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Project Report On

Electrocardiograms QRS Peak and Heart Rate Detection Using DWT.

Submitted by

1. Mitu Rani Kundu (190601)

2. Md. Rahatul Rabbi (190609)

3. Shahanur Rahman (190617)

4. Md. Rakibuzzaman (190626)

5. Md. Mehedi Hasan (190634)

Dept. of ICE,PUST

Submitted to

Dr. Md. Imran Hossain

Associate Professor

Dept. of Information and Communication Engineering

Pabna University of Science and Technology

Pabna-6600, Bangladesh.

Project Name: Electrocardiograms QRS Peak and Heart Rate detection Using DWT

Objective: Here we will look at how to obtain the peak and rate of detection of these ECGs using the ECG database.

Theory:

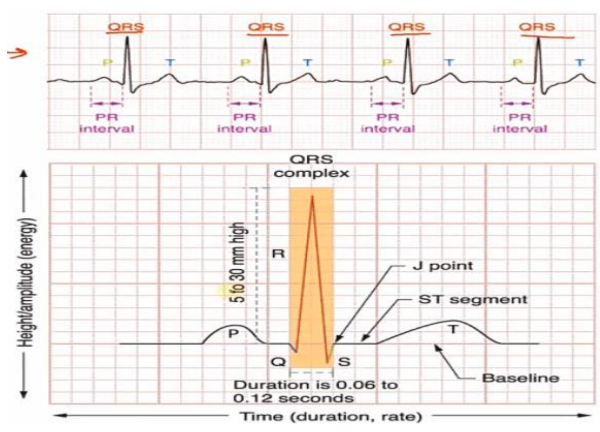
- The QRS combines three deflections (Q, R, and S) seen on a typical ECG. It corresponds to the depolarization of the right and left ventricles of the human heart and contraction of the large ventricular muscles.

- In numerical and functional analysis, a discrete wavelet transform (DWT) is any wavelet transform in which the wavelets are discretely sampled.

- The sym4 wavelet resembles the QRS, suitable for QRS detection. Therefore, this process can help to diagnose various heart diseases.

The QRS complex: It is a combination of three deflections (Q, R, and S) seen on a typical ECG signal.

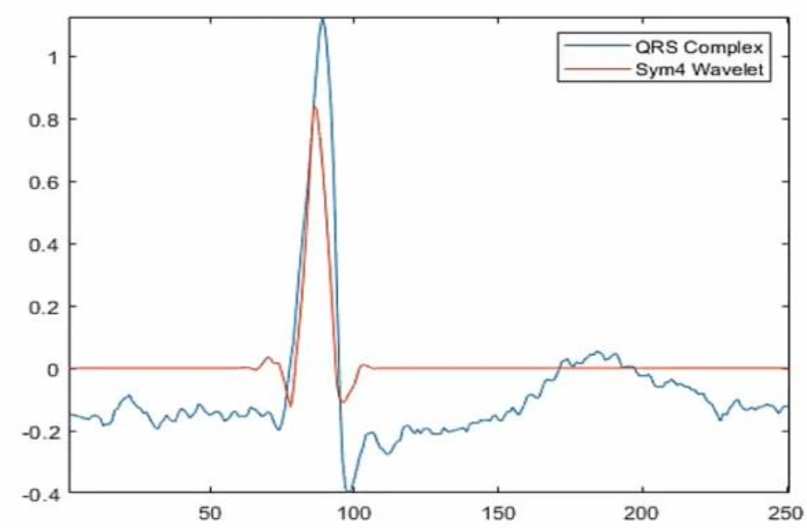
Here P is the first deflection.
Q is the first negative deflection to the baseline.
R is the highest positive deflection to the baseline.
S the second negative deflection to the baseline.



The amplitude of a normal QRS is 5 to 30mm, and the duration is 0.06 to 0.12 seconds. The width, amplitude, and shape of the QRS complex help diagnose ventricular arrhythmias, conduction abnormalities, ventricular hypertrophy, myocardial infarction, electrolyte rearrangements, and other diseases state.

Use of symlet4 wavelet for ECG signal Analysis:

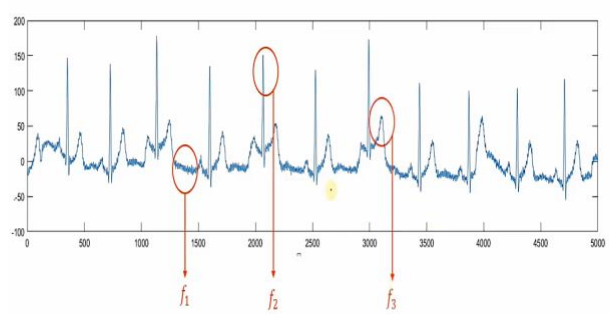
The sym4 wavelet is similar to the QRS complex. That is why it's preferred for QRS detection. To make this clear, here in the image of extracted QRS complex and dilated sym4 wavelet comparison.



Here we can see that QRS complex of the ECG is quite similar to the sym4 wavelet in shape. That's why sym4 wavelets are always preferred for the ECG signal analysis.

Proposed DWT based QRS detection:

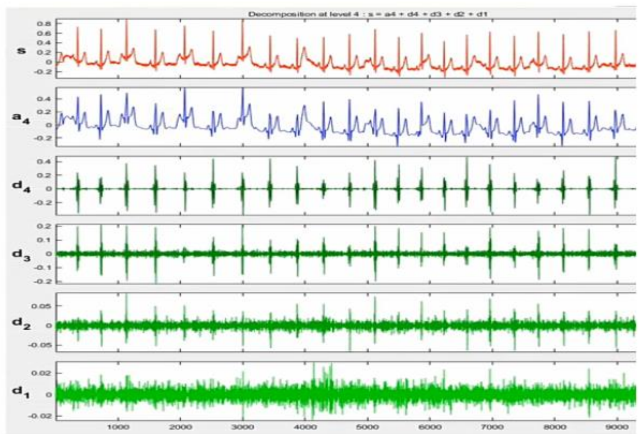
Below are the essential ecg signals, and if we look at them carefully, we can locate the labeled areas with a particular frequency contribution.



Here,
f1: Represents the high-frequency noise and has some frequency f1.
f2: It is the QRS that has the frequency contribution of f2.
f3: Slow varying content of the ecg and have a frequency contribution f3.

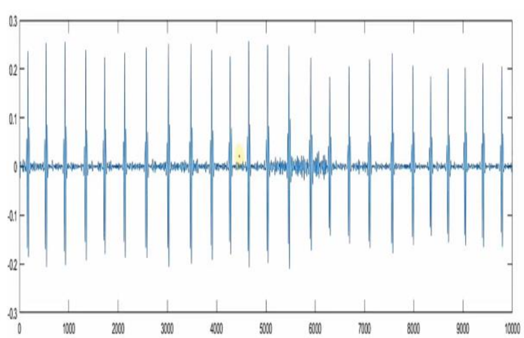
The relationship between these three frequencies will be f1>f2>f3.
Our objective to preserve all the R-peaks and eliminate all the other frequencies. To make it clear, we say that we want to eliminate f1 and f3 but preserve f2.

This is known as band pass filtering. We can achieve it with the help of the wavelet transform. Wavelet transforms groups signals of the same frequency bands. Therefore, we can implement band pass filtering by eliminating some frequency bands. A 4-level decomposition of an ecg signal using sym4 is shown in the figure below:



- ➢ The first plot is the ecg signal. The d's are the detailed coefficients at every level of the ecg signal. a_4 is the approximate coefficients at level 4.
- ➢ We will obtain the band pass filtering by removing the co-efficient a4 since it will not be considered—similarly, we eliminated1 and d2.
- ➢ The reason why we don't consider it is because it is an approximated coefficient. It carries all the low-frequency details. d_1 and d_2 are not considered because they contain details of the signal's high frequency. d_2 and d_4 are considered to reconstruct or achieve the signal the band pass is filtering.

We get the following signals by considering only d_3 and d_4 and taking the inverse wavelet transform.



With the help of a standard peak detection algorithm, we can locate these R-peaks. Also, you find the number of total R-peaks for a given time interval to find the heart rate.

MATLAB Code:

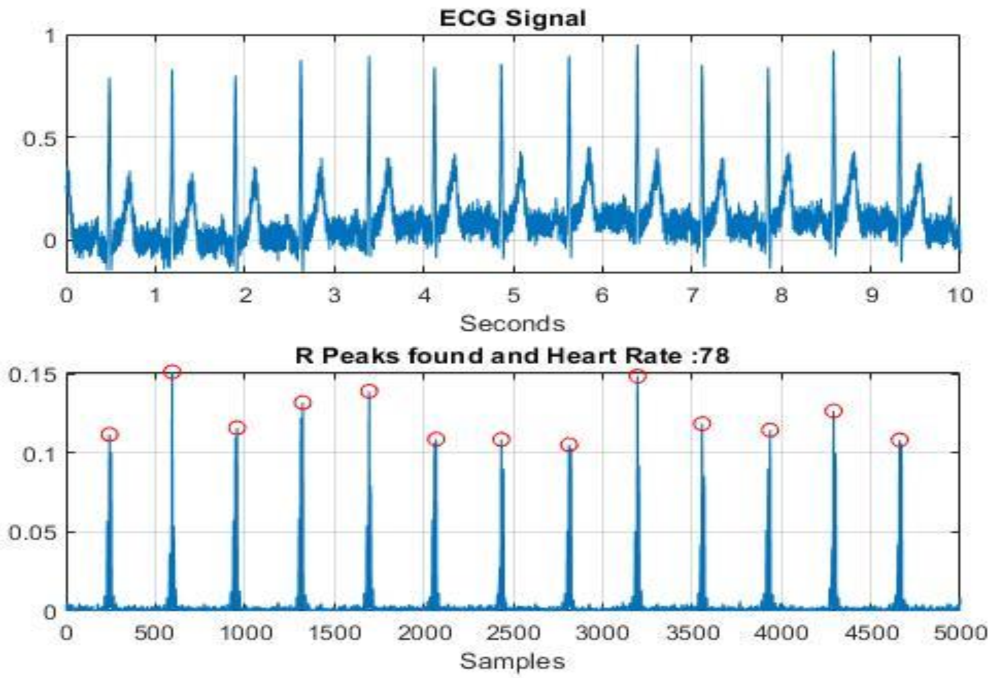
```
%program to get QRS Peaks and Heart Rate from ECG signal
[filename,pathname]=uigetfile('*.*','Select the ECG Signal');
filewithpath=strcat(pathname,filename);
Fs=input('Enter Sampling Rate : ');
ecg=load(filename);%Reading ECG signal
ecgsig=(ecg.val)./200;%Normalize gain
t=1:length(ecgsig);%No of samples
tx=t./Fs;%Getting Time Vector
wt=modwt(ecgsig,4,'sym4');%4-level undecimated DWT using sym4
wtrec=zeros(size(wt));
wtrec(3:4,:)=wt(3:4,:);%Extracting only d3 and d4 coefficients

y=imodwt(wtrec,'sym4');%IDWT with only d3 annd d4
y=abs(y).^2;%Magnitude square
avg=mean(y);%Getting average of y^2 as threshold
%Finding Peaks
[Rpeaks,locs]=findpeaks(y,t,'MinpeakHeight',8*avg,'MinPeakDistance',50);
nohb=length(locs);%No of beats
timelimit=length(ecgsig)/Fs;
hbpermin=(nohb*60)/timelimit;%Getting BPM
disp(strcat('Heart Rate = ',num2str(hbpermin)))
subplot(211)
plot(tx,ecgsig);

xlim([0,timelimit]);
grid on;
xlabel('Seconds')
title('ECG Signal')

subplot(212)
plot(t,y)
grid on;
xlim([0,length(ecgsig)]);
hold on
plot(locs,Rpeaks,'ro')
xlabel('Samples')
title(strcat('R Peaks found and HeartRate: ',num2str(hbpermin)))
```

Output:



Result and Discussion :

In ECG signals if we look at them carefully, we can locate the labeled areas with a particular frequency contribution. Some represents the high-frequency noise and has some frequency, say f1. Some is the QRS that has the frequency contribution of f2. And slow varying content of the ECG and have a frequency contribution f3. Here we preserve all the R-peaks and eliminate all the other frequencies. To make it clear, we say that we want to eliminate f1 and f3 but preserve f2. This is known as band pass filtering. We achieve it with the help of the wavelet transform. Wavelet transforms group's signals of the same frequency bands. Therefore, we can implement band pass filtering by eliminating some frequency bands.

While we run the code it asked us to enter sampling rate and select ECG signal. We choose rec_5m this time and choose sampling frequency 500. And we can see the result in the output. It shows us QRS peak and heart rate.