Electrical & Electronics Engineering Department
EE434 – Biomedical Signal Processing - Midterm Exam – Takehome Section
Deadline: November 28th, 2021 23:59
Instructor: M. Zübeyir Ünlü

Name: Student No:

Honor statement: *I pledge that I have not used any notes, text, or any other reference materials during this exam. I pledge that I have neither given nor received any aid from any other person during this examination, and that the work presented here is entirely my own.*

Signature:

You may use Matlab's functions directly!

Download ecg_2.mat. The signal was sampled at 1000 Hz.

Question (100 pts):

a) (5 pts) Obtain and plot the **frequency spectrum** of this signal (magnitude and phase).

b) (5 pts) What part of this spectrum corresponds to the signal, and what part corresponds to noise?

Note: You will see that the signal contains high frequency noise!

c) (20 pts) Since ECG is actually a random signal, a more appropriate spectral analysis tool is the PSD. Calculate and plot the **PSD** of this data using **periodogram** and **Welch's method**.

Moving Average Filtering:

d) (10 pts) Apply a 10-point **moving average filter** to ecg_2.mat.

i. Plot the filtered signal and the original signal on top of each other on the same plot (with a different color). Comment!

ii. Plot the filtered signal and the original signal **frequency spectrums** on top of each other on the same plot (with a different color). Compare them!

FIR filtering

e) (30 pts) Design a lowpass digital **FIR filter** using two window functions. Decide which ones you choose and why. Design the filter so that you get the cleanest ECG as possible. What filter specs provide you with the cleanest ECG? Convince the reader of your exam why your particular selection is the best. You may, for example, compare a few different designs obtained by different specs. Plot the magnitude and phase spectra of these filters.

i. Apply each of the above designed filters to the ECG signal you downloaded. Is the signal denoised? Play around with the filter specs, and find out whether other specs may give you better denoised signal.

ii. Plot the filtered signal and the original signal on top of each other on the same plot (with a different color). Comment!

iii. Plot the filtered signal and the original signal **frequency spectrums** on top of each other on the same plot (with a different color). Compare them!

IIR Filtering

f) (30 pts) Repeat part (e) by designing digital **IIR filters** using **Butterworth** and **Chebychev** filter approximations. Which type of **Chebychev** filter (type I or II) should you prefer? Why? Compare the filter characteristics to those of FIR filters. What differences are most prominent?

i. Apply each of the above designed filters to the ECG signal you downloaded. Is the signal denoised? Play around with the filter specs, and find out whether other specs may give you better denoised signal.

ii. Plot the filtered signal and the original signal on top of each other on the same plot (with a different color). Comment!

iii. Plot the filtered signal and the original signal **frequency spectrums** on top of each other on the same plot (with a different color). Compare them!