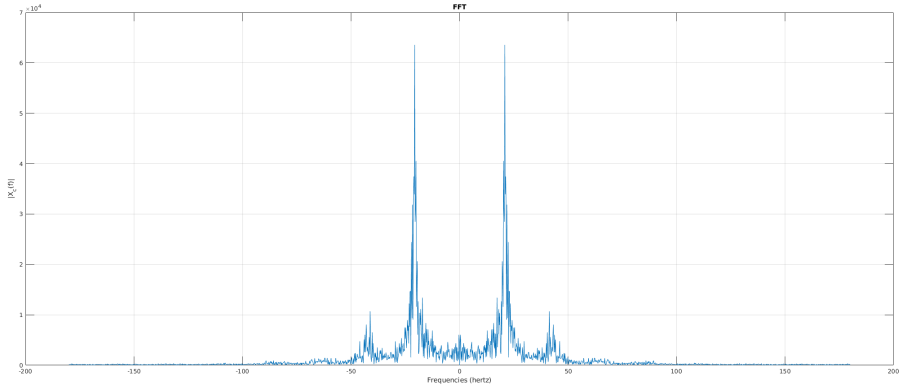
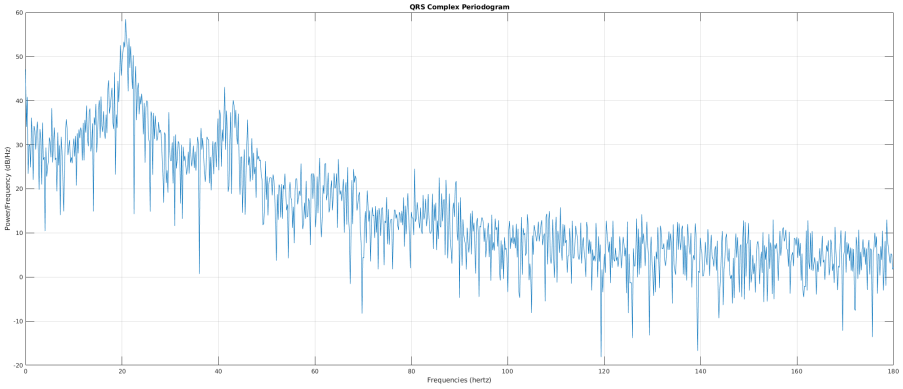
```
clear all; close all; clc;

% ECG Signals
% ecg_signals_path = '~/Dropbox/
processamento_sinais_biologicos_02_2019/programas_sinais_exemplos/
sinais_ecg/';
ecg_signals_path = './';
signalfield_name = 'x';

% Load Signals
[ecg_signals, fs] = loadmat_signals(ecg_signals_path,
 signalfield_name);
ecg = ecg_signals{1}(:,1); % multi-channel signal

% Perform R-Wave Detection
[qrs_i_raw, qrs_amp_raw] = rwave_detect(ecg, fs, 1.3);

% Segment QRS Complex in order to find Q and S
PR_len = round(0.12 * fs);
RT_len = round(0.28 * fs);
ecg_seg = zeros(PR_len + RT_len + 1, length(qrs_i_raw));
qrs_seg = [];
q_i = zeros(1, length(qrs_i_raw));
r_i = zeros(1, length(qrs_i_raw));
for s = 1:length(qrs_i_raw)
 ecg_seg(:,s) = -ecg(qrs_i_raw(s)-PR_len : qrs_i_raw(s)+RT_len);
 [~,locs] = findpeaks(ecg_seg(:,s));
 tmp_q = locs(locs < PR_len);
 tmp_r = locs(locs > PR_len);
 q_i(s) = qrs_i_raw(s) - PR_len + tmp_q(end);
 r_i(s) = qrs_i_raw(s) - PR_len + tmp_r(1);
 qrs_seg = [qrs_seg; ecg(q_i(s) : r_i(s))];
end

% Plot FFT
figure('units','normalized','outerposition',[0 0 1 1]);
X = fft(qrs_seg - mean(qrs_seg));
plot(linspace(-fs/2, fs/2, length(X)), fftshift(abs(X)));
title('FFT');
xlabel('Frequencies (hertz)');
ylabel('|X_c(f)|');
grid on;

% Plot Periodogram
figure('units','normalized','outerposition',[0 0 1 1]);
pxx = periodogram(qrs_seg);
plot(linspace(0, fs/2, length(pxx)),10*log10(pxx));
hold on;
title('QRS Complex Periodogram');
xlabel('Frequencies (hertz)');
ylabel('Power/Frequency (dB/Hz)');
grid on;
```

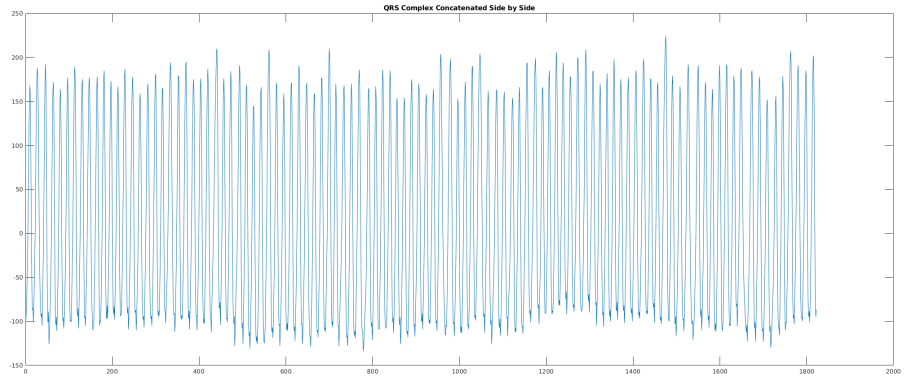
```
% Plot Results
figure('units','normalized','outerposition',[0 0 1 1]);
plot(qrs_seg);
title('QRS Complex Concatenated Side by Side');
figure('units','normalized','outerposition',[0 0 1 1]);
plot(ecg);
title('Annotated ECG Signal');
hold on;
stem(qrs_i_raw, qrs_amp_raw, 'LineStyle', 'none');
stem(q_i, ecg(q_i), 'LineStyle', 'none');
stem(r_i, ecg(r_i), 'LineStyle', 'none');
hold off;
```

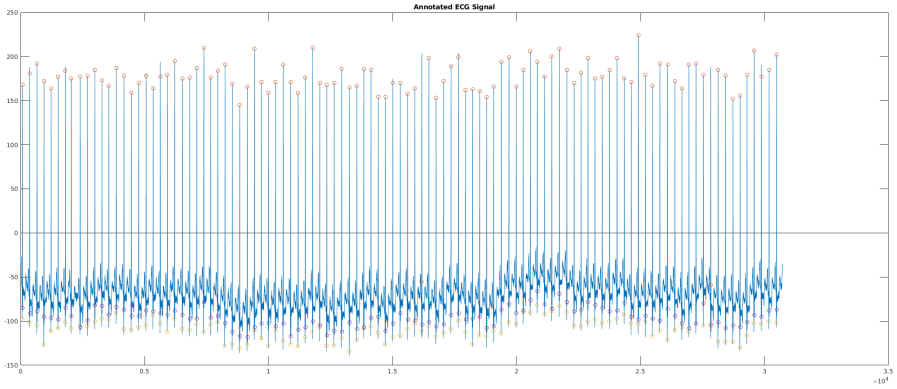
load_signals: Load .mat signals in a given folder path

```
function [signals, fs] = loadmat_signals(s_path, s_fieldname)
% Load signals into a cell array
 signals = {};
 dir_files = dir(s_path);
 for f = 1:length(dir_files)
  if contains(dir_files(f).name, '.mat')
   MAT = load([s_path dir_files(f).name]);
   signals{end+1} = MAT.(s_fieldname);

   % Check for sampling frequency
   try
    fs = MAT.fs;
   catch ME
    switch ME.identifier
     case 'MATLAB:nonExistentField'
      if ~exist('fs', 'var')
       fs = [];
      end
     otherwise
      rethrow(ME);
    end
   end
  end
 end
 if isempty(fs)
  warning('Sampling Frequency (fs) is empty in MAT files!');
 end
end
```


FFT
×10^4
7
6
5
4
3
2
1
0
|X_c(f)|
-200
-150
-100
-50
0
50
100
150
200
Frequencies (hertz)


QRS Complex Periodogram
60
50
40
30
20
10
0
-10
-20
Power/Frequency (dB/Hz)
0
20
40
60
80
100
120
140
160
180
Frequencies (hertz)


QRS Complex Concatenated Side by Side
250
200
150
100
50
0
-50
-100
-150
0
200
400
600
800
1000
1200
1400
1600
1800
2000



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