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# BEATz: A tools for making physiological data a bit less noisy

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BEATz is a Matlab program for cleaning physiological noise data. Its main use is preparing such file for inclusion in regression models in the context of fMRI analysis.  However, it can also be used for annotation of simple cardiac data prior to deriving heart-rate related measures.  It allows basic annotation of cardiac R-R data, and also generates limited information about heart rate and variance.

1. BEATz automatically detects heart beats from a Siemens pulse-oximetry (.puls) file.
2. It allows one to manually remove incorrectly detected heart beats
3. It outputs beats per minute and mean heart rate variability.

To start:
Place a pulse file in the BEATz directory. Point Matlab to the directory, and run BEATz.m
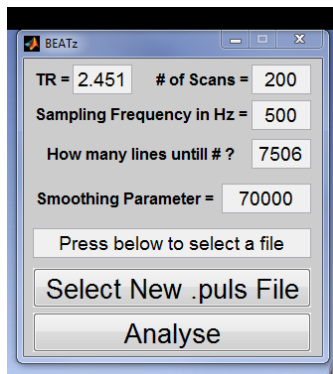
Step 1: Entering required parameters


Figure 1 The GUI

A Simple GUI will appear with fields for inputting needed parameters (Fig. 1). The first three parameters: Repetition time (TR), number of scans, and sampling frequency in hertz are used to truncate long data sets to match the length of the fMRI data. In addition, Siemens begins recoding physiological data prior to acquisition of the first fMRI volume, and for this reason the GUI asks for their number so they can be discarded.  In our MR scanner software, a hash mark indicates the timing of the first fMRI volume (How many lines until #). When opened in a proper text editor such as Notepad++, that line would show up as
'# CR LF'. An image showing this line is included at the end of this document.

A smoothing parameter is also required.  The raw physiological recording contains numerous peaks reflecting noise and other determinants of local maxima. For this reason, some degree of smoothing is necessary prior to editing.  The smoothing algorithm used is the Hodrick-Prescott filter.
http://en.wikipedia.org/wiki/Hodrick%E2%80%93Prescott_filter . Feel free to play with this value.  A

too-low value will result in false positive peaks being detected, and one too high will result in peaks being lost. As BEATz allows one to manually remove false positives, but not add peaks manually, one should err on the side of false positives (lower smoothing parameter).

All of the input parameters can easily entered in the *BEATz.m* script so that they do not have to be entered in the GUI every time.

Step 2: Editing the physiological data file
With the proper values entered into the GUI, press the button for "Select New .puls file", select the ,puls file that you want to analyze (example.log in our example) and press *analyze*.

At this point, two Matlab figure windows will appear. One with the Photoplethysmogram in blue with the detected beats as red stars (detection window) and one with red circles and no Photoplethysmogram (Fig 2). We recommend opening each on a separate screen.

The field of view of the selection window is the locked to the FOV of the detection window. You should use the matlab figure view tools on the detection window to zoom into a particular section of the the Photoplethysmogram. (Zoom figures here). Then on the selection window you can left click to remove false positives. Right clicking will re-introduce a previously removed beat.
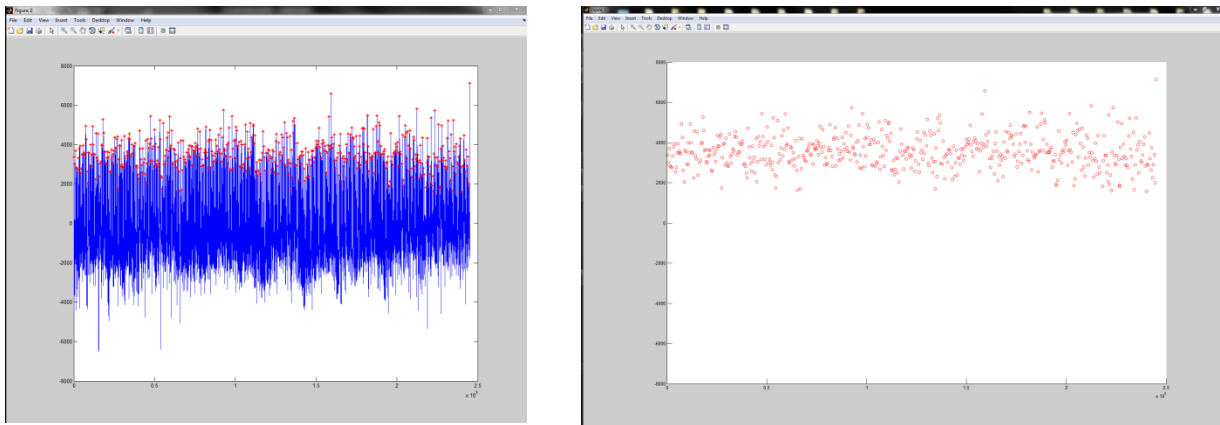


**Figure 2 dual window edit configuration**

False positives will most often by visible as two beats identified in very close succession.  For example, in Figure 3 we marked two of these.  In such a case, we removed the first of the two identified beats.
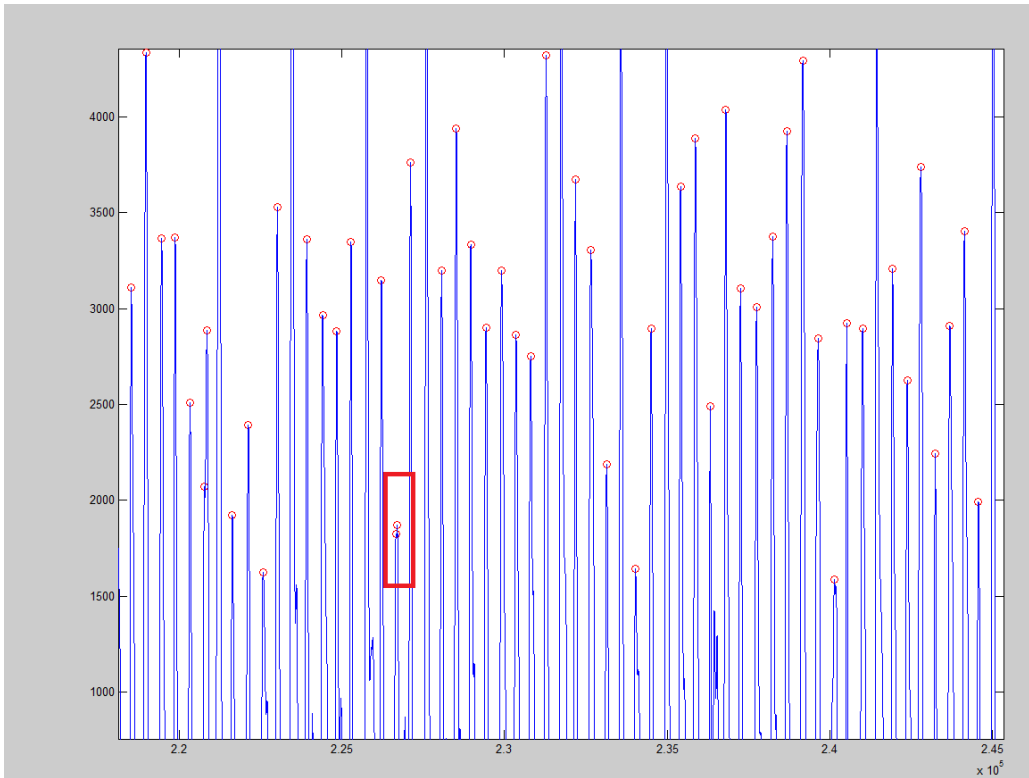
Step 3: Finishing
Once you are finished removing false positive heart beat detections, simply press any key when you have the selection window active and Beatz will output the mean HRV and the BPM for that particular .pulse file. These values are also automatically saved as .BPM and .HRV files with the name of the .pulse file as prefix.

The End: Finding the Hash line marking the beginning of the scanning session within a physiological data file

```
7487    0 0  0 0   3256 -578  0 0 0 0000CRLF
7488    0 0  0 0   3256 -578  0 0 0 0000CRLF
7489    0 0  0 0   3256 -578  0 0 0 0000CRLF
7490    0 0  0 0   3483 -580  0 0 0 0000CRLF
7491    0 0  0 0   3483 -580  0 0 0 0000CRLF
7492    0 0  0 0   3483 -580  0 0 0 0000CRLF
7493    0 0  0 0   3483 -580  0 0 0 0000CRLF
7494    0 0  0 0   3483 -580  0 0 0 0000CRLF
7495    0 0  0 0   3600 -569  0 0 0 0000CRLF
7496    0 0  0 0   3600 -569  0 0 0 0000CRLF
7497    0 0  0 0   3600 -569  0 0 0 0000CRLF
7498    0 0  0 0   3600 -569  0 0 0 0000CRLF
7499    0 0  0 0   3600 -569  0 0 0 0000CRLF
7500    0 0  0 0   3506 -586  0 0 0 0000CRLF
7501    0 0  0 0   3506 -586  0 0 0 0000CRLF
7502    0 0  0 0   3506 -586  0 0 0 0000CRLF
7503    0 0  0 0   3506 -586  0 0 0 0000CRLF
7504    0 0  0 0   3506 -586  0 0 0 0000CRLF
7505    0 0  0 0   3332 -588  0 0 0 0000CRLF
7506    #CRLF
7507    0 0  0 0   3332 -588  0 0 0 0000CRLF
7508    0 0  0 0   3332 -588  0 0 0 0000CRLF
7509    0 0  0 0   3332 -588  0 0 0 0000CRLF
7510    0 0  0 0   3332 -588  0 0 0 0000CRLF
7511    0 0  0 0   3002 -602  0 0 0 0000CRLF
7512    0 0  0 0   3002 -602  0 0 0 0000CRLF
7513    0 0  0 0   3002 -602  0 0 0 0000CRLF
7514    0 0  0 0   3002 -602  0 0 0 0000CRLF
7515    0 0  0 0   3002 -602  0 0 0 0000CRLF
7516    0 0  0 0   2762 -607  0 0 0 0000CRLF
7517    0 0  0 0   2762 -607  0 0 0 0000CRLF
7518    0 0  0 0   2762 -607  0 0 0 0000CRLF
7519    0 0  0 0   2762 -607  0 0 0 0000CRLF
7520    0 0  0 0   2762 -607  0 0 0 0000CRLF
7521    0 0  0 0   2517 -648  0 0 0 0000CRLF
7522    0 0  0 0   2517 -648  0 0 0 0000CRLF
7523    0 0  0 0   2517 -648  0 0 0 0000CRLF
7524    0 0  0 0   2517 -648  0 0 0 0000CRLF
7525    0 0  0 0   2517 -648  0 0 0 0000CRLF
7526    0 0  0 0   2144 -646  0 0 0 0000CRLF
```