask questions of me, Sanna, or your classmates if the musical terminology is not clear. The following table gives the common musical note names for the various possible equal tempered musical frequencies with  $f_0 = 440$ :

|                   |                         |
|-------------------|-------------------------|
| $f_0$             | A                       |
| $f_0 2^{(1/12)}$  | A $\sharp$ (B $\flat$ ) |
| $f_0 2^{(2/12)}$  | B                       |
| $f_0 2^{(3/12)}$  | C                       |
| $f_0 2^{(4/12)}$  | C $\sharp$ (D $\flat$ ) |
| $f_0 2^{(5/12)}$  | D                       |
| $f_0 2^{(6/12)}$  | D $\sharp$ (E $\flat$ ) |
| $f_0 2^{(7/12)}$  | E                       |
| $f_0 2^{(8/12)}$  | F                       |
| $f_0 2^{(9/12)}$  | F $\sharp$ (G $\flat$ ) |
| $f_0 2^{(10/12)}$ | G                       |
| $f_0 2^{(11/12)}$ | G $\sharp$ (A $\flat$ ) |
| $f_0 2^{(12/12)}$ | A                       |
| ...               | ...                     |

1. Using R, generate pitches at frequencies  $f, 2f, 3f \dots 8f$  where  $f = 440 * 2^{(-9/12)}$  Hz (middle c). For each pitch give the name of the note (eg. C,D,E, C $\sharp$ , E $\flat$ , ...) and compare the frequency with the frequency of the equal tempered approximation of the pitch giving the ratio of frequencies (which should be near 1).
2. In R two vectors  $x$  and  $y$  can be "concatenated" (strung together) using the notation

$$> \mathbf{z} = \mathbf{c}(x, y)$$

the result is a vector whose length is the sum of the two lengths. Use this to create the first 10 notes of "Amazing Grace" in the key of C. Create the correct rhythm as well. The pitches for the melody are (in one of the many variations) c(G,C,E,D,C,E,D,C,A,G) while the relative note lengths are c(1,2,1/2,1/6,1/3,2,1,2,1,2).

3. To simulate the bagpipes, add a low "drone" (long held low notes of C and G) to your melody. Optional: Add grace notes and use appropriate reedy tone color to simulate the feel of the bagpipes. Be prepared to play your example in class.
4. Suppose we generate a function

$$f(t) = a_1 \cos(2\pi ft + \phi_1) + a_2 \cos(2\pi 2ft + \phi_2) + \dots + a_{10} \cos(2\pi 10ft + \phi_{10})$$

where  $a_1 \dots, a_{10}$  are the amplitudes and  $\phi_1 \dots, \phi_{10}$  are the phases. Give the perceived pitch (in Hz) if we set

- (a)  $a_1 = a_3 = a_5 = a_7 = a_9 = 0$  and the others are 1.
- (b) all to zero except  $a_3 = a_6 = a_9 = 1$
- (c)  $a_1 = 0$  and all others 1.

In each of the cases explain why this is consistent with the ideas we have learned.

5. **Expressive octave leap** We want to create a somewhat expressive sounding leap of an octave. (Think of "Somewhere over the Rainbow." Our frequency must not suddenly jump an octave, but rather have a rapid *glissando* (smooth pitch change) and arrive at the top note with pitch vibrato.
  - (a) Create your pitch function, starting at the lower octave note, rising quickly, and sustaining the upper octave with vibrato, sampled at 16KHz and plot it.
  - (b) Use this function to create expressive leap. Be prepared to demonstrate your sound in class.
6. Create a pitch vibrato around 440 Hz of width 10 Hz that begins at a rate of 2 Hz and gradually increases to a rate of 10 Hz. The entire sound should be 10 secs. long. Be prepared to demonstrate your result in class.