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IoT Based Health Monitoring System for Drivers

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Abstract

The IoT-based health monitoring system for drivers continuously monitors the health conditions of the driver using sensors that make contact with the drivers. In this heart rate, ECG, oxygen level, temperature and blood pressure. By using various health sensors, the health state monitors built-in IoT systems using the decision tree algorithm and code that repeatedly monitors in a specified delay. The system also contains alcohol sensors that monitor the driver's state while driving. The GPS (geographical position system) module is used to share the location of the vehicle, and the GSM (global system for mobile communication) module is used for data service used to send notification when the condition and sensor results get below the normal range. The IoT BLYNK app also shows the regular analysis of the sensor, which can be viewed on a phone with internet access. The ethanol in the air triggered the alcohol sensor, and then it sent alert messages. The data from the sensors and databases is used to build an AI that continuously monitors the system. By using a suitable algorithm and various training, we can build a trained model.

Keywords: Sodium silicate, Rice husk ash, Activated Carbon

I. Introduction

The fast growth of Internet of Things (IoT) technologies has facilitated the creation of smart, networked systems in many industries, most notably in healthcare and transportation. One key application area where both fields converge is in the monitoring of driver's health and safety. With increasing road accidents attributed to sudden health complications, fatigue, intoxication, or environmental exposure, there is a growing need for real-time, automated systems that can assess and report the driver's health condition to mitigate risks. Traditional safety systems such as airbags or anti-lock braking systems (ABS) primarily respond post-incident. In contrast, proactive systems—especially those leveraging IoT—aim to prevent incidents by detecting abnormal driver states before they escalate into emergencies[1]-[3].

This paper introduces an IoT-based driver health monitoring system. It incorporates a set of sensors that track physiological parameters like heart rate, ECG, SpO_2 (blood oxygen saturation), body temperature, and blood pressure. These parameters are vital indicators of a driver's physical state and are often associated with fatigue, stress, or the onset of medical emergencies[4]-[5]. Also, the system features an alcohol sensor that picks up on ethanol vapor in the air to detect if the driver is intoxicated with alcohol, which is one of the most common reasons for unsafe driving. The system is run on an embedded microcontroller platform and utilizes a decision tree algorithm to decode the sensor readings and identify the driver's health condition in real time. The monitoring process is intended to be repeated at predetermined periods to provide constant surveillance without saturating the processor or communication modules.

In addition to local processing, the system also features a GSM (Global System for Mobile Communication) module for sending SMS notifications to preprogrammed emergency numbers when monitored values exceed critical levels. A GPS (Global Positioning System) module is also included to report the vehicle's current location, which can be very important for sending medical help during emergencies. The real-time sensor reading is also pushed to the Blynk IoT platform, where it is displayed in a smartphone app. This means that the fleet manager, medical team, or family members can remotely track the health status of the driver and receive instant notifications if required. The application gives a simple interface that facilitates 24/7 online access to health analytics as long as the device remains connected to the internet [6].

In addition, the system is architected not only for real-time monitoring but also for ongoing data collection, upon which AI integration is based. With a supervised learning algorithm—in this case, a decision tree classifier—the system learns to identify patterns of normal and abnormal behavior. With adequate training data acquired over time, the model can become a predictive system that issues early warnings based on subtle changes in physiology. This AI-facilitated monitoring supports a shift from reactive to predictive safety mechanisms, enhancing the system to prevent accidents before they happen [7].

A few earlier studies have investigated various aspects of driver health and safety monitoring with inherent limitations. A GSM and temperature-sensing wearable system was implemented to monitor patient vitals. It was, however, not integrated with decision-making algorithms and real-time vehicle deployment. In drowsiness detection, eye-blink analysis using cameras was applied. Although it could detect fatigue, it did not account for underlying health issues or environmental hazards like alcohol or gas exposure. A cloud-based health monitoring system reported in utilized IoT for telemedicine but was confined to indoor settings such as hospitals or residences and did not involve GSM-based alert systems for mobile applications[8].

The system proposed here fills these shortcomings by integrating physiological health monitoring with vehicle-specific safety features like alcohol detection and geolocation tracking. It adds a real-time alert system using GSM and mobile-based visualization using the Blynk platform. This is a more complete, on-the-go solution tailored to the needs of commercial and personal vehicle drivers. In addition, by using artificial intelligence in its analysis center, the system offers not only real-time condition checks but also long-term health trend analysis and early anomaly detection potential[9].

The combination of all the parts—sensors, Bluetooth and GSM modules, GPS, mobile application, and AI-driven analytics—yields an efficient and intelligent system that is power-saving, low-cost, and scalable. It can be deployed on private cars, public transport, or logistics fleets to improve road safety, assist driver health, and minimize the chances of health-related accidents. For commercial fleets, the system is also a useful asset to employers for observing the health of their drivers and ensuring increased efficiency and reduced liability[10]-[12].

In summary, the research here brings forth a new, IoT-enabled health monitoring system that takes advantage of real-time data capture, mobile connectivity, and AI-facilitated decision-making to ensure driver safety. It is set to decrease the rate of accidents, provide swift response in cases of medical emergencies, and, in the long run, make for smarter, safer transportation systems. By targeting physiological as well as behavioral risks—that vary from cardiac problems to intoxication—this system lays down the groundwork for more intelligent vehicle safety systems to come.

II. RESEARCH OBJECTIVES

The main goal of this research is to develop and deploy an IoT-based driver health monitoring system that provides real-time monitoring of vital physiological and environmental parameters to improve road safety and facilitate proactive medical intervention. The system intends to fill the gap between driver health and the prevention of accidents by employing embedded sensor networks, wireless communication modules, mobile visualization, and AI algorithms.

The system incorporates the main health sensors—monitoring heart rate, ECG, blood oxygen saturation (SpO_2), body temperature, and blood pressure—and an alcohol sensor to monitor the level of intoxication of the driver. Based on ongoing monitoring and smart decision-making, the system can recognize abnormal conditions that may jeopardize the safety of the driver or other road users. Whenever these conditions arise, alert messages are triggered and transmitted through the GSM module while the actual real-time location of the driver is made available utilizing the GPS module. The data is also being visualized through the Blynk IoT platform for remote stakeholders like fleet owners, healthcare officials, or parents.

The primary objective has been accomplished through the following objectives:

- The objective is to design a cost-effective and compact IoT prototype that can collect real-time physiological and environmental data from the driver, with embedded sensors and utilizing incorporated microcontrollers.
- To establish wireless connectivity through GSM for SMS notifications and GPS tracking for emergency response purposes.

- To create a virtual user interface for mobile devices using the Blynk IoT platform, which allows for real-time monitoring of the driver's health status from distant locations.
- The objective is to establish a system that can detect impaired driving and prevent the vehicle from operating while the driver is intoxicated.

The achievement of these objectives enables this project to develop a vehicular safety system that is intelligent and actively reacts to drivers' health conditions. The convergence of AI, IoT, and mobile technologies into a unified monitoring platform provides a scalable solution for improving driver safety for personal and commercial transport domains. Additionally, the study provides a basis for future work in preventive vehicle safety systems, over-the-air diagnostics, and individualized health monitoring in motion. This presents an IoT-based driver health monitoring system aimed at improving road safety by detecting fatigue or medical distress. The system incorporates sensors to track vital parameters like heart rate, ECG, SpO_2, temperature, and blood pressure, as well as an alcohol sensor. It utilizes an embedded microcontroller and AI-based decision tree algorithm for real-time health monitoring. GSM and GPS modules provide emergency notification and location tracking, and remote monitoring is provided by the Blynk IoT platform. The chapter also discusses the literature review, pointing out the limitations met by this system's intelligent, mobile, and scalable design for secure personal and commercial transportation.

III. IMPLEMENTATION OF A PROTOTYPE AND METHODOLOGY

The central processing unit is the ESP8266 NodeMCU microcontroller in Figure 1, which interacts with several sensors and communication modules. The MAX30100 sensor is utilized for the driver's heart rate and SpO_2 readings, whereas the DHT11 sensor monitors body temperature and humidity. The MQ3 gas sensor is utilized to detect alcohol by sensing ethanol or toxic gases in the driver's environment. All of these sensors are wired to the NodeMCU on a breadboard via jumper wires for effortless connectivity. A buzzer is integrated into the system to offer immediate audible warnings when any physiological parameters cross set limits of safety. Also, a GSM module is wired to give emergency SMS warnings to predefined contacts when a severe health condition arises. A GPS module is optionally integrated to transmit the actual location of the vehicle, facilitating rapid emergency response. The ESP8266 is coded to push sensor data via Wi-Fi to the Blynk IoT platform, where the data is graphically displayed through a smartphone app. This permits remote monitoring by healthcare professionals, fleet managers or family members.' Power is supplied to the system through a controlled power supply unit that can be used in vehicles.

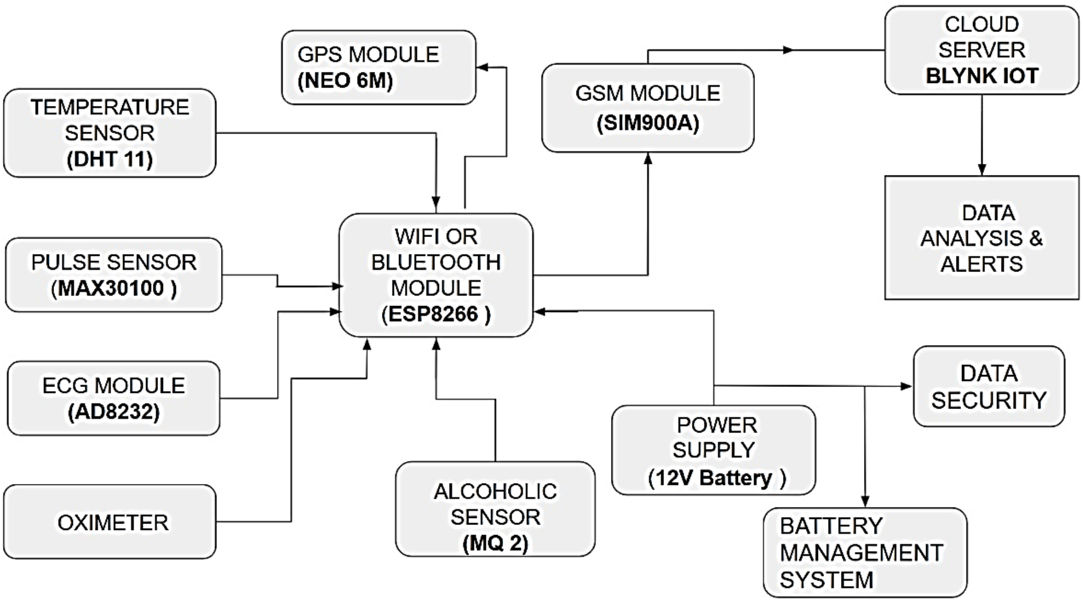


Figure 1. Hardware implementation of IoT-based Health Monitoring System

Initially, the firmware was flashed into the NodeMCU, and libraries for the MAX30100, DHT11, MQ3, GSM module, and GPS modules were installed and configured in the Arduino IDE. To ensure accurate data acquisition, the sensors were tested separately. The NodeMCU was programmed to continuously monitor, analyze, and compare sensor data with threshold values after achieving successful integration. When the system detects any abnormalities, such as a fever or alcohol spill, it activates its buzzer and sends out an SMS notification without delay. The system prototype was based on a breadboard, which allowed for its implementation in personal and commercial vehicles at a low cost.

IV. EXPERIMENTAL RESULT AND ANALYSIS

The health and safety of drivers is a top priority in today's fast-paced world to prevent road accidents caused by sudden medical problems. Sensor-based monitoring systems are essential for the continuous observation of vital health parameters and environmental conditions. By utilizing an IoT-based prototype, this project seeks to provide real-time monitoring of a driver's health, with the ability to detect anomalies such as high body temperature, low oxygen levels,

and harmful gases like alcohol. This chapter's primary focus is on testing the effectiveness and dependability of the system used. By examining the data obtained from multiple sensors, including MAX30100, DHT11, MQ2, and SIM900, it is determined if the system can be considered both accurate and responsive under various conditions. The evaluation sheds light on how well the prototype performs in practical use and highlights its potential to improve driver safety by providing real-time alerts through the Blynk app and SMS notifications. Figure 2 shows the prototype model. Figure 3. Shows the Output value in Arduino IDE.

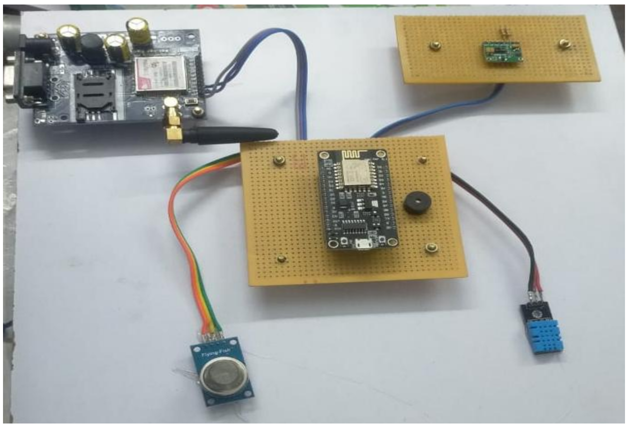
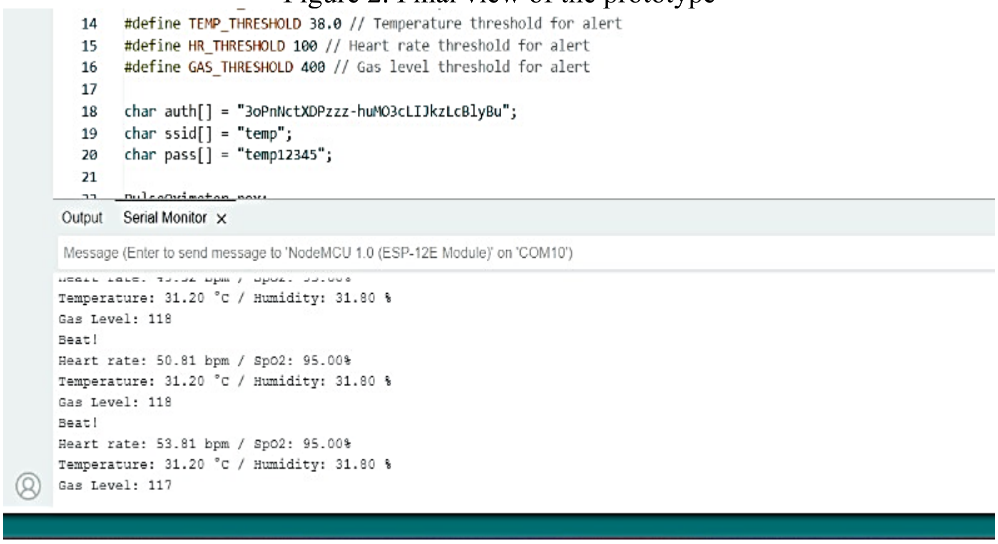


Figure 2. Final view of the prototype



```
#define TEMP_THRESHOLD 38.0 // Temperature threshold for alert
#define HR_THRESHOLD 100 // Heart rate threshold for alert
#define GAS_THRESHOLD 400 // Gas level threshold for alert

char auth[] = "3oPnNctXDPzzz-huMO3cLIJkzLcBlyBu";
char ssid[] = "temp";
char pass[] = "temp12345";
```

```
Output   Serial Monitor ×
Message (Enter to send message to 'NodeMCU 1.0 (ESP-12E Module)' on 'COM10')
Temperature: 31.20 °C / Humidity: 31.80 %
Gas Level: 118
Beat!
Heart rate: 50.81 bpm / SpO2: 95.00%
Temperature: 31.20 °C / Humidity: 31.80 %
Gas Level: 118
Beat!
Heart rate: 53.81 bpm / SpO2: 95.00%
Temperature: 31.20 °C / Humidity: 31.80 %
Gas Level: 117
```

Figure 3. Output value in Arduino IDE

The hardware configuration of the IoT-based health monitoring system comprises various components integrated to track the health of the driver and environmental parameters in real time. The main central component of the system is the ESP8266 NodeMCU, which serves as the primary controller and manages Wi-Fi connectivity for Blynk IoT integration. A MAX30100 pulse sensor takes the driver's heart rate and oxygen level (SpO2). A DHT11 temperature and humidity sensor tracks the body temperature and ambient humidity of the driver. For alcohol detection or toxic gas detection, an MQ-3 gas sensor is utilized. They are interfaced with the ESP8266 using its GPIO pins. For alerting in the event of abnormal readings, a GSM module like SIM800L is interfaced with the ESP8266 through serial communication to provide SMS alerts to a pre-configured phone number. By utilizing the Blynk IoT platform, it is possible to monitor all sensor data on a mobile application using Wi-Fi. A power source (like a 5V adapter or battery pack) is utilized to supply power to the entire system, with voltage regulation for safeguarding the components. Sensors and modules are safely mounted in the vehicle's dashboard or driver's seat compartment for precise monitoring. Figure 4. Shows the prototype output.

```
Heart rate: 61.78 bpm / SpO2: 96.00%
Temperature: 31.20 °C / Humidity: 31.70 %
Gas Level: 116
Heart rate: 0.00 bpm / SpO2: 0.00%
Temperature: 31.20 °C / Humidity: 31.70 %
Gas Level: 116
Beat!
Heart rate: 34.58 bpm / SpO2: 0.00%
Temperature: 31.20 °C / Humidity: 31.70 %
Gas Level: 116
```

Figure 4. Prototype Output

The microcontroller's sensors are verified, and data from the driver can be viewed in real time by using the serial monitor. This provides an easy way to verify sensor functionality and view live data.

- The heart rate displays a range of values, with the highest at 61.78 bpm and the lowest at 0.0% and 34.58 BP. Real changes in the heart rate or temporary disconnection or poor contact of the pulse sensor (MAX30100) with the skin may be responsible for this deviation, resulting in it reporting zero. Such fluctuations may be caused by slight motion or misaligned sensor positions.
- The initial SpO2 value (oxygen saturation) is 96.00%, which is considered a healthy range. This is the result. However, it eventually drops to 0.00%, suggesting a possible loss of signal or thinning sensor connections. A 0% SpO2 isn't realistic and implies that the sensor may have lost contact for a short time.
- The temperature values remain steady at 31.20°C, demonstrating that the DHT11 sensor is stable and working correctly. The value signifies either ambient or skin temperature, which is a common assumption when using whichever environmental sensor is in the vicinity.
- The gas level, measured by the MQ-3 sensor, is a low value of 116. It indicates that the driver is safe to breathe as there are no foul vapors or alcohol in the air.

A. Temperature Analysis

DHT11 is a simple digital temperature and humidity sensor offering calibrated digital output. It is designed using a thermistor to sense temperature and communicate via a single-wire digital interface, which is easy and effective for microcontroller-based systems. The DHT11 sensor is used in this project to sense the driver's body temperature or am bient temperature and send it to the NodeMCU ESP8266 for processing and alerting purposes.

The purpose of the test results is to compare the accuracy of the DHT11 temperature readings against a standard medical thermometer and calculate the error as a percentage difference between the temperature read by the DHT11 sensor and the thermometer, using the formula:

$$\% \text{ error} = (\Delta\text{temp} / thermometertemp) \times 100\ \%$$

Table 1. Temperature Measurement result compared with a thermometer

SL No	Gender / Age	Prototype Temp. (°F)	Thermometer Temp. (°F)	% Error Rate

1.	Male / 23	97	97	0
2.	Female / 25	98	98	0
3.	Male / 30	99	99	0
4.	Female / 40	100	100	0
5.	Male / 45	98	99	1.01
Average Error Rate (%)				0.40

Table 1. shows that the data obtained from the prototype using the DHT11 sensor closely matches the readings of a standard thermometer. The average percentage error is just **0.40%**, which confirms that the DHT11 sensor is reliable for basic health monitoring applications where ultra-high accuracy is not critical but general health tracking is required.

B. Pulse Rate and Oxygen Saturation Level Analysis

Pulse oximetry is a noninvasive and painless technique applied to quantify the level of oxygen saturation (SpO_2) in the blood as well as observe heart rate. It gives real-time and ongoing results, rendering it extremely useful for application in health monitoring systems. In the current system, the MAX30100 sensor is utilized, which integrates two LEDs (red and infrared), a photodetector, and low-noise signal processing circuitry to identify variations in the absorption of light in body tissues.

The sensor operates by passing red and infrared light through a fingertip, and based on the level of oxygenated and deoxygenated hemoglobin in the blood, different levels of light are absorbed. Oxyhemoglobin (HbO_2) absorbs more infrared light, while deoxyhemoglobin (Hb) absorbs more red light. By comparing the ratio of absorbed light by an AC/DC signal, the SpO_2 percentage is calculated. The calculation is estimated using the formula:

$$R=(ACRed/DCRed) \ / \ (ACIR/DCIR)$$

The standard model of finding SpO2 is :

$$\% \ SpO2 = 110 - 25 \times R$$

To evaluate the accuracy of the prototype system, test readings from the MAX30100 sensor were compared with those from a standard Jumper Pulse Oximeter (JPD-500D OLED Edition). The percentage error for heart rate (BPM) and oxygen saturation (SpO_2) was calculated using the following formulas:

$$\% \ error = (\ \Delta bpm \ / oxbpm) \times 100 \ \%$$

$$\% \ error = (\ SpO2 \ / oxSpO2 \ ) \times 100 \ \%$$

Table 2. Comparison of BPM and SpO_2

SL No	Gender / Age	BPM Prototype	BPM Oximeter	% Error Rate	SpO_2 Prototype	SpO_2 Oximeter	% Error Rate
1.	Male / 24	76	76	0	100	100	0
2.	Male / 26	80	81	1.23	98	98	0
3.	Female / 26	90	90	0	96	97	1.03
4.	Female / 30	79	79	0	98	98	0
5.	Female / 55	81	82	1.21	101	103	1.94
Average Error Rate for BPM (%)				1.48	Average Error Rate for SpO_2 (%)		1.32

Table 2 presents a side-by-side comparison of BPM and SpO_2 readings between the prototype and the oximeter. The results indicate a minimal error rate of 1.48% for heart rate and 1.32% for oxygen saturation, confirming the reliability and accuracy of the MAX30100 sensor in real-time driver health monitoring applications.

C. Alcohol Analysis

Alcohol level measurement is an important area of health and safety diagnostics, commonly used in clinical assessments, traffic policing, and workplace safety. BAC is the primary measure of alcohol content in an individual's blood, and it is used to determine this.By using a gas sensor (such as MQ3), he has developed 'non-invasive alcohol sensing' technology that measures the amount of ethanol in exhaled breath and estimates the BAC. Alcohol is absorbed into the bloodstream and then released into the alveolar air in our lungs. The release of ethanol vapor during exhalation can be detected through breath analysis. The sensor detects the vapor and outputs it as part of ppm, which is then converted to an approximate BAC value by using an empirically derived calibration formula . The standard deviation for the conversion is as follows**:**

BAC (%)=Breath Alcohol Concentration (mg/L)×2100

Table 3. Effects of Different BAC Levels

BAC (%)	Physiological Effects
0.00	Normal
0.02	Mild euphoria, decreased inhibition
0.05	Impaired coordination, slowed reaction times
0.08	Poor muscle control, blurred vision
≥0.10	Severe impairment, slurred speech, nausea

The semiconductor-based breath sensor alcohol detection system shows excellent accuracy compared to a commercial breathalyzer. The system provides a low-cost, portable approach to initial alcohol screening, although improvements can be enhanced by adding environmental compensation algorithms and advanced calibration procedures.

D. IoT Dashboard Output Using Blynk

1. Heart Rate: 47 bpm.

They show an average (typically 60–100 bpm) resting heart rate of 47 beats per minute or less. This low value could indicate bradycardia or sensor misreading, which may trigger the alert system. This information is then processed by the system to decide whether or not the driver will become unconscious due to fatigue from their heart condition.'

2. SpO2 (Blood Oxygen Level): 94%

SpO2 is 94% of normal and usually above 95 percent. Despite being on the lower end, it's not too severe, but dropping below that level could indicate hypoxia or respiratory problems. Both are true symptoms.

3. Temperature: 31°C.

This temp is 31°C (probably not the temperature of my core body, but it is plummeting from ambient to skin level). Being subcutaneously under the normal human body temperature (36.5 -- 37.5°C), it may serve as a measure of surface temperature from the DHT11, which is not always precise but useful for monitoring environmental conditions. There is currently no indication of a fever or high temperature.

4. Humidity

Despite the 31% humidity, the driver's comfort and hydration may be negatively affected due to the relatively dry conditions.

5. Gas Level: 114 (MQ-3 Sensor)

It is a safe and low gas reading of about 114.

The driver's heart rate and body temperature are among the vital signs monitored by the system.A health emergency is identified by the system when an abnormally high heart rate or temperature exceeds a predetermined safety threshold. Figure 5. Shows the Blynk Monitoring Page and Figure 6. Shows the SMS alert from GSM module on abnormal health detection

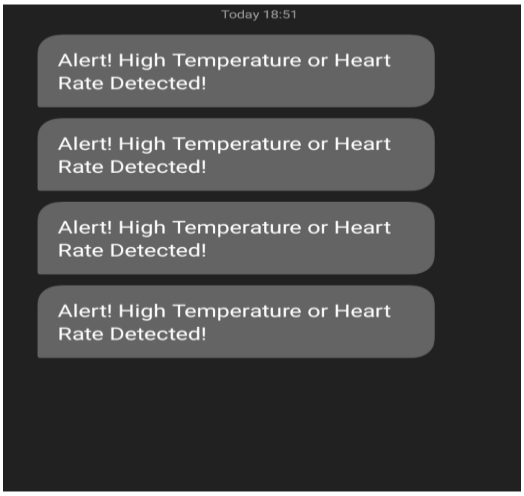


Figure 5. Blynk Monitoring Page

Figure 6. SMS alert from GSM module on abnormal health detection

This happens because of the above parameters. This image shows the active GSM module sending out repeated SMS alerts: "Alert!" This message tells us that the microcontroller has sensed unusual readings and has activated the alert system to inform a specified contact person, like a family member, fleet manager, The alert mechanism will notify notified contact person, such as EMS personnel, fleet manager etc..".This facility prevents health emergencies from being overlooked and immediate intervention can be made, which can avert accidents caused by driver fatigue, dizziness, or other medical complications. On a larger scale, the output above is an assurance that the GSM module is suitably interfaced within the system and is taking its important role in facilitating real-time communication under severe health conditions, thus enhancing driver safety and responsiveness in the event of emergencies**.**

V. CONCLUSION

The IoT-based health monitoring system is equipped with a range of sensors to continuously monitor the physical state of its users Vital health indicators, including heart rate, ECG signals, body temperature and blood pressure are monitored by these sensors. The system is implemented based on a decision tree algorithm that runs sensor data at predetermined intervals to ensure constant real-time monitoring without clogging the system. Additionally, there is an alcohol sensor that can detect the presence of ethanol vapor, which can identify drunk drivers on the roadside. The GPS module identifies and shares the current position of the vehicle, while the GSM module sends alert messages to emergency contacts in case the values differ from normal limits. The implementation of this allows for prompt assistance to be provided during a medical emergency. The IoT platform Blynk provides a user-friendly interface for real-time monitoring of sensors, which can be accessed remotely using satanic or smart phones. This system evolves into a predictive health monitoring solution that trains algorithms correctly with the input of data, improves road safety, and delivers timely alerts, ensuring rapid response and preventive action.The system can be embedded directly within the vehicle's infotainment dashboard, enabling real-time visualization of the driver's vital signs (e.g., heart rate, SpO_2, and temperature) during driving. If abnormal conditions are identified, the display can indicate alerts with warning tones, enabling the driver and passengers to instantly identify a health risk. The feature could also integrate with in-car voice assistants to provide audible health updates, improving safety without distracting the driver.

By training the AI model on big data over a period of time, the system would be able to identify minute changes in the driver's physiological data and provide early warnings before any serious health issue occurs. Employing lightweight ML algorithms such as decision trees or TinyML, the system would be able to run on the edge (in the car), without cloud computation and with faster response times. Notifications might also be issued to local medical stations or fleet owners in case there is a detected predictive risk. The system can be further extended to directly interact with emergency services or hospitals in the case of severe health conditions. When a critical condition is sensed (such as a heart attack or loss of consciousness), the GPS module can send the precise location to emergency personnel, while the GSM module can send detailed health information for improved preparedness.

For the purpose of sustained health monitoring outside driving time, the monitoring system might be miniaturized into a wearable device such as a smartwatch or fitness band. The wearable would communicate with the in-car system upon the driver's entry into the vehicle, providing seamless data gathering and analysis both within and outside the vehicle.The development of a separate mobile app can provide drivers or their families with ongoing access to health data, historical trends in data usage, and emergency notifications. The app could provide personalized health insights, reminders for routine medical checks, and AI-based suggestions to improve overall health

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