Wireless Framework for Automotive Monitoring Systems

Anushka A Muragod[1], Aneesh R[2], Bhuvan C. S. Gowda[3], Gokul V[4], and Dr. Roopa M[5]
[1,2,3,4] *Student, Dept. of Electronics and Communication, Dayananda Sagar College of Engineering, Bengaluru, KA, India*
[5]*Professor, Dept. of Electronics and Communication, Dayananda Sagar College of Engineering, Bengaluru, KA, India*

Abstract—Road accidents pose a significant threat to human lives, with delayed medical assistance often exacerbating the consequences. This paper presents the design and implementation of an efficient wireless vehicle system for accident detection and reporting, utilizing an accelerometer and GPS. The accelerometer detects collisions, while the GPS provides the precise location of the vehicle. Upon detecting an accident, the system automatically sends an alert message to preprogrammed contacts, such as family members or emergency medical services, via GSM. Additionally, supplementary sensors record real-time vehicle parameters, offering crucial evidence for understanding the events leading to the accident and ensuring a fair analysis..

Index Terms—**Accelerometer, Cloud Data, ESP8266, Global Positioning System (GPS), Global System for Mobile Communications (GSM), Real-time, Wireless**

I. INTRODUCTION

The World Health Organization reports that over a million people globally lose their lives each year due to transportation-related accidents. This alarming statistic highlights the urgent need for solutions that transcend national boundaries and address the safety and health risks posed by road accidents worldwide.
To mitigate this crisis, the implementation of black box technology in vehicles marks a pivotal step forward. Inspired by the flight data recorders used in aircraft, black box systems are now emerging as a critical tool for motor vehicle crash investigations. These systems provide invaluable data that can enhance our understanding of accident dynamics and contribute to the development of effective safety measures.

Modern vehicles are increasingly equipped with electronic systems capable of recording detailed information during a crash. Black box technology takes this a step further by objectively monitoring and documenting the vehicle's activities before, during, and after an accident. This data serves as a reliable complement to traditional accident investigations, which often rely on subjective accounts from victims, eyewitnesses, and police reports. By providing accurate, unbiased records, black boxes ensure a clearer understanding of crash events and help identify their root causes.

The benefits of integrating black box technology are far-reaching. Beyond aiding in the reconstruction of accidents, this technology contributes to reducing road fatalities by improving emergency response to crash victims, informing road safety enhancements, and enabling the design of safer vehicles. Furthermore, black boxes support insurance companies by providing concrete evidence during claims investigations, promoting fairness and transparency in resolving disputes.

By leveraging the capabilities of black box systems, stakeholders in transportation safety, including governments, automakers, and insurers, can collaborate to address the global road safety challenge more effectively. This technology not only empowers accident analysis but also paves the way for a safer and more secure future on the roads.

A sensor system is connected to a microcontroller, ESP8266, to monitor various parameters of a vehicle. In case of an accident, the microcontroller uses a GPS module to get the vehicle’s current location and sends an alert message to designated contacts through a GSM module. The data from the sensors is continuously monitored and displayed using ThingSpeak, an open-source IoT platform. ThingSpeak stores real-time data and provides simple visualization tools, making it easier to analyze the information and understand the events leading to the accident.

II. PROPOSED METHODOLOGY

A. Block Diagram

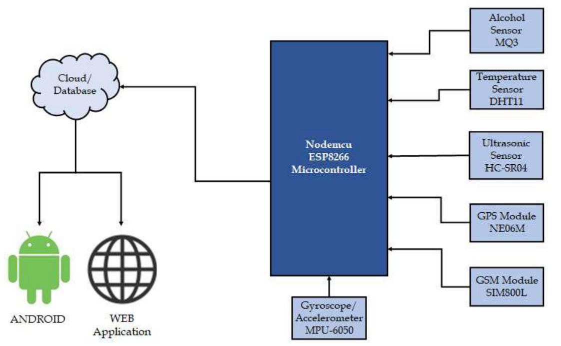

Figure 1: Block Diagram of the Proposed System

Figure 1 shows the block diagram of the system design, which includes a Temperature Sensor (DHT11), Alcohol Sensor (MQ3), MPU6050 gyroscope, GPS module, and GSM module. These components are connected to the ESP8266 microcontroller and work together to detect accidents and alert emergency services.

The DHT11 Temperature Sensor monitors the engine’s temperature and sends a warning if it goes beyond a set limit. The Alcohol Sensor (MQ3) checks if the driver has consumed alcohol by measuring the alcohol levels in their breath. The MPU6050 Accelerometer/Gyroscope tracks the vehicle’s tilt angle and alerts the microcontroller if it detects unusual movements.

When an event is detected, the microcontroller instructs the GPS module to get the vehicle’s location, which is then sent via the GSM module as a warning message. All sensor data is also sent wirelessly to the cloud for analysis, using the visualization tools available on the open-source ThingSpeak application.

B. Circuit Diagram

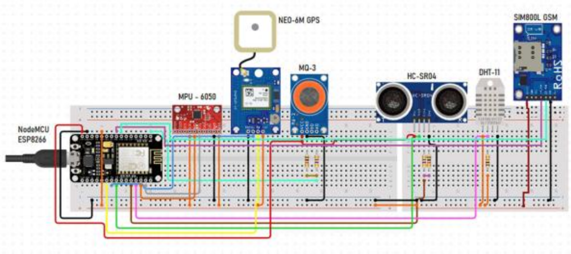

Figure 2: Simulated Circuit Diagram

Figure 2 shows the overall circuit diagram. This representation was prepared in Circuits.IO to visualize the sensors and actuators as it is and get a better understanding of their interfacing with the microcontroller.

The ESP8266 is a 30-pin microcontroller. The other hardware sensors and actuators are interfaced with this.

C. Algorithm

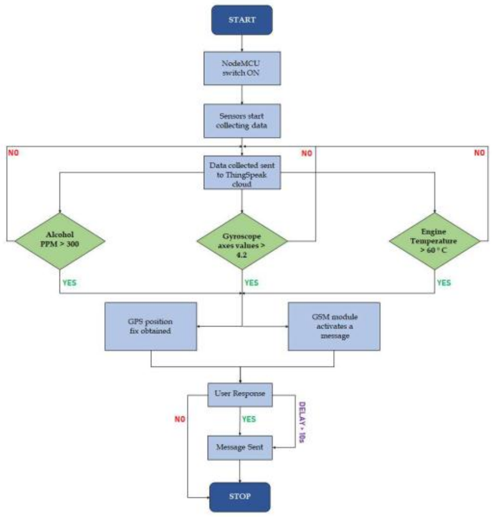

Figure 3: Algorithm of the Framework

The algorithm follows these steps:

1. The system begins with the NodeMCU being powered on, and the connected sensors start collecting real-time data.
2. The collected data is sent to the ThingSpeak cloud, where it is stored and analyzed using the platform’s visualization tools.
3. Threshold values are predefined for each sensor, and the system follows specific paths based on the data.
4. CASE 1:

No triggering occurs: The sensors continue sending real-time data to the ThingSpeak cloud without any interruptions.

5. CASE 2:

A trigger is detected, which can happen under three conditions:

- Alcohol sensor readings exceed 300 ppm.
- Gyroscope values surpass 4.2 on any of the three axes.
- Engine temperature goes above 60°C.
- The NodeMCU instructs the GSM module to retrieve the location and time from the GPS and generates a warning message with the accident details.
- The GSM module waits for 10 seconds for user approval to send the message.

- If the user rejects, the system returns to its initial state.
- If no response is received, the message is automatically sent to the concerned contacts and organizations.

6. The system stops at this point and resumes normal operation only after intervention from a third party.

III. WORKING PRINCIPLE

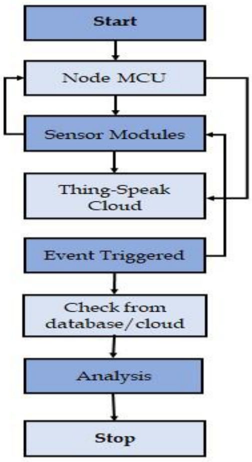

Figure 4: Working Principle

The proposed system begins with the NodeMCU being powered on, which activates all the connected sensors and devices. These sensors immediately start collecting data continuously:

1. The DHT11 sensor measures the engine's temperature in real time to keep track of any unusual increases.
2. The MQ3 alcohol sensor checks the driver's breath for alcohol levels. The reading is converted into a numerical value in Parts Per Million (PPM) and stored in the microcontroller.
3. The MPU-6050 gyroscope/accelerometer monitors the vehicle's position and movement in three dimensions. It measures rotation angles in degrees and shares this data with the NodeMCU.
4. The ultrasonic sensor measures the distance between the vehicle and any object in front of it.

The GPS module determines the vehicle's location using latitude and longitude coordinates by connecting to a satellite through a flat antenna. The GSM module is used for communication. It connects to the mobile network using a helical antenna and a SIM card to send messages.

Threshold values are set for each sensor. When a sensor's reading crosses its set limit, the NodeMCU triggers the GPS module to get the vehicle's location. The GSM module then uses this information to create a message with the location and time of the accident.

The system requires the user to authorize the message before sending it. It waits for 10 seconds for a response. If the user approves, the message is sent. If the user denies or doesn't respond, the message is automatically sent to pre-stored emergency contacts and services.

All the sensor data is stored wirelessly on a cloud platform, where it can be analyzed later to determine what happened and reach a fair conclusion.

IV. RESULTS & DISCUSSIONS

The below figure 5 shows the output obtained in the serial window, which depicts the output from the temperature sensor DHT11 and Alcohol Sensor MQ3. A message is displayed as it is transferred to the cloud.

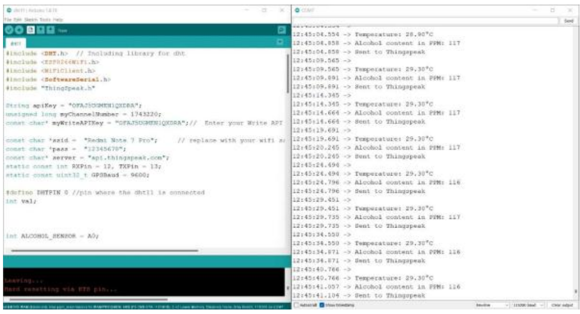

Figure 5: The Serial Window output in Arduino IDE

The GPS data is obtained and the microcontroller programming is done to convert the data into a HTTP link and its IP Address, to view it on a webpage. This is further converted to a Google Maps hyperlink which is transferred over by the GSM module in the form of an SMS.

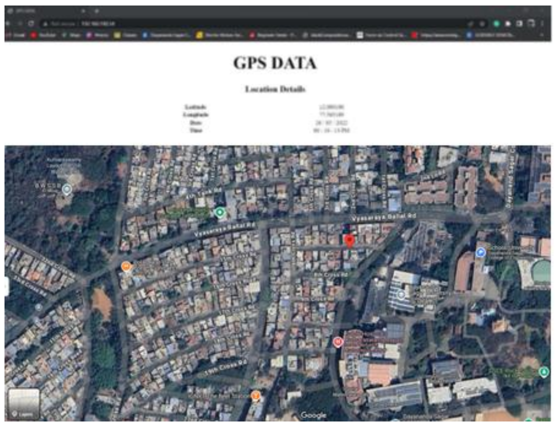

Figure 6: The GPS module output

The above figure shows the output from the gyroscope. The X-axis represents time and the Y-axis represents the angle. Each of the colored lines is with respective to a coordinate axis. The constant line tells that there is no fluctuation in the orientation of the vehicle. The dip and spike indicate a change in the orientation.

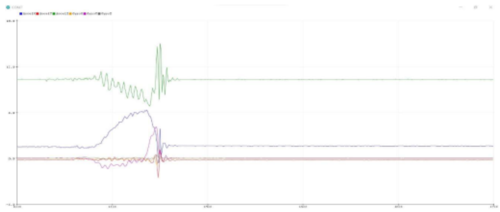

Figure 7: The graphical output of MPU-6050

This gives a comparative study of the Serial Window in Arduino IDE and the ThingSpeak platform. The graphs to the right are plotted in real-time.

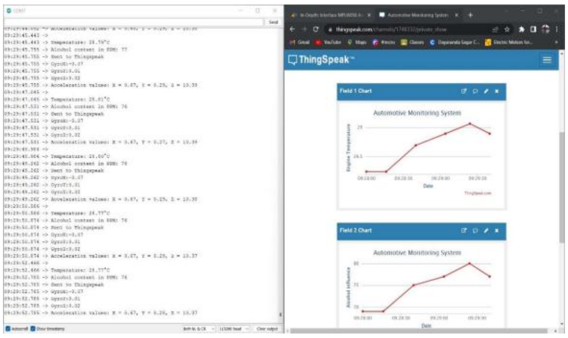

Figure 8: The ThingSpeak Window

V. APPLICATIONS AND OUTCOMES

A. Applications

1. Collection of real-time data from different sensors.
2. Real time location tracking.
3. Quick accident detection.
4. Timely transfer of message to emergency services and contacts.
5. Retrieval of data from the cloud to aid investigations by Transport Safety Board and Insurance agencies.

B. Outcomes

The main outcome of this project is this system can be implemented in the present-day automobiles and can be very helpful in saving lives of millions of people on roads. The cases related to the mishap and its complications can be solved in a fair manner to grant justice.

VI. CONCLUSION

In this project, we used various sensors connected to a microcontroller to create a system that detects unusual events on the road. Accidents are identified by comparing real-time sensor data with set values to check for any abnormalities. If an accident is detected, it is quickly reported to the concerned people and emergency services, ensuring timely help. Implementing this system in today's world can improve road discipline and reduce accidents. Even if accidents happen due to unavoidable reasons, this system can save lives by providing quick assistance before the situation worsens.

This project helped us focus on the value of human lives and ways to offer timely support. By using technologies like the Internet of Things and Embedded Systems, we realized how complex real-world problems can be broken down and solved more easily. Working with sensors and connecting them to the IoT cloud deepened our understanding of electronics and left a lasting impression on our future ideas.

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