Computer Assignment 2 Solution

Abstract:
This assignment looks into the spectral composition of voiced speech and the use of difference equations to create filters. The first part of the assignment looks into the effect of difference equations as filters. We specifically looked into difference equations of the form:

\[ y(n) = x(n) - ax(n-1) \]

We found that when \( a \) is a positive number the result is a high pass filter and that when \( a \) is negative the difference equation acts as a low pass filter. These filters can be used to clean up poorly recorded signals to make them audibly more intelligible. Next we looked into identifying the formant frequencies of the sounds /a/ and /u/. We were able to correctly observe the first three formants of the two vowels.

Questions:
Pre-Emphasis
1) Sketch the three pole-zero plots for \( a = 0.8, 0.5, -0.98 \). Label each by its difference equation and classify each as low pass or highpass.

\[ y(n) = x(n) - 0.8x(n-1) \text{ HIGHPASS} \]

\[ y(n) = x(n) - 0.5x(n-1) \text{ HIGHPASS} \]
\[ y(n) = x(n) + 0.8x(n-1) \] LOWPASS

2) Describe the effect of pre-emphasis on the sound of the female sentence and on the spectral representation of the female sound vector.

The filter has boosted the high frequencies and the low frequencies have been attenuated. The spectrum is flattened.
Formant Frequency Identification

3) Determine the approximate frequencies for the first three formants (F1, F2, F3) for the male /a/.

As you can see from the graph below, the formants are at approximately 750 Hz, 1200 Hz and 2400 Hz.
**Autocorrelation computation for the pitch period estimate**

4) *Compute the autocorrelation of “male_a” and “female_a” and plot them.*

```matlab
>> xcorr(male_a, male_a);
```

![Autocorrelation plot for male_a](image)

```matlab
>> xcorr(female_a, female_a);
```

![Autocorrelation plot for female_a](image)
5) What does the first autocorrelation coefficient correspond to? 
The first autocorrelation coefficient corresponds to the energy of the signal.

6) Estimate the pitch period of both male and female speakers from the autocorrelation.
As you can see from the autocorrelation graphs above, the pitch period for the male speaker is 113 Hz (71 samples distance from highest peak to next highest peak) and for the female speaker is 258 Hz (31 samples distance from highest peak to next highest peak).

7) What do you observe and why?
The autocorrelation of a time-limited periodic signal with period T has its highest positive peaks at multiples of T. The autocorrelation of a periodic time unlimited signal is periodic with the same period.