DashCam Integrated Accident Detection System

Ananya Nikam[1], Sayee Pagar[2], Varad Pakhale[3], Vaibhav Panchal[4], Rupali Gavaraskar[5]
Dept. of Electronics and Telecommunication engineering Vishwakarma Institute of Technology, Pune, 411037, Maharashtra, India

***Abstract*—In this paper, an IoT-based, novel DashCam system with real-time accident detection and emergency response is presented for improving road safety. The system uses an MPU 6050 sensor to measure impact severity, a GPS module to find accurate location, and a GSM module to send emergency alerts as SMS. A video footage is also captured and stored by an ESP32-CAM, which can be used as key evidence for post-accident investigation. By integrating real-time monitoring, automatic alerting, and video recording, this system will minimize emergency response time, enhance accident documentation, and assist in more efficient road safety measures.**

***Keywords*—IoT, DashCam, Accident Detection, GPS, SMS Alert.**

I. INTRODUCTION

Road accidents globally result in heavy loss of life and also result in various injuries, the majority of them due to delayed detection and response. Generally, the failure results from reporting the kind of accidents to authorities and non- accurate information on the location and severity of an accident. Also, adding to that, unreliable evidence makes it challenging to trace the origin of an accident; hence, insurance claims and investigations may become problematic. The data detection and alert notification system proposed here overcomes the key issues the system employs MPU sensor for identifying the accident and its intensity the new 6 MGPS module identifies the coordinates of the accident the sim 900L GSM module sends emergency SMS to the contacts and the ESP 32 cam module captures and stores the video records and provides dashcam for post- incident analysis.
Through the combination of real-time detection with instant notification and video evidence, the system thus guarantees faster response time, improves road safety, and offers credible data for future assistance in investigations and the insurance process.

1) NEED AND OBJECTIVES

Existing Challenges in Accident Response Systems:

1. Delayed emergency response: More than 60% of the fatalities from road accidents are caused by delayed medical treatment, with the average response time being more than 15 minutes in cities
2. Manual reporting dependency: Commercial dashcams do not have automatic accident detection, thus necessitating witness intervention for emergency alerts.
3. Evidence reliability issues: 32% of insurance claims are disputed owing to poor or doubtful accident evidence.

Our Technical Objectives to Meet These Challenges:

1. Real-time accident detection:
   - Employ MPU6050 sensor with dynamic thresholding (2g minor/6g major impacts)
   - Obtain <500ms detection latency (compared to 2s in [5])
2. Self-sufficient alert system:
   - GPS location tagging (NEO-6M module, ±500m accuracy)
   - GSM-based SMS alerts (SIM900L) independent of internet dependence
3. Tamper-evident documentation:
   - ESP32-CAM video recording (720p at 10fps) with pre/post-accident buffer
   - Sensor-data synced footage for forensic verification

2) NOVELTY

1. First Integrated Low-Cost Solution
   - Combines MPU6050-based impact classification (2g minor/6g major thresholds) with:

Offline GSM alerts (SIM900L module) and Evidentiary- grade video documentation (ESP32-CAM at 10fps)

2. Hybrid Sensor Fusion Architecture
   - Dual-layer validation using:
   - Accelerometer data (impact force

detection) and Gyroscope readings (vehicle rotation analysis)

II. LITERATURE SURVEY

Dashcams have gained a wide adoption worldwide due to their ability to improve road safety, provide evidence in accidents, and assist with legal proceedings. Several studies have examined its effectiveness and privacy concerns.

Paper [2] explores the technological aspects of dashcams, emphasizing their role in insurance claims and accident investigations. The paper discusses the advantages of dashcams, including their ability to capture unbiased evidence and reduce fraud claims. However, the study also highlights challenges such as privacy concerns, legal restrictions in certain countries, and the potential for misuse.

Paper [3] analyzes cross-national differences in dashcam video-sharing behavior, focusing on China, Korea, and Russia. The study finds that users primarily share dashcam footage for reasons related to social justice rather than monetary gain. However, privacy concerns vary significantly by region, influenced by cultural norms and national regulations. The research suggests that a well-structured legal framework can help avoid privacy risks while encouraging responsible sharing practices.

Paper [4] discusses the increasing use of dashcams and their role in traffic surveillance. The study highlights that dashcams are useful in recording road incidents, aiding in the resolution of insurance claims, and serving as digital evidence in legal cases. The research also points out that many European countries lack a unified legal framework regarding dashcam usage, leading to legal ambiguities.

How they helped in the project implementation:

1. Handling privacy and Data sharing - Ensuring secure storage (from [3]).
2. Integrating GPS and GSM sensor - Logging accident locations for emergency calls (from [2]).
3. Real-World Use Cases - Understanding insurance and legal benefits to design a useful system (from [2], [4]).

III. METHODOLOGY

The suggested system combines hardware and software modules to ensure real-time accidents and triggers an alert message with GPS coordinates to the emergency contacts with video logging of the accident.

The prototype structure is centered around a toy car with the hardware build, such that the GPS module and Sim900L GSM module receive enough exposure for network access. The design is such that there is smooth working, and one can retrieve the video recording at a later date from a memory card. There is hardware component assembly such that the accelerometer as well as gyroscope sensor in MPU 6050 senses change in acceleration as well as in velocity to know the accident occurred. Two values of threshold have been set to categorize whether the accident would be major or minor. The MPU 6050 sensor reads the acceleration in g values.

The Neo 6-M GPS module is employed to read real-time geographic coordinates when the accident is identified by the MPU 6050 sensor. The GPS module talks to the satellite for coordinates such that there is no requirement for an internet network. Values of the GPS module are then passed on to SIM900L GSM module to deliver SMS alerts containing the accident location to the contacts. The whole circuit is governed by Node MCU or ESP32 microcontroller centrally, which is an actuator to all sensors and modules. The operation of the dashcam is performed by the ESP32 cam module with an SD card that records and saves video before and after the accident as a dashcam. The ESP32 Cam module runs on an external power supply and is programmed by the ESP32 programming board to record certain frames per second so that those can be translated into video. The software Implementation is implemented in such a way that the MPU is initialized and the actual acceleration and gyroscope values are calculated on the basis of threshold 1 (Value = 2 m/s2) and threshold 2 (Value = 4m/s2). Minor Accidents and major accidents are differentiated, and respective trigger actions are implemented. When the accident is sensed, the GPS module reads longitude, controller and GSM module establish communication, and an SMS is sent to

the pre-programmed emergency contact in the form of accident type, GPS coordinates, and timestamp.

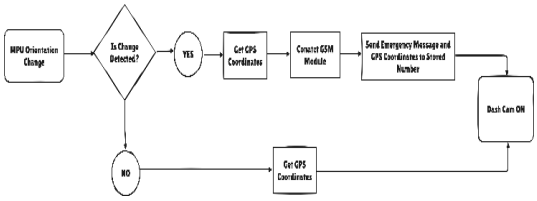

Fig.1 System Flow Diagram of Dash cam System

GSM 900 operates in the 900 MHz frequency band, commonly used in mobile communication. An accident detection system facilitates real-time communication by sending alerts and GPS coordinates to emergency services or predefined contacts upon detecting an accident.

Working Mechanism
Sensors: Accelerometers detect sudden changes in vehicle motion.
Microcontroller: Processes sensor data and triggers the GSM module.
GSM Module: Sends SMS with location details via GPS coordinates.
A typical block diagram includes components like the microcontroller, GSM module, GPS module, and sensors.

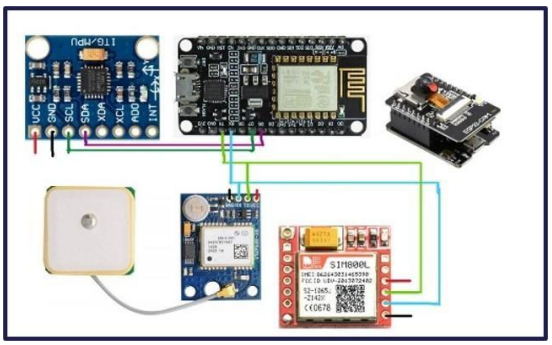

Fig.2 Circuit Diagram of Advanced DashCam System

The GSM 900L module is designed for communication with the frequency band over 900 MHz. It supports GPRS for low- speed internet connectivity, and also the SMS functionality in text as well as PDU modes, with storage of data on SIM card. The module operates on a 3.3V or 5V power supply and has a low power consumption on standby. It communicates via UART, making it easy to integrate with different microcontrollers and devices. The modules consist of an external antenna, which is connected via an SMA or UFL connector to ensure reliable signal catching. Along with it, the module includes a SIM card slot and LEDs for power and network indication, making it efficient and user-friendly.
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MPU 6050 is used to detect accidents by monitoring vehicle dynamics and detecting anomalies in alignment by setting appropriate thresholds. It is a 6-axis motion tracking sensor that combines 3 3-axis accelerometer and 3-axis gyroscopes. The accelerometer measures linear acceleration in the range
±2g, ±4g, ±8g, or ±16g, which can return if there is any sudden change during collision. The gyroscope captures angular velocity across roll, pitch, and yaw axis in the range of ±250°/s to ±2000°/s, which helps in detecting any rotations.

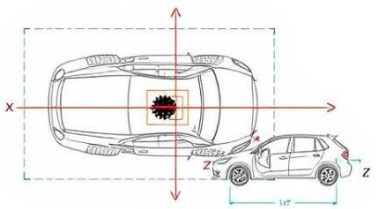

Fig.2 Initial Calibration of MPU6050

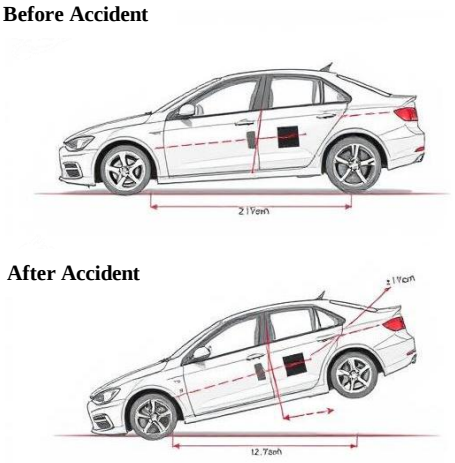

Fig.3 Angle Deviation of Vehicle

IV. RESULTS AND DISCUSSION

The system was thoroughly tested to ensure it works reliably. Each part was tested separately and then together in both simulated and real-world conditions. The MPU6050 sensor correctly detected accidents and classified their severity. The NEO-6M GPS provided accurate location

details, with an error margin of ±500 meters in open areas. The SIM900L GSM module sent SMS alerts successfully, taking 5-15 seconds depending on network strength and location. The ESP32-CAM recorded clear video footage and stored it without any issues.

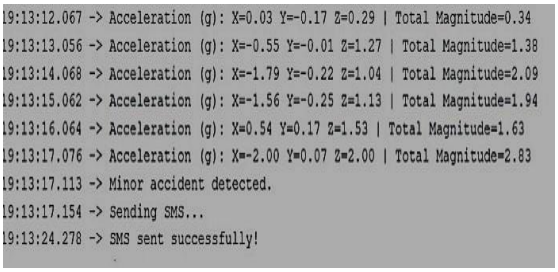

Fig.4 Program Output with MPU Coordinates.

To ensure the system's reliability, functionality, and adaptability across various regions, the project went under testing for individual modules, and an integrated performance special emphasis was placed on testing the SIM 900 GSM module, considering its dependence on 2G network availability and usability across various network operators.

Severity Level	Acceleration (g)	Gyroscope (rad/s)	Response Action
Low	2-4	1-3	Local alarm
Medium	4-6	3-6	Notify contacts
High	>6	>6	Alert emergency

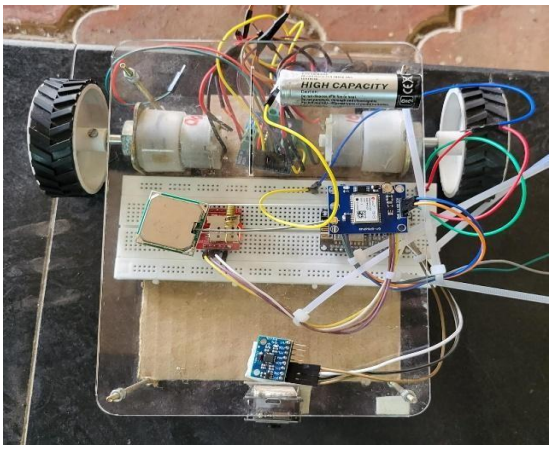

Fig.5 Actual System Prototype of Dash Cam System

Network Operator	Performance
BSNL	Moderate
Vodafone	Moderate
Airtel	Good

Table 1. Various Networks tested for SMS.

The ability of the GPS module to provide accurate location coordinates in given environments was tested, and the accuracy of the outcome was approximately ± 500 meters.

Using gyroscope and accelerometer data, the MPU6050 sensor continuously tracks motion and looks for possible collisions. The accelerometer records acceleration in the X, Y, and Z directions (a_x, a_y, a_z).

To detect abrupt acceleration or impact forces, whereas the gyroscope gauges angular velocity (ω_x ,ω_y, ω_z) to identify rotating forces, like rollovers in vehicles.

Based on a threshold mechanism, collision detection initiates an event when acceleration exceeds a predetermined threshold (e.g., exceeding 2–3g for a sustained time of 50– 100ms). Similarly, tilt detection uses gyroscope thresholds to detect anomalous vehicle orientation, including tilting that is greater than 45 degrees.

An intensity index is computed using the following formula to measure severity:

$$\text{Intensity}=(\Delta a_x)^2+(\Delta a^y)^2+(\Delta a_z)^2$$

Severity Level	Acceleration (g)	Gyroscope (rad/s)	Response Action
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Medium	4-6	3-6	Notify contacts
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Table 2. MPU Parameters for Dash Cam System

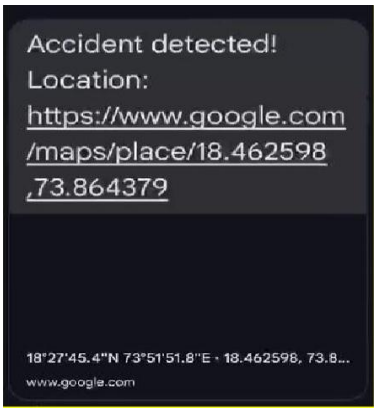

Fig.6 SMS Sent with Coordinates

Components	Cost (inRs.)
MPU6050	190
GSM 800L	150
ESP32 cam Module	300
Neo6M	200
esp8266	150
Total:	990

Fig. 7 Cost Estimation of Dash cam Sy

V. CONCLUSION

The DashCam Integrated with accident detection provides solutions to enhance road safety and post-accident response by the use of MPU 6050 censor for accident detection and neo 6 MGPS Model for location and sim 900 L module for real-time notification and communication with the verified emergency contacts shall help enhance road safety. The integration of the ESP32 cam module with video storage of the accident adds a layer of accountability when the accident has occurred.

The proposed system addresses the critical need for real-time accident detection and aids in post-accident investigation through stored dashcam footage. By providing data including accident severity and GPS longitude and latitude, as well as video evidence, it supports quicker responses for insurance claims, etc.

VI. FUTURE SCOPE

The Smart Dash Cam System has significant potential for improvement. One would be cloud integration, allowing real- time video uploads and GPS data storage for remote access by users, emergency services, and insurance companies. Additionally, AI-based analysis can be incorporated to differentiate between minor and major accidents so that false alarms are avoided and chaos is not created. These advancements will make the dashcam more scalable and effective.

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