IoT BASED HEALTHCARE KIT WITH STRESS DETECTION

Project report submitted in partial fulfillment of the requirement for the degree of Bachelor of Technology

in

Computer Science and Engineering/Information Technology

By

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Certificate

Candidate's Declaration

I hereby declare that the work presented in this report entitled **"Iot Based Healthcare Kit With Stress Detection"** in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science and Engineering/Information Technology** submitted in the department of Computer Science & Engineering and Information Technology**,** Jaypee University of Information Technology Waknaghat is an authentic record of my own work carried out over a period from August 2018 to December 2018 under the supervision of **(Dr. Hemraj Saini)** (Associate Professor in Computer Science Department).

The matter embodied in the report has not been submitted for the award of any other degree or diploma.

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This is to certify that the above statement made by the candidate is true to the best of my knowledge.

(Signature)
Dr. Hemraj Saini
Associate Professor
Computer Science
Dated:

ACKNOWLEDGEMENT

The success and final outcome of this project required a lot of guidance and assistance from many people and we are extremely privileged to have got this all along the completion of our project. All that we have done is only due to such supervision and assistance.

We owe deep gratitude to our project guide Dr. Hemraj Saini, who took keen interest on our project work and guided us all along the completion of our project work by providing all the necessary information for developing a good system.

We would also like to extend our sincere thanks to all the staff present in the laboratory for their timely support.

Parinita Kaushal

Suneet Kumar Singh

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LIST OF ABBREVIATIONS

ECG - Electrocardiogram

HRV - Heart Rate Variability

HR - Heart Rate

LPF - Low Pass Filter

HPF - High Pass Filter

Temp - Temperature

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ABSTRACT

Today the world is moving extremely quick and in this quick pacing world overseeing both work and wellbeing have turned into an exceptionally enormous worry for the majority of the general population. Of late stress has been a noteworthy issue in individuals' lives due to the remaining burden, peer strain to perform superior to anything others so as to get advanced, and so on. Long waiting hours for checkups is additionally a major issue.

The above stated issues demand for a healthcare system which can keep a track of the daily routine health parameters that is easy to use, and can report the same to the person concerned. The aim of this model is to enable users to improve their health by analyzing a persons health related problems and reduce healthcare costs by collecting, analyzing and sharing data streams in real time with efficiency. The idea of this project is to eliminate the need of patients to visit the hospital every time they need to check their heart rate, temperature, blood pressure, etc.

This project depicts the construction of low cost IoT based health care kit that can perform stress detection.

CHAPTER 1-INTRODUCTION

1.1 Introduction

Today the world is moving very fast and in this quick pacing world maintaining a balance between both work and health has become a matter concern for many people. Lately stress has been a major problem in people's lives because of the workload, peer pressure to perform better than others in order to get promoted, etc. Long waiting hours for checkups is also a very big issue.

The above expressed issues interest for a wellbeing observing framework which can screen the day by day schedule wellbeing parameters and pulse checking, that is anything but difficult to utilize, and can report the equivalent to the concerned individual. The point of this model is to empower clients to improve their wellbeing by breaking down health related dangers and reduce medicinal services costs by gathering, recording, and sharing information streams progressively and with incredible effectiveness. The possibility of this venture is to dispose of the need of patients to visit the emergency clinic each time they have to check their pulse, temperature, circulatory strain, and so forth.

With the help of this model, time of both the doctors and the patients will be saved along with cutting the cost of healthcare for patients. As the data is available in real time the doctors can help in case of emergency as well.

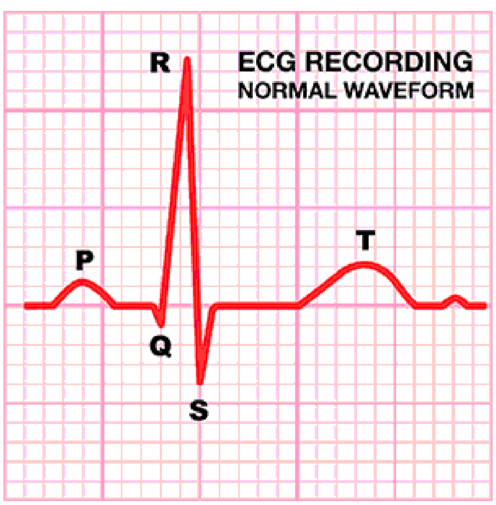
The proposed model measures the body temperature, heart rate, heart rate variability through electrocardiogram. Then this data will be uploaded on the cloud where electrocardiogram results will be used to detect whether the person is having stress or not. And all this data will also be visible to the respective doctors.

Electrocardiogram

An electrocardiogram looks at the heart's electrical activity, rhythm and heart rate. The first peak is known as P wave and it shows atrial contraction.

Then begins the QRS complex with a small downward deflection known as Q then comes the upward deflection known as R wave that is followed by another downward deflection known as S wave. These Q, R and S waves together known as QRS complex indicate ventricular depolarization and contraction.

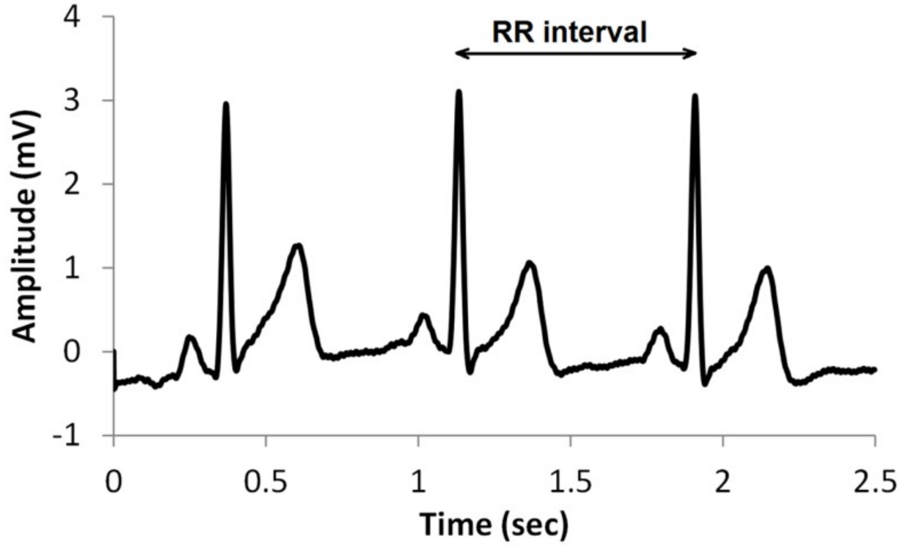
Then, finally comes a small upward deflection known as the T wave that indicates the ventricular re-polarization.



Graph 1.1: Components Of An ECG [8]

Heart Rate Variability

Heart rate variability is defined as the time interval between two successive heart beats or two successive R waves. Generally normal value lies between 60 and 100.



Graph 1.2: RR Interval [9]

1.2 Problem Statement

1. Today people do not have time to go for regular health checkups because of their workload.
2. Cost of healthcare is going up and many people cannot afford to go for regular checkups as they don't have enough money.
3. Ratio of doctors to patients in India is very low. If allopathy doctors alone are considered, the ratio is 1:1596. So it is difficult to get the required health care.
4. In India people don't consider stress or depression as a real problem. Out of 1.3 billion people in India over 5 crore people suffer from stress or depression. Around 1,35,000 people commit suicide because of depression. More than half of them could

have been saved if were diagnosed early. Tests to detect stress or depression are very time taking and people don’t have time.

1.3 Objective

1. Through this project we try to provide people with a healthcare system which can keep track of the daily routine health parameters, that is easy to use, and can report the above parameters to the person concerned.
2. The proposed model empowers users to improve their wellbeing by breaking down health related dangers and diminish human services costs by gathering, recording, investigating and sharing extensive information streams continuously and with extraordinary proficiency.
3. The possibility of this task is to dispense with the need of patients to visit the emergency clinic each time they have to check their pulse, body temperature, blood pressure, and so forth.
4. As the number of patients to number of doctors is very high in India it will help to save time of doctors to focus on more serious problems at hand.
5. In India people don’t take stress or depression seriously and most of them don’t even consider the possibility that they might have it. So they don’t go for a checkup. This device will help to lower this problem as people do not need to go to a doctor specially for this.

1.4 Methodology

1. Body temperature will be measured using a temperature sensor which is attached to raspberry pi.
2. Heart rate will be measured using a heart rate sensor which is attached to raspberry pi.
3. Heart rate variability will be measured using a electrocardiogram (ECG) sensor which is attached to raspberry pi.
4. Then all the data will be stored on cloud, where results of electrocardiogram will be used to detect stress or depression.
5. First there will be preprocessing performed on the signal obtained to remove noise from the signal.
6. Then feature extraction will be performed to take out the desired part from the electrocardiogram signal to perform stress or depression detection.
7. Results of the above procedure will be available on cloud platform for both the concerned doctor and the user.

CHAPTER 2-LITERATURE REVIEW

Through the last decade a large number of studies and research have been conducted to develop a relationship between heart rate variability, through electrocardiogram, and stress or depression. The outcome of mostly all the research has been positive and there is a way stress or depression can be detected using electrocardiogram.

Table 2.1: Summary Of Research Papers

Serial Number	Paper Name	Authors	Date of Publication	Advantages	Disadvantages
1	Depression and Heart Rate Variability in Patients With Stable Coronary Heart Disease [1]	Anil Gehi, MD, Dennis Mangano, PhD, MD, Sharon Pipkin, MPH, Warren S. Browner, MD, MPH, and Mary A. Whooley, MD	2008 June	Learned how to perform depression testing using heart rate variability. Wide classification based on sex, age, medical problems, etc.	This research had contradictory results. Around 25 percent results were incorrect.
2	Depression and heart rate variability in patients with coronary heart disease [2]	ROBERT M. CARNEY, PhD and KENNETH E. FREEDLAND, PhD	2009 April	Had more accurte results for stress and depression detection. Stress or depression detection using ECG.	This paper lacked classification based on sex, age, medical problems, etc.
3	Sensor Detects	Kristina Grifantini	October 26, 2010	This paper talks about	In this paper the author

	Emotions through the Skin [3]			emotion detection using skin conductance.	does not talk about the classification of detected emotion. This paper talks only about detecting the change in emotion and not what the emotion is.
4	Alteration of heart rate variability in patients of depression [4]	DEEPTI JANGPANGI, SUNITA MONDAL, RAJIV BANDHU, DINESH KATARIA, ASHA GANDHI	2016 December	In this paper the author has taken two groups of 30 people. In 1st group people with no problem of depression are kept and in the 2nd group people with depression are kept. Heart rate variability of the people from both groups are compared and the group of people with depression show a spiked rate of heart rate variability.	This study involved drug naïve depressed people and does not talk anything about depressed people without drug addiction.

5	Emotion Detection in Human Beings Using ECG Signals [5]	Shalini T., Vanitha L.	2013 May	This paper has step by step procedure on how to extract the required feature from electro-cardiogram result for emotion detection.	The process only detects general emotions like joy, sadness, angry and fear. It does not talk about stress or depression.

Though there has been a lot of research done, implementation is yet to be done. All these research have been performed on static data, real time implementation is yet to be performed.

Some products that are present in the market are:

Table 2.2: Summary Of Various Similar Products Available

Product Name	Product Company	Heart Rate Sensor	ECG	GSR	Temperature	Stress or Depression Detection
Q Sensor	Affectiva	No	No	Yes	Yes	Yes
Cooey Smart Health	Cooey	Yes	Yes	Yes	Yes	No

Microsoft has a website named as Microsoft vault that has the following features:

- The person can store all the medical records here.
- Can access it anytime, anywhere
- Can set reminders to visit a doctor
- Can set reminders for taking medicine
- Can upload and save prescriptions

It only stores the data that is entered by the user and cannot measure or do anything on its own.

CHAPTER 3-SYSTEM DEVELOPMENT

3.1 Hardware Required

- Raspberry Pi

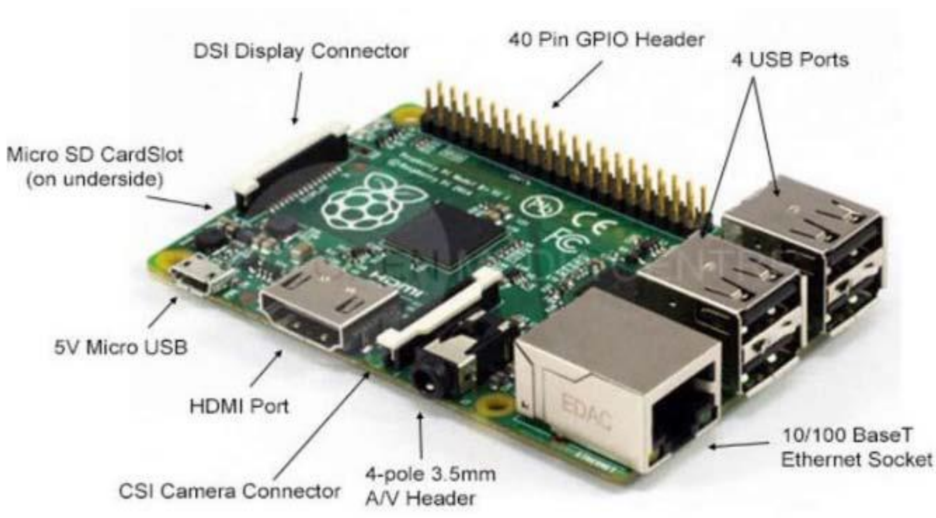


Figure 3.1: Raspberry Pi Board [10]

In this project Raspberry Pi 3 model B is used for connecting the sensors to power supply and to the internet to upload values on the cloud and it has the following specifications:

System-on-Chip : Broadcom BCM2837

Central Processing Unit : 4× ARM Cortex-A53, 1.2GHz

Graphic Processing Unit : Broadcom VideoCore IV

RAM : 1GB LPDDR2 (900 MHz)

Networking : 10/100 Ethernet, 2.4GHz 802.11n wireless

Bluetooth : Bluetooth 4.1 Classic, Bluetooth Low Energy

Storage : microSD

GPIO : 40-pin header, populated

Ports :HDMI, 3.5mm analogue audio-video jack, 4× USB 2.0, Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI)

- Pulse/Heart Rate Sensor

Figure 3.2: Heart Rate Sensor [11]

Heart rate sensor will be used to measure number of heart beats per minute. It has the following specifications:

Amplification factor: 330

Wavelength: 609nm

Voltage: 3v - 5v

- Temperature Sensor(DS18B20)

Figure 3.3: Temperature Sensor [11]

Temperature sensor is used to take the measurement of the human body temperature. It has the following specifications:

- -55 to 125°C (-67°F to +257°F) is the working temperature range
- Selectable resolution is 9 to 12 bit
- Uses only one wire for digital communication or has one wire interface
- Multiple sensors can share one pin
- Accuracy is ±5 degree Celsius ranging between -10°C to +85°C
- Takes less than 750 ms for a query
- Can be used with 3.0 Volts to 5.5 Volts

- ECG Sensor

Figure 3.4: ECG Sensor [11]

ECG sensor is used to record the heart rate variability with respect to time. The ECG sensor has the following specifications:

- It operates at 3.3 volts
- Output is analog
- Supports Leads-Off Detection
- Has a shutdown pin
- Has a LED Indicator
- Posses a 3.5 mm jack
- Has Biomedical pad connectors

- Analog to Digital Converter

Figure 3.5: Analog To Digital Convertor [11]

It is used to convert analog signal of the ECG sensor to digital signal as RPI only takes digital values. It has the following specifications:

- Voltage: 2.5 to 6 V
- 8-bit resolution
- Communication I 2 C
- 8 available I 2 C addresses
- 4 analog inputs;
- Speed sampling limited by communication speed (100 kHz max).

- Breadboard

Figure 3.6: Breadboard [11]

Breadboard is used to join all the sensors to Raspberry Pi.

- Jumper Wires

Figure 3.7: Jumper Wires [11]

Jumper wires are used to connect the sensors to breadboard and from breadboard to RPI.

3.2 Software Required

- Rasbian (OS)
- Spyder IDE
- Matlab
- Cloud Computing Using thingspeak.com

3.3 System Architecture

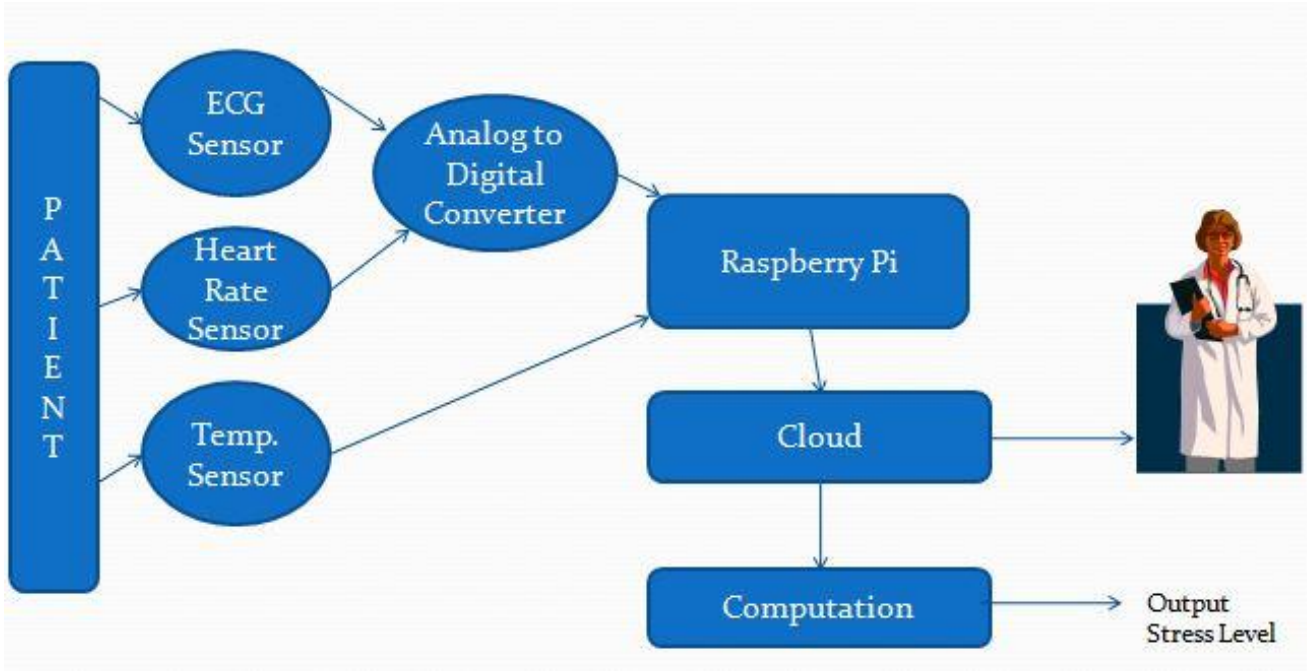


Figure 3.8: System Architecture

3.4 Use Case Diagram

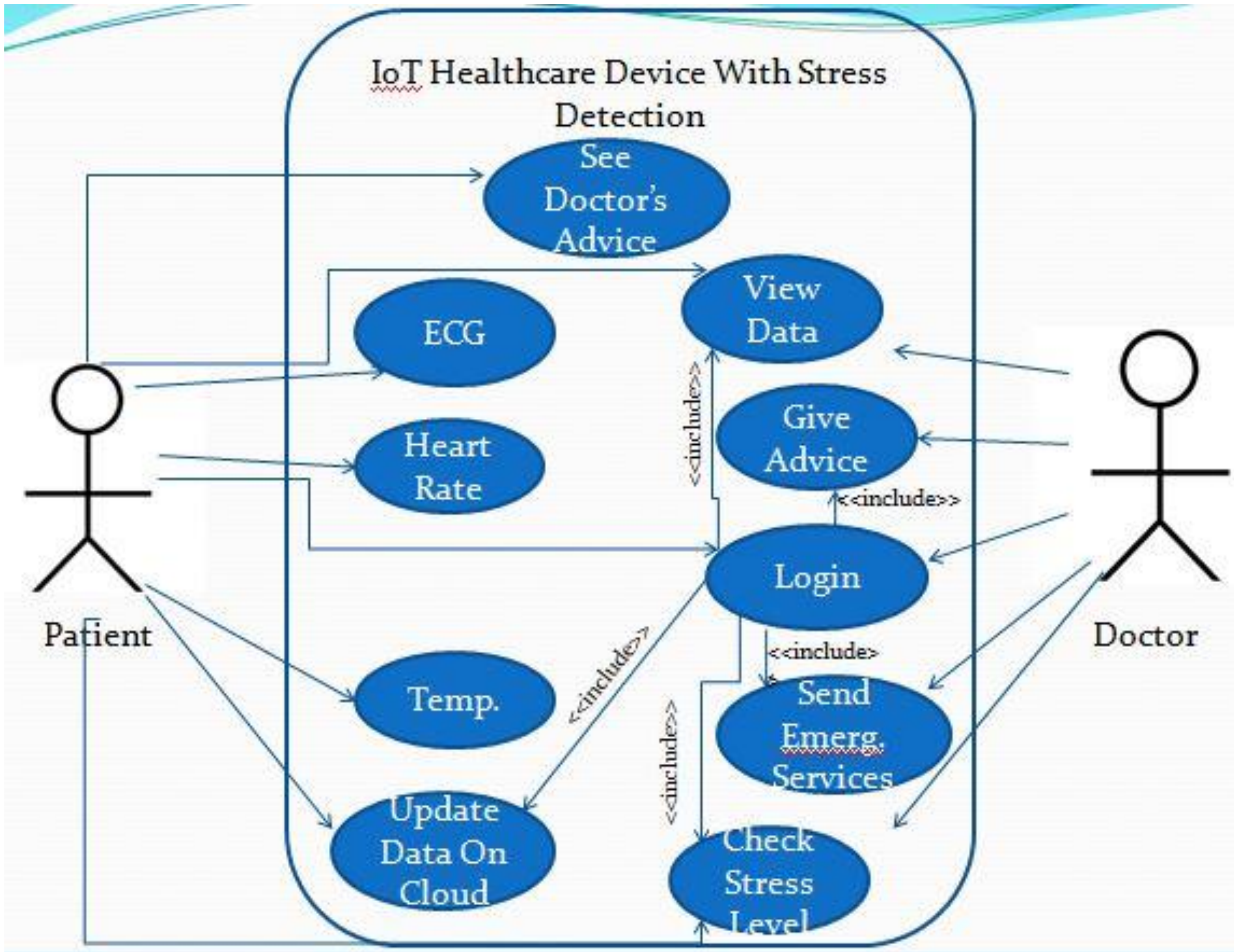


Figure 3.9: Use Case Diagram

3.5 Methodology

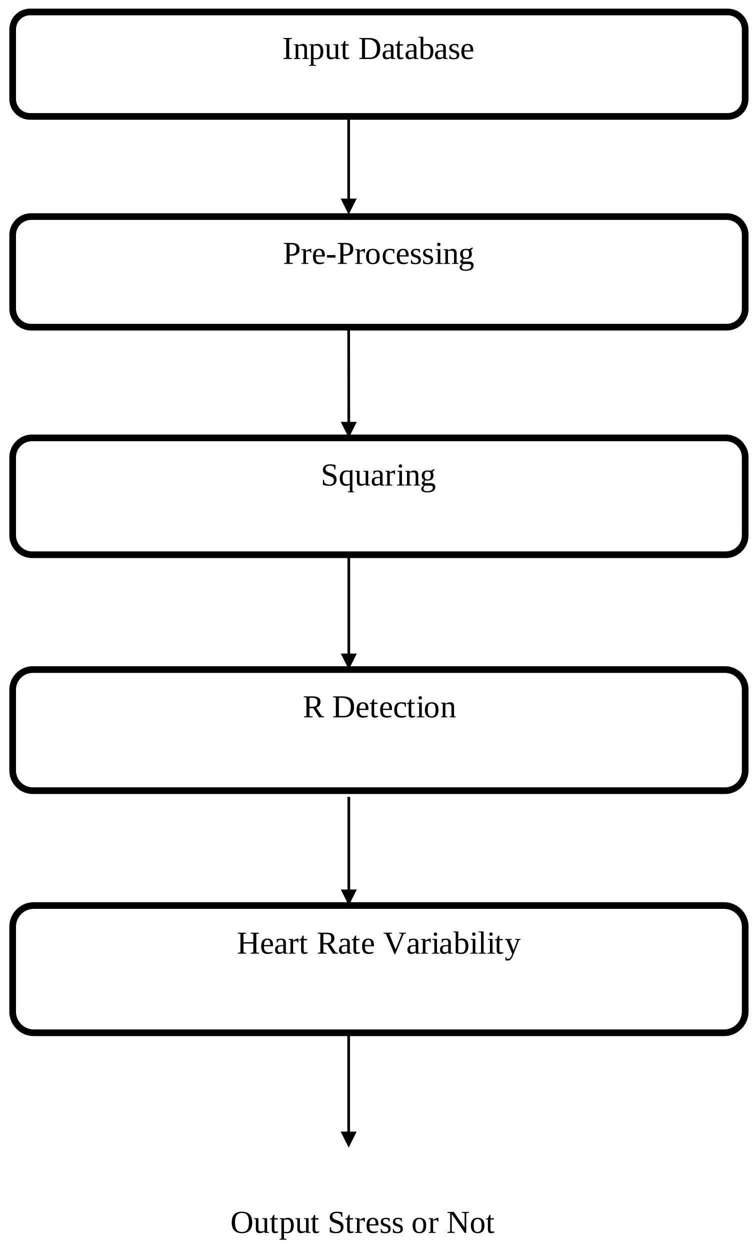


Figure 3.10: Flow Chart Of Methodology

3.5.1 Input Database

There are two types of database online and offline. In case of online the database is available from Physionet labeled as MIT/BIH Arrhythmia Database. Online data is categorized according to age, sex, problems of stress or any heart problem.

Offline data can be taken from various hospitals but the hospitals generally don’t share the data of patients. Therefore for this project online data is used that is available online on physionet.

3.5.2 Pre-Processing

The obtained signal of electrocardiogram contains noises such as noise of body muscle and muscle movement because perfect stillness can not be obtained and muscle movement due to breathing and also due to interference from the power line. So in order to remove the unwanted noise from the signal obtained from electrocardiogram sensor we need to perform pre-processing.

In order to perform pre-processing we need two types of filters:

1. To remove power line interference LPF is used.
2. To remove baseline wander HPF is used.

Derivative filter and moving window integrator is also used.

3.5.3 Squaring

Squaring is performed in order to make the negative parts of the electrocardiogram signal positive so that it reduces the time and cost of performing feature extraction or R detection.

3.5.4 R Detection

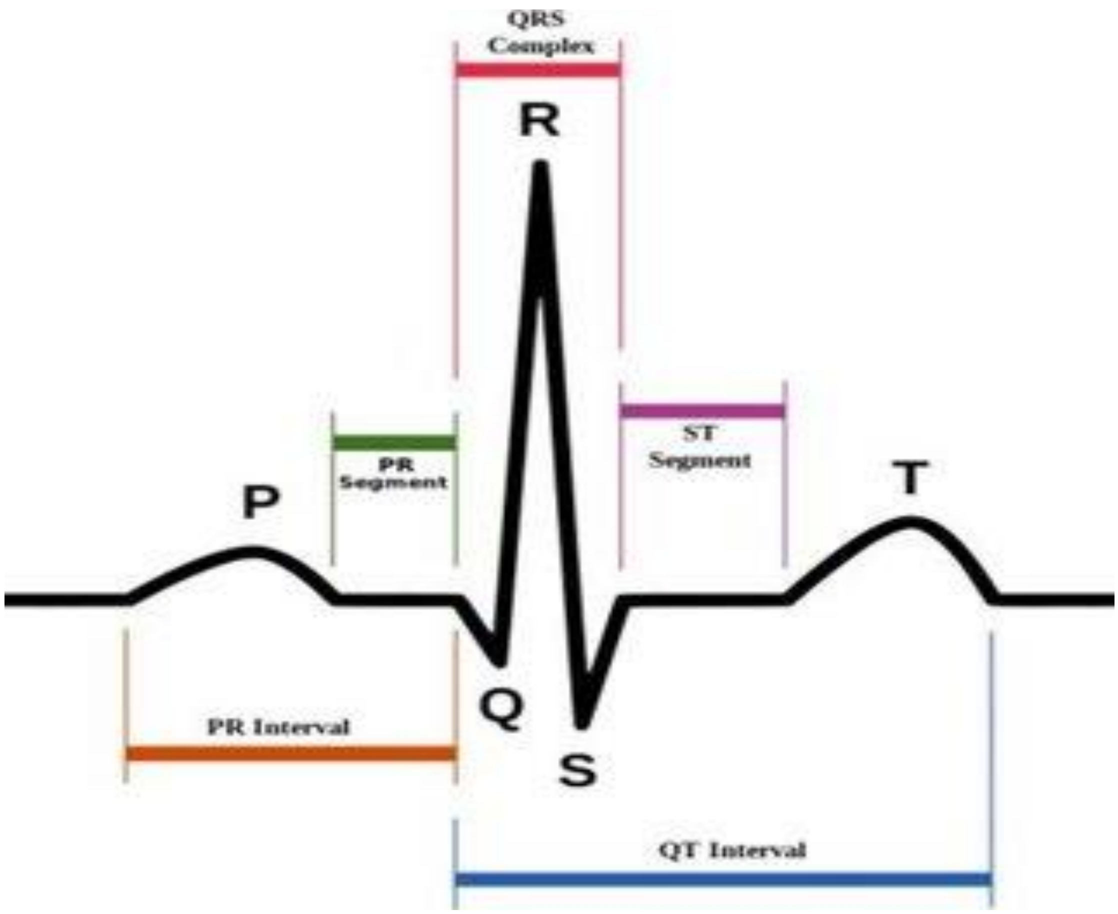
R detection or feature extraction is performed in order to get the desired value of R peak (from graph 3.1) from the squared electrocardiogram signal. In order to perform feature extraction QRS detection algorithm will be used.

3.5.5 Heart Rate Variability

In this part heart rate variability will be calculated using the following equation:

$$HRV = \frac{60}{RR\ Interval(R1 - R2)}$$

The output whether the person is stressed or not will depend on the value of calculated heart rate variability.



Graph 3.1: Segments Of An ECG [3]

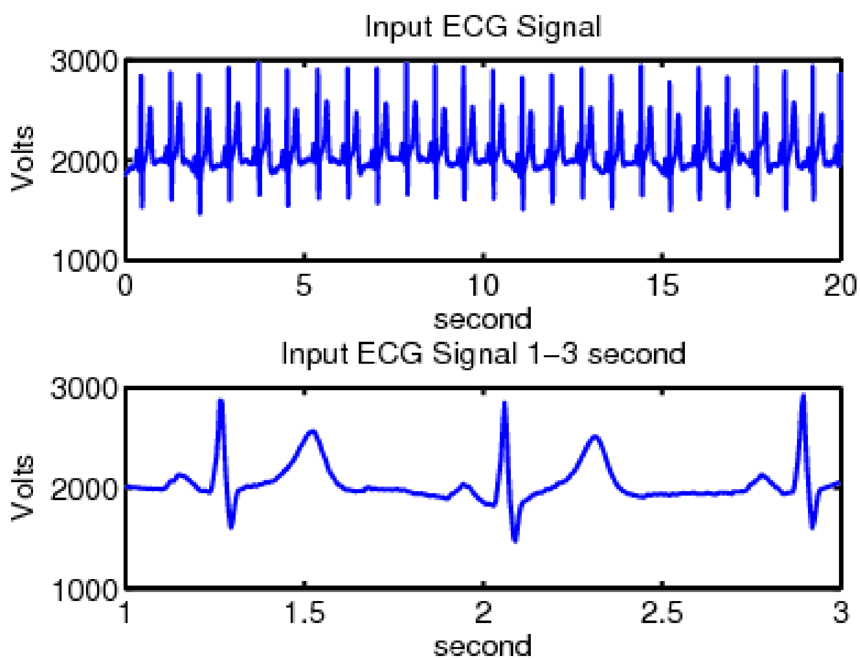
This diagram shows the different segments of an ECG signal. The part that is important for stress detection is QRS segment of the signal. QRS complex indicate ventricular depolarization and contraction.

CHAPTER 4-ALGORITHM

The QRS detection algorithm has the following parts:

1. Pre-Processing
2. Squaring
3. Moving Window Integrator
4. Feature Extraction or R Detection
5. Heart Rate Variability Calculation

Input Electrocardiogram Signal



Graph 4.1: Input ECG Signal [7]

Pre-Processing

The output of the electrocardiogram ranges between 0 Hertz to 100 Hertz that contains interference in the form of muscle noise, 60 Hertz interference, baseline wander and T-wave interference. The desirable frequency for QRS detection is 0.5 Hertz to 50 Hertz.

In order to remove the power line interference we use low pass filter that has the following transfer function:

$$F(k) = \frac{(1-k^{-6})^2}{(1-k^{-1})^2} \text{ [6]} \qquad (1)$$

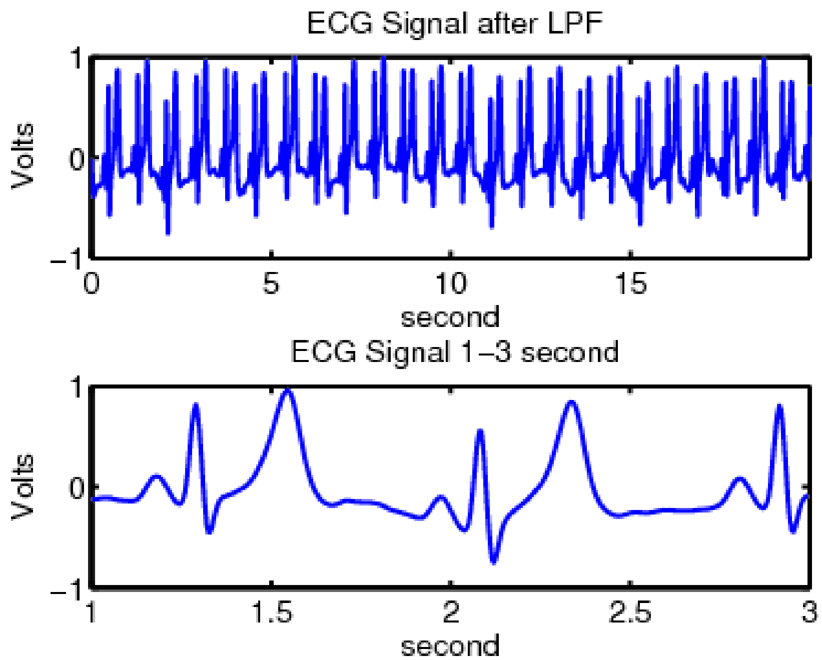
The amplitude is given as

$$|\boldsymbol{F}(\omega \boldsymbol{t})| = \frac{\boldsymbol{sin^2}(\mathbf{3}\omega \boldsymbol{t})}{\boldsymbol{sin^2}(\omega \boldsymbol{t}/\mathbf{2})} \textbf{ [6]} \qquad (2)$$

where sampling period is t. The equation to calculate difference is:

$$\mathrm{y(nt) = 2y(nt - t) - y(nt-2t) + x(nt) - 2x(nt - 6t) + x(nt - 12t)[6]} \qquad (3)$$

Example:



Graph 4.2: ECG Signal After Low Pass Filter [7]

Now we use high pass filter to remove the baseline wander. The HPF is made by subtracting the output of the LPF from the original sample. The transfer function is as follows:

$$F(k) = \frac{(-1+32k^{-16}+k^{-32})}{(1+k^{-1})} \text{ [6]} \tag{4}$$

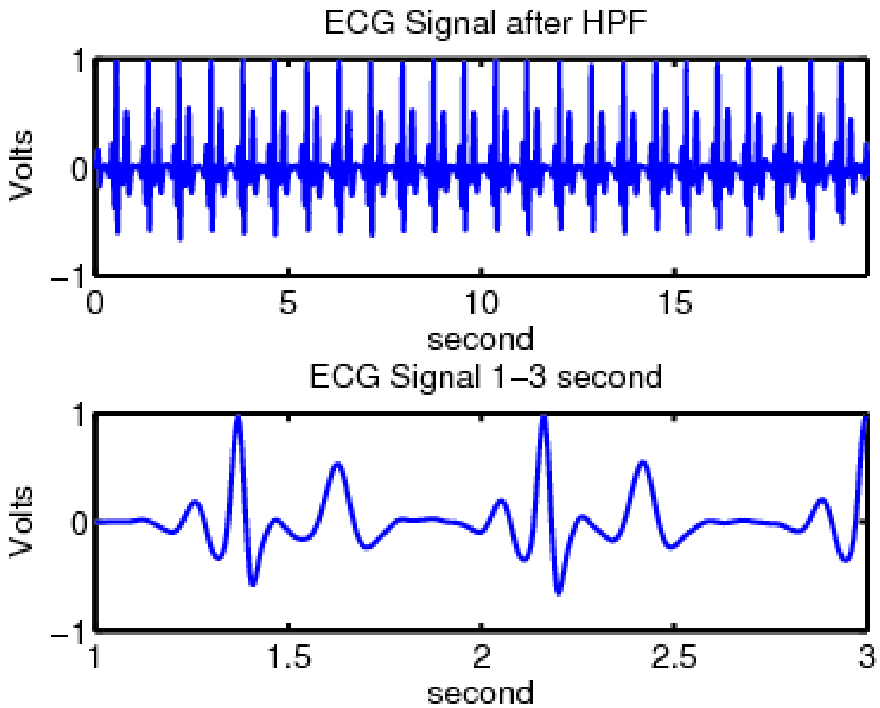
The amplitude is given as

$$|F(\omega t)| = \frac{[256+sin^2(16\omega t)]^{1/2}}{\cos(\frac{\omega t}{2})} \text{ [6]} \tag{5}$$

Where sampling period is given by t. The equation to calculate difference is:

$$y(nt) = 32x(nt - 16t) - [y(nt - t) + x(nt) - x(nt - 32t)]\text{[6]} \tag{6}$$

Example:



Graph 4.3: ECG Signal After Passing Through High Pass Filter [7]

After high pass filtering the signal is passed through a differentiator in order to provide the slope of QRS complex. The transfer function is:

$$F(k) = (1/8t)\,(k - 2k^{-1} + 2k^{1} + k^{2})\ [6] \qquad (7)$$

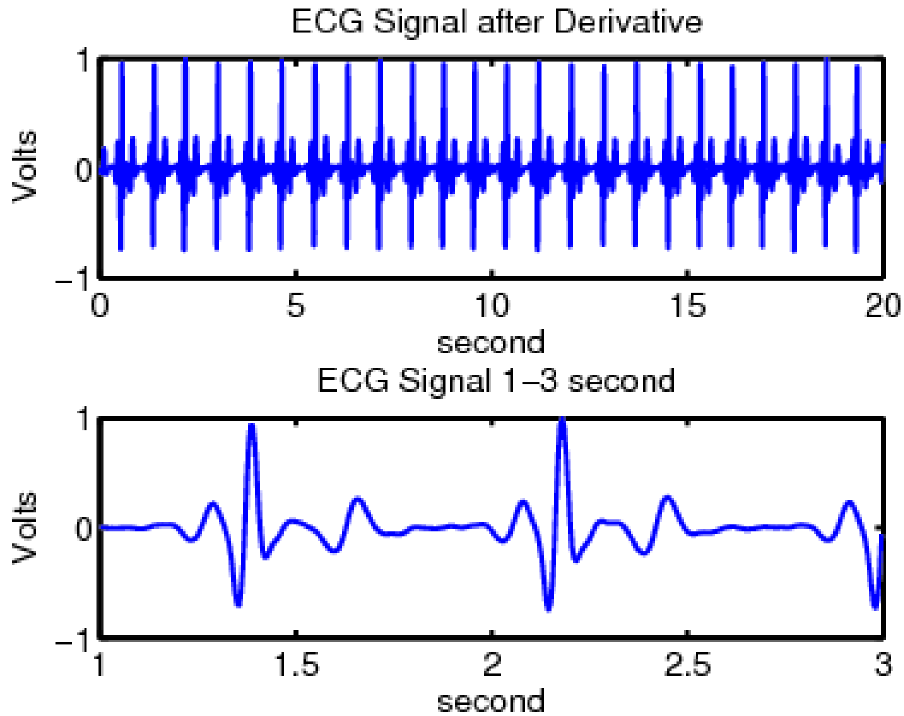
The amplitude is given as:

$$|F(\omega t)| = (1/4t)\,[\sin(2\omega t) + 2\sin(\omega t)]\ [6] \qquad (8)$$

where sampling period is given by t. The equation to calculate difference is:

$$y(nt) = (1/8t)[-x(nt - 2t) - 2x(nt - t) + 2x(nt + t) + x(nt + 2t)][6] \qquad (9)$$

Example:



Graph 4.4: Electrocardiogram Signal After Differentiator [7]

Squaring

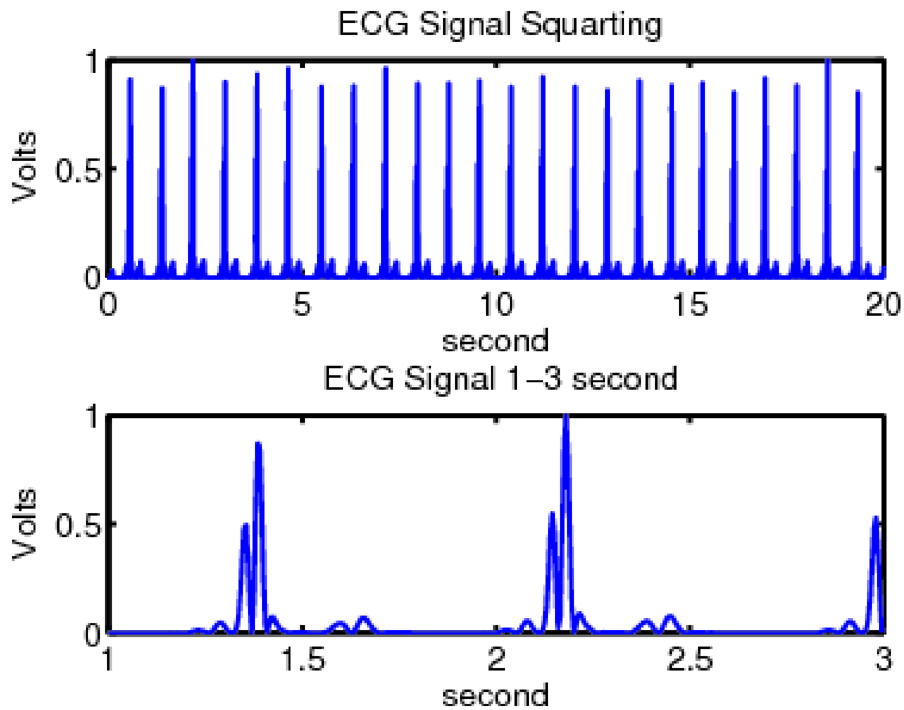
When the signal is passed through the differentiator the given signal will be squared. The equation is as follows:

$$y(nt) = [x(nt)]^2 \text{ [6]} \tag{10}$$

Via this process all the points are made positive and the data is amplified nonlinearly, emphasizing on the higher frequencies specially the required electrocardiogram frequencies.

The given graph shows the electrocardiogram signal after the squaring of the differentiated signal.

Example:



Graph 4.5: Electrocardiogram Signal After Squaring [7]

Moving-Window Integration

Through this process we try to get the wave-form feature information and we also try to calculate the slope of R wave. The equation used is as follows:

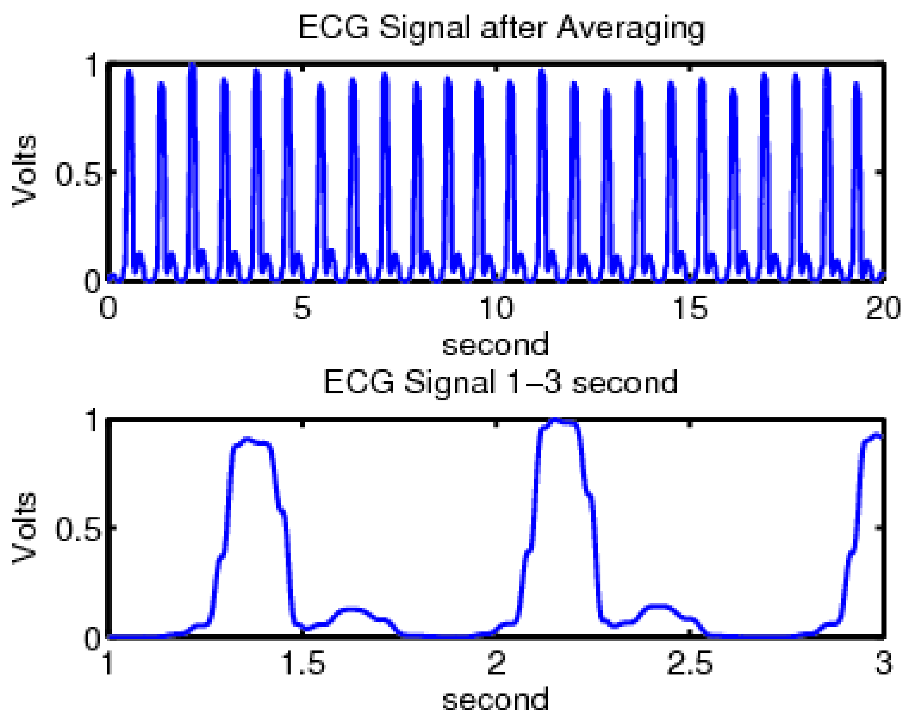
$$y(nt) = (1/N)\,[x(nt-(N-1)t) + x(nt-(N-2)t + \ldots\ldots + x(nt)\ \ [6] \qquad (11)$$

where the number of samples in the width of the integration window is N.

The number of samples ‘N’ in the moving window is important. Generally the value of ‘N’ is approximately the same as the widest possible QRS complex. If the value of N is too narrow, some QRS complexes will produce several peaks in the integration waveform. If the value of N is too wide, QRS and T complexes will get merged during the integration. These can cause difficulties in the rest of the steps of QRS complex detection.

The value of N is determined empirically. For this project the sample rate of 200 samples/s, the value of N is 30 or the window is 30 samples wide.

Example:



Graph 4.6: Signal After Moving Window Integration [7]

R-Detection

This part contains two subparts adjusting the thresholds and adjusting the average RR interval and rate limits.

Adjusting The Thresholds

The thresholds are balanced naturally to drift over the noise. There is a probability of low thresholds in light of the improvement of signal to noise proportion by the bandpass filter. For the primary investigation of the signal, higher of the two edges is utilized. On the off chance that no QRS is recognized in a specific time interim, at that point low edge is utilized so a search back strategy is important to look back in time for the QRS complex. The set of thresholds initially applied to the integrated waveform is computed from:

$$\text{SPK1} = \left(\frac{1}{8}\right)\text{PEAK1} + \left(\frac{7}{8}\right)\text{SPK1 (if PEAK1 is the peak of signal)[6]} \tag{12}$$

$$\text{NPK1} = \left(\frac{1}{8}\right)\text{PEAK1} + \left(\frac{7}{8}\right)\text{NPK1 (if PEAK1 is the noise peak) [6]} \tag{13}$$

$$\text{THRESH I1} = \text{NPK1} + (1/4)(\text{SPK1} - \text{NPK1}) \text{ [6]} \tag{14}$$

$$\text{THRESH I2} = (1/2)\text{ THRESH I1 [6]} \tag{15}$$

Where all the variables refer to the integration waveform:

PEAK1 is the overall crest,

SPK1 is the running assessment of the signal crest,

NPK1 is the running assessment of the noise crest,

THRESH Il is the first threshold applied, and

THRESH I2 is the second threshold applied.

A peak is a nearby most extreme dictated by seeing when the signal alters course inside a predefined time interim. SPK1 is a peak that the calculation has effectively settled to be a QRS complex. NPK1 clamor peak is any peak that isn't identified with the QRS. Running estimations of SPK1 and NPK1 give the limits. New estimations of these factors are figured to some degree from their earlier qualities. At whatever point another peak is recognized, it ought to be delegated a signal peak or noise peak. To be a signal peak, the peak must surpass THRESH I1 as the signal is first examined or THRESH I2 if search back is required to discover the QRS. When the QRS complex is found using the second threshold:

$$\text{SPK1} = \left(\frac{1}{4}\right)\text{PEAK1} + \left(\frac{3}{4}\right)\text{SPK1} \quad [6] \tag{16}$$

The set of thresholds applied to the filtered ECG is determined from:

$$\text{SPK2} = \left(\frac{1}{8}\right)\text{PEAK2} + \left(\frac{7}{8}\right)\text{SPK2} \quad \text{(if PEAK2 is the peak of signal) [6]} \tag{17}$$

$$\text{NPK2} = \left(\frac{1}{8}\right)\text{PEAK2} + \left(\frac{7}{8}\right)\text{NPK2} \text{ (if PEAK2 is the noise peak) [6]} \quad (18)$$

$$\text{THRESH F1} = \text{NPK2} + \left(\frac{1}{4}\right)(\text{SPK2} - \text{NPK2}) \text{ [6]} \quad (19)$$

$$\text{THRESH F2} = \left(\frac{1}{2}\right)\text{THRESH Fl} \text{ [6]} \quad (20)$$

where all the variables refer to the filtered ECG:

PEAK2 is the overall crest,

SPK2 is the running assessment of the signal crest,

NPK2 is the running assessment of the noise crest,

THRESH Fl is the first threshold applied, and

THRESH F2 is the second threshold applied.

If the QRS complex is found using the second threshold, then:

$$\text{SPK2} = (1/4)\,\text{PEAK2} + (3/4)\,\text{SPK2} \text{ [6]} \quad (21)$$

If heart rate is irregular, in order to increase the detection sensitivity and to avoid missing beats, the first thresholds of each set is reduced by half:

$$\text{THRESH II} \leftarrow (1/2)\,\text{THRESH II [6]} \quad (22)$$

$$\text{THRESH F1} \leftarrow (1/2)\ \text{THRESH F1.}\ [6] \quad (23)$$

To identify a QRS complex, a peak should be recognized as such a complex in both the basndpass filtered and integration waveforms.

Adjusting The Average RR Interval And Rate Limits

Two RR interim midpoints are kept up. One is the normal of the eight latest beats. The second one is the normal of the eight latest beats having RR interims that fall inside specific breaking points. Two separate midpoints are kept up so as to adjust to rapidly changing pulses.

$$\text{RR AVG1} = \left(\frac{1}{8}\right)(\mathrm{R}R_{n-7} + \mathrm{R}R_{n-6} + \ldots\ldots. + \mathrm{R}R_n)\ [6] \quad (24)$$

where $\mathrm{R}R_n$ is the most-recent RR interval.

The second average is based on selected beats.

$$\text{RR AVG2} = \left(\frac{1}{8}\right)(\mathrm{R}R'_{n-7} + \mathrm{R}R'_{n-6} + \ldots\ldots\ldots + \mathrm{R}R'_n)\ [6] \quad (25)$$

where $\mathrm{R}R'_n$ is the most recent RR interval that fell between the acceptable high and low RR-interval limits. The RR-interval limits are:

$$\text{RR LL} = 92\%\ \text{RR AVG2}\ [6] \tag{26}$$

$$\text{RR HL} = 116\%\ \text{RR AVG2}\ [6] \tag{27}$$

$$\text{RR ML} = 166\%\text{RR AVG2}\ [6] \tag{28}$$

Amid the interim indicated by the RR ML if a QRS complex isn't discovered, the maximal peak saved between the two set up edges is viewed as a QRS candidate.

In the event that every one of the eight latest consecutive RR-interims that are determined from RR AVG1 lies between RR LL and RR HL, we infer that the pulse is standard for these eight heart beats and RR AVG2 is given as:

$$\text{RR AVG2} \leftarrow \text{RR AVG1}\ [6] \tag{29}$$

Normal sinus rhythm is represented by this case.

Heart Rate Variability Calculation

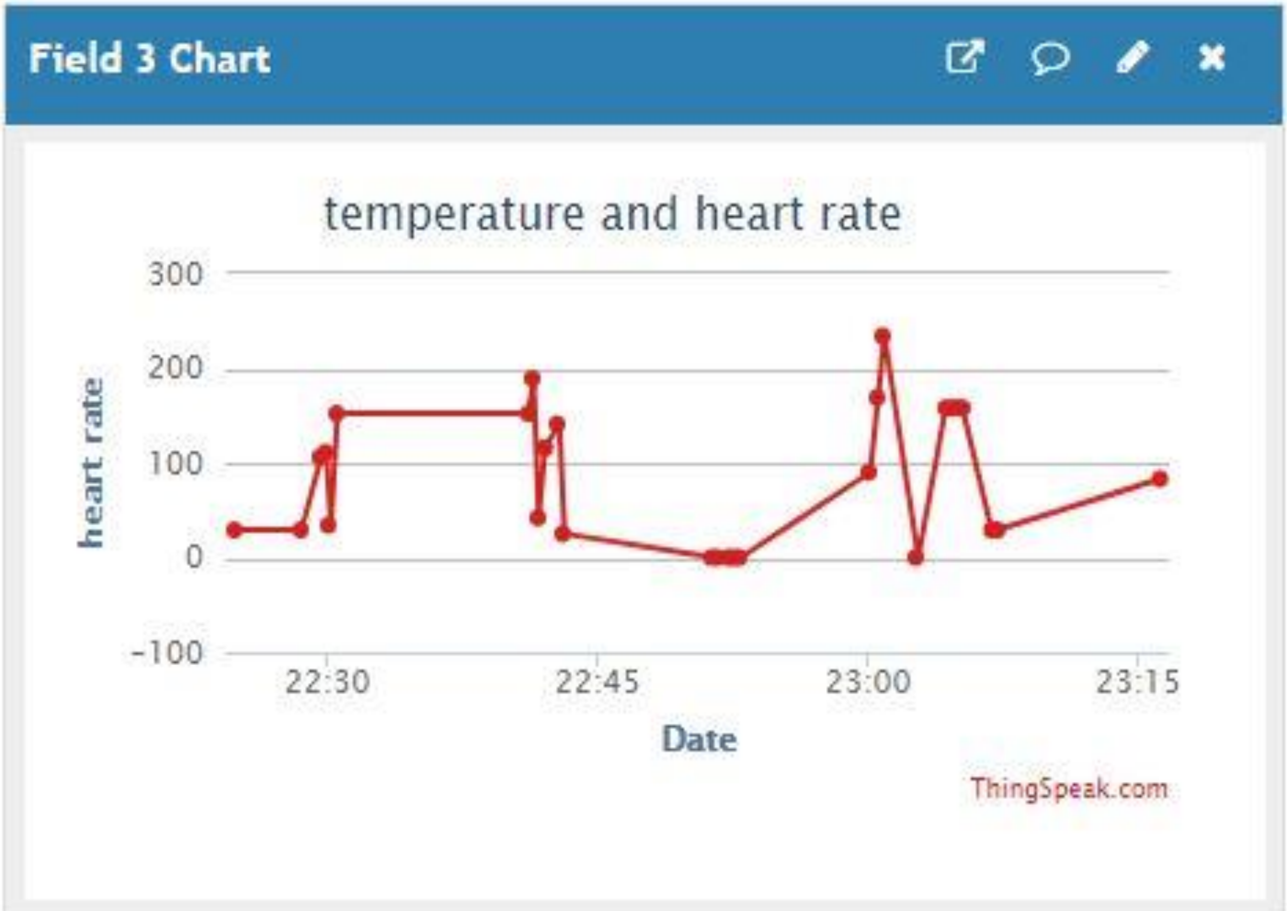
After R-Detection comes the calculation of heart rate variability. Heart rate variability is calculated as:

$$HRV = \frac{60}{RR\ Interval} \tag{30}$$

If the value of heart rate variability lies between 60 and 100 then the person is not in stress and if it does not lie between 60 and 100 then the person is in stress.

CHAPTER 5-RESULTS

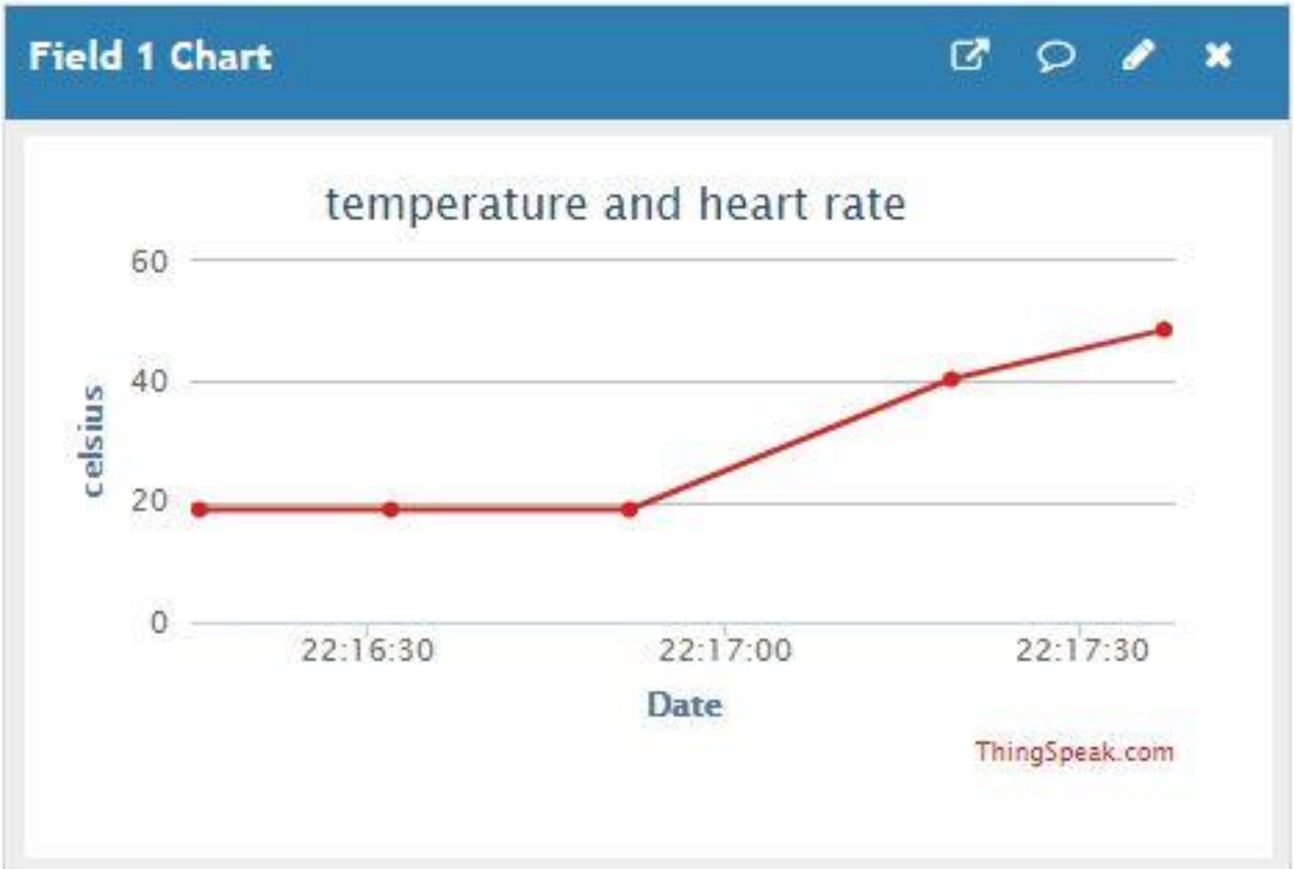
5.1 Heart Rate Sensor



Graph 5.1: Output of Heart Rate Sensor

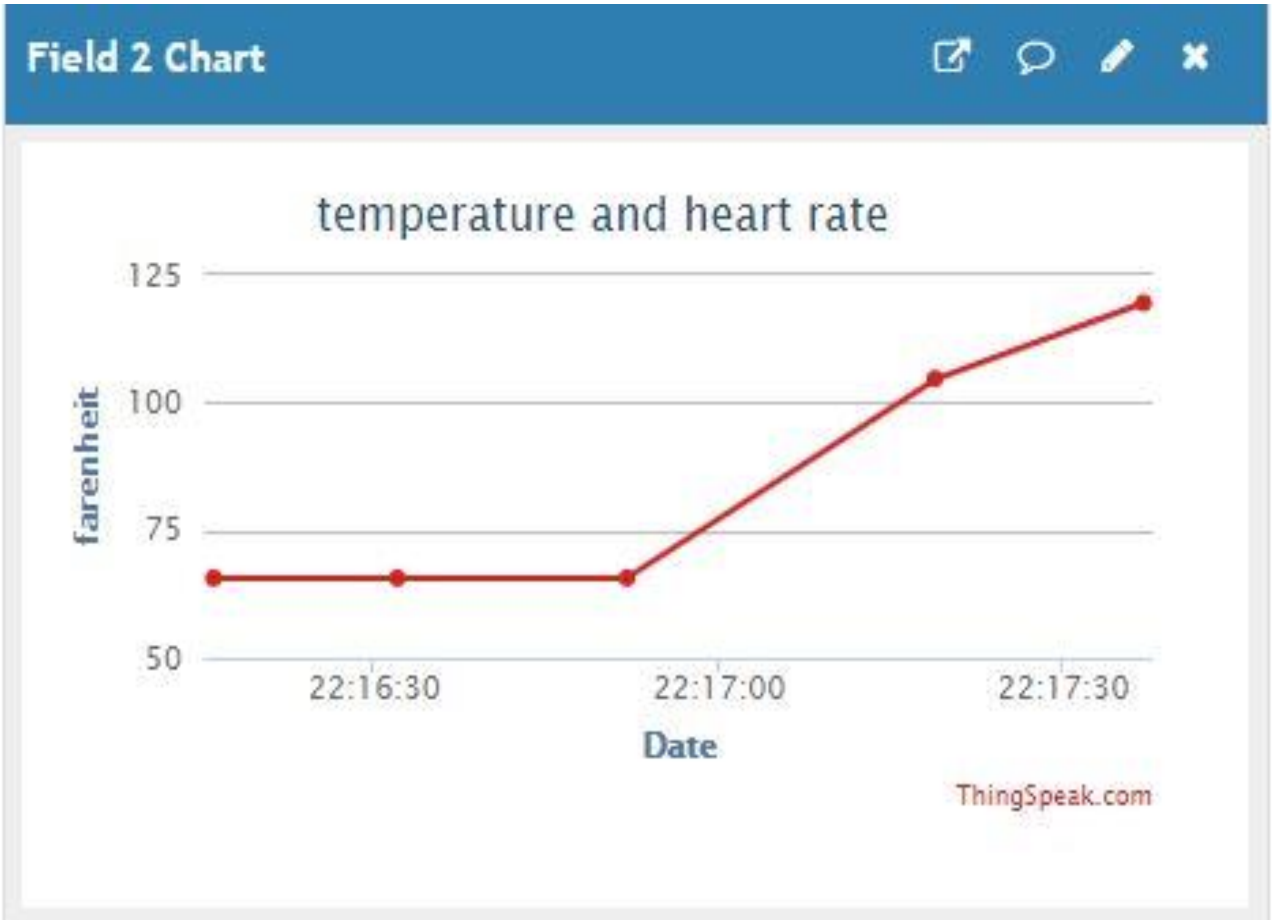
The above graph is the graphical representation of pulse sensor. The pulse sensor is pretty accurate with plus minus 2 error. It was cross checked with the Samsung S9 pulse sensor and there was a difference of plus minus 2. It was also cross checked by manually counting the heart beats in a minute and the difference was plus minus 2.

5.2 Temperature Sensor



Graph 5.2: Output Of Temperature Sensor In Celsius

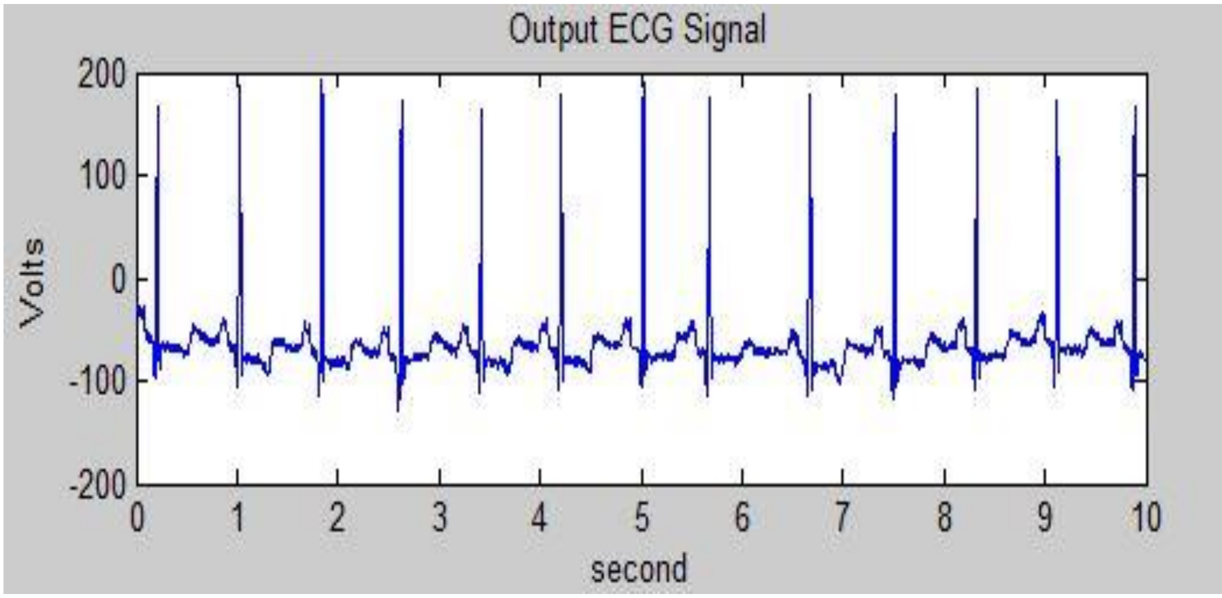
The above shows the graphical representation of temperature sensor in degree Celsius. The accuracy of this temperature sensor is good. It was cross checked with the manual thermometer and the difference was plus minus 1 degree Celsius. It can work between minus 55 degree Celsius to plus 125 degree Celsius.



Graph 5.3: Output Of Temperature Sensor In Fahrenheit

The above graph shows the graphical representation of the temperature sensor in degree Fahrenheit. The error is plus minus 1 degree Fahrenheit and it works in the range minus 67 degree Fahrenheit to plus 257 degree Fahrenheit.

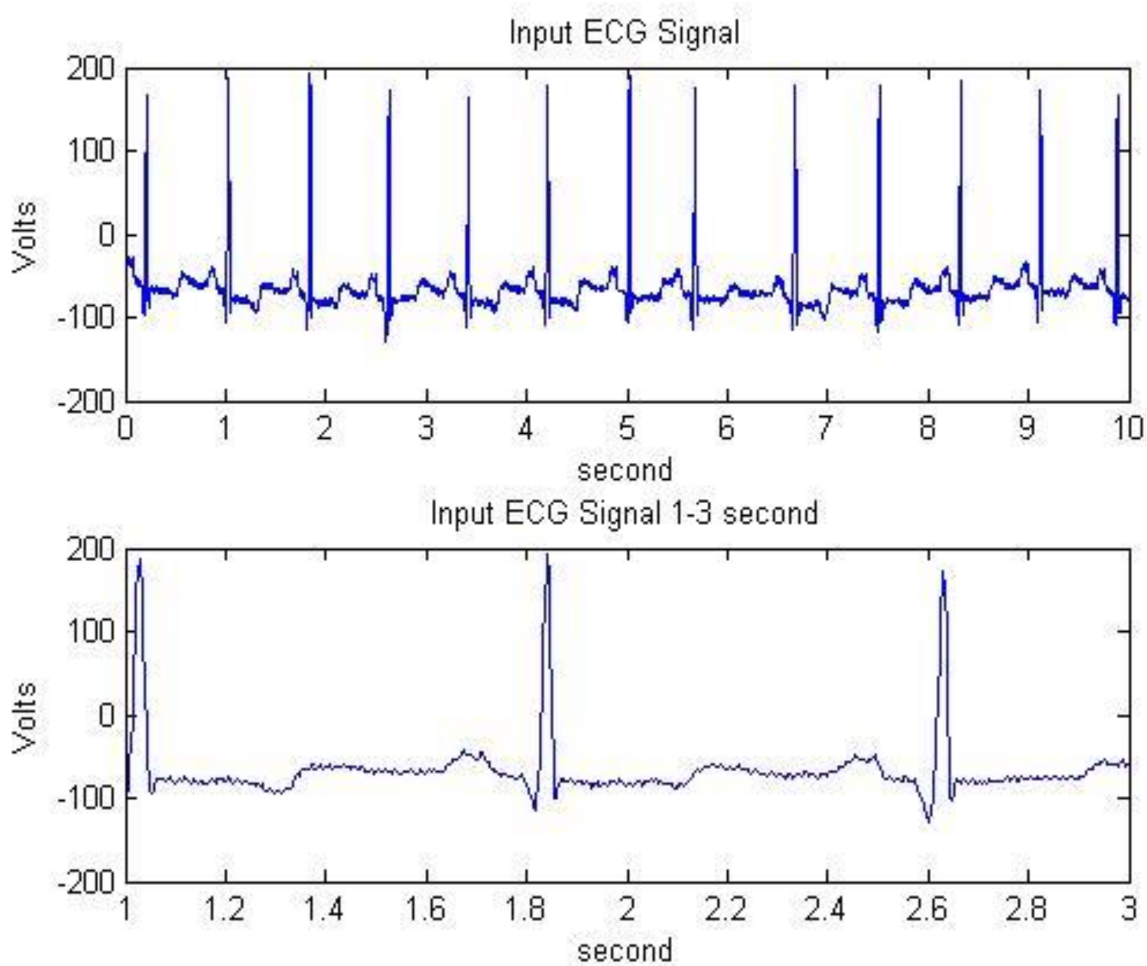
5.3 ECG Sensor



Graph 5.4: Output ECG Signal After Processing

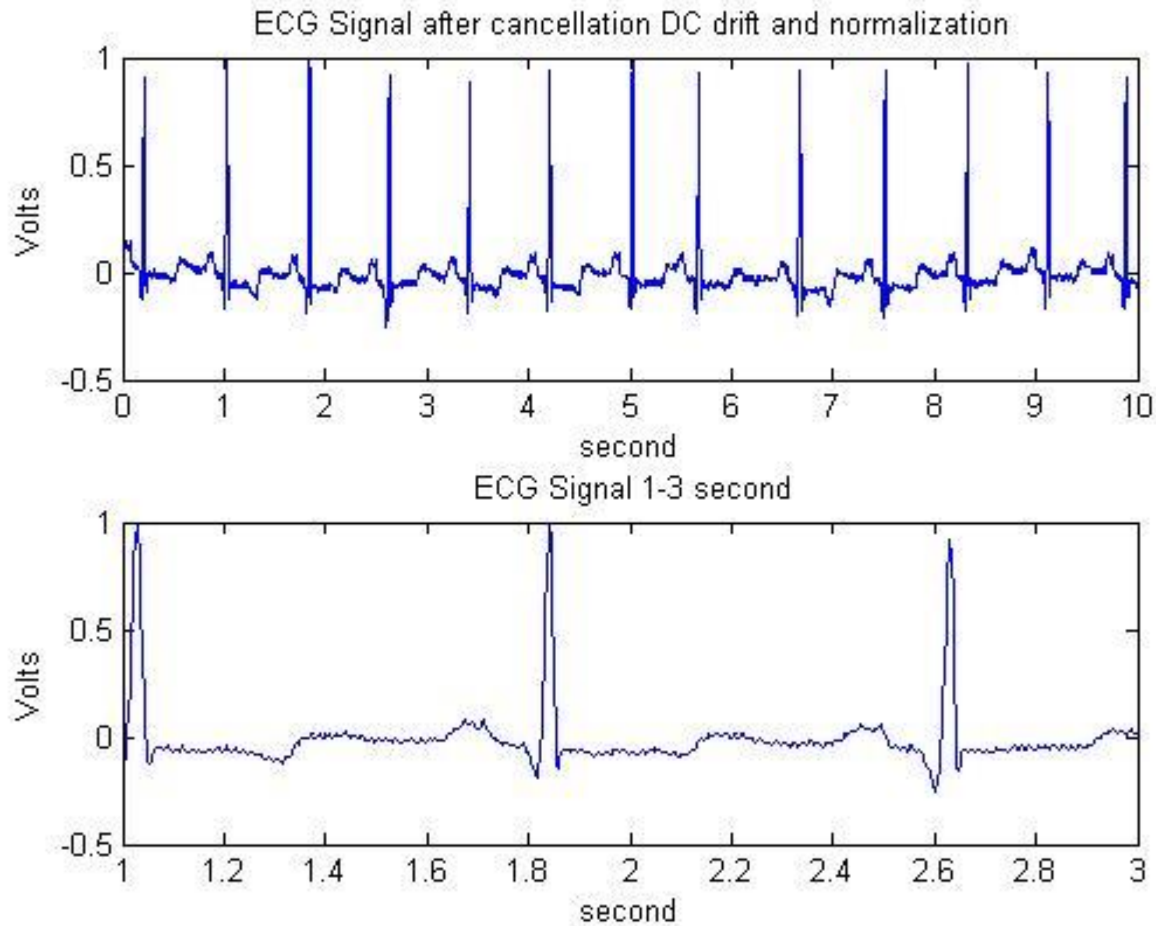
The above graph gives the output of the processed ECG signal taken from the ECG sensor. It has clearly defined QRS peaks.

5.4 Stress Analysis



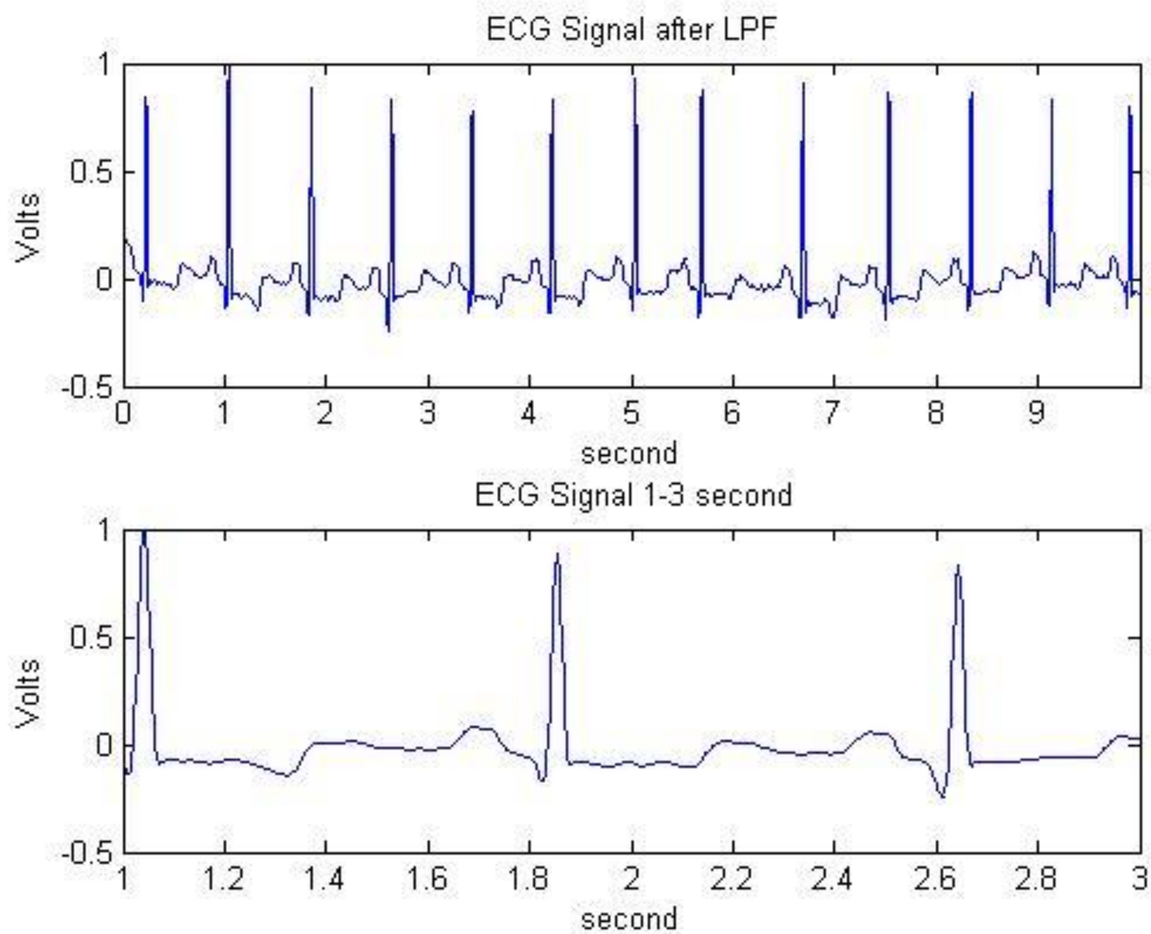
Graph 5.5: Input ECG Signal For Stress Detection

The first graph shows the ECG signal for 1 to 10 seconds and the second graph shows 1 to 3 seconds detailed view of the signal. The above signal is used for feature extraction and is used to determine the QRS complex. This in turn will be used to determine the RR interval for stress detection.



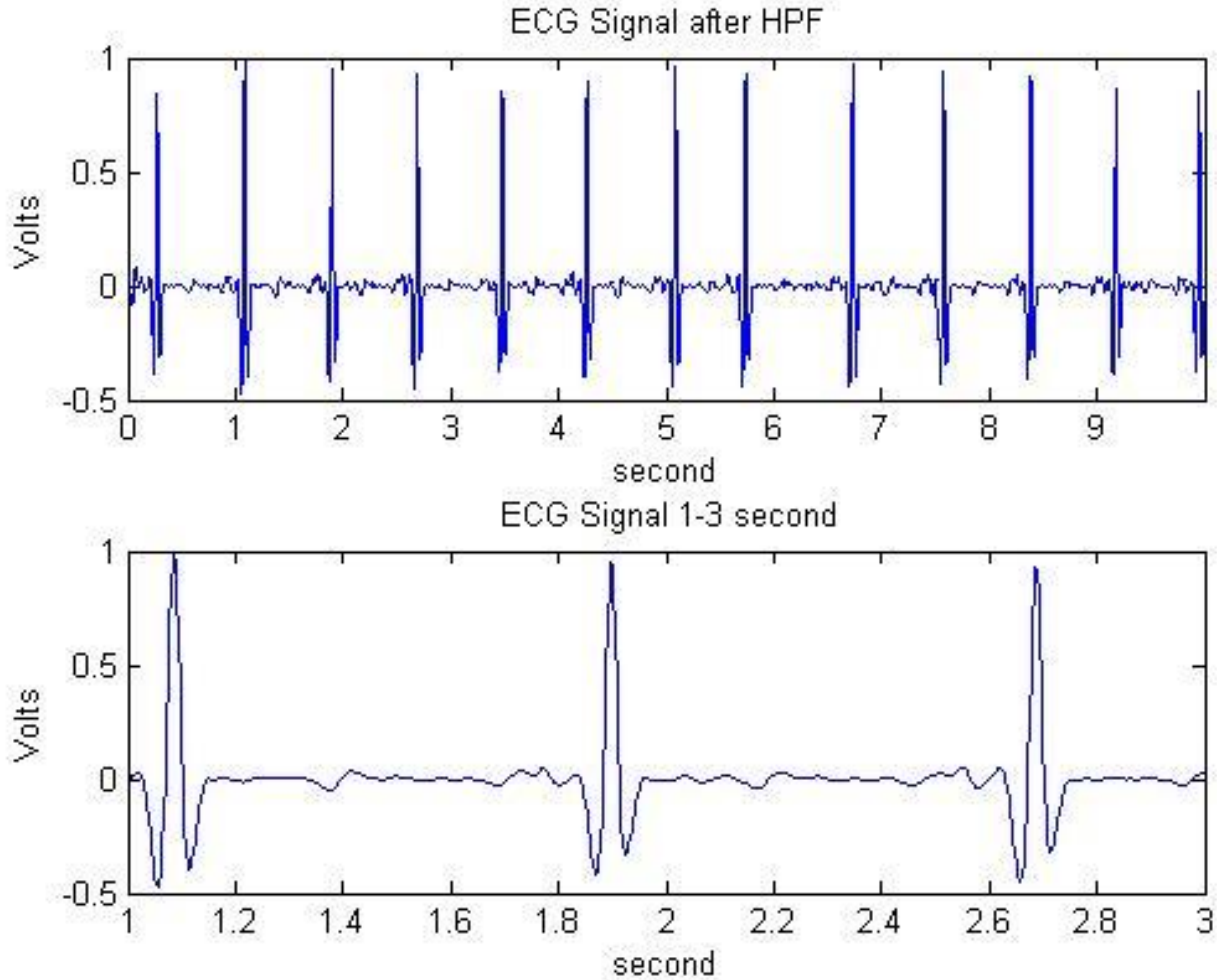
Graph 5.6: ECG Signal After Cancellation DC Drift and Normalization

The first graph shows the ECG signal for 1 to 10 seconds and the second graph shows 1 to 3 seconds detailed view of the signal. This is how the signal looks after cancellation dc shift and normalization and this signal will undergo through low pass filter.



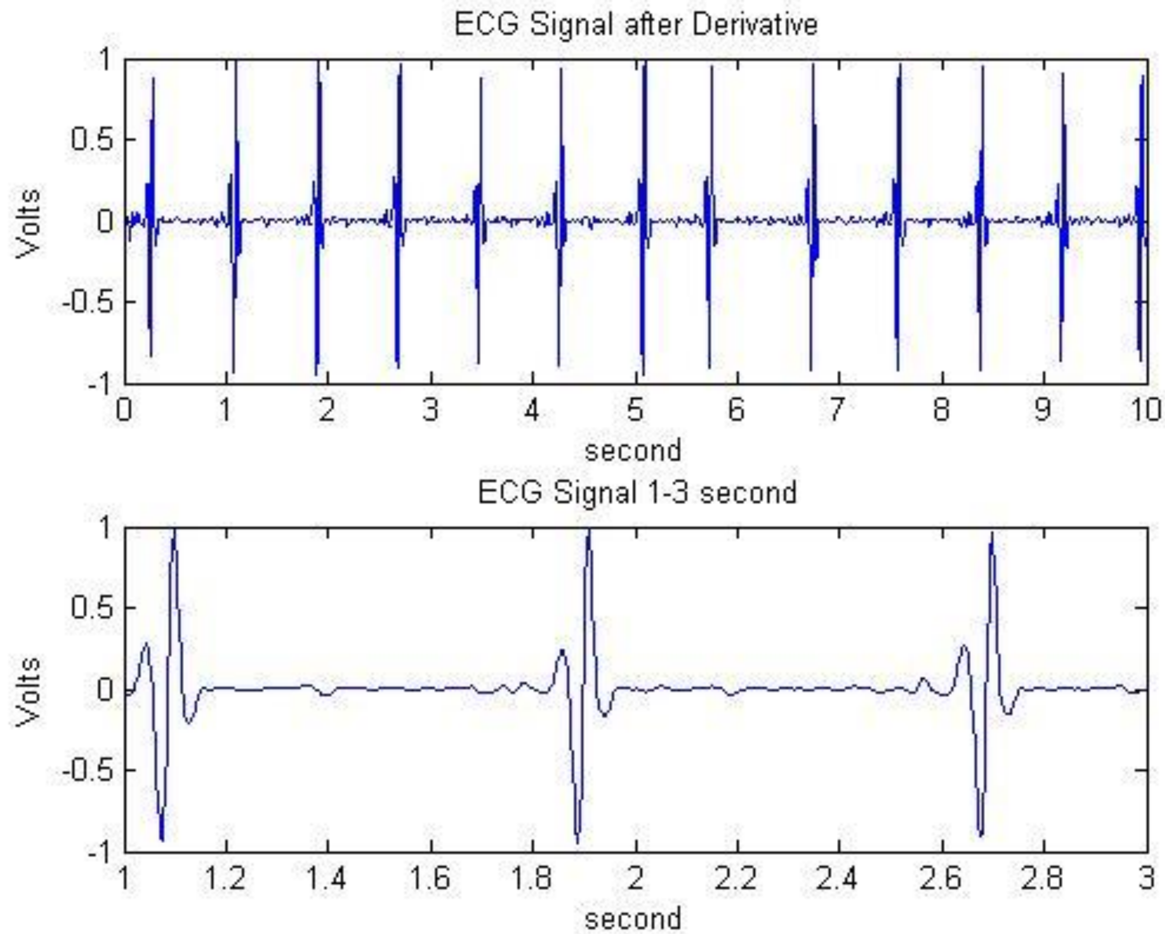
Graph 5.7: ECG Signal After Passing Through LPF

The first graph shows the ECG signal for 1 to 10 seconds and the second graph shows 1 to 3 seconds detailed view of the signal. Electrocardiogram signal after passing through low pass filter and, removing the power line interference. The signal is rounded in the frequency range of 0.5 Hertz to 50 Hertz, which is the ideal frequency for QRS detection .Signal is ready to pass through high pass filter.



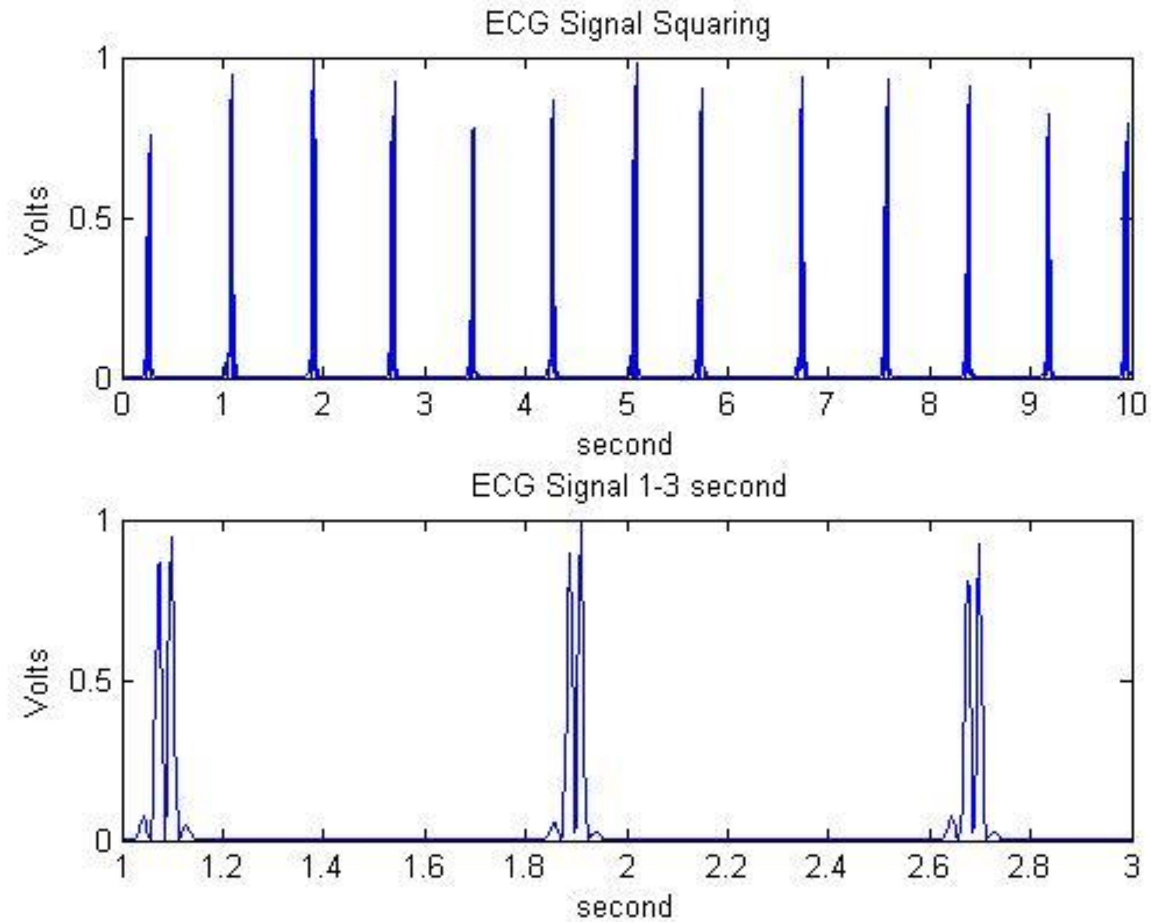
Graph 5.8: ECG Signal After Passing Through HPF

The first graph shows the ECG signal for 1 to 10 seconds and the second graph shows 1 to 3 seconds detailed view of the signal. Electrocardiogram signal after passing through high pass filter and removal of baseline wander. As it can be seen in this graph Q and S troughs are move defined in this graph than that in the previous graph and it will be very useful in the detection of QRS complex. Signal is ready to pass through differentiator.



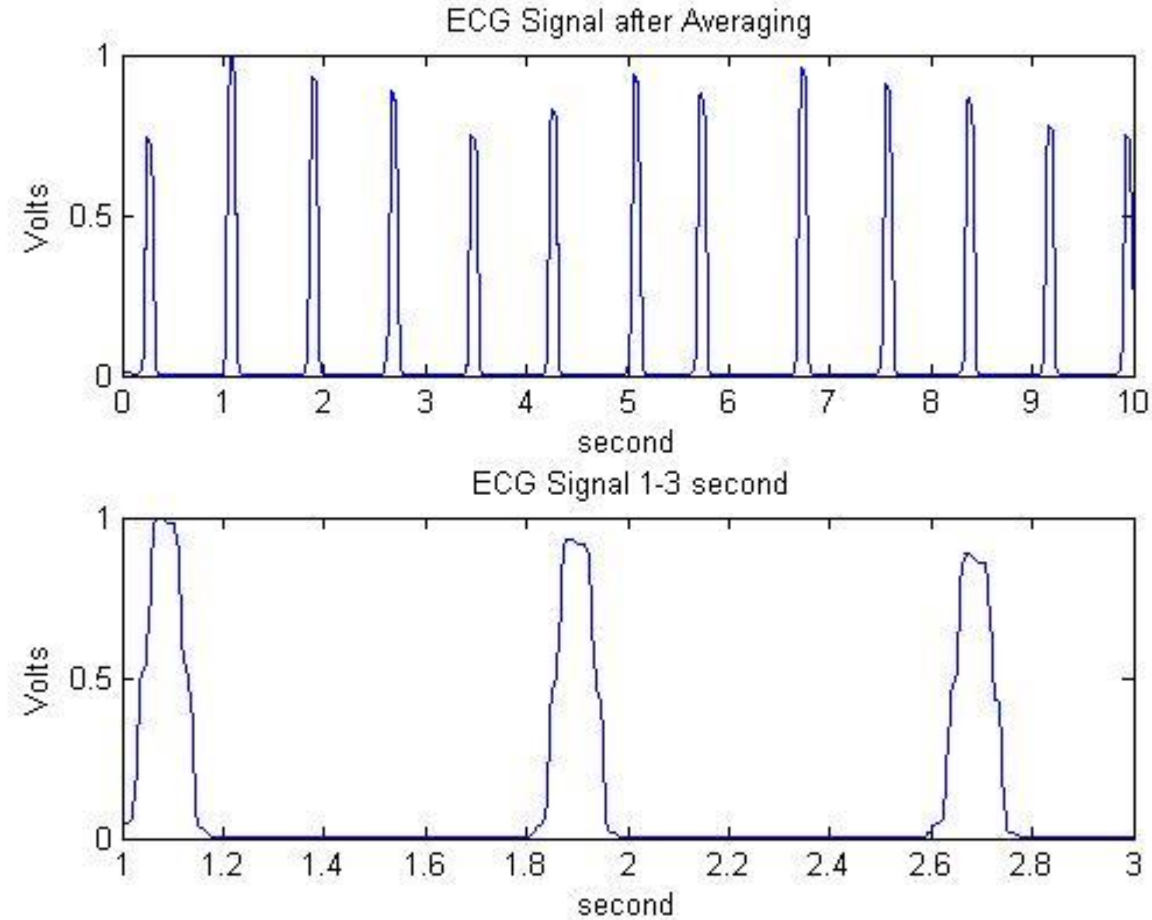
Graph 5.9: ECG Signal After Passing Through Differentiator

The first graph shows the ECG signal for 1 to 10 seconds and the second graph shows 1 to 3 seconds detailed view of the signal. Electrocardiogram signal after passing through differentiator showing the slope of the QRS complex. As it can be seen in this graph the slope of the whole QRS complex is clearly visible in this graph than that in the previous graph. Signal is ready to undergo squaring.



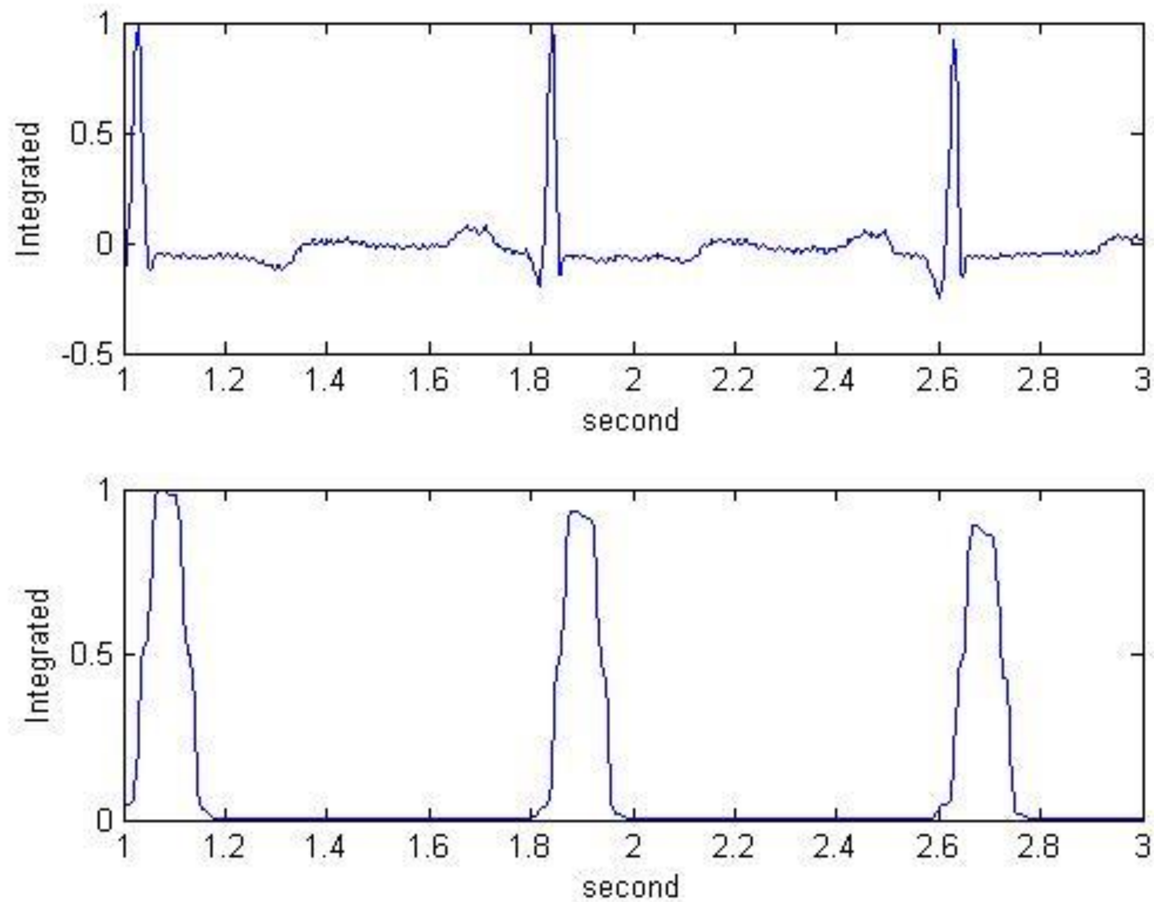
Graph 5.10: ECG Signal After Squaring

The first graph shows the ECG signal for 1 to 10 seconds and the second graph shows 1 to 3 seconds detailed view of the signal. Electrocardiogram signal after squaring and removing the negative parts of the signal in order to ease the feature extraction. As it can be seen the value of each point in the graph is squared and the amplitude of each point in the graph is more than it can be seen in the previous graph and all the negative parts are removed. Signal is ready to undergo averaging.



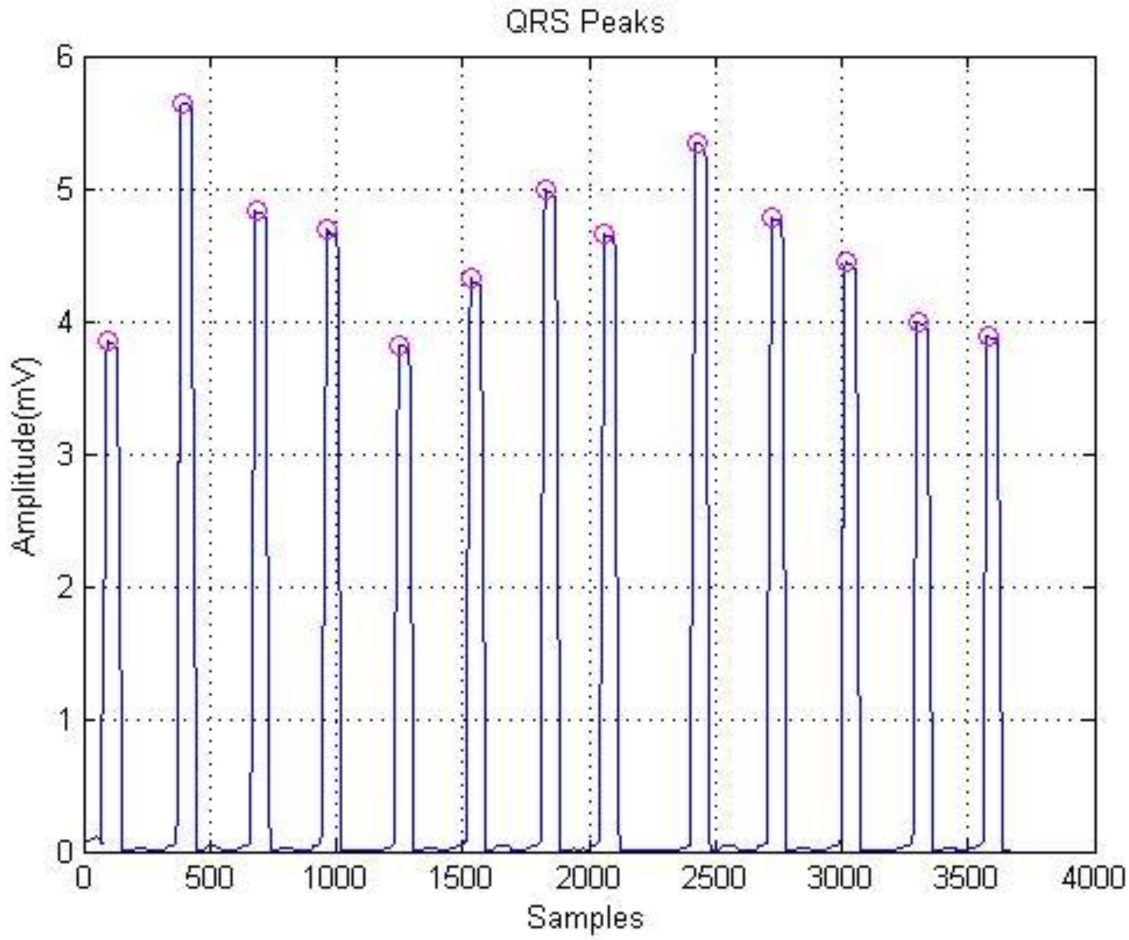
Graph 5.11: ECG Signal After Averaging

The first graph shows the ECG signal for 1 to 10 seconds and the second graph shows 1 to 3 seconds detailed view of the signal. Electrocardiogram signal after undergoing through averaging. Signal is ready to undergo through the integrator.



Graph 5.12: ECG Signal After Passing Through Integrator

The first part of this graph shows the integrated value of the original ECG signal with all the negative parts present. The second part of the graph shows the integrated value of the ECG signal that has been passed through various steps and has no negative parts. Electrocardiogram signal after passing through moving window integrator. Signal is ready to undergo R detection.



Graph 5.13: QRS PEAKS

Graph showing the QRS peaks with R peaks highlighted. Now the difference in values of R peaks will be used to calculate stress.

```
R =

   577   861   598   593   562
```

Figure 5.1: Different Values Of R Peaks

CHAPTER 6-CONCLUSION

6.1 Conclusion

This product is very useful as it helps to save time and money of the people and helps to tackle the problem of stress. As it stores data on the cloud it also helps to keep the track of your health and since the doctor is also connected he or she may give advice in order to tackle the current problem.

6.2 Future Scope

This product can be used to send real time data to doctors from the ambulance and the doctors can prepare accordingly before the patient reaches the hospital. This might help in saving the life of the patient as it save the precious time that might get wasted if the doctors perform those tests after the patient arrives and then start the treatment. If the ambulances are equipped with it, might increase the chances of survival of the patient.

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