Signals & Systems – Spring 2020

Final Project – Due date: 99/04/10

Introduction:

In this project, we are going to preprocess and process the ECG signal obtained from a healthy person. For the preprocessing section, we are going to use FFT and its properties very often. In the following, you can see a milestones of the project in which each part has been clarified briefly.

Preprocessing steps include:

- Visual signal validation
  Plotting the ECG signal helps to check validity of signal recording process

- Motion artifact removal
  Since the subject have motion during data recording in most cases, it is necessary to remove the effect of motion. Since the motion is slow, its effect will appear in low frequency range of signal. Now by rejecting the very low frequency range of signal we can avoid the motion artifact in our signal.

- line noise removal
  In all signal recording processes, we can see effect of line noise in our recorded signal called line noise artifact. This effect emerges as some peaks in power of signal in line frequency (50 or 60 Hz) and its multiplicands. So by using notch filters (search for Notch filter on web), we can remove this effect as well.

- SNR increasing
  In some case of signal processing analyses, in order to reduce noise level, we can use low pass filters to remove the noise. Be careful that you have to be sure that the main signal doesn't have power in the removed range of frequency.

Processing steps include:

- Heart rate calculation

Heart rate measure is one of the main clinical measures for testing the healthiness of the subject. In this project we are going to extract HR from ECG signal by means of autocorrelation of the ECG signal. (Autocorrelation gives us a sense of how the signal is similar to shifted version of itself in all shift values from –inf to +inf)

- Power Spectral density estimation
  For noisy signals which are probabilistic, we tend to calculate power spectral density function instead of Fourier transform. PSD is calculated by taking the Fourier transform of autocorrelation function of the main signal. Here we want to check power of ECG signal in each frequency band of interest by calculating its PSD. As a result, we can filter the signal without losing meaningful information.

- Clinical diagnosis of a heart disease (BONUS!!)
  By having an ECG sample for a healthy person, we could compare a new ECG signal with our sample ECG to diagnose the heart disease of the person owning the new ECG signal. For this task we have to take care of some considerations in order to get correct results.

Here in the following, there are steps of this project which you may be interested to do:

Preprocessing:

1. Load the signal to your workspace and plot the whole signal. then plot just a single period of it (approximately one period)
2. Calculate FFT of signal and plot its magnitude and phase.
3. Apply an ideal high pass filter to the signal to remove Motion artifact (Very low cutoff frequency is needed). Reconstruct filtered signal and plot it. Discuss the changes.
4. Apply notch filters to remove line noise. Reconstruct filtered signal and plot it. Discuss the changes.
5. Apply a low pass filter with reasonable cutoff frequency to remove high frequency noise in order to increase SNR of the signal. Reconstruct filtered signal and plot it. Discuss the changes.

Processing:

1. Calculate autocorrelation of the signal and plot it.

2. You may see approximate periodic peaks in the autocorrelation signal. Visually, find number of samples between the two first peaks.
3. Write a code to find the number of samples between two adjacent peaks algorithmically.
4. Average number of samples between all adjacent peaks to find a number representing average time period of heart stroke.
5. Change the number of samples to time (seconds) by getting help from sampling frequency.
6. The number generated in previous part is average time length between two heart strokes. Calculate HR from that number.
7. By means of autocorrelation function calculated beforehand, calculate PSD of the signal and plot it.
8. Disease diagnosis (BONUS!!)
    - Get a new ECG signal from the web or anywhere else (for a heart disease patient)
    - Do all preprocessing steps for this data.
    - By upsampling or downsampling, make sampling frequency of two datasets equal. Be aware which approach (upsampling or downsampling) will be much more robust.
    - Compare two ECG signals and their features in any way that comes into your mind in order to find out if there is any disease or not. Be comprehensive enough to validate your decision.

Best wishes…

*** Send your codes and report in zipped folder named Signal_Project_STDID to my mail psaco97@gmail.com. For each day of delay your grade will decrease 15%.