Low cost IoT based Heart Rate Monitoring system using node MCU and detection of early heart attack

Sayan Ghosh[1], Shourjyajit Maity [1*], Soumyajit Datta[1], Indumouli Nandy[1], Soumyadeep Nandy[1], Viswajeet Sharan[1], and Swati Chowdhury [1]*

[1]Institute of Engineering & Management, Salt Lake Electronics Complex, Sector V, Kolkata 700091, India

**Email: onlinestudy.sayan@gmail.com*

shourjyajitmaiti2000@gmail.com

Abstract

In this project, an IOT-based system has been implemented which can monitor heartbeat from the output given by a hardware system. This 'Hardware System' consists of a Node MCU and Pulse Sensor. An 'Alert System' remains added, which gets executed if heartbeat goes below or above the permissible level. Through a 'Mobile Phone Application', Doctor receives the alert message and Doctor can access the heartbeat data of the patient from any location. Doctors and Nurses at hospital will be able to monitor the heart rate of the patient by virtue of Real time Monitoring System.'. Heartbeat data and other personal details of patient remain stored in cloud and can be utilized for future studies on health condition of the patient.

Keywords: *Heart rate monitoring system using, NodeMCU, Internet of things.*

1. Introduction

'Heart' is one of the most important organs in human body. It acts as a pump for circulating blood and oxygen throughout the body. Presently 'heart diseases' are a common factor for causing of death of human being. Early detection of Heart- related diseases is very important, for preventing further complications in future. The prototype, which consist of hardware and software components can store the data of heartbeat as well as other details of the patient and it helps the Doctor to analyze the condition of heart of the patient. Hardware consists of NodeMCU, Pulse Sensor and LCD Display. Software consists of IOT Platform, Adafruit (along with GPS Technology) and blynk along with a mobile application.

For an example: Suppose; a patient who is suffering from Heart-diseases, gets admitted in a hospital and in that hospital, Heart-specialist Doctor visits only once in a day. But; if some serious situation occurs at night (Heartbeat of patient goes below or above the normal range), then an alert message will be sent to the Doctor and Doctor can monitor the patient from any location. As a result, Doctor can prescribe the required medicines accordingly and it will save the life of the patient. This paper proposes a system for heart rate monitoring and heart related disease that requires continuous and long-term monitoring. IoT is

very useful in this aspect as it replaces the conventional monitoring system with a more efficient scheme, by providing critical information regarding the condition of the patient accessible by the doctor in any remote place, at any time through the internet. Also, a warning system is incorporated in which if the patient's heartbeat goes below or exceeds a particular value an alert message is sent to the doctor through a mobile application. GPS technology is used in the software system for monitoring the live location of the device. The prototype can also store the data of the heartbeat as well as other details of the patient and this can be used by the doctor to analyze the heart condition of the patient and for other future purposes. Early recognition of the disease is very vital in preventing more complications in the future. The suggested prototype consists of both hardware and software components. The hardware consists of NodeMCU, pulse sensor, and LCD display. The software consists of two IoT platform. The system is based on a portable heart rate monitoring system designed in a cost-efficient manner. The prototype is also easy to use and access the data and also, can be used by people of different age groups. The real time data can be viewed as well as stored for future.

2. Proposed Methodology

2.1 ECG Waveform

ECG is a Test, which is used to check the rhythm of heart and electrical activity. Sensors attached to the skin are used to detect electrical signals; produced by heart, each time it beats. ECG is often used to investigate symptoms related to heart problems; like, 'Chest Pain', 'Palpitations', 'Shortness of Breath' etc. ECG machine has 'Electrodes' to arms, legs and chest. These are connected by wires to an ECG recording machine. Each peak in ECG is identified with a letter from P to T; corresponding to a specific electrical activity of the heart. The first deflection on ECG is P-Wave. The P-Wave or 'Electrical Excitation/Depolarization of the Atria', which leads to the contraction of both the atria. The second wave that occurs in ECG is QRS complex, which shows the spread of stimulus through the ventricle. QRS complex represents 'Depolarization of the Ventricles', which initiates the ventricular contraction. Contraction starts shortly after Q and marks the beginning of the Systole. The next part of ECG waveform is the ST segment, which begins after the QRS complex and ends at the beginning of T-Wave. The flow of current linked with the second phase of ventricular repolarization is depicted by ST segment. The ST segment is normally isoelectric with baseline. T-Wave represents the return of ventricles from excited to normal state (Repolarization). The end of T-Wave marks the end of Systole. The region from the beginning of the P-Wave to the QRS complex is called 'PR Interval', this region measures time period from the initial depolarization of atria to the initial depolarization of ventricles. 'QT Interval' is the region from the beginning of the QRS complex until the end of the T-Wave. QT Interval measures the time, in which ventricles depolarize and repolarize.

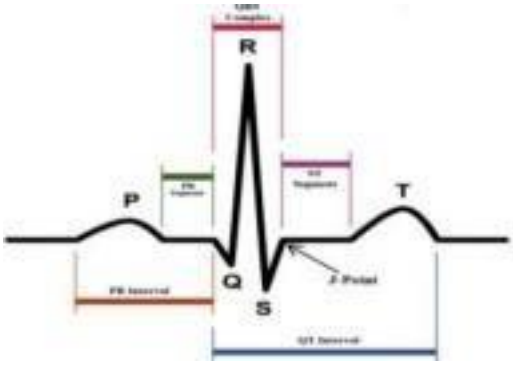

FIG 1. QRS Complex

2.2 Heart rates and ranges

Slow Heart-rate can occur in people due to reasons like 'High Potassium Levels in Blood', 'Underactive Thyroid Gland' etc. On the other hand; Faster Heart-rate can occur in people due to reasons like 'Infections', 'Overactive Thyroid Gland' etc. 'Arrhythmia' refers to a condition; in which the heart beats with an abnormal or irregular rhythm. 'Bradycardia' and 'Tachycardia' are the two forms of 'irregular heart-rates' or 'Arrhythmias'. These arrhythmias occur in upper or lower chambers of the heart. Normal rate of heart is 60-100 beats per minute. 'Bradycardia' refers to the condition, when heart-rate is irregularly slow (slower than 60 beats per minute). On the other hand; 'Tachycardia' refers to the condition, when heart-rate is irregularly faster (faster than 100 beats per minute). There are two types of Circulatory Disorders; 'Heart Attack' and 'Stroke'. 'Heart Attack' occurs when the flow of blood to the heart is blocked. The blockage is mainly a buildup of Fat, Cholesterol and other substances; which form plaque in 'Coronary Arteries', feeding the heart. 'Stroke' occurs when blood supply to the brain gets interrupted or reduced; preventing brain tissues from getting oxygen and nutrients. 'Heart Valve Problems' occur when valves of our heart do not work correctly. Common causes of 'heart valve problems' include 'Rheumatic Fever', 'Birth Defects', 'Infection' etc.; it can be caused by 'Valvular Stenosis' or '. 'Heart Failure' is defined as a condition, when heart is not pumping blood effectively enough to meet the needs of the body. 'Atrial Flutter' refers to a condition, in which upper chambers of our heart beat too quickly. Rapid contractions of upper chambers of heart may spread to lower chambers; which results in a rapid heartbeat. 'Atrial Fibrillation' is an irregular and very rapid heart rhythm (Arrhythmia), which can lead to blood-clots in the heart. It eventually increases the risk of 'Stroke', 'Heart Failure' and other 'Heart-related complications'. Every time our heart beats, an electrical signal travels from upper to lower chambers of the heart. Along the way, the electrical signal tells our heart to contract and pump blood. When the signal is slowed down, it causes blockage in heart. 'Long QT Syndrome' (LQTS) refers to a condition related to rhythm of heart; which can potentially cause fast, chaotic heartbeats. These rapid heartbeats might trigger an individual to faint suddenly. In some severe cases, 'LQTS' can cause sudden death also.

3. Literature Review

The whole process of the system is described below:

The authors in [1] works on health monitoring system which measures parameters like blood pressure, temperature, heart rate using Arduino and Raspberry Pi Pulse rate sensor which is placed on the wrist of the patient detects the heart rate of the patient and sends it to the Arduino. The data is then transferred to the Things Speak (cloud platform) platform where we can create graph and to analyze the heart health of the patient. If there is any fluctuation in the heart beat from the normal rate is an alert message is sent to the concerned person through email. The authors in [2], have implemented a heartbeat monitoring and heart attack detection system using the Internet of Things. This system which helps to measure body temperature, heartbeat, pulses of person. They used components like heart beat sensor, pressure sensor and temperature sensor in this project. The heartbeat of the person is displayed in a LCD screen. This system helps to detect if there is any heart blockage. The authors in [3], have implemented a method to detect heartbeat using fingertip using Arduino. It is based on the principal of photoplethysmography (PPG). The proposed methods are electrical method and optical method. PPG wave is plotted to detect the heart condition of the patient. The graph is also used to detect if a patient has a heart attack. The authors in [4], have worked on technology which monitor the healthcare of soldiers using IoT and machine learning. The sensors used in this project can help to track the location of the army and can also help to monitor the health of solider using gsm technology and wireless body area sensor networks (WBASNs). The data is shared to the cloud platform (Zigbee) from where the data is collected and is derived using K-Means Clustering which is machine learning algorithm. The authors in [5], have worked on a technology that monitors the health of high-risk cardiac patients. The sensor uses Bluetooth connection to send the data to the mobile app. The mobile app can even call an ambulance in a case of emergency. The ambulance can get the location of the patient using GPS. An SMS is sent to the cardiologist during e The authors in [6], have worked on a method to detect heart attack and monitor heart rate using IoT. The heart beat is measured by using pulse rate sensor and then the signal is transmitted to the NodeMCU. Could platforms such as Adafruit and blykn platform is used to obtain the heart rate. a Adafruit, uses MQTT protocol which has lots of advantages which is more secure to store information. The authors in [7], have make a wearable body area network (WBAN) to collect user data and a low-power wide area network (LPWAN) to connect the WBAN with the Internet. The wearable sensors in the WBAN are exerted to measure the environmental conditions around the subject using a Safe Node and monitor the vital signs of the subject using a Health Node. The authors in [8], has worked on a Wristwatch Based Wireless Sensor for monitoring health condition of a patients. In this paper it is discussed for arterial oxygen saturation (SpO2) and heart rate measurement using optical photoplethysmography (PPG).

The authors in [9], has worked on a low pass filter was used to filter inherent noise. These signals were counted by a microcontroller module (ATmega8L) and displayed on the LCD. The heart-rate signals were collected from finger or ears using IR TX-RX (Infrared Transmitter and Receiver pair) module which was amplified in order to convert them to an observable scale. The authors in [10], has worked on the method which is used to sense the temperature and the heart rate of the patient. It sends alerts message in case of any emergency to the doctor.

4. Software Description

4.1 Adafruit

Adafruit' is an IOT Platform, which keeps the data private and secure. This platform can display, respond and interact with the data of user. The main function of it is to store the data; acquired by one or more boards connected to sensors, to show them both in real time and subsequently it can also perform other interesting functions. Adafruit can handle andvisualize multiple feeds of data.

4.2 Blynk

'Blynk' is a popular IOT Platform, which connects devices to the cloud. It is a very well-known IOT platform for allowing users to design apps for controlling their IOT devices, analyzing telemetry data and managing deployed products at scale. Blynk is a IOT platform, having iOS and Android Apps; for controlling Arduino and Raspberry Pi. Functionality of this platform is very simple; it supports the hardware of our choice.

5. Hardware description

Major components required for hardware implementation: NodeMCU, Pulse Sensor, Bread Board, jumper wire etc.

i. First of all the pulse sensor is placed upon the patient hand in the form of smart wrist band for early detection of heart attack. The sensor is placed overa vein in human body (fingertip or ear tip). LED present in the sensor emit light and fall on the veindirectly and monitor the flow of blood, which can monitor the heartbeat as well.

ii. Once the data is fetched it immediately send to the blynk platform (cloud platform) that will used by doctor in their mobile.

iii. If some abnormal data found then the doctor of theparticular hospitals take the action.

The main modules used are –

a) NodeMCU:

'NodeMCU' is a low-cost open source IOT Platform. It initially included 'Firmware', which runs on 'ESP8266 Wi Fi SoC' from Espressif Systems. Hardware was based on 'ESP-12 Module'. Later on, support for the 'ESP32' 32-Bit MCU was added.

FIG 2. NodeMCU

b) Pulse sensor:

'Pulse Sensor' is a well-designed plug-and-play heart-rate sensor for Arduino. Working of this sensor can be done by connecting it from the Fingertip or Human Ear to Arduino Board, so that heart-rate can be calculated easily. Pulse Sensor includes a '24-inches Color Code Cable', 'Ear Clip', 'Velcro Dots-2', 'Transparent Stickers-3' etc.

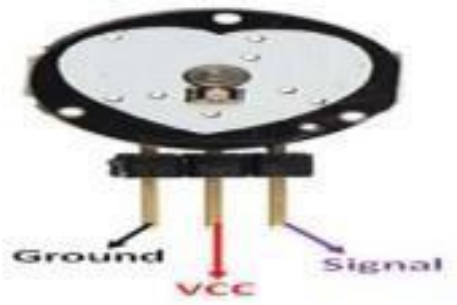

FIG 3. Pulse sensor

6. Results and description

1) Once all thing done check the connection carefully is there any loose connection is there. Once the system is ready upload the source code. After uploading the code place the index finger on the heartbeat sensor. The heartbeat sensor will start monitoring the pulserate. LCD is used for displaying the calculated pulse rate.

2) The system has configured maximum range of heart beat. Once the system starts measuring the Human heart beat, if it crosses the set limit then the system will send alert about heart rate. Also, the system alerts for lower heart rate.

3) The reading from sensor will be uploaded to server where data will be stored. The readings will be refreshed consistently giving the extension for constant seeing of the patient.

Table 1. The above observation is for the age group 18 to60 years at a particular room temperature.

Observation	Temperature ($\circ C$)	Heart rate (bpm)
1	25	104
2	23	124
3	10	88
4	23	100

5	25	124
6	27	144
7	29	148
8	31	152
9	33	156
10	35	164

7. Conclusion

In this system a real time heart rate monitoring and heart attack detection system is realized by using IoT. The proposed design is advantageous to patients of different age groups. It also provides security and privacy to the data of the patient. The proposed design is implemented as the real time monitoring system which helps in providing immediate health care facilities to the patient by using MQTT protocol and IFTTT protocol, alert system and location monitoring are other features of the design. In addition to this a local server is used to provide security, privacy and low latency.

8. Acknowledgements

The author also wants to acknowledge Institute of Engineering & Management, Kolkata for providing the necessary infrastructural facilities.

REFERENCES

[1] S. S. Kazi, G. Bajantri, and T. Thite, International Research Journal of Engineering and Technology (IRJET) 5, 4 (2018)

[2] A. A. Gurjar and Neha A. Sarnaik, International Research Journal of Engineering and Technology (IRJET) 5, 3 (2018)

[3] Bandana Mallick and Ajit Kumar Patro, International Journal of Science, Engineering and Technology Research (IJSETR) 5, 1 (2016)

[4] A. Gondalia, D. Dixit, S. Parashar, V. Raghava, A. Sengupta and V. R. Sarobin, Procedia Computer Science, 133, (2018)

[5] Leijdekkers, Peter and Valérie Gay, 2006 International Conference on Mobile Business (2006)

[6] T.V. Sethuraman, K.S. Rathore, Amritha G., Kanimozhi G, International Journal of Engineering and Advanced Technology (IJEAT) 8, 5 (2019)

[7] Fan Wu, Taiyang Wu, and Mehmet Rasit Yuce, Sensors 19, 1 (2019)

[8] S. Kumar, J. L. Buckley, J. Barton, M. Pigeon, R. Newberry, M. Rodencal, A. Hajzeraj, T. Hannon, K. Rogers, D. Casey, D. O'Sullivan and B. O'Flynn, Sensors 20, 6 (2020)

[9] Md A. Al Mamun, N. Ahmed, M. Alqahtani, O. Altwijri, Md Rahman, N. Ahamed, S. A. M. M. Rahman, R. B. Ahmad and K. Sundaraj Journal of Theoretical & Applied Information Technology 62, 3 (2014)

[10] M. Patil, A. Madankar and P. D. Khandait, 2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS) (2019)