Cardiovascular Function Monitoring Using IOT and Cardiovascular Disease Prediction System

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Abstract- Currently, healthcare domain is to offer better for people anytime and anywhere in the world in a more profitable and patient-friendly way. Unfortunately millions of people sustain from various Heart diseases, and Heart attack is the primary cause of Death in the world and increasing of heart diseases mainly due to the negligence of their health because they don't have time for themselves and forget about their health protection due to a massive workload. Accurate and exact prediction of the heart disease mainly depends on Electrocardiogram (ECG) data and patient clinical data. In this paper, we are going to make an IOT Based Heart Disease Prediction and Monitoring system using Arduino and raspberry pi 3. We utilize an AD8232 Heart rate sensor module to interface to the Arduino board, and Arduino board serially communicates to the raspberry pi board.NEO6MV2 GPS module interfacing to PL2303 USB to TTL for performing a function of USB to UART in between the raspberry pi and GPS. The software sketch we used here is python to control the entire system and to store all the sensor data in the cloud using the HTML and Wi-Fi. It offers security and facility for retrieving all the sensor information, and subject heart condition can monitor from at any time and any place in the world over the internet/mobile phone. This design system which is very helpful to patients and also produces if there are any changes in the condition of the health, then we have to alert immediately to the corresponding doctor or the referring physician for the further treatment process and notifications about the medicines, location change, etc.

Keywords- ECG electrodes, AD8232 heart rate monitor, Arduino Uno, raspberry pi 3, PL2303, GPS, python, HTML.

I. INTRODUCTION

The Embedded technology has entered almost in all Aspects of day-to-day life, and the healthcare field is no exception for that the requirement for fully-equipped hospitals and diagnostic centers growing day by day as the people are becoming more unaware of their health problems. Heart disease incorporates any disorder that affects the heart's ability to perform ordinarily. Traditional risk factors include smoking, hypertension, diabetes, and obesity [2] among many others. There are different types of coronary illness, for instance, heart attack, cardiac arrest, arrhythmia, hypercalcemia, hypokalemia, coronary artery disease, and so on. The most generally perceived reason for Heart disease is a narrowing of the coronary arteries that supply blood to the heart muscle, yet some heart diseases are available during childbirth. Different techniques have explored all in all, coronary illness; The signal can be effortlessly obtained by placing the electrodes on the chest and limbs and hooking them to an ECG machine. An ECG signal can trace the various physiological and abnormal conditions of the heart. But some symptoms such as heart murmurs frequently caused by defective heart valves can't be identified from an ECG signal. Consequently, some exploration has concentrated on diagnosing heart defects based on the relationship between ECG and clinical readings which can lead to high-performance heart diagnostics. Early detection of heart disease is essential because it can ease the treatment and also save people's lives.

II. RELATED WORK

This topic suggests the need for some ECG Detection and analysis techniques have evolved. N. Liu, Z. Lin et al.[5]directed mainly towards heart disease and stroke. They are found to remain the primary reason for killing. One of the CVD harm factors is Cardiac Arrhythmia. Nahina Islam, Nafis Imtiaz Bin Hamid et al. [6] discussed that many natural phenomena in several domains like physics, biology, and medicine, could have a fractal behavior. It has also applied to real success in the biomedical industry. B. Eggins [9} used the most standard method of measuring heart activity is through a 12-lead Electrocardiogram (ECG), using wet-gel electrodes. M. Fernandez and R. Pallas-Areny [10] discusses Conductive clothes are increasing demand because they are easy to use, and unlike Ag/AgCl electrodes do not need to be altered in long-term applications. Moreover, they are not flexible and can be shaped like a typical wristband or embedded inside garments that the user can wear. Shital L. Pingale[3] proposed that Cardiovascular diseases are some of the most prevalent and severe, life-threatening health problems in the world.

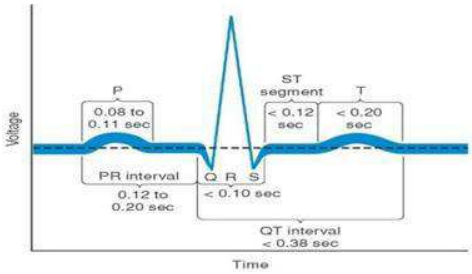


Figure 1. ECG Interpretation

Related work on this paper, we have used to plot ECG and Heart rate (in BPM) in a webpage, we have selected seven features of the model to predict heart diseases. We have a total of 10-15 readings taken from the different people. The ECG features recorded in 1) QRS duration 2) R-R interval 3) P-R interval 4) Q-T interval 5) R-wave amplitude 6) P-wave Duration 7) T wave duration. The QRS length (must be within 0.06 to 0.10 sec), R-R interval (must be within 65-85 BPM), P-R interval (Indicates the proper functioning of a Sino-atrial node), Q-T interval (Indicates the rate, the velocity of blood flow from atrial to ventricular chambers), Isoelectric line (indicates the resting time in the heart takes seconds in a single heartbeat, R wave amplitude (indicates the rate of blood flow from atrial to ventricular chambers), P wave amplitude (Indicates the extent of atrial excitation), T wave amplitude (indicates the extent of ventricular relaxation). The Figure as shown below describes the essential ECG analysis used to predict heart diseases.

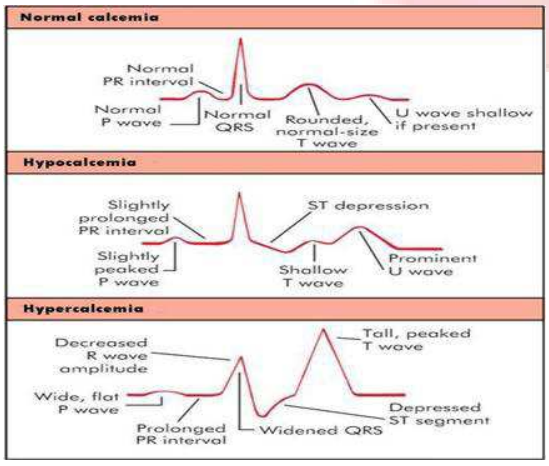


Figure 2. ECG analysis

III. PROPOSED SYSTEM ARCHITECTURE AND IMPLEMENTATION

The proposed system divided into two parts, Hardware part and software part each with their functionality. Below diagram shows the conceptual units like Arduino Uno R3, Raspberry Pi 3 model B and a micro USB power supply section, AD8232 ECG heart rate sensor, etc. We also have there is the NEO6MV2 GPS Receiver unit which delivers latitude-longitude information to the controller, and collected sensor data send them to the Raspberry Pi. Pi which sends the GPS information to the remote web server located at the control station. We can then expand them as possible way. It can have the improved design concept of health monitoring model. Through ECG and Heart rate looking on the webpage, basic block we can explain the further processing.

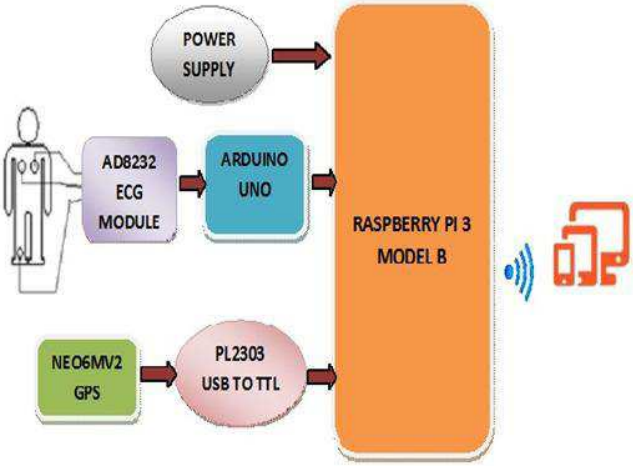


Figure 3. Block Diagram

IV. HARDWARE IMPLEMENTATION

1. ECG Electrodes

Utilize of Quality electrodes is an integral part of the overall monitoring process. When selecting electrodes that existed in different shapes and sizes, are made up of different materials, and are recommended for the various clinical applications (e.g., ambulatory ECG, critical care unit, etc.).In figure 3, Use only electrodes specified by the manufacturer of the monitor we are using. Selecting the same brand and type of all electrodes should be helped to minimize noise. It is significant to choose an appropriate lead that shows the high amplitude and pure signal. So that QRS complex and R-wave, in specific, can be accurately detected by the monitor.

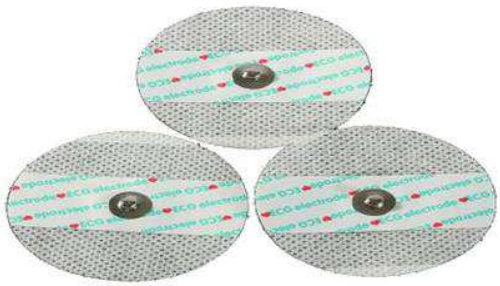


Figure 4. Ag/Cl Electrodes

2. AD8232 HEART RATE MONITOR

The AD8232 ECG Monitoring sensor module is a flexible board operated to test the electrical activity of the heart. This electrical activity charted an ECG or Electrocardiogram and output as an analog reading.ECG can be extremely noisy, and the AD8232 Single Lead Heart Rate Monitor acts as an op-amp to help obtain a clear signal from the PR and QT Intervals quickly. The AD8232 is an integrated signal conditioning block of ECG and another bioelectric potential measurement applications. It is intended to extract, amplify, and filter small biosignals in the presence of fluctuated conditions, similar to those created by motion or remote electrode placement.

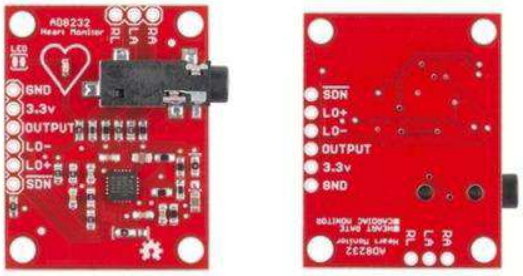


Figure 5. AD8232 heart rate chip

Figure 5, describes the AD8232 single Lead Heart Rate Monitor having nine connections with the IC that you can attach pins, wires, or other connectors too. GND, 3.3V, OUTPUT, LO-, LO+, SDN are necessary pins for operating this monitor with a Raspberry Pi or other development board. Also provided with this board are RA (Right Arm), LA (Left Arm), and RL (Right Leg) pins to attach and use your custom sensors. Additionally, there is an LED light indicates that will move in and out, with regular movements rhythmically in a heartbeat. Biomedical disposable electrodes pads and Sensor Cable are required to use the heart monitor.

3. ARDUINO UNO

Arduino is an open source which means that it consists of both microcontroller and piece of software. The heart of the board is the Atmel Microcontroller chip is the most significant chip on the board. The Arduino UNO uses Atmega328p. There are three main pin sections on an Arduino (i.e., 14 input and output pins, six analog pins, and power supply pins) and we use analog and digital pins to provide voltage to the components. It has 32 kilobytes of memory. It operates as a clock of 16MHZ, and we have a 3.3 and 5V regulator and a USB input to give the power to board. There's a reset switch that allows resetting the microcontroller to start the program all over again. Arduino software is used to write and upload the computer code to the physical board. The Arduino does not need a separate piece of hardware programmer. Only we can only use a USB cable to connect to the computers and load new code onto the board.

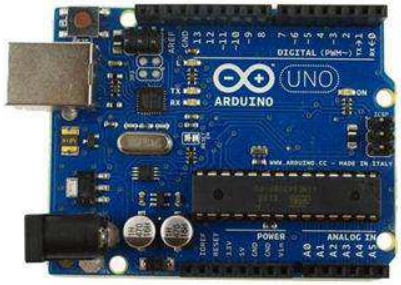


Figure 6. Arduino Uno board

4. RASPBERRY PI 3

Raspberry Pi3 Model B is a Low-cost small credit card sized single board minicomputer, which is the latest generation developed by the raspberry pi foundation in the United Kingdom. Its primary intended to help people to learn more about programming language and ideal to create new exciting and inspiring applications. The Raspberry pi3 maintains the same popular board size and layout. There are two Versions of the naming system. Model A, Model B indicate the “generation” of the model, where Pi 1 has released in 2012, Pi 2 is released 2015, and Pi3 is released in 2016. So pi 3 is better than 2, which is better than1. Model A, A+, B, and B+ indicate the power and features. It's not like grades though; model A is lower than B. There are now different versions of the Raspberry Pi which has gradually developed as computing has to move forward.

Figure 7. Raspberry Pi 3 model B

The heart of the Raspberry Pi 3 CPU is Broadcom 64-bit quad core ARMv7 processor which has updated to a BCM2837, that means it differs from a standard PC. Raspberry Pi based on a RISC based ARM processor. The ARM is similar to the processors used in many Embedded systems and many mobile phones and most tablet computers.

It runs at super-fast 1.2 GHz, and the RAM extended to 1 GB it is shared by CPU and GPU, which is a reasonably powerful graphics processor capable of displaying full Resolution 1080p HD Audio and Video output over HDMI.HDMI connected to a TV or monitor through an HDMI connection. The Raspberry Pi utilizes micro SD card for storage and loads the operating system, and it has four USB ports and a 10/100 base-T Ethernet socket for LAN connection. New Raspberry pi 3model B comes with Built-in wireless 802.11 b/g/n and Low Energy Bluetooth 4.1 connectivity making it the first Internet of things Ready. For connecting Raspberry Pi camera and Touch Screen Display, we use CSI port and DSI ports. The GPIO stands for general purpose input and output it is one of the most powerful features which allows communicating with other circuitry such as extension boards, sensors, custom circuits and much more. The Raspberry Pi GPIO extended to 40-pins these are easier to understand as they are in order. The Primary purpose of GPIO is being used to turn on and off the devices.

5. PL2303 USB to TTL

USB connectors are the kind of convention converters which utilized for changing over USB information signals to and from different communications standards. Typically, USB connectors are being used to alter over USB information to standard serial port information and the other way around. Most ordinarily the USB information signals are converted to either RS232, RS485, RS422 and TTL serial data. We will utilize converters that change over information from USB convention to TTL.

Figure 8. PL2303 USB to TTL chip

These modules come in little form factor. At the core of these modules is a converter chip that does all the convention conversion. We need to make just three associations with access to GPS. We need to Connect GND Pin of the PL2303 converter to GND pin of GPS. TXD pin of the PL2303 converter to pin number 10 of Raspberry Pi, i.e., RXD0 of Pi. Connect 5v pin of the converter to VCC pin of GPS.

6. GPS

The GPS module is minimal in size. It uses the Ublox NEO-6Mv2 GPS receiver, and this module has an embedded antenna at the back. The module also uses the serial interface to communicate with the microcontroller, so it is incredibly easy to connect it with raspberry pi by adding GPS receiver will figure out the moving objects or to know someone's position type they use. There are many satellites available all over the earth, and trilateration is a process the GPS receiver can find your location. Whenever we put a GPS Receiver, it takes the signals from satellites, GPS receiver gets this place from different satellites, and at least 4-satellites are necessary to find out the location. GPS Receiver is having the location of all the satellites it calculates the time delay between satellites converted into distance and gave the desired location. At first, we have to connect the GPS module.

Figure 9. NEO6MV2 GPS Module

It has four pins. The GND pin of the module is to connect raspberry pi GND pin. The Vcc pin of the module is attached to the positive rail of the board. Next, we have to connect RX and TX pins connected to TX and RX of the raspberry pi board. In this GPS module working under 9600 bps. It will able to get the GPS data onto the satellite, and it picks up the position given to this Raspberry Ri. We will see the location based on latitude, longitude values, date and time it will display on the screen.

Figure 10. Google Map

Google Maps is a free open source web service developed by Google. It offers satellite visually, street maps, 360° panoramic views of streets. Google Maps is also

allowing to select the shortest, cheapest to a particular point and you can adjust directions based on your preferred method of transportation. If we want to trace the route of a person, we have to load the obtained latitude, longitude and altitude GPS values into Google maps on the web or mobile devices then it will show the detailed or simple view of a particular location.

V. SOFTWARE IMPLEMENTATION

1. PYTHON

Python is a simple and very powerful general purpose open-source high-level scripting language. It was created by Guido van Rossum in early 1990s at a laboratory in Netherlands. There are two versions available in Python, python 2.0 and python 3.0 and the file will have an extension of dot .py and py is going to take as an input by the interpreter, and it is going to execute the code dynamically. Nowadays many software Applications are developed using dynamic languages; Python is a prime example of dynamically typed languages. Python is available on multiple platforms that mean the code that we write is available on Windows, Linux, MAC or any other operating system. If you want to learn to program language or if you have never programmed before, then learning python is an excellent idea. Python is very easy to learn compared to other languages, and Python offers multiple programming models. Which can utilize for a wide assortment of content processing, system administration, Internet-related tasks and to develop embedded applications? Python enables to use variables without declaring them, and it depends on indentation as a control structure and not to define classes in python unlike java, but you are free to do so when suitable.

2. HTML

Hypertext Markup Language is the standard markup for making website pages and web applications. With Cascading Style Sheets (CSS) and JavaScript, it frames a group of three of foundation advancements for the World Wide Web programs get HTML records from a web server or nearby capacity and render them into media site pages. HTML depicts the structure of a site page semantically and initially included prompts for the presence of the document.HTML can install programs written in a scripting dialect, for example, JavaScript which influences the conduct and substance of site pages. Consideration of CSS characterizes the look and design of element. Python would be a decent device to naturally produce the different HTML pages from a straightforward content record. It Would enormously rearrange the updates of my website pages, as I would just add one section to one document and after that make finish pages by running a Python script.

VI. RESULTS AND DISCUSSION

The primary objective of this paper is to develop a comprehensive system which can acquire and analyze ECG signals for identifying different peoples of Normal and cardiac diseases has been achieved. The designed method includes Raspberry Pi and Arduino based data acquisition and signals conditioning system which can acquire ECG signals of a person and sends it to the webpage. In the webpage, an algorithm is developed using HTML to extract the required features out of the acquired ECG signal for diagnosis of abnormalities present in particular person's ECG. Clinical data and ECG data as shown in below.

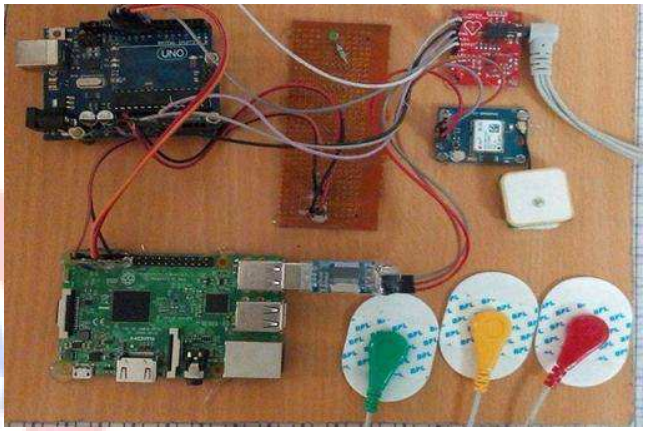


Figure 11. Experimental Setup

Table 1. ECG Parameters

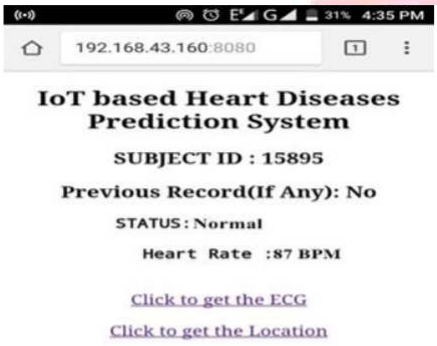
ECG	Description	Measurements
1)QRS Complex	Indicates the atrial systole, atrial diastole and ventricular excitation respectively	0.08 -1.2 sec
2)R-R interval	Indicates the heart rate in beats per minute	1 second
3)P-R interval	Indicates the electrical signal generated by the sinus node is normal and travelling in a normal fashion in the heart.	0.08-0.20 sec
4)Q-T interval	Indicates the flow of electrical impulse and blood from the atrial chambers to ventricles	0.36-044 sec
5)R-wave	Indicates the atrial	1 millivolt

amplitude	diastole	
6)P-wave duration	Indicates the rate of atrial excitation	0.06-011 <0.25 sec
7)T-wave duration	Indicates ventricular systole	0.16 <0.5 sec

From the ECG parameters, analysis of the ECG signal can be implemented. According to the parameters changes comparing to the standard parameters above, the system may predict which disease that the user potentially suffering from.

After calibration, the ECG waveform of different people (subject) are recorded as follows and are discussed below figures.

SUBJECT 1:



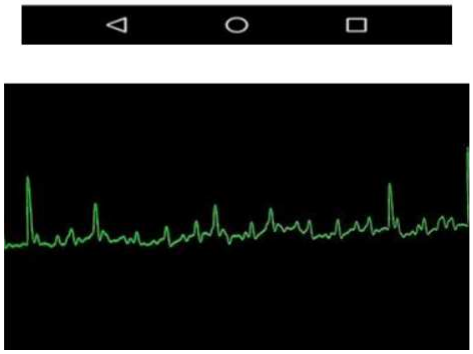


Figure 12. IOT showing normal levels

SUBJECT 2:

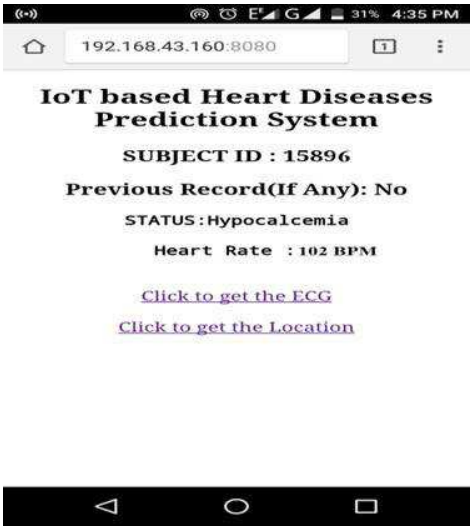


Figure 13. IOT showing abnormal levels

While Typing Local IP Address into the Browser, The System Displays Status Of A Person Along With Heart Rate. When a Person Click on to the ECG. The System Generate Live ECG Waveform On to the Web Page.

Table 2. Subject Readings

	SUBJECT -1	**SUBJECT -2**
Subject ID	15895	15896
Name	Kalyan	Maheshwari
Age	25	48
Gender	Male	Female
R-R Interval (heart rate in sec)	0.7 s	1.6 s
QT interval(400-440ms)	410 ms	390 ms
Condition	**NORMAL**	**SHORT QT**

Summarizing the ECG of healthy people and diseased people have been measured and compared with the standard ECG values. The system calibrated consistently.

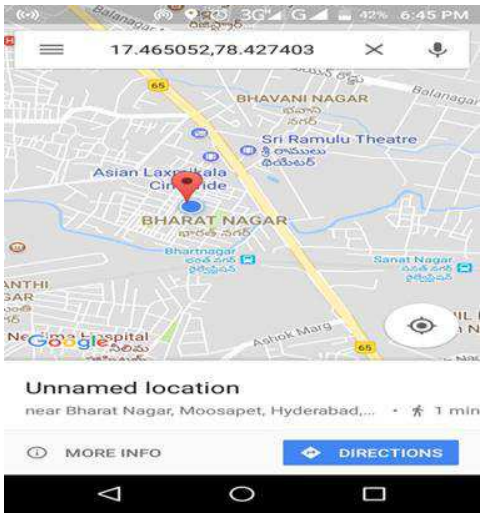


Figure 14. GPS location

When a person wants to see his location, he just Clicks on to the GPS. The System display location with latitude and longitude values On to the Web Page.

VII. CONCLUSION AND FUTURE WORK

The primary idea of this research paper is to designing and implementing web-based ECG system to display the real-time ECG signal along with GPS Location and allowing it in the monitoring of their heart to stop the need for usage of high priced equipment and reduce the need for the conveyance of patients to physicians and medical centers. Based on ECG signal, heart rate and subject's clinical data using Arduino and Raspberry Pi for visualizing the heart condition to diagnosing various heart diseases. The GPS which assist in finding the person's location.

A future task will intention on monitoring additional health-related parameters using a broader combination of sensors, improving ECG signal detector, Robustness to patient movements and connectivity losses. This system is an excellent choice for doctors and cardiac patients in advancing countries.

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