CONFLICT AVOIDANCE AND LANDSLIDE UPDATE FOR VEHICLES IN DEEP CURVES

Project Reference Number: *49S_BE_4990*

College : JSS Academy of Technical Education, Bengaluru
Branch : Department of Information Science and Engineering.
Guide(S) : Dr. Basamma U Patil
Student(S) : Ms. Siyana Rafath S
Ms. Tejashree
Mr. Ujwal H M
Mr. Vishwas H

Keywords:
IoT, ESP32, Smart Barricade System, Landslide Detection, Vehicle Conflict Avoidance, Ultrasonic Sensors, IR Sensors, MPU6050, Real-Time Monitoring, Twilio Alerts, Embedded Systems.

Introduction

In hilly and mountainous regions, road safety is a major challenge due to blind curves, narrow lanes, and unpredictable terrain conditions. Drivers often face difficulty in detecting oncoming vehicles, which leads to frequent accidents, especially in deep curves. Additionally, natural hazards such as landslides and seismic vibrations increase the risk by occurring suddenly without prior warning.

Existing systems mainly focus either on vehicle detection or landslide monitoring but fail to provide a combined real-time solution. This project proposes an integrated system that ensures both traffic control and environmental hazard detection. Using sensors and embedded systems, the solution enhances safety by preventing vehicle collisions and providing early alerts for landslides. The system uses ESP32, ultrasonic sensors, IR sensors, and MPU6050 to monitor both traffic and terrain conditions. It also provides real-time updates through a web dashboard and sends emergency alerts via WhatsApp using Twilio. This makes the system reliable, cost-effective, and suitable for deployment in remote areas.

Overall, this project presents a low-cost, practical, and highly responsive approach to road safety in terrain-sensitive regions. By combining vehicle detection, seismic monitoring, automated barricade actuation, and real-time communication into a single intelligent system, it demonstrates how embedded technologies and IoT can significantly reduce accidents, enhance disaster preparedness, and improve traffic efficiency in mountainous and landslide-prone environments. The system aims to create safer transport routes with minimal human intervention while ensuring timely alerts and proactive control.

Objectives:

1. To design an automated two-lane barricade system using sensor-based vehicle detection.
2. To measure the distance of approaching vehicles using ultrasonic sensors and provide intelligent warning alerts.
3. To operate the barricades using servo motors controlled by the ESP32 microcontroller.
4. To monitor vibration, shaking, and tilt using the MPU6050 accelerometer/gyroscope and detect seismic events.
5. To automatically close both barricades and activate alarms when seismic activity is detected.
6. To provide real-time remote notifications using the Twilio WhatsApp API and develop a web-based dashboard for real time monitoring.

Methodology:

The proposed system follows a structured methodology involving sensing, processing, decision-making, and communication. Initially, ultrasonic and IR sensors are used to detect vehicle presence and measure distance. The MPU6050 sensor continuously monitors vibration and tilt to detect landslide or seismic activity. All sensor data is processed by the ESP32 microcontroller, which acts as the central control unit. Based on sensor inputs, the system applies decision logic. Under normal conditions, only one lane is opened at a time using servo-controlled barricades to avoid collisions. In case of abnormal vibration or tilt detection, both barricades are automatically closed to prevent vehicles from entering dangerous zones.

The system also includes a web-based dashboard hosted on ESP32, which displays real-time data such as vehicle detection, barricade status, and hazard alerts. Additionally, Twilio API is used to send WhatsApp alerts to users during emergencies. This integrated approach ensures efficient monitoring, quick response, and improved road safety.

Several algorithms and techniques are used such as:

- Ultrasonic Distance Calculation Algorithm.
- IR Sensor Logic for Vehicle Presence.
- Seismic Event Detection Algorithm.
- Barricade Control Algorithm.
- Real-Time Communication Protocol

The proposed system relies on a combination of embedded hardware, IoT software, and communication APIs to achieve real-time monitoring and alerting. The ESP32 microcontroller serves as the central processing unit due to its dual-core architecture, built-in WiFi, PWM support, and low-power capabilities. Real-time vehicle detection is enabled through HC-SR04 ultrasonic sensors for distance measurement and IR obstacle sensors for immediate presence detection at close range.

For terrain and seismic monitoring, the MPU6050 accelerometer/gyroscope is used to measure ground vibrations, tilt changes, and sudden shock movements that may indicate a landslide or seismic activity. The actuation layer consists of servo motors, which operate barricades responsible for physically regulating traffic flow, while buzzers and 16×2 I2C LCD displays provide direct visual–auditory feedback to drivers.

On the software side, the Arduino IDE is employed for code development, debugging, serial monitoring, and library integration. Real-time communication is achieved through the Twilio WhatsApp API, which allows instant hazard alerts to be delivered to remote users, transport authorities, and monitoring personnel. The ESP32 also hosts a lightweight web server that displays status updates using HTML, CSS, and JSON endpoints. Core technologies involved include IoT- based sensing, WiFi-based communication, sensor fusion, and embedded C/C++ programming.

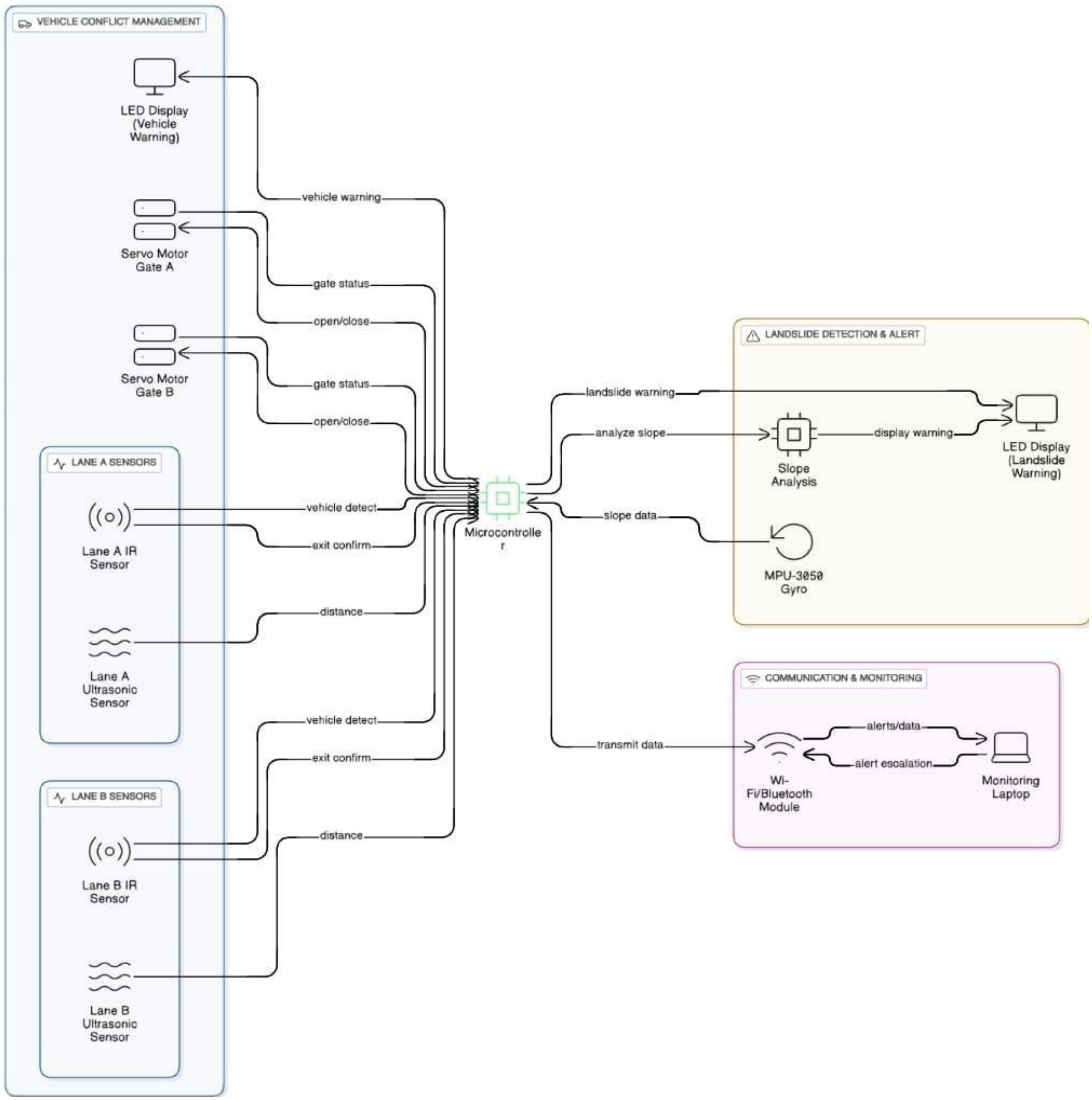

Figure 1: Block Diagram of the Proposed Smart Barricade and Landslide Alert System

Result & Conclusion:

We conducted various test scenarios to measure the accuracy, responsiveness, stability, and effectiveness of the system. This analysis aims to demonstrate how well the system meets the project goals of improving safety during vehicle movement in deep curves and providing early warnings during landslide or seismic events.

The combination of ultrasonic and IR sensors provided reliable and accurate results at different simulated vehicle distances. Figure 2 shows the experimental prototype setup used to test the vehicle detection and barricade control system on a curved road model. The figure illustrates where the ultrasonic sensors, IR sensors, servo-controlled barricades, and the LCD display are placed along Lane A and Lane B. It demonstrates real-time vehicle detection, barricade operation for each lane, and system response in traffic situations.

Figure 2: Experimental Setup for Vehicle Detection and Smart Barricade Operation

The servo motors executed opening and closing movements effectively. When the lane detection logic was used, the barricades responded quickly to all triggers. Gate A and Gate B showed no jittering or partial movements during operation, indicating stable PWM signals and power supply.

Figure 3 illustrates the physical operation of the servo-controlled barricade during vehicle detection test on the curved road model. The figure shows the barricade responding to sensor inputs by opening or closing smoothly, confirming accurate actuator control, stable PWM signaling, and reliable integration with the lane-wise decision logic.

The Smart Barricade Control Dashboard displays Lane A & B vehicle distance, Barricade status as OPEN / CLOSED, Landslide vibration magnitude, Seismic alerts, Real-time hazard notifications, The dashboard interface is responsive and works on any device connected to ESP32 Wi-Fi. Figure 4 shows the smart barricade control dashboard displaying real-time lane status information for both Lanes.

Figure 3: Barricade Operation results (Opening)

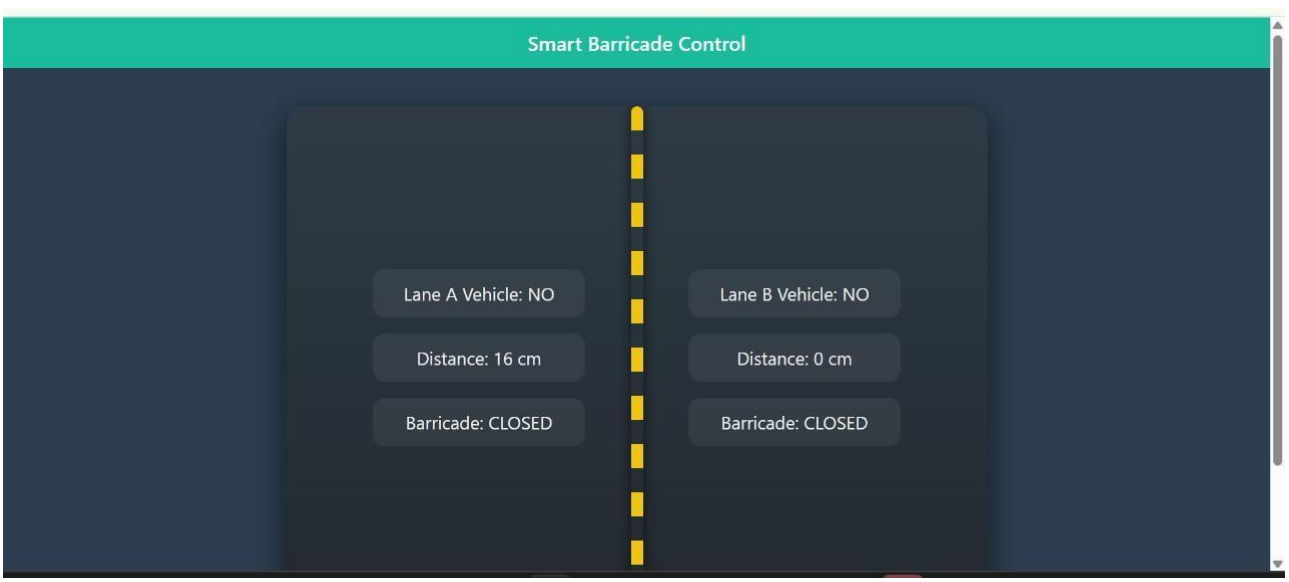

Figure 4: Smart Barricade Control Dashboard.

Whenever a seismic or landslide condition was triggered, a WhatsApp message was sent almost immediately. Figure 5 shows the WhatsApp alert notifications generated through the Twilio API when a landslide or seismic event is detected, displaying the event type, measured magnitude and automatic barricade safety status in real time.

Figure 5: Twilio WhatsApp Alert messages.

Scope for Future Work:

1. Integration with IoT-based wearable or environmental sensors: Collects real-time data from smart wearables and environmental sensors. Enables continuous monitoring and quick detection of issues.
2. Development of a mobile application for easier monitoring: Provides a simple interface to view data and receive alerts. Allows users to monitor the system anytime, anywhere.
3. Use of cloud storage for large-scale data management: Stores large amounts of data securely on cloud platforms. Ensures easy access, scalability, and backup.
4. Implementation of AI/ML for better prediction accuracy: Uses intelligent models to analyze data and predict risks. Improves accuracy and supports proactive decisions.
5. Expansion to multiple road segments and smart city infrastructure: Extends the system across wider areas and city networks. Enhances traffic control and centralized monitoring.
6. Addition of solar power for remote area deployment: Uses solar energy to power systems in remote locations. Ensures reliable and eco-friendly operation.