Assignment 2: Sound synthesis competition

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The goal of the following exercises is to compare additive synthesis to FM synthesis. You will realize how there isn't really the *best sound synthesis technique*, but each technique is better in some cases and for specific reasons and worst in others.

1 Implementation of additive synthesis

Basic additive synthesis can be considered as the sum of cosine waves given by

$$x(t) = \sum_{k=1}^{N} A_k cos(2\pi f_k t + \phi_k)$$

Write a matlab function that creates such waveform. The syntax of your function should be:

```
function y =sumcos(f,Z,fs,dur)
%  f = vector of frequencies in Hz
%  Z = vector of complex amplitudes A*e^(j*phase)
% fs = sampling rate in Hz
% dur = total duration of the signal in seconds
% f and Z must be of the same length:
% Z(1) corresponds to f(1) and so on.
```

2 Implementation of envelopes

Write a matlab function that creates a decaying exponential envelope of the form

$$y(t) = e^{-t/\tau}$$

Your function should look like:

```
function yy =bellenv(A0, tau,dur,fs)
% A0 = amplitude of the envelope.
% tau = time constant
% see section 5.2.2 page 53 of the 320 reader.
% dur = duration of the envelope in seconds
% fs = sampling frequency
%% returns yy =decaying exponential envelope
```

You will use this function later on as an envelope for FM synthesis.

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3 Implementation of FM synthesis

Write a matlab function that implements the general equation for an FM synthesizer:

$$x(t) = A(t)\sin[2\pi f_c t + I_0 \sin(2\pi f_m t + \phi_m) + \phi_c]$$

The syntax of your function should be:

```
function y =fm(ff,Io,tau,dur,fs)
%  ff = vector of frequencies in Hz containing fc and fm
%  Io = scale factor for modulation index
%  tau = exponential decay parameter for A(t) and I_0,
% see section 5.2.2 page 53 of the 320 reader.
% dur = total duration of the signal in seconds
% fs = sampling rate in Hz
```

4 Synthesis of a bell

Try to reproduce the sound of a bell using additive synthesis and FM.

1. In the case of additive synthesis, first download the soundfile at:
   http://www-ccrma.stanford.edu/~serafin/320/assign2/bell.wav
2. Look at the partials of its spectrum in Audiosculpt as shown in the lab session and try to reproduce them.
3. In the case of FM, both the amplitude envelope $A(t)$ and the index envelope $I(t)$ are decaying exponentials.
4. Use the matlab function env.m written before to create such envelope.
5. Now use your FM function to synthesize a bell sound. For the bell, a good choice is $f_c = 110$ Hz and $f_m = 220$ Hz.

5 Synthesis of a clarinet

Now try to synthesize the timbre of a clarinet sound using both additive and FM.

1. For **additive synthesis**, you can reproduce the soundfile in
   http://www-ccrma.stanford.edu/~serafin/320/assign2/clarinet.wav
   With $w = 2\pi f_0$, where f_0 is the fundamental frequency, the simulated clarinet waveform as a function of time t (in seconds), is:
   $$s(t) = \sin(w) + 0.75\sin(3w) + 0.5\sin(5w) + 0.14\sin(7w) + 0.5\sin(9w) + 0.12\sin(11w) + 0.17\sin(13w)$$
2. You can notice also from the equation a characteristic of the spectrum of a clarinet. Which characteristic is it?
3. As described during the lab session, ADSR envelopes are common in computer music in order to create a more natural synthesis. Try to add an ADSR envelope to make the synthesis more interesting.
4. To create the clarinet envelope for **FM**, use the matlab file in
   http://www-ccrma.stanford.edu/~serafin/320/assign2/woodenv.m
5. First implement a function that performs some scaling of the envelope.
6. Now use your fm.m function together with the woodenv.m function to synthesize the clarinet. Note that a good ratio of carrier to modulating frequency is 2:3.

6 Synthesis of a bluebird

Now try to reproduce the sound of the bluebird you find at
http://www-ccrma.stanford.edu/~serafin/320/assign2/bluebird.wav

1. Using again the data of the sonogram derived from Audiosculpt, find the partials of the bluebird sound.
2. Provide the matlab code you used to synthesize the sound.
3. How many partials do you need in the additive synthesis to obtain a faithful reproduction of the original sound?
4. Are you able to find the parameters for FM to obtain a "good synthesis"?

7 Optional questions

1. What would you like to get out of these labs?
2. What would you like to do during the lab sessions?
3. What would you rather do for the assignments?