EJETMS

Erudite Journal of Engineering Technology and Management Sciences

Vol. 3, No. 4, December 2024, pp. 01-09

Journal homepage: http://www.ejetms.com

Heart Attack Alert System: An Integrated IoT Solution for Driver Safety in Four-Wheeled Vehicle

Kota Muralidhar Reddy[1], Gogulothu Lokesh[2], Yadamakanti Sudharshan Reddy[3], Ch. Pavithra[4], Dr.P.Dileep

[1,2,3] B.Tech Student, Department Of CSE (Internet of Things), Malla Reddy College of Engineering and Technology, Hyderabad, India.
[4] Assistant Professor, Department Of CSE (Internet of Things), Malla Reddy College Of Engineering and Technology, Hyderabad, India.
[5] Professor, Department Of CSE (Internet of Things), Malla Reddy College Of Engineering and Technology, Hyderabad, India.

Corresponding Author Email: kota.muralidharreddy@gmail.com

Received: 10 September 2023
Accepted: 15 December 2023

Keywords:
GSM Module,
Arduino uno,
pulse sensor,
Iot Technology,
Emergency Alert

ABSTRACT

With the rise in cardiovascular diseases and associated emergencies, ensuring driver safety has become a paramount concern in the automotive industry. This project presents a groundbreaking integration of the Heart Attack Alert System into the seat belts of four-wheeled vehicles. Leveraging Internet of Things (IoT) technology, the system continuously monitoring the driver's heart rate, providing real-time data for early detection of heart-related emergencies. In this implementation, a GSM module, Arduino Uno microcontroller, and Pulse Sensor are seamlessly integrated into the seat belt mechanism. The Pulse Sensor, embedded within the belt, accurately detects the driver's heart rate, while the Arduino Uno processes the data in real-time. When irregular heart rate patterns indicative of a heart attack is detected, the system triggers an immediate alert. Utilizing the GSM module, alerts are promptly transmitted to both the driver and emergency response services, enabling rapid intervention. In case of abnormal heart rate detection, the system automatically alerts the driver and nearby emergency services through SMS via the integrated GSM module. The user-friendly interface allows drivers to configure personalized alert thresholds within a specified range, ensuring a tailored approach to their health monitoring needs. The system's proactive alert mechanism ensures timely medical intervention, potentially saving lives.

1. INTRODUCTION

Globally, heart attacks are the number one killer, and early diagnosis and treatment are essential to reducing heart muscle damage and enhancing survival rates. The creation of heart attack warning and detection systems that may be implemented in a variety of settings, including vehicles, has gained more attention in recent years. As many heart attacks happen while driving or because of the stress of driving, the idea of incorporating heart attack detection and alert systems into automobiles is founded on this reality. The "Heart Attack Alert System: An Integrated IoT Solution for Driver Safety in Four-Wheeled Vehicles" represents a revolutionary advancement in vehicular safety and healthcare technology. With cardiovascular diseases being a leading cause of emergencies, particularly heart attacks, safeguarding drivers on the road has never been more critical. This innovative project introduces a sophisticated integration of Internet of Things (IoT) technology tailored for four-wheeled vehicles, aiming to detect early signs of heart-related issues and trigger immediate responses. The system is meticulously designed to continuously monitor a driver's heart rate using advanced sensors and real-time data processing. By seamlessly integrating IoT components, including sensors and communication modules, within the vehicle's framework, the Heart Attack Alert System ensures real-time health monitoring. Unlike traditional approaches, this system utilizes predefined heart rate thresholds for accurate and rapid detection of abnormal heart activities. When irregular heart patterns indicative of a potential heart attack is detected, the system triggers instant alerts. These alerts, transmitted via SMS through integrated GSM modules, not only notify the driver but also prompt swift responses from nearby emergency services. The user-friendly interface allows for personalized alert thresholds, tailoring the system to individual health profiles [1-5].

In this project, we delve into the development, implementation, and rigorous testing of the Heart Attack Alert System. Through this pioneering integration of healthcare oriented IoT technology into vehicle safety measures, our project not only ensures driver safety but also sets a new standard in proactive healthcare monitoring within the automotive industry [6-7].

2. USE OF IOT TO TACKLE EMERGENCY SITUATIONS WHILE DRIVING

The advent of the Internet of Things (IoT) has revolutionized various aspects of our lives, including the way we approach emergency situations. One area where IoT technology has made significant strides is in ensuring safety and security while driving. Road accidents and medical emergencies while on the road pose substantial risks to drivers and passengers. In this context, leveraging IoT to tackle emergency situations while driving has become a pivotal area of research and development. This paper explores the innovative applications of IoT technology in addressing emergency situations, enhancing driver safety, and potentially saving lives.

IoT in Vehicle Safety: IoT technology facilitates the seamless integration of various sensors, actuators, and communication devices within vehicles. These IoT-enabled components can monitor real-time data such as vehicle speed, location, acceleration, and even the driver's health parameters. By analyzing this data in real-time, IoT systems can identify potential emergency situations, such as sudden braking, collisions, or abnormal health conditions of the driver, allowing for immediate response mechanisms to be activated.

Real-time Health Monitoring: One of the most critical applications of IoT in driving safety is real-time health monitoring of the driver. Wearable devices integrated with IoT sensors can continuously monitor vital signs like heart rate, blood pressure, and glucose levels. In the event of irregularities or sudden changes, the IoT system can alert both the driver and emergency services. This instantaneous alert system ensures that medical assistance can be dispatched promptly, reducing response times significantly.

Accident Detection and Response: IoT-enabled accelerometers and collision sensors can detect accidents or collisions. When a significant impact is detected, these sensors trigger an automatic alert, notifying emergency services and providing the precise location of the incident. This real-time data can be invaluable for paramedics and rescue teams, enabling them to reach the accident site faster and with the necessary resources.

Predictive Maintenance and Prevention: IoT sensors can monitor the vehicle's health in real-time, identifying issues such as engine problems, low tire pressure, or brake malfunctions before they escalate into emergencies. Predictive maintenance alerts can be sent to drivers, advising them to seek repairs, thus preventing potential breakdowns or accidents caused by faulty vehicle components.

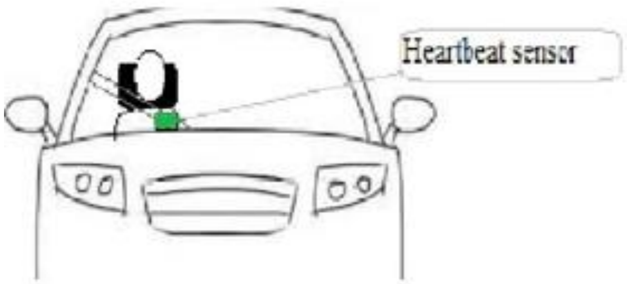

Fig.1. Integration of the Heart Attack Alert System into the seat belts of four-wheeled vehicles

3. LITERATURE REVIEW

3.1 Integration of IoT for Driver Safety

Researchers have explored the integration of IoT technology to enhance driver safety. IoT-enabled systems for health monitoring within vehicles have gained prominence, focusing on real-time data analysis and emergency response mechanisms. Studies emphasize the need for seamless integration, ensuring that IoT components do not interfere with vehicle functionality while providing reliable health monitoring.

3.2 Wearable Devices for Continuous Health Monitoring

A significant body of literature discusses the use of wearable devices, such as smartwatches and fitness trackers, for continuous health monitoring. These devices utilize optical sensors to measure heart rate. While convenient, challenges arise in terms of accuracy during motion and the need for consistent skin contact. Studies have explored techniques to enhance the accuracy of wearable devices, making them suitable for continuous heart rate monitoring in vehicular environments.

3.3 Real-time Health Monitoring in Emergency Response

Studies focusing on emergency response systems have highlighted the importance of real-time health monitoring for early detection of medical emergencies. Integrating health sensors within vehicles, especially for drivers, ensures rapid detection of abnormalities. Rapid response mechanisms, including automated alerts to emergency services, have been a subject of interest, emphasizing the role of IoT in reducing emergency response times.

3.4 Machine Learning Approaches for Heart Rate Analysis

Machine learning algorithms have been applied to heart rate analysis for anomaly detection. Research in this area delves into complex algorithms capable of identifying subtle patterns indicative of heart-related issues. While effective, these approaches require significant computational resources. Studies discuss the trade-off between computational complexity and real-time responsiveness, emphasizing the need for efficient algorithms in IoT-based health monitoring systems.

4. METHODS

4.1 Pulse Sensors

Method: Pulse sensors can be placed on the driver's body, commonly on fingertips, to detect the pulse rate.

Working: These sensors use light to detect the blood volume changes under the skin, which occur with each heartbeat. Variations in the detected blood volume help in determining the pulse rate.

Advantages: Non-invasive, cost-effective, real-time monitoring, suitable for continuous monitoring.

Limitations: Accuracy can be affected by motion artifacts and external light interference.

4.2 ECG (Electrocardiogram) Sensors

Method: Electrodes are attached to the driver's body to measure the heart's electrical activity.

Working: ECG sensors detect electrical signals generated by the heart with each beat. Irregularities in these signals indicate potential heart issues.

Advantages: Highly accurate, widely used in clinical settings, can detect various heart conditions.

Limitations: Invasive (requires skin contact), requires trained personnel for correct placement and interpretation, not suitable for continuous monitoring in a vehicle.

4.3 Photoplethysmography (PPG)

Method: PPG sensors use light to measure changes in blood volume in peripheral circulation.

Working: Similar to pulse sensors, PPG sensors utilize light absorption to detect variations in blood volume, indicating the heart rate.

Advantages: Non-invasive, used in wearable devices, suitable for continuous monitoring, and can be integrated into small form factors.

Limitations: Accuracy may be affected by motion, ambient light, and sensor placement.

4.4 Ballistocardiography (BCG) Sensors

Method: BCG sensors measure the mechanical activity of the heart by detecting the body's vibrations with each heartbeat.

Working: BCG sensors detect the subtle movements generated by the heart's pumping action. Changes in these vibrations indicate heart rate and rhythm.

Advantages: Non-invasive, detects mechanical activity of the heart, can be integrated into seats or vehicle structure for continuous monitoring.

Limitations: Requires sensitive sensors, vibrations can be affected by external factors.

4.5 Impedance Cardiography

Method: Impedance cardiography measures the electrical impedance of the thorax to assess blood flow and heart rate.

Working: Variations in thoracic impedance occur with changes in blood volume during the cardiac cycle. Impedance cardiography measures these changes.

Advantages: Non-invasive, can provide additional cardiovascular information, suitable for continuous monitoring.

Limitations: Requires multiple sensors, sensitive to body composition changes.

Table 1. Wearable and nonwearable systems.

Type of System	Measuring Methods
Wearable-type heartbeat measuring system	Wristwatch-type
	Ring-type
	Necklace-type
	Shirt-type
Nonwearable-type heartbeat measuring system	Steering-type
	Seat-type
	Seatbelt-type
	Portable device-type
	Camera-type

Table 2. Measuring heart rate methods and weak points of the general and traditional method.

Method	Technique	Device	Weak Point
ECG (Electrocardiogram)	Measures the electrical pulses generated by the body during each cardiac cycle	Electrodes	Difficult to position correctly, affected by body movement, electrodes become loose when the body is sweaty
Sphygmomanometer	A method for measuring changes in arterial pressure that vary with heart pulsation	Sphygmomanometer	Affected by body movement
Cardiogram	Measure the sound generated by the pulsation of the heart	Finger, stethoscope, microphone	Affected by hand and finger movement
Photoelectric pulse	Near-infrared light is applied to the skin surface and the reflected light is received by a photodiode or other device	Smartwatch	Affected by body movement, touching condition of fingers, skins, etc.

4.6 Machine Learning Algorithms

Method: Machine learning algorithms process data from various sensors to identify patterns associated with heart attacks.

Working: These algorithms analyze data patterns such as heart rate variability, sudden spikes, or irregular rhythms. Trained models can identify anomalies indicative of a heart attack.

Advantages: Can provide advanced predictive capabilities, adapt to individual variations, and improve accuracy over time.

Limitations: Require substantial training data, computational resources, and may not be suitable for real-time response in all scenarios.

5. METHODOLOGY: HARDWARE INTEGRATION

5.1 Selection of Hardware Components

The first step in our methodology involved the careful selection of hardware components: Pulse Sensors, Arduino Uno microcontroller, and GSM modules. Pulse Sensors are non-invasive devices that can accurately measure heart rate. Arduino Uno serves as the brain of the system, processing data and triggering alerts. GSM modules facilitate real-time communication by sending SMS alerts.

5.2 Hardware Setup

The Pulse Sensor was strategically integrated into the seat belt mechanism, ensuring unobtrusive and continuous heart rate monitoring. Arduino Uno microcontrollers were programmed to read data from the Pulse Sensor and process it in real-time. GSM modules were connected to the Arduino Uno, enabling SMS alerts to be sent when abnormal heart rate patterns were detected.

5.3 Real-Time Data Processing

Arduino Uno microcontrollers were programmed to process real-time data from the Pulse Sensor. Algorithms were developed to analyze the heart rate data, comparing it against predefined thresholds (such as heart rates below 20 or above 50 beats per minute). Abnormalities triggering potential heart attack alerts were detected based on these thresholds.

5.4 Alert Triggering Mechanism

When abnormal heart rate patterns were identified, the Arduino Uno triggered the GSM module to send SMS alerts. These alerts included information about the abnormality detected, ensuring that both the driver and nearby emergency services were informed promptly.

5.5 User Interface and Threshold Configuration

A user-friendly interface was designed to enable drivers to configure personalized alert thresholds. Using input devices, such as buttons or a touchscreen, drivers could set their specific heart rate thresholds based on their health conditions. The thresholds were stored in the Arduino Uno's memory and used for real-time comparison.

5.6 Testing and Calibration

Extensive testing was conducted to calibrate the system. Simulated scenarios mimicking various heart-related emergencies were created. The system's responses were evaluated, ensuring that it accurately detected abnormalities and triggered alerts. Calibration processes involved fine-tuning the algorithms and threshold values for optimal accuracy.

5.7 Integration with Vehicle Systems

The final step involved integrating the entire system into the vehicle's electronics. Secure connections and power management systems were implemented to ensure the stable operation of the Heart Attack Alert System within the vehicular environment.

5.8 Validation and Simulation

The integrated system was subjected to real-world simulations and validation tests. These tests included both controlled environment simulations and on-road trials, ensuring that the system functioned accurately under diverse conditions.

Fig. 2. Sensors integrated in seat belt

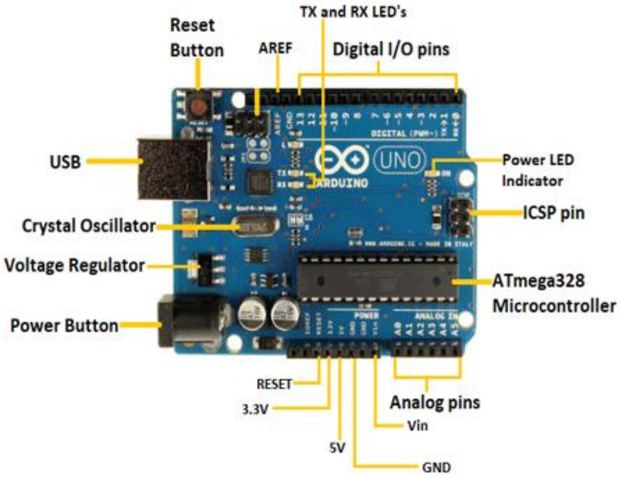

Fig. 3. Arduino

6. FUNCTIONAL UNITS OF THE SYSTEM

6.1 The Arduino Uno Board

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.

6.2 The Pulse Sensor Unit

A Heartbeat sensor is a monitoring device that allows one to measure his or her heart rate in real time or record the heart rate for later study. It provides a simple way to study the heart function. This sensor monitors the flow of blood through the finger and is designed to give digital output of the heartbeat when a finger is placed on it. When the sensor is working, the beat LED flashes in unison with each heartbeat. This digital output can be connected to the microcontroller directly to measure the Beats per Minute (BPM) rate.

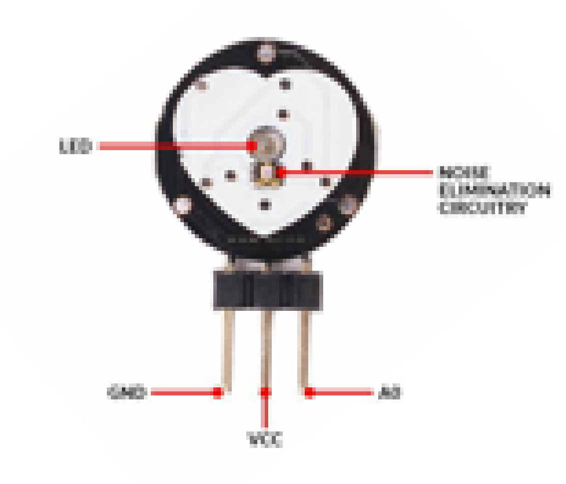

Fig. 4. Pulse sensor

6.3 Key Features of Pulse Sensors

Photoplethysmography (PPG) Technology: Pulse sensors typically use PPG technology, which involves shining light through the skin and measuring the variations in light absorption caused by blood flow. This method allows the sensor to detect the pulse rate.

LED and Photodetector: A pulse sensor consists of an LED (Light Emitting Diode) that emits light into the skin and a photodetector that measures the intensity of the light after it passes through the skin. Changes in blood volume affect the amount of light absorbed, providing information about the pulse rate.

Fingertip Placement: Pulse sensors are usually designed to be clipped onto a fingertip. The sensor pad comes into contact with the skin, allowing it to detect the pulse signal. Some sensors are integrated into wearable devices like smartwatches and fitness bands, enabling continuous heart rate monitoring.

Analog Output: Pulse sensors provide analog output signals proportional to the detected pulse rate. These signals can be read by microcontrollers or other processing units for further analysis and display.

Noise Filtering: Pulse sensors often include noise filtering algorithms to remove interference and provide a clean and accurate pulse signal, especially in dynamic and noisy environments.

Adjustable Thresholds: Some pulse sensors allow users to set customizable thresholds for heart rate detection. When the heart rate exceeds or falls below these thresholds, it can trigger alerts or actions in applications like fitness trackers or health monitoring systems.

Compatibility: Pulse sensors are compatible with various platforms and microcontrollers, making them versatile components for integrating heart rate monitoring capabilities into different electronic devices.

GSM Model: A GSM (Global System for Mobile Communications) module is a specialized type of hardware that enables devices to communicate over cellular networks. These modules are used in various applications where remote communication, messaging, or data transmission is required. GSM modules are commonly used in IoT (Internet of Things) projects, security systems, remote monitoring applications, and more.

Fig. 5. GSM

6.4 Key Features of GSM Modules

Network Connectivity: GSM modules provide connectivity to cellular networks, allowing devices to send SMS messages, make voice calls, and access data services over mobile networks.

SIM Card Slot: GSM modules typically require a SIM (Subscriber Identity Module) card, which is inserted into the module. The SIM card contains essential information such as the mobile number and authentication details.

AT Commands: GSM modules are controlled using AT (Attention) commands sent via serial communication (UART). These commands allow users to instruct the module to perform various tasks, such as sending messages or making calls.

SMS Functionality: GSM modules can send and receive SMS messages, making them useful for applications that require remote notifications, alerts, or data transmission via text messages.

Voice Call Support: Some GSM modules come with voice call capabilities, allowing users to make and receive calls. This feature is useful for applications that require voice communication, such as security systems with voice feedback.

Data Transmission: GSM modules can establish GPRS (General Packet Radio Service) or EDGE (Enhanced Data rates for GSM Evolution) connections for transmitting data over the internet. This functionality is vital for IoT applications that require internet connectivity.

Antenna Connection: GSM modules require an external antenna for reliable network reception. Antennas can vary in type, including PCB (Printed Circuit Board) antennas and external whip antennas, depending on the module's design.

Power Supply: GSM modules require a stable power supply, typically ranging from 3.4V to 4.5V. Adequate power management is crucial for the module's reliable operation.

Fig. 6. LCD

6.5 LCD (Liquid Crystal Display)

LCD, stands for Liquid Crystal Display, is a flat panel display technology commonly used in electronic devices like TVs, monitors, smartphones, tablets, digital clocks, and embedded systems. LCDs are versatile and widely utilized due to their low power consumption, thin form factor, and ability to display information with high resolution and clarity.

6.6 Key Features of LCDs

Liquid Crystal Technology: LCDs operate based on the unique properties of liquid crystals, which can change their alignment when an electric field is applied. These crystals modulate the light passing through them, creating the images displayed on the screen.

Pixel Structure: LCDs are composed of individual pixels arranged in a matrix. Each pixel consists of sub-pixels (typically red, green, and blue) that combine to produce a wide range of colors.

Backlight: Most LCDs require a backlight source to illuminate the screen. LEDs (Light Emitting Diodes) are commonly used for this purpose. The backlight provides consistent and uniform illumination for the display.

Resolution: LCDs come in various resolutions, denoting the number of pixels horizontally and vertically. Higher resolutions result in sharper images and text.

Color Depth: LCDs can display images in different color depths, such as 18-bit (262,144 colors), 24-bit (16.7 million colors), or more. Higher color depths offer more realistic and vibrant color representation.

Refresh Rate: LCDs have a specific refresh rate, typically 60 Hz, which refers to the number of times per second the screen refreshes its content. Higher refresh rates provide smoother motion display, crucial for applications like gaming and video playback.

Response Time: LCDs have a response time, measured in milliseconds, indicating how quickly a pixel can change from one color to another. Lower response times reduce motion blur in fast-moving images.

Viewing Angles: LCDs have specified viewing angles (horizontal and vertical) within which the display can be viewed without significant color distortion or brightness loss. IPS (In-Plane Switching) LCDs offer wide viewing angles compared to older technologies like TN (Twisted Nematic).

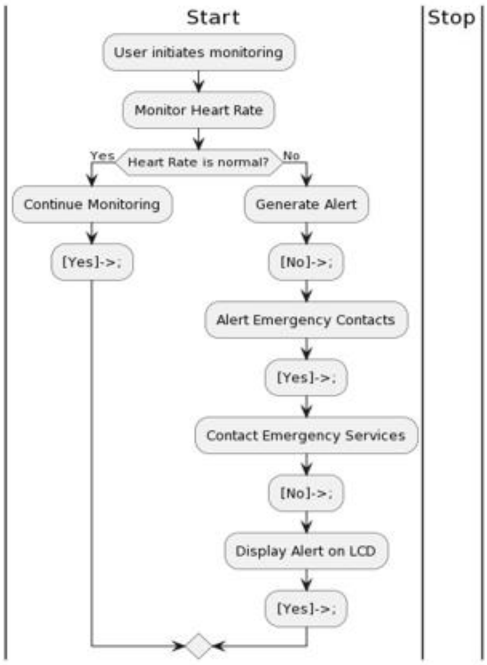

Fig. 7. Dataflow diagram

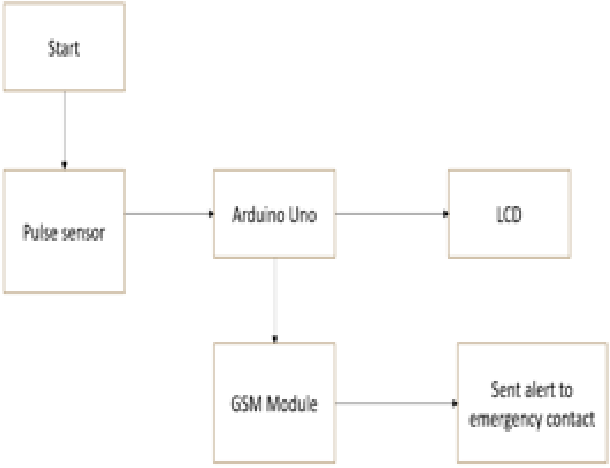

Fig. 8. System Architecture

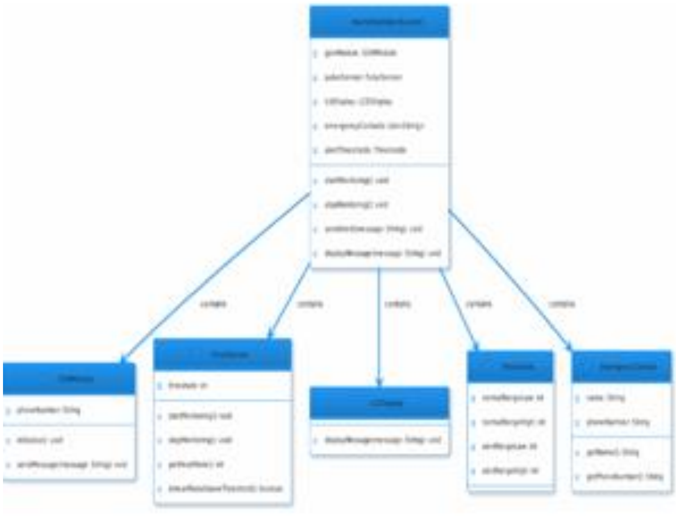

Fig. 9. Class diagram

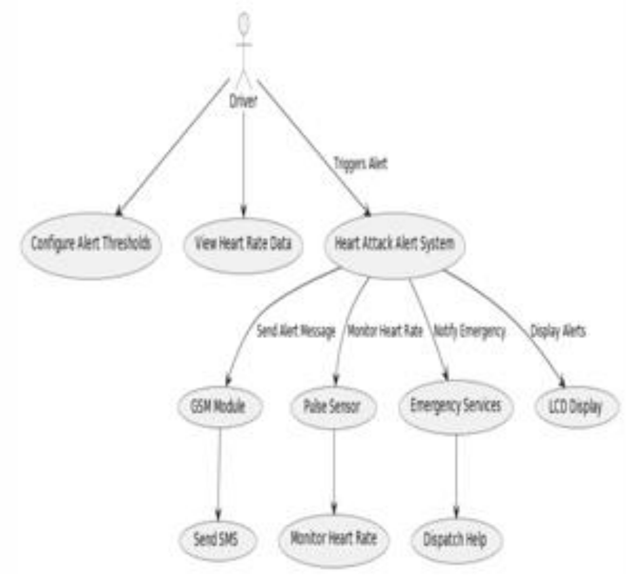

Fig. 10. Use diagram

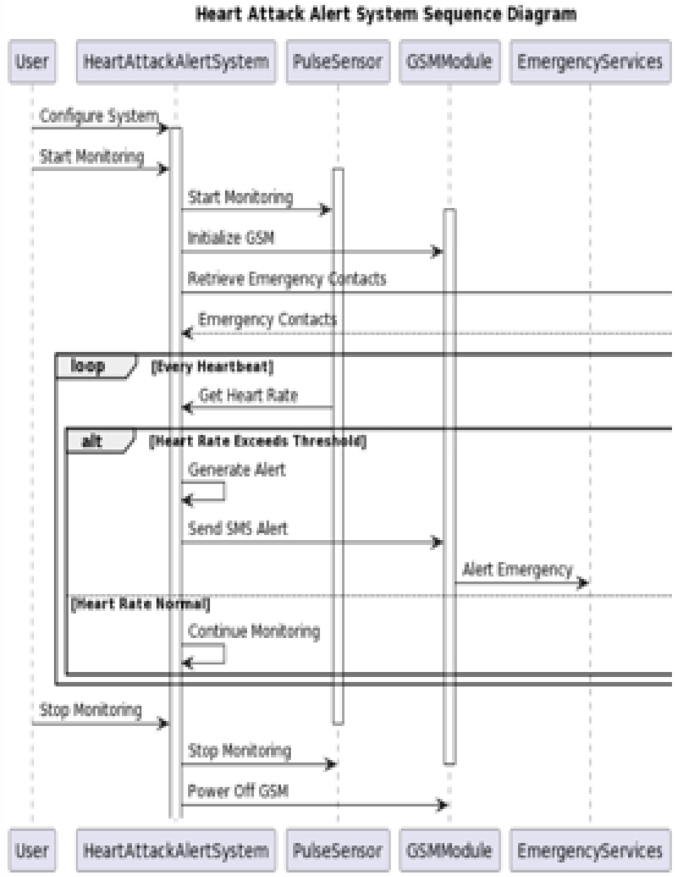

Fig. 11. Squence diagram

7. TEST CASES

7.1 Test Case: System Initialization

Objective: Ensure the system initializes properly upon startup.

- Power on the Heart Attack Alert System.
- Verify that all components (GSM module, pulse sensor, microcontroller, LCD display) initialize without errors.
- Confirm that the system is ready to monitor the driver's heart rate.

7.2 Test Case: Heart Rate Monitoring

Objective: Validate the accuracy and consistency of heart rate monitoring**.**

- Simulate a range of heart rates using the pulse sensor simulator.
- Verify that the system accurately detects and displays the simulated heart rates on the LCD display.
- Ensure the system responds promptly to changes in heart rate.

7.3 Test Case: Alert Generation

Objective: Confirm that alerts are generated appropriately when abnormal heart rates are detected.

- Simulate an abnormal heart rate (e.g., above or below the threshold) using the pulse sensor simulator.
- Verify that the system triggers an alert, either through SMS via GSM module or visual/audio alert on the LCD display.
- Ensure the alert message contains relevant information (e.g., type of alert, driver's information).

7. 4 Test Case: Alert Transmission

Objective: Validate the transmission of alerts to predefined emergency contacts.

- Trigger an abnormal heart rate to initiate an alert.
- Verify that the system successfully sends an SMS alert to the configured emergency contacts.
- Confirm receipt of the alert message on the recipient's phone.

7.5 Test Case: User Configurability

Objective: Ensure users can configure alert thresholds and emergency contact information.

- Access the system's configuration menu.
- Modify the heart rate thresholds to different values.
- Update the emergency contact information (phone numbers, names).
- Verify that the changes are saved and reflected in the system's behavior during subsequent tests.

7.6 Test Case: Power Management

Objective: Verify the system's behavior during power fluctuations and low power scenarios.

- Simulate power fluctuations and interruptions.
- Confirm that the system maintains its state and resumes normal operation after power is restored.
- Test the system's behavior under low power conditions and ensure it alerts the user before shutting down due to low battery.

7.7 Test Case: Emergency Response Integration

Objective: Validate the integration with emergency response services.

- Trigger an alert and confirm that the system communicates with local emergency services or nearby hospitals.
- Verify that the emergency response services receive accurate information about the driver and their location.

- Confirm the responsiveness and effectiveness of the emergency response process.

7.8 Test Case: System Reset and Recovery

Objective: Verify the system's behavior after a manual reset or recovery from an alert state.

- Manually reset the system after an alert.
- Confirm that the system clears the alert state and resumes normal operation.
- Trigger an alert and verify that the system recovers gracefully after the alert is resolved.

7.9 Test Case: User Interface Interaction

Objective: Validate user interactions with the system's user interface.

- Interact with the LCD display and confirm that all menu options are responsive.
- Test button inputs (if applicable) and ensure they trigger the intended actions.
- Verify that the user interface provides clear feedback during configuration changes and alerts.

7.10 Test Case: Data Logging and Reporting

Objective: Confirm that the system logs relevant data for future analysis and reporting.

- Trigger multiple alerts with varying heart rates.
- Access the system's data logs and verify that detailed information about each alert is record accurately.
- Generate a report based on the logged data and confirm its accuracy and completeness.

8. RESULT OUTPUT SCREENS

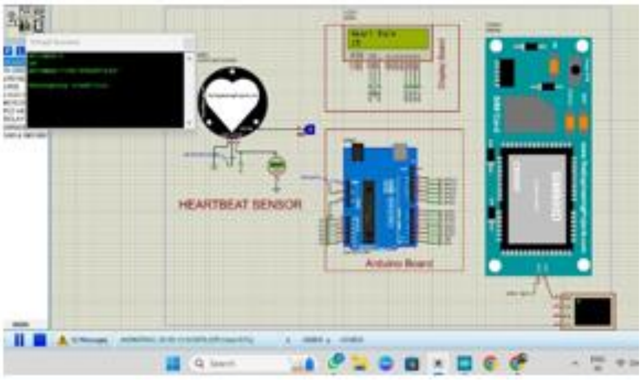

Fig. 12. Heart rate less than threshold value, it generates an emergency alert.

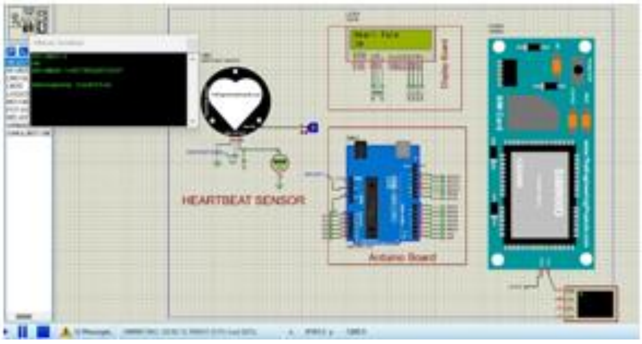

Fig.13. Heart rate less than threshold value, it generates an emergency alert.

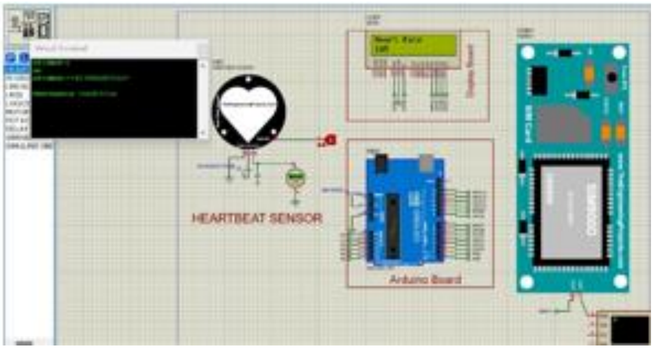

Fig.14. Heart rate more than threshold value, it generates an emergency alert.

9. CONCLUSION

In conclusion, the Heart Attack Alert System represents a groundbreaking leap in driver safety, offering an integrated IoT solution that can potentially save lives. By seamlessly combining advanced technologies such as pulse sensors, GSM modules, and Arduino microcontrollers, this system provides real-time heart rate monitoring for drivers. Its ability to accurately detect abnormal heart rate patterns and instantly alert both the driver and emergency services ensures swift medical intervention during critical moments, significantly enhancing the chances of survival in heart-related emergencies. Moreover, the user-friendly interface and configurability empower drivers to tailor the system to their specific health needs, fostering a proactive approach to health monitoring. With its robust performance, adaptability, and potential to revolutionize road safety, the Heart Attack Alert System stands as a testament to the transformative power of IoT solutions in ensuring the well-being of individuals within the automotive environment.

10. FUTURE SCOPE

The future scope of the Heart Attack Alert System extends beyond its current capabilities by integrating GPS technology, enabling precise location tracking and enhancing emergency response. Incorporating GPS functionality will enable the system to transmit real-time location data to emergency services, allowing for faster and more accurate response during heart-related emergencies. Additionally, future advancements could focus on predictive analytics by analysing historical heart rate data, enabling the system to detect subtle patterns and provide early warnings about potential heart issues. Integration with smart wearable devices and health platforms could further enhance the system's usability, enabling seamless data sharing with healthcare providers and creating a comprehensive health monitoring ecosystem. Furthermore, research into advanced biometric sensors and machine learning algorithms can lead to a more comprehensive health monitoring system, not only capable of detecting heart-related emergencies but also predicting and preventing them, thereby significantly improving driver safety and well-being.

References

1. Elliott, D., Keen, W. and Miao, L., 2019. Recent advances in connected and automated vehicles. journal of traffic and transportation engineering (English edition), 6(2), pp.109-131.

2. Deepa, A., Manikandan, N.K., Latha, R., Preetha, J., Kumar, T.S. and Murugan, S., 2023, August. IoT-Based Wearable Devices for Personal Safety and Accident Prevention Systems. In 2023 Second International Conference On Smart Technologies For Smart Nation (SmartTechCon) (pp. 1510-1514). IEEE.
3. Christy, A., Shyry, P., Gandhi, G.M. and Praveena, M.A., 2021, March. Driver distraction detection and early prediction and avoidance of accidents using convolutional neural networks. In Journal of Physics: Conference Series (Vol. 1770, No. 1, p. 012007). IOP Publishing.
4. Yousif, M.T., Sadullah, A.F.M. and Kassim, K.A.A., 2020. A review of behavioural issues contribution to motorcycle safety. IATSS research, 44(2), pp.142-154.
5. Hakkert, A.S. and Gitelman, V., 2014. Thinking about the history of road safety research: Past achievements and future challenges. Transportation research part F: traffic psychology and behaviour, 25, pp.137-149.
6. Seiniger, P., Schröter, K. and Gail, J., 2012. Perspectives for motorcycle stability control systems. Accident Analysis & Prevention, 44(1), pp.74-81.
7. World Health Organization, 2015. Global status report on road safety 2015. World Health Organization.

CC-BY