Matlab Code Walkthrough: Converting ECG to RRI

This document describes how to use the function `‘ECG_to_RRI.m’` to convert sample ECG data to RR interval (RRI) data. As illustrated, selecting an appropriate amplitude threshold is crucial to correctly identifying R peaks in ECG.

Load the sample ECG data into memory:

```
load('ECG_data.mat');
```

The file contains ECG data (x_ECG) and a scalar denoting the sampling frequency (fs_ECG, 1000 Hz in this instance). Plotting the ECG data (see Figure 1); the user should be able to distinguish different features of the ECG waveform. In particular the R peaks should be clearly identifiable.

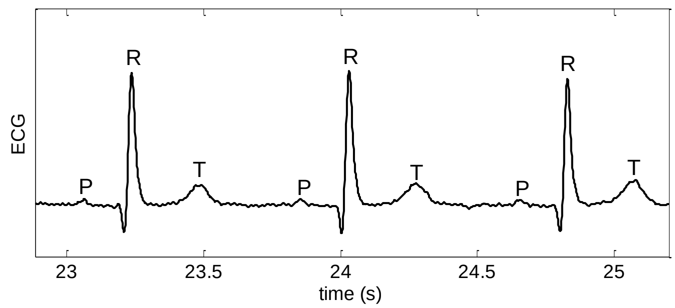

Figure 1. The ECG waveform. Observe that R peaks – dominant sharp peaks in ECG waveform – can be clearly distinguished.

Run the code on the ECG data as follows:

```
[x_RRI,fs_RRI]=ECG_to_RRI(x_ECG,fs_ECG);
```

The code will generate Figure 2 and prompt the following message:

```
Change parameters (Y/N) ?
```

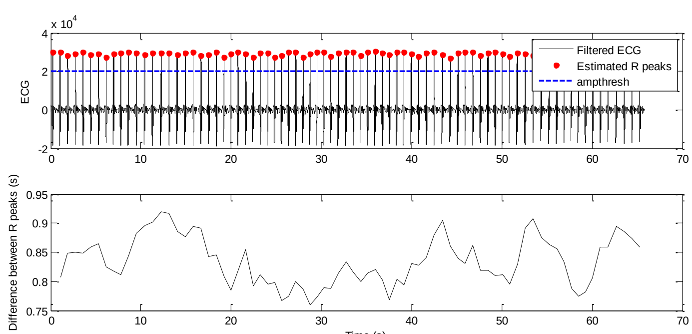

Figure 2. Output figure showing estimated R peaks (upper), and the time difference between successive R peaks (lower). The automatically detected amplitude threshold is appropriate.

By default, the function will automatically select the amplitude threshold (dashed blue line in Figure 1). In this instance, the automatically detected value for the amplitude threshold is appropriate and the user can proceed without changing the parameters:

```
Change parameters (Y/N) ? N
```

The function will now generate the RRI with regular sample intervals, plot the time series, and output it as 'x_RRI'.

In practice, the automatically detected value will not always be optimal and the user will need to determine a more appropriate value manually. The user may select the amplitude threshold as follows:

```
[x_RRI,fs_RRI]=ECG_to_RRI(x_ECG,fs_ECG,'ampthresh',0.5*10^(-3));
```

This will generate Figure 3. It is clear that spurious peaks have been detected because, in this instance, the amplitude threshold is too small. The user now has several options.

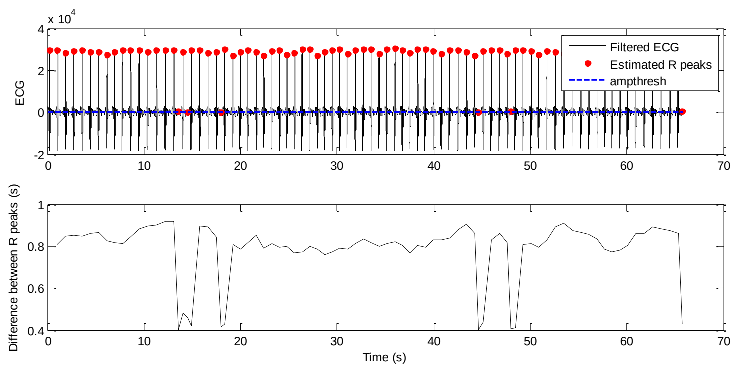

Figure 3. Output figure showing estimated R peaks (upper), and the time difference between successive R peaks (lower). It is clear that spurious peaks have been detected, see for instance the sudden changes in the lower plot at e.g. 13-15 s.

Option 1

The user can opt to change parameters by performing the following actions.

- Enter 'Y' to change the parameters:
  `Change parameters (Y/N) ? Y`

- Enter 'ampthresh' to change the amplitude parameter:
  `Which parameter (ampthresh,timethresh,sign) ? ampthresh`

- The user will then be prompted to enter a new value, enter the following:
  `Enter ampthresh 2*(10^4)`

- A new figure will be generated (see Figure 4). Note that the updated amplitude threshold ensures that no spurious peaks have been identified.

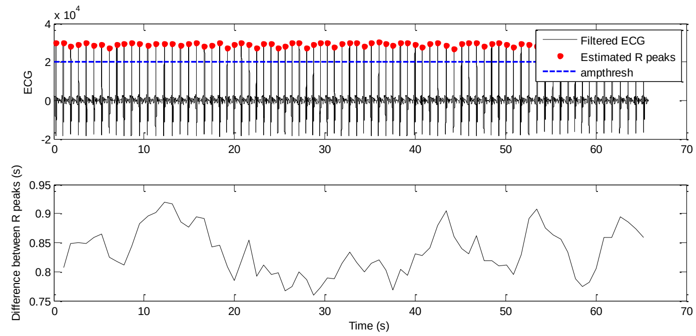

Figure 4. Output figure showing estimated R peaks (upper), and the time difference between successive R peaks (lower). With the revised amplitude parameter (see dashed blue line in upper plot), it is clear that no spurious peaks have been detected.

- With the update parameters, the function will report that no anomalies have been detected, and the RRI will be plotted (see Figure 5) and output.

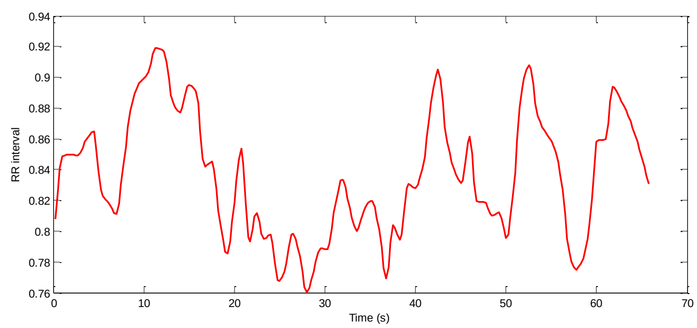

Figure 5. The output RRI time series.

Option 2

Alternatively, the user could have opted **not** to change the parameters and instead to review the anomalies manually.

- Enter 'N' to leave the default parameters unchanged:

```
Change parameters (Y/N) ? N
```

- The function will detect anomalies in the RR data, and will task the user with manually reviewing the data.

```
Possible anomaly detected on or after time 13.136 , remove (Y/N)?
```

- The user can then manually review the output figure at that time instant (see Figure 6). Clearly in this instance the peak is an anomaly and should be removed by entering 'Y':

```
Possible anomaly detected on or after time 13.136 , remove (Y/N)? Y
```

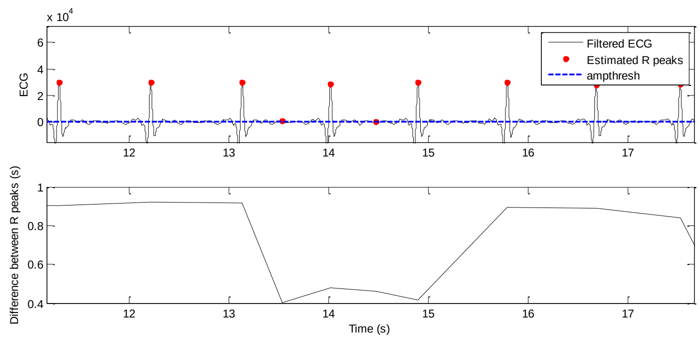

Figure 6. Output figure showing estimated R peaks (upper), and the time difference between successive R peaks (lower). It is clear that spurious peaks have been detected between 13 and 15 s.

- Finally, a plot will be generated showing the user the estimated RRI with the anomalies removed (see dashed red line in Figure 7).

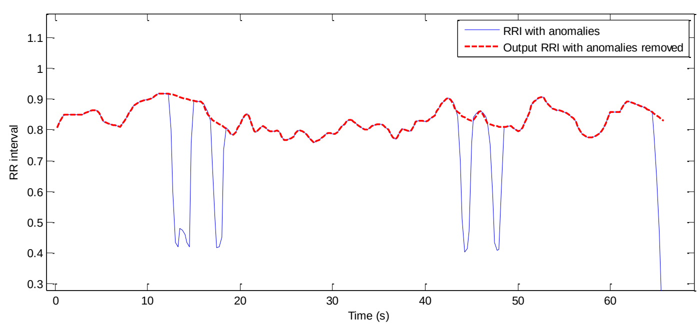

Figure 7. The output RRI time series, with and without anomalies.

The user could have entered a suitable amplitude threshold at the very start as follows:

```
[x_RRI,fs_RRI]=ECG_to_RRI(x_ECG,fs_ECG,'ampthresh',2*(10^4));
```