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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.

Set-Up

Input Dir:

The location of the patient files to access for the GUI is in:
F:\MATLAB\MIT-BIH-Arrhythmia-Database-MATLAB\MIT-BIH-Arrhythmia-Database-MATLAB\
Which is found on line 45. Update accordingly. Ensure any files that contain functions, such as LoadMITecg.m, 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 145. 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.

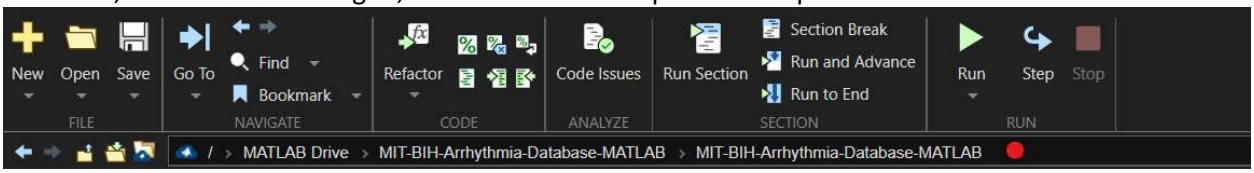

Figure 1: File pathing example for online MATLAB editor

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 45 and 145, 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 patient ECG 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

Patient 101:

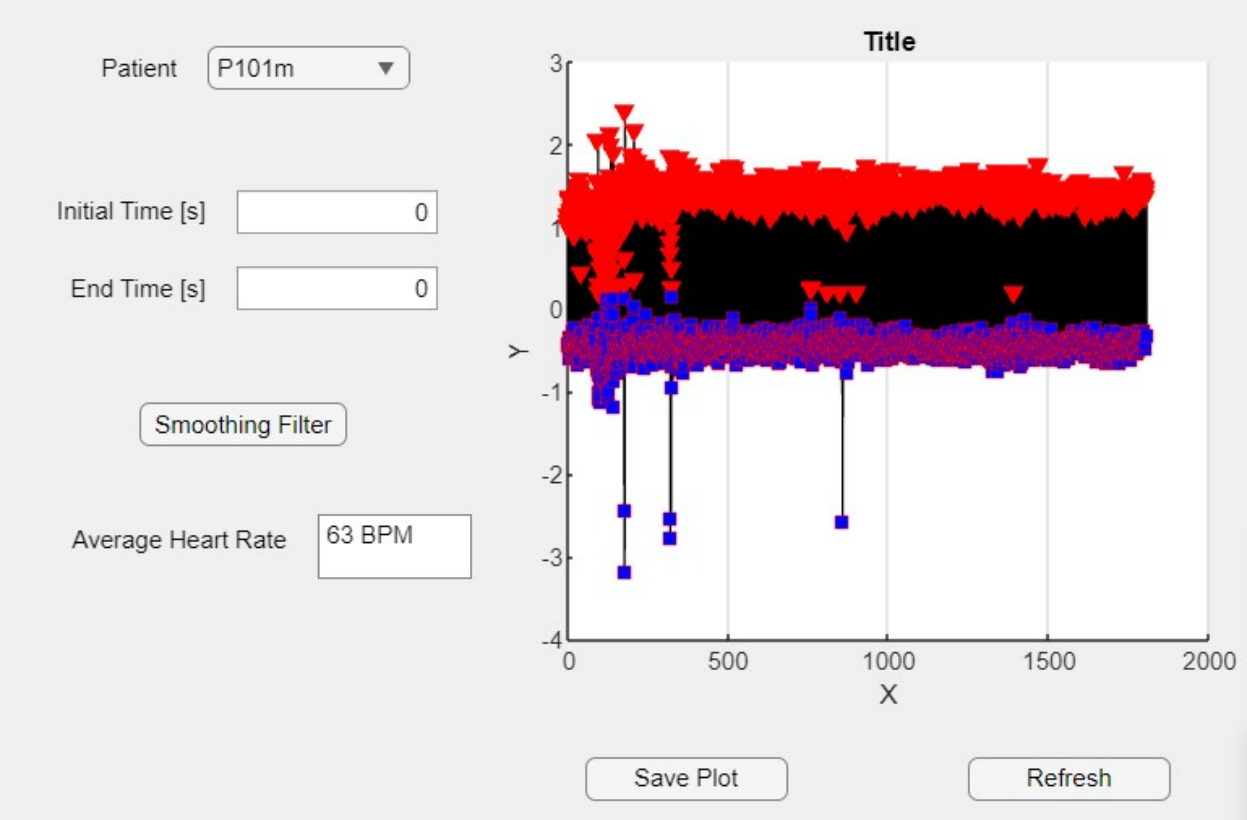

Figure 2: ECG GUI plot of patient 101m of all data points with no filter applied

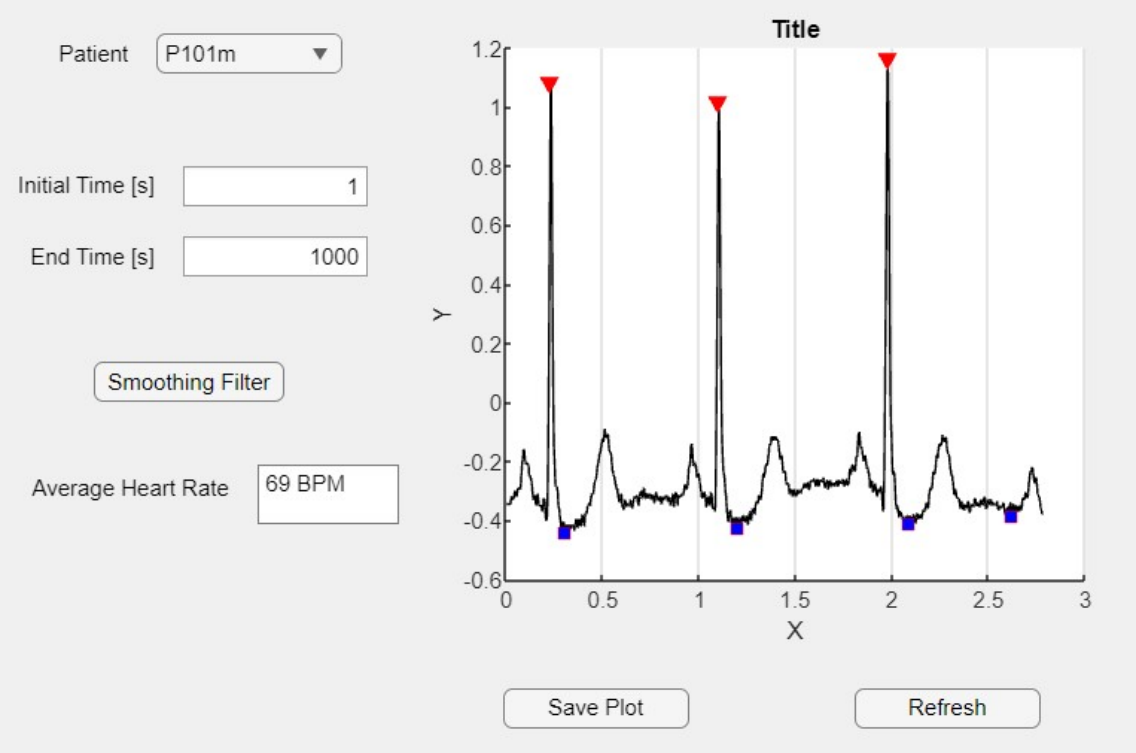

Figure 3: ECG GUI plot of patient 101m of data from points 1 to 1000 with no filter applied

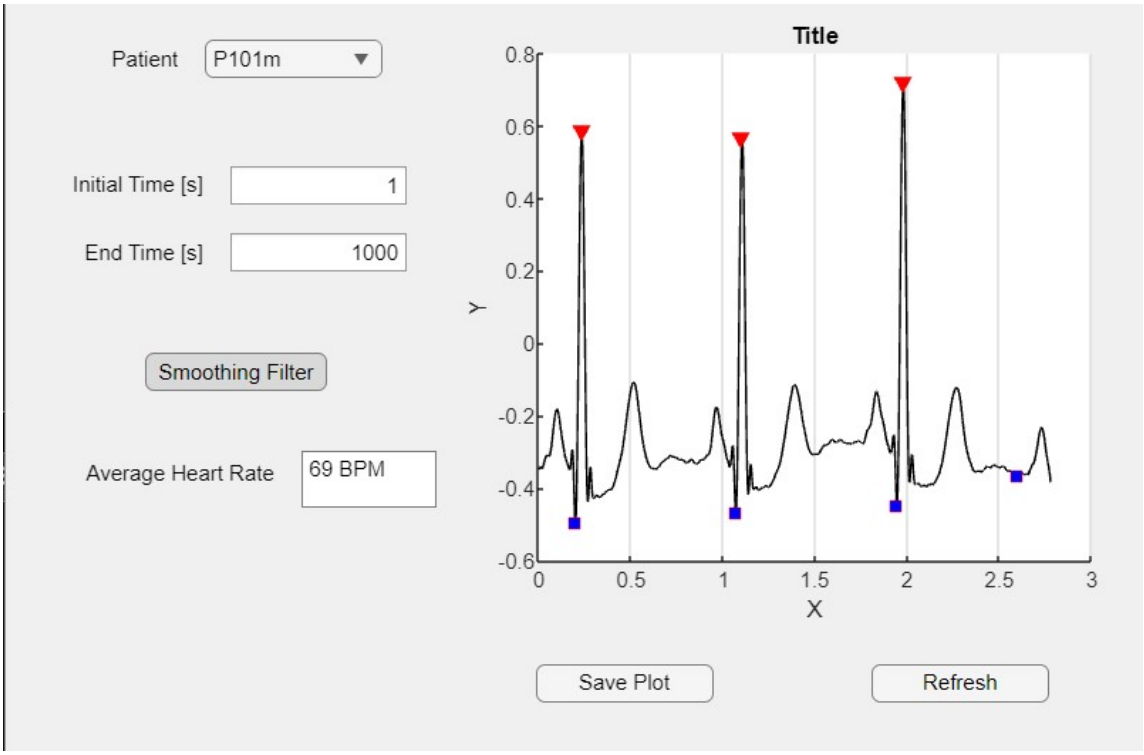

Figure 4: ECG GUI plot of patient 101m of data from points 1 to 1000 with smoothing filter applied

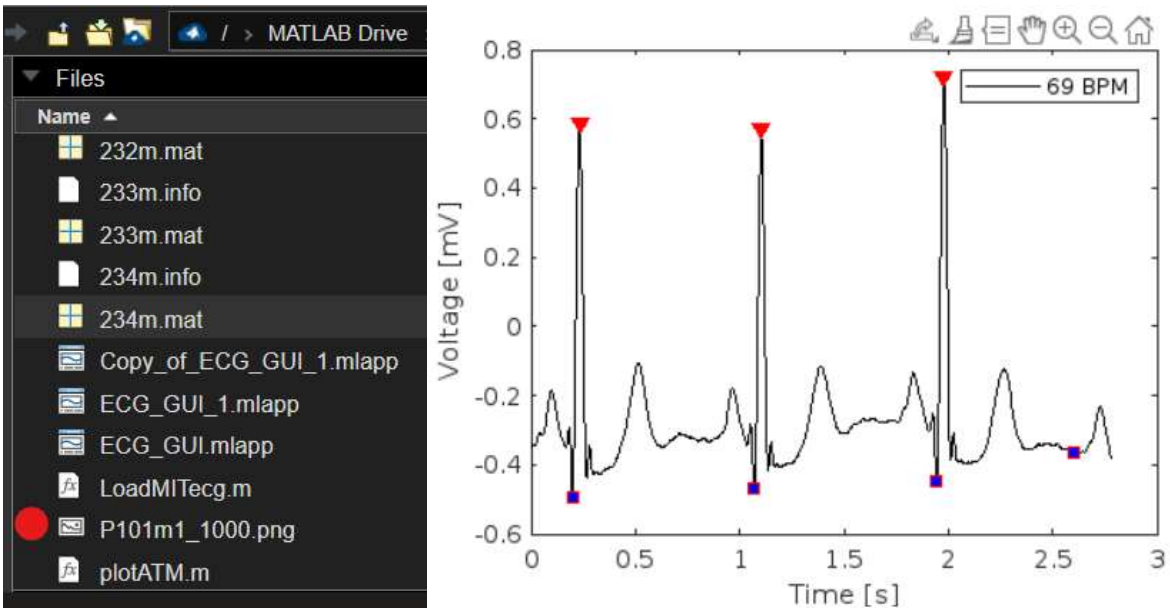

Figure 5: Saved ECG GUI image of plot for patient 101m from points 1 to 1000 with smoothing filter applied

Table 1: Heart rate data of patient 101m from points 1 to 1000	GUI Calculation (no filter)	GUI Calculation (smoothing filter)	Real Calculation
Heart Rate [BPM]	69	69	67

Patient 109:

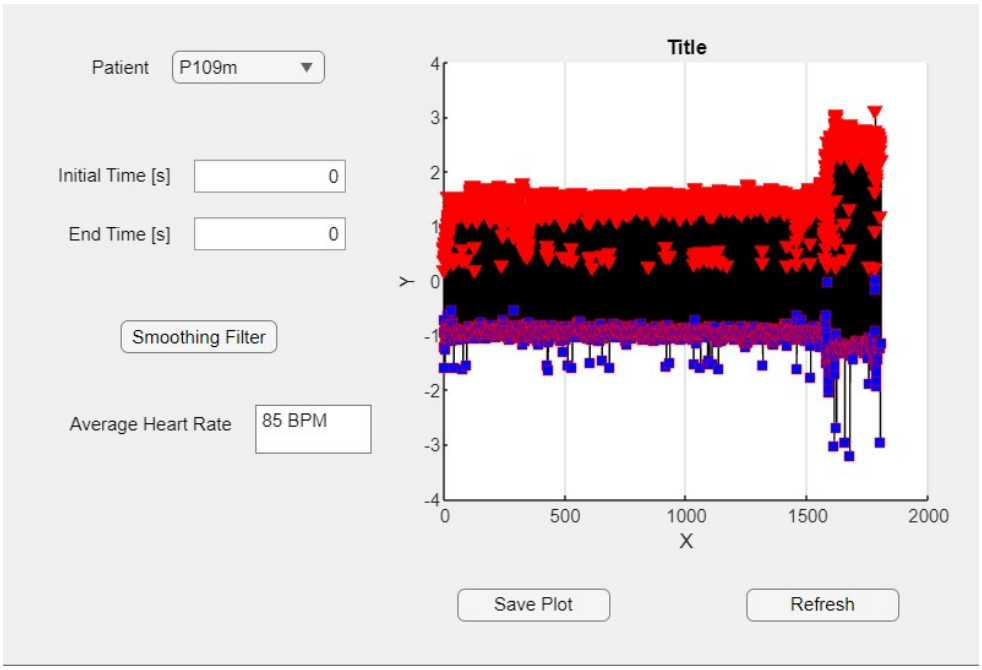

Figure 6: ECG GUI plot of patient 109m of all data points with no filter applied

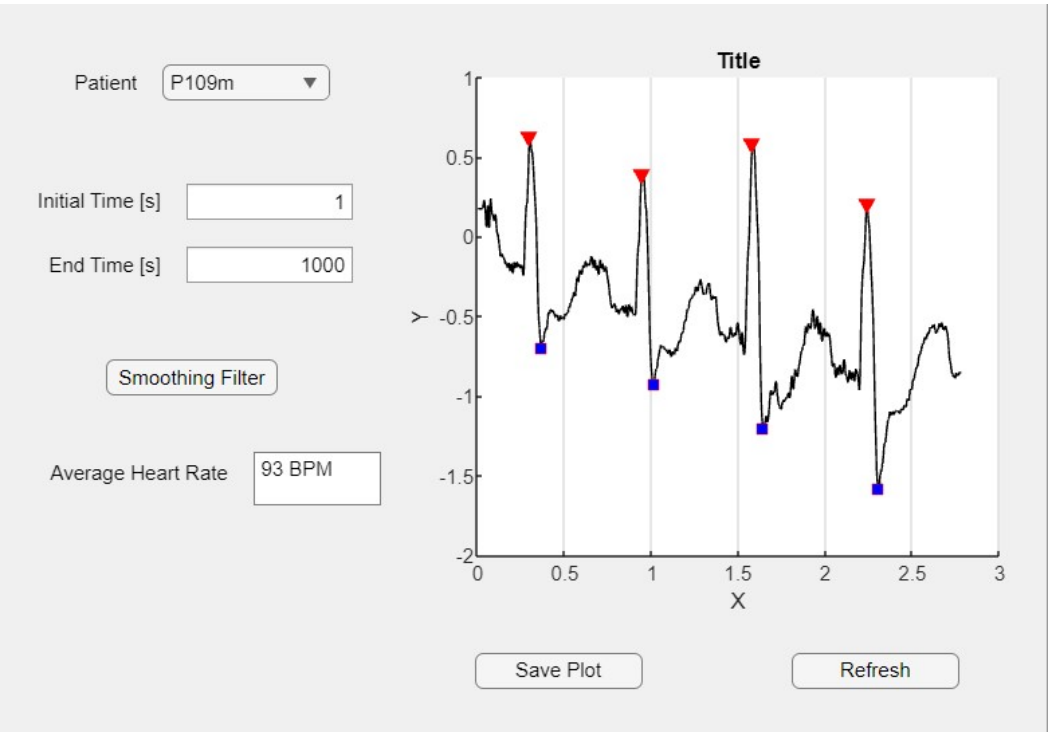

Figure 7: ECG GUI plot of patient 109m of data from points 1 to 1000 with no filter applied

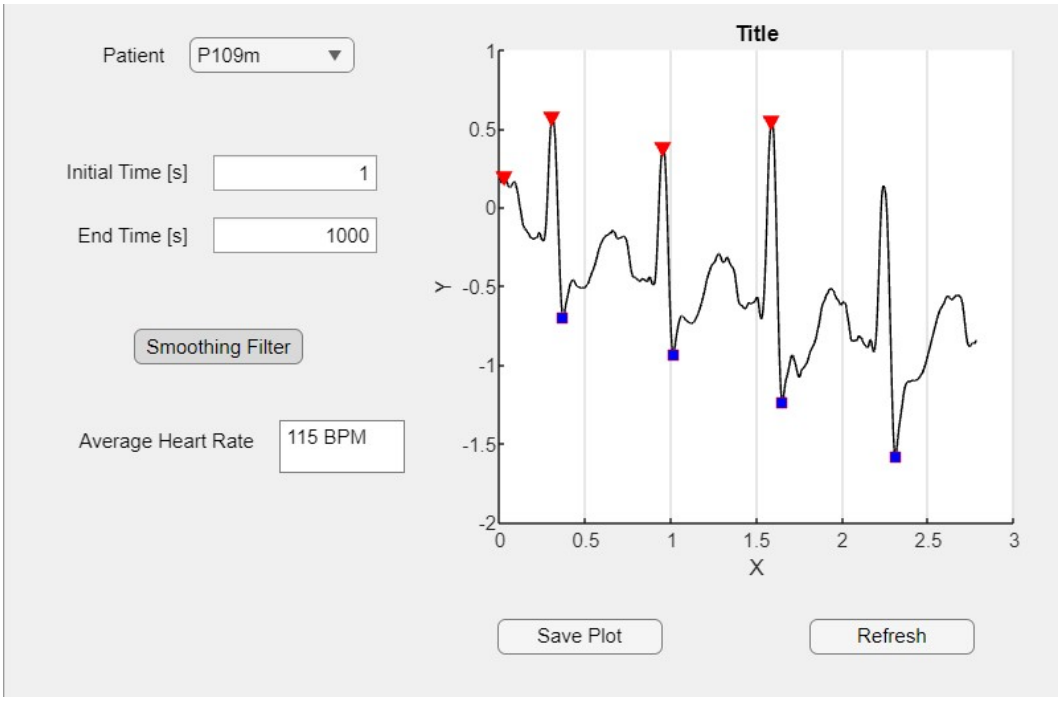

Figure 8: ECG GUI plot of patient 109m of data from points 1 to 1000 with smoothing filter applied

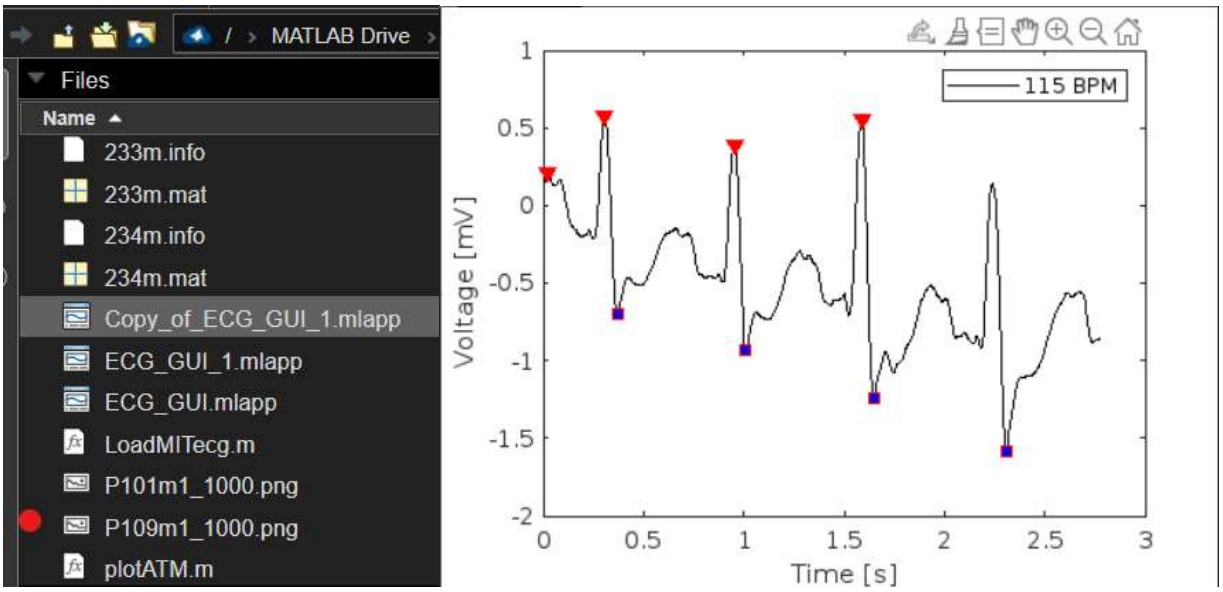

Figure 9: Saved ECG GUI image of plot for patient 109m from points 1 to 1000 with smoothing filter applied

Table 2: Heart rate data from patient 109m from points 1 to 1000	GUI Calculation (no filter)	GUI Calculation (smoothing filter)	Real Calculation
Heart Rate [BPM]	93	115	120

Patient 228:

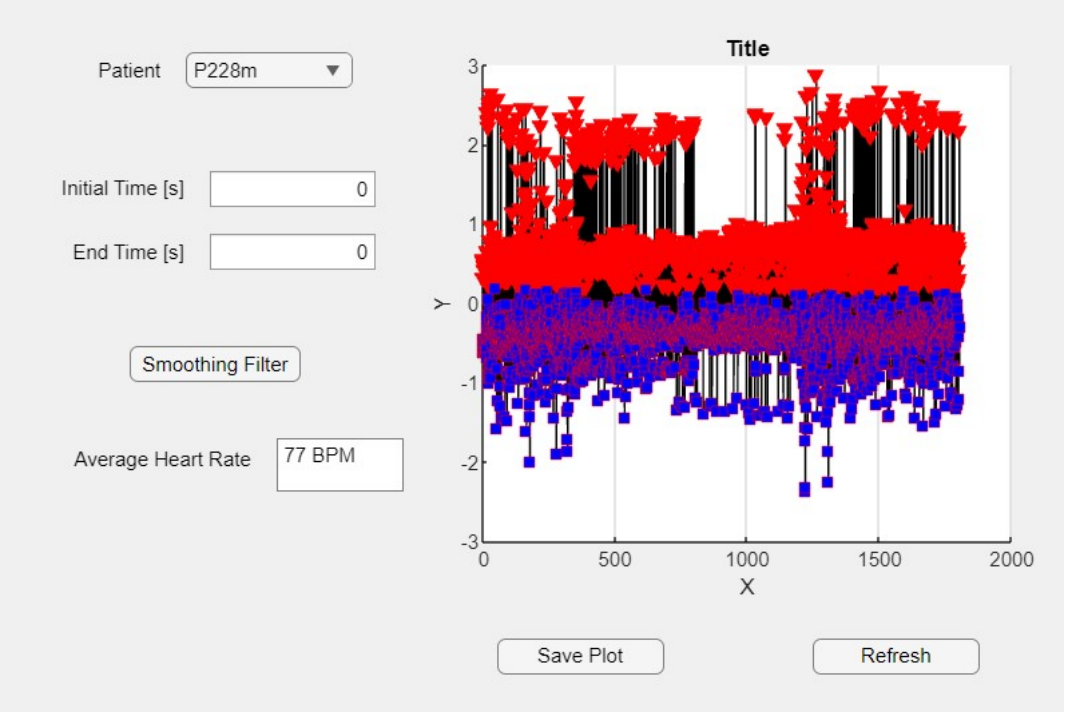

Figure 10: ECG GUI plot of patient 228m of all data points with no filter applied

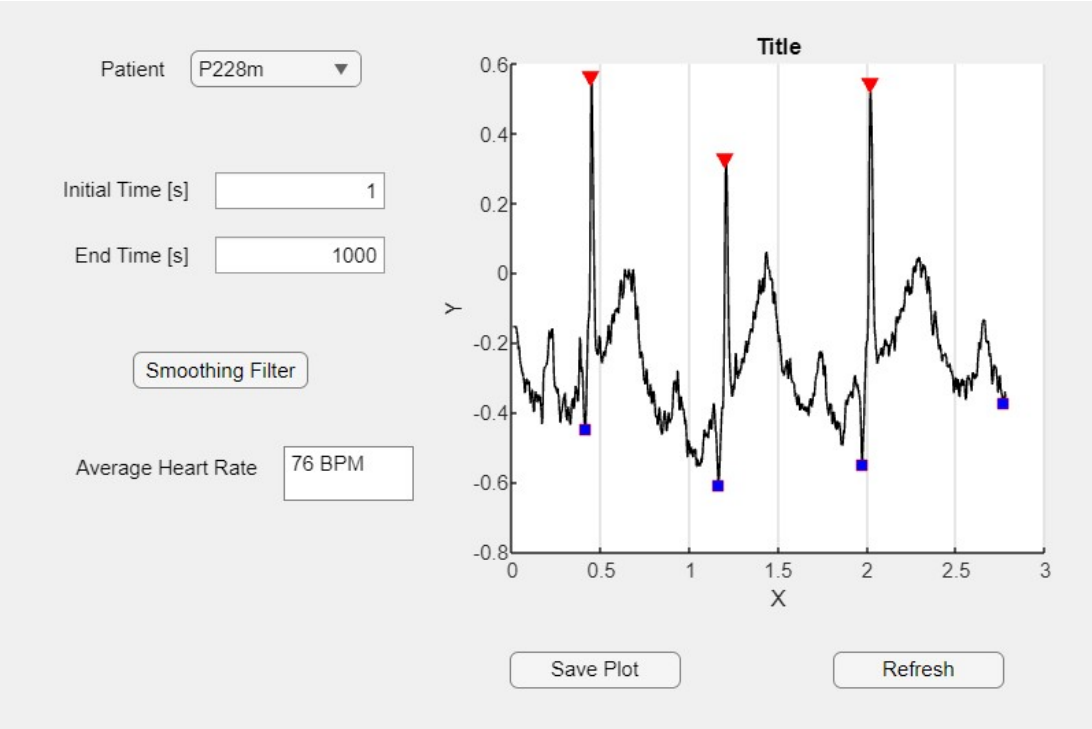

Figure 11: ECG GUI plot of patient 228m of data from points 1 to 1000 with no filter applied

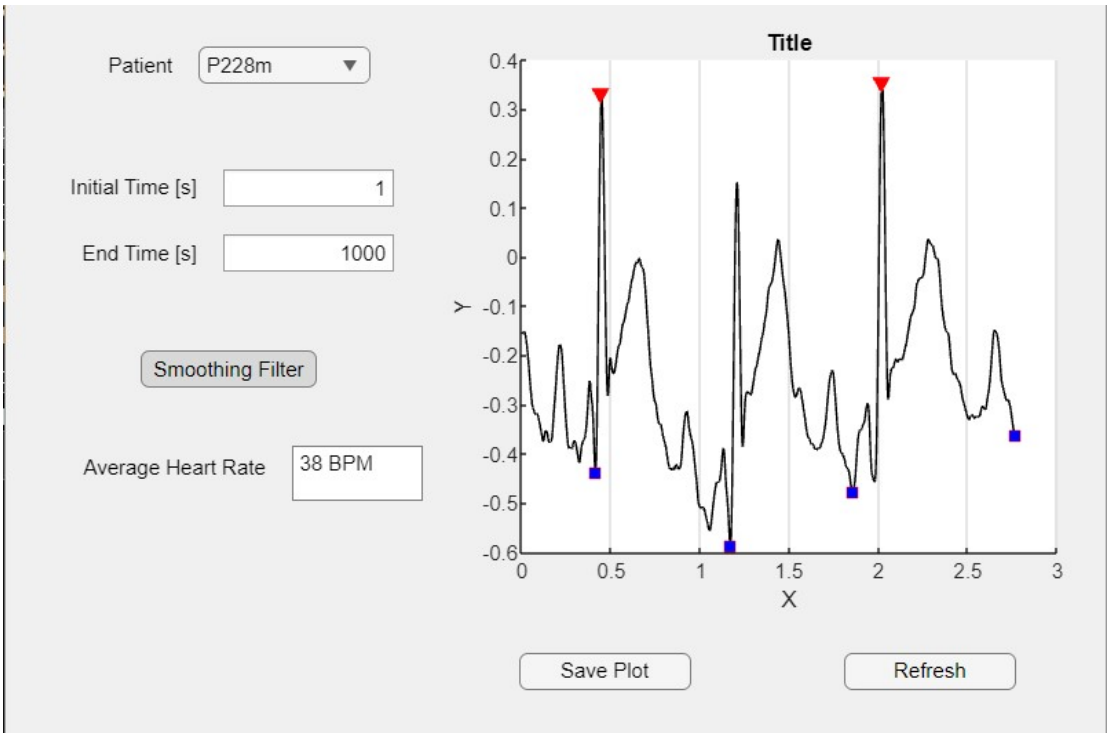

Figure 12: ECG GUI plot of patient 228m of data from points 1 to 1000 with smoothing filter applied

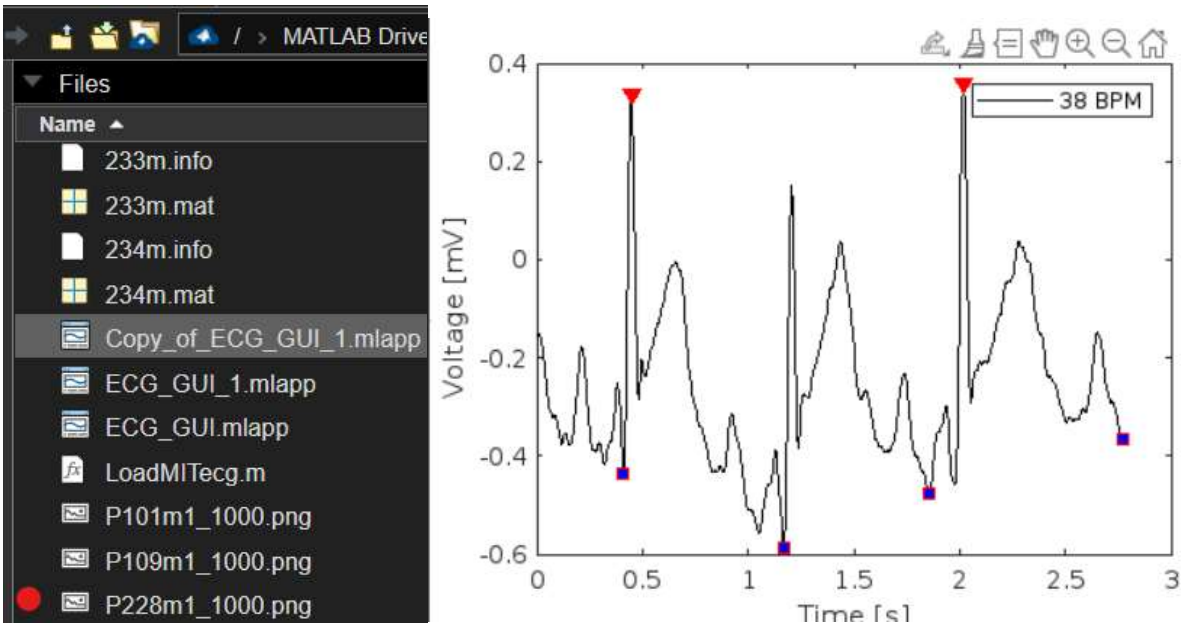

Figure 13: Saved ECG GUI image of plot for patient 228m from points 1 to 1000 with smoothing filter applied

Table 3: Heart rate data from patient 228m from points 1 to 1000	GUI Calculation (no filter)	GUI Calculation (smoothing filter)	Real Calculation
Heart Rate [BPM]	76	38	75

Patient 108:

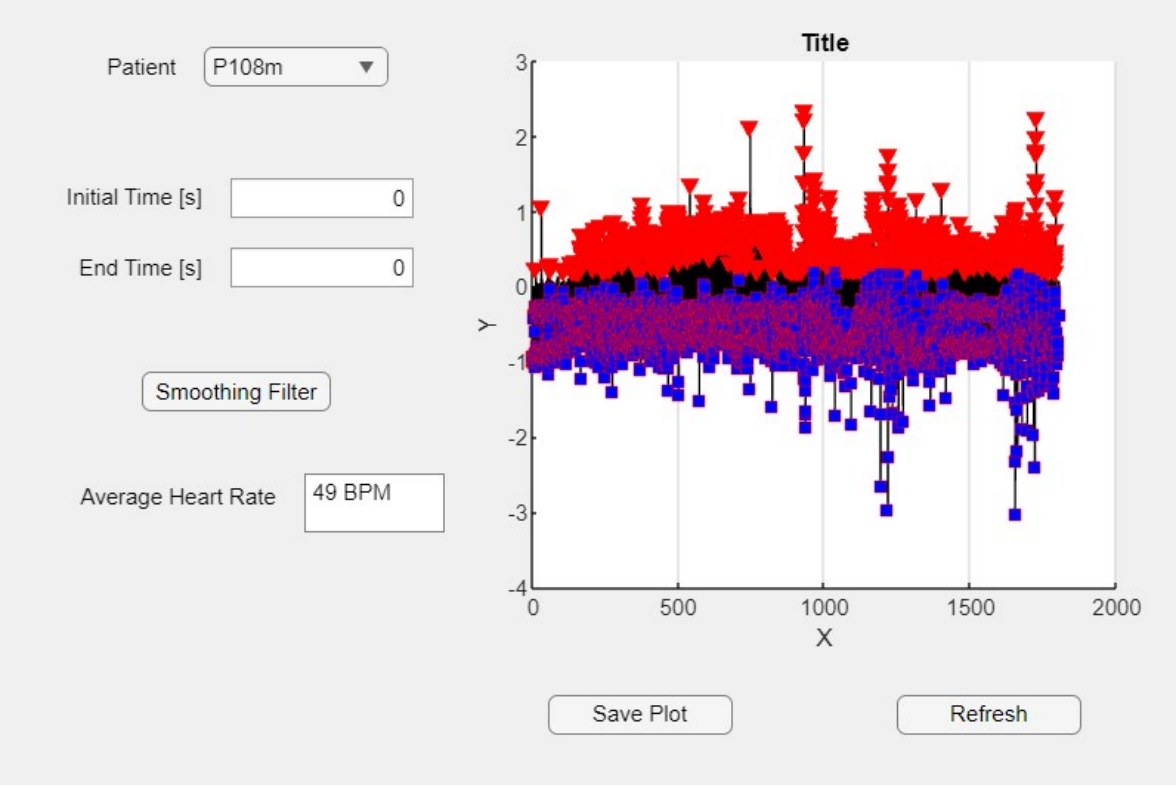

Figure 14: ECG GUI plot of patient 108m of all data points with no filter applied

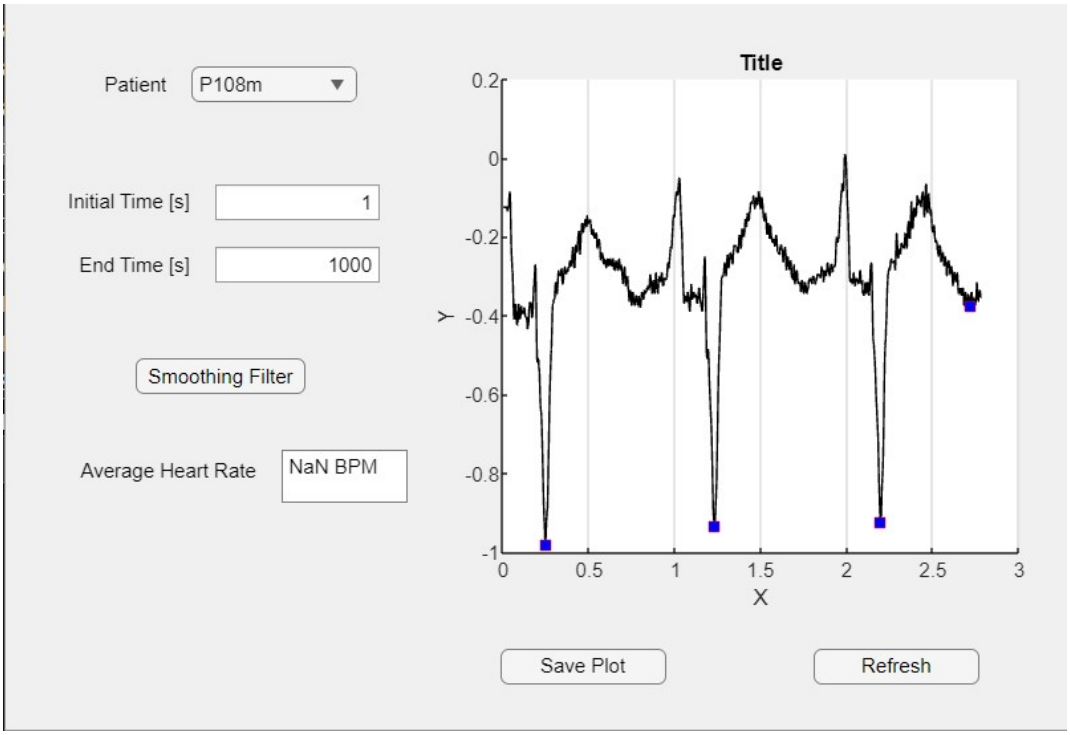

Figure 15: ECG GUI plot of patient 108m of data from points 1 to 1000 with no filter applied

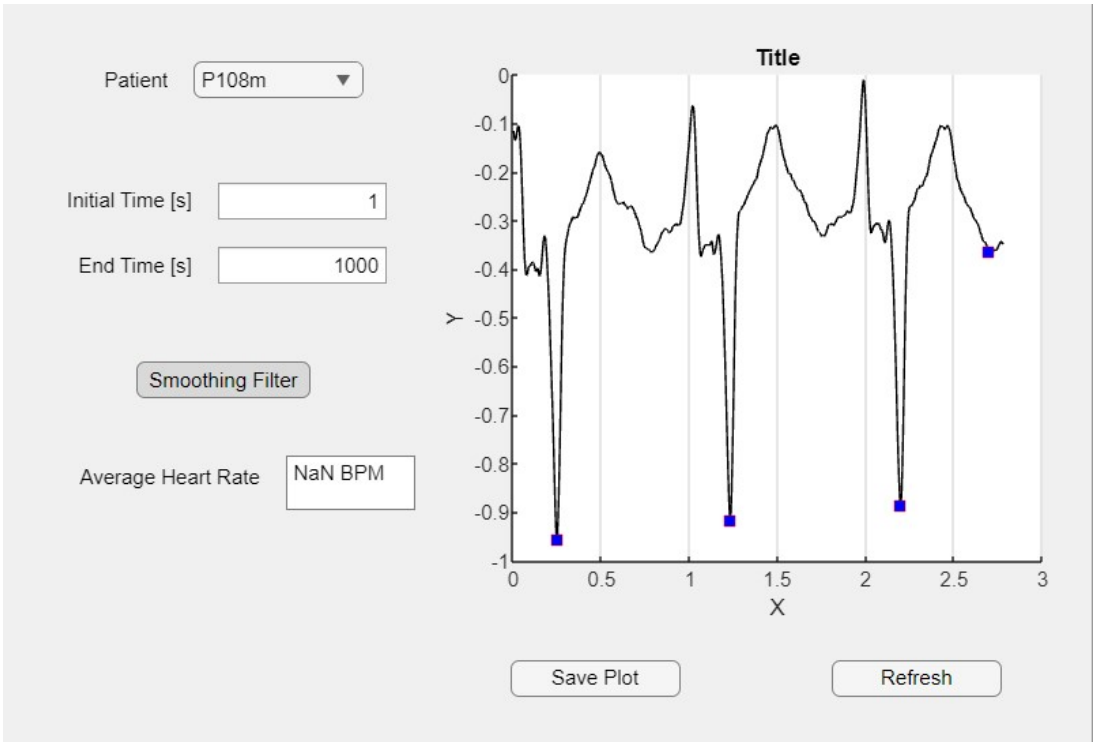

Figure 16: ECG GUI plot of patient 108m of data from points 1 to 1000 with smoothing filter applied

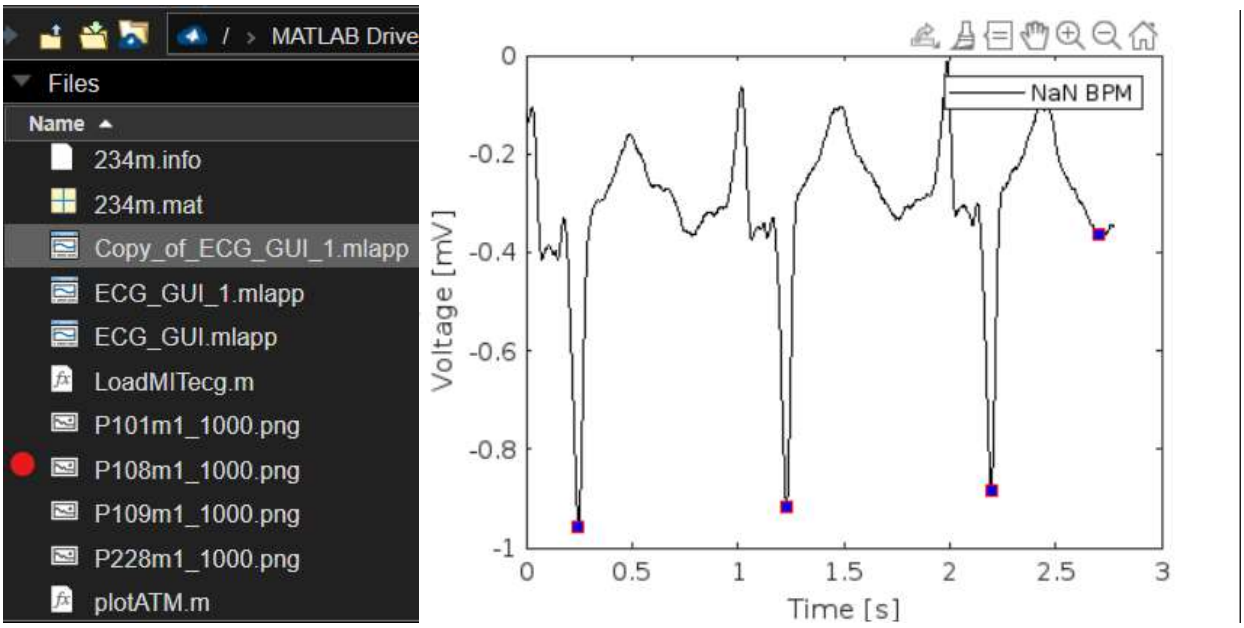

Figure 17: Saved ECG GUI image of plot for patient 108m from points 1 to 1000 with smoothing filter applied

Table 4: Heart rate data from patient 108m from points 1 to 1000	GUI Calculation (no filter)	GUI Calculation (smoothing filter)	Real Calculation
Heart Rate [BPM]	NA	NA	81

Limitations

Measuring BPM:

The measuring of the average heart rate is relatively accurate for any data set where the peaks occur above 0.2 mV. When most of the data reads below 0.2 mV, the GUI is unable to accurately plot the peaks and calculate the average heart rate. This condition can be seen in Figure 15 which is a plot of the patient data from patient 108m.

Smoothing Filter:

For most of the patient data, the smoothing filter can remove any interfering noise without causing signal distortion. If the ECG peaks occur near the limit of 0.2 mV, the filter may over filter and interfere with the measuring of BPM and signal peaks. This condition can be seen between Figure 11 and Figure 12 where one of the peaks is no longer measured after the filter is applied.