Assignment 3: FOF synthesis

TA: Stefania Serafin
CCRMA*
serafin@ccrma.stanford.edu

1 Implementation of FOF synthesis

1.1 Implementation of a FOF

Write a Matlab function that implements a FOF (formant wave function). As defined in class, a FOF function has the following structure:

$$s(n) = \begin{cases} 0, n \leq 0 \\ \frac{1}{2}(1-\cos(\beta n))e^{-\alpha n}\sin(\omega_c n + \phi), 0 \leq n \leq \pi/\beta \\ e^{-\alpha n}\sin(\omega_c n + \phi), n > \pi/\beta \end{cases} \quad (1)$$

where ω_c is the frequency of resonance, $\pi/\beta =$ attack time of the formant which determines the width of the skirts, $\alpha =$ decay time.

Your matlab function should look like:

```
y=fof(w,beta,alpha, phi,fs)
% w = central frequency (in rad/sec)
% beta = parameter for the width of the skirts (pi/beta= attack time in samples.)
% phi = phase (in radians)
% alpha = 1/(decay time-constant in samples)
% y = vector containing the time domain samples of a FOF
```

Verify if your function works:

1. Try with $\pi T/\beta = 0.1$ msec. and $\pi T/\beta = 1$ msec. Choose arbitrary values for the other parameters. Plot the two spectra. What is the width of the formants in the two cases?
2. Check in the spectrum that the fundamental frequency of the FOF corresponds to ω_c.

1.2 FOF synthesis

Now write a function that adds together a certain number of FOFs and creates a FOF synthesizer.

Your matlab function should look like:

```
y = fofsynthesizer(W,Beta,Alpha,Phi,Step,N,fs)
%
% N = number of FOFs desired
% W = vector of central frequencies for the FOFs. (in rad/sec)
% Beta = vector with parameters for the width of the skirts.
```

*http://www-ccrma.stanford.edu

```
% Phi = vector of phases.
% Alpha = vector of decay parameters.
% Step = vector containing the time delay between each FOF (in samples).
% y = vector containing the resulting FOF combination.
% fs = sample rate in Hz.
%
% Note that length(W)=length(Beta)=length(Alpha)=length(Phi)=N.
```

Your function `fofsynthesizer` should call the `fof` function.

1.3 Synthesis using FOFs

Using the correspondence between time domain and frequency domain parameters we saw in class, create a FOF synthesis using 5 FOFs with the parameters shown in the following table:

$\pi T/\beta$	**Frequency**	**Amplitude**	**BW**
.002 sec	650 Hz	0 dB	80 Hz
.0015 sec.	1080 Hz	-6 dB	90 Hz
.0015 sec.	2650 Hz	-7 dB	120 Hz
.003 sec.	2900 Hz	-8 dB	130 Hz
.001 sec.	3250 Hz	-22 dB	140 Hz

Table 1: Parameters for 5 FOFs

Use the functions `fof` and `fofsynthesizer` you created before to synthesize your sound.

1. What kind of sound do you get?
2. Using the matlab functions `freqz` and `plot`, plot the spectrum of each formant, and verify that you get the correct frequency and width of skirts.

1.4 Synthesizing the bluebird with FOFs

You have seen that the spectrum of the bluebird of the previous assignment is almost sinusoidal.

1. Try to synthesize it using a single FOF. Is a single FOF enough to create a decent synthesis?
2. Provide the matlab code you used to synthesize the bluebird.
3. As before, plot the spectrum of each formant, and verify that you get the correct frequency and width of skirts.

1.5 More synthesis with FOFs

1. Do you think that FOFs would be a good synthesis technique in the case of the clarinet and the bell? Explain why.
2. From your understanding of formant synthesis, explain which kind of sounds would be efficiently modeled using FOFs. Provide some examples.