A
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"Cardiac Anomalies detection from ECG"

Submitted in Partial Fulfillment of the Requirement
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Master of Technology

In

Software Technology

By

Vijay Kumar Patel
University Roll No. 2K14/SWT/516

Under the Esteemed Guidance of

Dr. Ruchika Malhotra
Associate Head &Associate Professor, Discipline of Software Engineering

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DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
DELHI TECHNOLOGICAL UNIVERSITY
DELHI – 110042, INDIA

STUDENT UNDERTAKING

Delhi Technological University
(Government of Delhi NCR)
Bawana Road, New Delhi-42

This is to certify that the thesis entitled**"Cardiac Anomalies detection from ECG"** done by me for theMajor project IIfor the award of degree of **Master of Technology** Degree in **Software Technology** in the **Department of Computer Science & Engineering,** Delhi Technological University, Delhi is an authentic work carried out by me under the guidance of Dr. Ruchika Malhotra.

Signature:
Student Name
Vijay Kumar Patel
2K14/SWT/516

Above Statement given by Student is Correct.

Project Guide:
Dr. Ruchika Malhotra
Associate Head&Associate Professor,
Discipline of Software Engineering,
Department of Computer Science & Engineering, DTU

DELHI TECHNOLOGICAL UNIVERSITY

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CERTIFICATE

This is to certify that thesis entitled **"Cardiac Anomalies detection from ECG",** is a bona fide work done by Mr. Vijay Kumar Patel (Roll No: 2K14/SWT/516) in partial fulfillment of the requirements for the award of **Master of Technology Degree in Software Technology** at Delhi Technological University, Delhi, is an authentic work carried out by him under my supervision and guidance. The content embodied in this thesis has not been submitted by him earlier to any University or Institution for the award of any Degree or Diploma to the best of my knowledge and belief.

DATE:

SIGNATURE:

Dr. Ruchika Malhotra
DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING.
DELHI TECHNOLOGICAL UNIVERSITY, DELHI 110042

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Vijay Kumar Patel
M.Tech (Software Technology)
2K14/SWT/516

ABSTRACT

Cardiac diseases are one of the leading cause of death across the world. Identification of many heart diseases involving irregular heartbeat relies upon the reading of an ECG. An ECG is the electrical signal of the heart that is taken using electrodes put on the skin. Ideally 12-lead ECG on the patients and on the chest. The magnitude of the heart is then measured from the twelve different angles and is recorded over a period of time. In this project we propose efficient technique to automatically extract the ECG features.

In this work we are able to identify at least 9 diseases (ischemia peaked, ischemia2, ischemia3, ischemia4, stemi1, stemi2, stemi3, stemi4 and stemi5) from data collected by ECG in raw form or in biometric form. The efficiency of the results is as high as 70% for regular (non-noisy) data.

All the ECG databases used here are from the Pysionet's [1] online databases.

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Chapter 1. Introduction

1.1 Introduction and Motivation

Studies conducted by WHO and CDC in the US have revealed that heart diseases are the leading cause of death among US citizens [2]. As of 2015, at least 11.7% of adults have been diagnosed with some form of heart disease [3]. Irregular heartbeat or Arrhythmia, in particular, is a problem associated with irregular rate of heartbeat. Diagnosis of this particular condition involves an electrocardiogram (ECG) [1]. An ECG measures the rhythm of heartbeat by measuring the timing and strength of electrical signals, essentially representing the electrical signature of heart. This signature can then by analyzed for presence of abnormalities.

In this work we analyze raw data from an ECG in the form of voltages, to identify the patterns which relate to a certain heart disease. This is done by extracting important features called P, Q, R, S and T points from the raw data. We are also able to detect heart disease from biometric, as well as ECG raw data. After the analysis, we are able to predict at least 9 type of diseases involving Ischemia (ischemia1, ischemia2, ischemia3, ischemia4) and STEMI (stemi1, stemi2, stemi3, stemi4 and stemi5).

In this, research we can diagnose the decease at primary level by own self and if do not find any suspicious pattern no need to consult with doctor. If found any suspicious pattern we can consult with doctor through email/call and send this report to doctor, he/she can suggest over call/email. No need to go and meet physically with Doctor. This software will reduce the effort and time of patient.

The ECG signal is composed of multiple cardiac cycles, and each cycle consists of P, Q, R, S, T andU. as shown in figure 1.

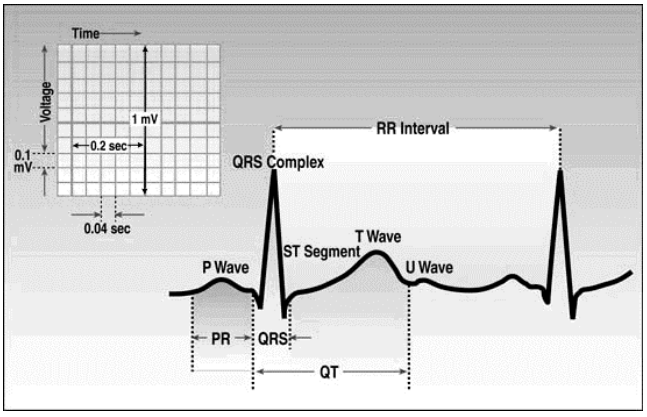

Figure 1. ***Description of one cardiac cycle of an ECG signal. [4]***

1.2 Goals of the Study

This thesis examines the nine types of cardiac anomalies currently. We are also able to detect the cardiac anomalies in biometric format, which is in the ECG report format.

The goals of this project is to provide the efficient method which should be able to detect all kind of cardiac anomalies and also able to read the user ECG report which is very challenging because the biometric (ECG soft) copy sometimes is not able to convert into software readable format because sometimes due to bad background ECG wave is not clear and sometimes it is very difficult to remove the background to extract the clear ECG wave.The beauty of this algorithm is that we can easily port this algorithm in the smart phone and user will be able to check their heart related parameter at their home itself before going to hospital in critical stage. Or he can take this as first opinion and share the test result online to the doctor based on this result doctor can suggest her for next action

1.3 Thesis Organization

This thesis work is divided into 5 different chapters. Starting with the abstract,

Chapter1 gives the brief introduction about the issues discussed in this study. The chapter explains the need and use of detection of cardiac anomalies detection.In this work we analyze raw data from an ECG in the form of voltages, to identify the patterns which relate to a certain heart disease. This is done by extracting important features called P, Q, R, S and T points from the raw data. We are also able to detect heart disease from biometric, as well as ECG raw data. After the analysis, we are able to predict at least 9 type of diseases involving Ischemia (ischemia1, ischemia2, ischemia3, ischemia4) and STEMI (ST elevation myocardial infarction) (stemi1, stemi2, stemi3, stemi4 and stemi5).

Chapter2 describes the related work and scope of improving in the existing methodologies.

This chapter gives the brief information about how this project is different from already existing methodologies. This project defines the new method to detect the cardiac anomalies.In this project we are able to calculate heart beat as well as various cardiac problems. Although extensive studies have been conducted for ECG based clinical applications, the research for ECG-based biometric recognition is still in its infant stage. In this chapter, we provide a review of the related works.

Chapter3 This chapter describes about proposed work. This includes the detail description about the algorithm and flow diagram. This chapter explain about the details description about each cardiac anomalies detection with clean pseudo code step by step.

Chapter4 This chapter describes about experiment and results of this project. Experiment is based on live data taken from each person and patient this live data is in the raw ECG format or biometric format that is ECG report. This raw data of each person is analyzed by the algorithm by comparing with the master database and gives the result of each person report whether the person ECG is normal or abnormal. It also gives the result of heart rate and various ECG parameter like ST(distance between S and T), QRS, and QT parameter.

Chapter5 This chapter describes about conclusion and future work.In the future work we will be able to identify the all kind of heart disease and their pattern. We will be also able to predict human life with the help of ECG parameter.

Chapter 2. Related Work

Currently all the smart devices and gear watch havea feature where they do heart beat calculation but they are not able to detect any cardiac problem based on that information.

In this project we are able to calculate heart beat as well as various cardiac problems. Although extensive studies have been conducted for ECG based clinical applications, the research for ECG-based biometric recognition is still in its infant stage. In this section, we provide a review of the related works.

Biel et al. [3] are among the earliest effort that demonstrates the possibility of utilizing ECG for human identification purposes. A set of temporal and amplitude features are extracted from a SIEMENS ECG equipment directly. A feature selection algorithm based on simple analysis of correlation matrix is employed to reduce the dimensionality of features. Further selection of feature set is based on experiments. A multivariate analysis-based method is used for classification. The system was tested on a database of 20 persons, and 100% identification rate was achieved by using empirically selected features. A major drawback of Biel et al.'s method is the lack of automatic recognition due to the employment of specific equipment for feature extraction. This limits the scope of applications.

MTM Ltd. developed the 'Smart Patient Care System (SPaCS)' with the support of the Ministry of Knowledge Economy of Korea [4]. SPaCS is a healthcare system that is consisted of two applications such as PCS (Personal Care Service) and PRM (Patient Record Monitoring & Feedback System) in order to manage personal health using smartphones.

Pukyong University in Korea developed the 'Wearable ECG module (USN Lab ver. 2.0)' which does not require electrodes on bare skin [5]. This module can be made into t-shirts which patients can easily put on and take off, and test results can be transferred wirelessly in real-time.

The medical engineering researcher team in UBC (University of British Columbia) developed a portable pulse oximeter - Phone Oximeter - using smartphones and released laboratory-level technology [6]. As shown in Figure 1, the Phone Oximeter measures oxygen levels in your bloodstream, heart rate, respiratory rate, and can to send the measured values to the remote hospital.

Chapter 3. Proposed work

3.1 Algorithm Description

The algorithm consists of following steps:

1) We took the raw ECG from the device. These devices must provide the ECG values in the voltage form with the sampling rate.

2)This algorithm is also able to process the biometric ECG, which is soft copy or scan copy of the ECG report.

3) After getting the biometric ECG, this algorithm converts the biometric ECG in raw ECG format so that same algorithm can work in both. Converting biometric ECG to voltage ECG require lot of image processing like, extracting sample frequency, removing back ground lines and noise and fetching only important ECG signal.

4) After getting ECG signal we give input ECG data to our algorithm. Which perform below task.

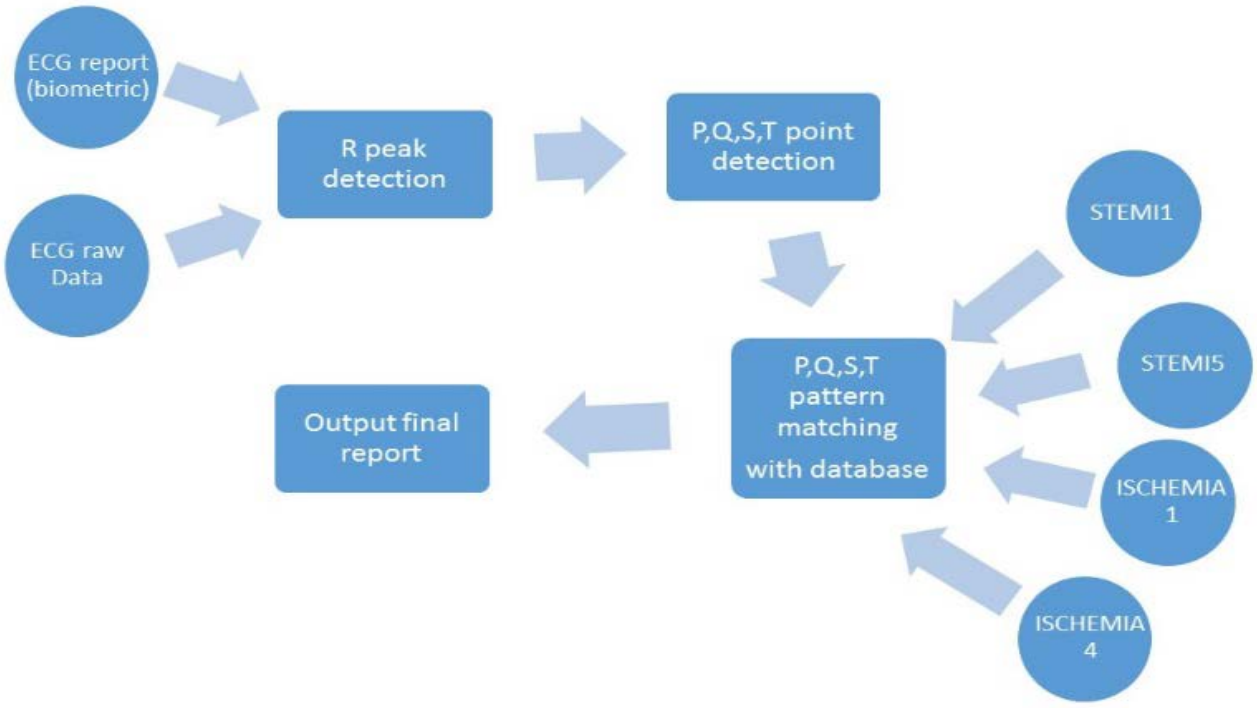

Figure 2.*Workflow diagram of the algorithm.*

Algorithm (anomalies detection from Raw ECG)

D <- ECG data

D(x,y) x is voltage domain and y is time domain

- **Step1:** Initialize the data

  Reset all the global variable to zero. Variable like stemi, RR window, P, Q, R, S, T point etc.

- **Step2:** Copy raw ECG data to local data structure.

  local data <---- raw ECG data

- **Step3:** Prepare ECG data

  In this stage the ECG data D is sorted based on x factor.

  Quick sort algorithm is used to sort the ECG data in log n time.

- **Step4:** Extract R Peaks

  This is very important step of this algorithm which is used to extract the R peaks from the ECG data D(x,y)

  Number of R peaks are decided based on the data length. RR window is used to scan the valid R peaks.

  Default RR window size is > 40 and < 200. After detecting first R peak RR window size is adjusted.

- **Step5:** Sort R Peaks

  Sort extracted R peaks based on the y parameter.

- **Step6:** Extract P, Q, S and T point taking reference of R Point.

  Q Point <--- First Left Minima from R Point.

  P Point <--- Left Maxima after Q Point.

  S Point <--- First Right Minima.

  T Point <--- Right Maxima after S Point.

Algorithm Biometric (anomalies detection from Biometric)

C <-- color ECG report

G <-- Gray Scale

B <-- Black and white

A <-- image having only ECG wave and background horizontal and vertical line.

D <-- image only have ECG wave removed all background.

F_{req}<-- Sampling frequency.

Step1: Take the scan copy or soft copy of ECG report (report.jpg)

G <-- C (Color to Gray)

B <-- G (Gray to Black and White)

Step2: Apply Morphological operation (Erosion and dilation) to get A image.

A <-- (Morphological operation on B)

Step3:

F_{req}<-- Extract sampling frequency from the horizontal and vertical line.

Step4: Removing horizontal and vertical background from the A image

D <-- A (Removing horizontal and vertical line)

Step5: Extract x and y parameter from D with the help of sampling frequency.

E(x, y) <-- D

Step6: Apply E(x,y) to input of Algorithm (anomalies detection from Raw ECG)whichis already explain in the previous topic.

Morphological Operations in biometric process

Binary image may have multiple non-perfections due to noise. In the biometric, process of this project color ECG report is input to the system this color image first get converted to the gray scale image using predefined the image processing library. This gray image is than converted to binary image using image processing predefined library. This binary image is nothing but black and white image. One is represent to black and zero is represent to white. Now this black and white image having the background horizontal and vertical line and ECG wave. But this black and white image may be not perfectly clear due to quality of the report taken or due to human error or due to noise introduced while converting image to gray and black and white. To remove the noise or getting clear image we need to perform some image processing operation like morphological techniques.

Morphological operation is based on the order relative of pixel values not on their amplitude or some numerical values. And this specially used and suit in binary image that's why we need to convert color image to binary image. In morphological operation, probe techniques is used that have small size or template called a structuring element. The structure element is placed on all the possible locations in the image and it is compared with the neighboringof pixels.

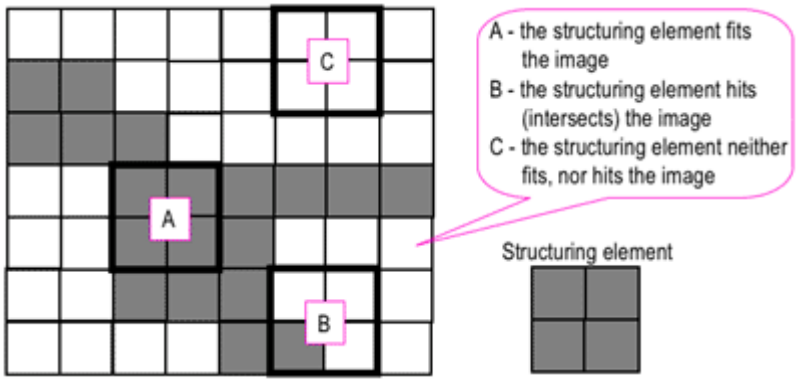

Figure 3 Probing of an image with a structuring element (white and grey pixels have zero and non-zero values, respectively).

P Point

The P Point is the peak point of the P wave shown in Figure4. The P wave shows the depolarization atrial. The P wave comes when the sinus node, known as sinoatrial node, that create an action potential of atria.The P wave should be upright in the lead 2 if action potential originating from the SA node.

Normal P Point:

- The lead to check the P wave is V1.
- The signal which is positioned before Q Point.
- This signal amplitude should not be more then R signal amplitude.
- The P point called normal if it is not more than one box of standard unit.
- The length of P wave should not be more than 1 second.

Abnormal P Point:

- If Psignal size (from where it starts and end) becomes more than one box of ECG standard than it is called the abnormal P Point.

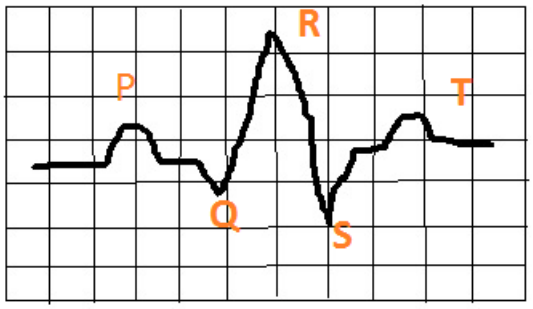

Figure 4 P, Q, R, and S and T Point

Q Point

The Q Point is the peak point of Q wave shown in Figure 4. The Q point or Q wave is the signal which comes after the P signal and before the R signal.

Normal:

- Q wave is very small or may be some times absent
- The Q point is normal if its peak point amplitude is lower then its left P point and it size should be greater than to 1 box size.

Abnormal:

- The Q wave is only recognize or measurable if its size is greater than or equal to the 1 box size of the ECG standard.
- Its length is greater than or equal to the one third of the QRS complex.
- Its length is greater than one fourth of the R wave.

Abnormal Q waves: Shows presence of infarct

QRS

QRS complex as shown in Figure 5is the distance between peak point of Q signal and peak point of the S signal.

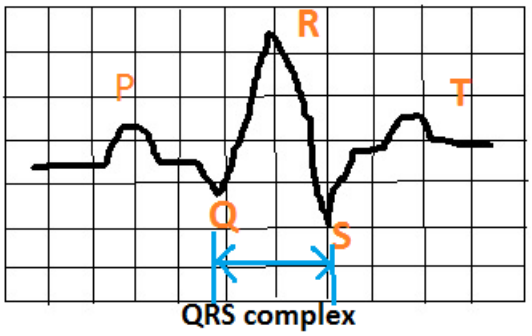

Figure 5 QRS complex

Naming convention:

- **Q Point:** the peak point of Q signal which is negative in amplitude relative to the P and R Point.
- **R Point:** This is the middle component of the QRS complex which has more amplitude than the Q and S Point.
- **S Point:** The last signal or point of the QRS complex.

Normal

Distance or time duration: Normal range of QRS complex is 0.08 second to 0.12 seconds.

Contour is same between beats

Abnormal

Distance or time duration:

Delay in conduction through the ventricles leads to prolongation of QRS complex

PR interval

Represents: PR interval is distance between peak point of P wave and peak point of Q interval, which include the Q wave also (see Figure 6).

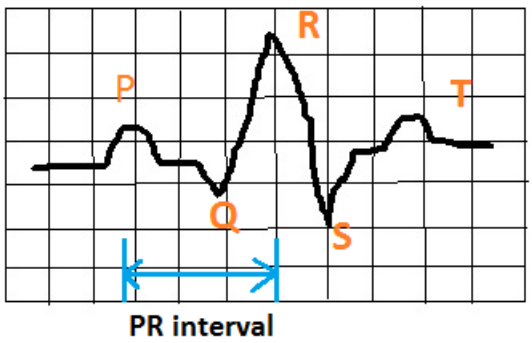

Figure 6 PR Interval

Normal distance in y axes or time duration: Normal duration of PR interval is 0.12-2.0 seconds (3 to 5 horizontal boxes).

Abnormal duration: Abnormal duration of PR interval is > 2.0 second

ST segment

ST segment is very important segment of ECG report which basically measured the distance between S signal peak point and T signal peak point.

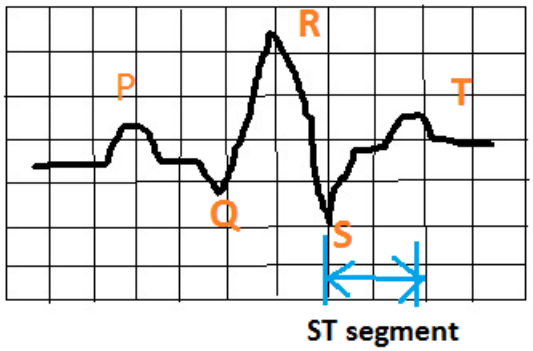

Figure 7 ST Segment

Abnormal ST segment:

This segment is used to identify the disease like pathology such as myocardial infarctions (elevations) and Ischemia (depressions).

ST segment elevation

- Infarction is the result of deviation of ST segment.
- ST segment elevation is a current of injury - can be seen in **pericarditis** as well as Prinzmetal's angina.

ST segment depression

- Ischemia is detected by the ST segment depression.

QT Distance

QT is the important component of the ECG signal it is distance between peak point of Q wave and peak point of the T signal which is clearly shown in the Figure8.

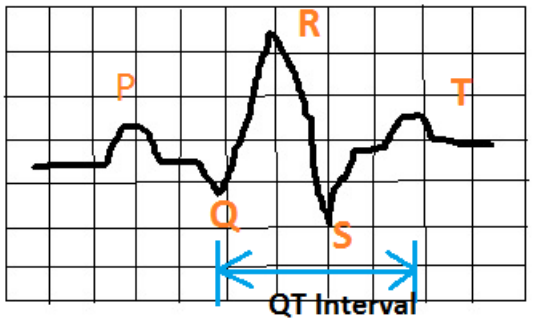

Figure 8 QT Interval

QT distance

QT = QT + 1.75 (ventricular rate - 60)

Normal:

The normal QTc is approximately 0.41 seconds. It tends to be slightly longer for females and increases slightly with age.

Abnormal:

Prolonged QT

- Quinidine Toxicity
- Hypocalcemia

Sampling Frequency:

Sampling frequency or sample rate is the number of samples taken of ECG wave in one second. Sampling frequency is very important because based on this actual heart rate. P, Q , R ,S and T can be measured.

3.2 Methodology

Algorithm description:

1. INPUT: ECG raw data OR ECG report soft copy (biometric).
2. R_{peak} detection from raw ECG data.
3. P, Q, S and T point detection.
4. P, Q, S, T re-calculation based on pattern matching with existing diseases.
5. OUTPUT: Name of disease identified.

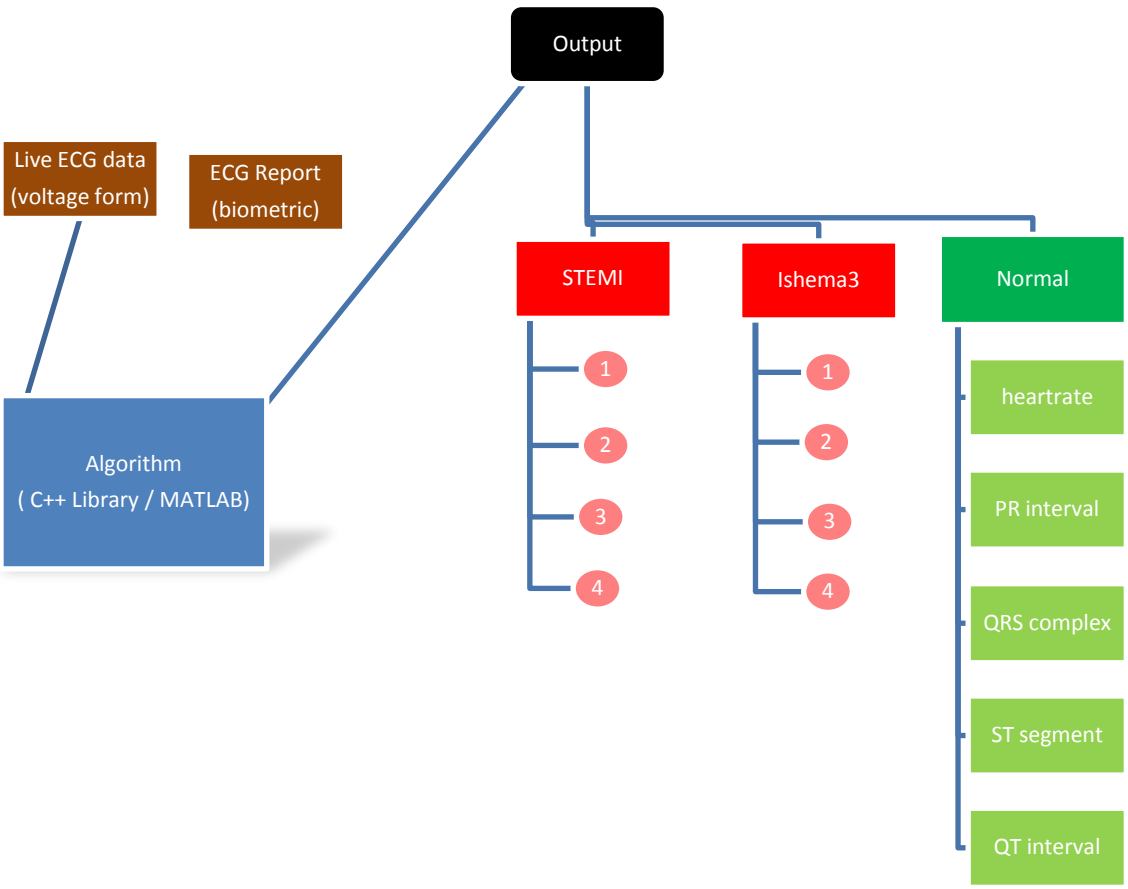

Figure 9. ***Algorithm overview.***

From the raw data we identify 10 or more R_{peak}s and each set of 10 cycles is compared with each disease pattern and then we return percentage matching for each set. P, Q, R, S and T points denote maxima or minima, which can be calculated taking the reference of R_{peak}. We calculate P and Q as left from R_{peak} and S and T will lie to the right. There will be window size to calculate P, Q and S, T. It means P, Q and S, T must come under this window size. So, selection of window size is very important. An example is shown below:

Figure10.*A comparison of Stemi5 pattern with normal ECG (shown in middle). Not a match. Comparison with rightmost pattern shows a match.*

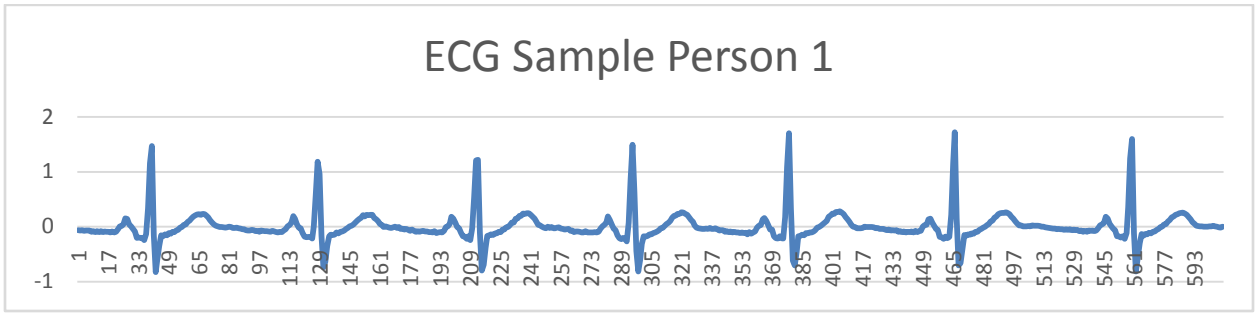

Figure 11. ***ECG Sample 1***

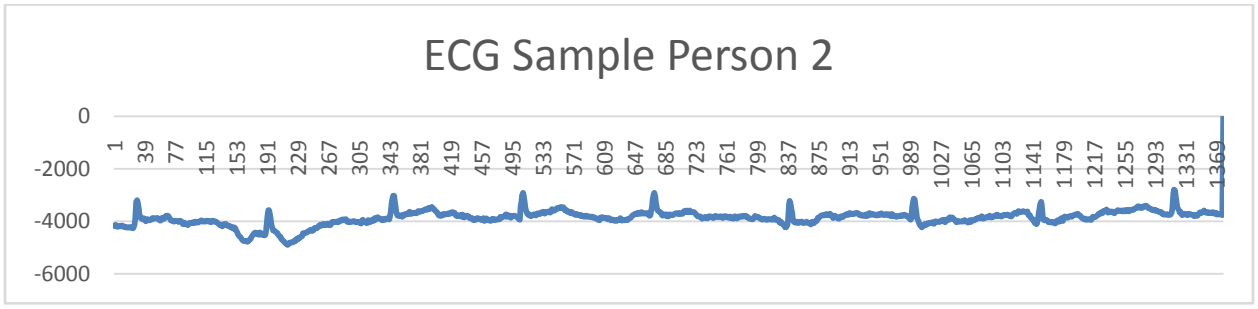

Figure 12 ECG Sample 2

In figure 10, the pattern matching is based on relative position of P, Q, R, S and T point. The algorithm employed to do the same is based on fuzzy logic where we check how much percentage of sample data is matched with stored data.

From the sample data, as shown in Figure 11 and 12, we try to find if collected sample P, Q, R, S and T points follow the same pattern and relative position with respect to the existing data base P-Q-R-S-T points.

For Rpeak detection, various algorithms can be used, combined with base line wandering and noise removal techniques, like Hilbert transform [7].

List of various cardiac anomalies:

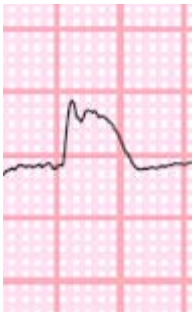

Figure 131RBBB LAFB atrial fib prox LAD occlusion

Ischemia is a type of disease in which blood supply to heart muscles gets restricted. This disease can also be life threatening in many cases.

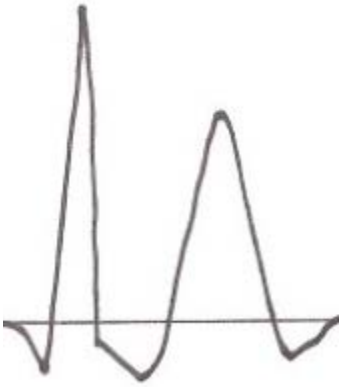

Figure 14ischemia peaked

In this type of ECG (Figure 14) we observe normal patterns for P, R and T waves. However, Q and S waves are located at almost same level, which should not be the case.

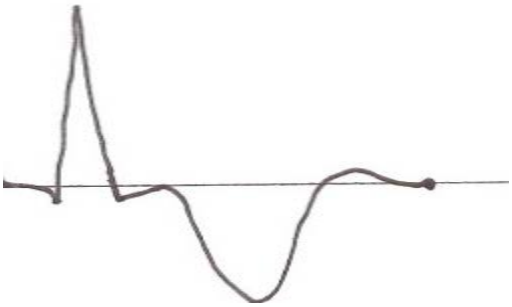

Figure 15ischemia2

In this type of ECG (Figure 15) we observe normal patterns for P, Q, R and S waves. However, T waves are located extreme below from it is normal range which should not be the case.

Figure 16ischemia3

In this type of ECG (Figure 16) we observe normal patterns for P, and Q waves. However, S and T waves are located extreme below from it is normal range which should not be the case.

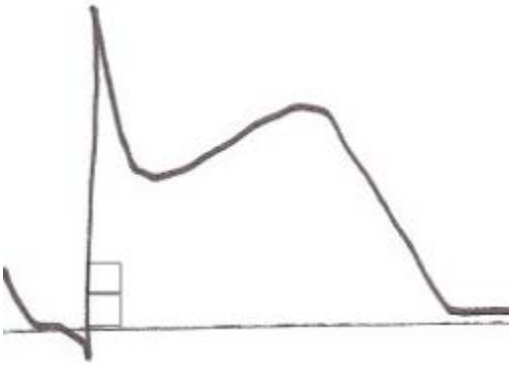

Figure 17ischemia4

In this type of ECG (Figure 17) we observe normal patterns for P, Q and Rwaves. However, S and T waves are located extremely above from it is normal range which should not be the case.

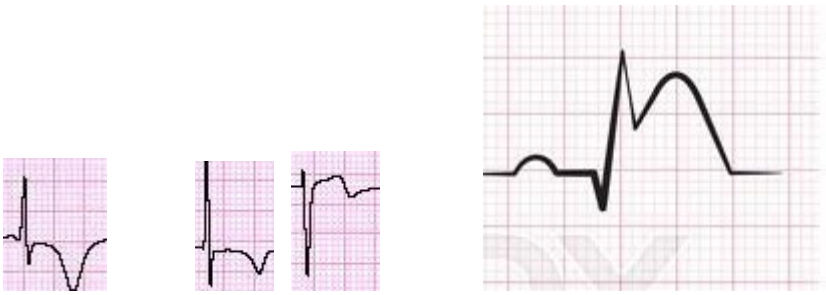

Figure 18. Different STEMI patterns which can be detected.

stemi1 stemi2 stemi3 stemi5

The R peak, heart rate and Feature detection implementation:

Once the device is connected to the human, the device start sending the raw ECG report in voltage form we can use this information live or we can first save the raw information in some files and after that give input to the our software.

1. Threshold detection: the computer receives 1000 samples in one second, but not all the samples contain the highest amplitude. To save the computational time we have generated a threshold. So, the system will start to scan when it receives the threshold value in order to find the highest amplitude. The procedure to detect the threshold is as follows:

a. First it receives samples for 3 seconds and identifies Maximum and Mean amplitudes.
b. If the Maximum amplitude is getter than the Mean amplitude, then from this range (Mean to Maximum), 2nd Mean amplitude is calculated. Otherwise 1st Mean is considered as the threshold.
c. Again, if the Maximum amplitude is still getter than the 2nd Mean, then 3rd Mean amplitude is calculated from the range between the 2nd Mean and the Maximum amplitudes. This 3rd mean value is treated as a threshold otherwise 2nd Mean is considered as the threshold.

2. R peak detection: Detecting R peak is very simple and also very important because based on this all other important parameter can be measured. R peak the point which is highest in the amplitude among the P, Q, S and T point. The temporary peak is being replaced as long as the next sample value is higher than it. When the sample value becomes lower than the peak, the system determines the amplitude value as the R peak. The next pick detection again starts when the sample value becomes less than threshold.

Chapter 4. Experiment and Results

In this study, I am able to implement the heart rate and nine type of heart disease. The input data is taken from the EGG devices or can be taken from various site ex;https://physionet.org/pn3/ecgiddb/ .

The experiment is taken from three or four person. The raw ECG voltage form is collected and the ECG report is collected from existing ECG device. The ECG report is taken multiple times. After that algorithm is run on the collected raw ECG sample. Below are the sample data for experiment.

In the same way the ECG report in biometric form is taken from the same set of data and converted into raw ECG form and then input to the algorithm and the result is again compared with the ECG devices.

```
	doubleinput data [9999] = {
		-0.06, -0.065, -0.06, -0.075, -0.065, -0.07, -0.07, -0.09, -0.08, -0.095, -
0.08, -0.095, -0.08, -0.095, -0.085, -0.09, -0.09, -0.1, -0.085, -0.105, -0.09, -0.045,
0.005, 0.015, 0.045, 0.155, 0.14, 0.045, 0.005, -0.04, -0.085, -0.2, -0.195, -0.2, -0.2,
-0.24, -0.13, 0.34, 1.155, 1.47, -0.155, -0.825, -0.59, -0.35, -0.155, -0.17, -0.14, -
0.155, -0.115, -0.125, -0.09, -0.095, -0.065, -0.055, -0.015, -0.005, 0.035, 0.045, 0.09,
0.11, 0.15, 0.18, 0.205, 0.225, 0.23, 0.22, 0.235, 0.23, 0.2, 0.17, 0.12, 0.075, 0.04,
0.02, 0.005, -0.005, -0.005, -0.01, -0.015, -0.01, 0, -0.005, -0.02, -0.02, -0.015, -
0.025, -0.035, -0.045, -0.045, -0.06, -0.065, -0.07, -0.055, -0.06, -0.08, -0.075, -0.09,
-0.065, -0.075, -0.08, -0.08, -0.085, -0.09, -0.075, -0.085, -0.095, -0.105, -0.09, -
0.095, -0.07, -0.045, 0.005, 0.03, 0.07, 0.195, 0.145, 0.05, -0.015, -0.025, -0.115, -
0.18, -0.19, -0.185, -0.185, -0.215, 0.01, 0.575, 1.185, 0.96, -0.16, -0.74, -0.64, -
0.35, -0.175, -0.145, -0.15, -0.145, -0.105, -0.12, -0.09, -0.085, -0.07, -0.04, -0.02,
0.005, 0.02, 0.045, 0.08, 0.115, 0.14, 0.165, 0.21, 0.19, 0.22, 0.21, 0.215, 0.215, 0.16,
0.135, 0.1, 0.05, 0.035, -0.005, 0.005, -0.005, -0.015, -0.02, -0.01, 0, -0.02, -0.005, -
0.04, -0.035, -0.05, -0.04, -0.055, -0.075, -0.05, -0.075, -0.09, -0.08, -0.09, -0.08, -
0.075, -0.085, -0.085, -0.095, -0.095, -0.105, -0.08, -0.115, -0.1, -0.095, -0.1, -0.075,
-0.005, 0.01, 0.055, 0.185, 0.145, 0.075, -0.005, -0.025, -0.11, -0.175, -0.18, -0.22, -
0.175, -0.24, -0.03, 0.53, 1.21, 1.22, -0.105, -0.795, -0.69, -0.375, -0.165, -0.155, -
0.135, -0.15, -0.12, -0.12, -0.09, -0.095, -0.05, -0.05, -0.01, -0.005, 0.03, 0.08,
0.075, 0.145, 0.155, 0.2, 0.2, 0.24, 0.235, 0.245, 0.245, 0.215, 0.18, 0.15, 0.09, 0.035,
0.025, 0, -0.015, -0.03, 0, -0.02, -0.005, -0.025, -0.03, -0.015, -0.01, -0.035, -0.04, -
0.05, -0.045, -0.04, -0.075, -0.065, -0.095, -0.085, -0.085, -0.09, -0.1, -0.1, -0.08, -
0.105, -0.105, -0.1, -0.105, -0.095, -0.1, -0.09, -0.035, 0.01, 0.035, 0.07, 0.19, 0.125,
0.045, -0.035, -0.06, -0.155, -0.21, -0.225, -0.2, -0.215, -0.265, 0.07, 0.865, 1.495,
0.625, -0.44, -0.815, -0.6, -0.31, -0.175, -0.18, -0.165, -0.135, -0.135, -0.115, -0.105,
-0.085, -0.06, -0.03, -0.02, 0.015, 0.05, 0.07, 0.105, 0.165, 0.2, 0.205, 0.235, 0.235,
0.265, 0.26, 0.235, 0.215, 0.17, 0.125, 0.09, 0.025, -0.015, -0.03, -0.035, -0.04, -0.04,
-0.035, -0.04, -0.02, -0.04, -0.04, -0.03, -0.045, -0.065, -0.06, -0.06, -0.09, -0.08, -
0.095, -0.085, -0.105, -0.09, -0.1, -0.105, -0.115, -0.1, -0.115, -0.11, -0.135, -0.095,
-0.125, -0.105, -0.085, -0.015, 0.02, 0.03, 0.135, 0.16, 0.105, 0.03, -0.05, -0.05, -
0.17, -0.205, -0.215, -0.175, -0.21, -0.215, 0.175, 1.09, 1.7, 0.335, -0.615, -0.705, -
0.46, -0.175, -0.165, -0.145, -0.155, -0.115, -0.12, -0.105, -0.105, -0.085, -0.06, -
0.015, -0.005, 0.02, 0.05, 0.08, 0.105, 0.18, 0.205, 0.24, 0.235, 0.27, 0.27, 0.28, 0.26,
0.23, 0.175, 0.135, 0.09, 0.045, 0, -0.005, -0.025, -0.025, -0.025, -0.02, 0, -0.005, -
```

```
0.005, -0.005, -0.005, -0.01, -0.025, -0.02, -0.04, -0.04, -0.04, -0.05, -0.06, -0.05, -
0.065, -0.06, -0.07, -0.06, -0.09, -0.08, -0.095, -0.085, -0.1, -0.09, -0.095, -0.085, -
0.1, -0.075, -0.095, -0.08, -0.075, 0, 0.03, 0.035, 0.135, 0.145, 0.07, 0.015, -0.045, -
0.055, -0.185, -0.19, -0.22, -0.18, -0.21, -0.185, 0.22, 1.15, 1.72, 0.155, -0.7, -0.66,
-0.405, -0.15, -0.16, -0.135, -0.145, -0.12, -0.125, -0.09, -0.09, -0.055, -0.04, -0.015,
0, 0.03, 0.05, 0.095, 0.11, 0.165, 0.19, 0.23, 0.245, 0.255, 0.255, 0.265, 0.255, 0.23,
0.185, 0.145, 0.1, 0.06, 0.025, 0.025, 0.01, 0.01, 0.01, 0.015, 0.01, 0.025, 0.02, 0.02,
0.02, 0.015, 0, 0, -0.01, -0.015, -0.02, -0.03, -0.035, -0.035, -0.045, -0.04, -0.045, -
0.045, -0.055, -0.045, -0.055, -0.045, -0.06, -0.05, -0.06, -0.055, -0.08, -0.065, -0.09,
-0.075, -0.09, -0.07, -0.075, -0.065, -0.08, -0.065, -0.03, 0.025, 0.04, 0.065, 0.18,
0.145, 0.055, 0.015, -0.035, -0.06, -0.175, -0.17, -0.195, -0.175, -0.22, -0.115, 0.355,
1.24, 1.595, -0.115, -0.815, -0.565, -0.3, -0.13, -0.16, -0.13, -0.135, -0.11, -0.12, -
0.09, -0.085, -0.055, -0.04, -0.005, 0, 0.04, 0.05, 0.095, 0.125, 0.17, 0.19, 0.22, 0.23,
0.245, 0.25, 0.26, 0.24, 0.22, 0.175, 0.135, 0.085, 0.055, 0.02, 0.015, 0.01, 0.01, 0, 0,
0, 0.01, 0.005, 0.02, 0.01, 0, -0.01, -0.015,
        };
```

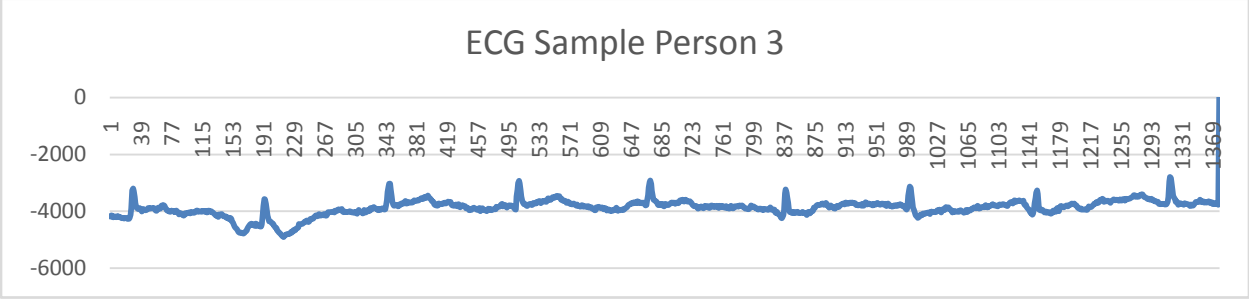

Figure 19 Sample ECG Person 3

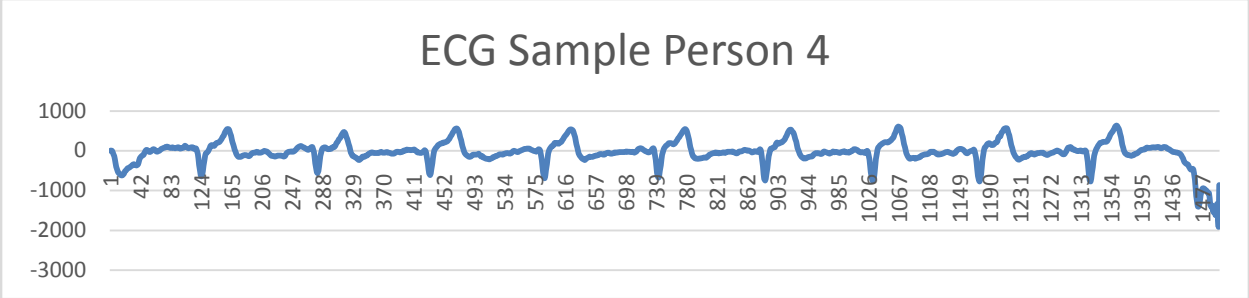

Figure 20 Sample ECG Person 4

Results

The table below gives the result for 3 people. In this experiment ECG data is taken from three different persons. The number of samples is based on number of R peaks which should be more than 100 R peaks. These three persons have different types of cardiac anomalies like first person has normal ECG, second person has STEMI5 cardiac anomalies and third person has ISCHEMAI1 type cardiac anomalies.

After taking the ECG raw data and ECG report soft copy of each person this data input to the algorithm and result is compared with the ECG device. As we already know about each person cardiac anomalies type so FP and FN are calculated accordingly.

Efficiency or % Matching is calculated as below:

Efficiency = 100 - (100*(FP+FN))/(No of R Peak Sample);

The efficiency for the result collected is about 70% in case of regular data. For noisy data, the efficiency may drop.

***Table 1*Disease detection with different R peak samples and comparison with ECG device at forties hospital.**

Person ECG data	***Rpeak Sample***	***STEMI1***	***STEMI5***			***ISCHEMIA1***	***NORMAL***			***Comparison with ECG device***		
			FP	*FN*	*%matching*		FP	*FN*	*%matching*	FP	*FN*	*%matching*
Person1	100	-	-			-	3	8	90	2	7	91
	110	-	-			-	7	7	88	9	10	86
	100	-	-			-	5	9	86	7	6	83
	120	-	-			-	5	10	90	5	11	90
	110	-	-			-	2	4	94	2	4	94
	200	-	-			-	8	1	95	9	1	93
	210	-	-			-	3	5	96	3	5	96
	150	-	-			-	6	9	90	6	9	90
	160	-	-			-	4	7	96	4	7	96
	150	-	-			-	3	6	96	3	6	96
Person2	200	-	13	18	85	-	-			13	18	85

	210	-	17	12	84	-			-	17	12	84
	200	-	15	19	83	-			-	15	19	83
	220	-	15	10	88	-			-	15	10	88
	210	-	21	14	83	-			-	21	14	83
	200	-	18	11	75	-			-	18	11	75
	210	-	13	15	75	-			-	13	15	75
	250	-	16	19	83	-			-	16	19	83
	260	-	14	11	90	-			-	14	11	90
	250	-	13	16	80	-			-	13	16	80
Person3	100	-	-			11	9	80	-	15	11	82
	110	-	-			7	6	87	-	9	6	85
	100	-	-			5	13	82	-	6	13	83
	120	-	-			13	8	82	-	12	8	85
	110	-	-			11	3	86	-	10	3	82
	100	-	-			5	11	84	-	5	11	84
	210	-	-			13	15	75	-	12	15	76
	150	-	-			12	9	83	-	11	19	73
	160	-	-			8	11	90	-	8	11	90
	150	-	-			13	6	83	-	13	6	83

Table 2 below is the experiment result of heart rate measurement for different person and comparison with ECG device.

Heart rate = (RR Interval*Frq)/60

RR Interval is the average distance between two R peak wave.

Frq is the sampling frequency.

Table 2**Heart rate measurement for different person and comparison with ECG device.**

Sample No:	Person Name	HR from algorithm	ECG Report	Report of ECG device
	vijay	77	NORMAL	76
2	ajay	80	NORMAL	81
3	arpit	84	NORMAL	83
4	vijay	74	NORMAL	74
5	Akashdeep	89	NORMAL	87
6	Rahul	90	NORMAL	96
7	Harshit	69	NORMAL	72
8	Naresh	78	NORMAL	78
9	vijay	75	NORMAL	75

Table 3**Comparison from ECG device reading**

Ischemia peaked	ischemia2	ischemia3	ischemia4	stemi1	STEMI2	STEMI3	STEMI4
FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

Table 4 Comparison from ECG device reading

Sample No:	Person Name	HR from algorithm	from ECG device

1	vijay	77	76
2	ajay	80	85
3	arpit	84	83
4	vijay	74	77
5	Akashdeep	89	89
6	Rahul	90	90
7	Harshit	69	66
8	Naresh	78	78
9	vijay	75	75

Comparison with existing Algorithm

Result Comparison with existing algorithm :- This algorithm is based on the voltage value which is basically amplitude denote the Y coordinates and time which is basically sampling frequency denote the X coordinates. This approach is very simple and easy to calculate with the good efficiency because with this algorithm we can utilize the existing rich image processing API.

The beauty of this algorithm is that the same code is work for biometric report. Till now there is no project which has implemented the biometric ECG report.

The main problem with this algorithm is that for noisy data result may be not proper and efficiency may drop because with noisy data it will be difficult to identify the R peaks. Other problem with this algorithm is that this algorithm is mainly based on the R peaks, based on R peaks others maxima and minima are calculated so if R peaks is not proper then other parameter may get affected.

Other project or algorithm based on purely digital signal processing and special hardware is required to calculate the all the waves in frequency domain. This algorithm is based on the simple two-dimension approach X coordinate time and Y coordinate for amplitude.

Chapter 5. Conclusion and Future Work

Right now our algorithm can identify 9 types of diseases with 70% efficiency. In the future we can extend same technique for identifying other diseases as well.

In the future work we will be able to identify the all kind of heart disease and their pattern. We will be also able to predict human life with the help of ECG parameter.

The beauty of this algorithm is that we can easily port this algorithm in the smart phone and user will be able to check their heart related parameter at their home itself before going to hospital in critical stage. Or he can take this as first opinion and share the test result online to the doctor based on this result doctor can suggest her for next action.

With the help of this project we can design the wearable small in size hardware which can be used for health purpose and this device will also be able to connect to the other smart device. In this paper, we can designed and implemented a wearable ECG measurement device and an application system based on the Android OS platform. This device can monitor and diagnose patients' heart conditions in real time by having them wear a sports-shirt with a compact ECG sensor. In addition, the application provides graphical information with personal history management tools and an automatic emergency call system. Further study and improvement are needed for less energy consumption and more accurate measurements.

References

[1] P. S. Addison, The illustrated wavelet transform handbook, IOP Publishers, 2002.

[2] H. Rabbani, M. P. Mahjoob and A. R. Farahabadi, "Peak Detection in Electrocardiogram Signal Based on an Optimal Combination of Wavelet Transform, Hilbert Transform, and Adaptive Thresholding," *Journal of Medical Signals and Sensors,* vol. 1, no. 2, pp. 91-98, 2011.

[3] R. J. Huzar, Basic Dysrhythmias, Interpretation and Management, C.V. Mosby Co., 1988.

[4] S. Z. Mahmoodabadi, "ECG Feature extraction using Daubechies Wavelet," in *Proceedings of 5th IASTED*, 2005.

[5] C. Li, C. Zheng and C. Tai, "Detection of ECG Characteristic Points using Wavelet Transforms," *IEEE Trans. Biomed. Eng.,* vol. 42, no. 1, 1995.

[6] K. Prasad and J. S. Sahambi, "Classification of ECG Arrhythmias using Multi-Resolution Analysis and Neural Networks," *IEEE Trans. Biomed. Eng.*, 2003.

[7] J. P. Martínez, R. Almeida, S. Olmos, A. P. Rocha and P. Laguna, "A Wavelet-Based ECG Delineator: Evaluation on Standard Databases," *IEEE Trans. Biomed. Eng.*, vol. 51, no. 4, 2004.