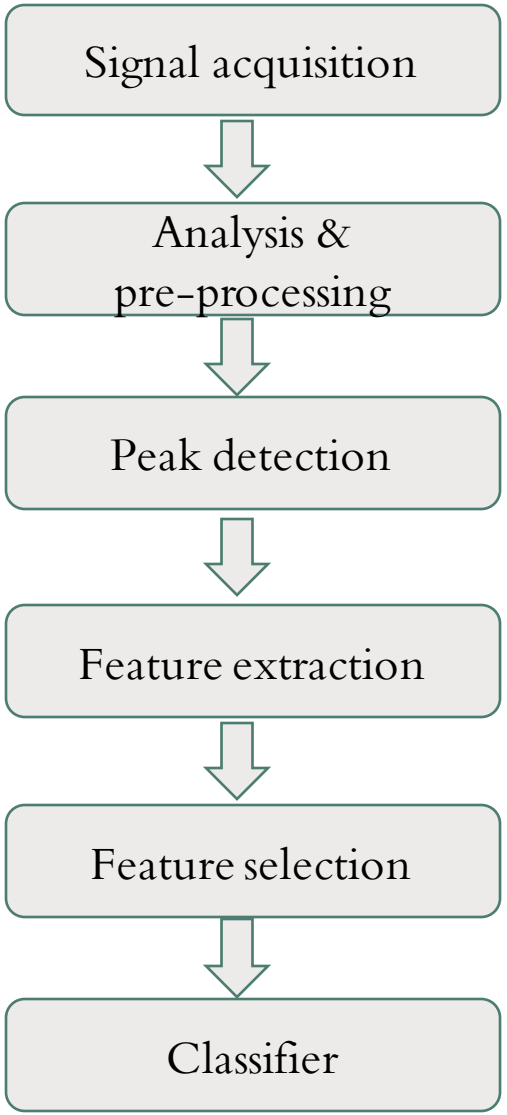
# AI BASED EMOTION DETECTION WITH ECG SIGNAL

# EMOTION DETECTION

- Why?
  - Behavior analysis
  - Early detection of disease
  - Motion intention
- Why biological signals?
  - Can’t be faked
  - Utilizing the available biological signals
- Why ECG?
  - Reliable
  - Well researched biological signal

# STEPWISE METHODOLOGY



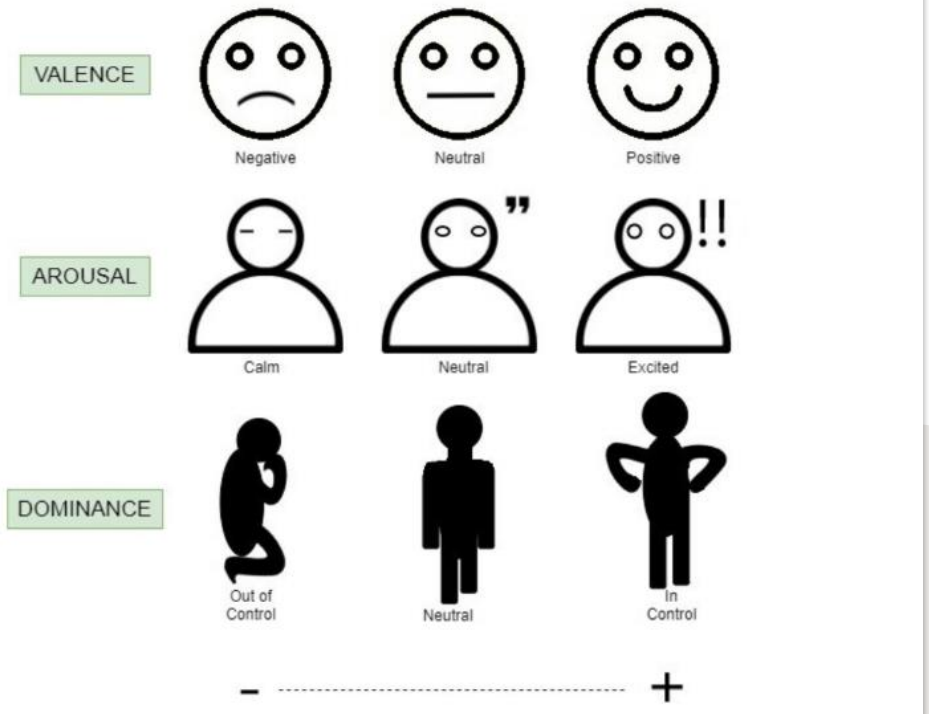
# SIGNAL ACQUISITION

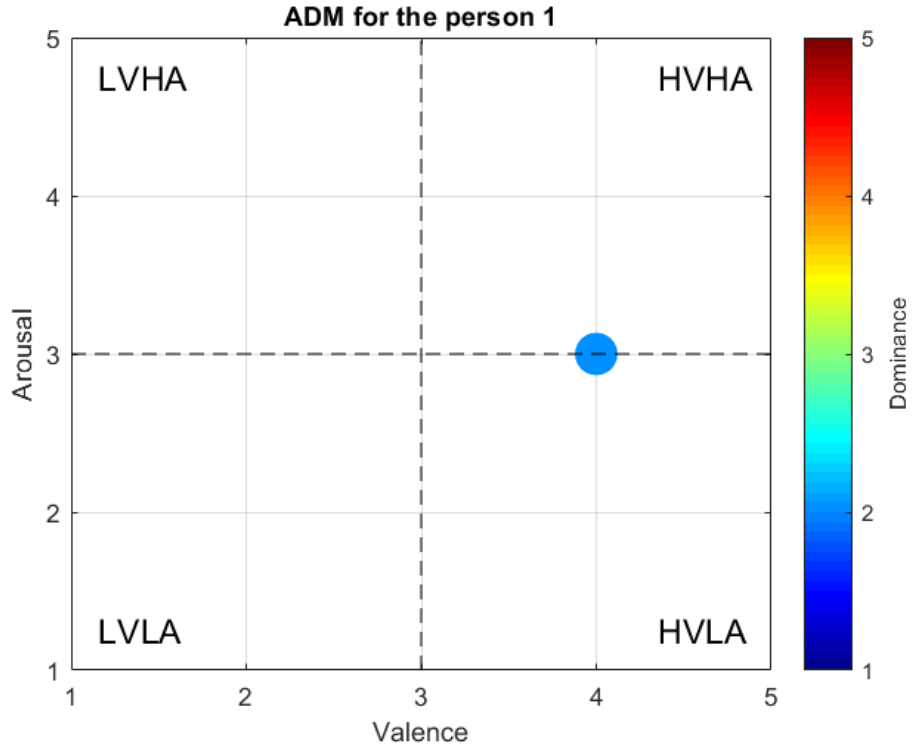
## Best available datasets

- DREAMER
- AMIGOS
- ASCERTAIN

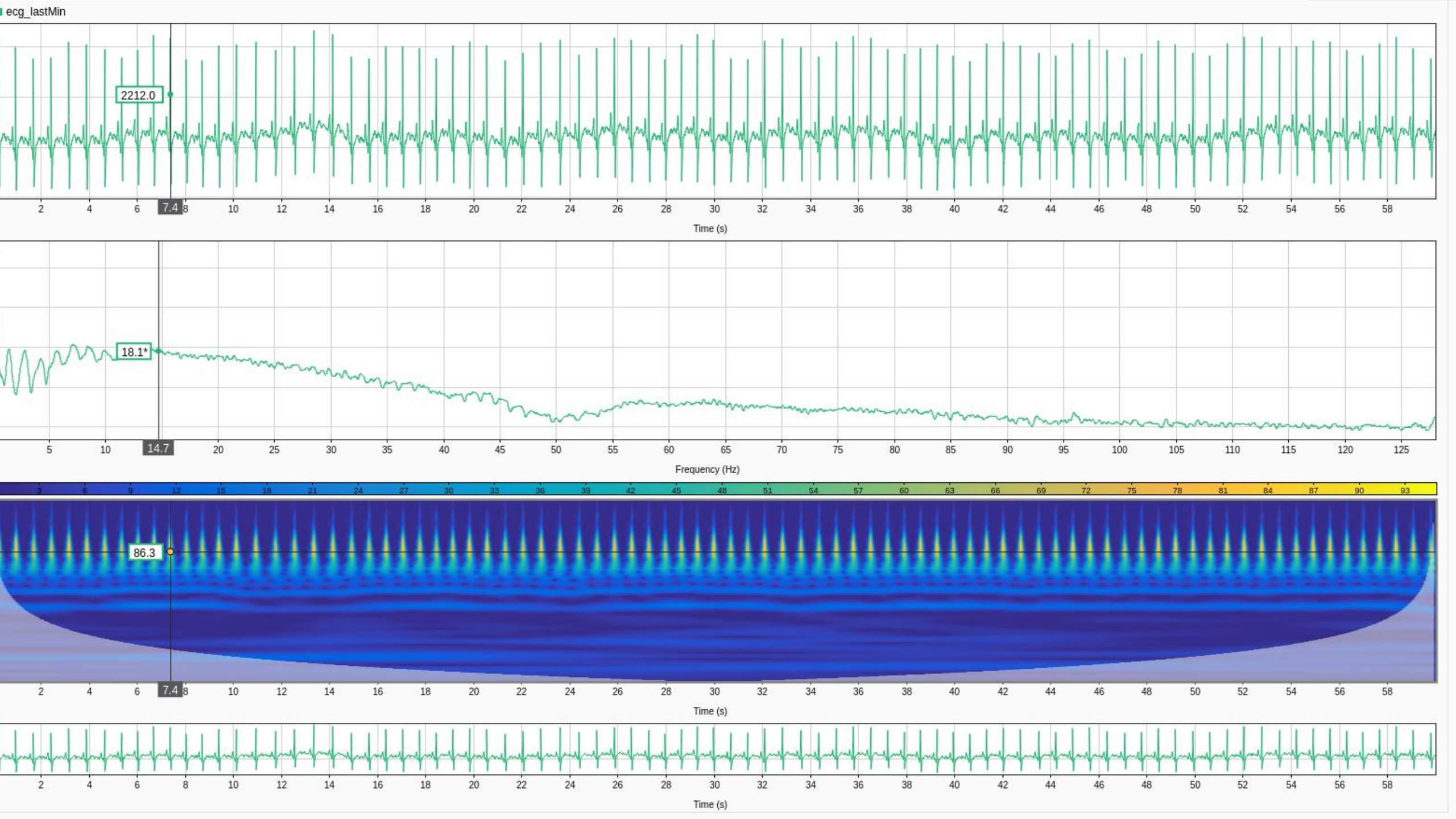
## DREAMER dataset

- Bimodal database (ECG and EEG)
- 23 participants x 18 tests
- 2 channels (stimuli, baseline)
- Self annotation
- Affective Dimensional model (ADM)
- Last 15360 samples (60 seconds * 256 Hz)



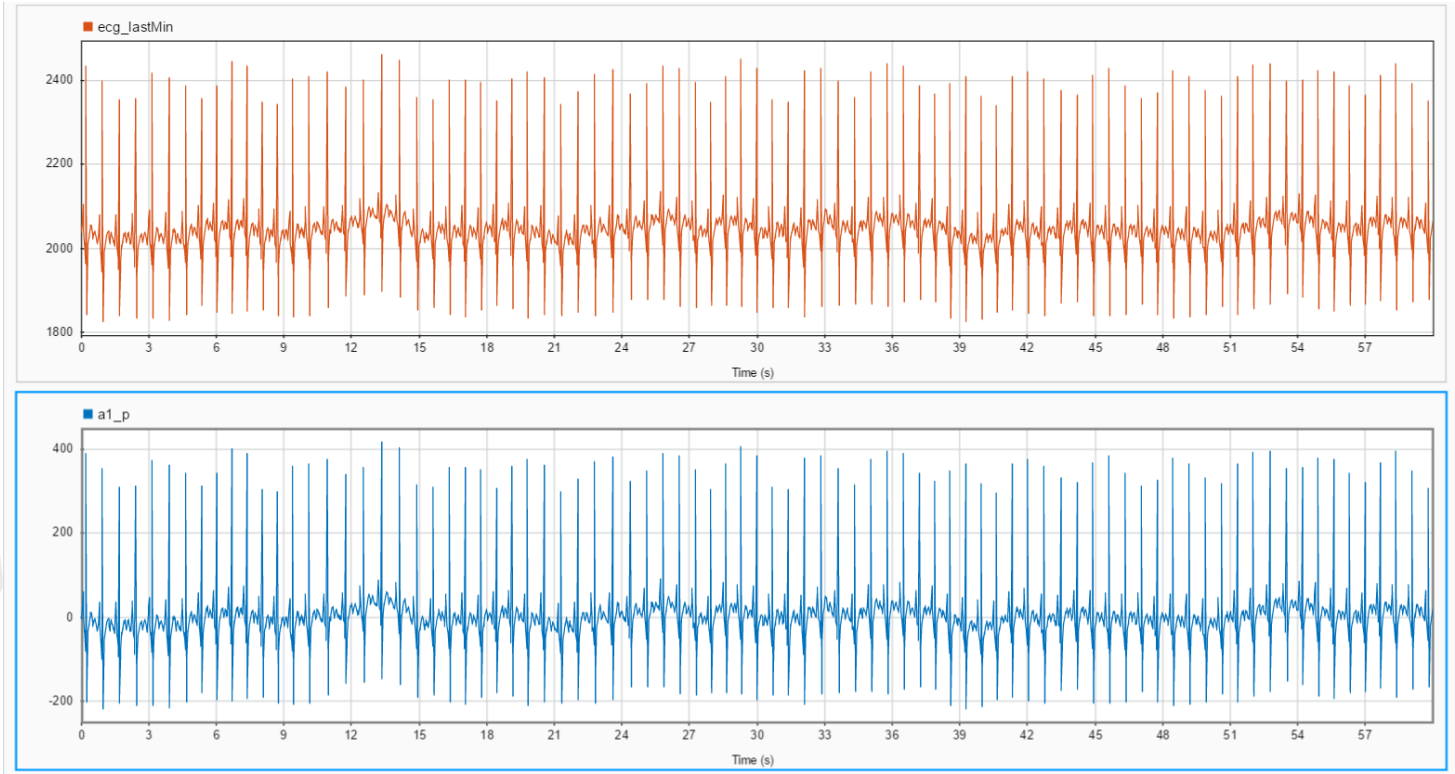

# AFFECTIVE DIMENSIONAL MODEL(ADM)


ecg_lastMin
2212.0
7.4
Time (s)
18.1*
14.7
Frequency (Hz)
86.3
7.4
Time (s)
Time (s)

# ANALYSIS & PRE-PROCESSING

## Remove offset

$$ecg_{signal} = ecg_{signal} - mean(ecg\_signal)$$

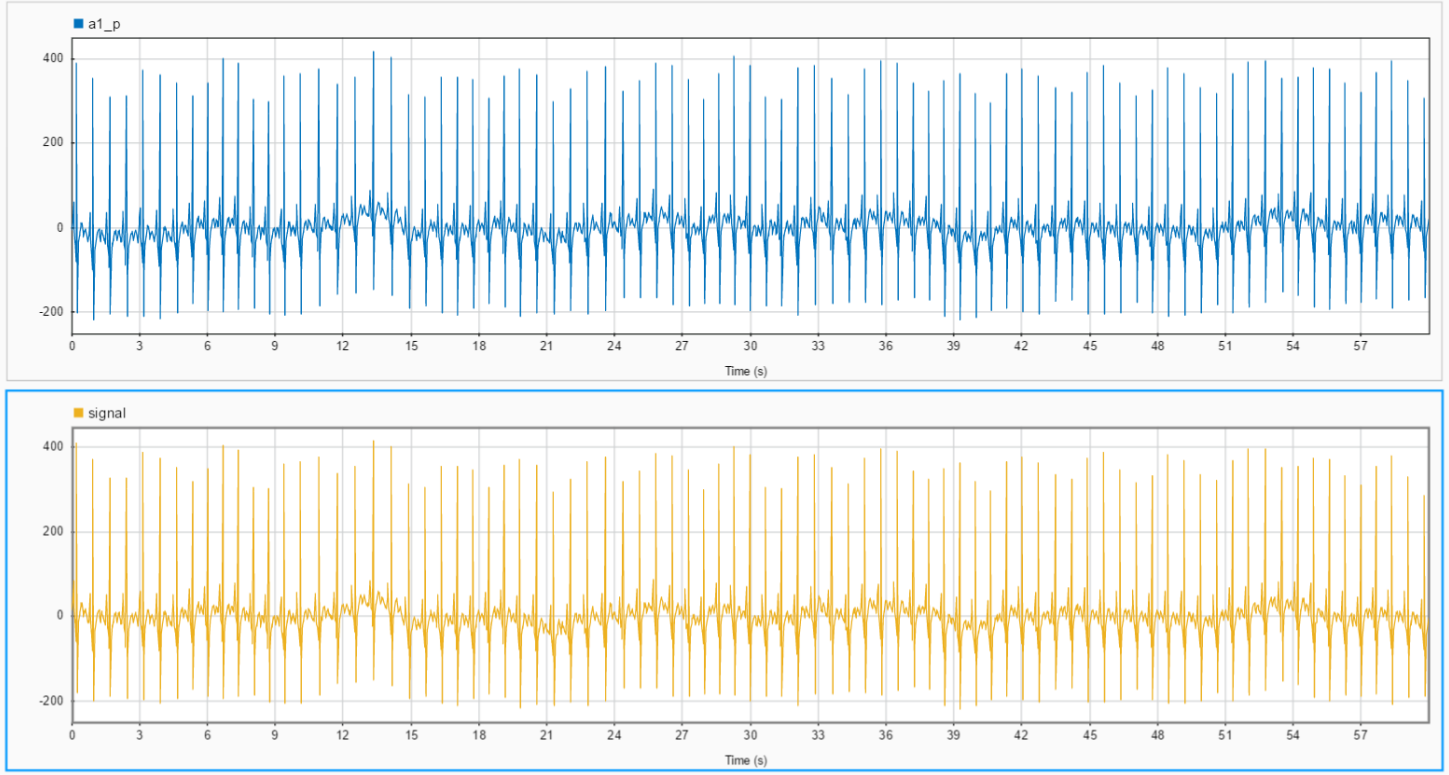


# ANALYSIS & PRE-PROCESSING

Remove trend

$$ecg_{signal} = ecg_{signal} - trend(ecg_{signal})$$

- 3rd order polynomial
- Savitzky-Golay (sgolay) filter



# R PEAK DETECTION

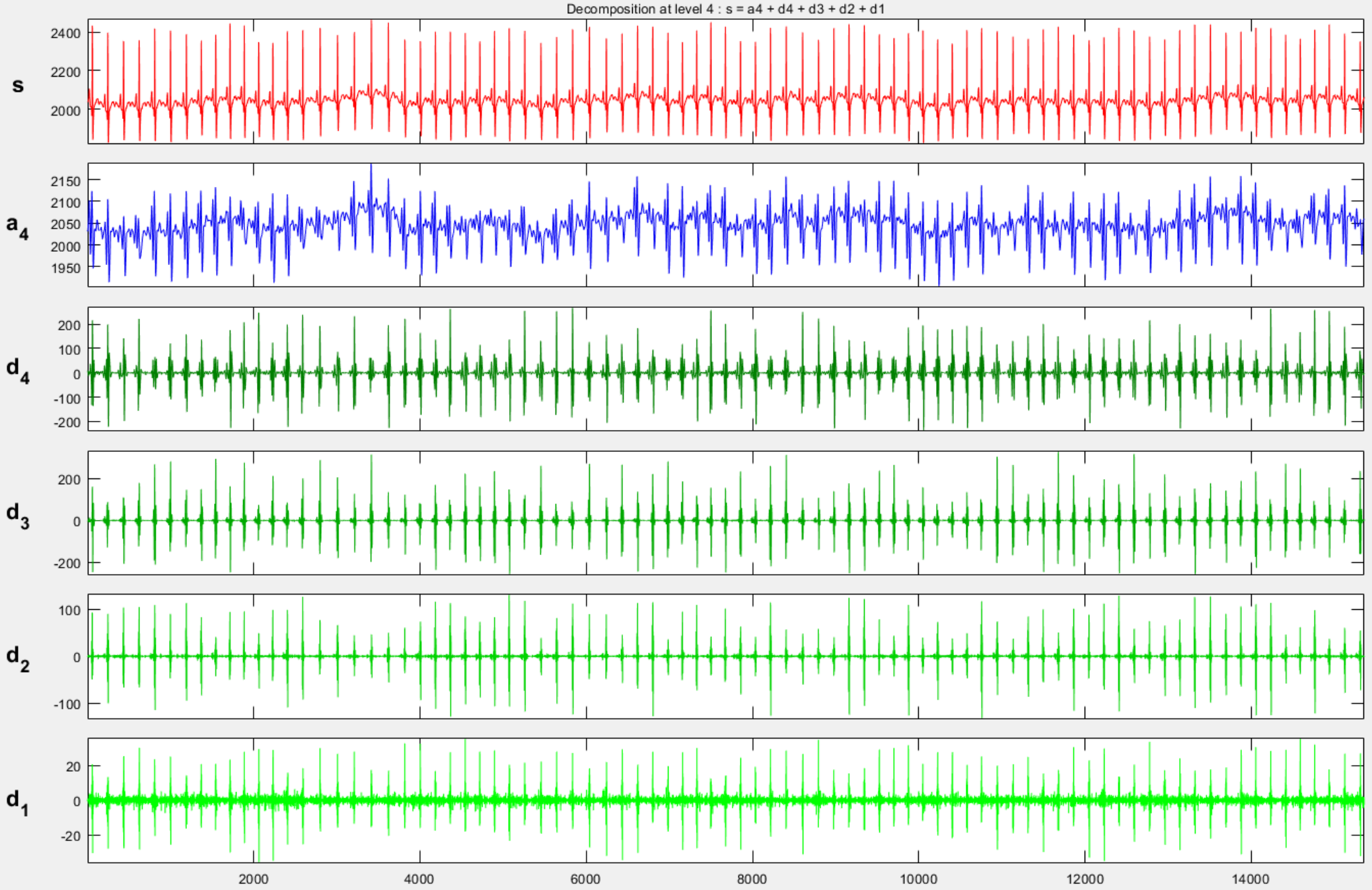
Wavelet Decomposition

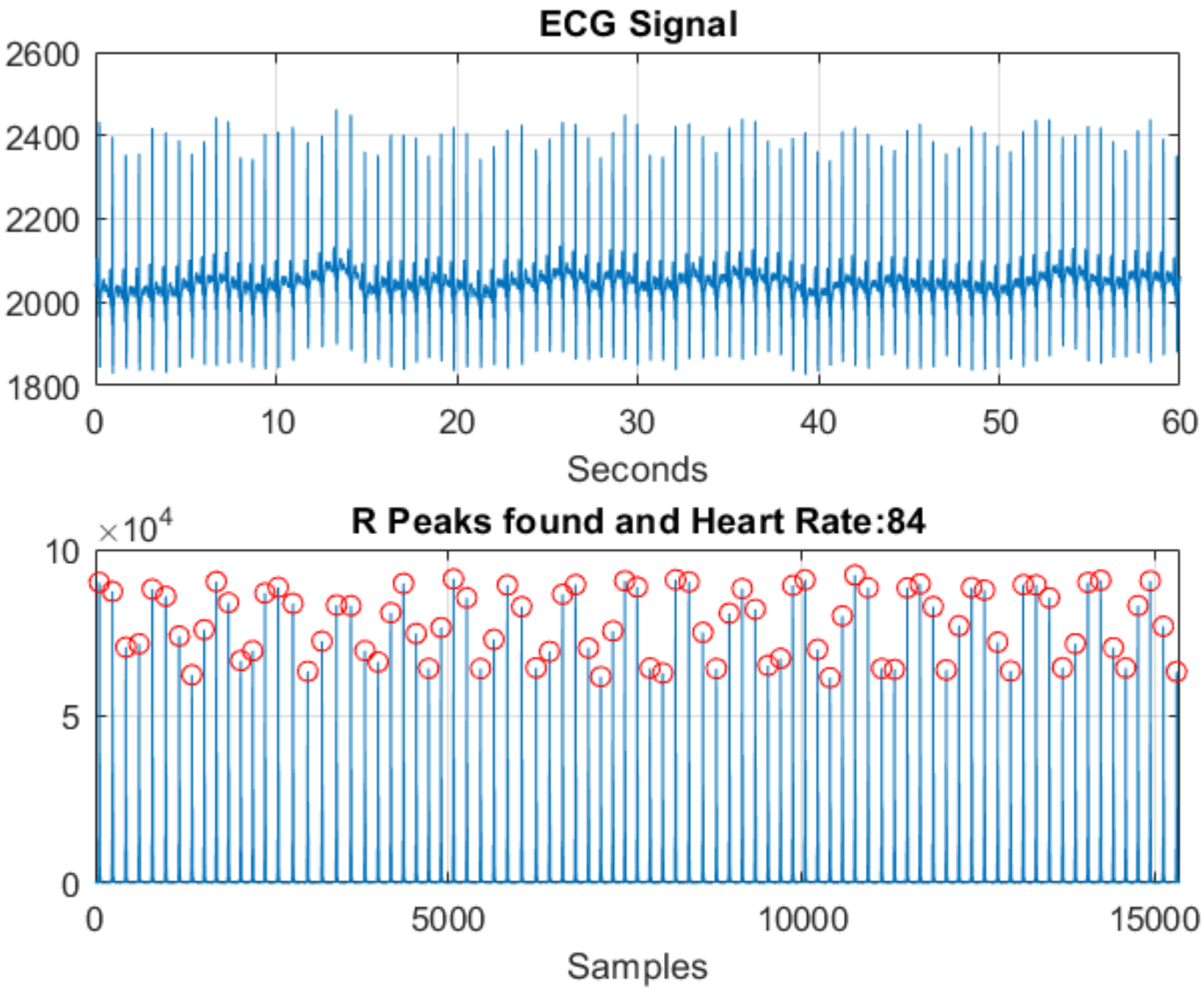
- Sym4
- 4 level decomposition

$$s = a_4 + d_4 + d_3 + d_2 + d_1$$

- Eliminating the approximate and HF components of the signal
- Taking inverse wavelet decomposition with the coefficients $d_3$ and $d_4$
- Squaring the resultant signal
- Finding R-peaks

```
findpeaks(signal,timescale,
   'MinPeakHeight',8*avg,
   'MinPeakDistance',50);
```


Decomposition at level 4 : s = a4 + d4 + d3 + d2 + d1
s
a4
d4
d3
d2
d1
2400
2200
2000
2150
2100
2050
2000
1950
200
100
0
-100
-200
200
0
-200
100
0
-100
20
0
-20
2000
4000
6000
8000
10000
12000
14000


ECG Signal
2600
2400
2200
2000
1800
0
10
20
30
40
50
60
Seconds
R Peaks found and Heart Rate:84
×10^4
10
5
0
0
5000
10000
15000
Samples

# FEATURE EXTRACTION

Time domain features

- BPM
- SDRR
- RMSRR
- RR50
- pRR50
- Mean IBI
- Min IBI
- Max IBI

Frequency domain features

- LF power
- HF power
- LF/HF ratio
- Total power
- LF percentage
- HF percentage

Poincare map

- SD1
- SD2

| Variable | Description |
|---|---|
| Statistical measures | |
| Mean and STD RR (s) | Mean and standard deviation of the selected RR interval series |
| Mean and STD HR (1/min) | Mean and standard deviation of the selected heart rate series |
| RMSSD (ms) | The root mean square of differences of successive RR intervals |
| NN50 (count) | Number of consecutive RR intervals that differ more than 50 ms |
| pNN50 (%) | The percentage value of consecutive RR intervals that differ more than 50 ms |
| Geometric measures | |
| RR triangular index | The integral of the RR interval histogram divided by the maximum of the histogram |
| TINN (ms) | Baseline width of the RR interval histogram |
| Nonlinear measures (Poincaré plot) | |
| SD1 (ms) | The standard deviation of the Poincaré plot perpendicular to the line-of-identity |
| SD2 (ms) | The standard deviation of the Poincaré plot along the line-of-identity |
| Spectral measures (parametric and nonparametric) | |
| Peak frequency (Hz) | Peak frequencies of the power spectral density estimate for VLF, LF, and HF frequency bands |
| Power ($ms^2$, %, and n.u.) | The powers for VLF, LF, and HF frequency bands in $ms^2$ and in percentage value. For LF and HF bands the power is also represented in normalized units (n.u.). |
| LF/HF (%) | Ratio of LF and HF frequency band powers in ($ms^2$) |

The parameters are divided into statistical, geometric, nonlinear, and spectral measures. A short description is given about each of the parameters.

MATLAB R2017b - academic use

HOME | PLOTS | APPS | SHORTCUTS | EDITOR | PUBLISH | VIEW

Search Documentation | Deepchand

New | Open | Save | Find Files | Compare | Print | Go To | Find | Insert | Comment | Indent | Breakpoints | Run Section | Advance | Time

Pause the currently executing code and enter debug mode (Ctrl+F5)

FILE | NAVIGATE | EDIT | BREAKPOINTS | RUN

E: ▸ Resources ▸ Prosthetic arm ▸ Emotion detection ▸ ECG ▸ resources ▸ scripts

Current Folder

| Name | Git |
|---|---|
| affective_dimensional_model.mlx | |
| ECG.m | |
| ECG_emotion_detection.m | |
| Extracted_features414x17x2.mat | |
| Feature_extracter.m | |
| FFT_ECG.fig | |
| find_heartbeat.m | |
| only_for_testing.m | |
| plot_ADM.m | |
| plotATM.m | |
| R_Peaks_Detection.m | |
| rec_1m.info | |
| rec_1m.mat | |
| ROI_FFT.fig | |
| scratch.m | |
| Time_Domain_Signal.fig | |
| Untitled.m | |

Feature_extracter.m (Class)

General

- name
- General Calculation
- Feature_extracter(ECGSignal, SamplingFrequency, N...
- init(obj, varargin)
- resample(obj, FsR, varargin)
- trim(obj, range, varargin)

Editor - E:\Resources\Prosthetic arm\Emotion detection\ECG\resources\scripts\ECG_emotion_detection.m

ECG_emotion_detection.m

```
1 -   tStart=tic;
2
3 -   fprintf("Loading the dataset...\n");
4 -   if ~exist('DREAMER','var')
5 -       load("C:\Users\user\Documents\MATLAB\DREAMER.mat");
6 -   end
7 -   fprintf("Dataset got loaded\n");
8
9 -   stimuli_features=[];
10 -  baseline_features=[];
11
12 -  Fs=DREAMER.ECG_SamplingRate;
13 -  samples_per_min=Fs*60;
14
15 -  total_person=length(DREAMER.Data);
16 -  total_stimuli=length(DREAMER.Data{1, 1}.ECG.stimuli);
17 -  total_baseline=length(DREAMER.Data{1, 1}.ECG.baseline);
18 -  total_channel=size(DREAMER.Data{1, 1}.ECG.stimuli{1,1},2);
```

Command Window

New to MATLAB? See resources for Getting Started.

```
Dataset got loaded
Extracting Features from person 1 ...
Extracted from stimulus 1   2   3   4   5   6   7   8   9   10  11  12  13  14  15  16  17  18
Extracted from baseline 1   2   3   4   5   6   7   8   9   10  11  12  13  14  15  16  17  18
Extracted from person 1
Elapsed time is 69.029279 seconds.
================================================================================================
Extracting Features from person 2 ...
Extracted from stimulus 1   2   3   4
```

Workspace

| Name | Value |
|---|---|

Busy | script | Ln 14 | Col 1

stimuli_features

PLOTS | VARIABLE | VIEW

New from Selection | Open | Print | Rows | Columns | Insert | Delete | Transpose | Sort

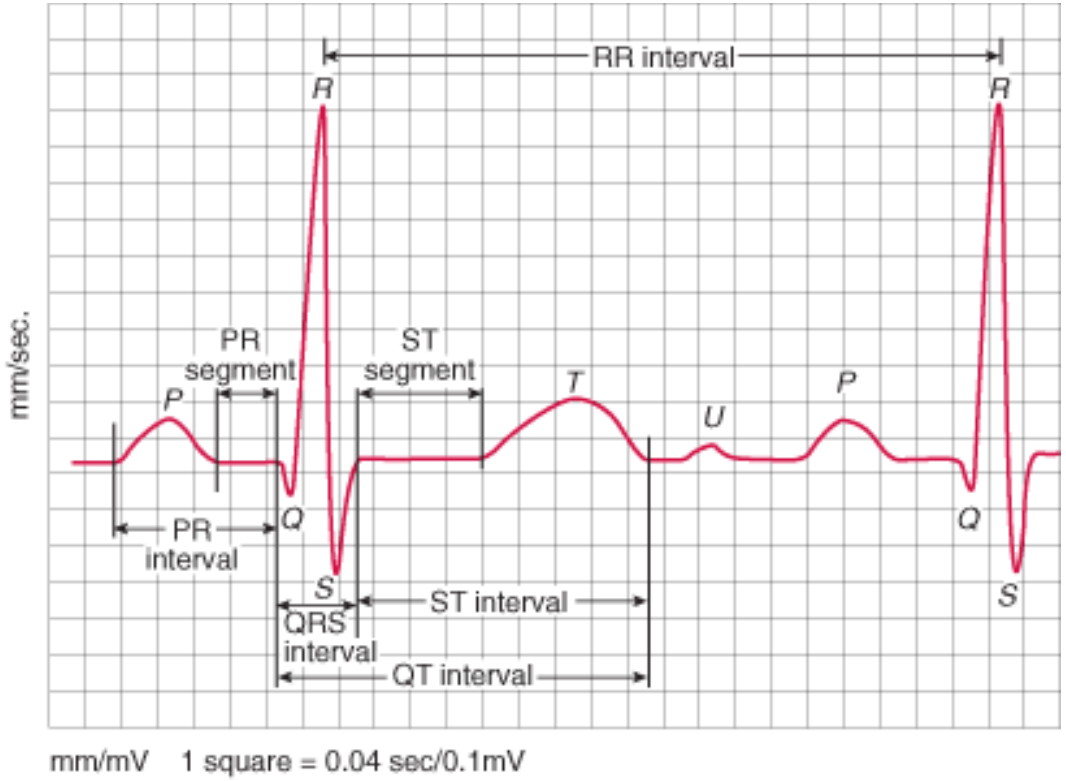
VARIABLE | SELECTION | EDIT

414x17x2 double

```
val(:,:,1) =

   1.0e+03 *

  Columns 1 through 10

    0.0336    0.0839    0.0320    0.0213    0.0030    0.0037    0.7154    0.7969    0.6641    0.0214
    0.0328    0.0811    0.0295    0.0227    0.0010    0.0013    0.7402    0.8086    0.6680    0.0228
    0.0402    0.1023    0.1756    0.1575    0.0290    0.0287    0.5866    0.8828    0.4023    0.1582
    0.0406    0.1042    0.1826    0.1662    0.0200    0.0196    0.5757    0.8398    0.4023    0.1670
    0.0320    0.0812    0.0284    0.0229    0.0040    0.0051    0.7388    0.8125    0.6953    0.0230
    0.0340    0.0834    0.0738    0.0222    0.0040    0.0051    0.7190    0.8477    0.5625    0.0223
    0.0430    0.1101    0.1837    0.1556    0.0200    0.0185    0.5450    0.8867    0.4023    0.1563
    0.0344    0.0876    0.1458    0.1203    0.0130    0.0151    0.6849    0.8086    0.4023    0.1209
    0.0313    0.0796    0.0245    0.0160         0         0    0.7534    0.8047    0.6992    0.0161
    0.0340    0.0874    0.1783    0.1858    0.0240    0.0282    0.6861    1.0352    0.4023    0.1869
    0.0367    0.0941    0.1899    0.1895    0.0240    0.0264    0.6374    1.0078    0.4023    0.1905
    0.0430    0.1101    0.1872    0.1597    0.0280    0.0259    0.5452    0.9063    0.4023    0.1604
    0.0418    0.1075    0.1815    0.1687    0.0250    0.0240    0.5579    0.8594    0.4023    0.1695
    0.0426    0.1099    0.1954    0.1571    0.0200    0.0189    0.5461    0.9375    0.4023    0.1578
    0.0437    0.1116    0.1860    0.1964    0.0260    0.0236    0.5374    0.8516    0.4023    0.1973
    0.0316    0.0799    0.0328    0.0239    0.0050    0.0065    0.7508    0.8438    0.6797    0.0240
    0.0332    0.0828    0.0464    0.0490    0.0060    0.0077    0.7250    0.8320    0.5508    0.0492
    0.0363    0.0940    0.2070    0.1986    0.0300    0.0337    0.6381    0.9141    0.4023    0.1997
    0.0328    0.0808    0.0505    0.0387    0.0180    0.0237    0.7424    0.8828    0.6484    0.0389
    0.0320    0.0787    0.0456    0.0430    0.0180    0.0243    0.7624    0.9141    0.6797    0.0433
    0.0344    0.0881    0.1654    0.1434    0.0330    0.0388    0.6814    1.0156    0.4063    0.1441
    0.0336    0.0814    0.0705    0.0648    0.0220    0.0297    0.7373    0.8984    0.4609    0.0652
    0.0344    0.0862    0.0692    0.0517    0.0170    0.0213    0.6957    0.8438    0.5391    0.0520
    0.0352    0.0878    0.1252    0.1251    0.0330    0.0393    0.6835    0.9023    0.4063    0.1257
    0.0328    0.0810    0.0513    0.0447    0.0160    0.0211    0.7403    0.8867    0.5586    0.0449
    0.0340    0.0867    0.1495    0.1438    0.0300    0.0353    0.6917    0.9141    0.4023    0.1446
```

# FEATURES TO BE EXTRACTED FURTHER

- P peak
- Q peak
- S peak
- T peak
- PR interval
- QRS interval
- ST interval
- QT interval
- PR segment
- ST segment
- and spectral features



THANK YOU