EE 513 HW6: LPC Analysis

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a) Running the analysis with aaa3.wav supplied in the course files page on Canvas, we can observe that the vocal tract length is estimated to be about 17 cm long. This is consistent with the example shown in class (as expected since it is essentially the same process.) However, every other sample I analyzed returned vocal tract lengths between 23 cm and 33 cm, which is clearly much larger than most human vocal tracts. It is currently suspected that the reason this analysis breaks down is that the equation to find tract length is unideal for the free vowel sound and invalid for any other vowel sound. Considering we cannot actually produce a perfect free vowel sound without extensive training, and considering the limitations of the tract length equation, it is not unreasonable to conclude that this process is unreliable for measuring the length of vocal tracts in a general population. using this analysis, It was found that MY vocal tract is about 23.91 cm long. I know this is not an accurate result because the average vocal tract length for males is about 18 cm, and this vocal tract length is not consistent with my voice type (tenor/baritone). According to a study published in the *International Journal of Speech-Language Pathology* on the vocal tract length of various professional singers, a tenor/baritone will have an average vocal tract length of 18 cm [1] .

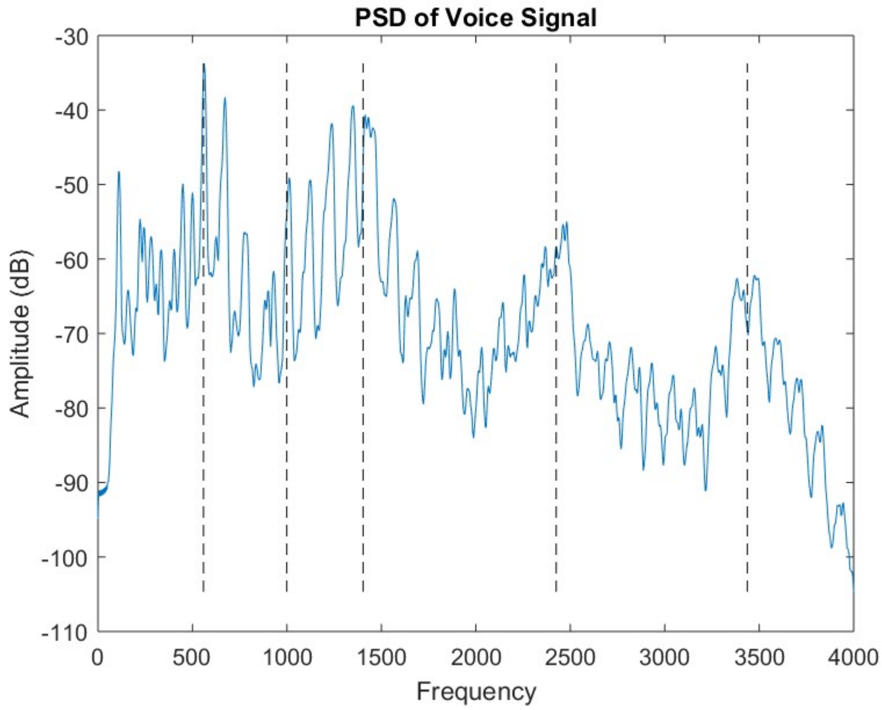
b)

When filtering the free vowel signal with the all-pole filter using the LPC coefficients, it was expected that the resulting signal will sound like it contains frequency content corresponding to the formant frequencies. This was evident in that the filtered signal had much less fidelity. Taking the PSD reveals that only the formant frequencies are present in the predicted signal as expected. This was expected because the predicted sequence resulting from the LPC analysis should characterize the resonant properties of a system in question.

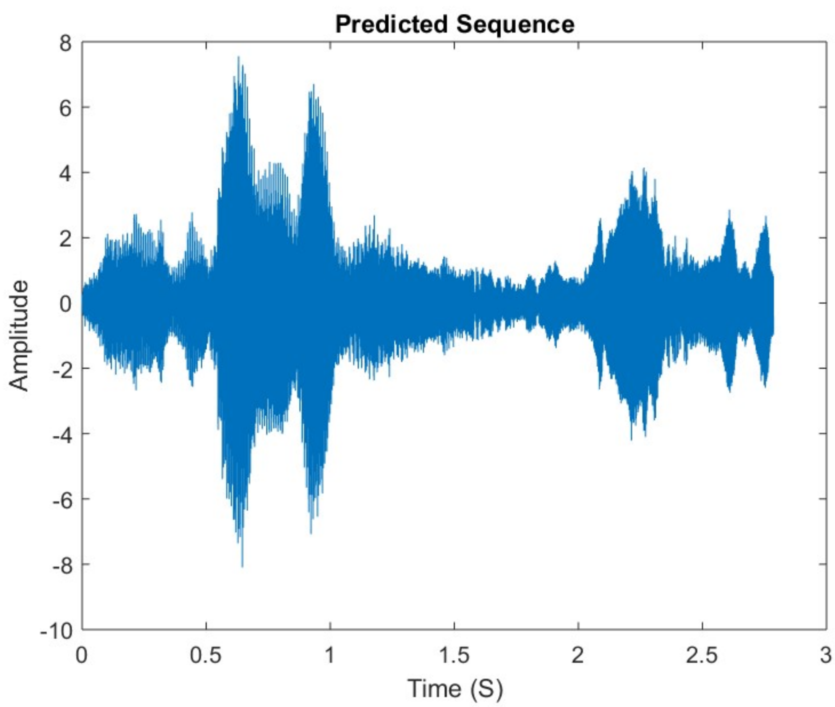
When filtering using the all-zero filter, the resulting signal characterizes the behavior of the vocal chords in the signal. This is because the all-zero filter extracts the error sequence (i.e. large changes in the input signal that are not consistent with the formant resonances.) The filtered signal sounds like a buzz similar to one a trumpet player forms with their lips. This is consistent with our expectations because the vocal tract acts as a spatial filter that resonates with the fundamental frequency produced by the vocal chords. This process by which speech is filtered in the vocal tract is extremely similar to the behavior of a trumpet or other wind instrument that can be modeled as a tube with one end closed.

c) By moving the poles of the LPC filter, we can expect that the impact of the filter will decrease. In general, for any filter, as the poles are moved away from the unit circle towards zero, the roll-off of the filter becomes less steep. because of this decrease in Q-factor, the filter will have a less differentiated response between the stop and pass bands. Since the pass and stop bands move closer to one another when poles are moved towards zero, the filter has a more consistent response across all frequencies, thus diminishing the effect of the filter overall. Listening to the filtered signal processed with the adjusted pole locations, it can be observed that the filtered signal sounds more like the original signa than the signal filtered using the original pole locations.

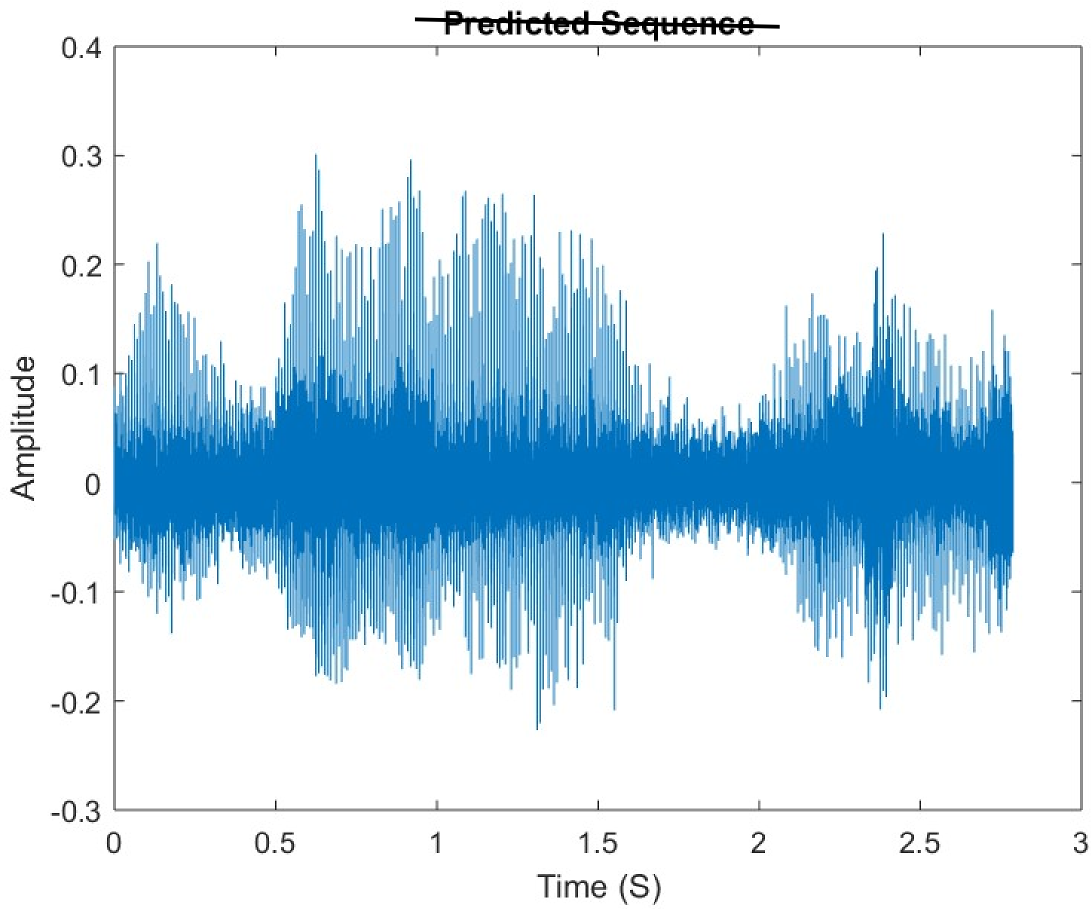
FIGURES:



PSD of Input Voice Signal with Formants Labeled at: 3.4369, 2.4258, 1.4029, 0.5582, 0.9994 Hz



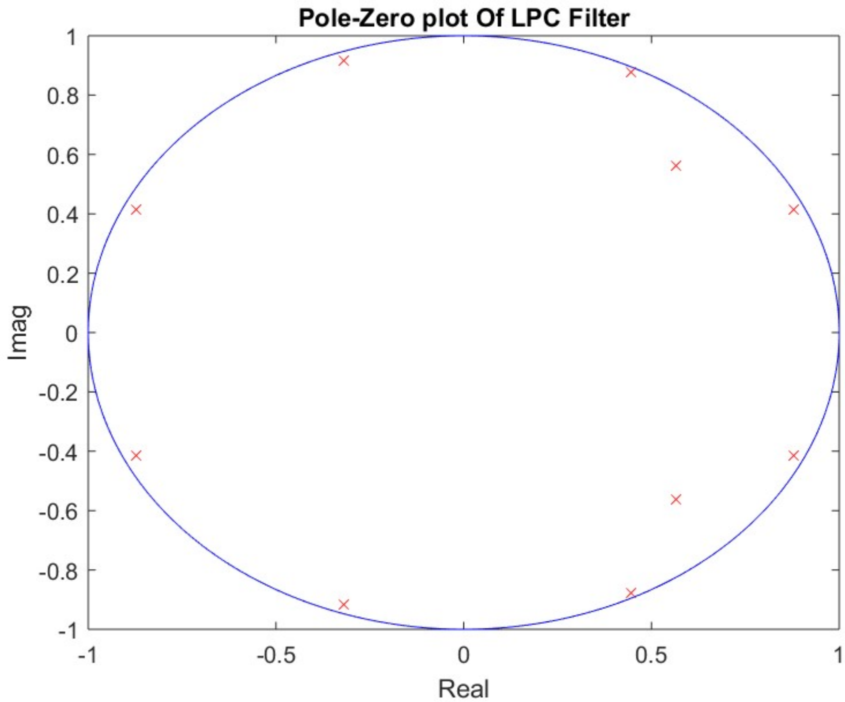
Predicted Sequence From LPC Analysis



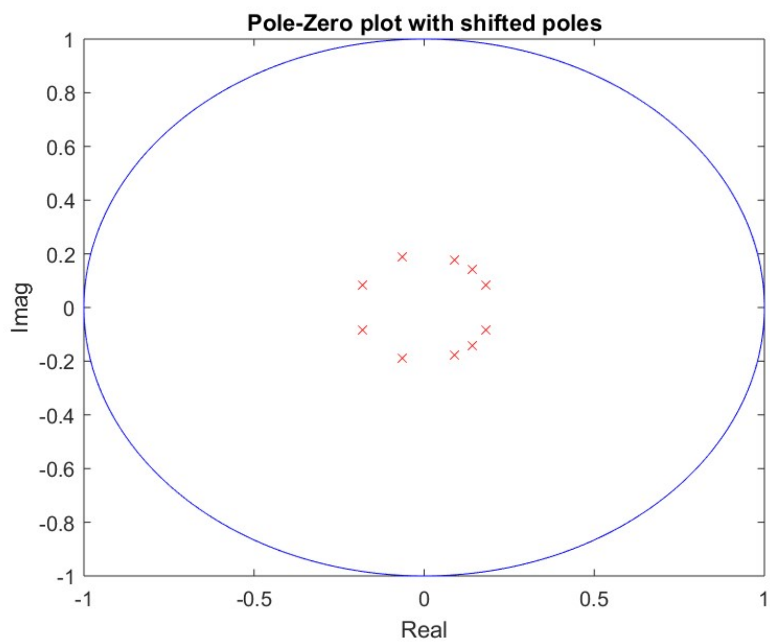
Error Sequence from LPC Analysis

----------!!!(NOTE: THIS SHOULD BE TITLED ERROR SEQUENCE)!!!--------

sorry



Pole-Zero Plot of Original LPC Filter



Pole-Zero Plot with Poles Shifted by A Factor of 0.2

Citation:

[1]: Vocal tract dimensional characteristics of professional male and female singers with different types of singing voices
https://www.researchgate.net/publication/236938228_Vocal_tract_dimensional_characteristics_of_professional_male_singers_with_different_singing_voice_types/download