MUS424:
Signal Processing Techniques for Digital Audio Effects Handout #5
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Laboratory Exercise 1: Impulse Response Measurement

Due Date: April 14, 2011

In this lab, we study impulse response measurement and wah pedals. Wah pedals filter the input signal differently for different pedal positions, producing a sort of 'oo' sound when the pedal is up and an 'ah' sound when it is down. You will measure the impulse response of a wah pedal at various pedal positions, and develop a parametric model of the wah pedal transfer function as a function pedal position.

Problem 1. [50 points]

Pick up the wah pedal from Jonathan—it should be in his office Thursday—or use your own. Set up a digital audio workstation to play back a test signal while simultaneously recording the wah pedal's response. (For instance, run Audacity on one of the CCRMA machines with a working interface.)

1(a). [20 points] Design a test signal (e.g., a pair of Golay codes or swept sinusoid) to measure the wah pedal impulse response with a high signal-to-noise ratio. Plot the test signal(s).

1(b). [20 points] Record the test signal response for the pedal in five positions: fully up, fully down, and three positions reasonably evenly spaced in between. Use specgram (or similar function) to plot spectrograms of the response.

1(c). [10 points] Form impulse responses from each of the test signal responses. Plot the wah pedal impulse responses for each of the five positions measured.

1(d). [10 points] On the same set of axes, plot the wah pedal transfer function magnitude for each of the pedal positions measured. Plot the transfer function magnitudes in dB, and use a logrithmic frequency axis (e.g., semilogx() in Matlab), say from 20 Hz to 20 kHz.

Problem 2. [50 points]

Many wah pedals have transfer functions similar to peaking filters of the form

$$H(s) = \frac{\gamma(s/\omega_c)}{(s/\omega_c)^2 + (s/\omega_c)/Q + 1}, \tag{1}$$

where s is a complex frequency and ω_c is the peak frequency in radians per second, γ is the overall gain, and Q controls the width of the peak. Some pedals will have more of a low-pass or high-pass characteristic, with a factor of γ or $\gamma(s/\omega_c)^2$ in the numerator of $H(s)$.

2(a). [**10 points**] Plot the magnitude of the transfer function $H(j\omega)$ in dB on a logarithmic frqeuency axis from 20 Hz to 20 kHz for $\gamma = 0.2$, $Q = 5$ and $\omega_c = 2\pi \cdot 1000$.

2(b). [**40 points**] For each of the five pedal positions measured, find filter parameters ω_c, γ and Q that produce a transfer function magnitude $|H(j\omega)|$ that closely matches that of your pedal. (You might need to use the low-pass or high-pass form of the filter. Note that it is more important to model the filter peak than it is quieter features away from the peak.) For each of the five measured positions, plot both the measured transfer function magnitude and the parametrized one you fit. (Note that by having a parametrized model of the transfer function, intermediate transfer functions can be estimated by interpolating the parameter values.)