University of Brasília

Electrical Engineering Department

Topics in Biomedical Engineering

Task 3

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August 19, 2022

Contents

1 R peaks detection - Fantasia Database

The R peaks detection was done using the CRSIDLab, that is a MATLAB toolbox. The step by step is shown in the sections below but more details are found in this tutorial: CRSIDLab-Tutorial.

Before using the CRSIDLab, it's necessary to treat the data downloaded from the database of PhysioNet [1], to create the variables used in the toolbox, for example, ecg variable, time axis and sampling frequency. Furthermore, it's necessary to restrict the interval between five minutes (300 seconds), and, in this subjects, the interval between 2100 and 2400 seconds (minute 35 and minute 40) has little noise and generates a good observation around electrocardiogram signal and their R peaks.

1.1 Subject f2o02 - Elderly subject

The MATLAB's code to treat the ECG signal of the subject **f2o02**:

```
clc; clear all; close all;
warning('off');

% subject f2o02
load f2o02m.mat;
fs2 = 250; % Hz
ts2 = 1/fs2;

% ECG
ecg = val(2,:);
base=0; gain=409.6; ecg = (ecg-base)./gain; % unit
    correction

% TIME CONVERSOR
% time vector for 5 min = 300 sec
% downloaded 1h of data from PhysioNet
tts = (60*60); % 1h00
tts_5min = (5*60);
n_points = length(ecg);

% POINTS CONVERSOR
% to calculate the number of points in 300sec
```

```
% proportion:
% tts -- n_points
% 300 -- n_points_5min
n_points_5min = ((n_points*tts_5min)-1)/tts;

t_points = ((7*n_points_5min:8*n_points_5min) * ts2); % time vector
ecg = ecg(7*n_points_5min:8*n_points_5min); % 2100 - 2400 seg

% uncomment to see the plot if necessary
% plot(t_points, ecg, 'r'); grid;
% xlabel('Tempo (s)');
% ylabel('ECG (mV)');
% title('f2o02 - ECG x Tempo');
```

As shown in the Figure 1, the ECG signal of the eldery subject has some noise in the low amplitude regions, mainly on P-wave and T-wave. Despite of that, it's necessary to apply a filtering process to get the signal more satisfying.

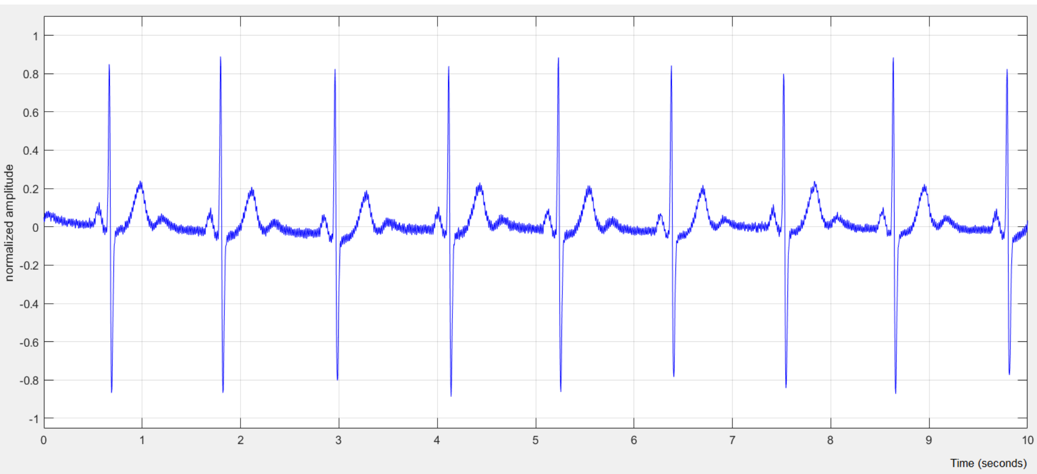

Figure 1: ECG signal of the elderly subject before filtering.

The filtering process depends on each situation and depends of the objective of the analysis in question. It is recommendable to use filters only if necessary, since unnecessary interference can be introduced to the original signal. In this case of the ECG signal of the elderly subject, the **Notch Filter** was applied with the width of 1% (default), that is a 60 Hz filter applied in order to remove possible interference from the frequency of the 60 Hz electrical network in Brazil. In sequence, the **High-Pass Filter** was also applied with frequency 0, 001 Hz (default), in order to filter trends or low frequency oscillations, such as baseline fluctuations, that can be caused by breathing, by variations in electrode impedance and by body movements during the exam.

These filter applying commands are shown in the Figure 2.

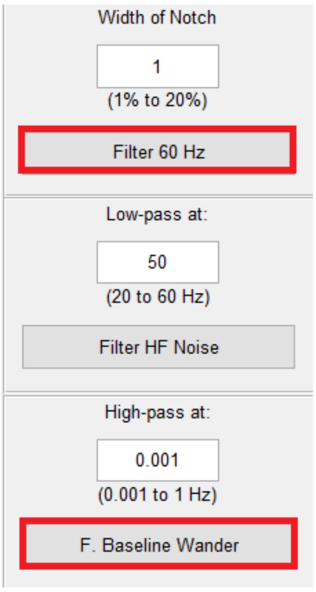

Figure 2: Steps: 1. Notch Filter, 2. High-pass Filter

In the Figure 3, it is possible to visualize the noise removal in the ECG signal

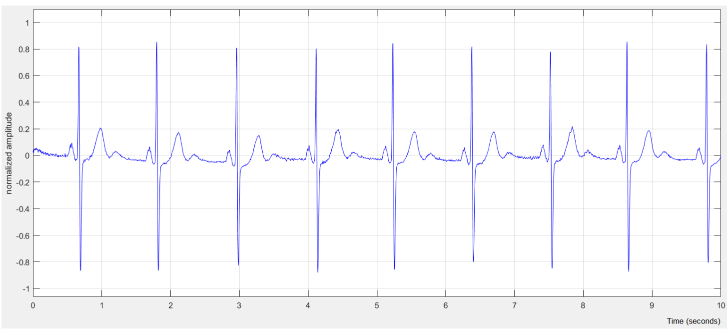

Figure 3: ECG signal of the elderly subject after filtering.

In sequence, it is necessary to select the **Filtered ECG data** to mark to R peaks, as shown in the Figure 4.

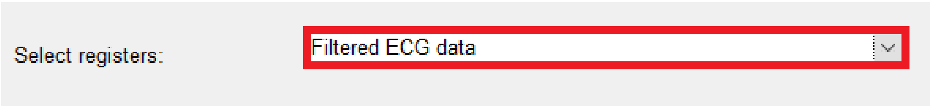

Figure 4: Command to select the filtered signal.

The mark process of the R peaks is **always** shown and follows the **Slow Algorithm**, that is a non-technique algorithm, but is a name chosen during the CRSIDLab creation. This step-by-step is exposed below:

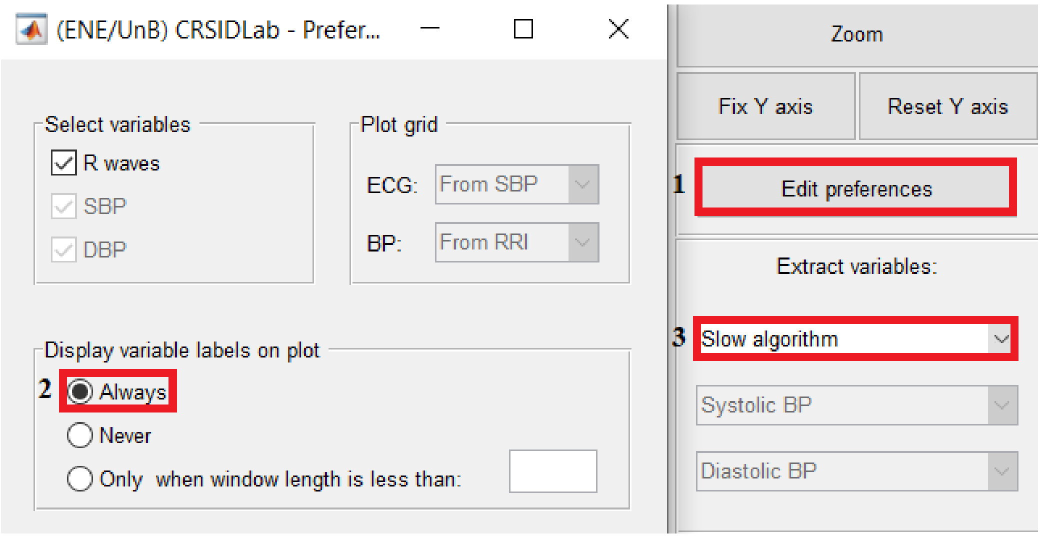

Figure 5: Step-by-step to mark R peaks.

The result of marking the R peaks during the 5 minutes (300 seconds) is represented by the Figure 6.

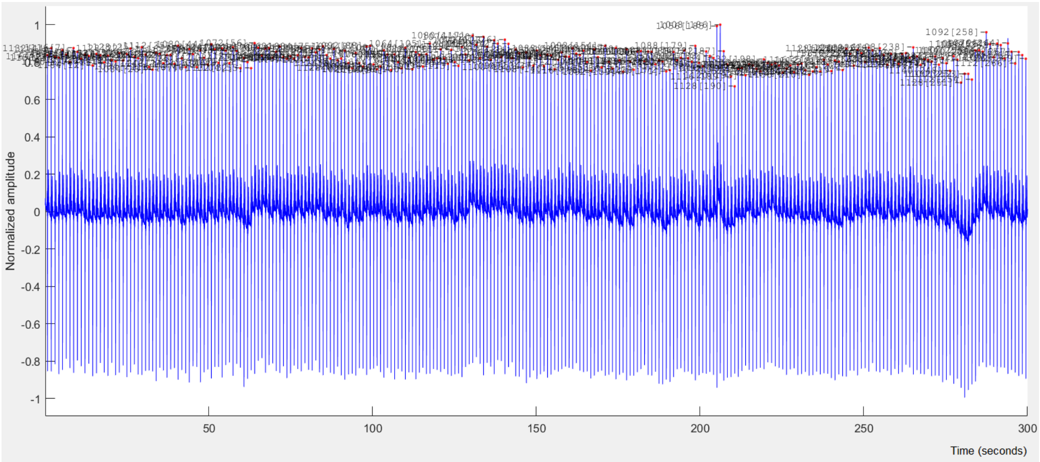

Figure 6: All the R peaks of the elderly subject during 5 minutes.

However, during all the 300 seconds, the visualization is compromised. Thus, the Figure 7 shows the R peaks marked during 10 seconds, more specifically, from the second 30 to the second 40. Notably generating a better view of R peaks and of RR interval (RRi).

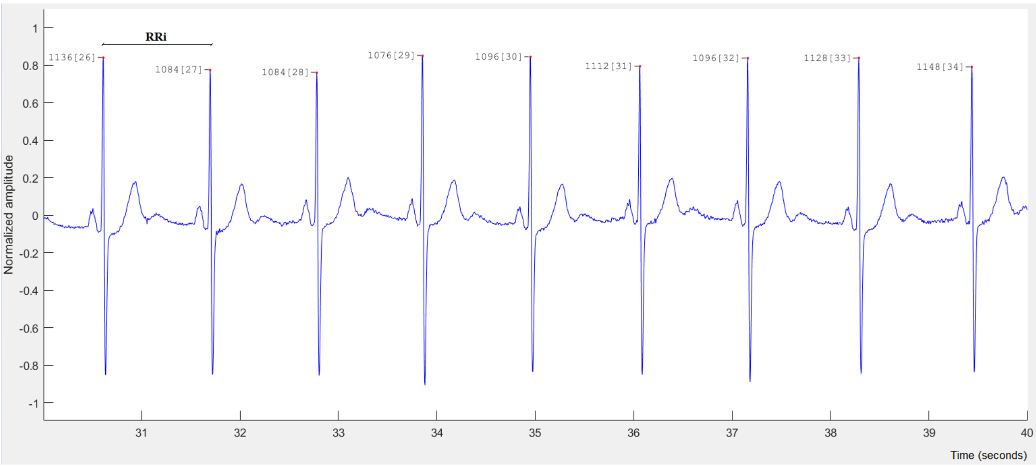

Figure 7: R peaks of the elderly subject during 10 seconds.

Furthermore, with the objective of complementing the analysis and making it richer, one ectopic beat was identified and marked. The Figure 8 shows how to mark this extrasystolic beat (ectopic beat).

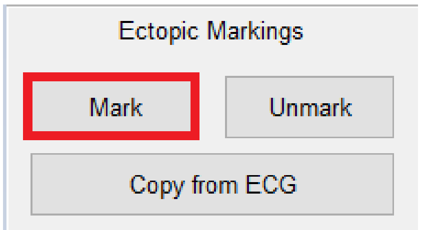

Figure 8: Command to mark an ectopic beat.

The ectopic beat and its compensatory pause is identified in the Figure 8. It is important to point out that, during the ectopic mark process, it is also necessary to mark the beat in sequence (compensatory pause) of the ectopic beat and also to verify possibles R peaks marked wrong for further analysis, like interpolation and resampling.

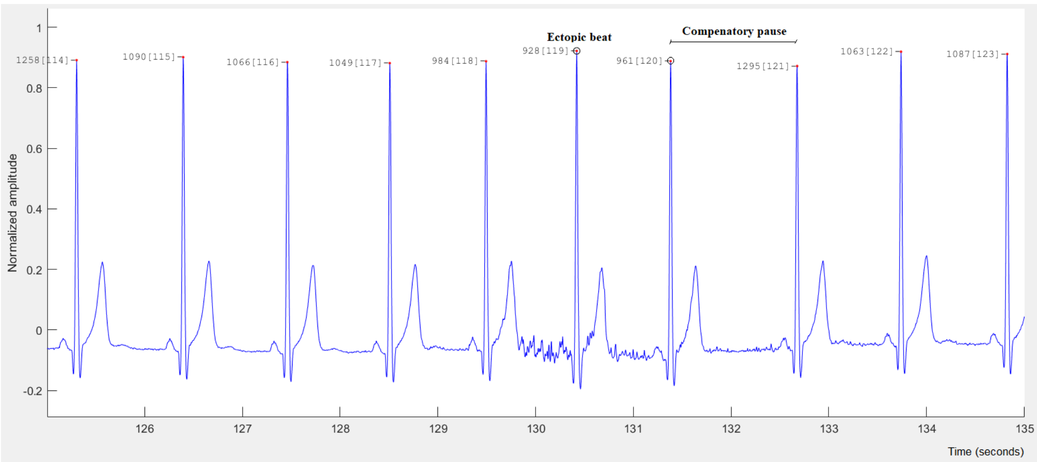

Figure 9: Ectopic beat and compensatory pause.

1.2 Subject f2y02 - Young subject

The MATLAB's code to treat the ECG signal of the subject **f2y02**:

```
clc; clear all; close all;
warning('off');

% subject f2y02
load f2y02m.mat;
fs = 333; % Hz
```

```
ts = 1/fs;

% ECG
ecg = val(2,:);
base=0; gain=409.6; ecg = (ecg-base)./gain; % unit correction

% TIME CONVERSOR
% time vector for 5 min = 300 sec
% downloaded 1h (50min3sec) of data from PhysioNet
tts = (50*60) + 3; % 50m e 3s
tts_5min = (5*60);
n_points = length(ecg);

% POINTS CONVERSOR
% to calculate the number of points in 300sec
% proportion:
% tts -- n_points
% 300 -- n_points_5min
n_points_5min = ((n_points*tts_5min)-1)/tts; % numero de pontos

t_points = ((7*n_points_5min:8*n_points_5min) * ts); % time vector
ecg = ecg(7*n_points_5min:8*n_points_5min); % 2100 - 2400 seg

% uncomment to see the plot if necessary
% plot(t_points, ecg, 'r'); grid;
% xlabel('Tempo (s)');
% ylabel('ECG (mV)');
% title('f2y02 - ECG x Tempo');
```

As the elderly subject, the ECG signal of the young subject before filtering, in the Figure 10, has some noise in low amplitudes regions and has also a slightly baseline.

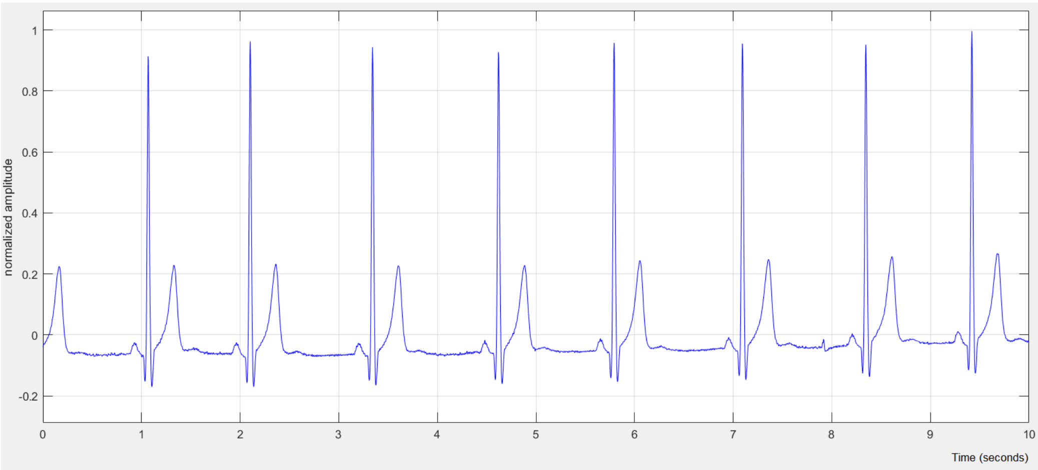

Figure 10: ECG signal of the young subject before filtering.

Despite of that, the **Notch** and **High-Pass** filters were applied with default values of width and frequency defined by the CRSIDLab. Additional details about these filters and their changes in ECG signal were mentioned on section **1.1** of the elderly subject. The filtered signal can be visualized in the Figure 11.

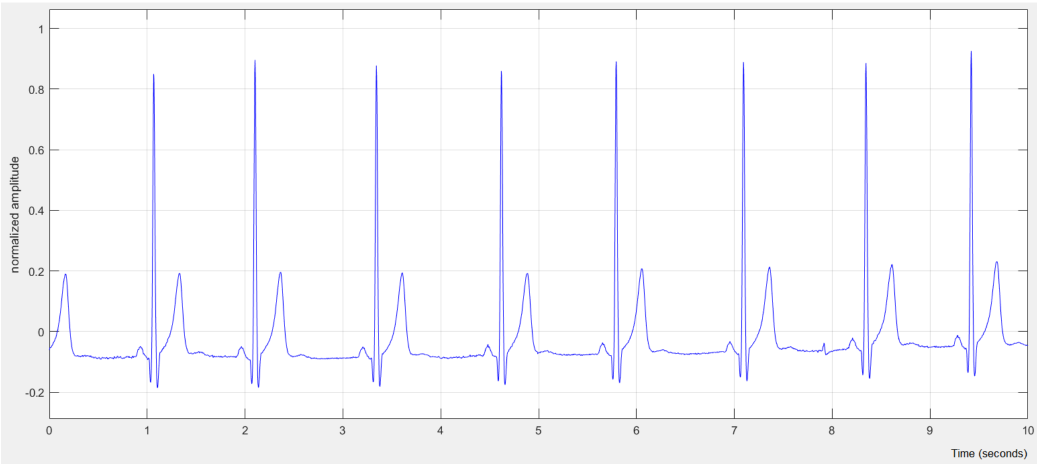

Figure 11: ECG signal of the young subject after filtering.

In the same way, the step-by-step to mark the R peaks of the young subject is the same adopted in the elderly subject, that is detailed on the section **1.1**. The Figure 12 shows all the R peaks of the young subject during the 5 minutes (300 seconds).

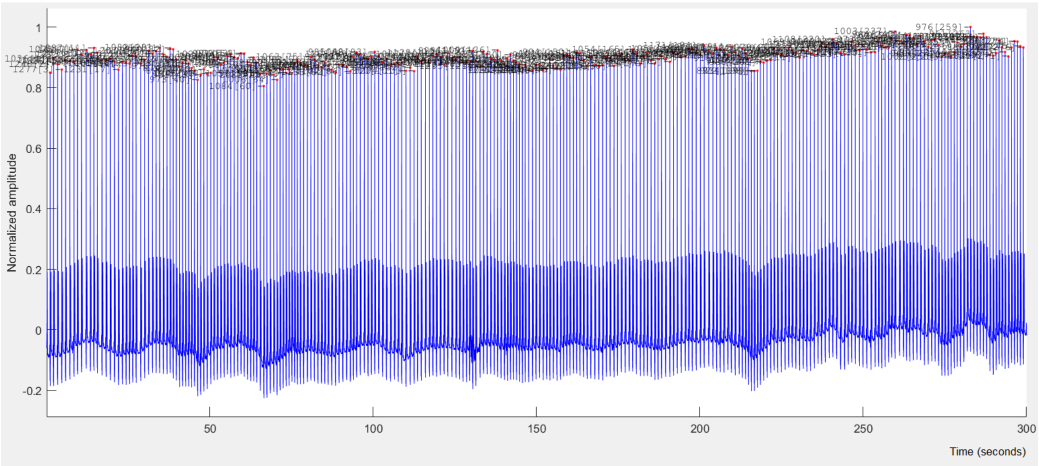

Figure 12: All the R peaks of the young subject during 5 minutes.

In addition, the Figure 13 represents the R peaks of the young subject during 10 seconds, more precisely, from the second 30 to the second 40. Evidently this view generates a better view of the R peaks and of the RR intervals (RRi).

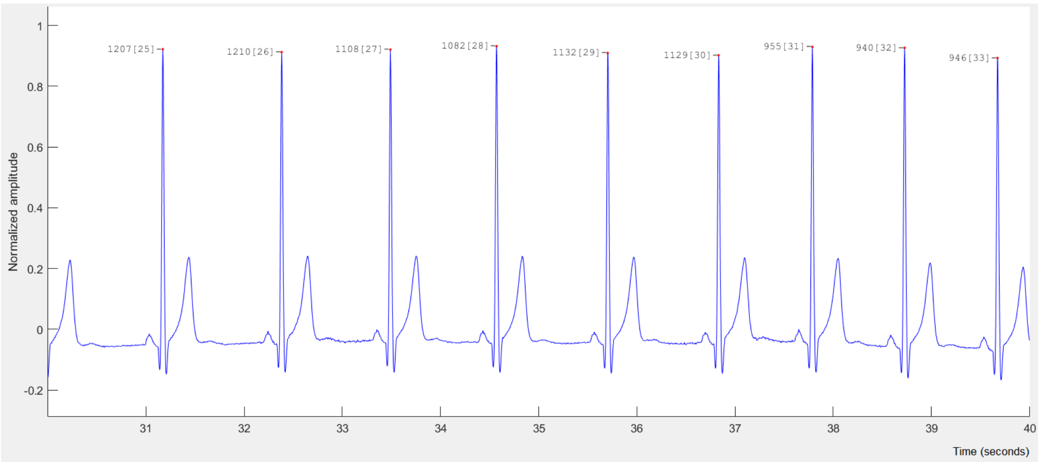

Figure 13: R peaks of the young subject during 10 seconds.

In relation to the ectopics beats of the ECG signal of the young subjects, a visual evaluation was carried out during the five minutes, but no ectopic beat was found. The fact that it is a signal of a young subject can be a primary explanation for the lack of ectopic beats. Certainly, the presence of these extrasystolics beats is generated by several other factors and this is an initial and superficial explanation.

References

[1] "PhysioBank ATM." https://archive.physionet.org/cgi-bin/atm/ATM?database=fantasia&tool=plot_waveforms.