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EECE 244 – ECG in MATLAB

Project Description

In general, the purpose of this project is to provide you with experience working to test the efficacy of an algorithm on data that was given to you and data that you collected. When starting large and complicated projects, having a visual way to look through data and test algorithms can be extremely helpful prior to moving the design to a smaller or embedded platform. Therefore, there are two sequential objectives relating to this project. The first objective is to demonstrate that you can visually work with a large dataset to test algorithms and functions written to clean-up a noisy signal and detect local peaks in those signals. Since the project requires working with ECG signals, the average heart rate can be determined using detected peaks in an ECG (aka the QRS complex). You are asked to use the MIT-BIH Arrythmia Dataset to look at abnormal ECG signals and assess when / why the algorithms might fail or behave in an unexpected way. To assist with loading signals from this database, go to D2L and download LoadMITecg.m to get the ecg signal, time, and sampling frequency from data provided in the MIT-BIH-Arrhythmia-Database-MATLAB folder. You will be asked to create a graphical user interface (GUI) to analyze these signals. The second objective requires building a device to collect the signals you're interested in and modifying your existing GUI to visualize data that you measured. The ECG circuit design will be given to you. Test your heart rate algorithm on your measured data. As a result of this objective, you will be able to determine where you should start when you move this to an embedded platform in the next project.

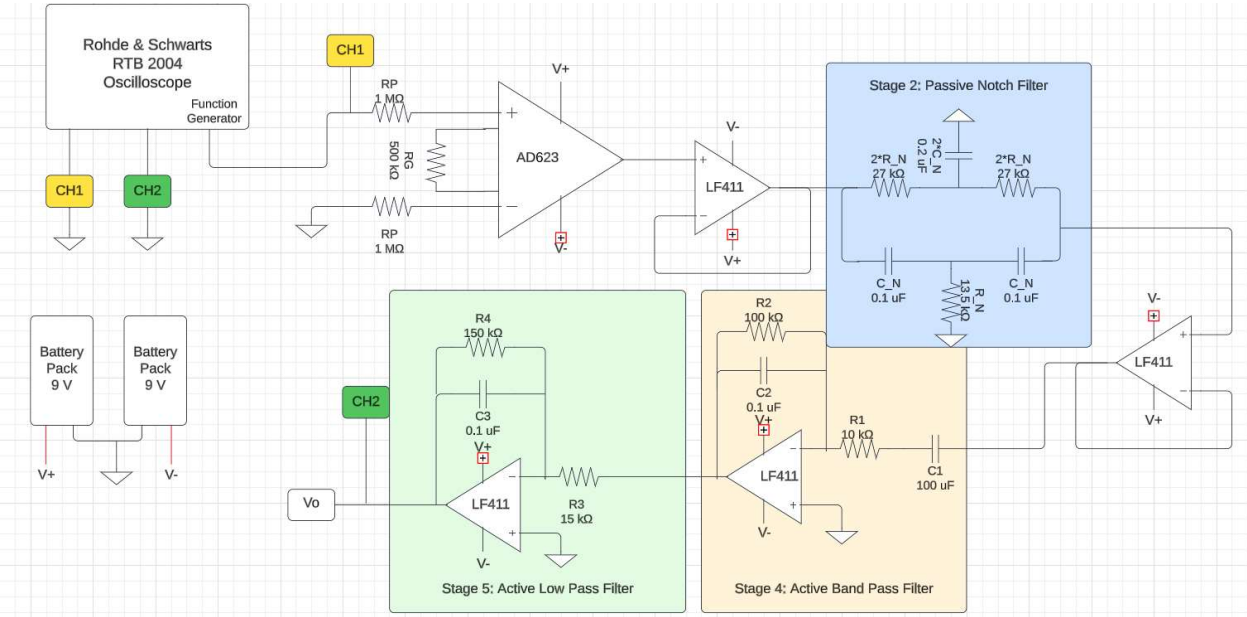

Figure 1: Circuit schematic of the ECG circuit for testing with an oscilloscope

Before the ECG circuit could be tested on a live subject, it was first tested using the oscilloscope in the electronics lab using the circuit schematic shown in Figure 1.

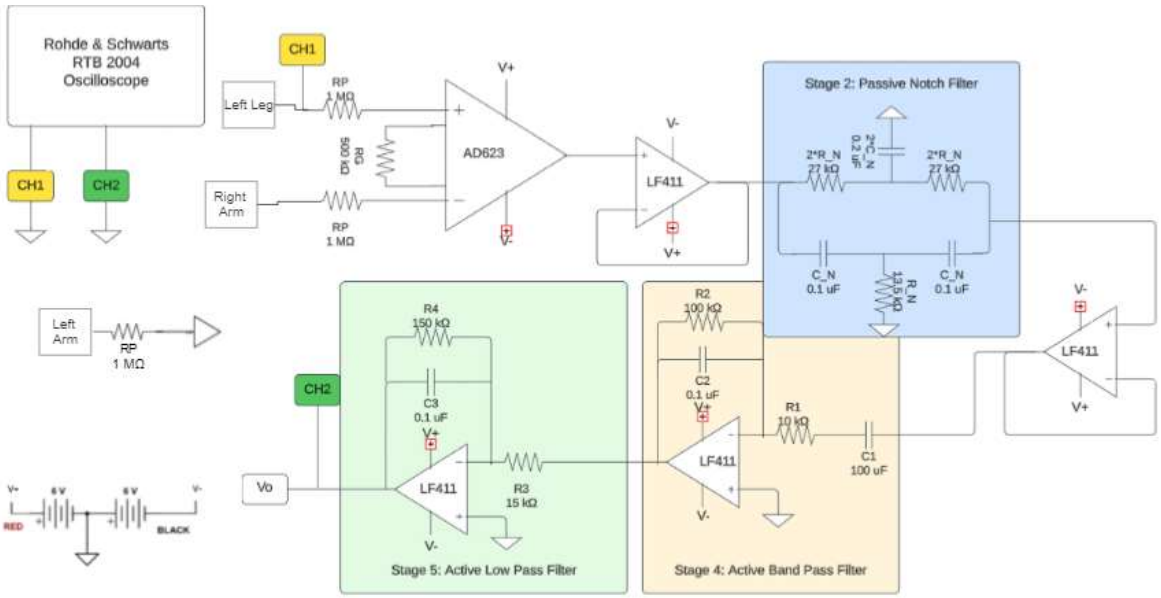

Figure 2: Circuit schematic for ECG circuit for testing on a live subject

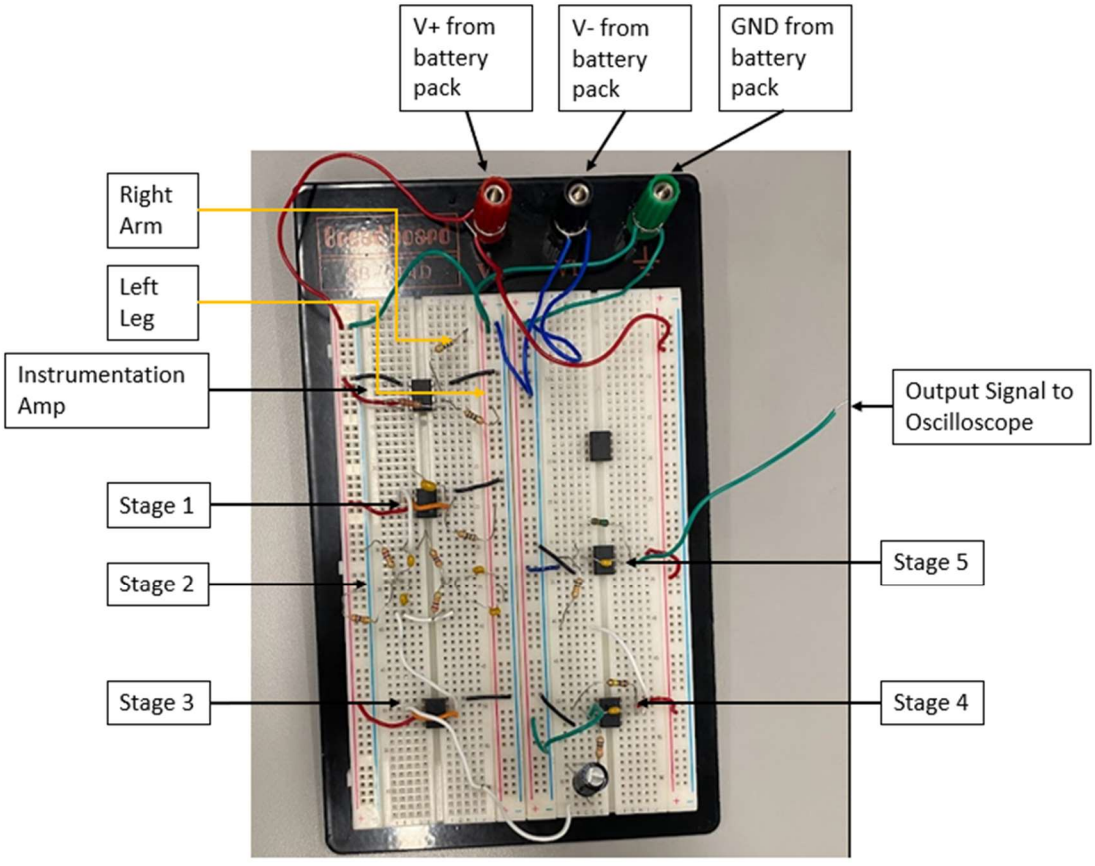

Figure 3: Circuit assembly for ECG circuit for testing on a live subject

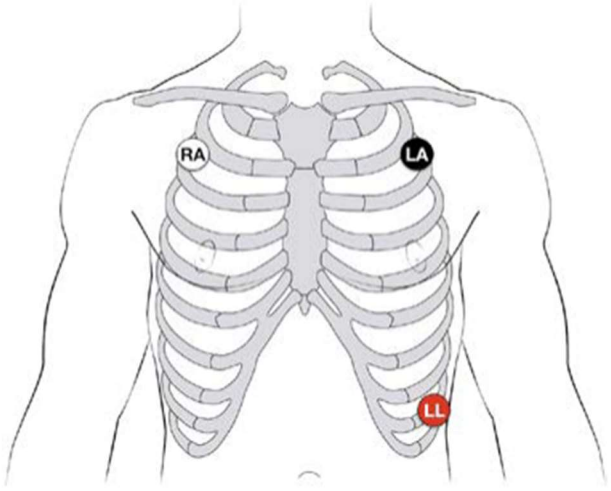

Figure 4: 3-Lead electrode placement for ECG circuit

Once the circuit was tested successfully using the oscilloscope with no troubles or complications, the ECG circuit was then tested on myself as the live subject test. The circuit schematic and placement shown in Figure 2 and Figure 3 was used for testing.

Set-Up

Input Dir:

The location of the .CSV ECG files to access for the GUI is in:
`F:\MATLAB\MIT-BIH-Arrhythmia-Database-MATLAB\ECGData\`
Which is found on line 40. Update accordingly. Ensure any files that contain functions are included in the specified file path.

Output Dir:

The location saved plot images will be saved in is in:
`F:\MATLAB\MIT-BIH-Arrhythmia-Database-MATLAB\PlotImage\`
Which is found on line 143. Update accordingly.

Online IDE:

When using on the online MATLAB editor, the line above in the GUI code is unnecessary. To access the correct files, ensure the path on the main MATLAB editor is set accordingly. Ensure any files that contain functions, such as LoadMITecg.m, are included in the specified file path.

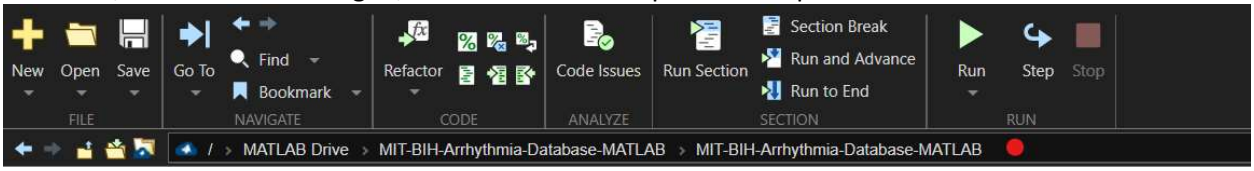

Figure 5: File pathing example for online MATLAB editor

All files will be accessed from and saved to this folder path, including plot images.
Be sure to remove any code, such as that found on lines 40 and 143, which specifies a path. Failure to do so will result in unsuccessful running of code.

To Use

- Patient: Click on the drop down to select which ECG trial data you wish to analyze.
- Initial Time [s]: Type in the text box which ECG data point you wish to start analyzing.
- End Time [s]: Type in the text box which ECG data point you wish to end analyzing.
- Smoothing Filter: Press the button to add on or remove an overlay smoothing filter on the ECG data
- Average Heart Rate: Displays the average heart rate in BPM of the window of data points you are currently viewing.
- Save Plot: Press the button to save an image of the plot you are currently viewing. The image will be saved to whatever you have set the path to be.
  Refresh: Press the button to update the plot when point viewing window (initial time, end time) is changed, or when smoothing filter button state is changed.

Test Cases

Trial 1 - 500m:

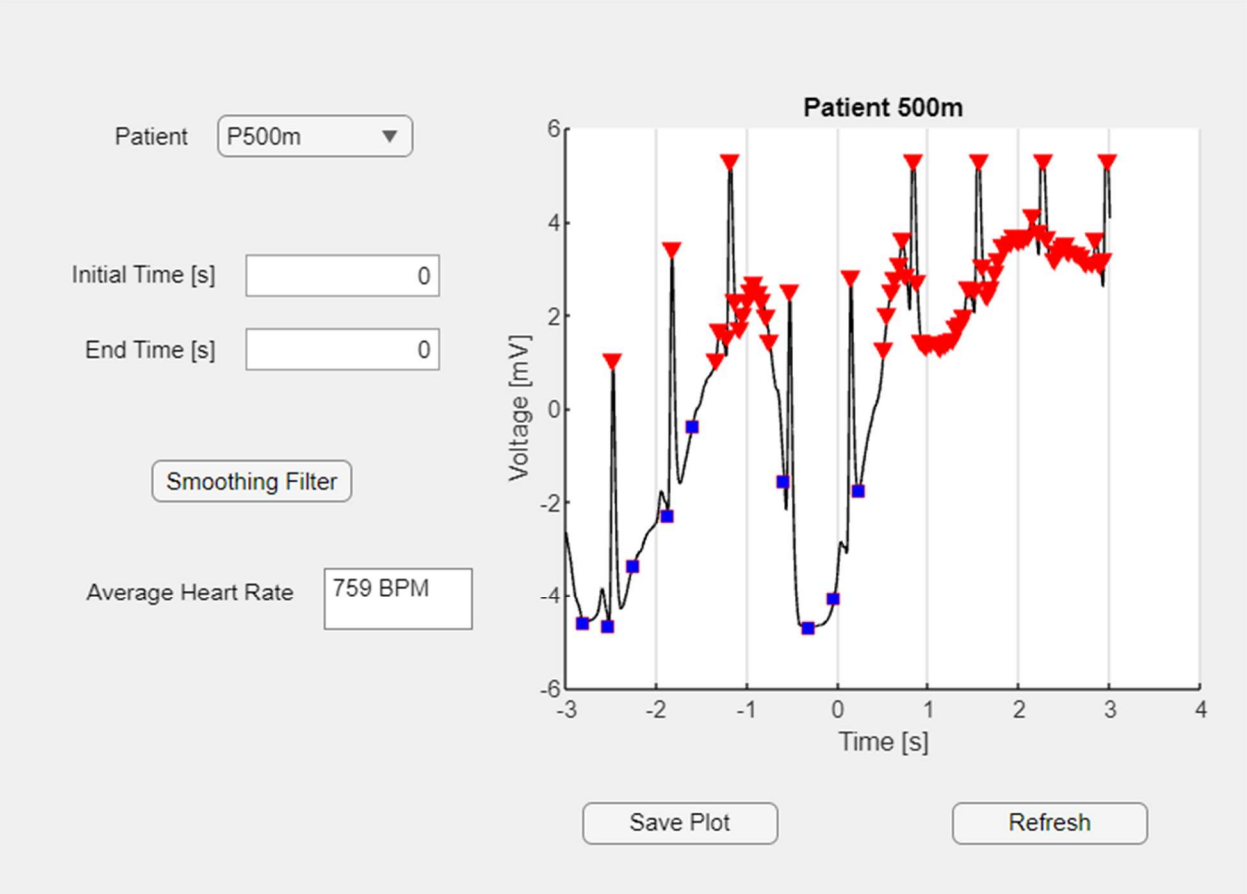

Figure 6: ECG GUI plot of trial 1 of all data points with no filter applied

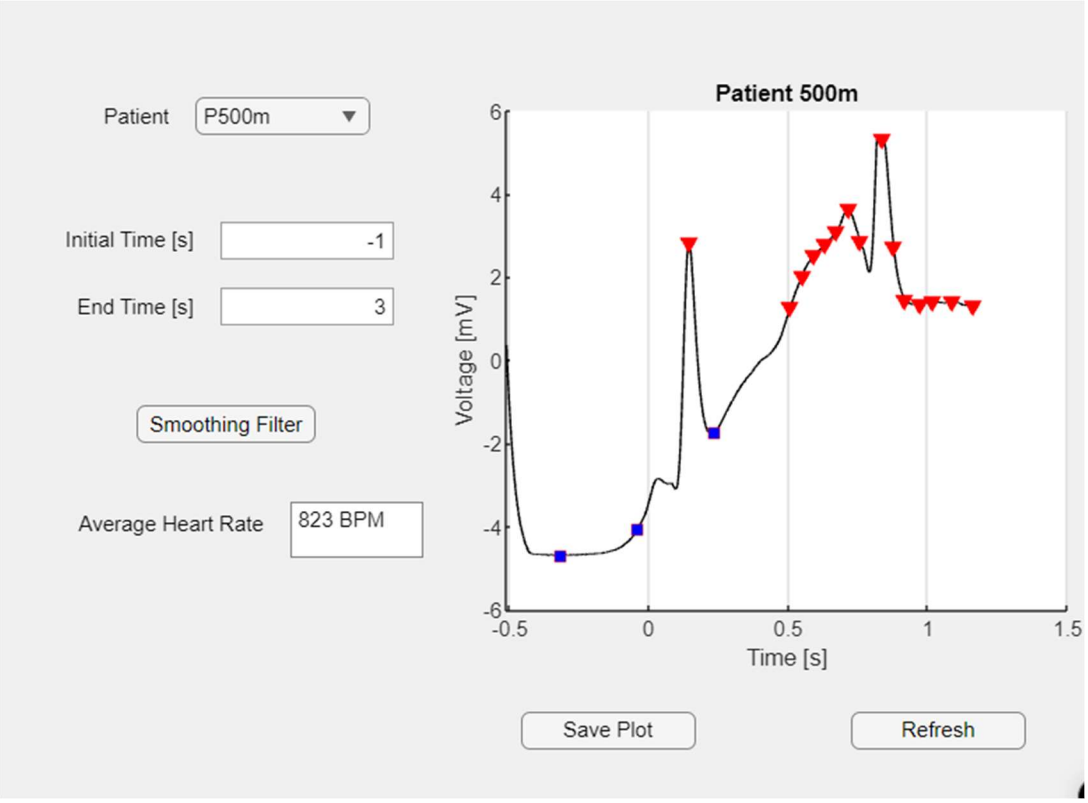

Figure 7: ECG GUI plot of trial 1 of data from -1 second to 3 seconds with no filter applied

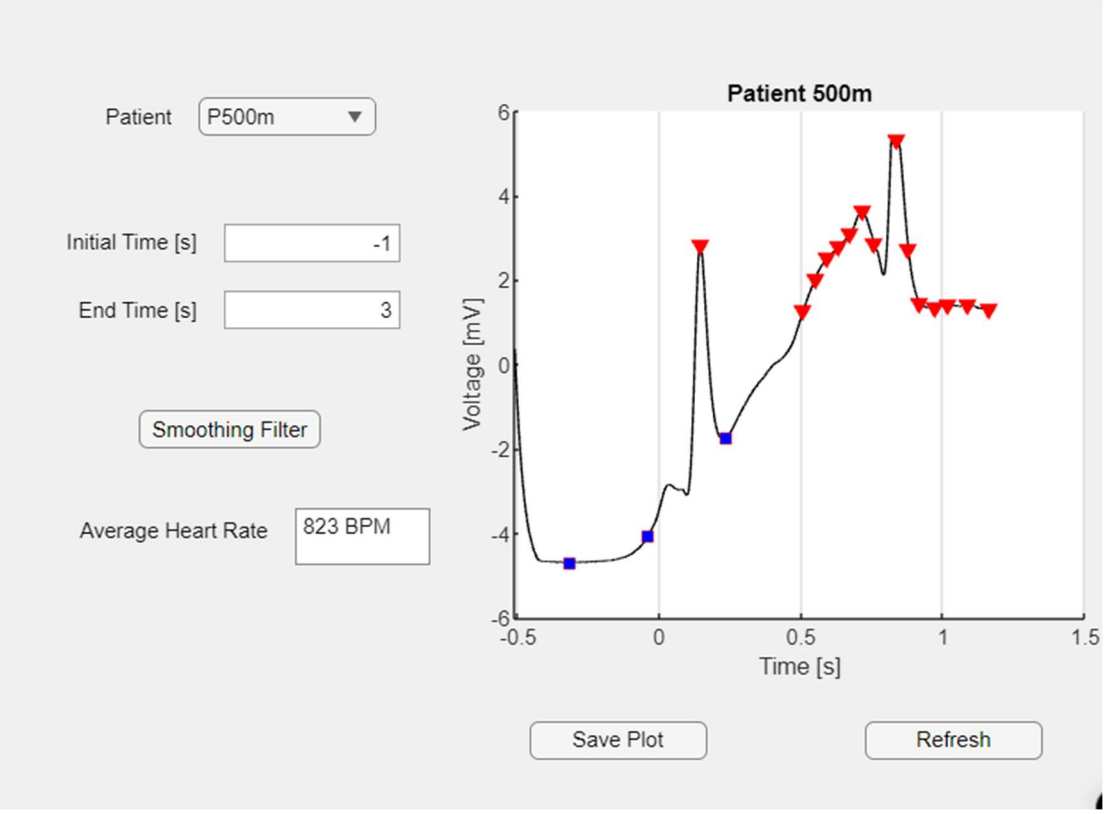

Figure 8: ECG GUI plot of trial 1 of data from -1 second to 3 seconds with smoothing filter applied

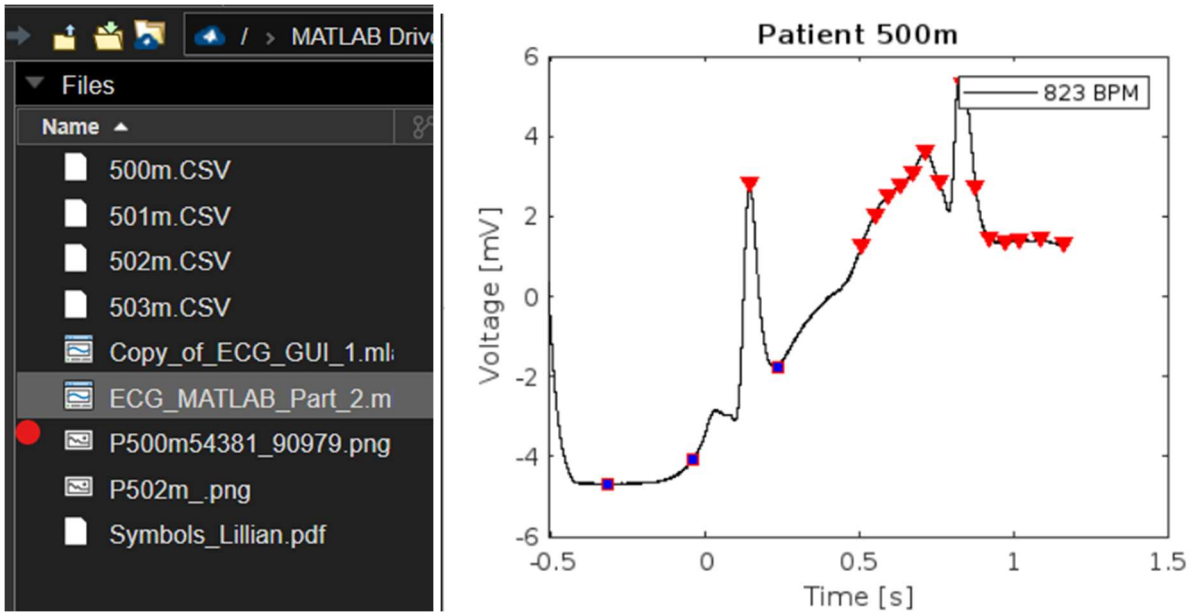

Figure 9: Saved ECG GUI image of plot for trial 1 from -1 seconds to 3 seconds with smoothing filter applied

Table 1: Heart rate data of trial 1 from -1 seconds to 3 seconds	GUI Calculation (no filter)	GUI Calculation (smoothing filter)	Real Calculation
Heart Rate [BPM]	823	823	72

Trial 2 - 501m:

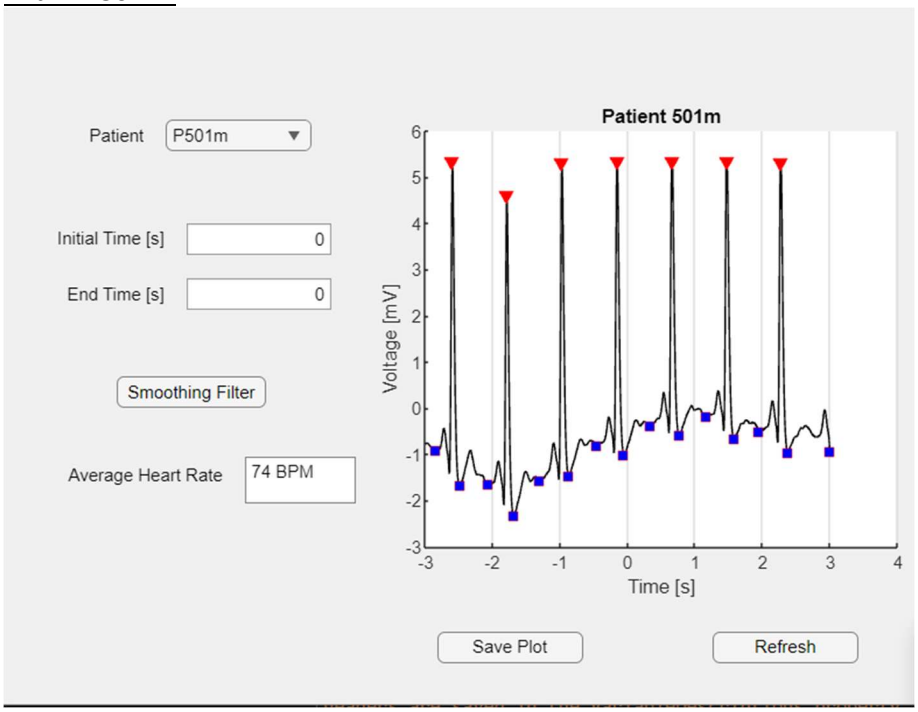

Figure 10: ECG GUI plot of trial 2 of all data points with no filter applied

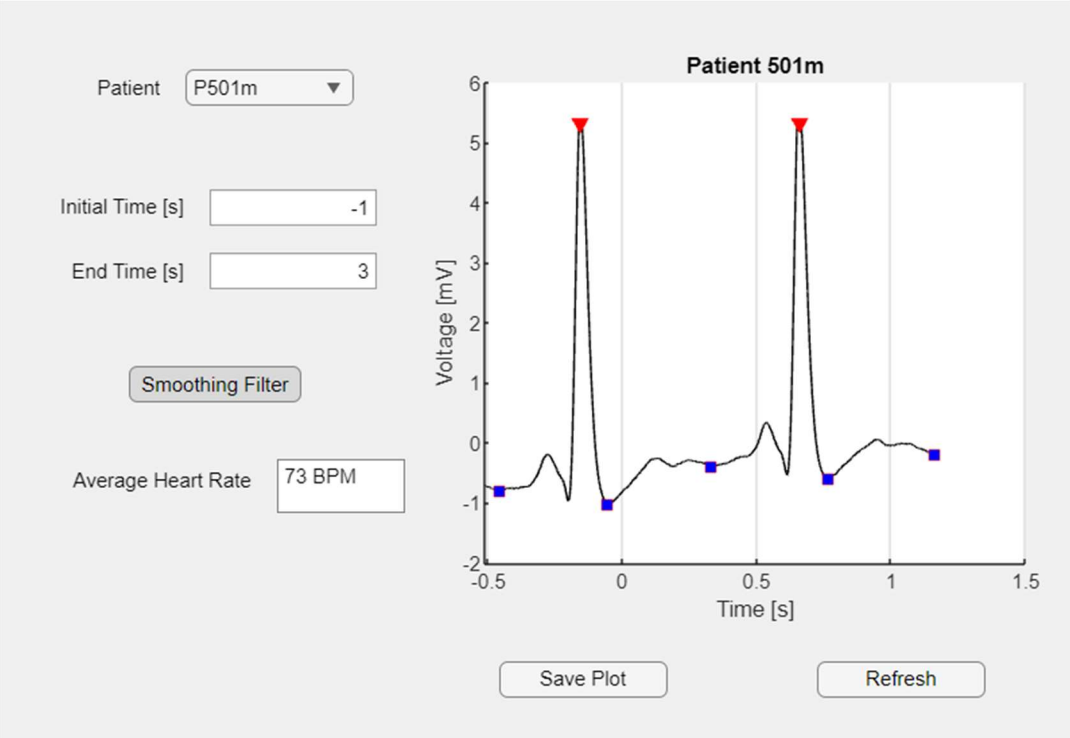

Figure 11: ECG GUI plot of trial 2 of data from -1 seconds to 3 seconds with no filter applied

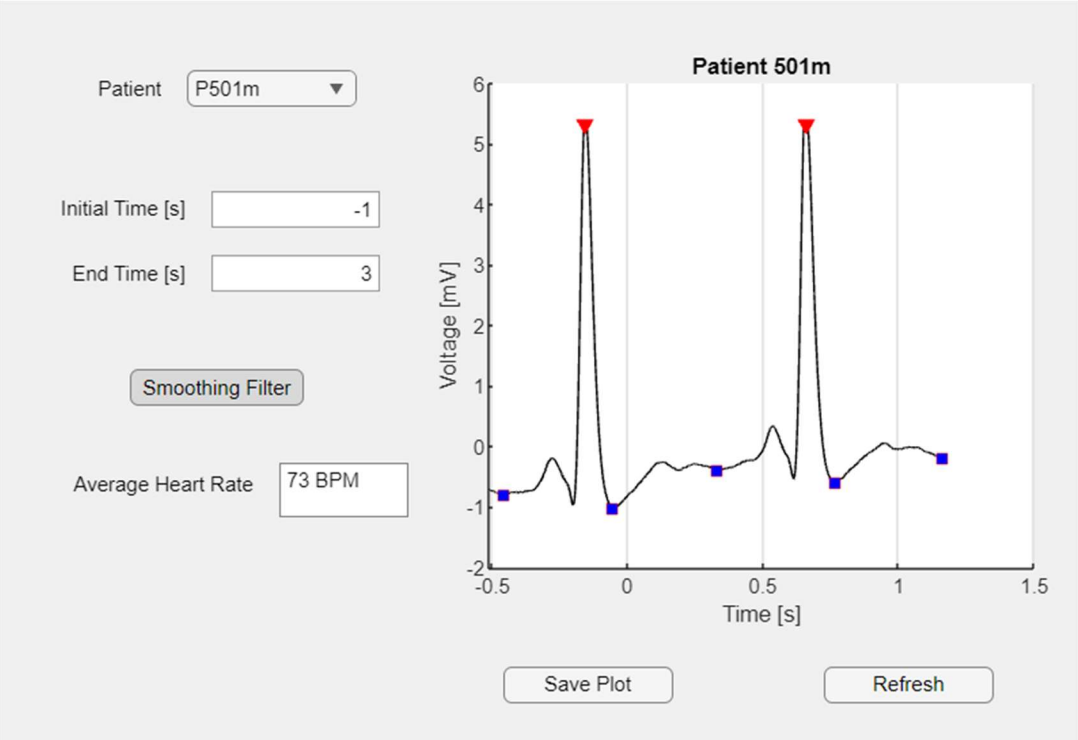

Figure 12: ECG GUI plot of trial 2 of data from -1 seconds to 3 seconds with smoothing filter applied

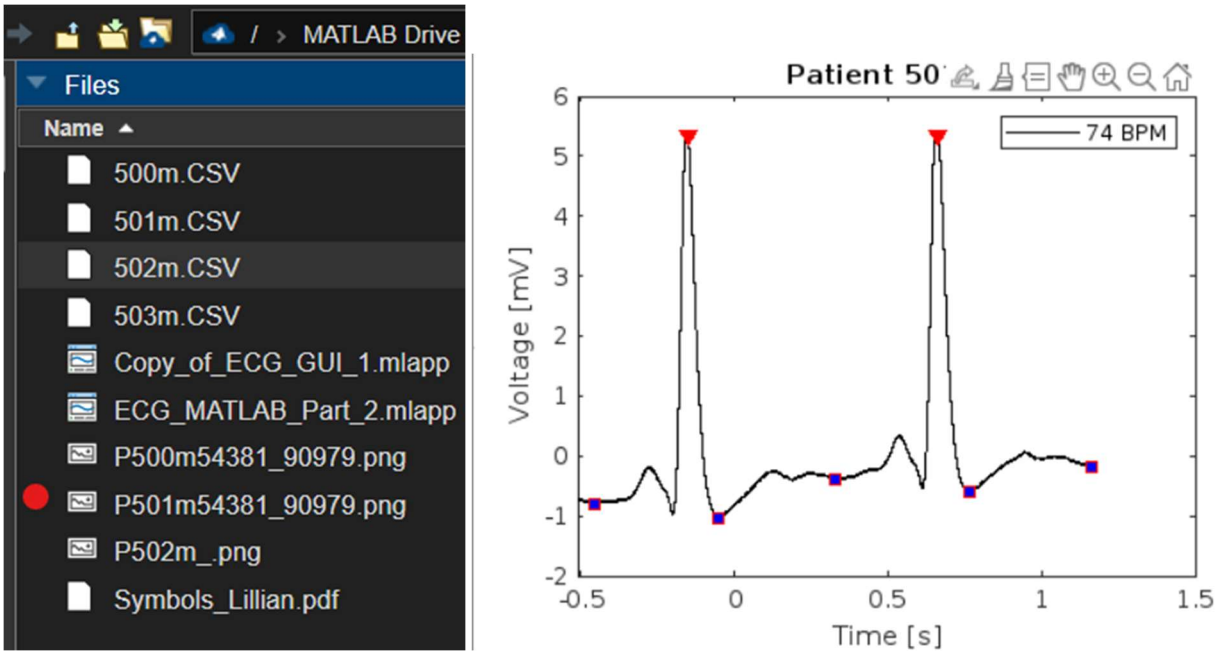

Figure 13: Saved ECG GUI image of plot for trial 2 from -1 seconds to 3 seconds with smoothing filter applied

Table 2: Heart rate data from trial 2 from -1 seconds to 3 seconds	GUI Calculation (no filter)	GUI Calculation (smoothing filter)	Real Calculation
Heart Rate [BPM]	73	74	73

Trial 3 - 502m:

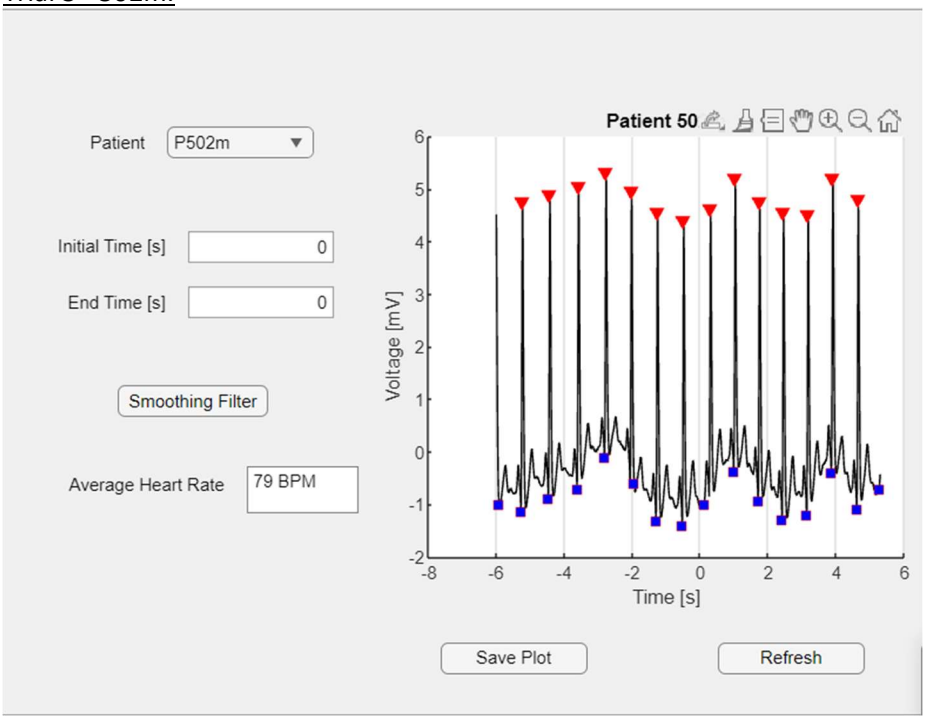

Figure 14: ECG GUI plot of trial 3 of all data points with no filter applied

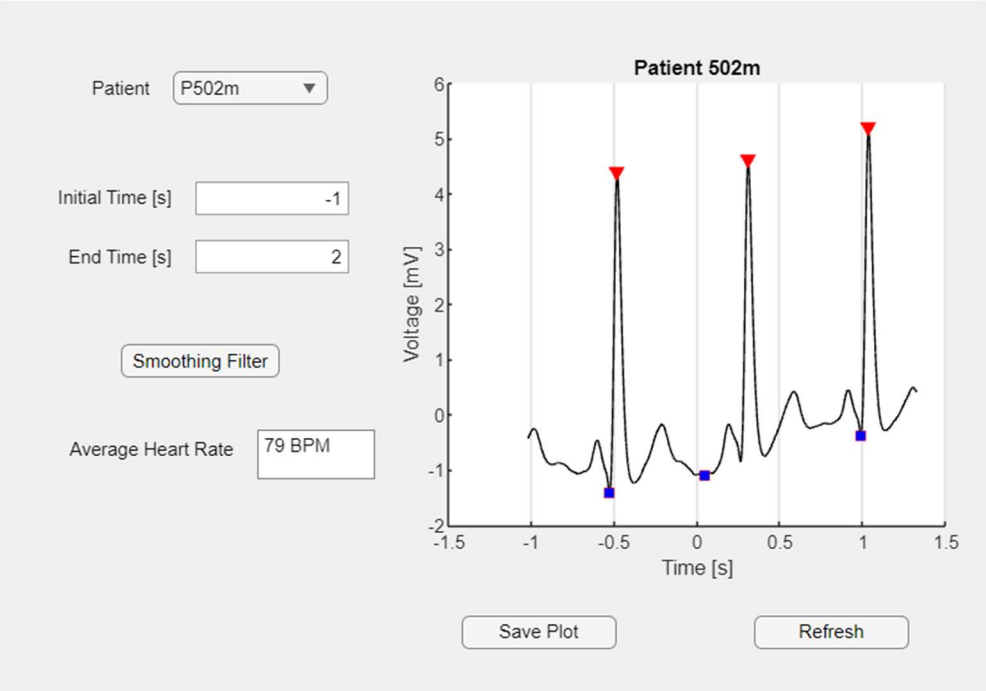

Figure 15: ECG GUI plot of trial 3 of data from -1 seconds to 2 with no filter applied

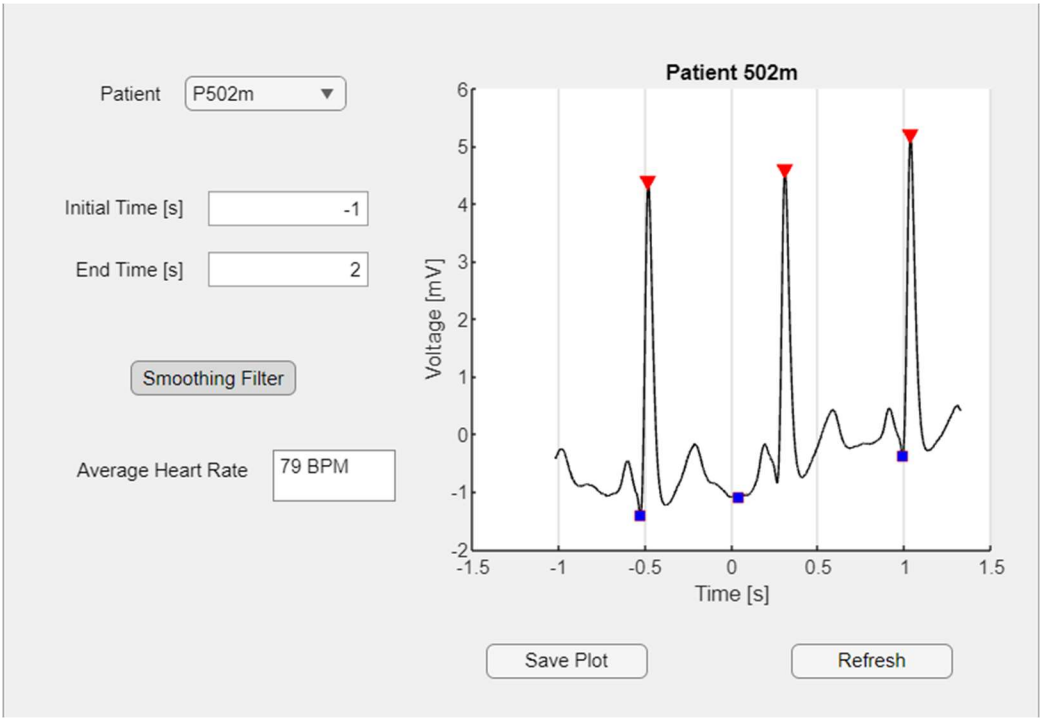

Figure 16: ECG GUI plot of trial 3 of data from -1 seconds to 2 with smoothing filter applied

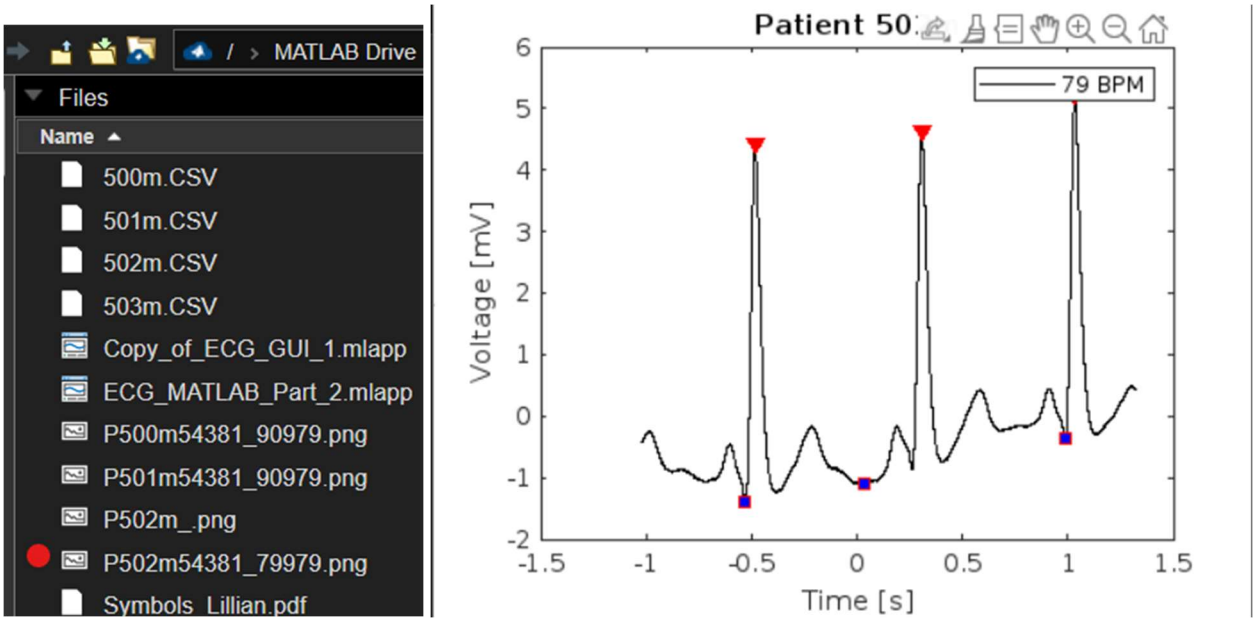

Figure 17: Saved ECG GUI image of plot for trial 3 from -1 seconds to 2 seconds with smoothing filter applied

Table 3: Heart rate data from trial 3 from -1 seconds to 2 seconds	GUI Calculation (no filter)	GUI Calculation (smoothing filter)	Real Calculation
Heart Rate [BPM]	79	79	78

Limitations

Measuring BPM:

The measuring of the average heart rate is relatively accurate for any data set where the peaks occur above 1 mV. When most of the data reads below 1 mV, the GUI is unable to accurately plot the peaks and calculate the average heart rate. This limitation can be seen in Figure 2 which is a plot of trial 1 file 500m.

If the subject has major movements or breathing while the ECG measurement is occurring, it can result in inconsistent readings which make it difficult to apply the features of the GUI which can be seen in Figure 2.

Smoothing Filter:

For most of the trial data, the smoothing filter can remove any interfering noise without causing signal distortion. Since the ECG circuit for this project was built to remove any external noise during measurements, the smoothing filter of this GUI does not provide any use and may cause over filtering.