International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

BLACK BOX AND BLIND SPOT DETECTION SYSTEM IN AUTOMOBILES

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Abstract - This paper presents the development of an affordable Black Box and Blind Spot Detection System for automobiles, integrating various sensors and microcontrollers. The Black Box monitors crucial parameters such as speed, tilt, temperature, and alcohol presence, uploading data to a cloud-based Firebase database in real-time. The Blind Spot Detection System utilizes an ultrasonic sensor to alert drivers of objects in blind spots, aiming to prevent accidents. The system's user-friendly website allows easy data access and analysis, potentially enhancing road safety and facilitating crash investigations.

Key words- Black box, Blind spot detection system, Firebase real time database.

1. INTRODUCTION

In the pursuit of safer roads and enhanced vehicle safety, advancements in technology have led to the development of innovative systems aimed at addressing critical aspects such as blind spot detection, real-time data monitoring, and accident investigation. Leveraging a combination of sensors, microcontrollers, and communication technologies, researchers have explored various methodologies to tackle these challenges.

Our project embarks on a journey to contribute to this ongoing endeavour by developing an affordable and comprehensive Black Box and Blind Spot Detection System for automobiles. Inspired by the existing techniques and methodologies employed in the field, we aim to integrate the best practices and innovations to create a robust solution that caters to the needs of modern drivers and road safety stakeholders.

The Black Box component of our system encompasses a multitude of sensors carefully selected to monitor crucial parameters within the vehicle environment. These sensors include the Neo 6m GPS module for real-time location tracking used by Ref. 2, the SW520D vibration sensor for crash detection, the MQ3 alcohol sensor for detecting alcohol presence used by Ref. 3, the MPU6050 accelerometer for monitoring tilt and speed used by Ref. 3, and the DHT11 temperature sensor for measuring temperature and humidity levels used by Ref. 3 as well. By employing an Arduino UNO and a NodeMCU microcontroller, we enable the seamless collection and processing of sensor data in real-time.

Furthermore, our system leverages the capabilities of cloud-based databases, utilizing Firebase as a platform for storing and managing the collected sensor data like which is implemented by Ref. 4. This integration enables not only real-time data uploads but also facilitates easy access and analysis of the stored information through a user-friendly web interface which is implemented by Ref. 4. By embracing Firebase's versatile tools and low-latency data transfer capabilities, we ensure that our system provides timely insights to drivers, authorities, and other stakeholders.

In addition to the Black Box functionality, our project incorporates a Blind Spot Detection System, further enhancing vehicle safety. By utilizing an ultrasonic sensor, we aim to alert drivers of potential hazards present in their blind spots used by Ref. 1, thereby mitigating the risk of accidents caused by inadequate visibility.

Through this project, we aspire to democratize access to advanced vehicle safety features, making them accessible to a wider audience at an affordable cost. By integrating the latest technologies with practical implementation strategies, we aim to contribute to the overarching goal of reducing road accidents and improving overall road safety standards.

2. METHODOLOGY

The project involves a systematic approach to developing an affordable Black Box and Blind Spot Detection System for automobiles. The methodology consists of the significance of each and every component used, each aimed at ensuring the successful implementation and functionality of the system.

Arduino UNO:

The Arduino UNO microcontroller board serves as the CPU for the black box as well as the blind spot system. Its versatility, ease of programming, and wide range of compatible sensors make it an ideal choice for hardware integration.

Fig -1: Arduino UNO

Neo 6m GPS Module:

The Neo 6m GPS module was chosen for its accuracy in determining location coordinates. Its compact size and compatibility with Arduino made it suitable for integration into the black box system.

Fig -2: NEO 6M GPS module

SW520 Vibration Sensor:

The SW520 vibration sensor was selected to detect impacts or collisions. Its sensitivity to changes in acceleration makes it ideal for identifying sudden movements indicative of a crash.

Fig -3: SW 520D Vibration sensor

MQ2 Alcohol Sensor:

The MQ2 alcohol sensor was chosen to detect the presence of alcohol within the vehicle.

Fig -4: MQ2 Alcohol sensor

MPU6050 Accelerometer and Gyroscope:

The MPU6050 accelerometer and gyroscope module were selected for their ability to measure tilt and acceleration.

Fig -5: MPU 6050

DHT11 Temperature and Humidity Sensor:

The DHT11 temperature and humidity sensor was chosen to monitor environmental conditions within the vehicle. Its ability to measure both temperature and humidity levels enables comprehensive monitoring of the vehicle's interior.

Fig -6: DHT 11

NodeMCU:

The NodeMCU microcontroller board was chosen for its built-in Wi-Fi capabilities. It serves as the interface between the Arduino UNO and the internet, facilitating data transfer to the Firebase database. The board's compatibility with Arduino IDE and ease of integration with Firebase make it a suitable choice for the black box system's connectivity requirements.

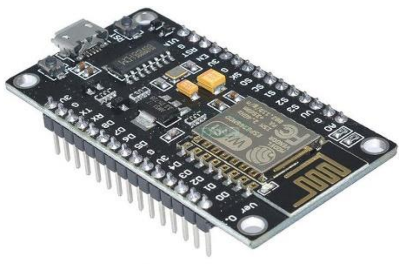


Fig -7: NodeMCU

Ultrasonic Sensor:

The ultrasonic sensor was selected to serve as the blind spot detector in automobile systems. Its ability to measure distances accurately using ultrasonic waves makes it suitable for detecting objects in the vehicle's blind spots. The sensor's wide detection range and adjustable sensitivity allow for customization according to the vehicle's dimensions and blind spot configuration.

Fig -8: Ultrasonic sensor

3. CONSTRUCTION AND IMPLEMENTATION

Black Box:

The construction of the Black Box involved the integration of various sensors and microcontrollers to monitor and collect crucial data pertaining to vehicle safety. The components selected for the Black Box included the Neo 6m GPS module, SW520 vibration sensor, MQ2 alcohol sensor, MPU6050 accelerometer, and DHT11 temperature sensor. Each sensor was carefully mounted and wired to ensure accurate data collection and transmission. In Sec. 2, we showed all the sensors and microcontrollers that we used.

The Neo 6m GPS module was securely mounted within the vehicle to obtain real-time geographical positioning data. The SW520D vibration sensor was strategically placed to detect sudden impacts or collisions, indicating potential accidents. The MQ2 alcohol sensor was installed in a location conducive to detecting alcohol presence within the vehicle cabin. The MPU6050 accelerometer was calibrated and mounted to measure tilt and speed variations, providing insights into vehicle dynamics. The DHT11 temperature sensor was positioned to accurately monitor temperature and humidity levels within the vehicle interior.

Additionally, the integration of Arduino UNO and NodeMCU microcontrollers facilitated the seamless processing and transmission of sensor data in real-time. Wiring diagrams and mounting arrangements were meticulously designed to ensure proper functionality and reliability of the Black Box system.

Blind Spot Detector:

The implementation of the Blind Spot Detector involved the integration of an ultrasonic sensor to detect objects present in the vehicle's blind spots. The ultrasonic sensor was strategically positioned to cover areas outside the driver's field of vision, such as the rear and side sections of the vehicle. We showed the details of the ultrasonic sensor that we used, in Sec. 2.

The ultrasonic sensor was mounted on the exterior of the vehicle, typically near the side mirrors or rear bumper, to provide optimal coverage of blind spot areas. Wiring and connectivity arrangements were carefully executed to ensure seamless communication between the ultrasonic sensor and the microcontroller unit.

The combined efforts in constructing the Black Box and implementing the Blind Spot Detector resulted in a comprehensive vehicle safety system capable of monitoring critical parameters, detecting potential hazards, and providing timely alerts to drivers, thereby enhancing overall road safety.

4. DATABASE DEVELOPMENT

The Firebase Realtime Database is a cloud-hosted NoSQL database that provides the ability to store and synchronize data between users in real-time. The data is stored in the form of JSON and is synchronized in real-time to every connected client. This implies that each time data is added, the entire tree is transmitted with each update. This feature is particularly beneficial for scenarios that require constant data updates and monitoring, making Firebase an ideal choice for such applications.

Interaction with Firebase involves the use of Node.js, a JavaScript runtime built on Chrome's V8 JavaScript engine. Node.js allows for the execution of JavaScript on the server side, extending the capabilities of JavaScript beyond the client side. This makes it possible to perform tasks such as file I/O operations, which are typically not possible in client-side JavaScript. After the Firebase tools are installed using Node.js, the command firebase login is executed to log into the Firebase account.

Once logged in, access is gained to the real-time database that was previously created. The database is structured as a tree, and it is possible to listen to events on any part of the tree. This allows for receiving updates from the database in real-time, ensuring that the data remains in sync with the Firebase server. This real-time synchronization is one of the key features of Firebase, making it a popular choice for applications that require real-time data updates.

In addition to the real-time database, a website is created using HTML, CSS, and JavaScript. HTML is used to structure the content of the website, CSS is used to style the content, and JavaScript is used to add interactivity to the website. This website serves as the user interface for the project, enabling users to view and interact with the data stored in the Firebase database.

Firebase's hosting service is utilized for hosting the website. Firebase Hosting provides fast and secure hosting for web apps, static and dynamic content, and microservices. The command firebase deploy is executed in the root folder where the website elements are stored. This command uploads the website to Firebase's hosting system, making it accessible to users on the internet.

The use of Node.js for server-side scripting and HTML, CSS, and JavaScript for creating the user interface makes the system versatile and user-friendly. The entire process demonstrates the potential of combining hardware and software tools to create complex IoT systems. This combination of technologies opens up a wide range of possibilities for the development of innovative IoT applications. The use of Firebase, in particular, simplifies the process of real-time data synchronization, making it easier to develop applications that require this feature. The use of Node.js for server-side scripting further extends the capabilities of the system, making it possible to perform tasks that are typically not possible in client-side JavaScript. The creation of a user interface using HTML, CSS, and JavaScript ensures that the system is user-friendly and easy to use. The hosting of the website on Firebase's hosting system ensures that the website is accessible to users on the internet, making it possible for users to interact with the data stored in

the Firebase database. This combination of hardware and software tools demonstrates the potential of IoT and the possibilities it opens up for the development of innovative applications.

5. BLOCK DIAGRAM

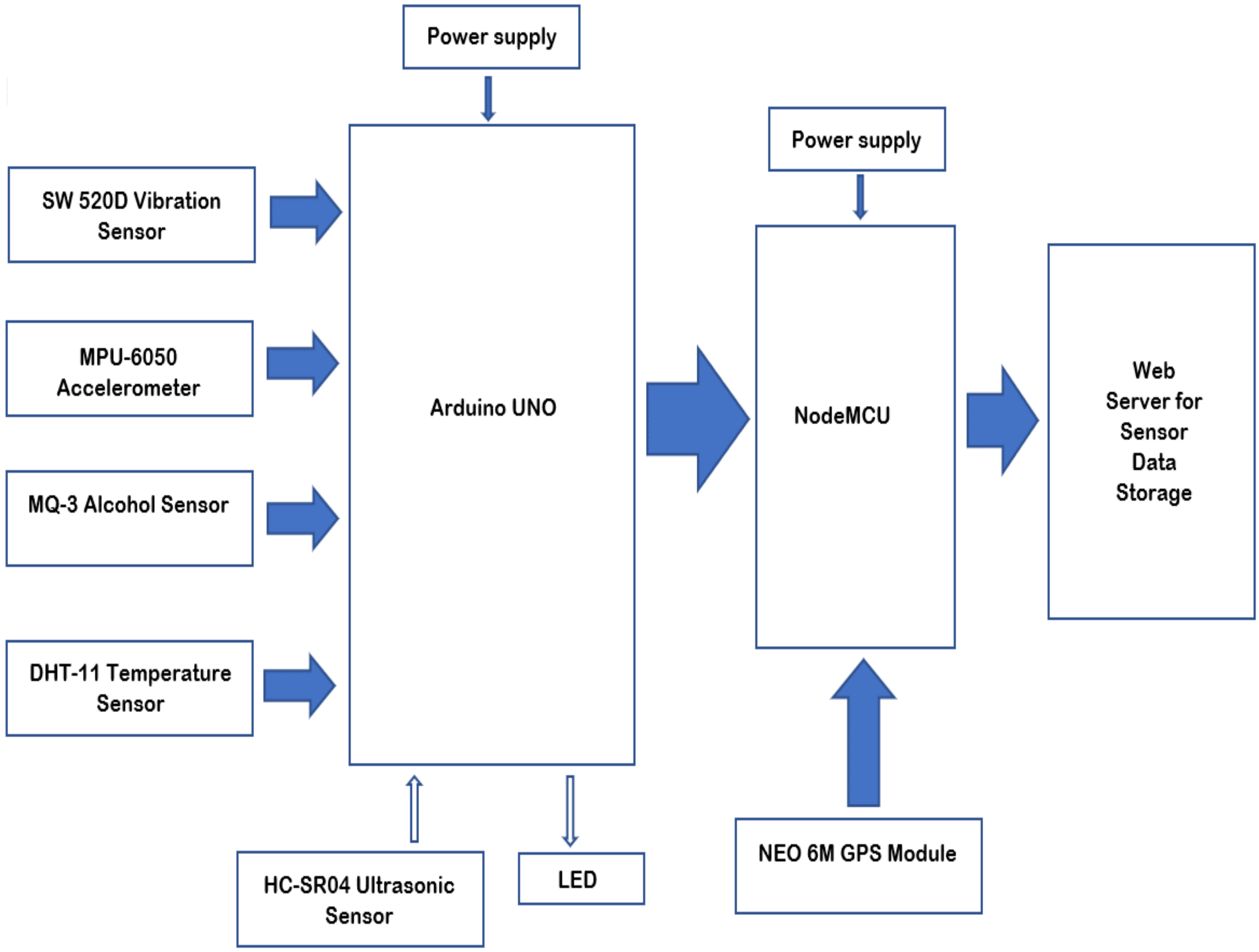


Fig -9: Block diagram

6. WORKING PRINCIPLE

The project involves a systematic approach to developing an affordable Black Box and Blind Spot Detection System for automobiles. The methodology encompasses several key stages, each aimed at ensuring the successful implementation and functionality of the system.

Sensor Selection:

The first step in our methodology involves carefully selecting the sensors that will be integrated into the Black Box component of the system. Sensors such as the Neo 6m GPS module, SW520D vibration sensor, MQ2 alcohol sensor, MPU6050 accelerometer, and DHT11 temperature sensor are chosen based on their ability to monitor crucial parameters relevant to vehicle safety. Its advisable to refer Sec. 3 for the construction and how we implemented the sensors.

Hardware Integration:

Once the sensors are selected, the next phase involves integrating them into the hardware setup. This includes connecting the sensors to the Arduino UNO and NodeMCU microcontrollers, ensuring proper communication and data transfer between the sensors and the microcontroller.

Real-Time Data Processing:

With the hardware setup in place, our methodology focuses on real-time data processing. The Arduino UNO and NodeMCU microcontrollers are programmed to collect sensor data continuously and process it in real-time. This involves implementing algorithms to analyse sensor readings and generate alerts or warnings based on predefined thresholds.

Cloud-Based Data Storage:

In parallel with real-time data processing, our methodology involves setting up a cloud-based database using Firebase. The collected sensor data is uploaded to the Firebase database in real-time, enabling seamless storage and management of the data for future analysis and reference.

User Interface Development:

To provide easy access to the collected data, our methodology includes the development of a user-friendly web interface. The web interface allows users to view real-time sensor data, receive alerts and warnings, and access historical data stored in the Firebase database. In Sec. 4, we clearly mentioned the procedure about the cloud-based data storage and the user interface development.

Testing and Validation:

The final stage of our methodology involves rigorous testing and validation of the developed system. This includes conducting simulated tests to evaluate the system's performance under various conditions, ensuring that it functions reliably and accurately in real-world scenarios.

7. RESULTS

The Black Box and Blind Spot Detection System demonstrated promising results in enhancing vehicle safety through real-time monitoring and alert generation. The system was subjected to comprehensive testing under various conditions to evaluate its performance and effectiveness in detecting critical events and mitigating potential hazards. The results of these tests are summarized below:

Collision Detection:

The SW520D vibration sensor accurately detected sudden impacts or collisions with high sensitivity and reliability. Upon detecting a collision, the system stores this information in the data base, allowing for immediate response and potential accident prevention.

Alcohol Presence Detection:

The MQ2 alcohol sensor effectively detected the presence of alcohol within the vehicle cabin. Alerts were generated and stored in the data base when alcohol presence was detected, enabling proactive measures to prevent drunk driving incidents.

Blind Spot Detection:

The ultrasonic sensor successfully identified objects present in the vehicle's blind spots. Visual and/or auditory alerts were triggered when objects were detected, alerting the driver to potential hazards outside their field of vision and reducing the risk of accidents.

Real-time Data Monitoring:

The Neo 6m GPS module provided accurate real-time geographical positioning and tracking of the vehicle. The MPU6050 accelerometer accurately monitored vehicle tilt and speed variations, facilitating comprehensive vehicle dynamics analysis.

Cloud-based Data Storage:

The Firebase cloud-based database effectively stored and managed the collected sensor data. Real-time data uploads and minimal latency ensured timely access to sensor data for analysis and monitoring purposes.

Overall, the results demonstrate the efficacy of the Black Box and Blind Spot Detection System in enhancing vehicle safety through proactive monitoring, timely alert generation, and comprehensive data analysis. The system's ability to detect and mitigate potential hazards in real-time holds promise for improving road safety and reducing the risk of accidents.

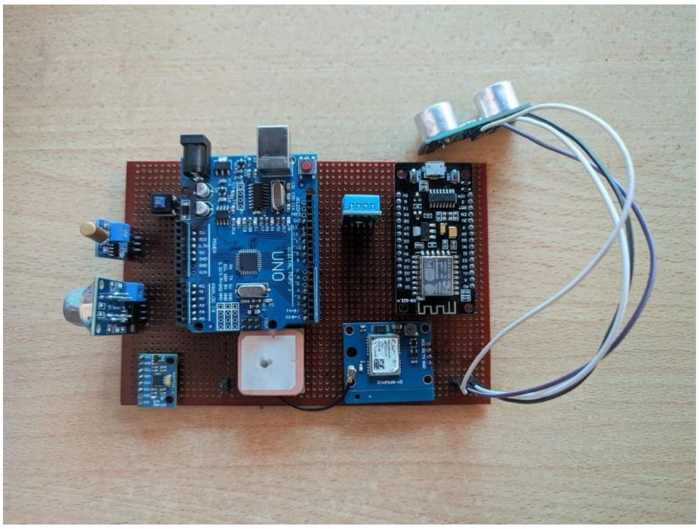
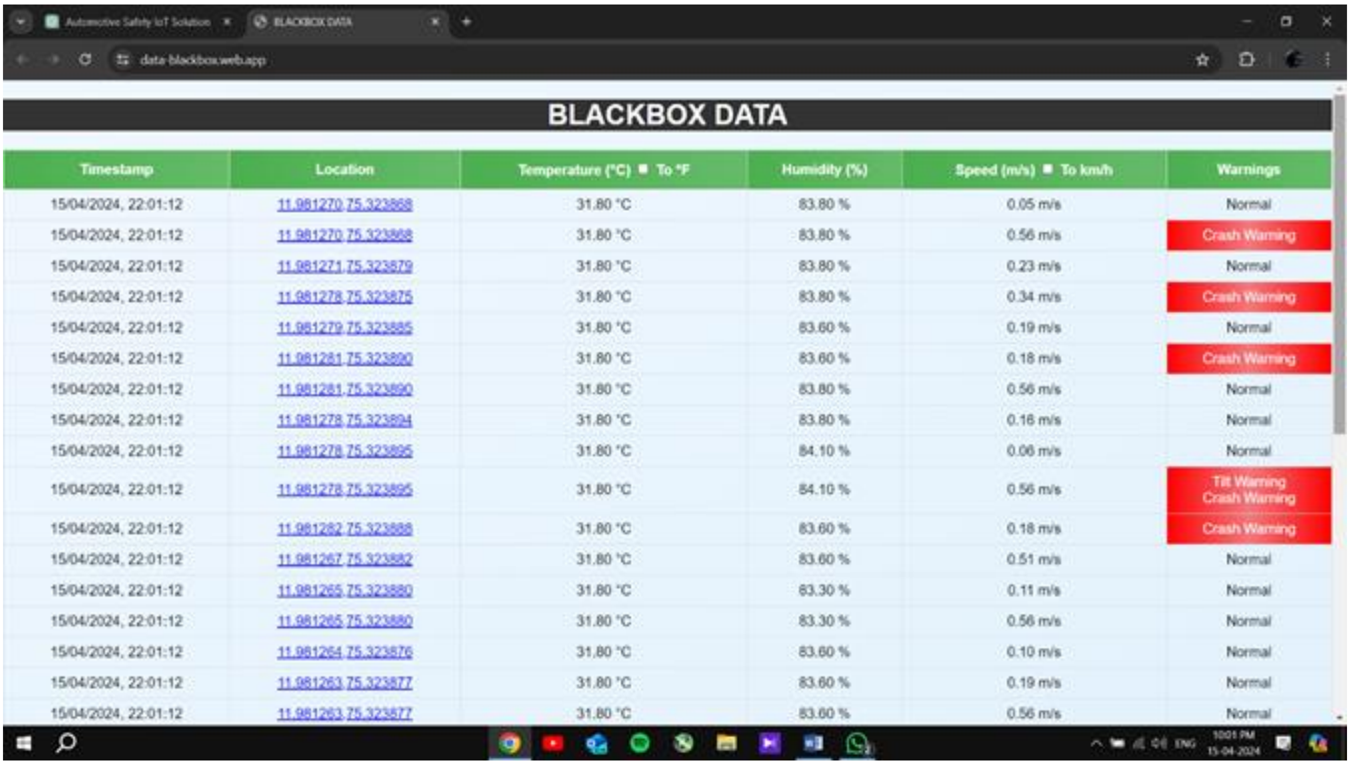


Fig -10: Black box and blind spot detector PCB



BLACKBOX DATA

Timestamp	Location	Temperature (°C) ■ To °F	Humidity (%)	Speed (m/s) ■ To km/h	Warnings
15/04/2024, 22:01:12	11.981270,75.323868	31.80 °C	83.80 %	0.05 m/s	Normal
15/04/2024, 22:01:12	11.981270,75.323868	31.80 °C	83.80 %	0.56 m/s	Crash Warning
15/04/2024, 22:01:12	11.981271,75.323879	31.80 °C	83.80 %	0.23 m/s	Normal
15/04/2024, 22:01:12	11.981278,75.323875	31.80 °C	83.80 %	0.34 m/s	Crash Warning
15/04/2024, 22:01:12	11.981279,75.323885	31.80 °C	83.60 %	0.19 m/s	Normal
15/04/2024, 22:01:12	11.981281,75.323890	31.80 °C	83.60 %	0.18 m/s	Crash Warning
15/04/2024, 22:01:12	11.981281,75.323890	31.80 °C	83.80 %	0.56 m/s	Normal
15/04/2024, 22:01:12	11.981278,75.323894	31.80 °C	83.80 %	0.16 m/s	Normal
15/04/2024, 22:01:12	11.981278,75.323895	31.80 °C	84.10 %	0.06 m/s	Normal
15/04/2024, 22:01:12	11.981278,75.323895	31.80 °C	84.10 %	0.56 m/s	Tilt Warning Crash Warning
15/04/2024, 22:01:12	11.981282,75.323888	31.80 °C	83.60 %	0.18 m/s	Crash Warning
15/04/2024, 22:01:12	11.981267,75.323882	31.80 °C	83.60 %	0.51 m/s	Normal
15/04/2024, 22:01:12	11.981265,75.323880	31.80 °C	83.30 %	0.11 m/s	Normal
15/04/2024, 22:01:12	11.981265,75.323880	31.80 °C	83.30 %	0.56 m/s	Normal
15/04/2024, 22:01:12	11.981264,75.323876	31.80 °C	83.60 %	0.10 m/s	Normal
15/04/2024, 22:01:12	11.981263,75.323877	31.80 °C	83.60 %	0.19 m/s	Normal
15/04/2024, 22:01:12	11.981263,75.323877	31.80 °C	83.60 %	0.56 m/s	Normal

Fig -11: Website to view stored data

8. CONCLUSIONS

In conclusion, the Black Box and Blind Spot Detection System present a comprehensive solution for enhancing vehicle safety. Through rigorous testing, the system demonstrated its effectiveness in detecting collisions, alcohol presence, and blind spot hazards in real-time. By leveraging advanced sensor technology and cloud-based data management, it offers a cost-effective means to improve road safety standards. Moving forward, continued development and collaboration are essential to further refine the system's capabilities and promote widespread adoption, ultimately contributing to safer roads and reduced accident rates.

ACKNOWLEDGEMENT

We extend our sincere appreciation to Dr. Roshini TV for their invaluable guidance and support throughout this project. Additionally, we thank Vimal Jyothi Engg. College for providing the necessary resources and facilities. Without their assistance, this project would not have been possible.

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