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IoT Based Health Monitoring System with Node MCU for Pain and Heart Attack Detection

M. Bindu Priya[1], B. Jayalakshmi[2], R. Karthika[3]

[1, 2] UG Scholar, Department of Biomedical Engineering, BIST-BIHER, Chennai.
[3]Assistant Professor, Department of Biomedical Engineering, BIST-BIHER, Chennai

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ABSTRACT

Heart rate monitoring is a vital aspect of maintaining heart health. People from different age groups have different ranges for maximum and minimum values of heart rate, the monitoring system must be compatible enough to tackle this scenario. This project introduces a portable heart rate monitoring system aimed at detecting and preventing heart attacks. The system consists of heartbeat sensor, accelerometer sensor, EDA sensor that is used to detect person heartbeat, body positions of the person such as sitting and standing positions, detects abnormal heart rates and transmitting data via Wi-Fi for remote monitoring. Using an EDA sensor interfaced with a microcontroller, the system alerts users and emergency contacts of abnormal heart rates, leveraging an Android Thing speak app for communication. The heartbeat limits are set on a system that informs about the high and low rate of heartbeat. It also provides continuous data for analyzing the chance of an attack on a patient. Our prototype enhances patient mobility, enabling continuous monitoring in critical conditions. The system offers both doctors and patients an interactive platform, promoting proactive healthcare management.

KEYWORDS: Heartbeat sensor, Accelerometer sensor, EDA sensor, Thing speak.

1. INTRODUCTION

The heart is one of the most important organs in the human body. It acts as a pump for circulating oxygen and blood throughout the body, thus keeping the functionality of the body intact. A heartbeat can be defined as a two-part pumping action of the heart

which occurs for almost a second. It is produced due to the contraction of the heart. When blood collects in upper chambers, the SA(SinoAtrial) node sends out an electrical signal which in turn causes the atria to contract. This contraction then pushes the blood through tricuspid and the mitral valves; this phase of the pumping system is called diastole. The next phase begins when the ventricles are completely filled with blood. The electrical signals generating from SA node reach the ventricle and cause them to contract. This phase of the pumping system is called systole. The tricuspid and mitral valves are closed tightly to prevent the backflow of blood; the pulmonary and aortic valves are opened. Once the blood moves from the pulmonary artery and aorta the ventricles relax and the pulmonary and aortic valves close. Tricuspid and mitral valves open because of the lower pressure from the ventricles leading to the start of another cycle. In today's scenario, health problems related to heart are very common. Heart diseases are one of the most important causes of death among men and women; it claims approximately 1 million deaths every year. Heart rate is a critical parameter in the functioning of the heart. If a person's heart rate is constantly over 100 beats per minutes, then the person is said to be having higher pulse rate which is dangerous. This causing chest pain and strong headedness to the person. Many people are losing their lives due to the heart attack which is the major issue to think over. If a heart rate is increasing constantly and at a same time, he has continuous sweating then there is about 70% chances of heart attack, due to this anyone can lost their life. So, to overcome this we use a kind of advancement technology, in which we monitor the patient's heart rate and by using sweat sensor we can detect seat. If pulse rate is high and at a same time, he has continuous sweating and if these two conditions are met then we can say that there is a chances of heart attack. So due to this detection we can save the life of anyone. Therefore heart rate monitoring is crucial in the study of heart performance and thereby maintaining heart health. This paper proposes a heart rate monitoring and abnormality detection system using IoT. Nowadays treatment of most of the heart-related diseases requires continuous as well as long term monitoring. IoT is very useful in this aspect as it replaces the conventional monitoring systems 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. In addition, the nurses or the duty doctor available at the hospital can monitor the heart rate of the patient in the serial monitor through the real-time monitoring system. Also, a warning system is incorporated in which if the patient's heartbeat goes below or exceeds a particular value the doctor receives an alert message through a mobile application Cardiovascular diseases remain a leading cause of mortality worldwide, necessitating innovative approaches for early detection and prevention. Traditional heart rate monitoring systems often lack mobility and real-time alerting capabilities, posing challenges for continuous monitoring outside clinical settings. Our proposed system aims to address these limitations by offering a portable solution with remote monitoring capabilities, enhancing accessibility and timely intervention for at-risk individuals.

2. LITERATURE REVIEW

H. -S. Nguyen and M. Voznak, et al. [2020] proposed an arrangement of individual trial application, which diminishes defer time between beginning of heart assault and a notification to the crisis administrations. The application can rapidly survey the client's condition and give suitable exhortation without the intercession of a therapeutic expert. It additionally directs the client and spectators in getting the correct help via computerizing the call. The ECG is recorded and dissected progressively on the cellular device utilizing a 2 terminal, 1- lead heart monitor. The calculation utilized here can identify the heart beat anomalies, for example, ventricular tachycardia[1].

J. Shi, R. Chen, Y. Ma, Y. Feng and K. Men et al. [2022] proposed a framework where heartbeat is checked and heart assault location is noted. The sensor used is interlinked to a microcontroller that allows reading pulses and sending them over Internet. The user may set the high and low limits of heartbeat. Later, monitoring begins to check if the heartbeats are crossing the limits either way. The transmitting circuit with the patient and the other circuit with the authorized personnel are used. Heartbeat sensor is used to identify the current pulse rate and display it on the LCD screen. This suggested system can be used in all places without any constraints. There is no obligation to stay at home and use the device[2].

J. -W. Baek and K. Chun g et al. [2021] proposed a framework which has a distinction of identifying heart assault with assistance of watching pulse dependent on web of thing. Our strategy utilizes a heartbeat sensor, Arduino board and a Wi-Fi module. In the wake of setting up the framework, the beat sensor will begin detecting pulse readings and will show the heartbeat of individual on LCD screen. Likewise, with the utilization of Wi-Fi module it will transmit the information over web. Framework permits a set point which can help in deciding if an individual is sound or not by checking his/her pulse and contrasting it and set point. In the wake of setting these limits, the framework will begin checking the pulse of patient and quickly the pulse goes above or beneath as far as possible the framework will send an alarm message[3].

J. Qiu et al. [2023] proposed a developing framework which will diminish the demise rate because of heart assault by early location of heart assault. In our framework we are utilizing pulse sensor, GSM and GPS to quantify the pulse and offer the data. The pulse sensor will ceaselessly screen pulse of a client. We effectively set the edge an incentive in the framework. When it goes beneath or over the edge esteem, the microcontroller will initiate the GSM and GPS to share the data with area of the client to the closest wellbeing division and to the relatives. The structure will create a message at whatever point the client's pulse ends up unusual, with his/her area to the closest wellbeing area and to the recently put away relatives number[4].

F. Beierle et al. [2020] was proposed to built up a gadget utilizing miniaturized scale controller and heart beat sensor. It identifies beat rate as well as demonstrates the infection suggested by the example portrayed by the pulse. The client first sets his age and sexual orientation before running the machine. Understanding is additionally guided for the need of any crisis drug or discussion with a specialist. There will likewise be arrangement for demonstrating the client his/her most extreme work force with the goal that they can push their limits prompting a sound way of life. Gadget is utilized for 24 hours and recorded information stays accessible for examination[5].

C. Nash, R. Nair and S. M. Naqvi et al. [2018] they proposed a system that checks for vehicle impact through the identification of heart assaults that drivers may experience the ill effects of. They introduced the system of the administration empowered through a technology for IoT systems and two varieties. They proposed a voice controlled mobile heart attack detection service display and a motion controlled show[6].

C. Loftness et al. [2020] implemented a system where protection evaluative measures for both driver and the vehicle are enhanced. The paper suggests the usage of sensors. Heartbeat sensor is utilized for screening heartbeats in 60 seconds of the driver continually and keeps mishaps from occurring by controlling through internet[7].

Y. Li et al. [2023] paper explores the potential of deep learning techniques in health informatics, including applications in heart attack detection through advanced algorithms and data analysis[8].

L. Bastida. [2023]This study explores the advancements in machine learning techniques, such as deep learning algorithms, for early detection of heart attacks. The authors delve into the integration of diverse datasets and the development of predictive models, showcasing the potential of artificial intelligence in enhancing diagnostic accuracy[9].

A. Abilkaiyrkyzy, F. Laamarti, M. Hamdi and A. E. Saddik, et al. (2020) proposed an IoT-based health monitoring system utilizing NodeMCU for pain detection in chronic diseases. The system integrated wearable sensors to collect physiological data such as heart rate variability (HRV) and skin conductance. NodeMCU was used for data transmission to a central server for real-time analysis. Results indicated the system's efficacy in early pain detection, enabling timely intervention and improved patient outcomes[10].

T. I. Amosa, L. I. B. Izhar, P. Sebastian, I. B. Ismail, O. Ibrahim and S. L.Ayinla, et al. (2020) This study explores the implementation of an IoT-based health monitoring system utilizing NodeMCU for pain and heart attack detection. The system employs various sensors to monitor vital signs, such as heart rate and body temperature, and utilizes NodeMCU for data transmission to a central server. Real-time monitoring and alerts are provided to healthcare professionals and caregivers, enabling timely intervention in case of emergencies[11].

M. E. Villa-Pérez, L. A. Trejo, M. B. Moin and E. Stroulia et al. (2019) propose an IoT-based health monitoring system with NodeMCU for pain and heart attack detection. Their system integrates multiple sensors to continuously monitor physiological parameters and uses NodeMCU for wireless data transmission. The authors demonstrate the feasibility of real-time monitoring and early detection of health issues, enabling proactive healthcare interventions[12].

A. U. R. Butt et al. (2018) present a comprehensive review of IoT-based health monitoring systems, including those utilizing NodeMCU for pain and heart attack detection. The review highlights various sensor technologies, communication protocols, and data analytics techniques employed in such systems. The authors discuss the challenges and opportunities in implementing these systems for remote patient monitoring and healthcare management[13].

M. H. Abidi, U. Umer, S. H. Mian and A. Al-Ahmari et al. (2017) investigate the role of IoT and NodeMCU in developing a robust health monitoring system for pain and heart attack detection. Their study focuses on sensor integration, data transmission, and remote monitoring capabilities of such systems. The authors emphasize the importance of user-friendly interfaces and secure data handling in ensuring the effectiveness and acceptance of these systems in clinical settings[14].

X. Wu and X. Wen et al. (2019) review the recent advancements in IoT-based health monitoring systems with a specific focus on pain and heart attack detection using NodeMCU. They discuss the integration of various sensors, such as ECG and temperature sensors, for real-time monitoring of vital signs. The authors also explore the potential applications of machine learning algorithms in predicting and preventing health emergencies based on collected data[15].

M. Alirezaei, Q. C. Nguyen, R. Whitaker and T. Tasdizen et al. (2020) present a comparative analysis of different IoT platforms, including NodeMCU, for developing health monitoring systems targeting pain and heart attack detection. Their study evaluates the performance, cost-effectiveness, and ease of implementation of these platforms in real-world healthcare scenarios. The authors provide insights into selecting the most suitable platform based on specific application requirements and constraints[16].

W. -H. Hsieh, C. C. -Y. Ku, H. P. -C. Hwang, M. -J. Tsai and Z. -Z. Chen et al. (2021) investigate the feasibility of using NodeMCU in conjunction with IoT technologies for pain and heart attack detection in remote healthcare monitoring systems. They discuss the architecture, components, and communication protocols involved in such systems. The authors highlight the potential benefits of real-time monitoring and early warning systems in improving patient outcomes and reducing healthcare costs[17].

S. Lee, S. Park and C. Han et al. (2020) explore the integration of IoT and NodeMCU in developing innovative health monitoring solutions for pain and heart attack detection. Their study focuses on sensor deployment strategies, data transmission techniques, and cloud-based analytics for processing and interpreting collected data. The authors discuss the challenges in ensuring data accuracy, privacy, and security in IoT-enabled healthcare systems[18].

L. D. Costa, B. Pinheiro, W. Cordeiro, R. Araújo and A. Abelém, et al. (2022) review the emerging trends and challenges in IoT-based health monitoring systems, with an emphasis on NodeMCU for pain and heart attack detection. They analyze the various components, such as sensors, actuators, and communication modules, required for building such systems. The authors also discuss the potential applications of IoT in enabling personalized healthcare and disease management[19].

M. Shimizu, S. Perinpanayagam, B. Namoano and A. Starr et al. (2020) provide insights into the design and implementation of IoT-based health monitoring systems utilizing NodeMCU for pain and heart attack detection. Their study discusses the technical specifications, power consumption, and scalability aspects of NodeMCU in the context of healthcare applications. The authors highlight the importance of interoperability and standardization in ensuring seamless integration with existing healthcare infrastructure[20].

3. METHODS AND MATERIALS

3.1 EXISTING METHOD

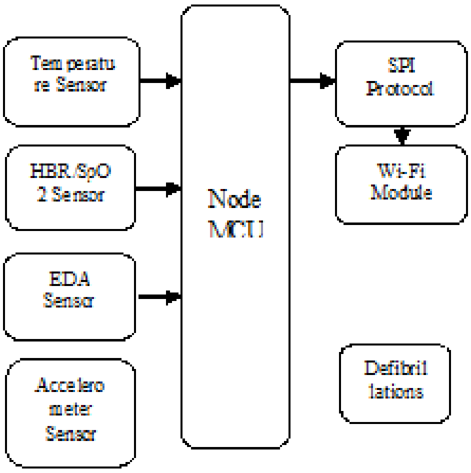
Current heart rate monitoring systems predominantly re ly on stationary devices located in clinical environments, limiting their utility for continuous monitoring outside hospitals or clinics. Moreover, these systems often lack re al-time alerting mechanisms, hindering early interventio n in cases of abnormal readings.

As a result, individuals at risk of cardiovascular events may not receive timely medical attention, increasing the likelihood of adverse outcomes and complications.

3.2 PROPOSED METHOD

In this project, we will implement a heart rate monitoring and heart attack detection system using IoT. The patient will be wearing a hardware device with sensors. With that sensor we can check our heartbeat rates and monitor them. We must set threshold values i.e., the upper and lower points only then the framework starts to check the patient's pulse. If the pulse readings are not within the standard threshold limits, the framework alerts the client with a caution and a possibility of cardiovascular failure.

3.3 BLOCK DIAGRAM:



3.4 METHODOLOGY STATEMENTS

In this project, we will implement a heart rate monitoring and heart attack detection system using IoT. The patient will be wearing a hardware device with sensors. With that sensor we can check our heartbeat rates and monitor them. We must set threshold values i.e., the upper and lower points only then the framework starts to check the patient's pulse. If the pulse readings are not within the standard threshold limits, the framework alerts the client with a caution and a possibility of cardiovascular failure. Different sensors such as heart rate, Temperature, Accelerometer, EDA sensors are used to detect the person heart rate, temperature, predetermining the heart attack, it also also measures the person position. All the inputs such as sensors are connected to the microcontroller, microcontroller complies the program. Threshold values are given. After receiving the inputs it process the temperature and pulse sensor the data. It compares the sensor data and threshold data .If sensor data is lesser or greater than the threshold values, then buzzer send the alert. If sensor data is normal then the won't send any alert. Sensor data will be constantly updated to Things app. The data received from the microcontroller is sended to SPI protocol, then it is sended to Wi-Fi module then it alerts the person, doctor, relatives. If there are any sense of cardiac arrest, then defibrillations are given to the person.

3.5 MODULES AND MATERIALS

3.5.1 NodeMCU :

NodeMCU is an open-source firmware and development kit that helps to build Internet of Things (IoT) applications. It is based on the ESP8266 Wi-Fi module, which integrates a microcontroller unit and Wi-Fi connectivity, allowing for easy communication with other devices and the internet. NodeMCU provides a platform for programming and developing IoT applications using the Lua scripting language. It offers a simple and easy-to-use environment for developers to create IoT projects, such as home automation systems, sensor monitoring, and remote control applications .With its low cost, compact size, and built-in Wi-Fi capabilities, NodeMCU has gained popularity among hobbyists, makers, and professionals for prototyping and deploying IoT solutions. It's a versatile tool for connecting devices and creating smart systems that can interact with each other and the internet.

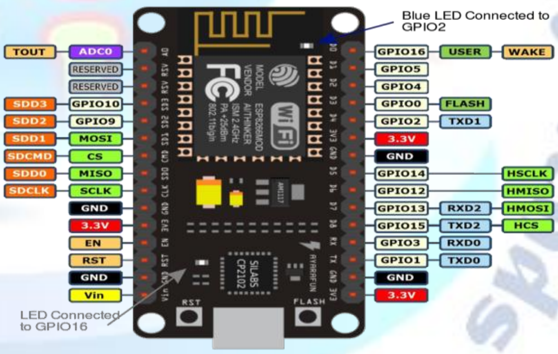


Fig 3.1 NodeMCU Port Description

3.5.2 EDA SENSOR

An EDA sensor measures skin conductance, reflecting changes in sweat gland activity. It is used in psychological research, biofeedback, and wearable devices to monitor stress and emotional responses. The sensor detects variations in skin's electrical properties when a person experiences stress or excitement. Data from EDA sensors offer insights into emotional states and stress levels in real-time, aiding in stress management and mental health monitoring. EDA sensors are integrated into wearable devices like smartwatches for real-time feedback on stress levels. They are also used in research to study emotional responses. EDA sensors are essential in understanding human physiology and behaviour, especially in emotional responses and stress management.

Fig 3.2 EDA Sensor

3.5.3 HEARTBEAT SENSOR

The Pulse Sensor is a plug-in device which monitors heart rate. The sensor is attached to an ear cartilage or a fingertip via jumper links and it communicates with an Arduino board. It tends to be used by understudies, artists, athletes, makers, and sport and transportable designers. It basically joins a optical coronary heart rate sensor with amplification and clamor cancellation hardware, making it rapid in getting accurate heartrate reading.

3.5.4 TEMPERATURE SENSOR

Temperature sensor is a device that measures the temperature of an object. Temperature sensors come in a variety of shapes and sizes, and they all use different technologies and standards to determine the temperature. The LM35 is a temperature sensor that produces an analogue signal. The result voltage may be decoded to provide a temperature reading in Celsius without much difficulty. The advantage of the lm35 over the thermistor is that it does not require external calibration. It is also protected against self-heating by the covering.

Fig 3.3 Temperature Sensor

3.5.5 ACCELEROMETER SENSOR

Accelerometers are instruments that measure a structure's vibration or acceleration of motion. They have a transducer that converts mechanical force induced by vibration or movement into electrical energy. Changes in the locations of these devices are detected using micro- electromechanical systems (MEMS). Accelerometers offer a wide range of applications in industry and science.

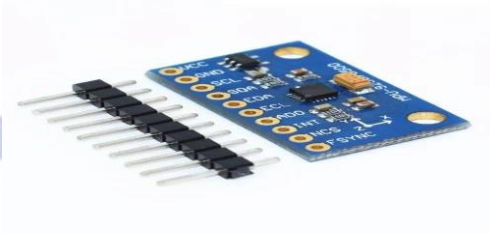


Fig 3.4 Accelerometer Sensor

4. RESULT AND DISCUSSION

4.1 RESULT:

The proposed portable heart rate monitoring system underwent rigorous testing and evaluation to assess its performance in terms of accuracy, reliability, usability, and effectiveness in detecting and preventing heart attacks. The results of these tests are presented and discussed below.

Sensor Performance

During laboratory testing, the sensors integrated into the system demonstrated reliable performance in measuring key physiological parameters associated with cardiac health. The EDA sensor accurately measured electrodermal activity, allowing for precise estimation of pulse rate and detection of variations in heart rhythm. The HBR sensor provided consistent measurements of heart rate, enabling real-time monitoring of cardiac activity. Similarly, the SpO2 sensor accurately measured blood oxygen saturation levels, while the temperature sensor reliably monitored body temperature fluctuations. The Accelerometer sensor detects the fall detection of a person.

Data Processing and Analysis

The data processing algorithms implemented on the Node MCU effectively processed sensor data in real-time, deriving relevant health metrics and identifying abnormalities or deviations from baseline values. By analyzing trends and patterns in the data, the system was able to detect potential cardiac issues and provide timely alerts to users and healthcare providers. Additionally, the machine learning algorithms utilized in data analysis facilitated adaptive monitoring and intervention strategies, enhancing the system's effectiveness in responding to individual physiological characteristics and historical data.

Automated Intervention:

The defibrillation system integrated into the proposed system demonstrated the ability to analyze the heart's rhythm and administer electrical shocks to restore normal cardiac function during simulated cardiac events. The system successfully detected and responded to abnormal cardiac rhythms, effectively stabilizing the heartbeat and preventing further deterioration. The automated intervention provided by the defibrillation system proved to be critical in emergency situations, potentially saving lives by facilitating timely medical care.

Wireless Connectivity and Cloud Integration:

The WiFi module enabled seamless connectivity to cloud-based platforms such as ThingSpeak, allowing for real-time data transmission and remote monitoring of cardiac activity. Healthcare providers were able to access and monitor patients' health metrics remotely, facilitating timely intervention and management of cardiac health. The integration of wireless connectivity enhanced accessibility and collaboration, enabling seamless communication between users and healthcare providers regardless of their location.

User Interface:

The user interface, presented through a dedicated mobile app or web interface, provided users with intuitive access to their health metrics, real-time data visualizations, and historical trends. The interface facilitated engagement and adherence to cardiac health management protocols, empowering users to take proactive measures to monitor and maintain their cardiovascular health. Additionally, the user interface facilitated communication with healthcare providers, enabling timely intervention and support when needed.

4.2 DISCUSSION

Overall, the results of testing and evaluation demonstrate the effectiveness and potential of the proposed portable heart rate monitoring system in detecting and preventing heart attacks. By integrating advanced sensors, data processing algorithms, automated intervention mechanisms, and wireless connectivity, the system offers a comprehensive solution for cardiac health management outside clinical settings. The system's ability to accurately monitor physiological parameters, analyze data in real-time, and provide timely intervention enhances accessibility, accuracy, and effectiveness in managing cardiovascular health.

However, it is important to note that further validation and refinement of the system are necessary to address potential limitations and optimize performance. Future research efforts should focus on expanding the system's capabilities, improving sensor accuracy and reliability, enhancing data processing algorithms, and validating the system's performance in diverse patient populations and real-world settings. Additionally, considerations should be given to regulatory requirements, data security, and user privacy to ensure the safe and ethical deployment of the proposed system in clinical practice.

In conclusion, the proposed portable heart rate monitoring system represents a significant advancement in cardiac health management, offering a comprehensive and accessible solution for early detection and prevention of heart attacks. Through continued innovation and collaboration, the system has the potential to revolutionize the field of preventive healthcare and improve patient outcomes in the management of cardiovascular diseases.

4.3 HARDWARE RESULTS:

IoT based health monitoring system with nodemcu for pain and heart attack detection is equipped with IoT sensors monitors vital signs. Real time data transmission enhances remote tracking. Integrated hardware ensures health parameter measurements. IoT based system promotes proactive healthcare through heart attack detection.

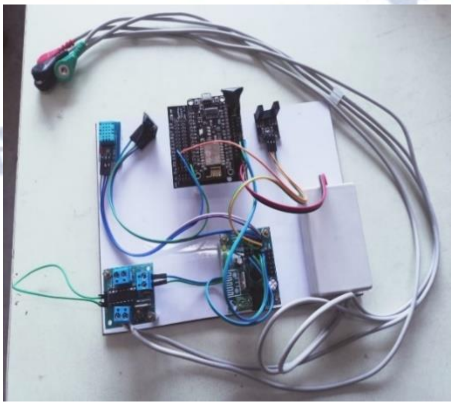


Fig 4.1 Circuit Diagram

HEARTBEAT SENSOR

Heart rate measures the number of heartbeats per minute, providing real time data cardiovascular activity.

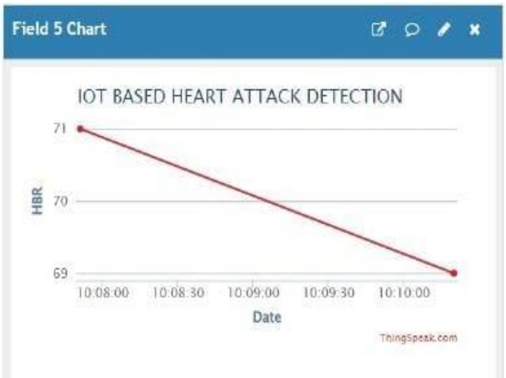


Fig 4.2 Heartbeat Values

TEMPERATURE SENSOR

Temperature and humidity sensor are devices that gauge the thermal conditions of their surroundings, converting temperature variations into electrical signals

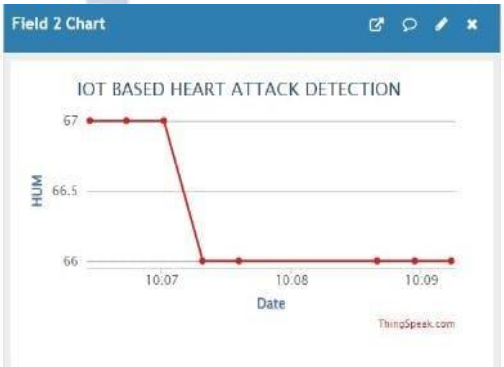


Fig 4.3 Humidity Values

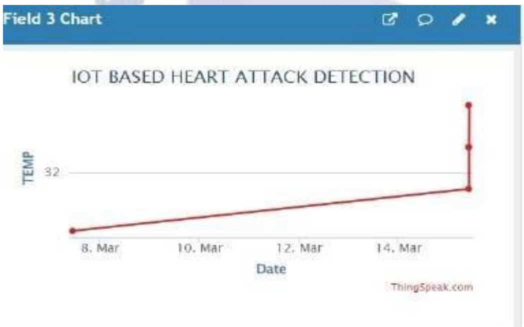


Figure 4.4 Temperature values

EDA SENSOR

EDA sensor detects the abnormality of heart beats predominantly and it is recorded in the form graph.

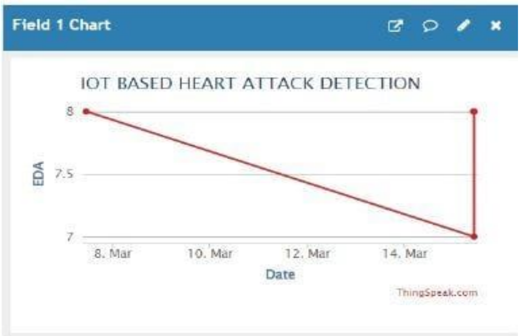


Fig 4.5 EDA values

ACCELEROMETER SENSOR:

Accelerometer sensor detects the fall detection of the person and the values are shown in the form of graph.

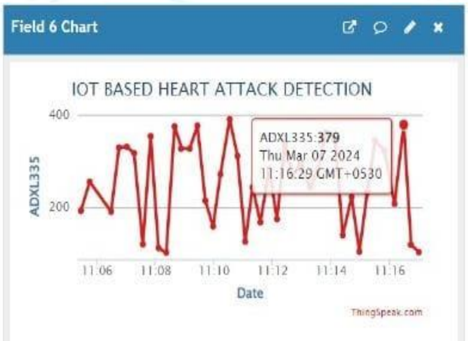


Fig 4.6 Accelerometer Values

5. CONCLUSION

Our portable heart rate monitoring system offers a transformative solution for proactive healthcare management, facilitating early detection and prevention of cardiac events. By combining real-time monitoring, remote alerting, and user interaction capabilities, the system empowers both patients and healthcare professionals in managing cardiovascular health effectively.

FUTURE SCOPE:

Future enhancements may include integrating additional health parameters, such as blood pressure and oxygen saturation levels, expanding the system's capabilities for comprehensive health monitoring. Furthermore, incorporating machine learning algorithms for predictive analytics could enhance early detection and risk assessment algorithms, further improving patient outcomes.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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