Electrical & Electronics Engineering Department
EE434 – Biomedical Signal Processing - Midterm Takehome Exam
Deadline: December 7th, 2023 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 or any other tool's functions directly!

Important Notes:

1. **In below questions, the value selection of some parameters to be used (window type, width, etc.) is left to you in order to detect cheating and plagiarism situations. Please explain why these choices were made this way.**
2. **When you make the plots please label all the axes, write their units, and give an explanatory title for each plot.**
3. **Put everything (Matlab functions you wrote, results, plots, comments, explanations etc.) sequentially for each question in a pdf file and load your Midterm Exam using the name template: Midterm-Your_School_ID.pdf**

Download ecg_1.mat , ecg_2.mat and ecg_3.mat. The signals were sampled at 1000 Hz.

Question #1 (20 pts):

Moving Average Filtering:

Apply a 10-point **moving average filter** to ecg_2.mat.

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

Question #2 (20 pts):

IIR Filtering

In Homework #1 Question #2; we designed **FIR filter**s for ecg_2.mat data. In this question, we will design 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 filter**s. What differences are most prominent?

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

Question #3 (20 pts) (About Lecture #4):

About time-and-frequency analysis, Short-time Fourier Transform (STFT) and plotting the spectrogram.

Again we will use the same signals we downloaded above to make time and frequency analysis using STFT.

To calculate STFT and plot the spectrogram, we will use Matlab's stft.m or spectrogram.m functions. Some versions have stft.m, some have spectrogram.m. But they perform almost the same thing. Check which one you have! You may use whatever you want! Or any other similar function.

These pages may help you:

https://www.mathworks.com/help/signal/ref/stft.html

https://www.mathworks.com/help/signal/ref/spectrogram.html

a) Using a rectangular window with a length of 256 samples and length of overlap as 128 samples: Plot the STFT (spectrogram).
b) Using a hamming window with a length of 256 samples and length of overlap as 128 samples: Plot the STFT (spectrogram).
c) Compare the spectrograms you obtained in parts (a) and (b).
d) If you make a comparison between the spectrograms you obtained in Question #3 and the spectrums in previous questions and in Homework #1, what are the advantages of spectrograms and the disadvantages of spectrums?

Question # 4 (20 pts) (About Lecture #5):

You remember that in Homework #1 and some of the questions above we obtained and plotted the **frequency spectrum** (magnitude and phase) of the ECG signals. However, since ECG is actually a random signal, a more appropriate spectral analysis tool is the Power Spectral Density (PSD).

a) Calculate and plot the **PSD** of the above data using **periodogram** method.
b) Calculate and plot the **PSD** of the above data using **modified periodogram** method.
c) Calculate and plot the **PSD** of the above data using **Welch's method**.
d) Calculate and plot the **PSD** of the above data using **Levinson-Durbin Algorithm**.

Compare all of the above results among themselves and also with the results obtained before and Homework#1.

Question #5 (20 pts) (About Lecture #7):

Please implement the same "QRS Detection Algorithm" mentioned in "EE434_Lecture_07.pdf" lecture slides (pages between 2 and 18).

You can use any of the ECG signals you found on the internet or which I gave you.

Please include all the steps mentioned in the lecture slides and plot all the signals in each step. Please also include your explanations and comments.