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Monitoring of Coronary Infarction using IOT based Electrocardiogram

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Abstract: A large number of people die every year due to cardiovascular diseases. The frequency of coronary heart diseases in young Indians is 15-18% higher than in any population group globally. Heart attack, officially known as myocardial infarctions (MIs) or cardiac arrest, is known to be the most deadly cardiovascular disease. Nearly half of the patients suffering from a heart attack die just because they are unable to reach the hospital in time. Most of these patients are likely to have had an unnoticed heart attack or symptoms of heart attack. These unnoticed heart attack or so-called silent heart attack can be detected by analyzing the recording of the heart's electrical activity or electrocardiography (ECG). ECG is a widely accepted approach for monitoring of cardiac activity and can be used to detect any type of heart damages in a person.

With the development of technologies in every aspect of human society, the area of medicine has greatly benefited from them. A wearable real-time ECG monitoring system that incorporates heart attack detection and uploads the ECG data to save it in the cloud for subsequent analysis is what we are recommending. A health centre can also obtain the data from the cloud so that, in addition to the patient, it can be notified if any unusual fluctuations in the ECG data. The deployment of this technology will allow for the provision of immediate care and treatment. The patient can restrict his diet and take the appropriate medication to avert a serious heart attack when a quiet heart attack is discovered using ECG sensors.

Internet of Things, or IoT, enables data flow to the cloud in this system. It is a relatively new technology, and it may be characterised as an intelligent and interoperable node connected in a dynamic global infrastructure network, utilised to express a modern wireless telecommunication network.

Index Terms – Myocardial Infarction, Electrocardiogram, Internet of Things

I INTRODUCTION:

In the last ten years, human civilization has advanced to noteworthy levels. Healthcare plays a key role in the growth of global productivity as a whole. On the other hand, it is the most neglected yet important component of a person's overall nutrition. The main factors influencing the onset and advancement of chronic diseases that are preventable include bad lifestyle decisions like smoking, excessive alcohol consumption, poor food, lack of physical activity, and insufficient treatment for chronic stress.

One of the leading causes of death in India (and around the world) is cardiovascular disease, which accounts for 16% of all fatalities. Between 2005 and 2015, there was a significant growth of 17% in the number. In India in 2018, deaths due to heart disorders made up 28.1% of all fatalities. The leading cause of death in India is heart disease, which has been rising along with a rapid change in lifestyle brought on by India's rapid industrialization, greater urban migration, and economic expansion. India will emerge as the heart disease capital by 2020, predict the WHO and Indian Council of Medical Research.

Lifestyle diseases are becoming more prevalent among the population as a result of lifestyle inflation in society. Diseases known as "lifestyle diseases" are those that are linked to a person's or a group of people's way of life, which includes their behaviors. This demonstrates a distinct shift in the types of diseases in India from infectious diseases to chronic diseases influenced by lifestyle. A number of risk factors, including pollution (of the air, water, and soil), obesity, use of tobacco, alcohol, and drugs, poor diet, stress, and inactivity, increase the risk of developing these diseases. It is clear that the majority of the aforementioned causes are caused by human action. India's economy is expanding, and as of 2018, there were 138 crore people living there.

In essence, a heart attack is the death of a section of heart muscle brought on by a reduction in blood flow. It is characterized by signs and symptoms such as abrupt shortness of breath, upper-body discomfort, and tightness in the chest that lasts for several minutes or resolves then returns. Not everyone who suffers from a heart attack experiences the same symptoms or symptoms that are as severe. 45 percent of heart attacks are silent attacks, also referred to as silent myocardial infarctions (SMI). They are referred to be "silent" heart attacks because when they happen, they don't produce the same severe chest pain and pressure that a traditional heart attack does. typically identified by an electrocardiogram (ECG) or other

A wearable detector demonstrates the intelligent application of technology advancement. The heart's electrical activity is recorded in real time by a tiny ECG sensor built into the apparatus. A patient's ECG data is gathered by the gadget using an AD8232 sensor, and it is then Bluetooth-transferred to the patient's cell phone. On the mobile application, the patient must provide personal information such as name, age, and gender. Over the internet, the data from the mobile application is sent to the laptop. The laptop's MATLAB software processes the signals. With the help of a direct consultation with a cardiac expert, the user of the portable and practical equipment is able to monitor the state of his cardiac health.

II.LITERATURE REVIEW

Madhura Patil1, Rima Jadhav et al [1] The use of data mining techniques to be combined with the prognosis of heart diseases is explained in their paper. By taking into account risk factors linked to heart disease, the study seeks to offer specific conclusions for the prognosis of heart disease. The system uses the support vector machine algorithm on the patient's past information and data, and it offers features like age, sex, smoking, being overweight, drinking alcohol, having bad cholesterol, blood pressure, and heart rate to more accurately forecast coronary heart disease. Naive Bayes (NB), Decision Tree (DT), Neural Network (NN), Genetic Algorithm (GA), Artificial Intelligence (AI), and Clustering Algorithms like KNN and Support Vector Machine are just a few of the classification approaches used (SVM). This article provides a prediction model that can be used both independently and in combination with other strategies.

Fizar Ahmed [2] In contrast to other health fitness measurements like blood pressure, serum cholesterol, and blood sugar level, heart rate monitoring is the most significant scale of measurement and influence factor for heart attack. According to certain reports, IoT for healthcare would be crucial for diagnosing and monitoring some health-related tasks. Data is always supplied to a remote cloud, where various types of analysis reports are created and results are sent to the appropriate patient or healthcare personnel by mobile phone or other active devices. The Internet of Things (IoT) is producing large amounts of healthcare data that are valued highly from a business perspective. IoT data mining algorithms are used to uncover previously undiscovered information.

Susan Purkiss et al [3] the reaction of the cardiovascular system to environmental stressors in both men and women is highlighted in their publication. Men and women have different normal cardiovascular physiology in several significant aspects. The main distinctions between cardiovascular reactions in men and women are discussed in this article. It will consist of heart rate, blood pressure, cardiac output, stroke volume, and reaction to exercise training. Given that cardiovascular disease is the primary cause of death in both men and women, it is crucial to concentrate research and analysis on these variations. The primary distinction between cardiovascular disease in women and men is that it typically manifests later in life in women, around the time of menopause. The cardio-protective benefits of oestrogens in routinely ovulating women appear to be declining.

III. PROBLEM DEFINITION

A cardiac patient undergoes resting ECGs are to monitor them automatically, along with physicians performing diagnosis by reading the ECG. However, abnormalities may not be detected on standard resting ECG machines since the condition may not be present at that moment in time. Furthermore, it is unlikely that the patient will be in a clinical setting at the onset of the heart attack due to their sporadic nature. While Holter-based portable monitoring solutions offer 24 to 48-hour ECG recording, they lack the capability of providing any real-time feedback for the thousands of heart beats they record, which must be tediously analyzed offline. In the case of acute MI, Holter monitors are not an effective diagnosis tool because they simply record the heart’s activity and provide no assistive diagnosis or warnings. Some common problems faced by cardiac patients which drives the need for a portable heart monitor which provides timely analysis would be:

- Inability to detect silent heart attacks

Silent heart attacks are the ones which shows no perceptible symptoms. If the patient is suffering from a silent heart attack, he might not show any symptoms or in some cases, he might misinterpret the pains as normal chest pains. If a silent heart attack is diagnosed early,it can prevent the person from suffering from an actual heart attack.

- Delayed diagnosis

There are a lot of cases where the patient doesn’t undergo any treatment resulting in the condition to worsen. By the time he receives treatment, it becomes very late and the chance of successful diagnosis is reduced considerably.

- Cumbersome ECG process in hospitals

If a person has to take an Electro-cardiogram scan, he has to undergo a tiresome process of going to the hospital, getting an appointment, waiting in long queues and he has to bear the expensive bill amount. Not everyone can afford a regular ECG checkup.

- Non-availability of doctors

The doctors-population ratio in India is not up to the mark. A patient has to wait for hours to get his reports checked by a doctor. Cardiologists in India are very low in number and heart patients find it difficult to get appointments from them.

- Visit to hospitals

Not every hospital in the country is equipped with machines to treat cardiac patients. Many people living in remote areas have to travel long distances to take a routine checkup. In other cases, patients have to sit through hours of traffic before reaching a hospital.

Through our Project work, we have designed a mobile-device which collects ECG data from a person at the ease of his house. The ECG data is then processed, analyzed and gives a final out on whether there is any anomaly in the person’s heart. This device negates the visitto the hospital unless urgent medical care is required. The process of taking the ECG data from this device is simple and effective. The device helps with the early diagnosis of symptoms if the person has any which would give him access to medical care before it is too late.

OVERVIEW OF COMPONENTS

AD8232 ECG SENSOR:

Medical expert systems are increasing day by day where one part is transferrable and smart healthcare nursing devices which can be used in everyday life. Medical applications have greater importance in this fast moving and competitive world. Any change in heart rate or rhythm, or variation in the morphological ECG signal pattern, is a symptom of an arrhythmia,which could be identified by the analysis of stored data of ECG.

ECG monitoring system plays an important role in determining cardiac diseases. There are number researchers working on to archive long term ECG monitoring system. Various types of ECG measuring systems have been introduced. The ECG monitoring system that are used currently in hospitals are big and heavy so it is less portable and also the measuring system have 12 electrodes where 2 on anklet 2 on wrist and other electrodes upon chest of the body. These electrodes are gel electrodes which causes allergy and infection in case of regular use so it is difficult to do long term measurement. These devices are very expensive and home monitoring is not possible so the aged people who need to be tested their heart rate frequently is very difficult in this high population, and it is a main problem in hospitals to check the ECG of all the patients. To provide home monitoring system smart technology place an important role where the result of ECG data collected is analyzed and shared with doctor and the family members.

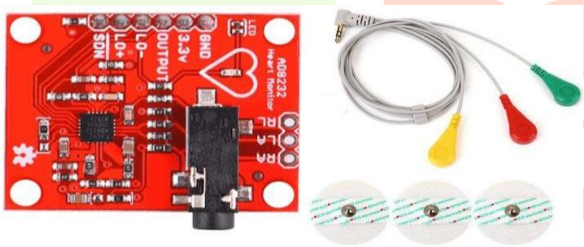

Fig 1: AD8232 ECG Sensor Module

The AD8232 module breaks out nine connections from the IC that you can solder pins, wires, or other connectors to. SDN, LO+, LO-, OUTPUT, 3.3V, GND provide essential pins for operating this monitor with an Arduino or other development board. Also provided on thisboard are RA (Right Arm), LA (Left Arm), and RL (Right Leg) pins to attach and use your own custom sensors. Additionally, there is an LED indicator light that will pulsate to the rhythm of a heartbeat. The AD8232-EVALZ contains an AD8232 Heart Rate Monitor Front End conveniently mounted with the necessary components for initial evaluation in fitness applications. Inputs, outputs, supplies and other circuit test points have been routed to vector pins to simplify connectivity to test clips and probes. Switches and jumpers are available for setting the input common-mode, shutdown (SDN) and AC/DC leads-off detection

APPLICATION CIRCUITS

I.HEART RATE MEASUREMENT

For wearable exercise devices, the AD8232 is typically placed in a pod near the heart. The two sense electrodes are placed underneath the pectoral muscles; no driven electrode is used. Because the distance from the heart to the AD8232 is small, the heart signal is strong andthere is less muscle artifact interference. In this configuration, space is at a premium. By using as few external components as possible, the circuit in Figure 4.3 is optimized for size. A shorter distance from the AD8232 to the heart makes this application less vulnerable to common-mode interference. However, since RLD is not used to drive an electrode, it can be used to improve the common-mode rejection by maintaining the midscale voltage through the 10 MΩ bias resistors. A single-pole high-pass filter is set at 7 Hz, and there is no lowpass filter. No gain is used on the output op amp thereby reducing the number of resistors for atotal system gain of 100.

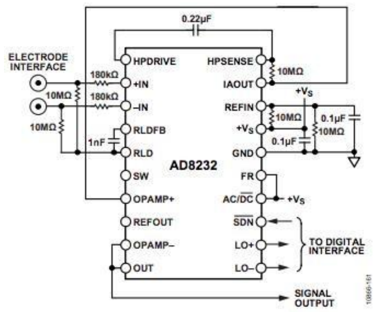

Fig:2 Circuit for Heart Rate Measurement Next to Heart

The input terminals in this configuration use two 180 kΩ resistors, to protect the user from fault conditions. Two 10 MΩ resistors provide input bias. Higher values for electrodes with high output impedance, such as cloth electrodes are used. The Figure also shows two 10 MΩ resistors to set the midscale reference voltage. If there is already a reference voltage available, it can be driven into the REFIN input to eliminate these two 10 MΩ

II.EXERCISE APPLICATION: HEART RATE MEASURED AT THE HANDS

In this application, the heart rate signal is measured at the hands with stainless steel electrodes. The user's arm and upper body movement create large motion artifacts and the long lead length makes the system susceptible to common-mode interference. A very narrow band-pass characteristic is required to separate the heart signal from the interferers. The circuit in Figure 3 uses a two-pole high-pass filter set at 7 Hz. A two-pole low-pass filter at 24 Hz follows the high-pass filters to eliminate any other artifacts and line noise. The overall narrow-band nature of this filter combination distorts the ECG waveform significantly. Therefore, it is only suitable to determine the heart rate, and not to analyze the ECG signal characteristics. Because the ECG signal is measured at the hands, it is weaker than when measured closer to the heart.

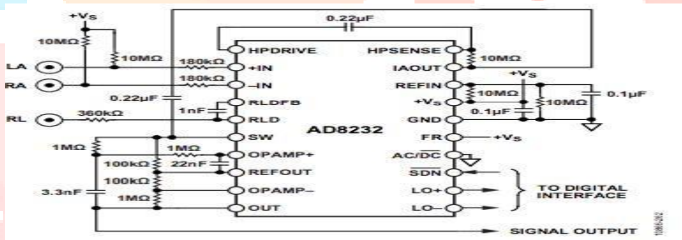

Fig 3 Circuit of 2 pole high pass filter

III.CARDIAC MONITOR CONFIGURATION

This configuration is designed for monitoring the shape of the ECG waveform. It assumes that the patient remains relatively still during the measurement, and therefore, motion artifacts are less of an issue. To obtain an ECG waveform with minimal distortion, the AD8232 is configured with a 0.5 Hz two-pole high-pass filter followed by a two-pole, 40 Hz, low-pass filter. A third electrode is driven for optimum common-mode rejection. In additionto 40 Hz filtering, the op amp stage is configured for a gain of 11, resulting in a total system gain of 1100. To optimize the dynamic range of the system, the gain level is adjustable, depending on the input signal amplitude and ADC input range.

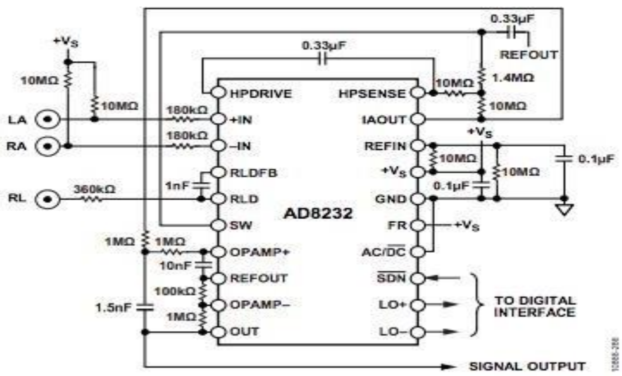

Fig 4: Circuit for ECG Waveform Monitoring

IV:ARDUINO NANO

The Arduino Nano, as the name suggests is a compact, complete and bread-board friendly microcontroller board. The Nano board weighs around 7 grams with dimensions of 4.5 cms to1.8 cms (L to B). This article discusses about the technical specs most importantly the pinoutand functions of each and every pin in the Arduino Nano board.

Arduino Nano has similar functionalities as Arduino Duemilanove but with a different package. The Nano is inbuilt with the ATmega328P microcontroller, same as the Arduino UNO. The main difference between them is that the UNO board is presented in PDIP (Plastic Dual-In-line Package) form with 30 pins and Nano is available in TQFP (plastic quad flat pack) with 32 pins. The extra 2 pins of Arduino Nano serve for the ADC functionalities,while UNO has 6 ADC ports but Nano has 8 ADC ports. The Nano board doesn't have a DC power jack as other Arduino boards, but instead has a mini-USB port. This port is used for both programming and serial monitoring. The fascinating feature in Nano is that it willchoose the strongest power source with its potential difference, and the power source selecting jumper is invalid.

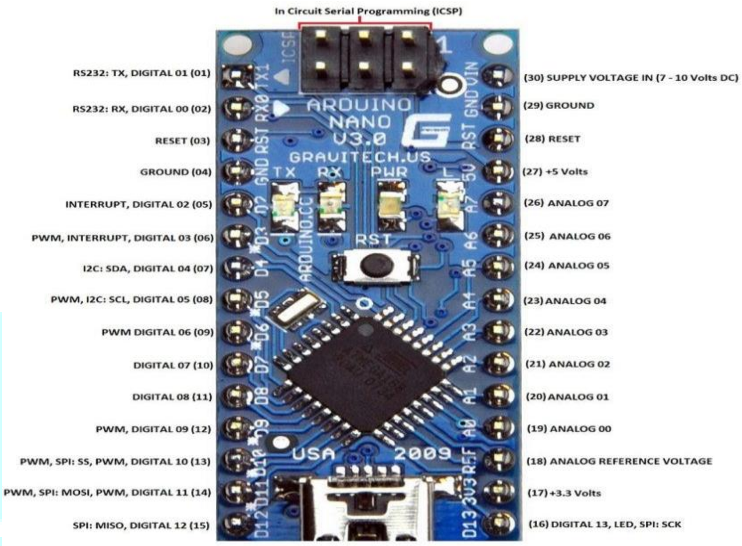

Fig 5: Arduino Nano

The Arduino Nano is very much similar to the Arduino UNO. They use the same Processor (ATMEGA328P) and hence they both can share the same program. One bigdifference between both is the size UNO is twice as big as Nano and hence occupies more space on your project. Also Nano is breadboard friendly while Uno is not. To program a Uno you need Regular USB cable where as for Nano you will need a mini USB cable

V HCO5 BLUETOOTH MODULE:

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. This serial port bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4 GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Rluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). The Bluetooth module HC-05 is a MASTER/SLAVE module. By default the factory setting is SLAVE. The Role of the module (Master or Slave) can be configured only by AT COMMANDS. The slave modules cannot initiate a connection to another Bluetooth device, but can accept connections. Master module can initiate a connection to other devices. The user can use it simply for a serial port replacement to establish connection between MCU and GPS, PC to your embedded project, etc.

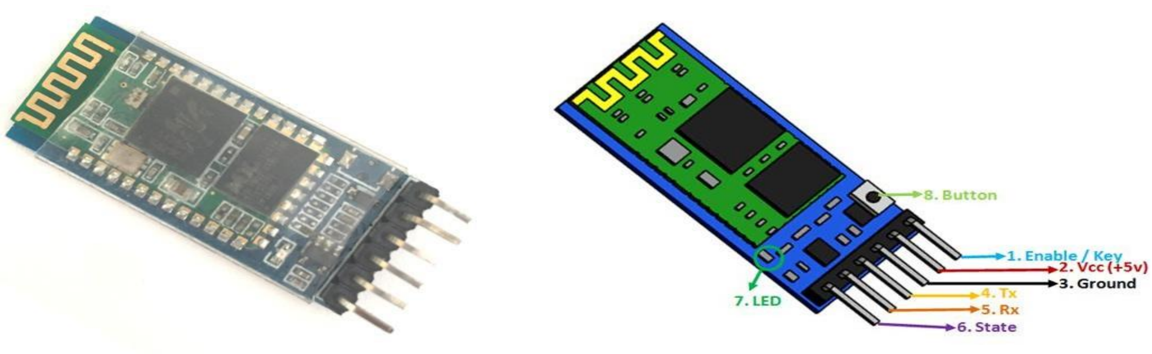

Fig 6: HCO5 BT Module

SOFTWARE FEATURES

- Slave default Baud rate: 9600, Data bits:8, Stop bit:1,Parity:No parity.
- Auto-connect to the last device on power as default.
- Permit pairing device to connect as default.
- Auto-pairing PINCODE: "1234" as default.

HARDWARE FEATURES

- Typical -80dBm sensitivity.
- Up to +4dBm RF transmit power.
- 3.3 to 5 V I/O.
- PIO(Programmable Input/Output) control.
- UART interface with programmable baud rate.
- With integrated antenna.
- With edge connector.

IV.Results and Discussion:

SOFTWARE CLASSIFICATION

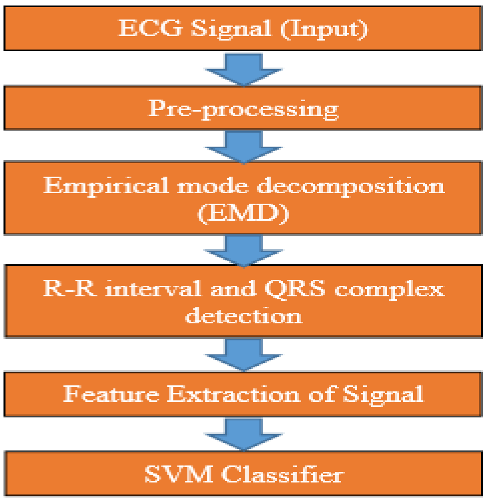

Fig 7: Software Classification

Automatic detection of ECG signals can be performed using R-R intervals and QRS value. The R-R interval signals are non-linear and non-stationary in nature. Hence, linear methods cannot be used to capture the presence of hidden information in the signal. Empirical mode decomposition, a non-linear method, is proposed to discriminate between abnormal and normal R-R intervals. Pre-processing steps are performed on the RCG signals to obtain the R-R signals. The unwanted noise is filtered by passing the original ECG signal through a low pass filter. Then, the signal is passed through high pass filter to remove baseline wander. The median filter used to determine the baseline wander of the proposed ECG signal and this baseline wander has been subtracted from the proposed ECG signal in order to obtain baseline wander free ECG signal. Then, the Pan-Tomkins algorithm is used to find the QRS complexes from the proposed ECG signal. The R-R signals are calculated as the time between two consecutive QRS complexes. This is shown in Fig 7

EXPERIMENTAL RESULT

The MATLAB software (version R2016) command window is shown in the Fig 8:

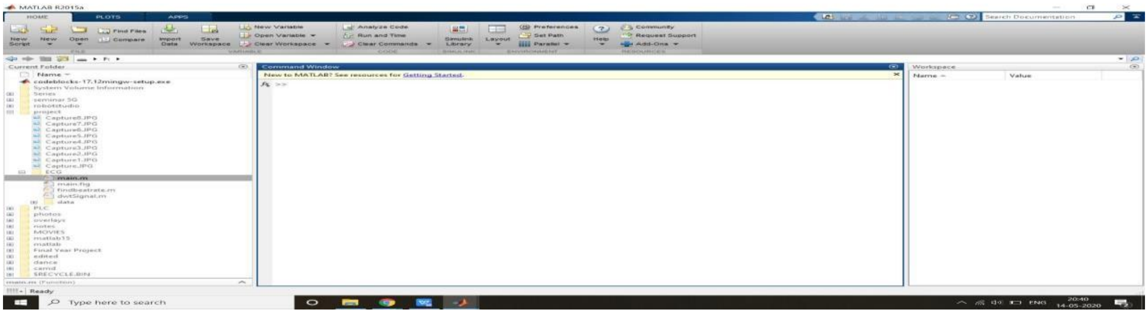

Fig 8: MATLAB R2016

The following Fig 9 is the screenshot of the output screen of the code.

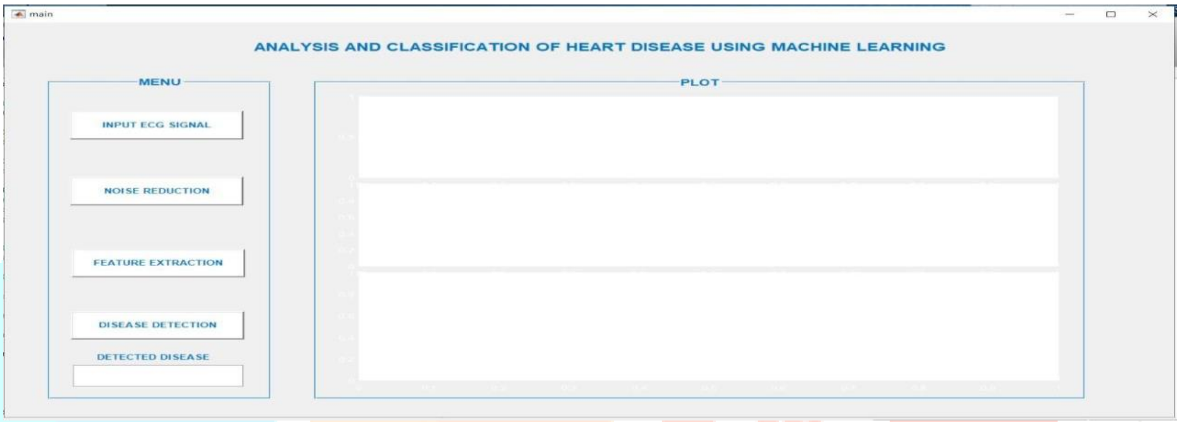

Fig 9: Output Screen Code

The ‘MENU’ consists of four options. They are

1. Input ECG Signal
2. Noise Reduction
3. Feature Extraction
4. Disease Detection

The following Fig 10 shows how to use input ECG data into the MATLAB code. The input data is a ‘.wav file’. There is a pre-existing dataset which is used here to check the accuracy of the code. The datasets consist of ECG data of patients having heart diseases and also of healthy people. The input dataset is obtained from the repository of the cardiovascular care department at Indiana Heart Research Institute

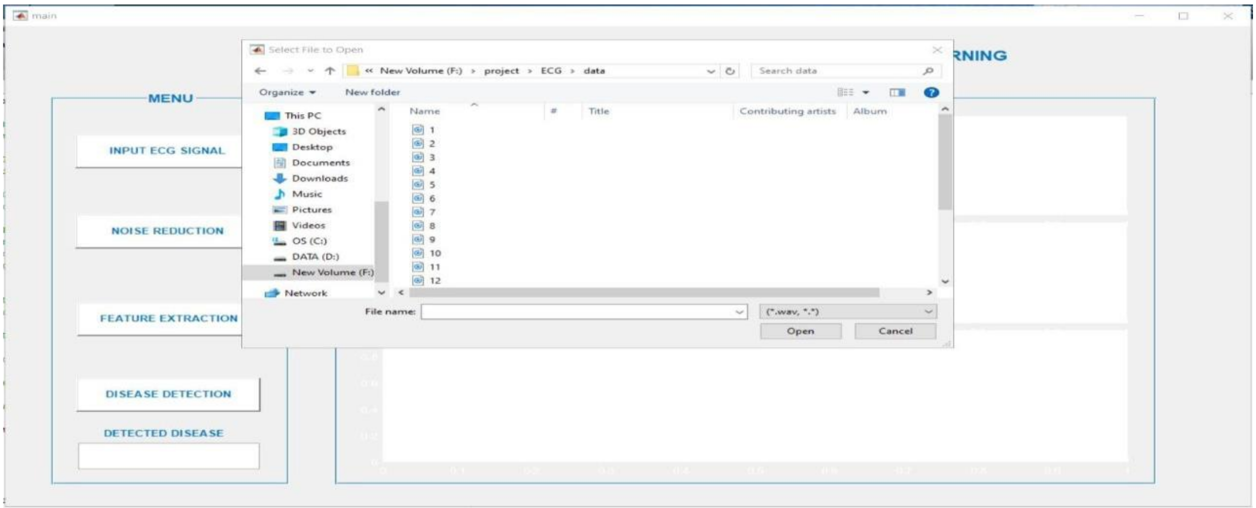

Fig 10: Input Selection

The Input data is taken from the dataset. The figure shows the waveform of the input signal.

The input signal undergoes noise reduction and we get a filtered sound signal.

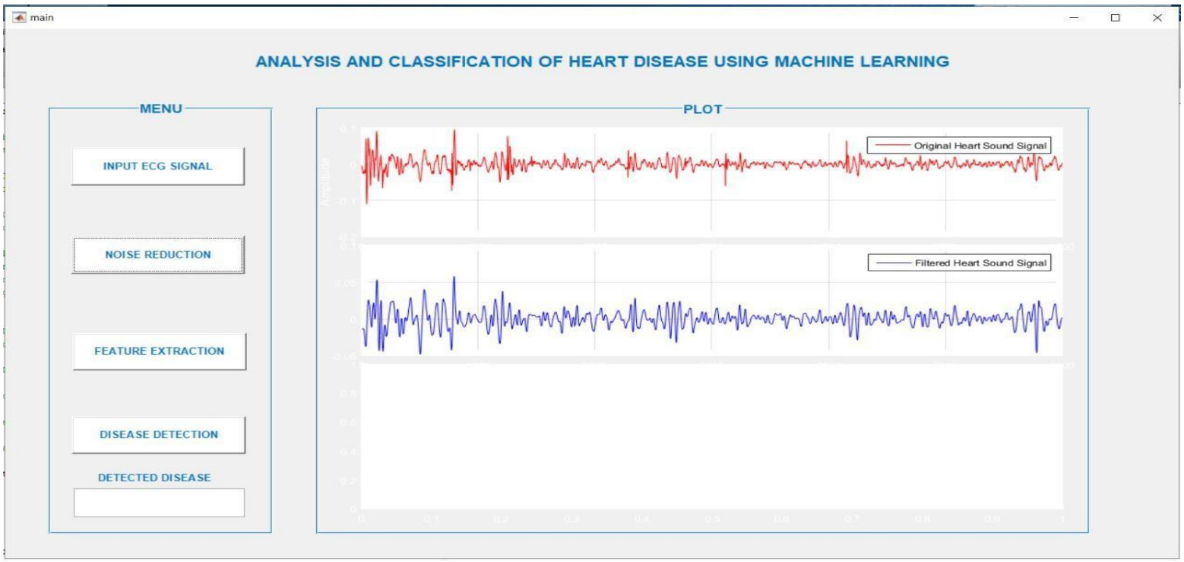

Fig 11: Noise Reduction

After the noise reduction of the input signal, the signal undergoes feature extraction. This is avital part of the algorithm. Here, the QRS complex is obtained in Fig12.

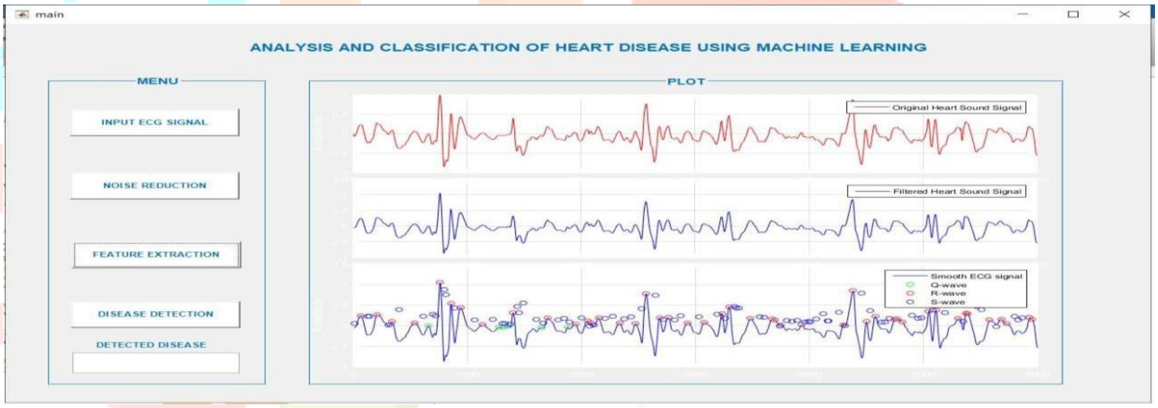

Fig 12: Feature Extraction

The following Fig 13 is the result window after processing the ECG signal of a healthyperson. It clearly shows that the person doesn't have any cardiac ailments.

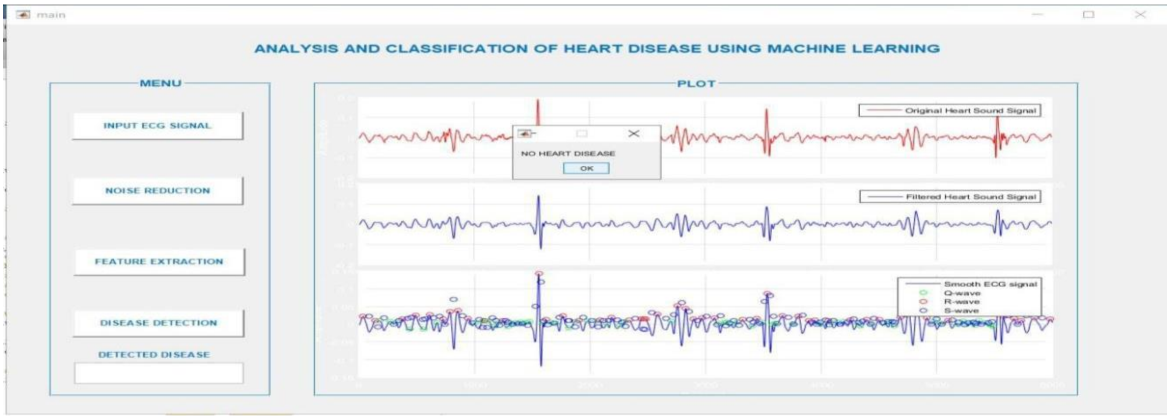

Fig 13 Disease Detection

The next Figure 14 is the result window after processing the ECG signal of a cardiac patient.It indicates that the person has some form of cardiac illness.

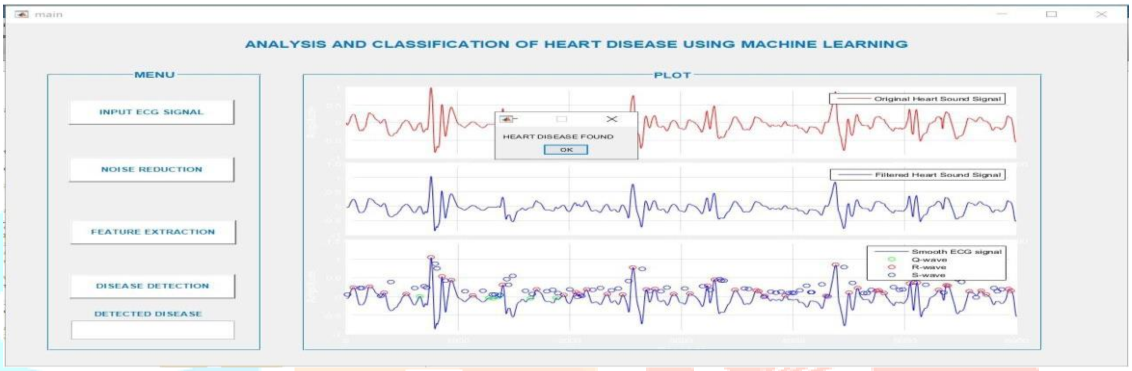

Fig 14: Disease Detection

Table 1 : **Distribution of Myocardial Infarction(MI) [7]**

Age (Decade)	**No AMI(%)**	**AMI(%)**	**N**
15	100.000	0.000	1
25	100.000	0.000	7
35	91.892	8.108	37
45	78.632	21.368	117
55	76.571	23.429	175
65	79.125	20.875	297
75	81.694	18.306	366
85	77.083	22.917	192
95	77.083	22.222	27
105	100.000	0.000	1

The effect of gender on ECG was obtained from earlier tests. The table below gives an overview on the result of the test conducted.

Table 2 : **Distribution of MI in the test set by gender**

Sex	No AMI (%)	AMI (%)	Total	N
Female	40.226	30.242	38.197	466
Male	59.774	69.758	61.803	754
N	972	248		1220

Another Study was conducted taking only females of different age groups to study all the differences in ECG waveform and not just the myocardial infarction. This study was smallerin the number of people taken. They took 75 healthy female in the age group of 21 to 80years. They were classified in to three subgroups according to their age. Group-I consisted of people between 21-40, Group-II consisted of people between 41-60 and Group-III consistedof 61-80 years. The subjects of the test, i.e., each single female, were also made sure if they had a history of systematic diseases like hypertension, heart diseases, diabetes mellitus,

smoking, alcohol consumption etc. People with these kind of systematic diseases were removed from the study. Blood pressure, Body Mass Index and Waist/Hip ratio were also measured in all the subjects. The results from this study is tabulated and is given below:

***Table 3*:** Comparison of ECG Parameters between females of different age groups

Parameters	**Group I**	**Group II**	**Group III**	**Post hoc multiple comparison**
RR Interval(s)	0.68± 0.18	0.69± 0.06	0.76±0.07	Gr I vs II,p>0.05 Gr I vs III,p<0.05*Gr II vs III,p>0.05
HR (bpm)	85.52±11.3	83.26±12.3	77.33±10.1	Gr I vs II,p>0.05 Gr I vs III, p<0.05*Gr II vs III, p>0.05
QTc Interval (s)	0.22 ±0.05	0.26±0.07	0.26±0.05	Gr I vs II, p>0.05 Gr I vs III, p<0.05*Gr II vs III, p>0.05
ST height (mv)	0.052±0.06	0.011±0.01	0.03±0.018	Gr I vs II, p<0.01* Gr I vs III, p>0.05 Gr II vs III, p>0.05

The final result of how these tests have helped improve Glasgow's sensitivity and specificity is also given below. In general, the sensitivity of the new criteria increased to 46.8% compared to 41.5% using the old criteria. Similarly, specificity improved from 96% to 98.5%. Corresponding figures for males were 40.5% to 45.7% for sensitivity and 96.4% to 98.8% for specificity. For females the data showed an improvement in sensitivity from 44% to 49.3% and in specificity from 95.4% to 98%.

Table 4: Distribution of results by gender

	Sensitivity (%)		**Specificity (%)**	
	Glasgow	ACC/ESC	Glasgow	ACC/ESC
Males	45.7	40.5	98.8	96.4
Females	49.3	44.0	98.0	95.4

V.CONCLUSION

In this paper, heart attack detection using ECG data obtained through the device and later processed by MATLAB code, thus making the process of testing the ECG data at home is successfully completed. With the sample datasets obtained from the Cardiology Department at Indiana Heart Research Institute, Mangalore, we were able to achieve an accuracy of greater percentage using the algorithm.

A web-based system was created to process the ECG data and give out a result. The ECGdata went through the process of pre-processing to reduce the noise. Pan-Tomkins Algorithm is used to find the QRS complex from the resulting signal. The R-R signals are calculated as the time between two consecutive QRS complexes.

This project uses a variety of technologies for its smooth functioning. The technologies include Internet-of-Things (IoT), MATLAB programming, Bluetooth, Arduino, AD8232,Android App development etc.

It is to be acknowledged that the prototype presented is not an out and out replacement for the ECG monitors present at hospitals but it does serve as an assistive diagnosis tool. Furthermore, it provides a cheap alternative to the ECG scans and it can be done several times without having to spend even a rupee. With this system, the patient needn't depend on symptoms like chest pains, which may or may not occur, rather testing the ECG on aconsistent basis at home will notify the patient about the anomaly (if any).

Furthermore, there is immense scope for this technology to go on a commercial market. There is a dearth in the number of doctors in our country and devices like this will help mitigate that issue. The future of medicine will involve a lot of tele-diagnosis and devices likeours will drastically improve on that front.

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