– HRVTool$_{1.04}$ –

An Open-Source Matlab Toolbox for Analyzing Heart Rate Variability

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Matlab Class

1. Available at **github.com/MarcusVollmer/HRV**
2. **Open Source** (MIT License) – free modification, transparent code
3. Programmed for **continuous calculation in sliding windows**

```
% Example:  HRV analysis of data from PhysioNet.
  % Load annotation file from the MIT-BIH Arrhythmia Database.
    Ann = rdann('mitdb/100','atr');
    Fs  = 250;
    Ann = Ann/Fs;
    RR  = [NaN; diff(Ann)];

% The RR tachogram shows obvious artifacts:
  plot(Ann, RR)

% Filter from artifacts and plot the average heart rate:
  RRraw = RR;
  RR = HRV.RRfilter(RR, 0.15);
  plot(Ann, RR)

% Plot the average heart rate:
  plot(Ann, HRV.HR(RRraw, 60)); hold on;
  plot(Ann, HRV.HR(RR, 60))

% Corresponding relative RR intervals:
  rr = HRV.rrx(RR);
  figure
  plot(Ann, rr)

% Compute certain HRV measures for continuously for 60
   successive RR intervals:
  rmssd = HRV.RMSSD(RR, 60);
  rrhrv = HRV.rrHRV(RR, 60);
  plotyy(Ann, rmssd, Ann, rrhrv)
```

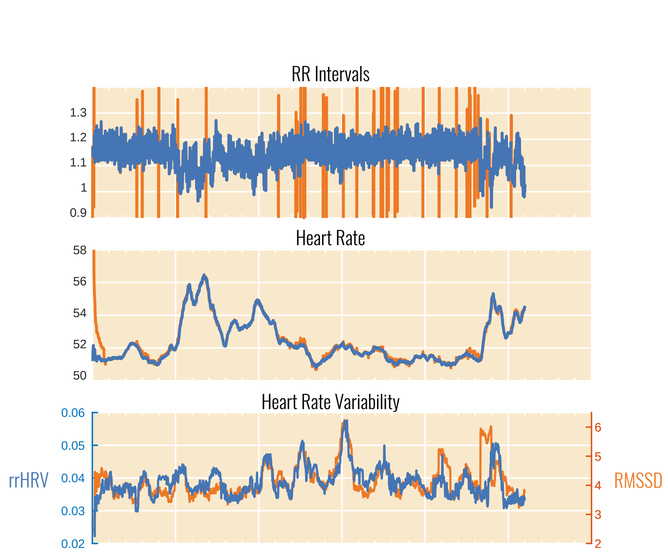
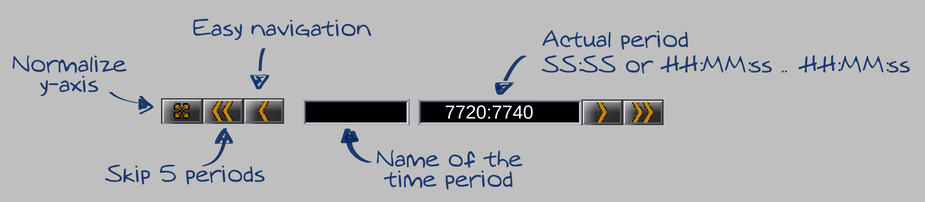


Table 1: Table of available methods in HRV.m

Name	Description
SDSD	Standard deviation of successive differences
SDNN	Standard deviation of NN intervals
RMSSD	Root mean square of successive differences
pNNx	Probability of intervals greater x ms or smaller $-x$ ms
pNN50	Probability of intervals greater 50 ms or smaller −50 ms
triangular_val	Compute Triangular Index and TINN
TRI	Triangular index from the interval histogram
TINN	TINN, performing Triangular Interpolation
DFA	Detrended Fluctuation Analysis
CD	Correlation Dimension
ApEn	Approximate Entropy
fft_val_fun	Spectral analysis of an IBI sequence (LF,HF,ratio)
fft_val	Continuous spectral analysis in a windowed approach (LF,HF,ratio)
returnmap_val	Results of the Poincaré plot (SD1,SD2,ratio)
HR	Average heart rate
rrx	Relative RR intervals
rrHRV	HRV based on relative RR intervals
RRfilter	Remove artifacts from RR sequences using rrx
pattern	Recognition of patterns and regularities in data

Intuitive User Interface

1. Available at **marcusvollmer.github.io/HRV/** or MatlabCentral
2. **Open Source** (MIT License) – free modification, transparent code
3. **Hard-coded** (no use of GUIDE/App Designer)
4. **No additional toolboxes required**
   Signal Processing Toolbox recommended



Batch Processing

```
% Set the path to your working directory
  path = 'C:\Users\yourpath';
% Set your output file
  outputfile = 'results.xlsx';

% Settings for automated beat detection
  load('qrs_settings.mat')
  s = 1;    % s=1 for human ECG settings
  Fs = 256; % Set your sampling frequency
  Beat_min = qrs_settings.Beat_min(s);
  Beat_max = qrs_settings.Beat_max(s);
  wl_tma = ceil(qrs_settings.wl_tma(s)*Fs);
  wl_we  = ceil(qrs_settings.wl_we(s,:).*Fs);
```

```
for id = 1:n  % Loop recordings
  % Import ECG - use an appropriate import function
    sig_waveform = loadwaveform(id);

  % Heart beat detection
    Ann = singleqrs(sig_waveform, Fs, 'downsampling',
      d_fs, 'Beat_min',Beat_min, 'Beat_max',Beat_max,
      'wl_tma',wl_tma, 'wl_we',wl_we);
    Ann = Ann/Fs;

  % RR intervals and filtering of artifacts
    RR = diff(Ann);
    RR_filt = HRV.RRfilter(RR,20);
```

```
  % Computation of local HRV measures
    RR_loc = RR_filt;

    rrHRV_loc = HRV.rrHRV(RR_loc,0);
    SDNN_loc  = HRV.SDNN( RR_loc,0) * 1000;
    RMSSD_loc = HRV.RMSSD(RR_loc,0) * 1000;
    pNN50_loc = HRV.pNN50(RR_loc,0) * 100;
    HR_loc    = HRV.HR(   RR_loc,0);

  % Save results in an Excel spreadsheet
    Column = calc_xls_idx(1+2);
    xlRange_HR    = ([Column num2str(id+3)]);
    xlRange_SDNN  = ([Column num2str(id+4)]);
    xlRange_RMSSD = ([Column num2str(id+5)]);
```

```
    xlRange_pNN50 = ([Column num2str(id+6)]);
    xlRange_rrHRV = ([Column num2str(id+7)]);
    xlswrite([path filesep outputfile], rrHRV_loc,
      [xlRange_rrHRV ':' xlRange_rrHRV]);
    xlswrite([path filesep outputfile], SDNN_loc,
      [xlRange_SDNN  ':' xlRange_SDNN]);
    xlswrite([path filesep outputfile], RMSSD_loc,
      [xlRange_RMSSD ':' xlRange_RMSSD]);
    xlswrite([path filesep outputfile], pNN50_loc,
      [xlRange_pNN50 ':' xlRange_pNN50]);
    xlswrite([path filesep outputfile], HR_loc,
      [xlRange_HR    ':' xlRange_HR]);

end
```

Universitätsmedizin Greifswald

'Mockup .- Macbook Pro (15.4 inch)' by Tomasz Mikrut
www.behance.net/tomaszmikrut

MarcusVollmer.github.io

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