EEL 5525 Foundations of Signal Processing

Project
Due Dec 4, 2012

You will find the data file "hand ECG.txt" in the course website. This file is in text format and contains about 150,000 samples of ECG (electrocardiogram) collected from the hand of an individual. The signal is amplified with a gain of 1,000 by the instrumentation amplifier providing a dynamic range of +/- 2.5 volts. The signal is then digitized with a 12 bit A/D converter and sampled at 1,000 Hz. In spite of all the precautions, the signal is corrupted by artifacts. In this data set there are basically two major artifacts: a baseline fluctuation (skin contact, movement) and a 50Hz power-line interference (data was collected in Europe, hence the 50Hz).

The purpose of this project is to design and evaluate the performance of a signal processing frontend built from two filters: a bandstop filter that will attenuate the power-line interference and its harmonics, and a highpass filter that will attenuate the baseline fluctuation, distorting the LEAST the signal of interest that is the PQRST waves. Figure 1 shows a plot of the data and figure 2 shows a zoom in one of a rendered PQRST complex. In the literature, the bandwidth that contains 95% of the ECG energy is 0.5 to 100 Hz.

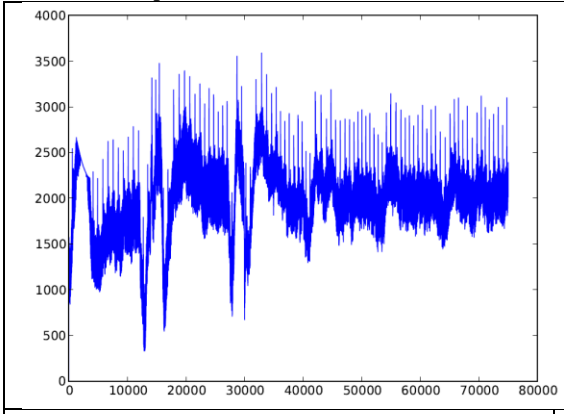

Figure 1

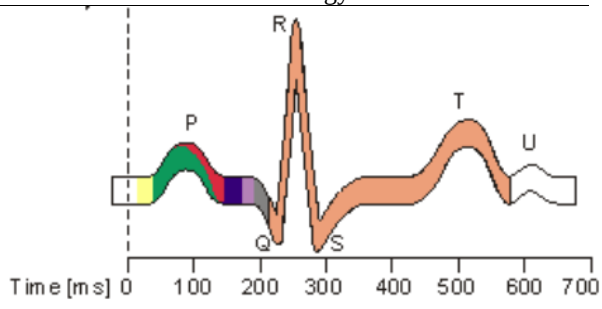

Figure 2

You should investigate (at least) the following issues:

1- Do you need 1000 Hz of sampling frequency?
2- Come up with a design specification and justify the need for the two types of filters.
3- Find an appropriate cutoff frequency for the highpass filter, which means finding the compromise between reducing the fluctuations without distorting the signal. Likewise you have to design the bandstop (also called a notch) filter.
4- Find out how many notch filters you need because there may be harmonics of the powerline noise
5- Design in MATLAB and justify the filter order, the filter type and the filter parameters in the design.
6- Validate the quality of the preprocessing step that you implemented. This is the toughest part. You have first to identify the possible sources of error and then verify that your solution meets the specification.

The project requires a report explaining the experimental procedures you followed and you must include data to support your conclusions. Please use the format of an IEEE Transactions paper (limited to 7 double column pages). This means you have to write a brief intro to the theory, explain well the methods and present carefully the results (see below) and conclude. Remember that any scientific paper should, by definition, contain sufficient information such others can replicate your results. A scientific paper must also contain ORIGINAL material only. If you happen to use text or equations from other source you have to reference what you cut and paste (this is not allowed in a normal publication, but here it is OK provide you reference). Of course, I expect the results to be done by the student alone.