UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Electrical and Computer Engineering

ECE 498MH Signal and Image Analysis

Homework 11

Fall 2014

Assigned: Thursday, 4/13/2017 Due: Thursday, 4/20/2017

Reading: 394–415

Do **one** of the following two problems, and submit by 11:59pm 4/20/2017 (on Compass). Homework will be returned on 4/25/2017. If you don't like your grade, then you can hand in the **other** problem for a grade, no later than 5/2/2017.

Problem 11.1

The vowel /a/, as in "father," is produced by dropping your tongue down and back. The resulting vocal tract shape has resonant frequencies of F1=900, F2=1100, F3=2700, F4=3300Hz, with bandwidths of roughly B1=100, B2=150, B3=250, and B4=300Hz, respectively.

(a) Assume a sampling rate of $F_s = 8000$Hz. Express the four resonant frequencies, and their bandwidths, in units of radians/sample.

(b) This transfer function can be written as

$$H(z) = \frac{1}{\prod_{k=1}^{8}(1 - p_k z^{-1})}$$

Give the eight pole locations, p_1 through p_8. How do you know this filter is stable?

(c) It is possible to implement this filter as

$$H(z) = H_1(z)H_2(z)H_3(z)H_4(z)$$

where each of the filters $H_1(z)$ through $H_4(z)$ is at most second-order, and each one has real-valued coefficients. What is $H_1(z)$?

(d) Write an LCCDE that implements $H_1(z)$.

(e) Find the impulse response $h_1[n]$ of $H_1(z)$.

Problem 11.2

The vowel /u/, as in "boot," is produced by raising your tongue and pursing your lips. The resulting vocal tract shape has resonant frequencies of F1=300, F2=1000, F3=2000, F4=3000Hz, with bandwidths of roughly B1=100, B2=150, B3=200, and B4=300Hz, respectively.

(a) Assume a sampling rate of $F_s = 10,000$Hz. Express the four resonant frequencies, and their bandwidths, in units of radians/sample.

(b) This transfer function can be written as

$$H(z) = \frac{1}{\prod_{k=1}^{8}(1 - p_k z^{-1})}$$

Give the eight pole locations, p_1 through p_8. How do you know this filter is stable?

(c) It is possible to implement this filter as

$$H(z) = H_1(z)H_2(z)H_3(z)H_4(z)$$

where each of the filters $H_1(z)$ through $H_4(z)$ is at most second-order, and each one has real-valued coefficients. What is $H_1(z)$?

(d) Write an LCCDE that implements $H_1(z)$.

(e) Find the impulse response $h_1[n]$ of $H_1(z)$.