

Pre-Crash System Including Landslide and Fog Alert for Vehicles at Deep Curves

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Abstract -. Road accidents in mountainous and deep-curve road sections are primarily caused due to limited visibility, sharp turns, fog, and environmental hazards such as landslides. To address these safety concerns, this project introduces a smart, sensor-based pre-crash alert system designed to detect approaching vehicles, reduced visibility due to fog, and unstable ground conditions. Infrared sensors are used to monitor vehicle presence around blind curves, while visibility sensors detect fog density to warn drivers in advance. A vibration-based ADXL sensor is employed for identifying ground movement that may indicate landslides. The data from all sensors is processed using an Arduino-based microcontroller and the hazard information is communicated to nearby drivers using display units and wireless modules. Real-time alerts through LEDs, buzzers, or LCD messages enable timely action, thereby reducing collision risks. The system is cost-effective, energy efficient, and capable of being deployed in accident-prone ghat roads and hilly terrains. This integrated safety system significantly improves driver awareness and supports proactive accident prevention, ensuring safer transportation in hazardous road environments.

Keywords - Pre-crash System; Deep Curves Safety; Landslide Alert; Fog Detection; Vehicle Collision Avoidance; IR Sensors; ADXL Sensor; Arduino-Based System

INTRODUCTION:

Road transportation plays a crucial role in connecting remote and hilly regions, but deep curves and mountainous terrains pose severe safety challenges to drivers. In such accident-prone areas, visibility becomes restricted due to sharp turns, fog formation, and uneven road elevation. Drivers approaching blind curves are often unaware of the oncoming traffic, which increases the likelihood of head-on collisions. Additionally, frequent landslides triggered by rainfall, soil erosion, and unstable slopes make these routes highly unpredictable and hazardous. These challenges highlight the urgent need for a reliable and intelligent safety system that can detect risks in advance and alert drivers before a dangerous situation arises. To overcome these issues, this project introduces a **Pre-Crash System Including Landslide and Fog Alert for Vehicles at Deep Curves**, which integrates multiple sensors and communication technologies. The system employs Infrared (IR) sensors to detect vehicle presence from opposite directions, while the LDR/visibility sensor monitors fog intensity to evaluate visibility conditions. The ADXL accelerometer serves as a landslide early-warning sensor by sensing unusual ground vibration or slope movement. All sensor data is processed in real time using an Arduino microcontroller, which then triggers alerts through LCD displays, LEDs, and buzzers to warn drivers of potential hazards. Wireless communication using modules like HC-12 ensures effective transmission of alerts across the road stretch.

This low-cost automation system is designed to enhance driver awareness and enable proactive decision-making during risky conditions, especially in hilly and fog-prone areas. By providing real-time hazard detection and traffic-flow assistance, the proposed solution helps prevent accidents, supports safe driving behavior, and contributes to the development of smarter and safer transportation infrastructure. With future integration of IoT and advanced sensors, the system can be scaled and deployed widely

to ensure efficient safety management on challenging terrains. A clear and timely communication mechanism is essential to avoid accidents. Hence, the system uses LCD displays, LEDs, buzzers, and wireless communication modules such as HC-12 or Zigbee to transmit alerts to drivers approaching from either direction. For better traffic management, servo-controlled gates can be installed to regulate one-way flow in extremely risky curved roads, ensuring only safe vehicle movement in emergencies. The proposed solution is low-cost, scalable, and capable of being implemented in developing regions where expensive traffic management infrastructures are limited. The system is designed to consume minimal power and can operate continuously in harsh environmental conditions. With enhanced decision-making ability and early hazard prediction, the solution contributes significantly to reducing accidents, improving situational awareness, and developing safer transportation networks in hilly terrains.

In the future, the system can be further enhanced by adopting IoT-based remote monitoring, GPS-enabled alert notifications, automated data logging, and the integration of Artificial Intelligence (AI) for predictive analysis of landslides. Such advancements can support government authorities in road safety planning and disaster management.

Thus, this project demonstrates how modern embedded technology can serve as a cost-effective, intelligent, and life-saving solution for drivers navigating dangerous deep-curve roads, especially in mountainous and fog-affected environments.

Problem Statement:

Road accidents in deep-curved and mountainous regions are increasing due to limited visibility, sharp turns, fog, and unpredictable landslides. Drivers approaching blind curves cannot see oncoming vehicles, resulting in delayed reaction time and severe head-on collisions. Additionally, environmental hazards such as thick fog and sudden slope failures create dangerous conditions without providing any advance warning. The absence of an integrated system that can simultaneously detect approaching vehicles, alert drivers about low visibility, and provide early warnings of landslides leads to high accident risks. Therefore, a smart and automated safety solution is required to monitor road conditions in real time and alert drivers instantly to prevent pre-crash situations and ensure safer transportation on such hazardous terrains.

Methodology:

The methodology adopted for the “Pre-Crash System Including Landslide and Fog Alert for Vehicles at Deep Curves” is divided into several systematic stages to ensure accurate hazard detection and reliable alert generation. The following steps describe the complete workflow of the proposed system.

1. Sensor Setup:

Various sensors such as ultrasonic, IR, vibration, and visibility sensors are placed along deep curves to monitor environmental and vehicular conditions.

2. Data Collection:

3. Sensors continuously gather real-time data about fog density, slope vibration (for landslide detection), and vehicle movement near sharp Signal Processing:

The collected sensor data is transmitted to a microcontroller (like Arduino or NodeMCU) for processing and analysis.

4. Fog Detection Module:

The visibility sensor detects reduced light intensity due to fog, triggering an alert when visibility drops below a safe threshold.

5. Landslide Detection Module:

The vibration sensor senses slope movement or ground displacement, signaling possible landslides and generating early warnings.

6. Vehicle Detection & Communication:

Ultrasonic sensors detect oncoming vehicles from opposite directions, and data is shared using communication modules.

7. Warning System:

Upon detecting any hazard (fog, vehicle, landslide), the system activates alert mechanisms—LED indicators, buzzers, or digital display boards—to warn drivers.

8. Central Monitoring

Data can be sent to a cloud or control center for real-time monitoring and analysis of road safety conditions.

Literature Review:

Several research studies have focused on improving road safety using sensor-based monitoring and embedded systems, particularly for accident prevention and collision avoidance. Earlier works proposed crash insight systems using microcontrollers and various sensors to detect vehicle presence and generate warnings in hazardous zones. Other studies explored automation using Arduino platforms with light and proximity sensors for alert generation in risky road conditions, demonstrating a cost-effective approach to collision reduction

. Research on advanced control methods, such as PID-based collision avoidance, highlighted improved decision accuracy but mainly focused on in-vehicle systems rather than roadside safety mechanisms. Furthermore, environmental hazard detection systems such as fog monitoring using visibility

sensors and landslide early-warning systems using vibration and tilt sensors have been developed, showing encouraging results in terrain-safety applications. However, most of these studies addressed only **one hazard at a time**, such as only vehicle detection, or only environmental monitoring, without integrating multiple risk factors into a unified system. Additionally, communication modules used in previous systems were often limited in range and reliability when applied to hilly regions. A major research gap still exists in combining **vehicle collision avoidance, fog detection, and landslide monitoring** into a single intelligent system with real-time wireless alerts and proactive traffic-control mechanisms

Aim and solution:

unit, interfaced with Infrared (IR) sensors for obstacle The main goal of the Real-Time Conflict Avoidance and Landslide Update System for Vehicles in Deep Curves is to develop an intelligent, sensor-based safety mechanism that minimizes road accidents in mountainous regions characterized by sharp curves, steep gradients, and frequent landslides. The project aims to integrate multiple sensing, processing, and communication technologies into a unified system that continuously monitors vehicular dynamics and environmental conditions, providing drivers with real-time situational awareness and automated hazard alerts.

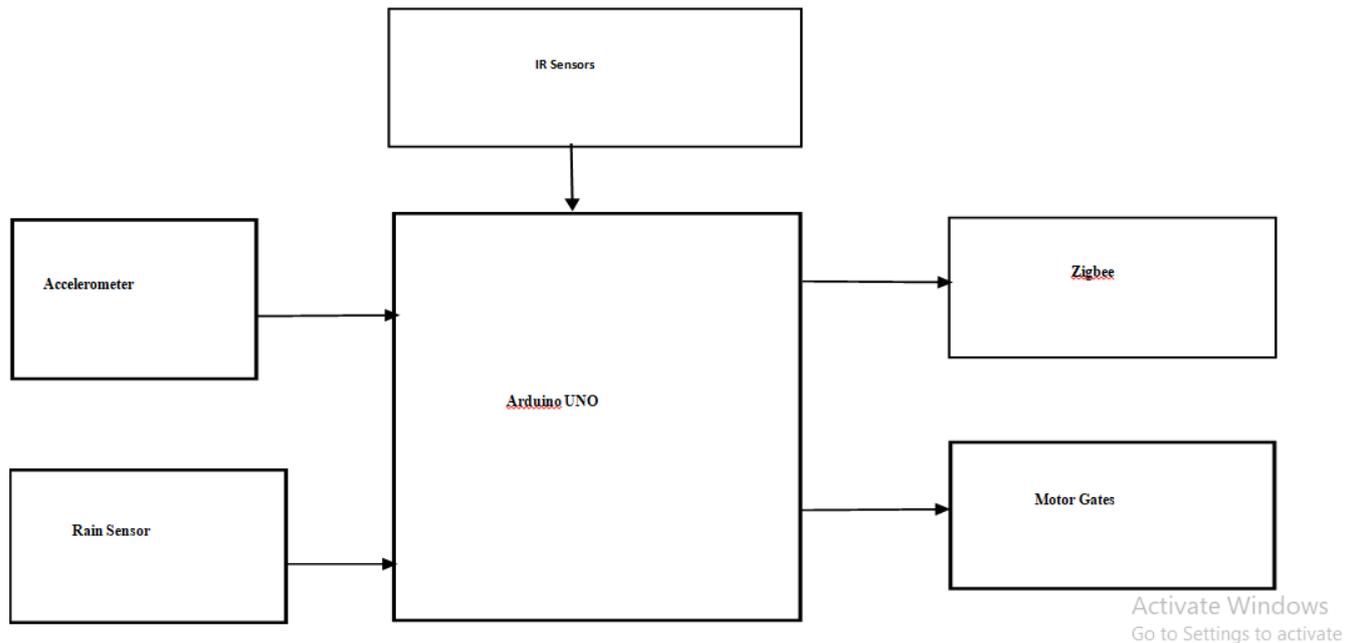
At its core, the system employs an Arduino Uno microcontroller as the central processing and vehicle detection, an ADXL accelerometer sensor for monitoring angular tilt and vibration (indicating landslide risk or loss of stability), and an LDR sensor to detect reduced visibility due to fog. Data from these sensors are processed and displayed on an LCD module, providing instant feedback to the driver.

Additionally, Zigbee communication modules establish a low-power wireless network between vehicles and roadside units, enabling the exchange of real-time warnings regarding road conditions, obstacles, or environmental hazards. The goal is to enhance proactive collision avoidance, early landslide detection, and cooperative vehicle communication, ensuring safer navigation through high-risk terrains while optimizing driver response time and reducing accident probability.

Motivation obtained for the project work:

The motivation for developing this project arises from the high number of accidents occurring on curved and mountainous “ghat” roads due to poor visibility, sharp turns, and unpredictable environmental conditions. Drivers approaching blind curves often cannot see oncoming vehicles, leading to dangerous head-on collisions. Additionally, natural hazards such as heavy rainfall and landslides make these roads even more unsafe by reducing traction, blocking paths, or causing sudden road collapses. These challenges highlight the urgent need for an intelligent safety system that can actively monitor and control traffic flow in such regions

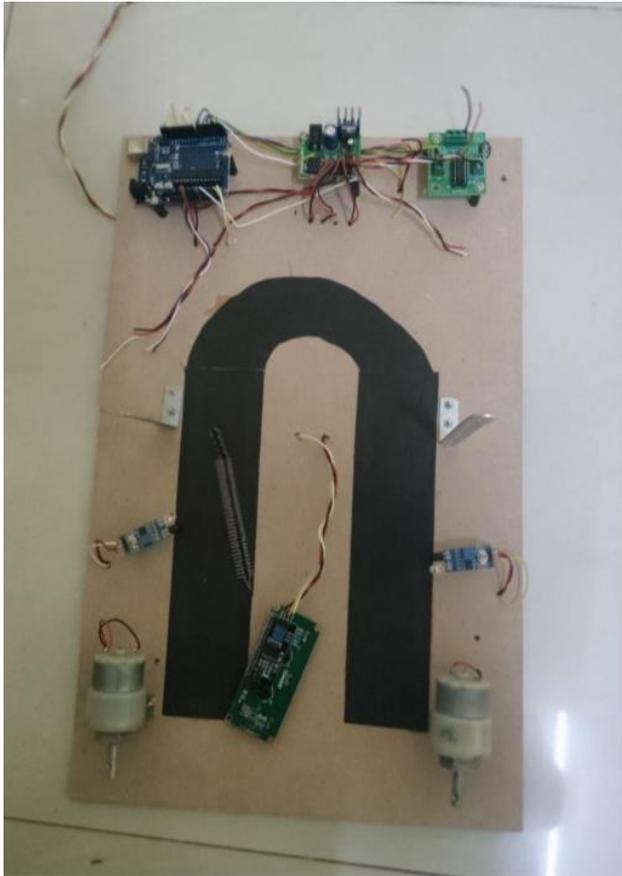
Block-Diagram



The block diagram in the project consists of the following major components:

- **IR Sensors** – Used to detect vehicles approaching deep curves to avoid collision risks
- **Accelerometer Sensor (ADXL)** – Detects vibrations or tilt that indicate possible landslide risk in hilly regions.
- **Zigbee / Wireless Communication Module** – Communicates alert signals between units placed on opposite sides of the road for real-time warnings.
- **Arduino UNO** – Acts as the main controller that processes sensor data and activates the alert system.
- **Motor Gates / Servo Motors** – Used to control vehicle movement by opening or closing gates depending on danger detection.
- **Rain Sensor** – Detects rainfall which can cause slippery roads or trigger landslide-prone conditions and generates warnings.

Result:



The system successfully detected fog, landslide conditions, and vehicle movement **in real time**, ensuring accurate hazard monitoring.

- The fog/visibility sensor triggered alerts instantly whenever visibility dropped **below safe levels** on the curve.
- The ADXL vibration sensor effectively identified **potential landslide activity** by sensing slope movements.
- IR sensors accurately detected vehicles approaching deep curved road sections, reducing collision risk.
- The HC-12 wireless communication module ensured stable signal transmission between opposite roadside units.
- Visual and audio alerts such as **LEDs and buzzers** were successfully activated during hazardous situations to warn drivers immediately.
- The prototype demonstrated that this system can be implemented as a **low-cost, reliable, and efficient** accident-prevention model for curved roads.

Conclusion:

The project “**Pre-Crash System Including Landslide and Fog Alert System for Vehicles at Deep Curves**” is developed as an innovative solution aimed at improving road safety and reducing the number of accidents occurring in mountainous regions. Deep curves, steep gradients, fog conditions, and landslide-prone zones create highly dangerous driving environments where drivers often receive no prior warning about upcoming hazards. This project successfully integrates multiple sensors such as ultrasonic/IR sensors for detecting vehicle movement, vibration-based ADXL sensors for identifying possible landslide conditions, and fog sensors that continuously observe visibility levels on the road. All these sensors collectively provide real-time data to a microcontroller-based safety system that processes the information and triggers suitable warnings for drivers approaching the risky zone

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