SCHOOL OF ELECTRONICS AND COMMUNICATION ENGINEERING (SENSE)

PROJECT REPORT DIGITAL SIGNAL PROCESSING ECE2006

Aim of Our Project:

- IMPLEMENTATION OF PAN THOMPKINS ALGORITHM
- Heart Rate Counting and hence detecting any abnormality in the patient using r-peak detection of two ECG samples,

Team Members

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done under the guidance of **PROF. SARANYA K.C**

OCTOBER 2019

CERTIFICATE

This is to certify that the project work entitled “Heart Rate Counting and hence detecting any abnormality in the patient using r-peak detection of two ECG samples” submitted by “BHAVYA CHHABRA, SHUBHRA DOLAWAT AND PRUTHVESH DESAI” for DIGITAL SIGNAL PROCESSING, ECE2006 is a record of bonafide work done under my supervision. The contents of this Project work, in full or in parts, have neither been taken from any other source nor have been submitted for any other CAL course.

Place: Vellore
Date: 5. 11. 2019

Signature of Students

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Signature of Faculty

PROF.SARANYA KC

ACKNOWLEDGEMENT

We are very grateful to VIT UNIVERSITY for providing us such a golden opportunity to perform our project „HEART RATE COUNTING AND HENCE DETECTING ANY ABNORMALITY IN THE PATIENT USING R-PEAK DETECTION OF TWO ECG SAMPLES". We are thankful to various websites for helping us for our progress in project.

We extend our sincere thanks to Prof. Saranya KC for providing us with the guidance and facilities for the project.

We express our sincere gratitude to the digital signal processing lab in charge, for his cooperation and guidance for preparing and presenting this project.

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ABSTRACT

In recent years, electro diagram (ECG) has been used as main method for the diagnosis of heart diseases. The purpose of this study is to implement pan and Thompkins algorithm for measuring QRS complex and hence measuring R-peaks .. This program can also be used in education for physicians.

In this project, peak classification approach is used in ECG signal for determining various diseases. As known the amplitudes and duration values of P-Q-R-S-T peaks determine the functioning of heart of human. Therefore duration and amplitude of all peaks are found. R-R and P-R intervals are calculated. Finally, we have obtained the necessary information for disease detection.

This project is implemented by using MATLAB software. An interface was created to easily select and process the signal. “.mat” format is used the for ECG signal data. We have detected bradycardia and tachycardia.

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INTRODUCTION

- **General overview:**

The population increases day by day. Therefore, people do not get enough benefit from health services. It is impossible for patients to be kept under the supervision of a physician at all times. Speed and time are very important for physicians. This project is intended to help doctors to analyse the ECG signal. Doctors will save time thanks to program. This program can also be used for education for.

- **The Electrocardiogram:**

Open and see method were used for diseases of internal organs by physician. It meant that people were always suffering. This was also a very difficult situation for both physicians and patients. Technology has improved. Now doctors use non- invasive methods. For example, urine and blood tests. Various signals are taken from the organs in the human body. The information generated by these signals is in this group. For example, EEG (electrical activity of the brain, electroencephalogram), EMG (electrical activity of muscles, electromyogram) and ECG. ECG signal analysis was performed in this project. Detailed information about this signal is given below.
The electrical current is spread through the body when the heart undergoes depolarization (The electrical activation of the tissues is positive) repolarization (The discharge of electrical charge of the tissues). This electrical activity generated by heart. It can be measured by an array of electrodes placed on the body surface. These records are called electrocardiograms (ECG or EKG).
Over the past few years, there has been an increased trend toward processing of the electrocardiogram (ECG) using microcomputers. A survey of literature in this reach area indicates that system based on microcomputers can perform needed medical services in extremely efficient manner.

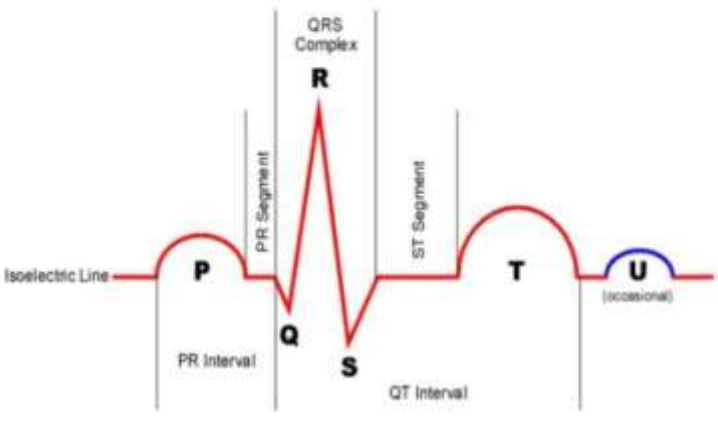
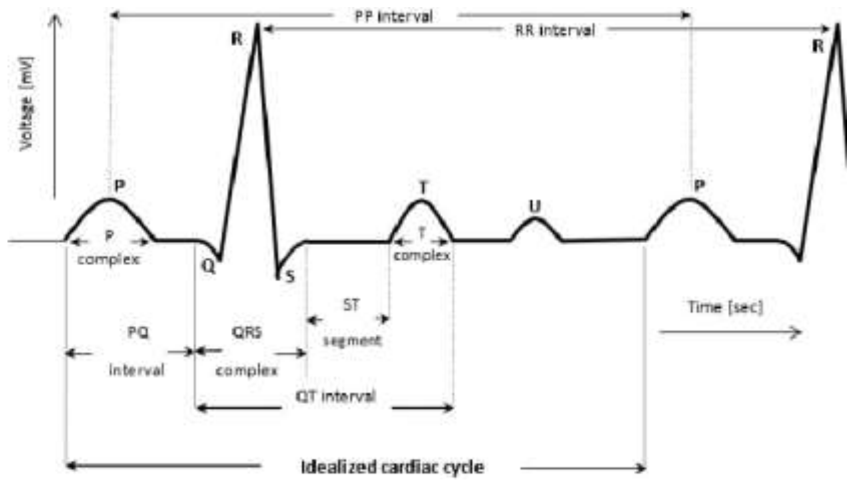


Figure 1: Represents a typical ECG waves. [2]



The heart beat period of time curve (typical ECG waveforms) is examined in figure 1. There is a sharpness in the figure. Periodic sharpness can be seen in figure 2. This sharpness associated with the contraction of the ventricular. These are called "depolarization". Muscle fibres lost resting potential during depolarization. Signal prepared to go slightly negative deviation as a rule, it continues with a big positive taper. Followed by a second negative deviation income. The contraction of the ventricles is called "QRS complex". An oscillation is seen after QRS complex. This oscillation also is called ST range or ST wave. Now the potential difference is immeasurable. A zero line is drawn at this time is called the isoelectronic line. This is followed by T- wave (representing the depolarization). The P wave indicates that they are in the excited state to the atrium. Finally, U waves is not always seen. It is typically small. U waves are thought to represent repolarization of the papillary muscles. An ECG signal can be examined in figure 2 (this is a theoretical signal. The actual ECG signal is not as smooth as this signal).

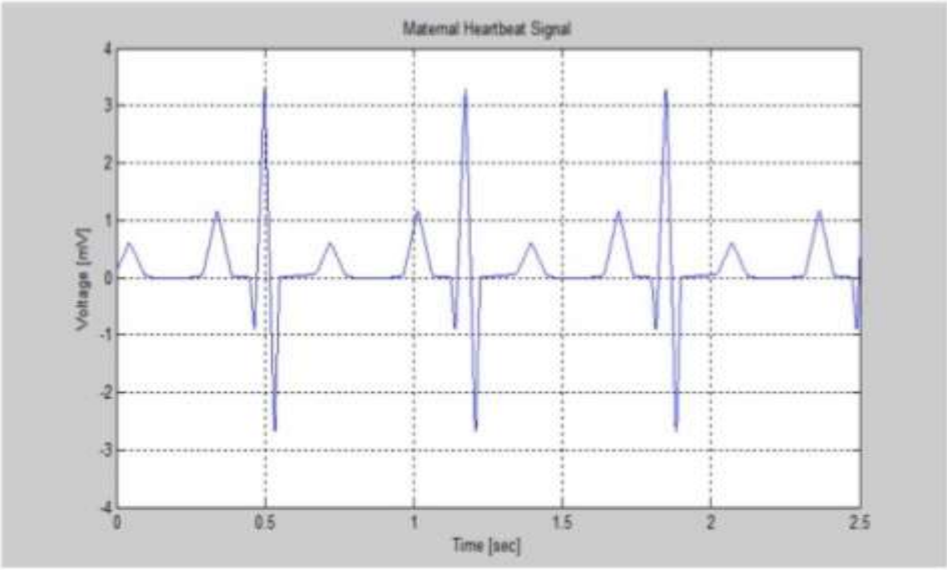


Figure 2 . Shapes of the electrocardiogram : signal heart might produce assuming a 4000 Hz sampling rate. The heart rate for this signal is approximately 89 beats per minute, and the peak voltage of the signal is 3.5 millivolts [4]

An electrocardiogram is a measurement of the electrical activity of the heart muscle which can be obtained from the surface of the skin and from different angles like figure 3. When the heart muscle contracted and pumping the blood for all parts of the body, action potentials will be released through the mechanical process within the heart muscle which leads to electrical activity.

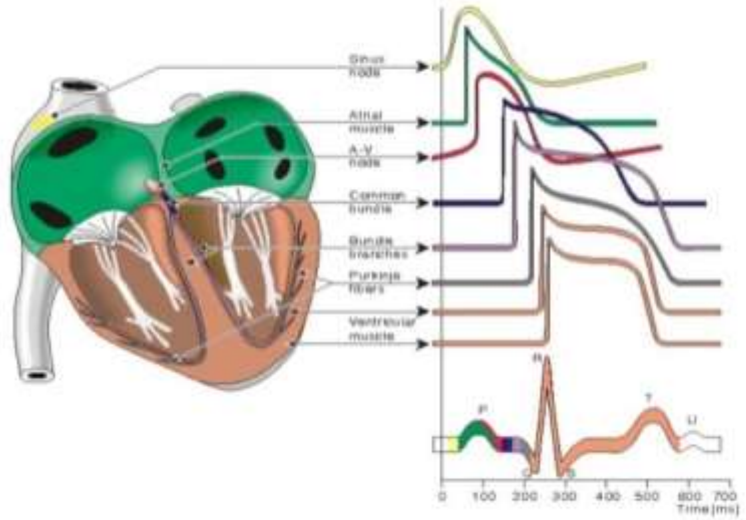


Figure 3: The heart's anatomy with waveforms from different specific part of the heart . [3]

DATA

ECG signals are collected from Physio net MIT- BIH arrythmia database. ECG signals are described by a text header file (.hea), a binary file (.dat) and a binary annotation file (.atr). header file consists of detailed information such as number of samples, sampling frequency, format of ECG signal, type of ECG leads and number of ECG leads, patient‟s history and the detailed clinical information. In binary data signal file, raw ECG recordings were sampled at 360 Hz with a 12-bit resolution over the 10-mV range. Binary data file store raw data signals (12 bits used for each sample). Binary data files are created with reference to header files. The signal is stored in 212 formats. Other files are .atr files (annotation file). ".atr" files contain some comments for the record files. So which storages some experts note about the analysis of signal quality results.

ARRHYTMIA

For a normal healthy person, the ECG comes off as a nearly periodic signal with depolarization followed by repolarization at equal intervals. However, sometimes this rhythm becomes irregular.
Cardiac arrhythmia (also dysrhythmia) is a term for any of a large and heterogeneous group of conditions in which there is abnormal electrical activity in the heart. The heart beat may be too fast or too slow, and may be regular or irregular. Arrythmia comes in varieties. It may be described as a flutter in chest or sometimes "racing heart". The diagnosis of arrythmia requires electrocardiogram. By studying ECG, doctors can diagnose the disease and prescribe the required medications. Most of time arrythmia‟s are harmless and happen in healthy people free of heart disease. However, some abnormal heart rhythm can be serious or even deadly. Having other types of heart disease can also increase the risk of arrhythmia‟s.

NORMAL SINUS RHYTHM

The first measurement is known as the "P-R interval" and is measured from the beginning of the upslope of the P wave to the beginning of the QRS wave. This measurement should be between 0.12 and 0.20 seconds (120-200 ms). Duration of PR is represented "res" in MATLAB code.
When measuring the PR interval, the lead with the longest PR interval should be chosen. (In some leads, the initial part of the PR interval may be isoelectric. This may be misinterpreted as a short PR interval). The R-R intervals are constant; the rhythm is regular for normal sinus rhythm. Duration of RR interval should be between 480 and 600 ms.

SINUS TACHYCARDIA

Generally, occurs normally in exercises and stress. Other causes may be under lying medical problems (Anaemia, fever, blood loss, etc). electrical signal is faster than usual. The heart rate is fast. But heart beats is properly. Therefore, RR interval is constant and regular. Due to the above reasons, duration of RR peak should be shorter than normal sinus (it is between 0.45 and 0.48 second). PR interval is between 0.12- 0.20 second.

SINUS BRADYCARDIA

Electrical signal is slower than usual. The heart rate is slower. But heart beats is properly. Therefore, RR interval is constant and regular. PR interval is in between 0.12-0.20 second. Causes of bradycardia are sleep, hypothermia, some drugs, etc. duration of RR peak should be bigger than tachycardia and sinus rhythm.

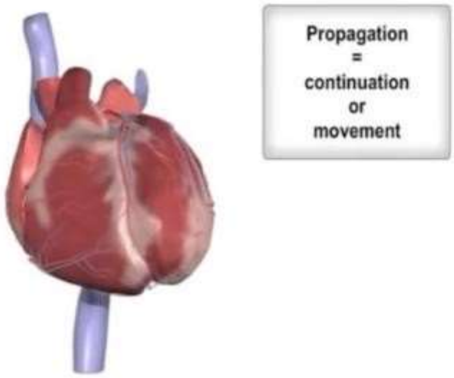
HEART BLOCK

Heart block is an abnormal heart rhythm where the heart beats too slowly. It is slower than bradycardia. PR interval is bigger than 0.20 second.

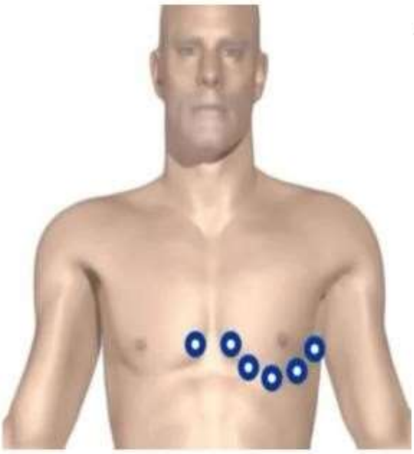
<u>ECG SIGNAL PROCESSING IN MATLAB: DETECTING R- PEAKS</u>

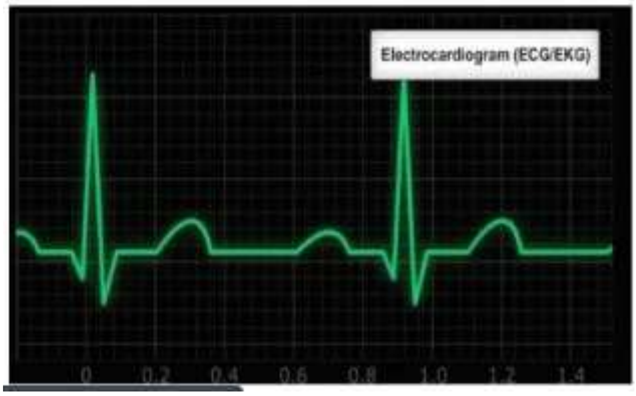
- How ECG is recorded?
- Why the ECG occurs?
- Detecting R-peaks and measuring the heart rate of a person using MATLAB.

ECG INTRODUCTION

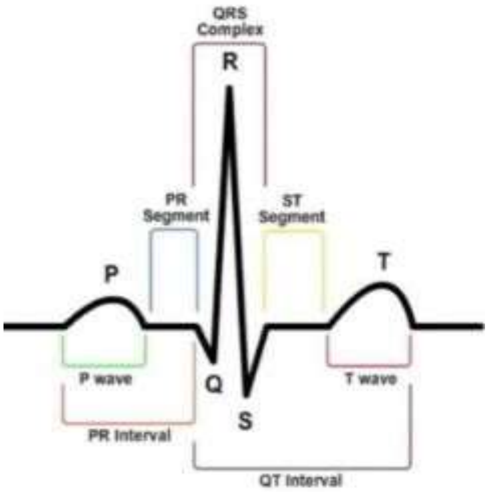


- The heart muscles contract and expand to generate signals that is recorded as ECG.
- ECG is the measured electrical activity of the heart.
- This electrical activity and be measured by placing electrodes at specific points on the skin.





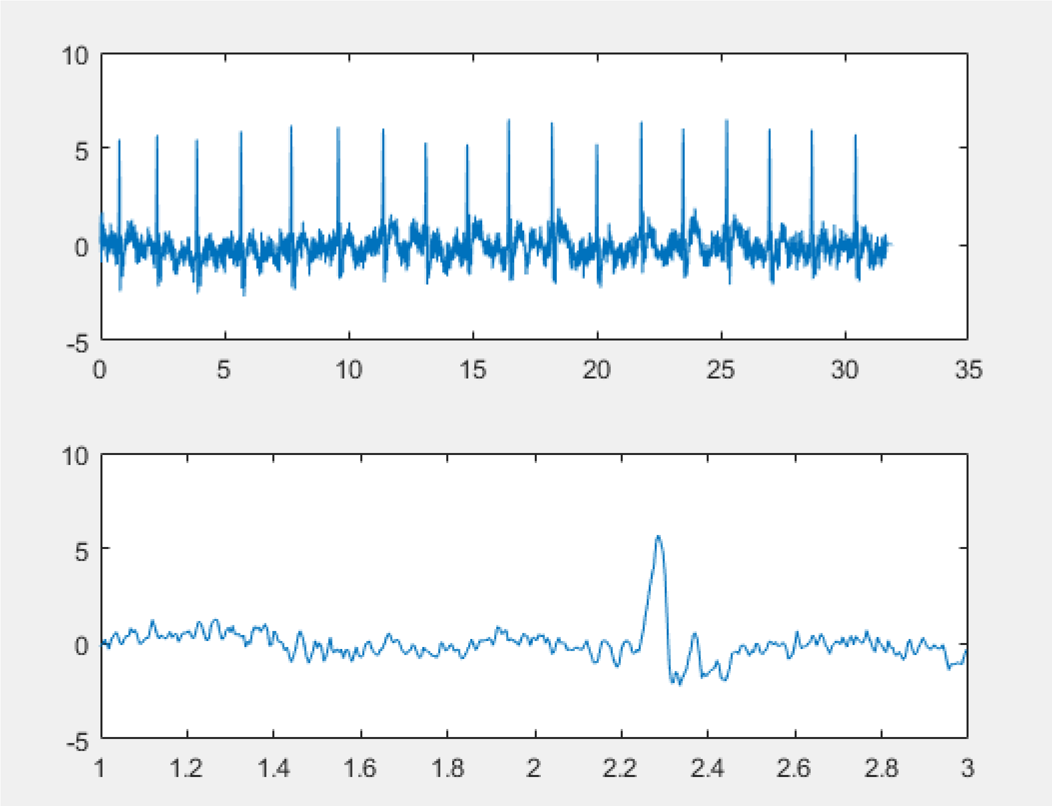
- An Ideal ECG looks like this and it keeps repeating itself.
- We will try to detect the R-peaks in this presentation.



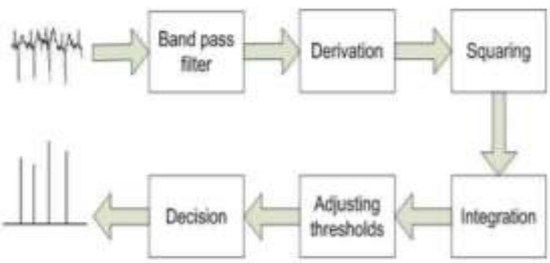
METHODOLOGY

- **R PEAKS DETECTION IN MATLAB**

- The ECG signal we are going to work with looks like this. A closer look at the signal.

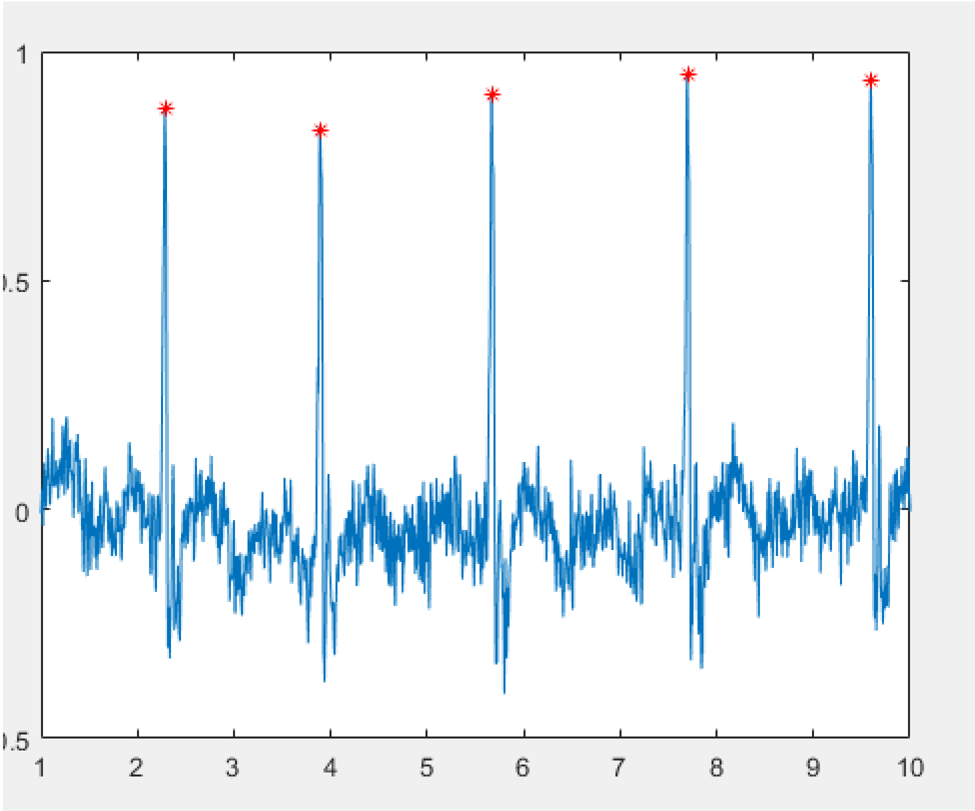


STEPS FOR DETECTION:

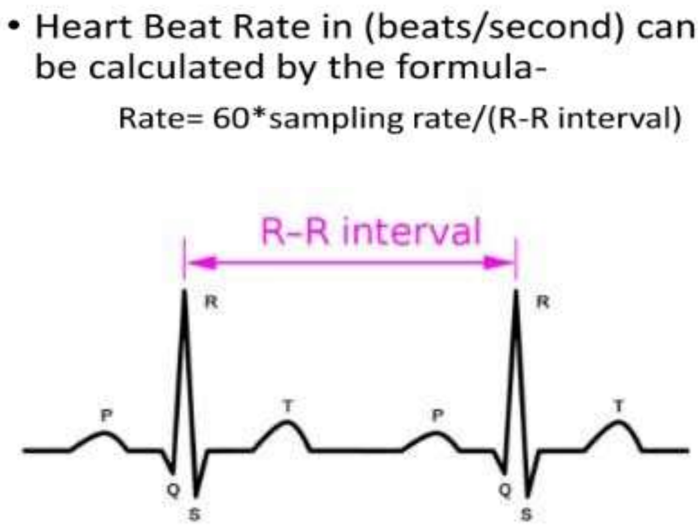


1. After removing low frequency components.
2. Using a windowing filter.
3. Thresholding.
4. Using the adjusted filter.

FINAL RESULT OF ALGORITHM



CALCULATING HEART BEAT



Heart rate calculation: The number of times a heart beats per minute is heart rate. For a normal person, heart beats 60 to 100 times per minute so the normal value is 60 to 100 beats per minute.

If the heart rate is slower, then the condition is called Bradycardia. If the heart rate is higher, then it is tachycardia and unevenly spaced cycles specify an arrhythmia [10]. If PR interval is more than 0.2 Sec, blockageof AV node is indicated. The equation to calculate heart rate is given below:

Heart Rate=(1/RR Interval in sec)*60 [1]

Bradycardia: If heart beats less than 60 BPM [8] then it is slower heart rate. This condition can be observed in athletes and the patients suffering from jaundice, myxedema and in patients with increased intra carinal pressure.

Tachycardia: If heart rate is greater than 100 BPM it is tachycardia. Atrium having ectopic focus that regularly beats at a higher rate [8] causes tachycardia.

OUR DATA

- We have used 2 sample ECG data frames for the completion of our project.
- They are “signal.txt‟, and “testchannel.txt‟

MATLAB CODE

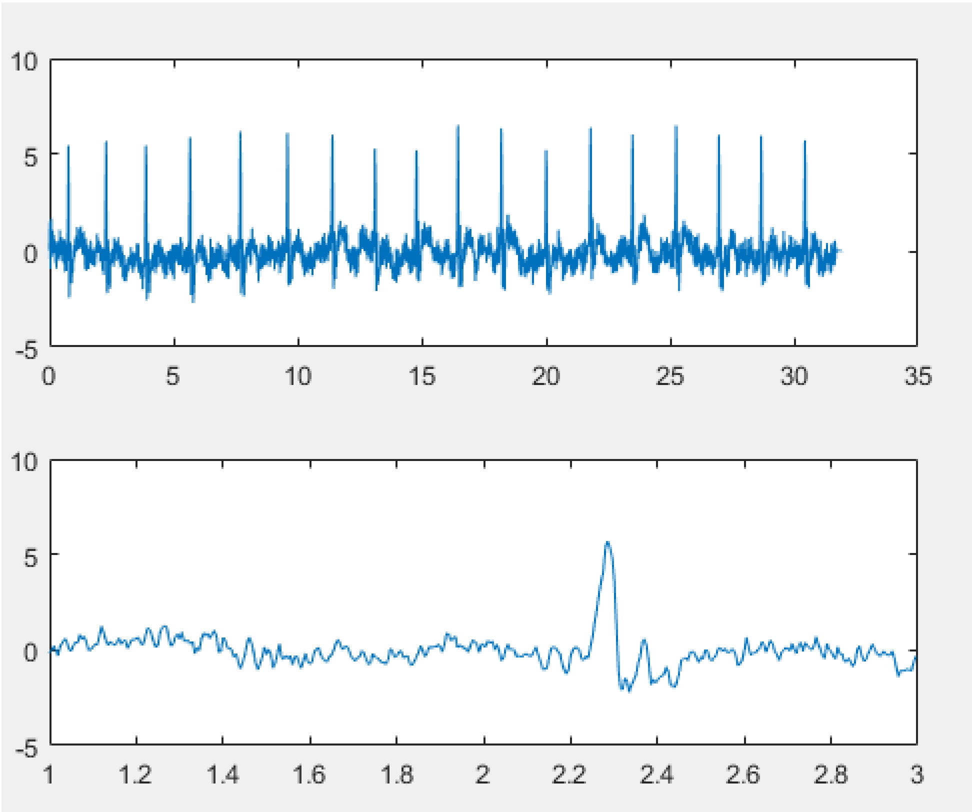
```
clc;
clear all
close all

loadstr = 'testchannel.txt';

fid = fopen(loadstr);

readin = textscan(fid, '%f', 'delimiter', '\n');
fclose(fid);
testdata = readin{1,1};
clear('readin');
x1 = testdata';

fs = 200;

N = length (x1);
t = [0:N-1]/fs;
figure(1)
subplot(2,1,1)
plot(t,x1)
subplot(2,1,2)
plot(t(200:600),x1(200:600))
xlim([1 3])
x1 = x1 - mean (x1 );
x1 = x1/ max( abs(x1 )) ;
figure(2)
subplot(2,1,1)
plot(t,x1)
subplot(2,1,2)
plot(t(200:600),x1(200:600))
xlim([1 3])
b=[1 0 0 0 0 0 -2 0 0 0 0 0 1];
a=[1 -2 1];
h=filter(b,a,[1 zeros(1,12)]);
x2 = conv(x1 ,h);
x2 = x2/ max( abs(x2 ));
figure(3)
subplot(2,1,1)
plot([0:length(x2)-1]/fs,x2)
xlim([0 max(t)])
subplot(2,1,2)
plot(t(200:600),x2(200:600))
xlim([1 3])
b = [-1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 32 -32 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1];
a = [1 -1];
h1=filter(b,a,[1 zeros(1,32)]);
x3 = conv (x2 ,h1);
x3 = x3/ max( abs(x3 ));
figure(4)
subplot(2,1,1)
plot([0:length(x3)-1]/fs,x3)
xlim([0 max(t)])
subplot(2,1,2)
plot(t(200:600),x3(200:600))
```

```
xlim([1 3])
h = [-1 -2 0 2 1]/8;
x4 = conv (x3 ,h);
x4 = x4 (2+[1: N]);
x4 = x4/ max( abs(x4 ));
figure(5)
subplot(2,1,1)
plot([0:length(x4)-1]/fs,x4)
subplot(2,1,2)
plot(t(200:600),x4(200:600))
xlim([1 3])
x5 = x4 .^2;
x5 = x5/ max( abs(x5 ));
figure(6)
subplot(2,1,1)
plot([0:length(x5)-1]/fs,x5)
subplot(2,1,2)
plot(t(200:600),x5(200:600))
xlim([1 3])
h = ones (1 ,31)/31;
x6 = conv (x5 ,h);
x6 = x6 (15+[1: N]);
x6 = x6/ max( abs(x6 ));
figure(7)
subplot(2,1,1)
plot([0:length(x6)-1]/fs,x6)
subplot(2,1,2)
plot(t(200:600),x6(200:600))
xlim([1 3])
figure(7)
subplot(2,1,1)
max1 = max(x6);
thresh = mean (x6 );
kk=thresh*max1;
yy =(x6>kk)';
figure,plot(yy,t)
figure (8)
subplot(2,1,1)
plot (t(200:600),x1(200:600)/max(x1))
box on
xlim([1 3])
subplot(2,1,2)
plot (t(200:600),x6(200:600)/max(x6))
xlim([1 3])
left = find(diff([0 yy'])==1);
right = find(diff([yy' 0])==-1);
for i=1:length(left)
   [Rv(i) Rl(i)] = max( x1(left(i):right(i)) );
   Rl(i) = Rl(i)+left(i) ;
   for j=1:(length(left)-1)
        x(j)=left(j);

        for l=1:(length(left));
            k(l)=left(j)-left(j+1);
            y=-1*mean2(k(l));
        end
    end
end

figure
plot (t,x1/max(x1) , t(Rl) ,Rv , 'r*');
```

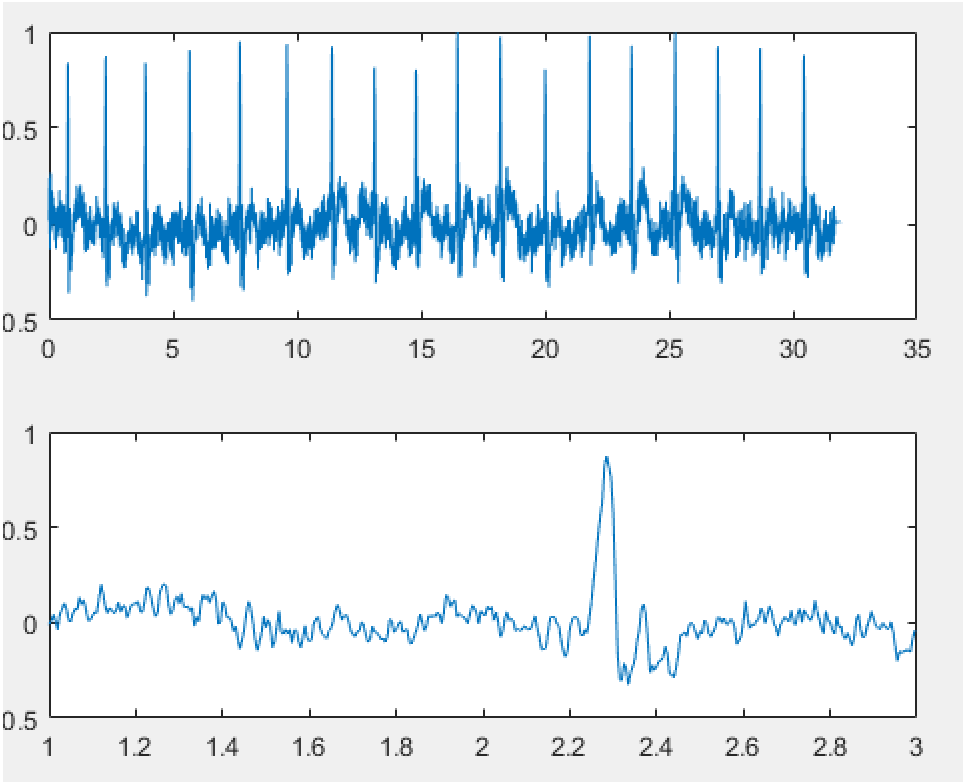
```
xlim([1 3])
heartrate=(fs*60)/y;
tx=0:N-1/fs;
figure,plot(tx(200:600),x1(200:600))
disp('HEART RATE IS:::')
fprintf('%d\n', round(heartrate));
if (heartrate==72)
disp('HEART RATE OF THE SUBJECT IS NORMAL');
end
if(heartrate<72)
disp('HEART RATE OF THE SUBJECT IS BELOW NORMAL ,THE SUBJECT IS SUFFERING
FROM BRADYCARDIA');
else
disp('HEART RATE OF THE SUBJECT IS ABOVE NORMAL ,THE SUBJECT IS SUFFERING
FROM TRACHYCARDIA');
end
```

RESULTS

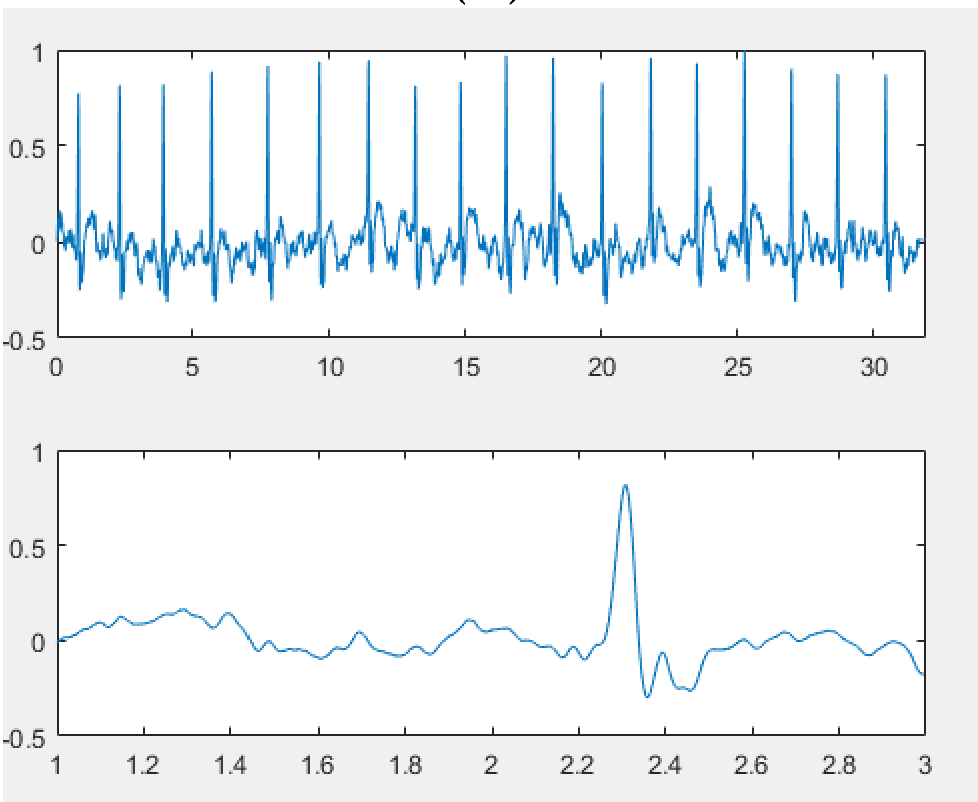
- INPUT ECG WITH A CLOSER LOOK:



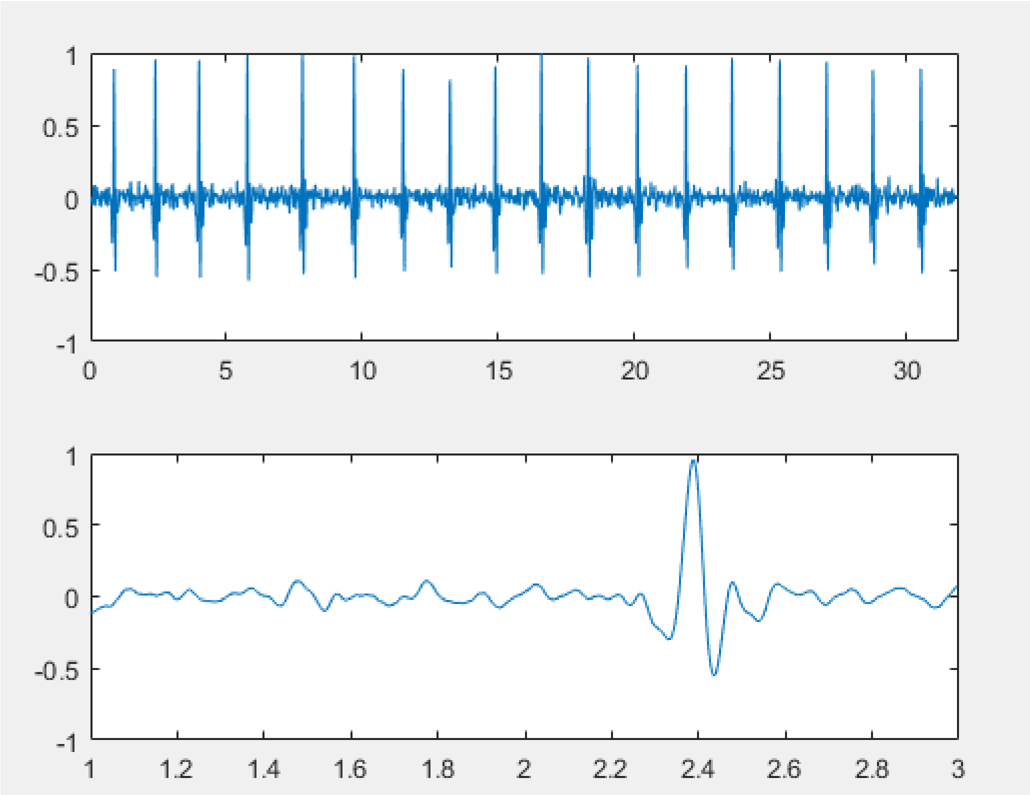
- **NORMALISED ECG**



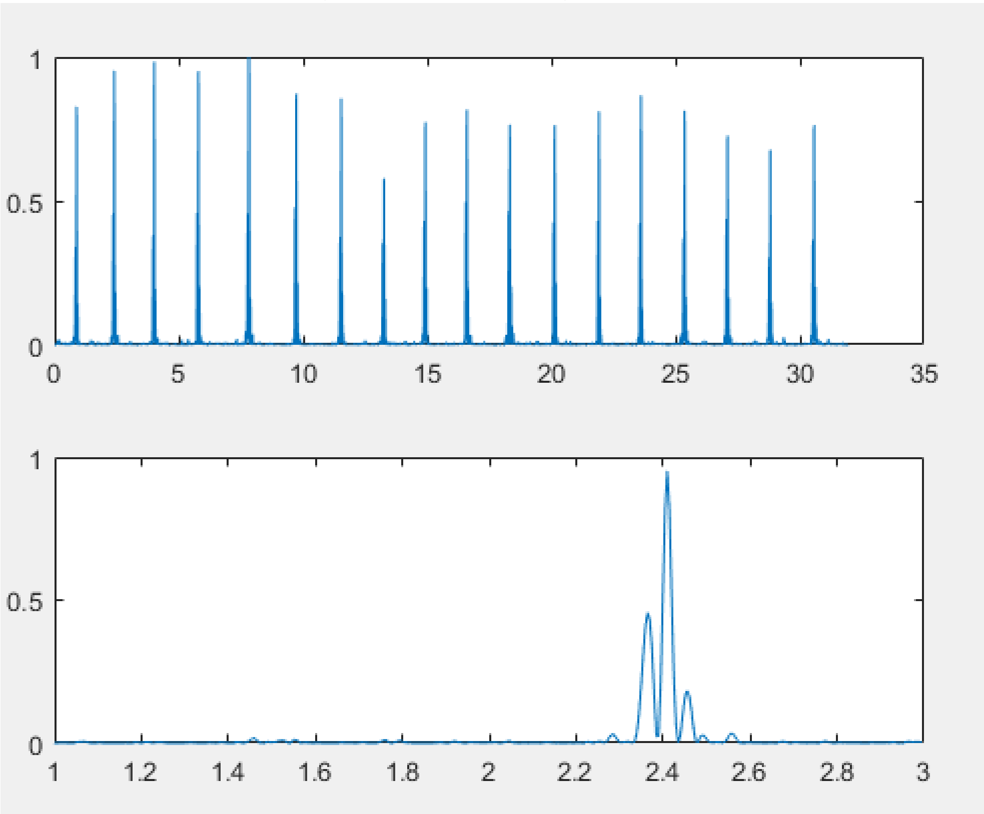
- **BANDPASS FILTERING(1ST)**



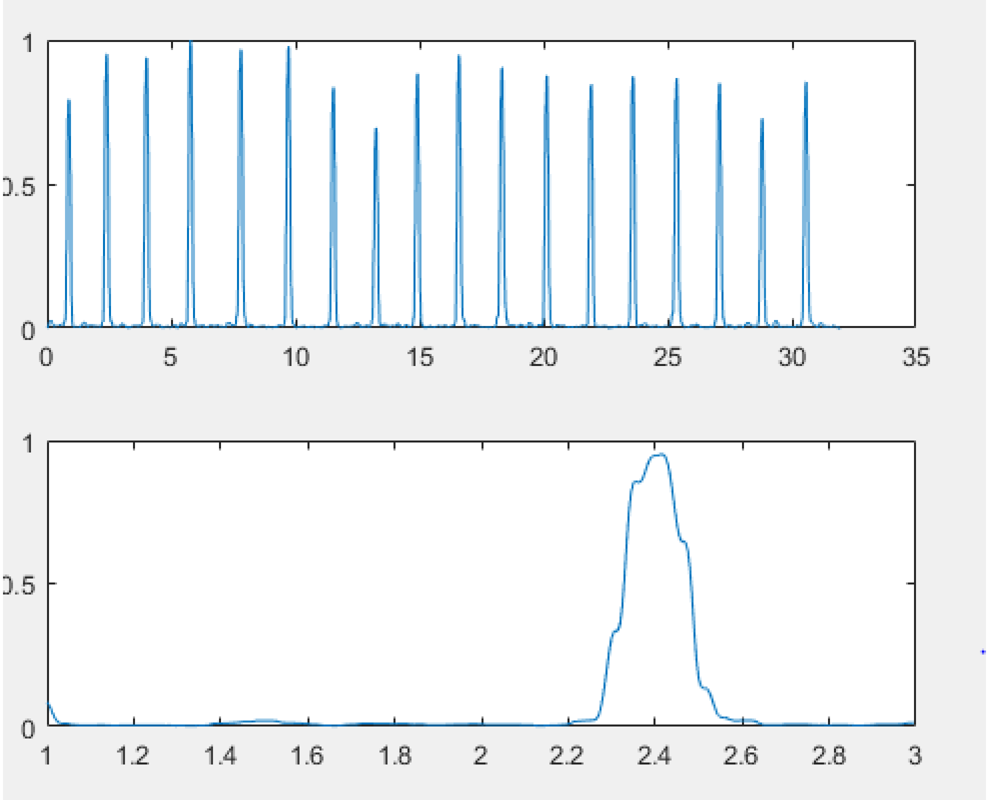
- FILTERING OF HIGHER ORDER



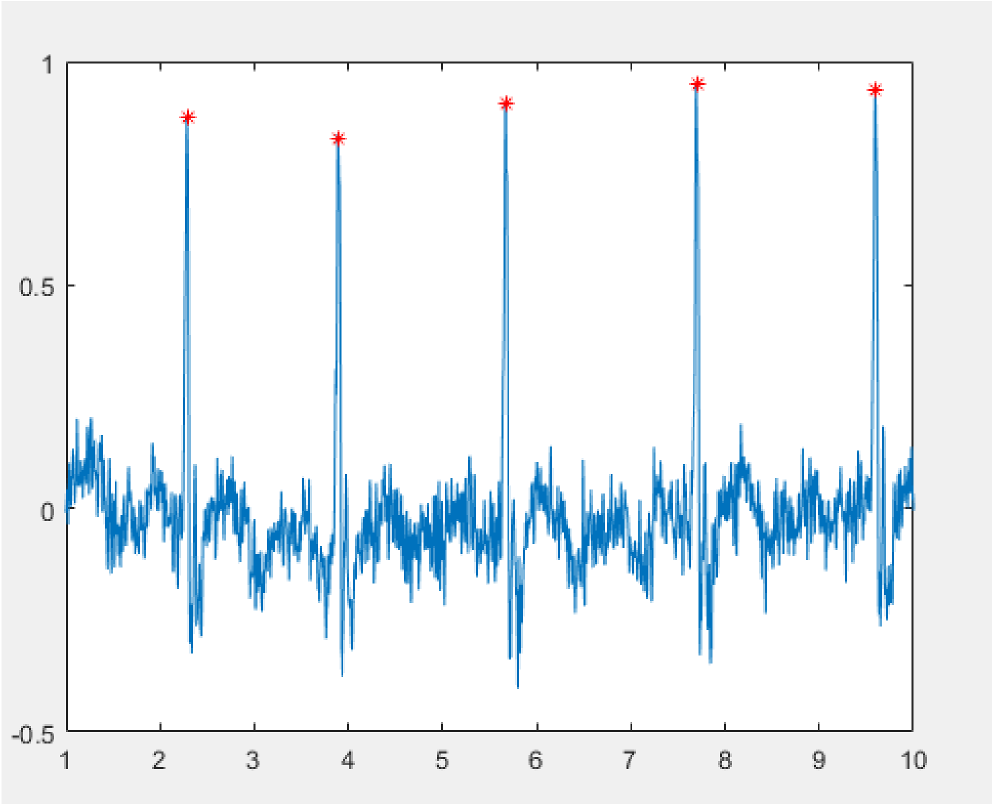
- **SQUARING(QRS COMPLEX):**



- **FILTERING TO REMOVE HIGH AND LOW FREQUENCY COMPONENTS:**

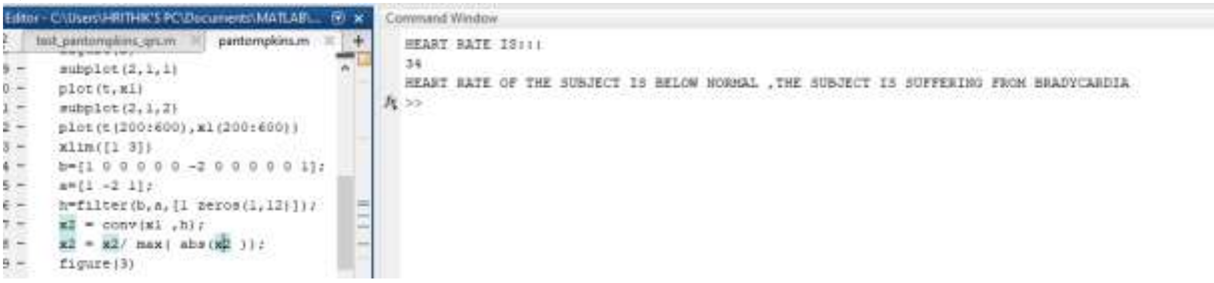


- **POSITION OF R PEAKS**

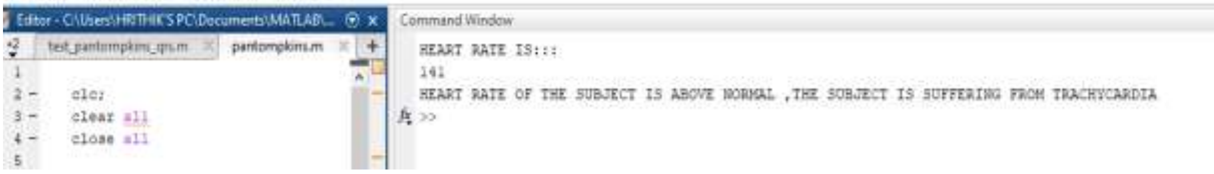


Heart Rate Output

1)



2)



- This average heart rate can be used to determine various heart diseases

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