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Implementation of Intelligent Smart Heart Health Monitoring System using IOT

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Abstract—There are a lot of severe diseases that are associated with humans, but one of them is cardiac arrest, which, in general terms, we call a heart attack. The already existing heart rate monitoring systems are not mobile, are expensive, and take a little longer to give out the results. So, in this work, we will go for a system called Heart Rate Monitoring system using an ECG sensor and a Raspberry Pi, which actually represents the acquisition and interpretation of a human heart's data collected with the help of sensors, anywhere and everywhere on the earth, through IOT. We generally consider heart rate while noting the status of the heart, but the oxygen level and body temperature also play a major role in determining the exact heart status. So, the hardware required to implement this heart rate monitoring model consists of different health sensors and a Raspberry Pi configured in a way to communicate with the guardian and the respective doctors over the Internet through an available smart mobile phone. In this work, the sensors configured with the hardware collect the required information about the patient's health, which includes parameters such as the patient's heart rate, body temperature, and SPo2 levels. Then, using the collected information from the sensors, the patient's heart activity is actively observed. Thus, the patient himself or herself can easily identify his or her heart condition with the help of collected data anywhere on the earth through the internet. An alert indicating that their heart status is not good is displayed to the caretakers on the mobile, which shows a message called "abnormal condition to the patient" given the condition that the collected sensors' values are beyond the threshold information through the GSM module, and also the GPS location of the patient will be sent to the caretakers as well as to the doctors.

Keywords- ECG, sensors, GSM and GPS.

I. INTRODUCTION

The Internet of Things (IoT) is an advanced and ever-growing technology that has greater technical significance when compared to other technologies in this emerging era of technology. IOT includes or depicts different sorts of physical peripherals or objects that are embedded with sensors, microprocessors, microcontrollers, and other devices that can be connected to one another and used for the purpose of communication, i.e., the exchange of information over the internet. It has become one of the vital parts, being made with simple protocols that are helpful for the purpose of interacting and communicating with different users around the world. IoT constitutes a big and very important factor in healthcare that retards the difficulties involved for patients as well as doctors.

The system [1] proposed shows non-interrupted checking of a patient's condition anywhere on the earth, based on a Raspberry Pi and IoT. The patient carries a bunch of health sensors to collect his or her body parameters. The major concentration here was taken from an ECG sensor, and no mobile indication was given. In [2], as proposed about a system for heart attack detection using IoT that gives the heart condition based on the values measured by an ECG sensor, here the system only uses an ECG sensor and has no indication through the GSM and as well as GPS modules. As given in [3], we can review the IoT-based health monitoring system that gives out the results of body parameters, heart rate, and temperature efficiently using the temperature and pulse sensors but doesn't concentrate more on the heart, and the system doesn't send out the alert messages. In [4], the proposed physical parameter monitoring system concentrates on an extra parameter than proposed in [3], which is a blood pressure sensor, which is good but doesn't give greater priority to the heart, alert messages, or mobile applications. The system [5] proposed has IoT-based cardiac patient monitoring, which gives the ECG output based on the ECG sensor with Arduino

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as the hardware kit. Since, the system actually works on the Arduino, which is not efficient as it is not capable of storing data, and coding is also a little difficult. In [6], a patient monitoring system using Raspberry Pi that describes only parameters like temperature and humidity, and this system is also connected to a mobile app through the DTH11 sensor, but the drawback is that it is not efficient for understanding the status of the heart and is only useful for understanding general health status. The system proposed in [7] gives an idea about remote heart rate monitoring using IoT that works on both Arduino Uno and Raspberry pi configured to each other and with the pulse sensor only, which measures the BPMs in an efficient manner, but doesn't talk about the other sensors and modules that are used for mobile treatment. The system given in [8] proposes a human health monitoring system using IoT, which has LM35 as its main component for measuring the heart rates and Raspberry pi as its main working hardware, which measures the heart rates and gives the mobile information, but it may not be suitable since the used sensor LM35 is not so efficient since it may undergo some extra noise if fingertip is not placed correctly. In [9], efficient ECG signal measurement using biomedical sensors stresses on the ECG sensor which measures the heart rates so efficiently and gives the results based on the biomedical signals. The major stress in this work is done here on the ECG sensor, and no other sensors are studied, as the study here on the ECG sensor is much more focused on the biomedical signals, which are hard to understand by general people. As proposed in [10], this article gives a glance at an automatic health monitoring system using a Raspberry Pi, which works with the pulse and ECG sensors as well. The major drawback is that no mobile indication is given when there is some risk factor for the patient.

This system thus provides homecare solutions instead of costly medical care, and prevention can also be provided with the minimum physical effort, saving a lot of time. This model will overcome all the difficulties faced by each and every particular patient by simply following basic heart care, which leads to better and more effective results. In this work, IOT is described as a hardcore" or "backbone" technology that is suitable for many sorts of medical applications and suited to low-cost applications as well. The acquired data from the ECG sensor and other sensors involved in this application will support people in identifying the possible threats involved in the heart, which is the major part of the human body, and also in informing the respective doctors in emergency situations for the best advancement of human's heart health, which would help the entire medical system for the purpose of home care.

So, in this work, we are trying to create a system that is fully proficient in being interfaced and configured with a device like a Raspberry Pi, as they are capable of being implemented with rather small IoT devices. The proposed system also interfaced with human health parameter sensors to continuously monitor the patient through IoT and indicate the heart rate and detection of heart attacks more accurately. So, this proposed work will not only help the doctors identify the initial heart attacks but also help patients' guardians or caretakers notice the patient's state of heart.

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II. MODELLING OF THE SYSTEM

In this section of the paper, we describe the basic architecture behind the heart rate monitoring system. Different significant devices are combined in this heart rate monitoring system, which is shown in Fig.1. Let us take a glance at the details, how these health sensors and different other devices in this heart rate monitoring system are connected and used to their full efficiency.

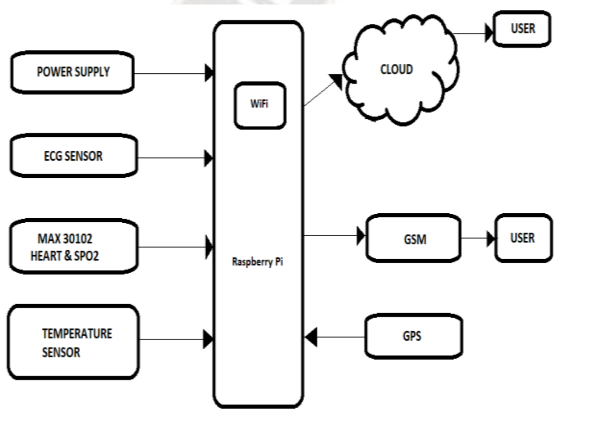

Figure 1. Diagram of Heart Rate Monitoring System

The Raspberry Pi is used as the processor and aggregator unit in this particular heart rate monitoring system. Raspberry Pi has become one of the most affordable system-on-chip devices that can accomplish all sorts of instructions or

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functions that a basic computer performs. Raspberry-Pi functions as a communicator among different health sensors and the Internet of Things. Each of the pieces of equipment, such as health sensors and modules, is usually connected through wires to the processor unit. As the Raspberry Pi kit is already manufactured and integrated with different sorts of protocols, including Bluetooth, USB, and 802.11 WLAN, a connection can be established with the internet with just one press. The Raspberry-Pi kit usually consists of 40 pins, out of which 26 pins are GPIO (General Purpose Input Output), which indicates that the kit has the ability to get connected to 26 different peripherals. If extra pins are needed for high end applications, then a multiplexer can be placed in the circuitry to count up the number of GPIO pins as essential. A written Python3 programming code will be running inside the hardware kit, which constantly controls the pins by monitoring their stats every time. There are a lot of hardware kits that can be used for this work, but the main reason for selecting Raspberry pi kit is the cheap price and the extra quality of allowing GSM and GPS modules to configure various peripherals with it very easily.

ECG stands for electrocardiography, and these ECG sensors are used to identify the state of a patient's heart when it has direct contact with the patient's body [9]. The three electrodes of the ECG sensor should be placed at the respective points. The basic module of an ECG sensor, which has three electrodes attached to it and also six pins in it.

The ECG sensor that we are going to use here is the AD8232, which is a technical health sensor used to calculate the electrical pulses of a human heart. These measurements of electrical impulses can be drawn or charted on white paper, like an electrocardiogram (ECG). Electrocardiograms measured for a human body are often very noisy, so to decrease the effect of the noise in the ECG, the AD8232 ECG Sensor can be used. The basic functioning of the AD8232 is similar to that of an operational amplifier, which is to get noise-less signals efficiently.

Electrocardiography, or ECG, is a simple procedure for collecting the electrical impulses generated from the human heart [6]. When someone feels physical pain around the area of the heart, the procedure of finding out the ECG allows him/her to identify the severity of cardiac arrests in humans. So, an ECG sensor is utilized to calculate the electrical pulse status of the human heart. So, electrocardiography is utilized to aid in recognizing the status of the heart.

The AD8232 ECG sensor operates as a pulse conditioner in ECG as well as for other biomedical applications in different medical usages and medical therapies. The important and vital role of this sensor is to select, amplify, and filter heart impulses, which are generally small in noisy conditions [8]. The ECG AD8232 contains the pins, OUTPUT, 3.3V, LO+, LO-, GND, and SDN. Besides, this sensor also includes the right arm (RA), left arm (LA), & right leg (RL) electrodes to attach them to different parts of the body. An LED indicator is available on this AD8232, which is used to indicate the heart rate in humans.

The Python console acts as the bridge for the users. The console and Raspberry pi are connected to the ThingSpeak cloud over a private channel [10]. This ThingSpeak furnishes data about the status of the heart rate, and if any abnormality is found, the stats are sent to the respective caretakers and doctors by utilizing the available GPS and GSM features in this mobile application.

In the proposed application, the normal heart rate and state of the heart are already given, i.e., the threshold values are fixed, and according to the values grabbed from the ECG sensor, the abnormalities are detected [5]. The flow chart and pictorial representation of the Heart Rate Monitoring System in our real-time environment, starting with the detection of any heart abnormalities and providing statistics on heart rate, is shown in Figure 2.

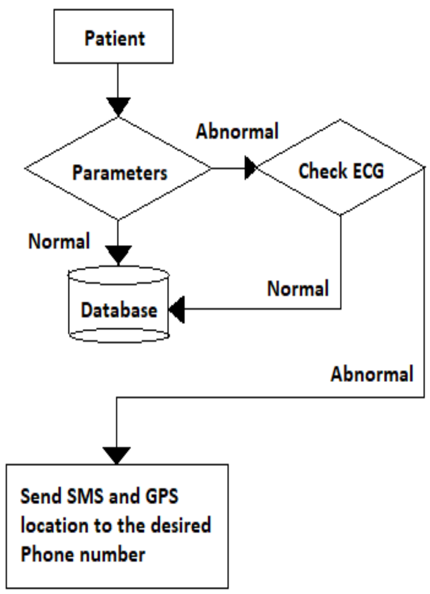

Figure 2. Flow Chart of Heart Rate Monitoring System

The measurement or indication of the electrical pulse rates or heart rate information of a human body is known as electrocardiography (ECG). The heart rate monitoring measured in general hospitals has always been wired and involves a lot of sensors, which are costly to afford as well. Due to the above hardware requirements and the large time requirement of disease detection, this system may be a little bit complex in nature. So, to counter this problem, we go for some simple and less-time consuming systems using IoT, which would give us approximate results.

This stated and proposed system consists of a different number of sensors connected to the hardware kit, and they exchange information through the Raspberry Pi. In this system, the Raspberry Pi kit is used as an information collector as well as a processing unit. A personal computer is used as a monitoring system where the data collected and processed are shown out. The ECG sensor placed on the hardware kit is used to acquire the information or readings, and those readings are transformed and provided for the purpose of processing on the Pi kit. The Raspberry-Pi then shows the data on the monitor and also sends this set of data over the cloud. If any sort of emergency situation occurs, the patient will be provided with an instant message alert through SMS. In cases where patients may not be able to contact their caretakers, the location of that particular patient is sent to their respective guardians through the GPS module already installed in the proposed system. This would reduce the time taken to find out where the patient is and increase the chance of rescuing the patient.

III. RESULTS AND DISCUSSION

As there are several sensors included in the proposed system, we are integrating and then processing the data obtained from the sensors. There are several steps to take while testing this system, in which we will first take readings from the MAX30102 temperature sensor and then the ECG sensor and then predict the results of the system. Check the results on the console, and if there is any abnormality, then go for an ECG. If the ECG is also abnormal, then an alert message along with the location is sent to the caretaker, indicating an emergency, and these results will also be stored in the ThingSpeak cloud forever. The proposed system includes the hardware as well as the software components to communicate between themselves and give the system user a desired output. The testing steps are given pictorially as follows:

Step 1: Connect the Raspberry Pi kit and configure it with your personnel computer as shown in Fig.3.

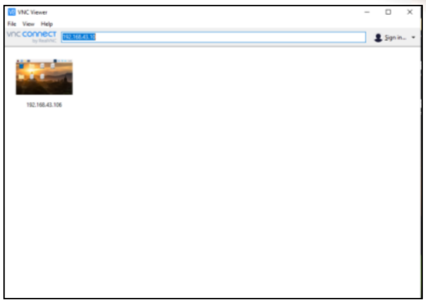

Figure 3. Step-1

Step 2: Attach your finger tip to the MAX30102 sensor to get heart rate and oxygen levels as shown in Fig.4.

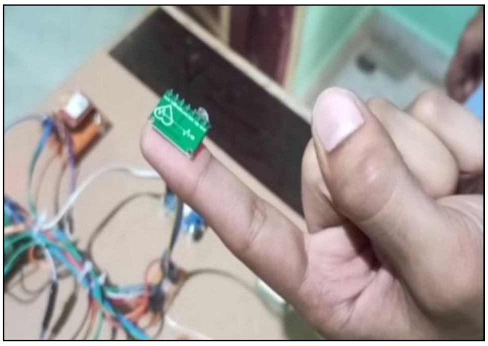

Figure 4. Step-2

The second step is to measure the ECG to determine if there are any abnormalities present with the heart or oxygen levels. Attaching the three electrodes at three different places on the body will make the AD8232 sensor grab the voltage levels, which are the electrical activity of the heart. These levels are then converted to digital values, and a graph is plotted between these voltage levels and the time. Fig. 5 shows the ECG plot when there are no electrodes connected to the person. When there are no electrodes attached, there will be no voltage generated, and thus the ECG plot will be on the ground line. There will be no values plotted, making the plot visible as all null values. When no sensor data is collected, the graph plotted always lies on the axis itself, indicating that no parameter is being measured. If the electrodes are attached to the body of a human, then there will be a generation of the voltage that is the electrical activity of the heart, and thus, when the graph is plotted, we can see it as shown in Fig. 6.

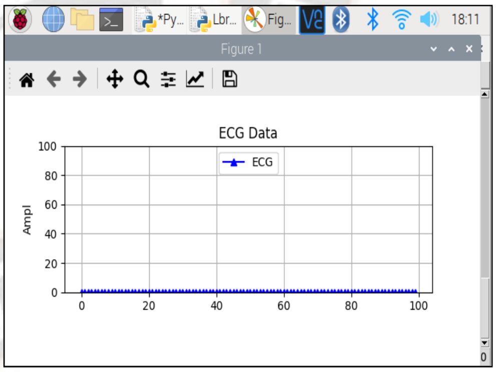

Figure 5. ECG graph when no electrodes are attached

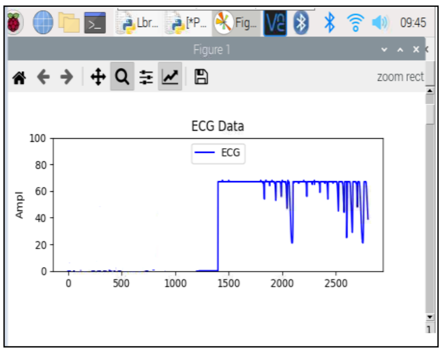

Figure 6. ECG graph when electrodes are attached

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According to the status of heart condition (Case I and Case II), the decision to send messages or the location to the caretakers and doctors is decided by the processor. As shown in Fig.7, when the status of the heart is normal and there is no need for any medical emergency, the patient, caretaker, and doctor can observe the heart status, and no GPS or GSM modules will pump out the signals.

Case I: When the patient's heart is in a normal state as shown in Fig.7.

Case II: When a patient's heart is abnormal as shown in Fig.7.

(a)

(b)

(c)

Figure 7. Console output when the heart beat is normal; (a) Heart-rate, (b) Spo2 and (c) Temperature

When the patient is normal, after a loop of fifteen measuring times, the system will itself understand that the patient's heart is not normal, and according to the code written, after fifteen loops, the parameters are compared with the threshold values, and then the proper location points, i.e., the latitude and longitude values, are sent as the message. Also, a message showing the ill state of the heart will also be sent to the prescribed phone number, and the Python console will appear.

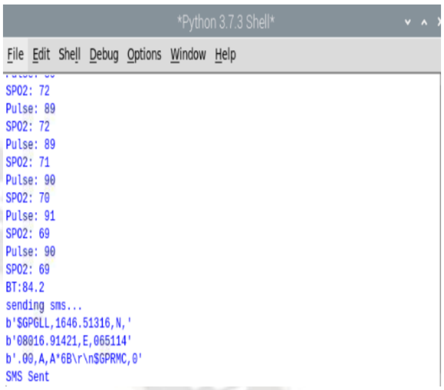

Figure 8. When the ECG is abnormal

As shown in Fig.8, when a patient's heart state is not so normal or is fluctuating, a signal called abnormal is sent out or shown out, the location of the person is sent out, and a message is also sent to the caretakers stating that the patient's heart rate is abnormal. This will reduce the time taken to detect heart attacks and other heart-related problems and increase the probability of rescuing the patient from these ailments.

If there are any abnormalities found in one of the two results in Fig.7, then the system will send an emergency alert message to the caretakers and their concerned doctors without any involvement from the patient himself. This reduces the time taken to respond to the emergency situation immediately and will be helpful in taking the precautions needed.

The emergency alert message would comprise the heart rate, body temperature, and oxygen levels along with ECG values, indicating that the condition of the person's heart health is not very good and that proper measures are to be taken in order to prevent any severe issues related to the heart health and also improve and help in the better understanding of the heart health, as shown in Fig.9.

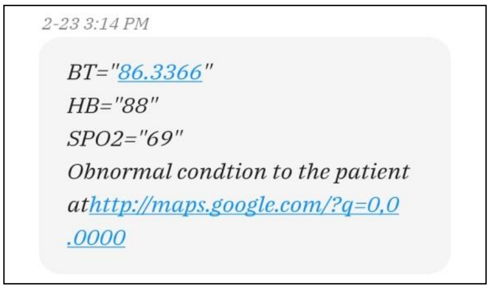

Figure 9. Emergency alert message

IV. CONCLUSIONS

In this particular paper, we've implemented a solution for the issue of cardiac arrests: a heart health monitoring system. The Heart Rate Monitoring System (HRMS) adds strength to already existing systems by saving time and money, and it can also become a replacement for the heart rate measuring equipment. Further additions to this heart rate monitoring system are to add the available system with AI, with which the recognition of abnormalities looks simpler and more heart attacks can be identified at proper times and appropriate measures can be taken. Also, with the acquired information in the cloud, the health condition of any patient can be kept recorded and can be used whenever required, i.e., accessing will be easier. This system has major potential if used correctly, both for housebound patients and in the medical field.

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