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GUARDIAN DRIVE

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Abstract: This project deploys a sophisticated network of strategically positioned force sensors on a car's sides to register accidents, classifying them based on the severity of impact forces. The resulting data is securely transmitted to a centralized server, creating a comprehensive accident history for each vehicle. This information serves to significantly reduce fraudulent activities within the used car market. Furthermore, the system also features an integral function for notifying emergency responders about accidents, ensuring a swift response and facilitating effective traffic management and accident scene assistance, thus further enhancing overall road safety.

Index Terms – Force sensors, Accident classification, Centralized Server

I. INTRODUCTION

In the year 2023, WHO which is also known as the world health organization published data that showed that more than about 1.3 million casualties occur every season because of road tragedies. The accident of a vehicle can be described as an unexpected scenario that may lead to physical damage to the person and the vehicle. Usually, a black box is a system or a device that is used in flights or aircraft for the sole purpose of collecting accident information in case it occurs for investigation purposes. In our system, we are implementing the same black box concept on street vehicles. It is a very efficient system that is used to collect important data such as the temperature of the vehicle, and the presence of gaseous substances, and sends alerts in case an accident occurs. This proposed system consists of three sensors each of them used for checking different parameters. It also contains a gps and a gsm module. The gps device is integrated for gathering current data when an incident takes place and the gsm is kept for sending emergency SMS in the situation. For photo capturing an esp32 camera is used. To store the data and the photos recovered an SD card module is used as a storage container in this proposed system. Overall, the proposed black box system is an easy and extremely effective way of collecting important accident-related information and is helpful in sharing this data when an accident occurs with the coordinates or the live location where it has occurred.

II. EXISTING SYSTEM

2.1 EVENT DATA RECORDER (EDR)

Existing automotive safety systems often integrate with Event Data Recorders (EDRs), utilizing them primarily for retrospective analysis of accidents. EDRs capture critical data such as vehicle speed, throttle position, brake status, and airbag deployment during an accident. This data is then used for post-incident analysis, helping to understand the sequence of events leading up to the collision and assess its severity. Integrating with EDRs allows these systems to provide valuable insights into accident dynamics and aid in the reconstruction of events for investigative and legal purposes.

2.2 ADVANCED DRIVER ASSISTANCE SYSTEM

Many modern vehicles come equipped with Advanced Driver Assistance Systems (ADAS), which utilize sensors and cameras to provide real-time assistance to drivers and enhance vehicle safety. ADAS features include collision avoidance systems, lane departure warnings, adaptive cruise control, and automatic emergency braking. These systems actively monitor the vehicle's surroundings and assist the driver in avoiding potential collisions or hazards on the road. By integrating with ADAS, automotive safety systems can leverage the data generated by these sensors to enhance their own accident detection and response capabilities.

2.3 THIRD-PARTY DEVICES

Automotive safety systems often collaborate with third-party devices such as GPS trackers, telematics devices, and smartphone apps to enhance their functionality and data collection capabilities. GPS trackers provide real-time location information, allowing for accurate positioning and tracking of vehicles in the event of an accident. Telematics devices offer additional data such as vehicle diagnostics, driving behavior analysis, and fuel consumption metrics, which can be used to improve the overall effectiveness of automotive safety systems. By collaborating with third-party devices, these systems can access a broader range of data sources and provide more comprehensive safety features to vehicle owners.

2.4 COLLISION WARNING SYSTEMS

Automotive safety is significantly enhanced through the integration of Collision Warning Systems, which utilize advanced sensor technologies to detect potential collisions with other vehicles, pedestrians, or obstacles on the road. These systems employ radar, lidar, or cameras to monitor the vehicle's surroundings in real-time, continuously assessing the proximity and relative speed of nearby objects. In the event of an imminent collision, Collision Warning Systems provide timely visual, audible, or haptic warnings to alert the driver, enabling swift and effective evasive action. By offering proactive collision detection capabilities, these systems serve as vital aids in accident prevention, helping to mitigate the risks associated with distracted driving or unexpected road hazards.

III. BLOCK DIAGRAM

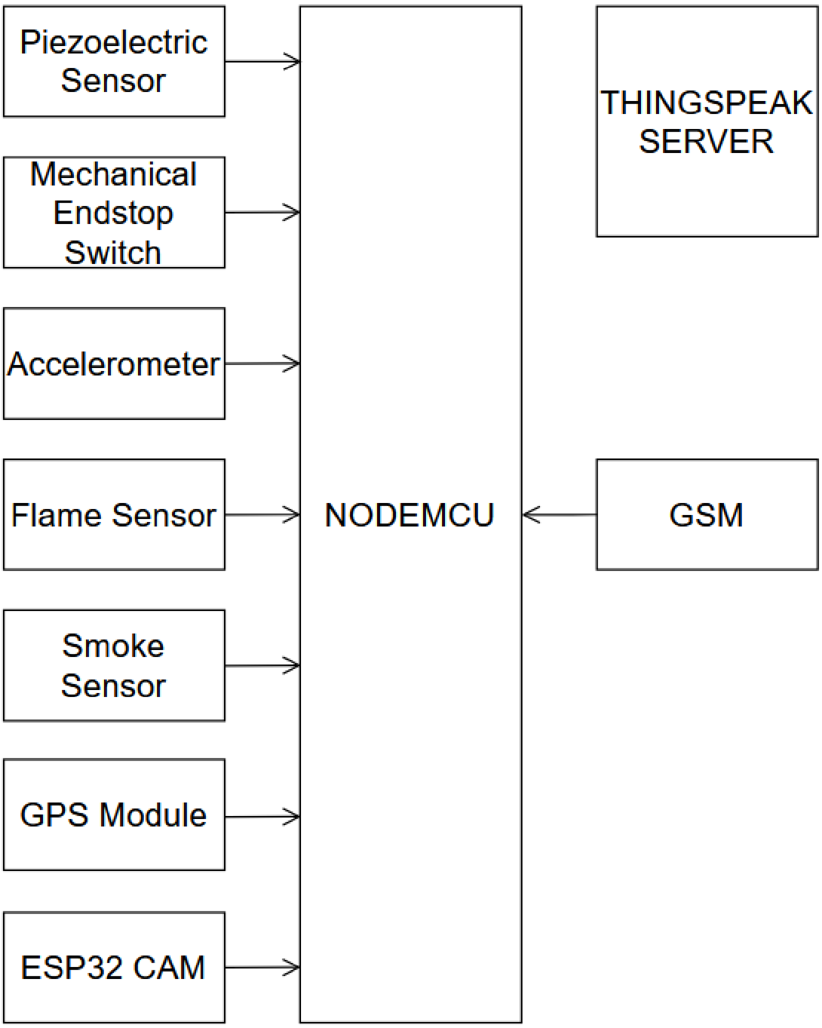

Fig. 1. Block diagram

The Guardian Drive System's block diagram illustrates a sophisticated network of interconnected components designed to enhance vehicle safety and performance. At its core are various sensors dispersed strategically throughout the vehicle, including crash sensors, accelerometers, flame sensors, and gas detectors. These sensors continuously monitor the vehicle's surroundings and internal dynamics, detecting potential hazards such as collisions, fires, or gas leaks.

The sensor data is then transmitted to the central processing unit like the NodeMCU. Here, real-time analysis is conducted using sophisticated algorithms to assess the severity of detected hazards and determine appropriate response actions. Concurrently, communication modules such as the GSM and GPS modules facilitate the transmission of critical information to external recipients, enabling swift response to incidents and allowing for the recording and analysis of crash data for post-incident evaluation.

IV. CIRCUIT DIAGRAM

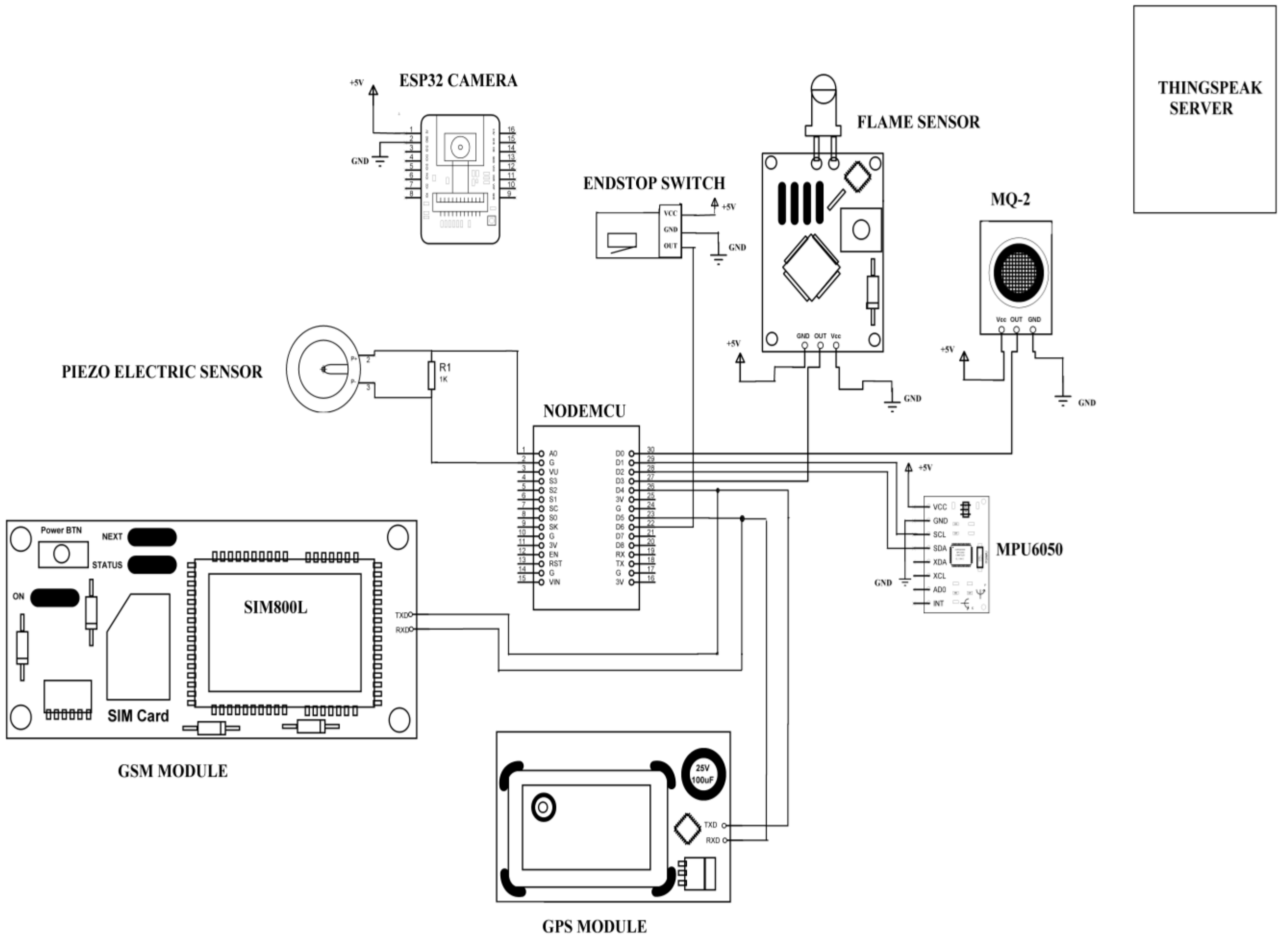

Fig. 2. Circuit diagram

The circuit diagram for Guardian Drive includes piezoelectric sensors, a mechanical endstop switch, accelerometers, flame and smoke sensor, a GPS module, an ESP32 Cam, a NodeMCU, a GSM module, and integration with the ThingSpeak server. Here's a brief explanation of how these components are used.

1. **NodeMCU:** Facilitates wireless communication between components of the guardian drive
2. **Piezoelectric sensor:** Detects minor crashes by registering impact forces on the vehicle's sides.
3. **Mechanical endstop switch:** Activates emergency protocols upon detecting major crashes, ensuring swift response measures.
4. **Accelerometer:** Identifies rollover events by monitoring changes in vehicle orientation and acceleration.
5. **Flame and smoke sensors:** Detect fires or hazardous conditions within the vehicle, triggering appropriate safety measures.
6. **GPS module:** Provides precise location tracking, enabling real-time monitoring of vehicle movements.
7. **ESP32 Cam:** Captures visual data of accident scenes or driver behavior for analysis and documentation.
8. **GSM module:** Transmits alerts and notifications to emergency responders or vehicle owners in case of accidents.
9. **ThingSpeak server:** Stores and processes data collected from sensors, facilitating remote monitoring and analysis of vehicle condition

V. PROJECT DESIGN AND WORKING

In designing the sensor placement for the Guardian Drive System, strategic positioning is key to ensuring comprehensive coverage and effective crash detection capabilities. The flame sensor and MQ2 gas sensor are placed within the engine compartment to swiftly detect fire or gas leaks, while the piezoelectric sensor is strategically dispersed across structural points to detect impacts and vibrations. Internally, the crash sensor and accelerometer sensor are strategically positioned near airbag systems and within the vehicle's computer system to detect sudden changes in velocity, providing crucial data for crash detection algorithms.

Complementing the sensor array are essential components such as the GSM module, GPS receiver, ESP32 camera, NodeMCU, and buck converter. These components are carefully integrated into the vehicle's architecture, with the GSM module and GPS receiver typically mounted for optimal signal reception, the ESP32 camera discreetly placed for visual monitoring, and the NodeMCU securely housed within the control module. The buck converter is seamlessly integrated into the vehicle's electrical system to regulate power supply, ensuring reliable performance of all Guardian Drive System components. This meticulous design approach ensures that the system operates seamlessly to detect and respond to potential crashes, enhancing overall vehicle safety and reliability.

5.1. WORKING OF SENSORS

1. **Flame Sensor and MQ2 Gas Sensor:** These sensors are primarily installed within the engine compartment to detect fire or hazardous gas leaks. The flame sensor detects the presence of flames by measuring infrared radiation emitted by combustion, while the MQ2 gas sensor is sensitive to various gases commonly associated with vehicle fires, such as methane and propane. When either sensor detects abnormal levels of heat or gas, it triggers an alert within the Guardian Drive System, prompting immediate action to mitigate the risk of fire or explosion.
2. **Piezoelectric Sensor:** Strategically positioned at key structural points throughout the vehicle, the piezoelectric sensor detects impacts and vibrations indicative of collisions or accidents. When the vehicle experiences a sudden impact, such as a collision with another vehicle or a stationary object, the piezoelectric sensor generates electrical signals proportional to the force of the impact. These signals are then processed by the Guardian Drive System's crash detection algorithms to assess the severity of the collision and initiate appropriate safety measures, such as deploying airbags or activating seatbelt pre-tensioners.
3. **Crash Sensor and Accelerometer Sensor:** Located within the vehicle's interior, the crash sensor and accelerometer sensor play crucial roles in detecting changes in velocity and acceleration associated with collisions. The crash sensor is typically integrated with the vehicle's airbag system and is designed to trigger airbag deployment when it detects a significant impact. Meanwhile, the accelerometer sensor measures acceleration forces in multiple directions, providing real-time data on the vehicle's movement. By analyzing data from both sensors, the Guardian Drive System can accurately detect and respond to collisions with precision.

5.2. WORKING OF NODEMCU

The NodeMCU serves as a central component in the Guardian Drive System, facilitating communication and data processing between various sensors and the system's control unit. Equipped with Wi-Fi connectivity and a powerful microcontroller, the NodeMCU collects sensor data from the vehicle's surroundings, including inputs from crash sensors, accelerometers, and other safety sensors. It then processes this data in real-time, running algorithms to detect potential hazards such as collisions or fires. Additionally, the NodeMCU enables the transmission of crucial information to the system's control unit and external servers, allowing for swift response and recording of incidents. By serving as a versatile communication hub, the NodeMCU plays a vital role in enhancing the Guardian Drive System's capabilities, ultimately contributing to improved safety and responsiveness on the road.

5.3. WORKING OF NEO-6 GPS MODULE AND GSM MODULE

The NEO-6 GPS module accurately tracks the vehicle's location using satellite signals, enabling real-time monitoring of its movements. Meanwhile, the GSM module establishes wireless communication with cellular networks, facilitating the transmission of data and alerts to designated recipients or servers. Together, these modules provide the Guardian Drive System with crucial location tracking and communication capabilities, ensuring swift response to emergencies and enhancing overall safety on the road.

5.4. WORKING OF DC BUCK CONVERTER

The DC buck converter is a vital component in the Guardian Drive System, responsible for regulating the voltage supplied to various electronic devices and sensors. By converting a higher input voltage to a lower output voltage, the buck converter ensures that sensitive components receive stable and reliable power, regardless of fluctuations in the vehicle's electrical system. This helps prevent damage to electronics and ensures consistent performance of the Guardian Drive System's sensors and communication modules. Additionally, the buck converter may incorporate features such as overvoltage protection and thermal shutdown to further safeguard against electrical faults and ensure safe operation in diverse driving conditions. Overall, the buck converter plays a crucial role in optimizing the efficiency and reliability of the Guardian Drive System, contributing to its overall effectiveness in enhancing vehicle safety.

VI. SOFTWARE REQUIREMENTS

6.1. ARDUINO IDE

The Arduino Integrated Development Environment (IDE) is a software platform used for programming Arduino microcontroller boards. It provides a user-friendly interface for writing, compiling, and uploading code to Arduino-compatible hardware. The IDE is built on the Java programming language and is compatible with Windows, macOS, and Linux operating systems. It offers a simplified programming environment using a variant of the C++ programming language, making it accessible to both beginners and experienced developers. With its extensive library support and vast online community, the Arduino IDE empowers users to create a wide range of projects, from simple blinking LED lights to complex robotics and Internet of Things (IoT) applications.

6.2. THINGSPEAK

ThingSpeak is an Internet of Things (IoT) platform and open API that enables users to collect, analyze, and visualize data from sensors or other devices in real-time. Developed by MathWorks, ThingSpeak allows individuals and organizations to easily connect their IoT devices and sensors to the cloud, where data can be stored and accessed securely. Users can then create custom dashboards, charts, and graphs to monitor and analyze their data, as well as set up alerts and notifications based on specified conditions. With its simplicity and versatility, ThingSpeak is widely used for a variety of IoT applications, including environmental monitoring, home automation, industrial automation, and more.

VII. HARDWARE REQUIREMENTS

7.1. NODEMCU

The NodeMCU is an open-source firmware and development kit based on the ESP8266 Wi-Fi module. It is specifically relevant to the Guardian Drive project as it serves as a crucial component for facilitating wireless communication between various sensors and devices within the system. With its built-in Wi-Fi capabilities and support for the Lua scripting language, the NodeMCU enables seamless data transmission and connectivity, allowing Guardian Drive to relay real-time information, such as accident alerts and sensor data, to remote servers or monitoring systems. Additionally, the NodeMCU's compact form factor and low power consumption make it ideal for integration into automotive applications, providing reliable and efficient wireless communication functionality essential for enhancing vehicle safety and enabling intelligent transportation systems.

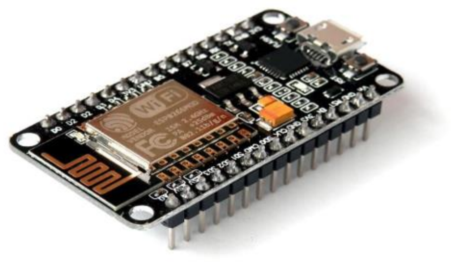

Fig. 3. NODEMCU

7.2. GPS MODULE

The GPS module employed in the Guardian Drive project is a critical component designed to provide precise location tracking capabilities. Integrated into the vehicle's system, this module utilizes signals from satellites to determine the vehicle's exact geographic coordinates, enabling real-time monitoring of its movements and location status. By incorporating the GPS module, Guardian Drive enhances its accident detection and emergency response functionalities by accurately pinpointing the vehicle's position in the event of an incident. This information is invaluable for promptly notifying emergency responders, facilitating swift assistance at the accident scene, and aiding in post-incident analysis. Furthermore, the GPS module ensures that Guardian Drive-equipped vehicles can be efficiently tracked and monitored, enhancing overall road safety and enabling effective management of fleet operations.

Fig. 4. GPS MODULE

7.3. GSM MODULE

The GSM (Global System for Mobile Communications) module plays a crucial role in the Guardian Drive project, serving as a vital communication component for transmitting alerts and notifications in real-time. Integrated within the vehicle's system, the GSM module enables Guardian Drive to establish cellular connectivity, allowing it to communicate with external entities such as emergency responders, vehicle owners, or centralized monitoring systems. In the event of an accident or emergency situation, the GSM module facilitates the swift transmission of alerts, providing essential information about the incident, including location data and severity, to designated recipients. This enables prompt response and assistance, enhancing overall safety on the road. Additionally, the GSM module ensures reliable communication capabilities, even in remote or low-coverage areas, thereby ensuring that Guardian Drive remains effective in various driving environments.

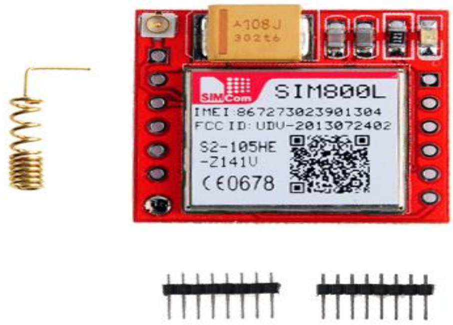

Fig. 5. GSM MODULE

7.4. ACCELEROMETER

The accelerometer utilized in the Guardian Drive project is a key sensor designed to detect changes in vehicle acceleration and orientation, particularly relevant for identifying rollover events. Integrated within the vehicle's system, the accelerometer continuously monitors and measures the rate of change of velocity in multiple axes, providing crucial data on the vehicle's movement dynamics. In the event of a rollover or sudden change in orientation, the accelerometer detects these anomalies and triggers appropriate response protocols within Guardian Drive, such as initiating emergency alerts or deploying safety measures. By accurately detecting rollover events, the accelerometer enhances the system's ability to promptly respond to critical situations, thereby improving overall vehicle safety and reducing the risk of severe accidents.

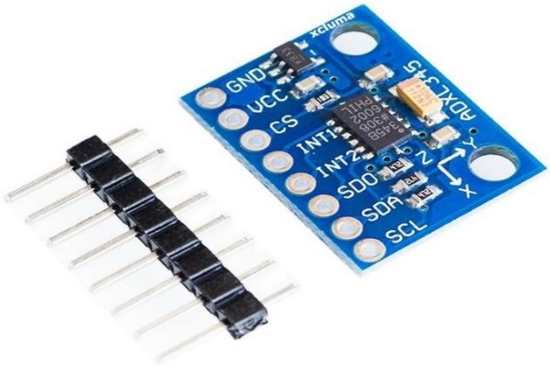

Fig. 6. ACCELEROMETER

7.5. ESP32 CAM

The ESP32 Cam is a compact camera module integrated into the Guardian Drive project, providing visual data capture capabilities essential for accident documentation and analysis. This module utilizes the ESP32 microcontroller, renowned for its versatility and performance, to capture high-resolution images or video footage of accident scenes or driver behavior. Integrated within the vehicle's system, the ESP32 Cam enables Guardian Drive to record visual evidence in real-time, offering valuable insights into the circumstances surrounding accidents or incidents. This visual data can be instrumental in post-incident analysis, insurance claims processing, or legal proceedings, providing an objective record of events. Additionally, the ESP32 Cam's compact form factor and low power consumption make it well-suited for automotive applications, ensuring reliable operation and minimal impact on the vehicle's electrical system.

Fig. 7. ESP32 CAM

7.6. MQ2 GAS SENSOR

The MQ2 gas sensor is a critical component integrated into the Guardian Drive project, providing the capability to detect and measure various types of gases, including smoke, carbon monoxide, and flammable gases. This sensor utilizes a tin dioxide semiconductor to detect changes in the concentration of gases present in the vehicle's environment. Integrated within the vehicle's system, the MQ2 gas sensor continuously monitors the air quality within the vehicle cabin, providing early detection of potential hazards such as smoke from fires or the presence of toxic gases resulting from vehicle malfunctions or accidents. Upon detection of abnormal gas levels, the MQ2 sensor triggers appropriate response protocols within Guardian Drive, such as activating ventilation systems, alerting occupants, or initiating emergency alerts to external responders. By providing real-time monitoring of gas levels, the MQ2 sensor enhances vehicle safety and ensures timely responses to hazardous conditions, ultimately contributing to a safer driving experience for occupants.

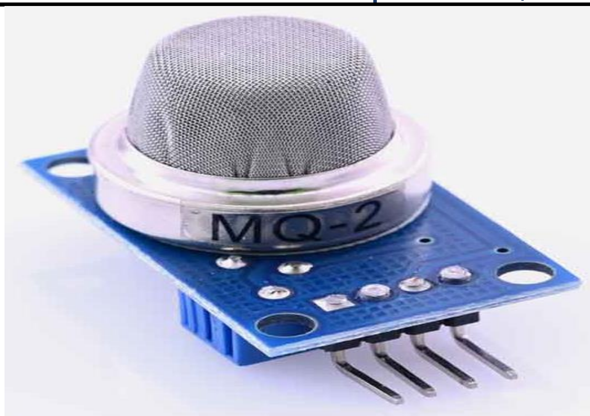

Fig. 8. MQ2 GAS SENSOR

7.7. FLAME SENSOR

The flame sensor employed in the Guardian Drive project is a crucial safety component designed to detect the presence of flames or fires within the vehicle's vicinity. This sensor utilizes an infrared-sensitive photodiode to detect the infrared radiation emitted by flames, enabling rapid detection of fire outbreaks. Integrated within the vehicle's system, the flame sensor continuously monitors the surrounding environment for signs of fire, such as ignition sources or combustible materials. Upon detection of flames, the sensor triggers immediate response protocols within Guardian Drive, such as activating fire suppression systems, alerting occupants, or initiating emergency alerts to external responders. By providing real-time detection of fire hazards, the flame sensor enhances vehicle safety and ensures prompt responses to critical situations, ultimately minimizing the risk of fire-related accidents and protecting occupants from harm.

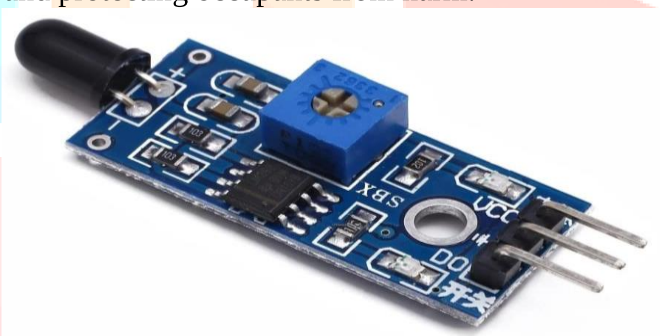

Fig. 9. FLAME SENSOR

7.8. PIEZOELECTRIC SENSOR

The piezoelectric sensor utilized in the Guardian Drive project is a critical component designed to detect minor impacts or collisions on the vehicle's sides. This sensor operates on the principle of piezoelectricity, where mechanical stress applied to certain materials generates electrical charge. Integrated strategically along the vehicle's sides, the piezoelectric sensor continuously monitors for sudden changes in mechanical pressure or impact forces, such as those caused by minor collisions or bumps. Upon detection of such events, the sensor triggers immediate response protocols within Guardian Drive, such as logging the incident data, activating safety features, or initiating notifications to vehicle occupants or external responders. By providing real-time detection of minor impacts, the piezoelectric sensor enhances vehicle safety and facilitates prompt responses to potential hazards, ultimately contributing to a safer driving experience for occupants.

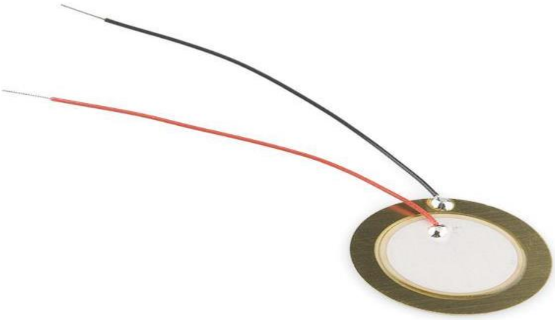

Fig. 10. PIEZOELECTRIC SENSOR

VIII. IMPLEMENTATION AND SCOPE

8.1. ROAD ACCIDENTS

1. **Immediate Detection:** One of the primary benefits of these systems is their ability to instantly detect accidents. They utilize a variety of sensors such as accelerometers, gyroscopes, and sometimes even cameras to recognize sudden changes in vehicle motion indicative of a crash. This immediate detection is crucial, especially in situations where occupants might be incapacitated or unable to call for help themselves.
2. **Automatic Emergency Alerts:** Once an accident is detected, the system automatically sends out alerts to emergency services or designated contacts. This ensures that help is on the way as quickly as possible, reducing the response time compared to relying solely on individuals to call for assistance. This swift response is particularly important in cases of severe injuries or if the accident occurs in remote areas where help might not be readily available.
3. **Precise Location Information:** Systems often incorporate GPS technology to provide precise location information along with the alert. This allows emergency responders to pinpoint the exact location of the accident, even if the occupants are unsure of their surroundings or unable to communicate their location effectively. This feature is invaluable for expediting the arrival of assistance, especially in large or unfamiliar areas.
4. **Remote Monitoring and Assistance:** Some advanced systems offer remote monitoring capabilities, allowing emergency responders or designated contacts to assess the situation in real-time through connected devices. This can provide valuable information about the severity of the accident and the condition of the occupants, enabling responders to better prepare for the assistance required upon arrival.

8.2. PUBLIC SAFETY

Public safety is a fundamental aspect of societal well-being, encompassing measures and initiatives aimed at safeguarding the lives, health, and security of individuals within communities. It involves the coordinated efforts of various stakeholders, including law enforcement agencies, emergency responders, government bodies, and community organizations, to mitigate risks, prevent harm, and respond effectively to emergencies. Public safety initiatives encompass a wide range of activities, including crime prevention, disaster preparedness, traffic management, public health interventions, and infrastructure development. These efforts aim to create environments where individuals can live, work, and interact safely, fostering trust, resilience, and social cohesion within society. Ultimately, public safety is essential for ensuring the protection and welfare of all citizens, promoting thriving and resilient communities.

IX. COST OF THE PROJECT

Table 1. Cost of the project

Sl. No	Item	No of items	Cost
1	NodeMCU	1	1500
2	Crash switch	1	50
3	Accelerometer	1	1025
4	Flame sensor	1	250
5	MQ2 sensor	1	750
6	GPS Module	1	500
7	Piezoelectric sensor	1	480
8	GSM Module	1	500
9	ESP32 Camera	1	850
10	Miscellaneous Components		600
	Total cost		**6270**

X. SIMULATION

In the simulated Guardian Drive system using Proteus, Arduino Uno is utilized in place of NodeMCU due to compatibility constraints within the simulation software. This substitution allows for the emulation of the Guardian Drive's functionality, including sensor monitoring, threshold detection, and response triggering, albeit with Arduino Uno's capabilities. Here's a detailed elaboration of the system setup and its operation:

1. **Piezoelectric Sensor:**

- The piezoelectric sensor is configured to measure mechanical stress or impact forces on the vehicle's sides.
- A threshold value of 49% is set, indicating the level at which a minor accident is detected.
- When the measured value exceeds or equals the threshold, Arduino Uno interprets it as a minor accident and triggers the corresponding actions.

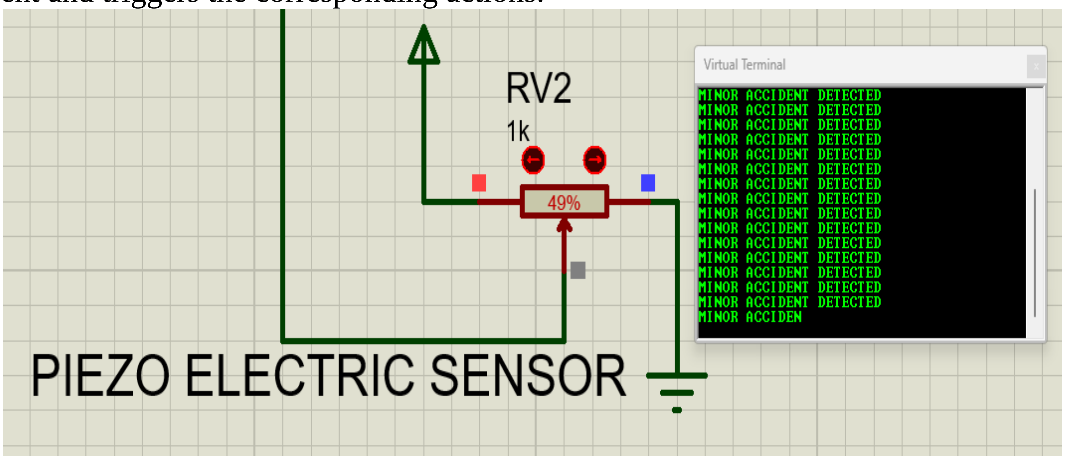

Fig. 11. MINOR ACCIDENT DETECTION

2. **Accelerometer:**

- The accelerometer is programmed to monitor changes in the vehicle's acceleration and orientation.
- A threshold value of 51% is defined, indicating the level at which acceleration or rollover is detected.
- If the measured value surpasses the threshold, Arduino Uno recognizes it as acceleration or rollover and initiates appropriate responses.

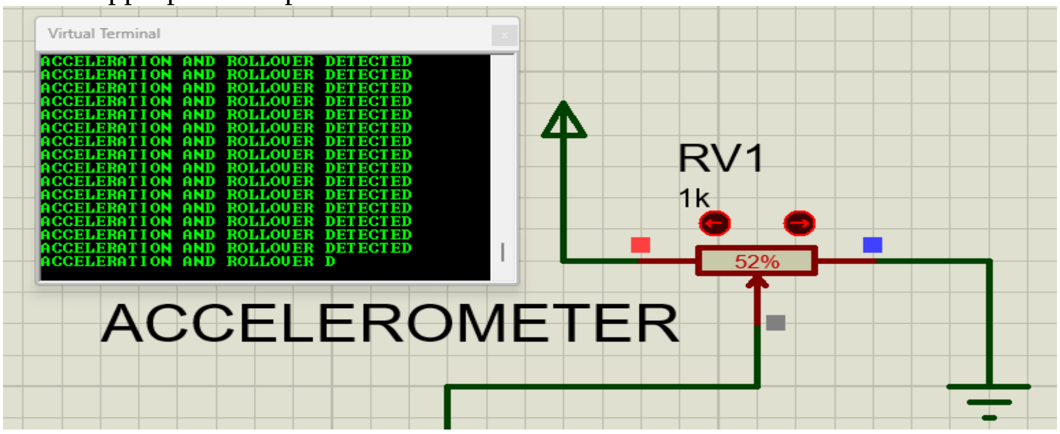

Fig. 12. ACCELERATION AND ROLLOVER DETECTION

3. **Mechanical Crash Switch:**

- The mechanical crash switch serves as an emergency cutoff mechanism.
- When activated (turned ON), it signifies a major accident occurrence.
- Arduino Uno monitors the state of the switch and, upon detection of activation, triggers emergency protocols and captures GPS coordinates for incident documentation.

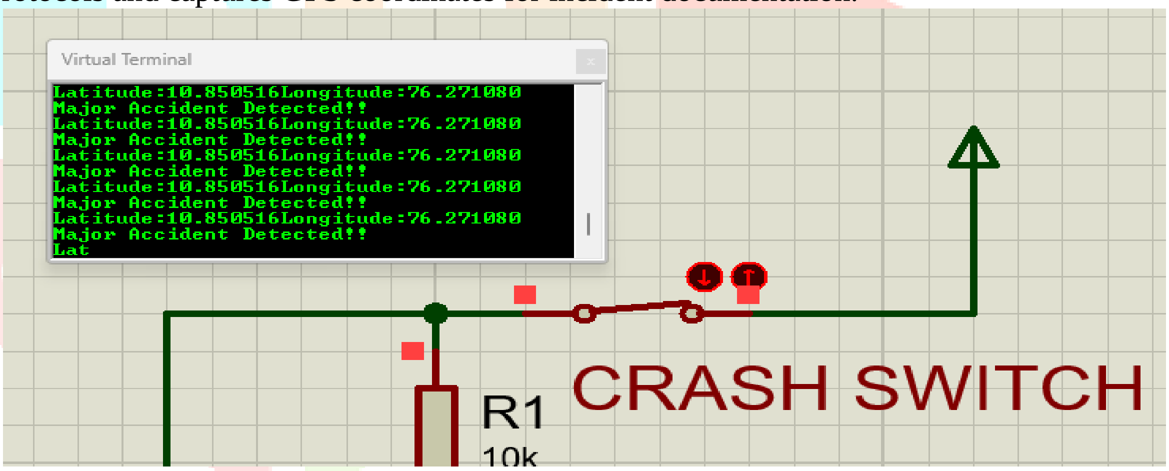

Fig. 13. MAJOR ACCIDENT DETECTION

4. **Flame and Gas Sensor Integration:**

- The flame sensor detects the presence of smoke or fire within the vehicle.
- A digital switch is incorporated to control the sensor's functionality.
- If the switch value is HIGH (1), indicating smoke detection, Arduino Uno responds accordingly by activating safety measures.
- Similarly, if the switch value indicates flame detection, appropriate actions are taken to mitigate the fire hazard.

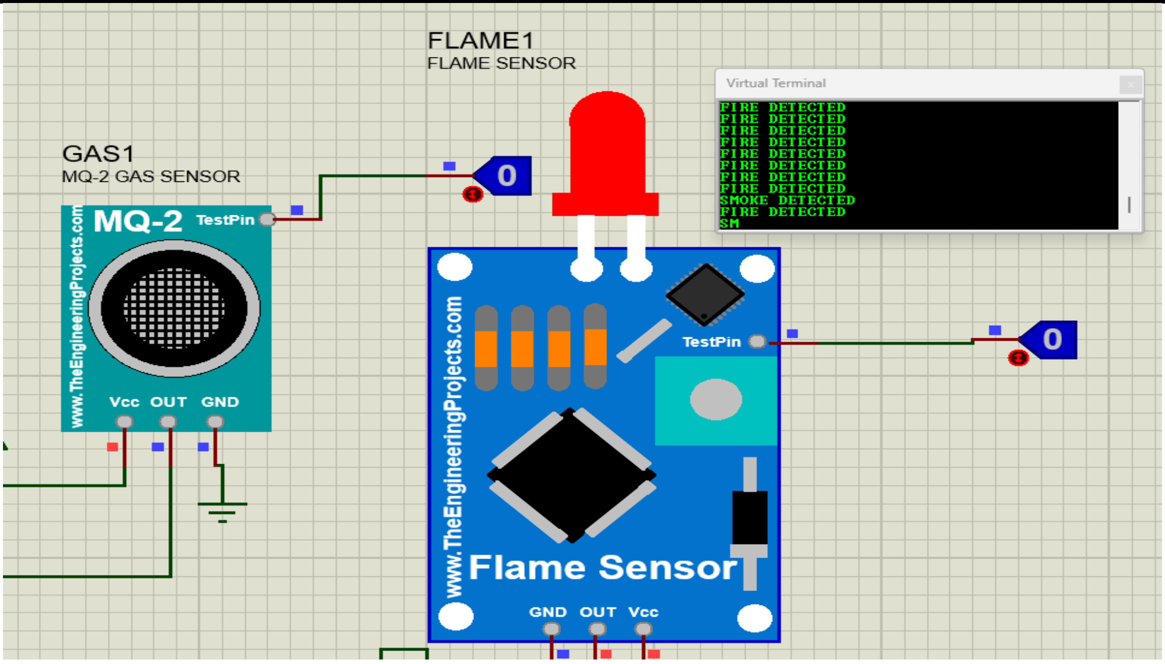

Fig. 14. SMOKE AND FLAME DETECTION

XI. RESULT ANALYSIS

To conduct a result analysis for major crash, minor crash, fire detection, rollover, and gas detection, we would typically collect data from the sensors integrated into the Guardian Drive system. This data would include timestamps, sensor readings, and event triggers. Based on this data, we can generate graphs to visualize the occurrence and frequency of each event. Here's a breakdown of how we can analyze the results for each scenario:

11.1. MAJOR CRASH

- Graph: Time series plot showing the occurrence of major crashes over the monitoring period.
- Analysis: Identify peaks or spikes in the graph corresponding to major crash events. Calculate the frequency and severity of major crashes to assess their impact on vehicle safety.

Fig. 15. MAJOR CRASH

11.2. MINOR CRASH

- Graph: Time series plot displaying the frequency of minor crashes detected by the piezoelectric sensors.
- Analysis: Determine the frequency distribution of minor crashes and analyze trends over time. Compare the occurrence of minor crashes with major crash events to understand the overall collision pattern.

Fig. 16. MINOR CRASH

11.3. FIRE DETECTION

- Graph: Time series plot illustrating the number of fire detection events recorded by the flame sensors.
- Analysis: Evaluate the distribution of fire detection events and identify any patterns or clusters. Assess the effectiveness of the fire detection system in detecting and responding to potential fire hazards.

Fig. 17. FIRE DETECTION

11.4. ROLLOVER

- Graph: Line plot showing the occurrence of rollover events detected by the accelerometers.
- Analysis: Analyze the frequency and distribution of rollover events to identify any trends or patterns. Evaluate the effectiveness of rollover detection mechanisms in detecting and mitigating rollover accidents.

Fig. 18. ROLLOVER DETECTION

11.5. GAS DETECTION

- Graph: Time series plot displaying the types and frequencies of gases detected by the gas sensors.
- Analysis: Identify the most common types of gases detected and assess their potential hazards. Evaluate the performance of the gas detection system in detecting and alerting occupants to gas-related risks.

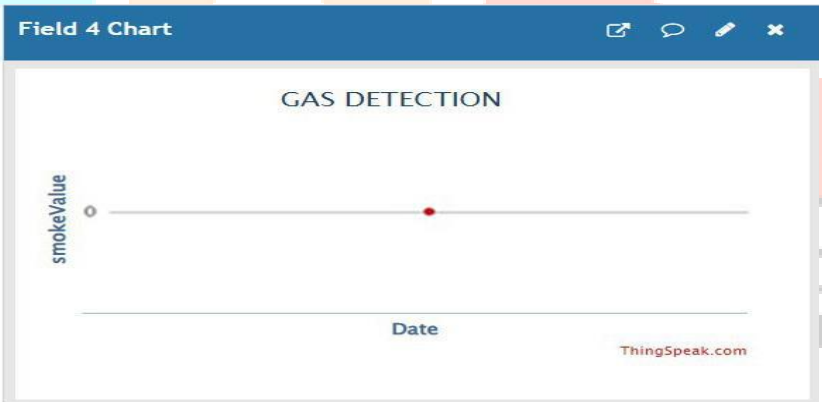

Fig. 19. GAS DETECTION

11.6. ACCIDENT FOOTAGE

- Result: An image captured by the ESP32 Cam.
- Analysis: The captured image provides visual documentation of the accident scene or surrounding environment. It allows for post-incident analysis, documentation, and potential evidence for insurance claims or legal proceedings. The image quality, clarity, and content are essential factors to consider in evaluating the effectiveness of the image capturing functionality.

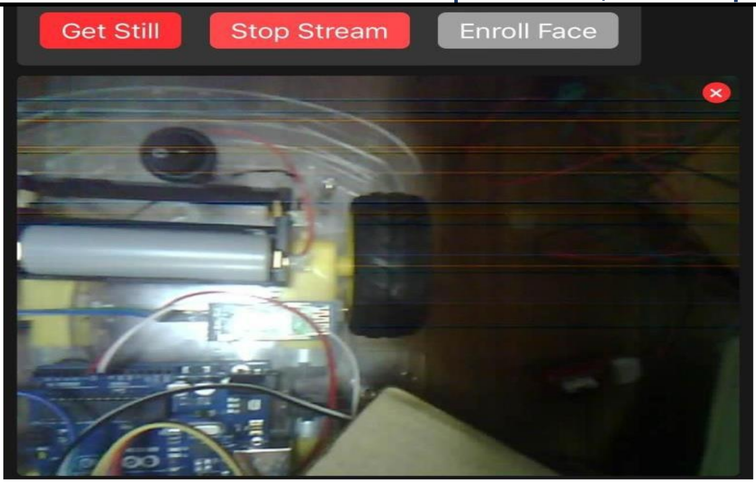

Fig. 20. ACCIDENT FOOTAGE

11.7. SMS MESSAGE

- Result: A screenshot of the SMS message containing latitude and longitude coordinates.
- Analysis: The SMS message provides real-time notification of the vehicle's location in case of an accident or emergency. The latitude and longitude coordinates included in the message offer precise location information, facilitating prompt response and assistance from emergency responders or vehicle owners. The accuracy, timeliness, and format of the SMS message are critical aspects to assess in determining the reliability and effectiveness of the communication system.

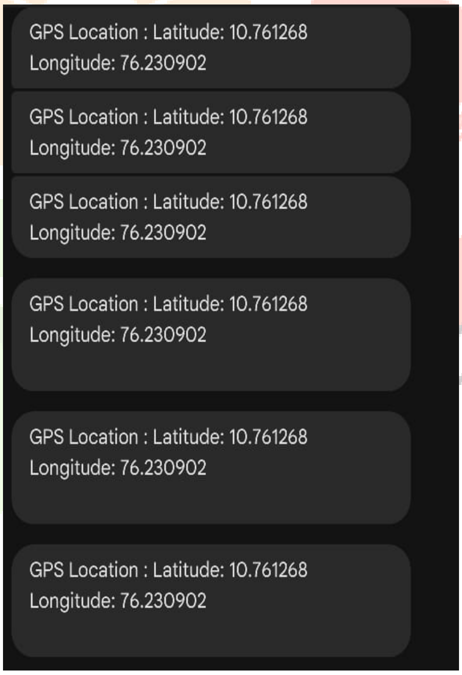

Fig. 21 SMS MESSAGE

XII. APPLICATIONS

12.1 **Insurance Industry:** Guardian drive aid insurance companies in accurately assessing claims by providing objective data on accidents. This ensures fair compensation for policyholders while minimizing fraudulent claims, leading to improved risk management and cost savings for insurance providers.

12.2 **Law Enforcement:** Law enforcement agencies utilize Guardian drive to expedite emergency response and accident investigation processes. By promptly identifying accident locations and severity, authorities can efficiently allocate resources, ensure public safety, and gather evidence for legal proceedings, enhancing overall traffic management and law enforcement efforts.

12.3 **Automotive Manufacturers:** The systems serve as a crucial safety feature in modern vehicles, offering occupants enhanced protection and reducing the likelihood of severe injuries or fatalities in accidents. Automotive manufacturers integrate these systems into vehicles to meet safety standards and enhance brand reputation for producing reliable and secure vehicles.

12.4 **Smart Cities Initiative:** Guardian drive systems contribute to the development of smart city infrastructure by enhancing road safety and traffic management capabilities. Integrated with existing traffic monitoring systems, these systems enable cities to identify accident hotspots, implement targeted interventions, and improve overall road infrastructure, fostering safer and more sustainable urban environments.

XIII. ADVANTAGES AND DISADVANTAGES

13.1 ADVANTAGES

1 **Improved Response Time:** Guardian drive enable faster response times to accidents by automatically notifying emergency services. This swift response can be crucial in situations where immediate medical attention is required, potentially reducing injury severity and saving lives.

2 **Enhanced Safety:** By promptly detecting accidents and alerting emergency services, guardian drive contributes to overall road safety by reducing the time it takes for help to arrive at the scene. This can minimize the risk of secondary accidents and mitigate the severity of injuries sustained by occupants.

3 **Fraud Prevention:** Guardian drive can help prevent fraudulent claims related to accidents by capturing detailed data about the incident, including timestamps and location information. This data can be used to verify the authenticity of claims and deter fraudulent behaviour.

4 **Data for Analysis:** Guardian drive collect valuable data about accidents, which can be analyzed to identify patterns, trends, and risk factors contributing to collisions. This information can inform road safety initiatives, infrastructure improvements, and targeted interventions to reduce accident rates.

13.2 DISADVANATGES

1 **Cost:** The installation and maintenance of guardian drive can be costly, particularly for vehicles or infrastructure retrofits. This cost may limit the widespread adoption of guardian drive, especially in regions with limited resources or infrastructure.

2 **Privacy Concerns:** Guardian drive collect sensitive data about driving behaviour and accident events, raising privacy concerns among some individuals. There may be concerns about how this data is stored, accessed, and used by authorities or third parties.

3 **Reliance on Technology:** Guardian drive rely on advanced technology, which may be susceptible to malfunctions, errors, or hacking attempts. A failure of guardian drive systems could compromise their effectiveness in detecting accidents and summoning assistance.

4 **Complexity:** Guardian drive systems can be complex to design, integrate, and maintain, requiring expertise in various fields such as sensor technology, data analysis, and software development. This complexity may pose challenges for implementation and troubleshooting.

XIV. CONCLUSION

In conclusion, the Guardian Drive project represents a comprehensive and innovative approach to enhancing vehicle safety and accident response through the integration of advanced sensor technology, wireless communication systems, and intelligent monitoring capabilities. By leveraging a combination of sensors such as piezoelectric sensors, accelerometers, flame sensors, and gas sensors, along with communication modules including GSM and GPS, the Guardian Drive system offers robust accident detection, emergency response, and communication functionalities.

Through simulation using Proteus, the Guardian Drive system's performance was evaluated across various accident scenarios, including minor and major crashes, rollovers, and fire hazards. The analysis of simulation results highlighted the system's effectiveness in promptly detecting and responding to critical events, thereby enhancing overall vehicle safety and mitigating potential risks on the road.

Furthermore, the integration of features such as image capturing with the ESP32 Cam and SMS messaging with latitude and longitude coordinates provides additional layers of functionality, enabling real-time documentation of accident scenes and precise location tracking for emergency responders. These features contribute to the system's ability to facilitate swift and efficient emergency response measures, ultimately improving the safety and security of vehicle occupants and reducing the impact of accidents on roadways.

Overall, the Guardian Drive project showcases the potential of integrated sensor and communication technologies to revolutionize vehicle safety and accident management systems. Further research and development in this area hold promise for advancing the state-of-the-art in automotive safety, paving the way for safer and more secure transportation systems in the future.

REFERENCES

[1] **M. Reininger, S. Miller, Y. Zhuang, and J. Cappos**, “A first look at vehicle data collection via smartphone sensors,” 2015 IEEE Sensors Applications Symposium (SAS). IEEE, Apr. 2015. Doi: 10.1109/sas.2015.7133607.

[2] **A. Ali and M. Eid**, “An automated system for Accident Detection,” 2015 IEEE International Instrumentation and Measurement Technology Conference (I2MTC) Proceedings. IEEE, May 2015. Doi: 10.1109/i2mtc.2015.7151519.

[3] **Vanitha, M., Arunkumar, K., Hemamalini, A. and Yaswanth, A**. (2023). A smart IOT based black-box system for automobiles. https://doi.org/10.1088/1742-6596/2484/1/012052

[4] **Swathi Sangala, Simran Revankar, Soniyashree N D, Thanvi** (2020). BLACK BOX FOR VEHICLES 2023 International Research Journal of Engineering and Technology Vol 7, Issue8 e-ISSN: 2395-0056

[5] **Vidya S A, Basavaraj G. Kudamble**. Implementation of Car Black-Box using ARM. International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181

[6] **R. Kavya p.vemaiah**. Vehicles Black Box System Using Arduino 2021 JETIR February 2021, Volume 8, Issue 2 ISSN-2349-5162

[7] **D. Khandelwal and r. Manoov**, “Airbag ECU coupled vehicle accident SMS alert system,” 2017 International Conference on Inventive Computing and Informatics (ICICI). IEEE, Nov. 2017. Doi: 10.1109/icici.2017.8365258.

[8] **S. Khan and S. Sonti**, “Data acquisition system for a 600cc formula SAE race car,” 2019 IEEE International Conference on Vehicular Electronics and Safety (ICVES). IEEE, 2019. Doi: 10.1109/icves.2019.5400316.

[9] **M. D. Sankari, M. Kiruthiga, and B. T. Tharanisrisakthi**, “Accident inference and data acquisition in automobiles,” International Conference on Information Communication and Embedded Systems (ICICES2021). IEEE, Feb. 2014. Doi: 10.1109/icices.2014.7034179.

[10] **M. K. Almohsen, R. khlief alonzi, T. H. Alanazi, S. N. BinSaif, and M. M. almujally**, “Smart Car Seat Belt: Accident Detection and Emergency Services in Smart City Environment,” 2021 1st International Conference on Artificial Intelligence and Data Analytics (CAIDA). IEEE, Apr. 06, 2021. Doi: 10.1109/caida51941.2021.9425108.

[11] **A. Mukhtar, L. Xia, and T. B. Tang**, “Vehicle Detection Techniques for Collision Avoidance Systems: A Review,” IEEE Transactions on Intelligent Transportation Systems, vol. 16, no. 5. Institute of Electrical and Electronics Engineers (IEEE), pp. 2318–2338, Oct. 2015. Doi: 10.1109/tits.2015.2409109.

[12] **S. T. S. Thong, C. T. Han, and T. A. Rahman**, “Intelligent Fleet Management System with Concurrent GPS & GSM Real-Time Positioning Technology,” 2022 22nd International Conference on ITS Telecommunications. IEEE, Jun. 2017. Doi: 10.1109/itst.2017.4295849.