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Research Article

A Pulse Rate-Triggered Wearable Device for Critical Assistance

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It has always been a concern in elder people that they can die during sleeping due to irregularities in the heart. Mostly, we have seen senior citizens die while sleeping and there is nothing that their families can do. Sometimes they are alone and no one is there to help them in case of emergency. To prevent this helplessness and to overcome this problem we have come up with a life-saving alarm. This device will help save many lives. It will monitor the heartbeat. The life-saving alarm will monitor the heartbeat of a person using a pulse sensor, and in case of any critical condition, it will trigger an alarm and send an emergency notification to the guardian. The device based on the Arduino microcontroller along with the associated GUI is ready and performing well according to the conditions specified. The work is aimed at saving the lives of people by monitoring their heartbeat and informing their guardians in case of a critical condition.

1. Introduction

Our work focuses on the application of IoT in healthcare. Continuous monitoring of vital parameters of a patient is very essential in the medical field which gives more attention to caretakers which can be provided using IoT devices and systems. We will design and develop a low-cost Arduino-based pulse monitoring system that will monitor the pulse rate constantly and at any point in time if the value is out of range, i.e., critical an alarm will be triggered along with a notification which will be sent to the corresponding guardian and nearby hospital. The main advantage of the presented system in this article is this method does not require a doctor all the time.

It will be a wearable device that can we wear either on the wrist like a band or a ring on the finger. To make the device wireless, we will be requiring NodeMCU. The proposed ideas of using the Internet of Things in healthcare consist of a life-saving alarm mounted with a pulse sensor, a buzzer, and NodeMCU.

The life-saving alarm will be built using an Arduino Uno (an open source micro controller board), a pulse sensor, a Wi-Fi module, batteries, and Velcro tape to attach it to the wall. It is possible to monitor human critical functions using the Internet of Things (IoT) method, regardless of where they are or what they are doing. In the sphere of healthcare, the Internet of Things plays an important role in easing the burden on patients and clinicians [1–3]. The life-saving alarm will be a device that will monitor the pulse of a person and if there is a case where the pulse rate is abnormal or any life-threatening situation occur the device after a certain period will turn on the alarm and send the notification to a nearby hospital as well the guardian. It serves as a lifesaver in case of any emergency that otherwise runs silently on your wrist and becomes active only in the case of an emergency. The microprocessor transmits the pulse rate via a pulse sensor, and then, when the range is crossed, the alarm is triggered which is connected to the microcontroller itself. The paper suggests and focuses on the creation of a continuous pulse rate monitoring system for patients. The pulse

Table 1: Related work.

Citation	Technology focused	Trigger point	Remarks
(Bhagchandani and Augustine, 2019) [15]	Pulse sensor, barometric sensor	Abnormal pulse rate	Pulse sensor and barometric pressure is measured continuously. Information for ambulance assistant is sent once triggered.
(Sinnapolu and Alawne, 2018) [16]	Apple watch, microcontroller	Serious heart rate	In case of serious heart rate as detected by apple watch, notification sent to relatives and navigation for the nearest care center routed for the vehicle.
(Sana et al., 2020) [17]	Ambulatory monitoring devices	—	The remote monitoring solutions for heart patients has been summarized and analyzed. Various limitations and challenges are listed.
(Li et al., 2017) [18]	Monitoring system for health patient	Mode dependent	Monitoring system for heart patients that trigger on selected mode, like periodic, real time, and patient call.
(Mahapatra and Singh, 2020) [19]	Application of IoT-based smart dvices	Healthcare	The importance of fog computing with IoT in healthcare sector with the help of different services and applications.
(Murali et al., 2018) [20]	IoT and Google assistant	Deviation from standard values or patient call	Patient's physical conditions are measured using medical sensor and trigger alert system when a deviation from standard values is notices. Can be trigger by patient using voice through google assistant.
(Alam and Hamida, 2014) [21]	Body area network	Absence of traditional infrastructure	Body area networks can be useful in case traditional infrastructure of communication is demolished or not working. It can be helpful in critical alarming.

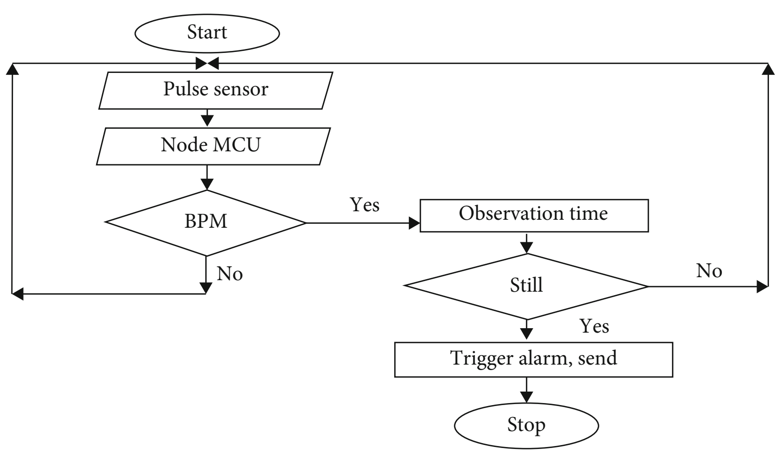

Figure 1: Proposed system.

rate per minute is calculated using this signal and the microcontroller. Then, it sends an SMS alert to hospitals' and patients' family members' or relatives' mobile phones, informing them of the patient's status and aberrant details, whereas the alarm alerts the patient as well as anyone nearby. There are very few pulse monitoring devices designed specifically for the elderly. All of the existing devices are wired and are only suitable for bedridden patients [4, 5]. The life-saving alarm is an enhanced and improved gadget over previous models in that it is wearable and wireless, allowing patients to move around freely while wearing it. The life-saving alarm is not costly. Since it does not involve complex sensors, it is relatively cheaper than most of the existing devices. The life-saving alarm is very small in size and can be easily worn. The prime objective of this research is to develop a user-friendly and smart device that can assist the elder in critical conditions related to abnormal pulse, especially when a medical practitioner is not easily reachable.

Apart from this introductory discussion which covered the introduction, motivation of the work, objectives, and problem statements, Section 2 covers the relevant work done earlier by academicians and researchers in this domain. Section 3 discusses the motivation behind the work and ultimately formulates a problem statement. The proposed system model and the pseudocode are discussed in Section 4. Section 5 discusses the experimental setup and working of the associated app. Section 6 then discusses the

```
Step 1: Setup serial port with baud rate 9600
Step 2: Read current time using millis() I start_time
Step 3: Delay by 10 ms
Step 4: Setup Wifi connection
Step 5: Setup thingspeak connections
Step 6: Start loop() function
Step 7: Initialize flag with 1
Step 8:        Read input in analog form from pulse sensor in val variable
Step 9:        Convert the reading into BPM using (1.0/Val) * 60.0 * 1000
Step 10:        Print the BPM value
Step 11:        Send the value to the things speak and plot the graph
Step 12:        If val > = 150 and val < = 40 then
Step 13:              goto step 15
Step 14:        else goto step 26
Step 15:              Loop till flag is 1
Step 16:              Initialize time1 with current time using millis()
Step 17:              If time1-start_time > = 1 minutes then
Step 18:                  go to step 20
Step 19:              else go to step 22
Step 20:              Print critical condition
Step 21:              Trigger the buzzer on
Step 22:              Send notification to the guardian
Step 23:              If val < = 150 or val > = 40 then
Step 24:                  Flag = 0
Step 25:                  break the if loop
Step 26:            Keep the buzzer off
Step 27:        Repeat step 6
*Codes available at: https://github.com/Sumyak-Jain/Life-Saving-Alarm/tree/master/LSAhttps://github.com/Sumyak-Jain/Life-Saving-Alarm/blob/master/LSA/final.ino.
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Pseudocode 1:

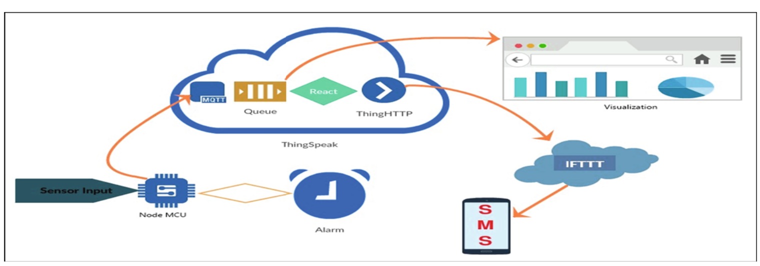


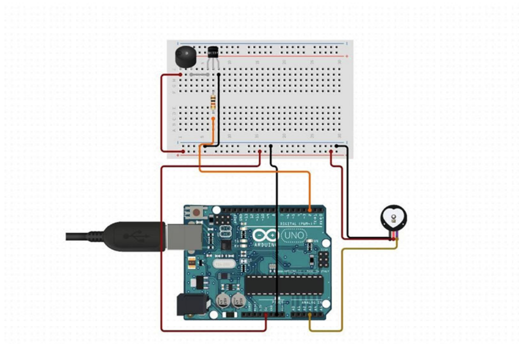
Figure 2: Workflow for visualization and notifications.

performance of the device and the validation and testing steps. Section 7 concludes our work and lists the scope for future extension.

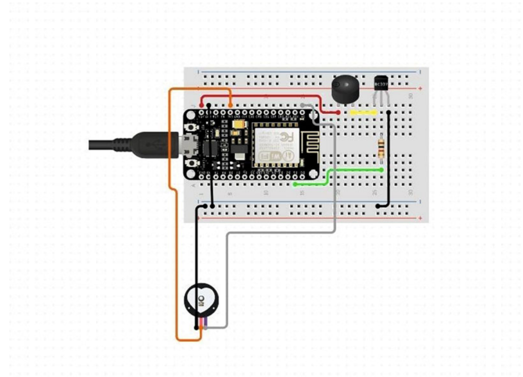
2. Literature Review

In [1], the majority of heart attacks result in sudden death before the patients receive any medical assistance. The Republic of China, for example, has a traditional healthcare system. This implies that concerned patients contact the healthcare service centers directly. In the event of a sudden heart attack, the unconscious patient may be unable to summon assistance, resulting in an unwelcome death situation. The design and implementation of the Internet of Things (IoT) smart framework for human cardiac rate monitoring and control is presented in this research study. A thorough examination of the various strategies and technologies utilized to control cardiac rate is conducted. With the various system components, the suggested system was created and constructed on a breadboard. The goal of this research article was to create a functioning prototype that could detect and monitor a user's heartbeat rate in real time and then display it on a liquid crystal display (LCD) screen.

[6] states that with the increase in hypertension and terrible counting calories timetable of the individuals, the number of heart failures is expanding. This requires the computerization of the wellbeing exam of an individual so an individual is very much educated before any of the variables prompting cardiovascular failure to ascend to risky levels. He can visit a specialist and take an appropriate drug that may forestall a coronary episode. The primary target of their paper was to structure a programmed respiratory

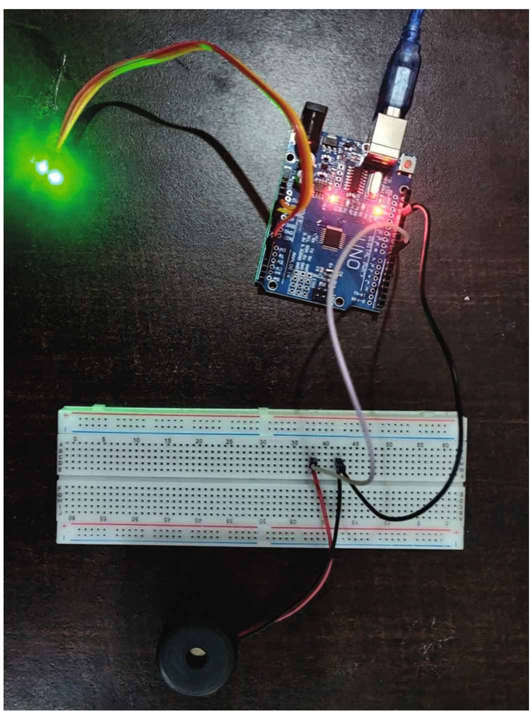


(a) Circuit diagram using Arduino UNO

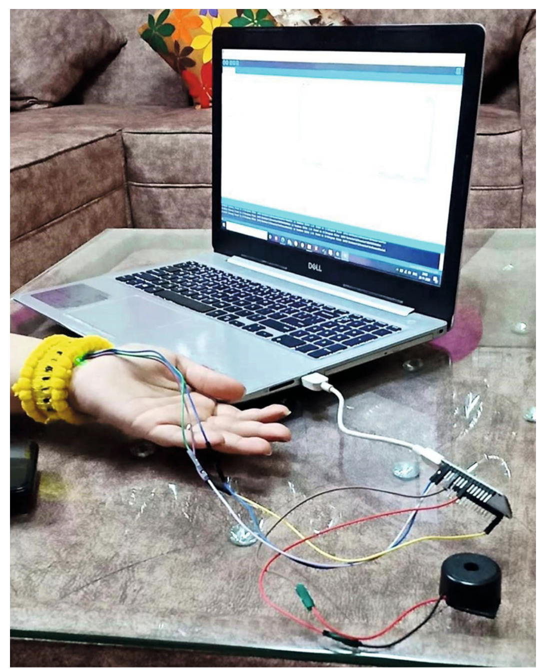


(b) Circuit diagram using NodeMCU

Figure 3: Circuit diagram using Arduino UNO and NodeMCU.



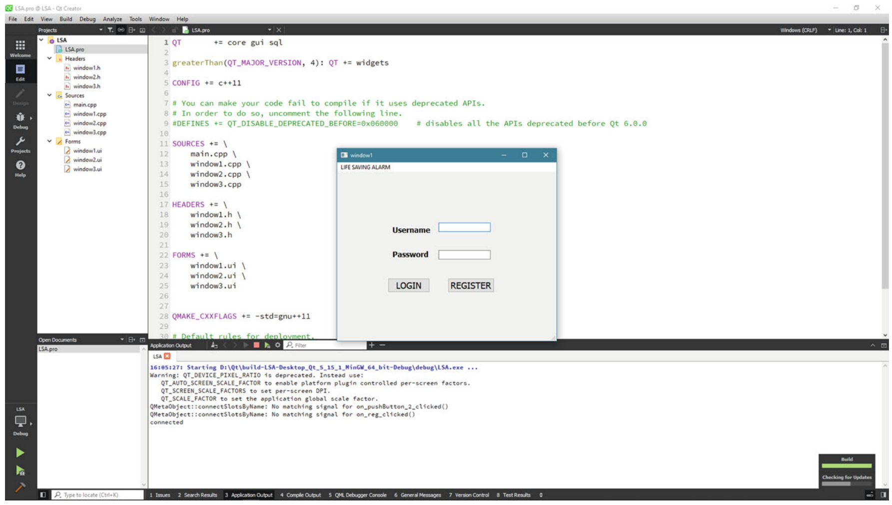
(a) Working setup



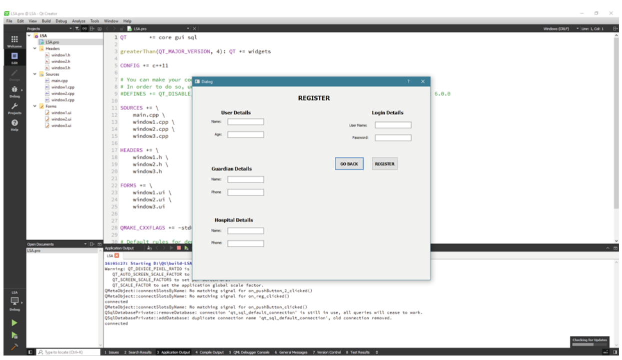
(b) Device mounting on the wrist

Figure 4: Life-saving alarm in use.

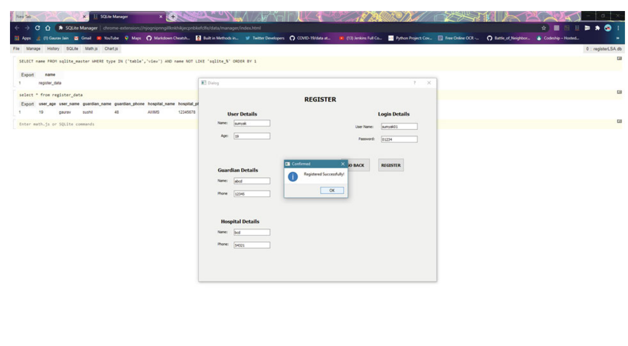
failure discovery framework. In their paper, the fluffy c-implies are utilized to check the respiratory failure causing variables of an individual that they are leveled out or not. The proposed calculation can effectively distinguish the odds of cardiovascular failure utilizing the fluffy c-implies (FCM) bunching method. Subsequently, this paper intends to accomplish a numerical model that will foresee abrupt respiratory failures in individuals and spare their lives on time by communicating something specific or email to the enlisted client utilizing the utilization of IoT. They proposed a potential remote health monitoring and alert system in [7]. A photoplethysmography- (PPG-) based pulse sensor to identify arrhythmia, a temperature sensor to continuously monitor their body temperature, and a sweat sensor to monitor the galvanic skin response (GSR) and send out SMS notifications when it exceeds emergency levels are all included in the proposed system. When a heart attack occurs, it causes a variety of symptoms, according to the article. Because the person is unaware of the signs that can lead to a heart attack in cases like silent heart attacks, recognizing these types of heart attacks is critical. Breathlessness, heavy perspiration, a sudden shift in body temperature, cardiac arrhythmia, and other visual symptoms of a heart attack are common. [8] proposes a multisensory embedded IoT system to predict heart attack with the help of a smartphone with a temperature sensor and ECG. A quantitative analysis will be done



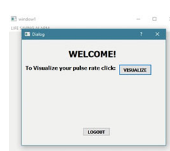
(a) Login page



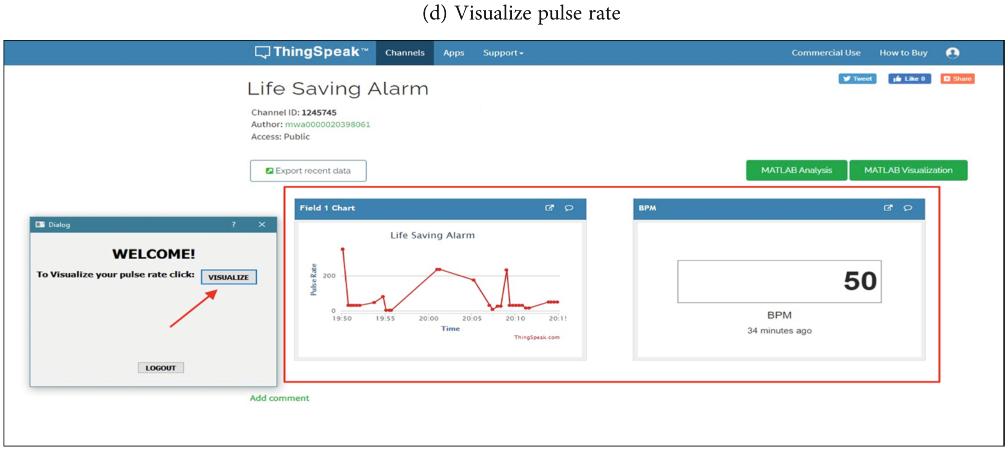
(b) Registration page



(c) Registration done

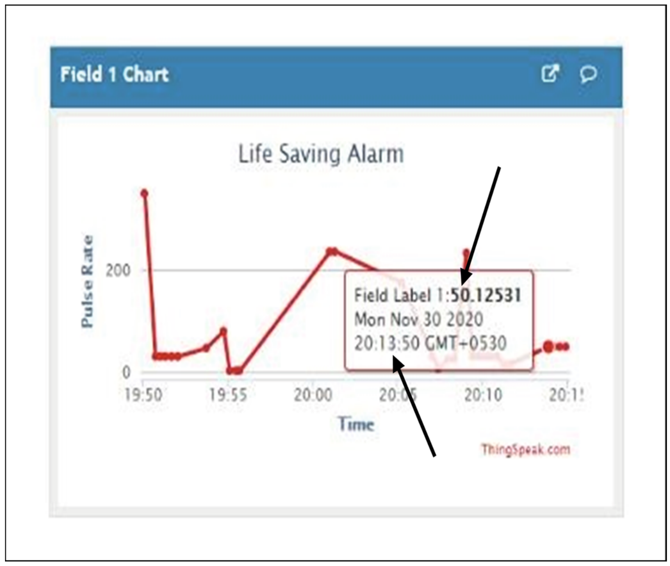


(d) Visualize pulse rate

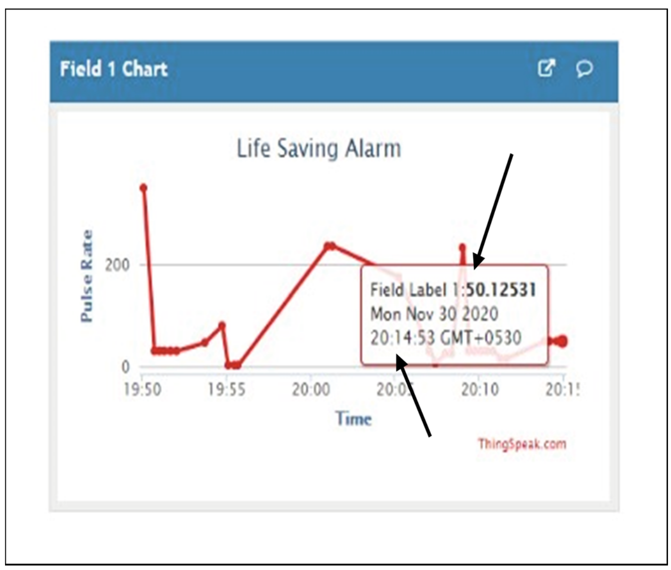


(e) Visualization of pulse rate

Figure 5: Working of app.



(a) BPM at 8:13 pm

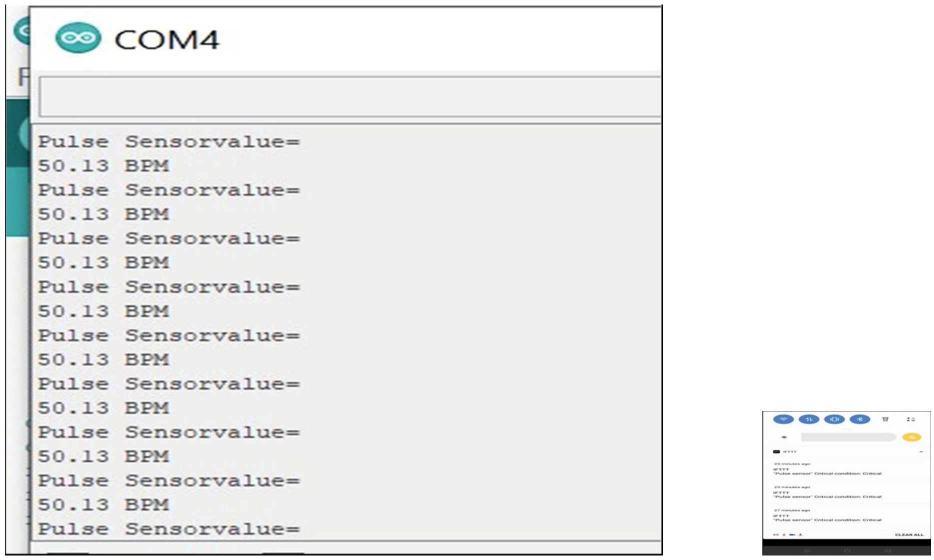


(b) BPM at 8:14 pm (after 1 min)

Figure 6: BPM monitoring.

on android platforms which will give all users this facility to view their real-time ECG signals and temperature as well. Their prediction algorithm is divided into two approaches. First is the prediction technique where data is taken and matched with some threshold values if a patient's heart rate and temperature are normal the algorithm focuses on detecting the fluctuations in ECG signals for more accurate data. If it is abnormal, the smartphone application will warn the user by giving an alert message that he has a cardiac arrest.

In [9], humans have many activities so they are constrained by cost problems and time to check the real-time condition of their heartbeat. As a result, an alternative system that can monitor the status of the heartbeat is required so that the body's health can be monitored on a personal or family level. This article offers a heart rate detection system (HERDES) based on a pulse sensor that uses the internet of things to monitor heart rate health in real time. The research method incorporates simulation and a design strategy. The article [10] explains how a wireless heartbeat and temperature monitoring system based on the ATmega328 microcontroller works (Arduino Uno). The majority of monitoring systems in use today operate in an offline mode; however, our solution is designed to allow a patient to be tracked remotely in real time. The proposed method consists of sensors that measure a patient's heart rate and body temperature and are controlled by a microcontroller. Both readings are shown on the LCD monitor. The measured data is transmitted from a remote location via wireless technology. The temperature sensor measures the temperature while the heartbeat sensor counts the heartbeat for a particular interval of time and estimates the beats per minute. Both data are transmitted to the microcontroller.



(a) Notification visible on the console

(b) Notification visible on the phone

Figure 7: Notifications.

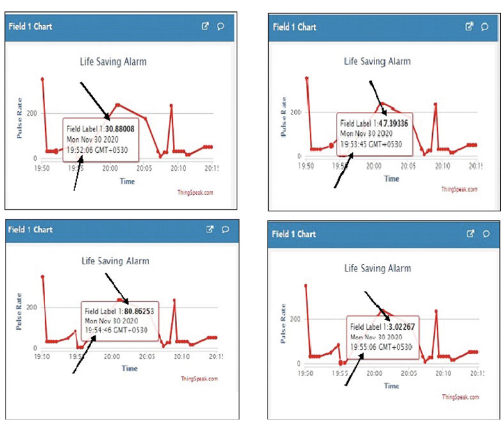


Figure 8: BPM monitoring after removing the device.

The work seen in [11] is a representation of which heart attacks are one of the most common causes of death in people all over the world. Every year, over 610,000 people in the United States die of a heart attack, accounting for one out of every four deaths. However, there are well-understood early indicators of heart attack that might be used to save many lives and minimize damage by recognizing and reporting at an early stage. On the other hand, around 2.35 million people are injured or incapacitated as a result of traffic accidents each year. Unexpectedly, many of these tragic incidents occur as a result of a driver's heart attack, which causes the car to lose control. The work proposes the creation of a wearable device that can detect and warn in real time. The work presented in [12] demonstrates how smart devices play a vital role in healthcare. The sensor-generated data in IoT create a network that provides data on demand. The article [13] gives clear insight into the network-based application of devices in the IoT environment. The novel work in [14] depicts the volume of blood in predetermined area increments in the systole stage and diminishes in the diastole stage during the cardiovascular pattern of the heart. This changing blood volume can be straightforwardly used to figure the pulse and to gauge different qualities of cardiovascular capacities. It utilizes LEDs and their comparing sensor assets in recovering data as electrical signs which shows insufficiency. This electrical sign known as the blood volume beat signal must be shifted from high recurrence commotion sources, for example, daylight and surrounding light, the sign likewise contains low recurrence clamor as movement antiques. The high recurrence commotion can be killed from the sign totally with the assistance of a functioning low pass channel. The greater part of the low recurrence commotion contributed by the movement antiquities can be wiped out with the utilization of an inactive high pass channel. The issue with movement antiques is that they cover with the blood volume beat and is hard to dispose of totally. The discussion of related work is summarized in Table 1.

3. Motivation and Problem Statement

In today's hustling life, due to a busy schedule and lack of time, it is difficult for people to be there for older people every time or even bother about their health. Old age is an age where health has always been an issue. Can technology provide a way in which we can monitor or see the pulse rate of older people and in case of emergency [22, 23], if we are not available for them then can we have someone or something to trust upon? The curiosity and motivation to answer this question have led us to work on a problem related to health.

We have seen that elder people have some kind of heart problems at their age, and it is not humanly possible to always be around them sometimes; they lose their life because someone is not around them or they are sleeping. So, overcoming this problem and intention to save lives gave

21us the motivation. The life-saving alarm will be a device that will monitor the heart rate of a person and if there is a case where the heartbeat rate is abnormal or any life-threatening situation occurs, the device after a certain period of time will turn on the alarm and send the notification to a nearby hospital as well the guardian.

In many cases, old aged people lose their life just because there was no one to help them or to take them to a hospital in case of an emergency [24]. If there is already an automated tool to help someone in that conditions lives can be saved. Most of the tools that are already built are just to analyze their health but what if someone is unable to check the results and that can lead to an emergency. Also, there are conditions like there is no one to watch on old aged people every time so it is not possible to provide information to someone regarding them which can also lead to severe emergencies like heart disorder and low blood pressure.

4. Proposed Work

Firstly, the pulse rate of the user is read using a pulse sensor. Then, the pulse rate is changed into BPM and transferred to NodeMCU. The pulse sensor mounted on the band will read the heart rate of the user. It is not easy for a person to sit or sleep with many wires so NodeMCU will be used as a microcontroller that is small in size and allows to connect to the device wireless and make it easy to wear and carry. NodeMCU will check if BPM is normal or falls under a critical condition. We will upload the code on NodeMCU which will continuously monitor the heart rate data received from the pulse sensor, and then, it will check for the critical conditions, i.e., heart rate and pulse rate, fall or increase to undesirable levels for a certain period of time. The working of the proposed system is explained using a flowchart as shown in Figure 1. Section 4.1 presents the Pseudocode 1 of this model.

4.1. Pseudocode. We have used “Thingspeak” and “IFTTT” API for visualizing pulse rate and sending the notification. When input from the pulse sensor is sent to NodeMCU it is automatically sent to the “Thingspeak” cloud in the form of a data frame and a real-time graph is plotted. And when a critical condition occurs alarm was turned on also, notification was sent using IFTTT. The flow of visualizations and notifications is presented in Figure 2.

The device developed has a bundle of specific features, like reduced cost (few USD only), configuration and management using mobile app, easy to mount, and low power consumption. These features make this product a cost-effective, user-friendly, and power efficient solution for the critical assistance of elders.

5. Experimental Setup

Figure 3 shows the experimental setup of the device. Figure 3(a) shows the setup using Arduino Uno at a fundamental level. Figure 3(b) shows the setup using NodeMCU. The use of NodeMCU as a microcontroller provides many additional functionalities for future development perspectives as well. Figure 4(a) represents the conceptualized version of the device where it behaves as per the expectations. Figure 4(b) shows the utilization of the device as wearable. It can be easily mounted on the wrist without much expertise needed.

5.1. Working of Application Designed. An android application is developed to configure the device. After the required formalities are completed, the app enables to visualize the heartbeat using line graphs. As part of the configuration, the user needs to register first as shown in Figure 5(b) asking for contact details. Once registered successfully, the popup window will notify as shown in Figure 5(c). The registered candidates are expected to log in as per the details mentioned in Figure 5(a). After successful login, the user gets the option of either logging out or visualizing the pulse rate. Figure 5(d) represents this scenario. When the user clicks on visualization, the pulse rate is visualized using a line graph with an interval of 50 seconds. Additionally, the instant value of pulse rate is displayed in another window in numeric form.

6. Validation and Testing

We have tested the working of our model in two ways:

(1) Reversing the actual conditions, i.e., our model will turn on the alarm and send the notification in normal conditions because we cannot simulate the actual conditions for such a long time period so we tested it in this way. Figures 6(a) and 6(b) show the validation graphically

As you can see, our BPM is 50 and it is the same for 1 min, i.e., in normal condition.

So, the alarm was turned on and notifications were sent; the visualization was also made simultaneously as shown in Figures 7(a) and 7(b).

(2) To test whether the conditions in our code work properly if BPM fluctuates between critical and normal conditions. So, to test this we removed the sensor from hand and try reading random values

As you can see in the graphs the BPM first falls, then increase, and then fall again this does not make our model turn on the alarm and send a notification because when it enters the critical condition it checks it for a particular time period and if it continues to remain same then it turns on the alarm. But, in this case, BPM was not the same it was changing every min. This does not make it turn the alarm on. Figure 8 represents this testing step.

7. Conclusion and Future Work

After studying various research papers and other documents, we came to a solution of developing a life-saving alarm which is a fully automated tool to help someone in case of an emergency so that lives can be saved. From this tool, we can determine a person’s abnormal heartbeat which often leads to heart palpitations, blood clots, heart attack, and stroke. Till now, we were able to determine abnormal heart rates by developing a fully functional code for it using Arduino with its working model which rings the alarm in case of any emergency. Also, we made the GUI and Database in Sqlite for our device.

In the future, we would extend the "life-saving alarm" with more features which will include measuring the temperature of the patient, monitoring the heartbeat of the patient, and the level of oxygen. Further, we can extend this work by building an integrated app that will store all the information about the patient, his medical needs, and help the patient and his guardian monitor the health of the patient on the mobile itself also the app can predict some diseases using the past health data of the user.

Data Availability

Access to data will be available on request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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