

ECE 537 Homework 4

Due: September 25, Urbana time

1. The lecture notes suggested that the following error metric:

$$\mathcal{E}_K = \sum_n (s[n] - \hat{s}_{K-1}[n] - a_K h[n - n_K])^2$$

...is minimized by the following gain factor:

$$a_{K,opt} = \frac{R_{EH}[n_K]}{R_{HH}[0]}$$

...and that the resulting optimal error is given by:

$$\mathcal{E}_{K,opt} = \mathcal{E}_{K-1} - \frac{R_{EH}^2[n_K]}{R_{HH}[0]}$$

Prove these claims.

Solution:

$$\begin{aligned} \frac{\partial \mathcal{E}_K}{\partial a_K} &= - \sum_n (s[n] - \hat{s}_{K-1}[n] - a_K h[n - n_K]) h[n - n_K] \\ &= a_K R_{HH}[0] - R_{EH}[n_K] \end{aligned}$$

Setting the second line to zero gives the desired coefficient. The second derivative is $R_{HH}[0]$, which is always positive, guaranteeing that this value of a_K is a global minimum.

$$\begin{aligned} \mathcal{E}_{K,opt} &= \sum_n (s[n] - \hat{s}_K[n])^2 \\ &= \sum_n (s[n] - \hat{s}_{K-1}[n] - a_K h[n - n_K])^2 \\ &= \mathcal{E}_{K-1} - 2a_K R_{EH}[n_K] + a_K^2 R_{HH}[0] \end{aligned}$$

...which simplifies to the form given in the problem statement.

2. Using the figures from Zheng et al. (2003) reproduced in lecture slides, sketch four different midsagittal views of the vocal tract: One for [a] (positive loading factor 1), one for [e] (negative loading factor 1), one for [o] (positive loading factor 2), one for [ɪ] (negative loading factor 2). Vowels are sometimes described by their location of maximum constriction. Assign one of each of the following words to each vowel, based on its location of maximum constriction: pharyngeal, uvular, palatal, pre-palatal.

Solution: Drawings should show that: [a] is pharyngeal, with the tongue down and back. [e] is palatal, with the tongue bunched straight up into the hard palate. [o] is uvular, with the tongue pushed back into the bend of the vocal tract. [ɪ] is pre-palatal, with the tongue pushed up and forward.

3. Provide IPA notation for a reasonable American English pronunciation of the sentence: “What’s in a name? A rose by any other name would smell as sweet.” Note that the English labiovelar glide “w” (labiovelar = it has constrictions at both the lips and the velum) could be denoted as [w̥] (to explicitly show the velar and labial constrictions), but we usually just write it as [w].

Solution: [watsmənem]? [əɹɔzbɑɪɛniʌðz-nemwʊdsmɛlæzswit].