QRS COMPLEX AND ST SEGMENT DETECTION OF ECG SIGNAL FOR THE ANALYSIS OF MYOCARDIAL ISCHEMIA

B.Tech. Project Report

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QRS COMPLEX AND ST SEGMENT DETECTION OF ECG SIGNAL FOR THE ANALYSIS OF MYOCARDIAL ISCHEMIA

A Project Report

Submitted in partial fulfillment of the requirements for the award of the degree
of

Bachelor of Technology

In

Computer Sc. and Engineering

By

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June 2020

DECLARATION

We hereby declare that the project entitled **“QRS COMPLEX AND ST SEGMENT DETECTION OF ECG SIGNAL FOR THE ANALYSIS OF MYOCARDIAL ISCHEMIA”** submitted for the B. Tech. (CSE) degree is our original work and the project has not formed the basis for the award of any other degree, diploma, fellowship or any other similar titles.

Name and Roll No. of the Students **Signature of the Students**

1. Debalekha Chakraborty (GCECTB-R16-3010)
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Date: 22nd June 2020

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BONAFIDE CERTIFICATE

Certified that this project report titled **QRS COMPLEX AND ST SEGMENT DETECTION OF ECG SIGNAL FOR THE ANALYSIS OF MYOCARDIAL ISCHEMIA** is the authentic work carried out by **DEBALEKHA CHAKRABORY (GCECTB-R16-3010) , DEEP BHUINYA (GCECTB-R16-3011) , DEVANSHI GUPTA (GCECTB-R16-3012) , PRATIKSHA DAS (GCECTB-R16-3017)** who carried out the project work under **my** supervision. Certified further, that to the best of my knowledge the work reported herein does not form part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

…………………………………

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Abstract

Myocardial Ischemia is a condition where ample amount of oxygen is not supplied to the heart. This reduction causes partial or complete blockage in coronary arteries causing damage to heart muscle. This problem may lead to Ischemic heart disease(IHD).

In present world, according of world health organization 2019 around 32.4million people dies every year due to Myocardial Infarction(MI) caused by myocardial ischemia, also referred as heart attack.

Symptoms of this disease are shortness of breath, tightness, heaviness,chest discomfort may gradually develop in many cases ,patient with ischemic episode remains unaware of IHD in early stages .Detection and treatment of this disease in time may prevent rupturing of the heart muscle and can save many lives.

Our main aim is to design an algorithm to detect ischemic episode in ECG signal with less time complexity and cost effective and easy to implement in homecare ECG devices . Elevation (or depression) in the ST segment indicates presence of ischemia. The proposed method measures slope of ST segment which must vary in case of ST changes.People living in remote areas without proper medicinal facilities may get benefited. This can be further used for regular monitoring of the suspected ischemic patient and can help in early detection of myocardial ischemia.

Acknowledgement

We express our sincere gratitude to those concern who have been associated with Seminar on Proposed Project and have helped us with it and made it a worthwhile experience.

Firstly, we are thankful to Our guide Mr.Bimal Pal, Who imparted the interest into us about the topic and helped us with all the necessaries for the project . We got help from him at every Stage until now and wish to have the same for the later part also.

We are thankful to our college, our H.O.D. Dr. Kalpana Saha Roy.

Lastly, but most importantly, we thank our family, friends and the almighty that has been with us from the beginning of this project.

With Gratitude,

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LITERATURE SURVEY

The most prominent feature in ECG graph that helps us to detect Myocardial Ischemia is the elevation of depression of ST segment i.e. the slope of ST segment. Generally, ST segment stays at almost same level of isoelectric level, but in Ischemic cases, it forms a clear elevation. Many scientists have done so many researches on automated detection of Ischemia with the help of different algorithms. For example, we can mention the Karhunen-Loeve Transformation, popularly known as KLT. Besides, there had already been beat-to-beat quantification, back propagation algorithm, Continuous Wavelet Transform (CWT). Application of different neutral network, machine learning techniques, deep learning methods, real time analysis etc. have been visible in this field in recent times. Recently, there has been an approach to make this detection technique suitable for cell phone like devices. Predictive values for ST slope has been measured for some patients, who underwent coronary angiography, using per functional radionuclide images with 99mTc-2-methoxy-isobutil-isonitrile. These values showed 96% sensitivity whereas the conventional method can show only 73%.

Analysis of receiver-operating curves confirmed the superior performance of the heart rate-adjusted indexes throughout a wide range of test specificities. These findings suggest that heart rate adjustment of ST segment depression can markedly improve the clinical usefulness of the treadmill exercise electrocardiogram.

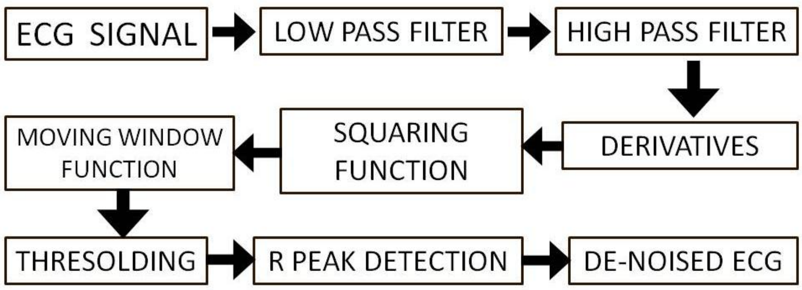
SYSTEM ANALYSIS & DESIGN

In this section detailed algorithm is written. At first the R peak is detected and based on that the ST segment is detected. After Calculating the slope the ischemic episode is detected based on the threshold.

- **Database:** ECG Signals are generated in lab and after plotting the it in graph, the sample values are collected.

- **QRS Complex (R peak) Detection:** The Pan-Tompkins algorithm is used to detect the QRS segment and the R peak.

Fig. 1: Pan-Tompkins Algorithm



The BPM can be calculated from this algorithm from the QRS complex of an ECG signal. It can detect if the heart is suffering from Tachycardia (BPM>100) or Bradycardia (BPM<60).

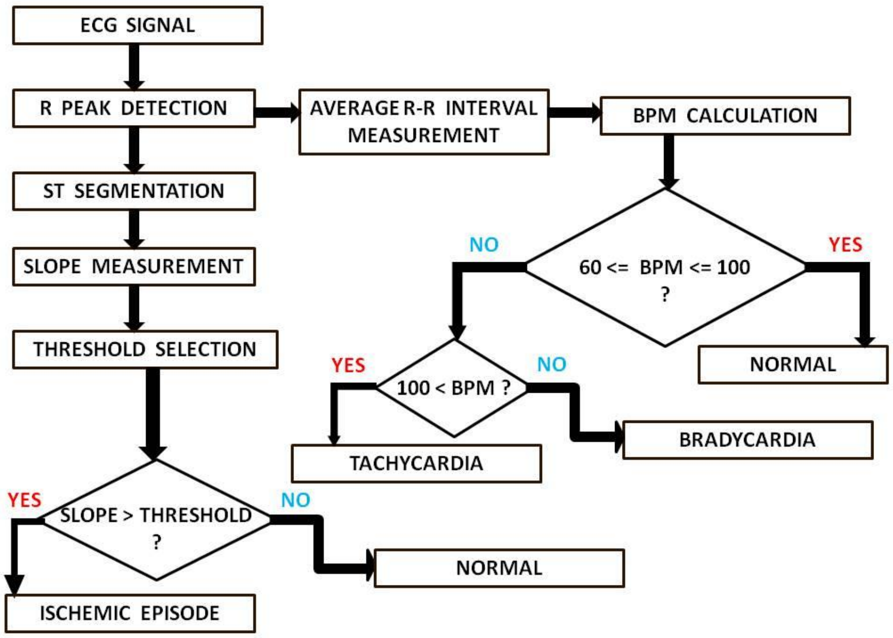
To Calculate the BPM , Machine Takes the Average R-R interval and Convert It into BPM.

Step 1: Average R-R interval in ms = ((RR_interval / fs) * 1000.0) where fs is Sampling Frequency

Step 2: BPM (Beats per Min) = 60,000 / average R-R interval of signal.

Once R peak is detected and machine is done with the QRS Complex ,moving towards ST segmentation is possible.

Fig. 2: Proposed Algorithm Process Flow



- **ST Segmentation Algorithm for various ranges of BPM :**

  For the detection ST segment of a signal with any range of BPM, a signal where the BPM is 60, where the duration of every segment of ecg signal is experimentally proven, the approximate duration for every BPM value is to be calculated considering BPM 60 as base value.

  Here, for 60 BPM, the duration of a complete cycle of ECG signal is 60/60 sec = 1sec = 1000 ms.

  For every BPM value, the duration of one complete cycle will be (60/BPM)*1000 ms . Now considering the base 60 BPM, the time duration of each segment is calculated.

  So, The steps are :

Step 1: Start

Step 2: Locate R Peak by Pan-Tompkins Algorithm.

Step 3: Calculate the BPM.

Step 4: Calculate the duration of one complete cycle.

Step 5: Calculate the time duration of QRS and ST segment.

Step 6: Convert the time into sample values.

Step 7: Take the A (Where A = duration of QRS / 2) samples after the R peak.

Step 8: Take approximately B (Where B = duration of ST Segment) samples after the Ath sample.

Step 9: Save these B samples as ST SEGMENT.

Step 10: End

Table 1 : Calculated Durations of each Segments of ECG signals where the BPM is in normal range (60 < BPM < 100)

BPM	DURATION OF A COMPLETE CYCLE	DURATION OF PR SEGMENT	DURATION OF QRS SEGMENT	DURATION OF ST SEGMENT
60 to 65	1000 ms	110 ms	110 ms	120 ms
66 to 70	910 ms	100 ms	100 ms	109 ms
71 to 75	850 ms	94 ms	94 ms	102 ms
76 to 80	790 ms	87 ms	87 ms	95 ms
81 to 85	740 ms	81 ms	81 ms	89 ms
86 to 90	700 ms	77 ms	77 ms	84 ms
91 to 95	660 ms	73 ms	73 ms	80 ms
96 to 100	630 ms	70 ms	70 ms	76 ms
101 to 105	600 ms	66 ms	66 ms	72 ms

Fig. 3: R Peak & ST Segment Detection (Sample 1)

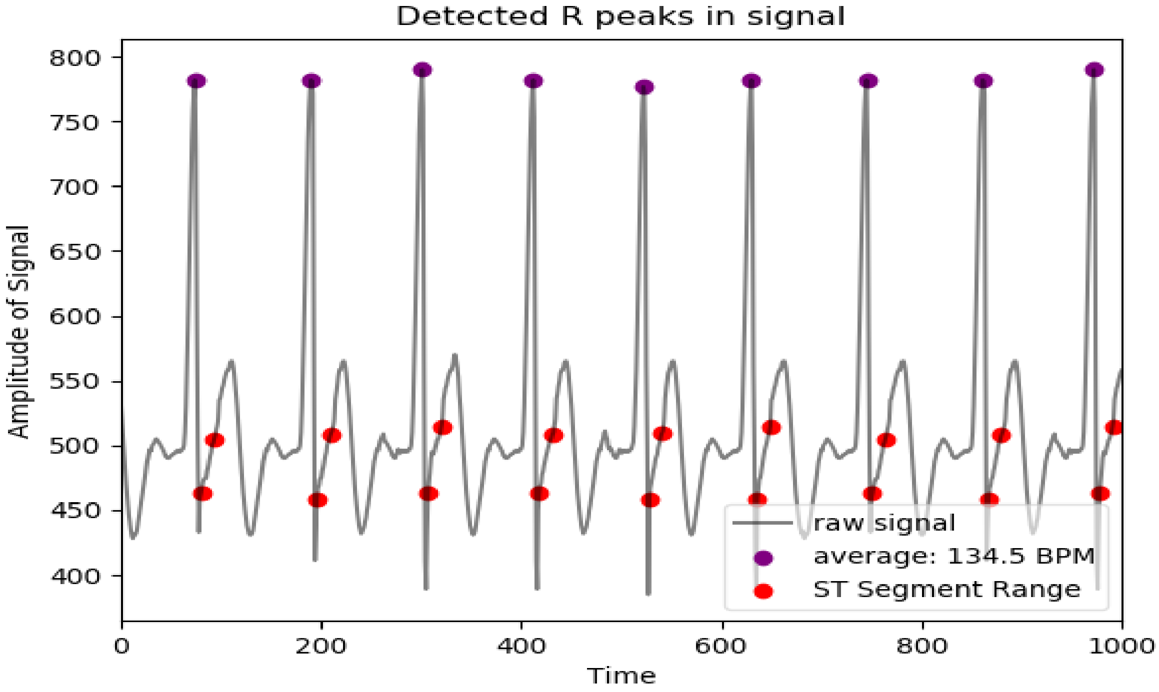
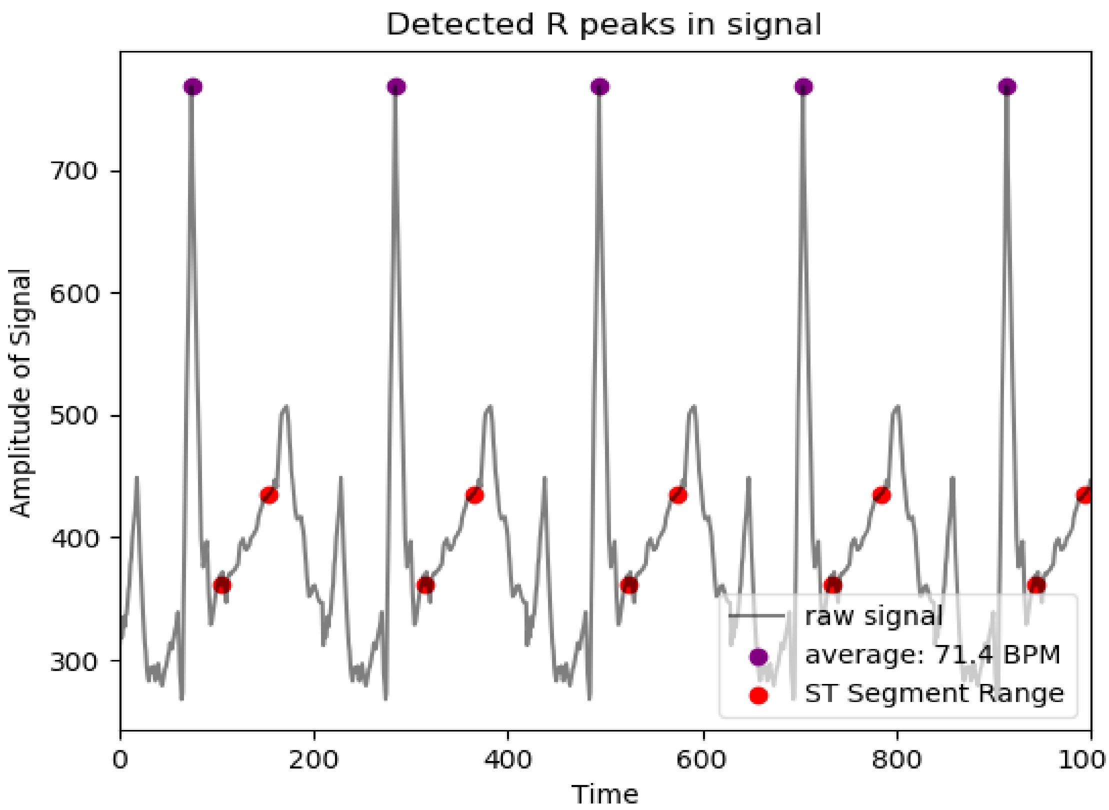
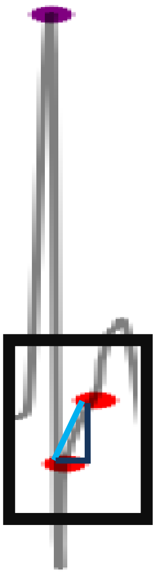


Fig. 4: R Peak & ST Segment Detection (Sample 2)



- **Slope Measurement :** For calculation of The slope, the tanX formula is used and that can be defined by m = rise/run = (y2 - y1) / (x2 – x1) , where y2 is the value of y axis at the ending of the ST segment and y1 is the value of y axis of starting of ST Segment and x2 and x1 is the value of x axis (sample number) in respective of y1 and y2.

Fig. 4: Slope Value Calculation



- **Thresholding:** The threshold of the slope is needed to detect the ECG Signal is ischemic or normal. It is done by selecting the threshold of 0.35 which is experimentally proven.

  If Slope < Threshold then *NORMAL*

  if Slope > Threshold then *ISCHEMIA*.

- **Source Code of Proposed Method :**

  [On Python 3.7]

- **R Peak Detection :**

File Edit Format Run Options Window Help

```
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import math
dataset = pd.read_csv(r"C:\Users\MAHABHARAT\Desktop\ECG\FINAL PROJECT 8 SEM\data 2
#Calculate moving average with 0.75s in both directions, then append do dataset
hrw = 0.200 #One-sided window size, as proportion of the sampling frequency
fs = 250 #The example dataset was recorded at 250Hz
mov_avg = dataset['hart'].rolling(int(hrw*fs)).mean() #Calculate moving average #1
#Impute where moving average function returns NaN, which is the beginning of the s
avg_hr = (np.mean(dataset.hart))
mov_avg = [avg_hr if math.isnan(x) else x for x in mov_avg]
mov_avg = [x*1.2 for x in mov_avg] #For now we raise the average by 20% to prevent
dataset['hart_rollingmean'] = mov_avg #Append the moving average to the dataframe

#Mark regions of interest
window = []
peaklist = []
listpos = 0 #We use a counter to move over the different data columns
for datapoint in dataset.hart:
    rollingmean = dataset.hart_rollingmean[listpos] #Get local mean
    if (datapoint < rollingmean) and (len(window) < 1): #If no detectable R-comple
        listpos += 1
    elif (datapoint > rollingmean): #If signal comes above local mean, mark ROI
        window.append(datapoint)
        listpos += 1
    else: #If signal drops below local mean -> determine highest point
        maximum = max(window)
        beatposition = listpos - len(window) + (window.index(max(window))) #Notate
        peaklist.append(beatposition) #Add detected peak to list
        window = [] #Clear marked ROI
        listpos += 1
ybeat = [dataset.hart[x] for x in peaklist] #Get the y-value of all peaks for plot
print (peaklist)
```

- **BPM Calculation :**

```
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RR_list = []
cnt = 0
while (cnt < (len(peaklist)-1)):
    RR_interval = (peaklist[cnt+1] - peaklist[cnt]) #Calculate distance be
    ms_dist = ((RR_interval / fs) * 1000.0) #Convert sample distances to m
    RR_list.append(ms_dist) #Append to list
    cnt += 1
bpm = 60000 / np.mean(RR_list) #60000 ms (1 minute) / average R-R interval
print ("Average Heart Beat is: %.01f" %bpm) #Round off to 1 decimal and pr
if (bpm>100):
    print (" Heart Condition : TACHYCARDIA ")
elif(bpm<60):
    print(" Heart Condition : BRADYCARDIA ")
else:
    print (" Heart Condition : NORMAL ")
```

- **ST Segment Detection :**

```
File  Edit  Format  Run  Options  Window  Help
CycleTime = 60000/bpm    # Time duration of a single cycle (60*1000)/bpm in ms
STStartTime = CycleTime*0.055    # CycleTime*(110/1000)/2 = 0.055
STStartTimeSample = round (STStartTime*0.250)  # converting ms to sample value
STDuration = CycleTime*0.120  # Duration of ST
STDurationSample = round (STDuration*0.250) # converting ms to sample value

S_Point=[]
count=0
while (count <= (len(peaklist)-1)):
    S = (peaklist[count] + STStartTimeSample)
    S_Point.append(S)
    count +=1
    print (S_Point)
y1beat = [dataset.hart[x1] for x1 in S_Point] #Get the y-value of S points for plotting purpose:


T_Point=[]
count=0
while (count <= (len(S_Point)-1)):
    T = (S_Point[count] + STDurationSample)
    T_Point.append(T)
    count +=1
    print (T_Point)
y2beat = [dataset.hart[x2] for x2 in T_Point] #Get the y-value of T points for plotting purpose:


ST = []
ST_interval = np.subtract(y2beat,y1beat)
ST.append(ST_interval)
print(ST)
```

- **Slope Calculation :**

File Edit Format Run Options Window Help

```
T_Point=[]
count=0
while (count <= (len(S_Point)-1)):
    T = (S_Point[count] + STDurationSample)
    T_Point.append(T)
    count +=1
    print (T_Point)
y2beat = [dataset.hart[x2] for x2 in T_Point] #Get the y-value of T points f


ST = []
ST_interval = np.subtract(y2beat,y1beat)
ST.append(ST_interval)
print(ST)

slope=[]
slope_is =np.divide(ST,STDurationSample)
slope.append(slope_is)
print(slope)

avg_slope =np.mean(slope)
print ("Average Slope is: %.01f" %avg_slope)

if (avg_slope>0.35):
    print (" Heart Condition : MYOCARDIAL ISCHEMIA ")
else:
    print (" Heart Condition : NORMAL ")



plt.title("Detected R peaks in signal")
plt.xlim(0,1000)
plt.xlabel('Time')
plt.ylabel('Amplitude of Signal')
plt.plot(dataset.hart, alpha=0.5, color='black', label="raw signal") #Plot s
#plt.plot(mov_avg, color ='red', label="moving average") #Plot moving averag
plt.scatter(peaklist, ybeat, color='purple', label="average: %.1f BPM" %bpm)
plt.scatter(S_Point, y1beat, color='red',label="ST Segment Range")
plt.scatter(T_Point, y2beat, color='red')
plt.legend(loc=4, framealpha=0.6)
plt.show()
```

RESULTS :

As a result of the above mentioned code, the following result is generated with the picture of plotted graph. In the result we can see the algorithm successfully detected the heart rate and the heart condition with ischemic episode.

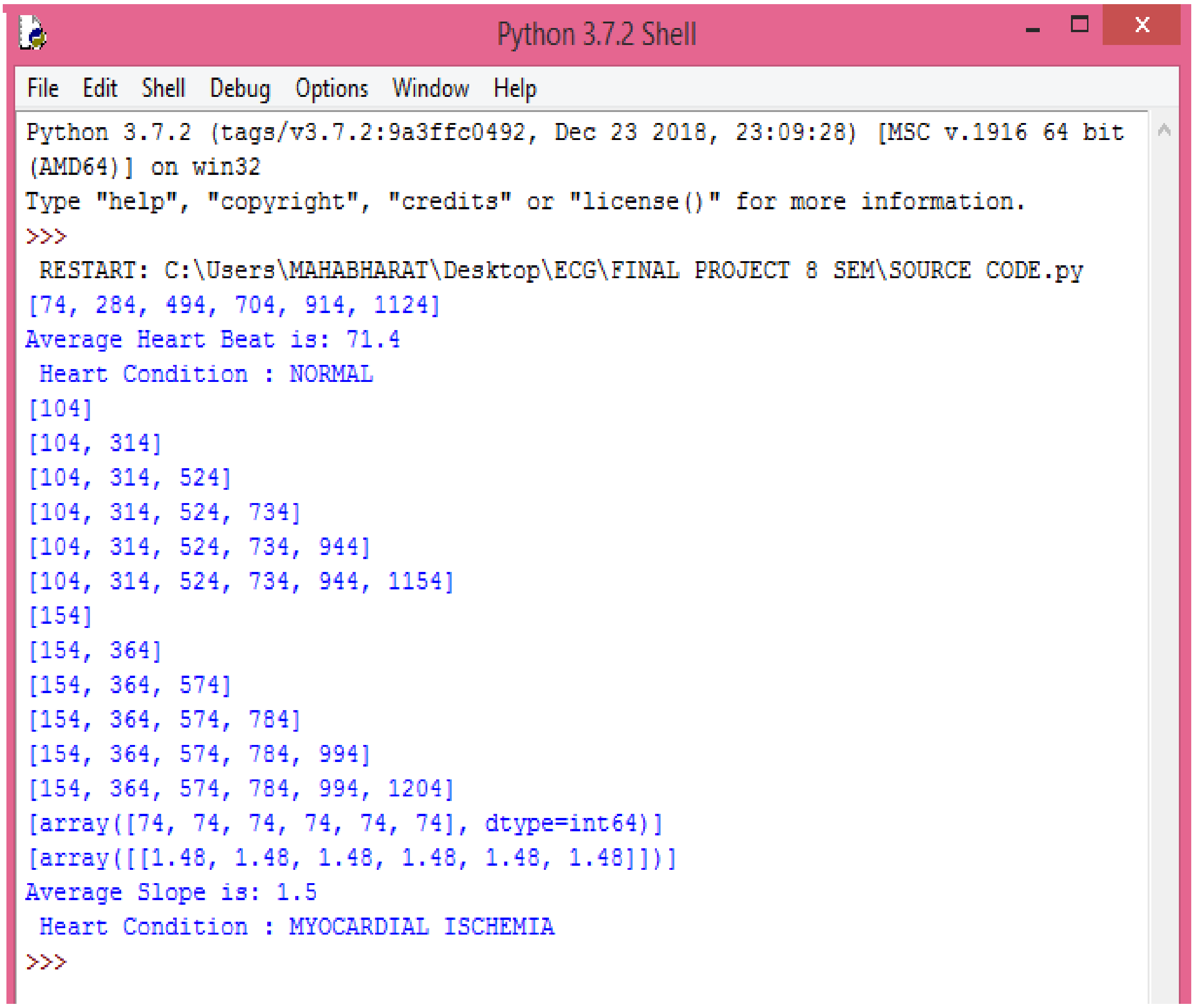
Fig. 6: Sample Output Of Source Code (Sample 1)

Python 3.7.2 Shell

File Edit Shell Debug Options Window Help

```
Python 3.7.2 (tags/v3.7.2:9a3ffc0492, Dec 23 2018, 23:09:28) [MSC v.1916 64 bit
(AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
 RESTART: C:\Users\MAHABHARAT\Desktop\PROJECTS\PYTHON Projects\6 sample bpm calc
ulation.py
[74, 209, 343, 477, 610, 745]
Average Heart Beat is: 111.8
 Heart Condition : TACHYCARDIA
[89]
[89, 224]
[89, 224, 358]
[89, 224, 358, 492]
[89, 224, 358, 492, 625]
[89, 224, 358, 492, 625, 760]
[119]
[119, 254]
[119, 254, 388]
[119, 254, 388, 522]
[119, 254, 388, 522, 655]
[119, 254, 388, 522, 655, 790]
[array([82, 82, 82, 82, 86, 82], dtype=int64)]
[array([[2.73333333, 2.73333333, 2.73333333, 2.73333333, 2.86666667,
        2.73333333]])]
Average Slope is: 2.8
 Heart Condition : MYOCARDIAL ISCHEMIA
>>>
```

Fig. 6: Sample Output Of Source Code (Sample 2)



Python 3.7.2 Shell

File Edit Shell Debug Options Window Help

```
Python 3.7.2 (tags/v3.7.2:9a3ffc0492, Dec 23 2018, 23:09:28) [MSC v.1916 64 bit
(AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
 RESTART: C:\Users\MAHABHARAT\Desktop\ECG\FINAL PROJECT 8 SEM\SOURCE CODE.py
[74, 284, 494, 704, 914, 1124]
Average Heart Beat is: 71.4
 Heart Condition : NORMAL
[104]
[104, 314]
[104, 314, 524]
[104, 314, 524, 734]
[104, 314, 524, 734, 944]
[104, 314, 524, 734, 944, 1154]
[154]
[154, 364]
[154, 364, 574]
[154, 364, 574, 784]
[154, 364, 574, 784, 994]
[154, 364, 574, 784, 994, 1204]
[array([74, 74, 74, 74, 74, 74], dtype=int64)]
[array([[1.48, 1.48, 1.48, 1.48, 1.48, 1.48]])]
Average Slope is: 1.5
 Heart Condition : MYOCARDIAL ISCHEMIA
>>>
```

CONCLUSION & SCOPE FOR FUTURE WORK

It is an statistical analysis based algorithm and can be modified further with implementation on various dataset . A person's ECG can be analyzed in a system and detect if the ischemic episode is present.

In future the computer vision and machine learning approach can be used to detect the ischemic episode. A large set of data can be used to train the machine and test the output. This concept will possibly be very effective in near future.

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