

Design Project Assignment II

Energy and Zero-Crossings of Signals

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Objective:

This project assignment will introduce some fundamental DSP concepts that are used to process speech signals. You will segment (window) a speech signal into sections and develop procedures to calculate the average energy and zero-crossings for each segment. These procedures will be used in the final design project.

Deliverables:

The report should include all relevant graphs integrated with the text. Also for the report:

- Incorporate all graphs and plots into body of report
- Make sure to explicitly label all axes and title all graphs.
- Use the grid option when graphing signals.
- Comment your Matlab code so that it is obvious what process you are using.
- Include all Matlab code as either a referenced appendix or integrated into the report.
- Number all of your pages.

Procedures:

Record and save the phrases "*We were away*" and "*She is Aware*". Speak the phrases drawn out enough so that the voiced and unvoiced portions of the speech are apparent. Use Sound Recorder with the following properties:

Format = Pulse Code Modulation
Sampling Rate = 11,025 Hz
Bits per Sample = 16
Recording Mode = Mono.

- 1) Open the "*She is Aware*" file in Matlab. Extract the word "*She*" and create a labeled plot of the signal versus time.
- 2) Verify mathematically that 220 samples should be used to represent 20msec of speech sampled at 11,025 Hz.
- 3) Create a function, `avg_energy`, to calculate the average energy for an array, where:

`[ENERGY] = avg_energy(ARRAY, WINLENGTH)`

`ENERGY` is the Average Energy output array
`ARRAY` is the input vector
`WINLENGTH` is the length of the moving window (even number of point)

Use a Hamming window to filter each analysis frame before calculating the energy. Move the window by `WINLENGTH/2`. If the length of the array is greater than a constant times `WINLENGTH`, ignore the extra samples at the end of the array (as shown in example code).

Include the Matlab code for your function. Test the function on the "*She*" speech signal with a window size of 220 samples. Include labeled subplots of "*She*" and the average energy vs. time.

- 4) Create a function to calculate the average magnitude where:

`[ENERGY] = avg_magnitude(ARRAY, WINLENGTH)`

Use the same specifications as in 3 except `ENERGY` is the Average Magnitude.

Include the Matlab code for your function. Test the function on the "*She*" speech signal with a window size of 220 samples. Include labeled subplots of "*She*" and the average magnitude vs. time.

- 5) Comment on the difference between the results of the average magnitude and average energy calculations. Which algorithm is faster? Comment on the scales of the amplitudes. In your opinion, which algorithm "better" describes the amplitude properties of the signal? Define your criteria and explain why you chose this algorithm.

6) Create a function to calculate the zero crossings where:

`[CROSSINGS] = zero_crossings(ARRAY, WINLENGTH)`

CROSSINGS is the Number of Zero-Crossings output array

ARRAY is the input vector

WINLENGTH is the length of the moving window (even number of point)

Use a Rectangular window to filter each analysis frame before calculating the zero-crossings. Move the window by WINLENGTH/2. If the length of the array is greater than a constant times WINLENGTH, ignore the extra samples at the end of the array (as shown in example code).

Include the Matlab code for your function. Test the function on the “*She*” speech signal. Include labeled subplots of “*She*” and the zero-crossings vs. time.

7) Edit the file “*She is aware*” and remove any noise, pause, or clicks before and after the signal. Create subplots of the following signals vs. time:

1. The speech signal “*She is aware*”
2. The average energy of the speech signal
3. The zero-crossings of the speech signal

8) Edit the file “*We were away*” and remove any noise, pause, or clicks before and after the signal. Create subplots of the following signals vs. time:

1. The speech signal “*We were away*”
2. The average energy of the speech signal
3. The zero-crossings of the speech signal

9) From your results in 7 and 8, describe how the energy and zero-crossings are related to voiced and unvoiced speech utterances.