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IOT BASED TELE-ASSISTANCE AND MONITORING OF HEART PATIENTS

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Abstract:

According to a recent WHO survey, heart disease is the leading cause of death for people of all races and ethnicities. Heart's activity is monitored with the help of ECG to predict different heart problems in the heart. Electrocardiogram is often used along with other medical tests to diagnose and treat heart conditions. The death rate of people suffered by heart problems can be prevented and reduced by efficiently determining heart disease. Existing devices collect the data from the sensors and transmit it to the cloud. In the proposed work, Medical IoT and Telemedicine technologies are used to transfer the data from medical devices and communicate with the physicians. Medical IoT is a combination of medical devices and the internet used to collect and transmit patient data. Telemedicine is the provision of remote clinical services to patients via video or phone appointments with their healthcare providers. A model is developed with an ECG sensor, blood pressure sensor, temperature sensor and heartbeat sensor to gather the data from the patient and is shared with Physicians. Shared data is accessed through a website portal from the cloud. If any irregularities are found in the collected data, a warning message will be sent out to the doctor. The Doctor accesses the data and identifies the heart-related problem with the help of the ECG graph and the other data received and can communicate with the patient through the portal.

1 Introduction

One of the most serious and prevalent diseases around the world today is heart disease. Every year, approximately 17.9 million people die as a result of cardiovascular disease, making it the leading cause of death. A collection of heart and blood vessel abnormalities collectively constitute cardiovascular disease. Different heart conditions, such as coronary artery disease (CAD), congenital heart disease, cardiomyopathy, pericardial disease, heart valve disease, heart failure, and heart arrhythmias. These heart diseases can develop over the course of a person's lifetime depending on their daily activities or routines or immature growth of heart in mother's womb. Plaque, a sticky substance that accumulates in the arteries and restricts blood flow to the heart, causes coronary artery diseases.

Heart diseases may be caused due to stress, genetics, infection and lifestyle such as being overweight, unhealthy diet, smoking, and excessive alcohol use. High blood pressure and high cholesterol are major causes of cardiovascular disease. Hence the treatment for the heart disease are important that includes a healthy lifestyle, medicines, surgeries, and cardiac rehabilitation. Various sorts of testing, including blood tests and chest X- rays are used to diagnose cardiac disorders. ECG is used to diagnose in addition to these testing. Because ECG accurately identifies different types of cardiac illness.

An ECG generates a graph of the electrical activity of the heart and also indicates whether the heart has enlarged due to hypertension or a history of myocardial infarction. Increased blood pressure is the fatal factor. The prevention and treatment of blood pressure-related disorders, such as cardiovascular disease, include proper blood pressure measurement.

Medical IoT depicts a group of medical equipment that communicate wirelessly to share health care information and do remote monitoring. It offers medical services and develops a cost-effective approach for both hospitals and patients. It is composed of three components: biomedical devices for data collection, a means of connecting to the internet, and applications for processing, sending, protecting, and displaying the values [1].

The term "telemedicine" refers to the delivery of therapeutic services remotely via two-way, real- time audio or video communication between a patient and a healthcare professional [2]-[4]. Audio and video calls are now inexpensive and accessible to a far wider range of society because of the usage of broadband internet technology, providing an alternative to the current system. The use of broadband internet technology has made both audio and video calls low-cost and available to a much wider spectrum of society, making this an alternative to the conventional system.

2 Literature Survey

Guangyu Xu et al. [4] implemented a Framework for ECG monitoring supported by IoT and secure data Transmission by using Android phones, Bluetooth, and pall waiters to transmit the ECG signal, which is provided by ECG detectors and Arduino. The Lightweight Secure IoT (LS-IoT) and Lightweight Access Control (LAC) have been employed for secure data transmission. But this system requires an android phone for transferring the data.

A cloud connected multi lead ECG sensor ring has been used to asynchronously deduce 12 lead ECG that can upload the data to a cloud based medical IoT informatics system via smartphone. It is complex to fix the device [5]. A wearable sensor system to detect Arrhythmia has been designed using machine learning where the input ECG sensor signal is gathered and analyzed in LabVIEW to classify whether the patient is healthy or not [6].

Framework for heart disease prediction has been proposed using Multi task Cascaded Convolutional Neural Networks (MDCNN) classifiers where the smartwatch and heart monitoring device monitor blood pressure and ECG to classify whether the patient is normal or abnormal. This achieves an accuracy of 98.2% [7]. A wearable tele ECG and coronary heart rate monitoring system is designed with Textile Electrodes (TE) which is attached to the body via conductive gel on the electrode skin interface for signal acquisition in order to generate ECG leads [8].

Wireless ECG and cardiac monitoring systems are developed to support aging people that are helpful to promote the user's free movements and regular way of life without being hampered by the presence of wires. When a wireless ECG system is employed in daily life, motion-related noise becomes more significant. [9]. A variable resolution controller based on fuzzy logic to effectively layout the analogue to digital converter in terms of circuit complexity and power. A power gating approach is used for static power reduction to reduce electricity intake. This system only reduces power consumption by 40% [10].

A neural network classifier is used in the predictive analysis of ECG signals for heart monitoring, where a global classifier is trained by analysing large datasets of ECG signals to identify abnormalities [11]. Biosignal monitoring clothing system is designed by integrating the ECG electrodes and respiratory transducer in clothing systems to provide high quality ECG and respiratory signals. The heart rate and breathing rate is determined using the respiratory rate detection algorithm and a highly effective real time ECG QRS complex detection technique [12].

An E- Health solution for home patient telemonitoring using portable devices for blood pressure, heart rate and temperature has been designed which is helpful for the patients during pandemic period [13]. An improved heart disease detection from the ECG signal has been designed using Deep Learning (DL) models such as Auto Encoder (AE), Radial Basis Function Network (RBFN), Self-Organising Map (SOM) and Restricted Boltzmann Machine (RBM). The performance of an ensemble model is hard to predict in this system [14].

Secured heart rate monitoring using IoT has been developed for predicting the heart condition of patients using a heart rate sensor which is detected by placing the fingertip on the sensor and alerting the caretaker about heart condition [15]. An IoT in nano integrated wearable biosensor device has been implemented for healthcare applications for detecting health problems such as curing, monitoring and detection of disease. This system requires 5G network connection [16].

An IoT based ECG system is used to diagnose cardiac pathologies by processing algorithms where the cardiologist gets ECG records of the patients which is used to characterize abnormality in the ECG waveform [17].

Hence to overcome these problems an Iot based remote heart patients monitoring system has been designed [18-20]. This system consists of an ECG sensor, blood pressure sensor, heart beat sensor and temperature sensor which is connected to a microcontroller and data collected from patients are sent to the cloud. The doctor can access the cloud data through a website and view it in real time using IoT.

3 Real Time Monitoring system for Heart Patients

Health is important in everyone's life, but in the modern world, many don't have enough time to care for their health. Heart disease is caused because of unhealthy diet, lack of physical activity, use of tobacco and excessive alcohol consumption. Everyone has a responsibility to take care of their health and get them the best medical care. Hence the proposed technology offers a way to save the patient lives. People can use this technology to remotely check their health status, receive alerts when their heart condition is abnormal and can communicate with the doctors.

The proposed work consists of an ECG sensor, temperature sensor, blood pressure sensor and heartbeat sensor which are interfaced to the microcontroller and collects the data such as electric signals of heart's rhythm, blood pressure, temperature and heart rate from the patient respectively. ATMEGA 328 is used as the controller in this system. The data gathered by the sensor is displayed on the LCD module. The Fig.1 shows the proposed block diagram of real time monitoring system of heart patients.

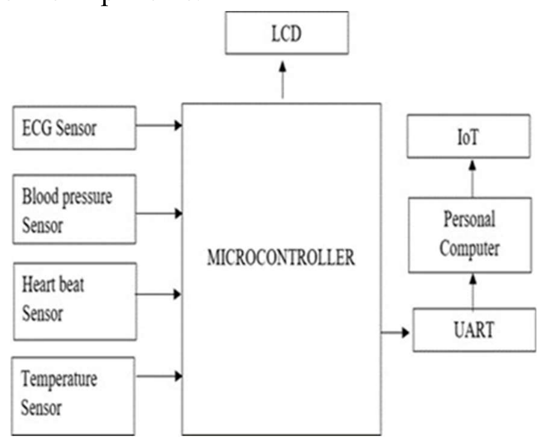

Figure 1. Block Diagram of Real-Time monitoring System of Heart patient.

ECG sensors are used in medical devices that monitor the bio-signal generated by electrical impulses that regulate the enlargement and contraction of heart wall. The AD8232 ECG Sensor extracts, amplifies, and filters small bioelectric signals generated by the movement or remote electrode position. It has a decoder that allows translating the data from the device into readable sensor data.

The values from the ECG sensors are used to construct the ECG signals. A software is built to get the data from the ECG sensor and to construct the ECG waveform. This software has been built using Visual Basic.net. Machine learning is used to train the software using a large number of ECG waveform images. This system gets ECG waveform from the patient as the input and process it using the previously trained data. The waveform is analysed and if any abnormality is predicted, an alert message is sent to the doctor through IoT.

A blood pressure sensor has been designed by using Near-Infrared Spectroscopy (NIRS) to measure human blood pressure. By measuring the blood's pulse wave velocity from the upper arm to the index finger, the blood pressure can be estimated. The heart contracts and relaxes as it pumps blood throughout the body, causing the pulse to flow in various parts of the body. This pulse is a continuous increase in blood flow that can be detected as a periodic signal. When the finger is placed between the infrared source and the detector, the pulse wave reaches a specific point in the body, the amount of IR light reflected back out through the skin increases. The near- infrared spectroscopy (NIRS) method is used to measure blood pressure by collecting data on pulse transit time between two points in the body. When the heart beats the systolic rate of a human is measured in the artery.

The photoplethysmography method is used by the heartbeat sensor. It has been designed with infrared sensors as shown in Fig.2 which consists of a transmitter and receiver that measure the variation in blood flow through any part of the body, causing a change in the intensity of light through that organ. The IR transmitter emits IR light into the tissue, and a light detector nearby measures the reflected light from the tissue. The volume of blood that flows depends on heartbeat frequency, and since blood absorbs light, signal pulses corresponds to the heartbeat pulses.

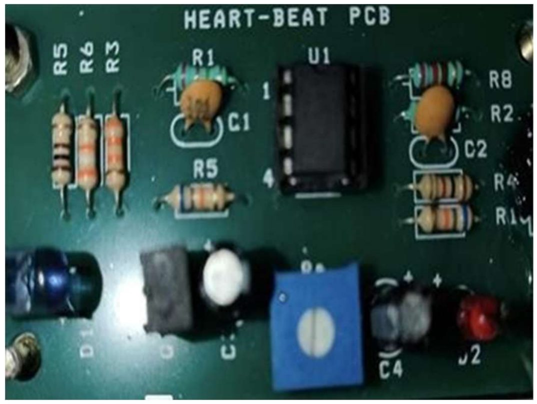

Figure 2. Heartbeat Sensor

The information obtained from the sensors is transmitted to the IoT Cloud via the Node MCU ESP32 Wi-Fi standards because it can provide larger data values and wider inclusion zones. The Wi-Fi device can obtain the data via Universal Asynchronous Receiver/Transmitter (UART), which allows for quick and efficient web access and the sending and receiving of data to the IoT cloud.

A web browser can be used to access and view data stored in the cloud. The doctors can access the website using his login credentials. The historical data and the real-time data is displayed on the website. The link to make audio and video communication with patients is attached in the webpage. The doctor can identify the heart related problem with the help of the collected values and ECG waveform and can communicate with the patient in real- time and make further decisions based on the data obtained from the patients.

4 Results and discussion

The proposed work has been evaluated using IoT. The recorded data for monitoring a person is visible on the LCD module, and it is also saved in the cloud. Real-time monitoring conditions are used to monitor the heart patient. An alert message will be sent to the doctor if an abnormal condition occurs. Fig.3 depicts the hardware implementation of the proposed work.

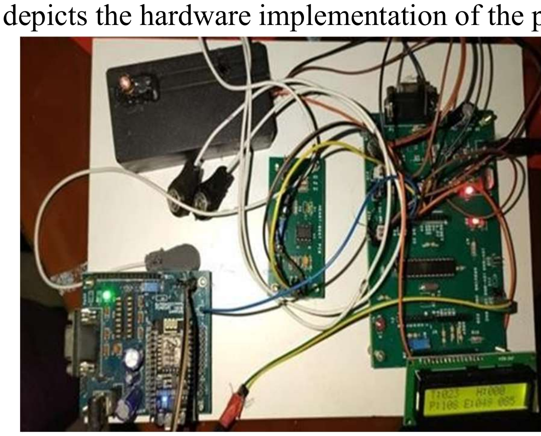
Figure 3. Hardware Setup of the Proposed System

The LCD will represent the output of the monitoring system connected to the ATmega328 microcontroller. The LCD output in Fig.4 shows the results of all the sensors. It displays data from the temperature sensor (T), heartbeat sensor (H), blood pressure sensor (P), and ECG sensor (E).

Figure 4. Parameters Measured are Displayed in LCD Display

The personal hotspot of the mobile phone is changed according to the Wifi module Service Set Identifier (SSID) and password. After connecting, all data from the system is uploaded and saved in the cloud. The data can be accessed by entering the username and password to login through the website as shown in Fig5.

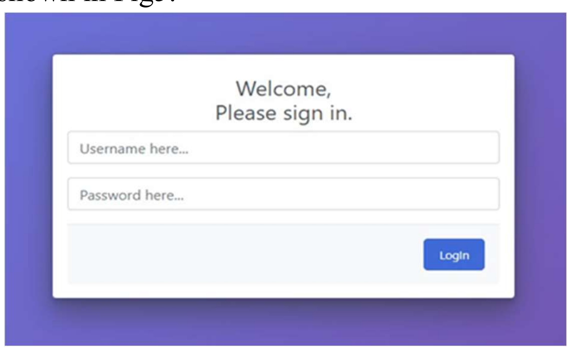

Figure 5. Login Page of the Website

The Data of the patient is displayed in the webpage, which can be viewed by the doctor for treating the patient as shown in Fig.6. A website is created using which is a general-purpose scripting language called Hypertext pre-processor (PHP), used in web development. The doctor can check the patient’s data by accessing the website. The Temperature, heart rate, Blood pressure and ECG information are recorded on the IoT cloud. The doctor can also get the historical data of the patients in this cloud platform. If any deviation occurs in the value an alert message is shown on the cloud platform like ECG Irregular, High heart rate etc.

LogID	DATA	Logdate	LogTime
172	Temp:32_HB72_Pres105_P:8_Q:8_R:8_S:0	02/14/2023	06:06:29
170	Temp:33_HB72_Pres105_P:8_Q:9_R:8_S:5	02/14/2023	06:06:11
167	Temp:34_HB72_Pres105_P:2_Q:1_R:0_S:7	02/14/2023	06:05:51
165	Temp:33_HB72_Pres105_P:8_Q:8_R:8_S:0	02/14/2023	06:05:33
162	Temp:31_HB72_Pres105_P:2_Q:0_R:0_S:2	02/14/2023	06:05:13
160	Temp:28_HB72_Pres105_P:10_Q:9_R:8_S:3	02/14/2023	06:04:54
157	Temp:25_HB72_Pres105_P:2_Q:0_R:0_S:2	02/14/2023	06:04:35
155	Temp:23_HB72_Pres105_P:0_Q:0_R:0_S:0	02/14/2023	06:04:17

Figure 6. Data Stored on the IoT Cloud

As shown in Fig.7 the P wave, which is the first wave that appears in an ECG cycle and it indicates the atrial depolarization or "atrial contraction". The T wave is also known as "ventricular relaxation," as it represents ventricle depolarization. The QRS complex consists of three waves: Q, R, and S. The QRS complex corresponds to the contraction of the ventricles, or the depolarization complex of the ventricles. The R wave is the largest wave because it reflects depolarization of the ventricle's main mass. The S wave represents the final depolarization of the ventricles at the heart's base.

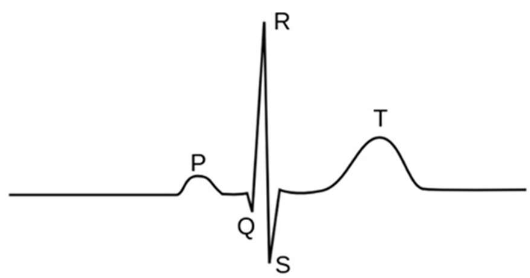

Figure 7. Normal ECG Waveform

A software is developed using Visual Basic.net (VB.net) which is used to construct the ECG waveform as shown in Fig 8. This ECG waveform is used by the doctor to identify the heart related problems.

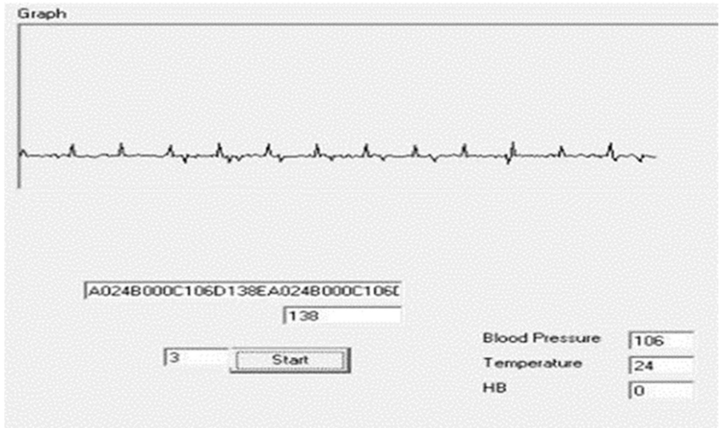

Figure 8. ECG Waveform Obtained from the Patient.

All the data collected from the sensors are compared with Table 1, Table 2 and Table 3 ranges to detect any abnormalities by comparing it to the specified range. Each sensor has a different range and the ranges of the sensor used are shown in the tables below.

Table 1. Comparison illustrating the low, high, normal and recorded data for temperature

Low	<36°C
Normal range	36.1°C – 37.2°C
High	>37.9°C
Recorded value	36.5°C

Table 2. Comparison illustrating the low, high, normal and recorded data for Heartbeat

Low	<60bpm
Normal range	60-100bpm
High	>100bpm
Recorded value	70bpm

Table 3. Comparison illustrating the low, high, normal and recorded data for Blood pressure

Low	<90mmHg
Normal range	90mmHg – 120mmHg
High	>120mmHg
Recorded value	110mmHg

5 Conclusion

An IoT-based heart patient monitoring system has been designed and discussed. A wearable monitoring node with three electrodes can collect the real-time ECG signal with sufficient accuracy. A blood pressure sensor, a temperature sensor, and a heartbeat sensor can all be used to measure the patient's heart rate, blood pressure, and temperature. The data collected from all sensors is transferred to the IoT Cloud and stored using the ESP32 module. Wi-Fi can provide faster data rates and greater coverage zones. The ECG data is visualised and saved by the IoT cloud server for further analysis. The output data of the sensors are displayed on a custom web interface and a local LCD display. If any of the collected values are abnormal, a warning message will be sent to the doctor. The doctor can then communicate with the patient via video call to discuss further treatment options. In the future, the project can be modified with 9 or 12 ECG leads for increased precision.

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