SMART ACCIDENT PREVENTION SYSTEM FOR CURVED HILL ROADS USING IR SENSORS

T.G. Tejaswini[1], C. Praveena[2], B. Jahnavi[3], K. Mounika[4], M. Uday Kumar[5], P. Ankanna[6]

[1]Research Supervisor, Assistant Professor, Department of ECE, ALTS, Anantapuramu.

[2,3,4,5,6]UG Scholar, Dept. of ECE, ALTS, Anantapuramu.

ABSTRACT

Road accidents in hilly regions are a major concern due to sharp curves, poor visibility, steep slopes, and unpredictable weather conditions, including fog and rain. Traditional safety measures like signboards and mirrors are often ineffective in such challenging terrains. This paper proposes an IR Sensor-Based Accident Prevention System designed to reduce collisions at blind curves. The system uses IR sensors to detect vehicles on either side of a curve and activates LED indicators (red and green) to alert drivers. A Light Dependent Resistor (LDR) controls a white LED in low-light conditions, while a buzzer provides an audio warning during potential collision risks. A 16×2 LCD display shows real-time status and system activity, and an Arduino Uno microcontroller manages all components efficiently. The system is low-cost, energy-efficient, reliable, and easy to install, making it ideal for improving road safety in remote mountainous areas. Road accidents in hilly regions are a major concern due to sharp curves, poor visibility, steep slopes, and unpredictable weather. Traditional safety measures like signboards and mirrors are often ineffective in such terrains

Keywords: - IR sensors, Arduino UNO, RGB LED Indicators, LDR Sensor, Street Lighting System, LCD, Vehicle Detection.

I. INTRODUCTION

In the 21st century, rapid population growth has led to an alarming increase in road accidents, making accident prevention a critical issue for public safety and transportation planning.

A significant number of these accidents occur due to driver negligence, inadequate safety measures, and poorly designed road infrastructure.

Despite advancements in technology and the implementation of various preventive strategies, the frequency of accidents—particularly in hilly and remote regions—remains disturbingly high.

Accidents in mountainous areas are primarily caused by sharp and poorly designed curves, absence of guardrails, narrow or uneven road shoulders, blind turns, steep inclines, poor visibility at intersections, and obstructed sightlines.

Weather-related conditions like fog, rain, and snow further aggravate the problem by reducing traction and visibility, making driving even more hazardous.

To address these challenges, this paper proposes an intelligent accident prevention system that utilizes advanced sensor-based signalling to alert drivers about potential hazards in real time, enabling timely precautionary actions and minimizing human error.

This study is structured into nine sections: an introduction to the proposed model, system design and architecture, a detailed explanation of the components used, methodology with a structured block diagram, working procedures with a process flowchart, experimental results with analysis, and a final conclusion summarizing key findings and observations.

By integrating modern technology with smart traffic management systems and low-cost automation, this model aims to significantly reduce accident risks, enhance road safety, and promote a more efficient, secure, and sustainable transportation network—particularly in topographically challenging regions.

II. EXISTING METHOD

In many hilly regions, accident prevention primarily depends on conventional methods such as road signs, convex mirrors, and manually operated warning signals.

However, these traditional approaches often prove ineffective due to poor visibility in adverse weather conditions, such as fog, and the absence of adequate illumination at night.

While some roads are equipped with reflectors or streetlights, they do not provide real-time alerts about approaching vehicles at sharp turns, increasing the likelihood of collisions.

TABLE 1 - Issues & Impacts

Issues in Hilly Roads	**Impact**
Poor visibility	Increased accident risk due to lack of clear roads guidance
No active vehicle alerts	High chance of collisions at blind curves
High power consumption of streetlights	Unnecessary energy wastage when no vehicles are present

Certain advanced highways incorporate radar-based detection or CCTV surveillance systems to monitor traffic and enhance road safety.

However, these solutions are costly, require a continuous power supply, and demand regular maintenance, making them impractical for remote or underdeveloped hilly regions.

Moreover, conventional street lighting remains operational throughout the night, leading to unnecessary energy consumption even when no vehicles are present.

The absence of an efficient and cost-effective accident prevention system in hilly areas contributes to frequent road accidents, resulting in injuries and fatalities.

Addressing these challenges requires an innovative solution that can provide real-time alerts, improve visibility, and optimize energy usage while being affordable and feasible for widespread implementation in mountainous terrains.

- Detects and alerts drivers about oncoming vehicles in real-time.
- Functions efficiently in all weather conditions.
- Is cost-effective and consumes minimal energy.

III. PROPOSED METHOD

The proposed IR Sensor-Based Accident Prevention System is an affordable and automated solution aimed at improving road safety in hilly areas.

Accidents on hilly roads, especially at sharp curves, are a major concern due to limited visibility and the absence of real-time warning mechanisms.

The IR Sensor-Based Accident Prevention System is a low-cost, automated solution designed to enhance road safety by alerting drivers about oncoming vehicles. This system employs infrared (IR) sensors, LED indicators, a buzzer, and a light-dependent resistor (LDR) sensor to provide timely warnings and improve visibility, reducing collision risks.

The system consists of multiple components that work together to detect vehicles and alert drivers effectively. The IR sensors are strategically placed on both sides of a curve to detect vehicles and activate warning signals.

When a vehicle is detected, a Red LED and a buzzer alert driver approaching from the opposite direction. If no vehicle is detected, a Green LED signals a safe passage.

Additionally, White LEDs provide illumination during nighttime, which is controlled by an LDR sensor to conserve energy. A 16×2 LCD display presents real-time status updates, such as vehicle detection and lighting conditions.

TABLE 2 - Components & Functions

Component	Function
IR sensor	Detect vehicles on both sides of a curve
Red LED	Lights up when a vehicle is detected on the opposite side, warning drivers to slow down
Green LED	Lights up when no vehicles is detected, indicating a safe passage
White LED	Provides illumination during nighttime or low-light conditions
LDR sensor	Detects ambient light levels and automatically turns on the white LED when needed
16*2 LCD display	Shows real-time status updates, such as vehicles detection and warning messages
Buzzer	Sounds an alarm to reinforce visual warnings when a potential collision risk is detected

A. WORKING PRINCIPLE:

The IR Sensor-Based Accident Prevention System operates by detecting vehicles approaching a sharp curve and providing real-time alerts to drivers on the opposite side. IR sensors, placed strategically on both sides of the curve, continuously monitor vehicle movement.

When a vehicle is detected, the Arduino Uno processes the data and activates warning indicators accordingly.

If a vehicle is approaching from the opposite side, the Red LED turns on, signalling the driver to slow down, while the buzzer sounds an alarm for additional awareness. If no vehicle is detected, the Green LED remains illuminated, indicating a safe passage.

For enhanced visibility during nighttime or low-light conditions, the LDR sensor detects ambient light levels and automatically switches on the White LED when darkness is detected.

The system also features a 16×2 LCD display, which provides real-time status updates on vehicle detection and lighting conditions. This automated, energy-efficient setup significantly reduces accident risks by providing timely warnings and improving visibility at hazardous road curves.

B. CHALLENGES:

Hilly regions pose significant challenges for road safety due to poor visibility, sharp curves, and the limitations of conventional accident prevention methods. Traditional road signs and convex mirrors often fail to provide real-time alerts, especially in foggy or low-light conditions, increasing the risk of collisions and head-on crashes.

Static warning indicators do not dynamically respond to approaching vehicles, leading to delayed driver reactions and reduced situational awareness, particularly at blind curves or intersections.

Additionally, conventional streetlights remain operational throughout the night, causing unnecessary energy consumption even when no vehicles are present. This inefficiency contributes to higher maintenance costs and energy wastage in remote areas.

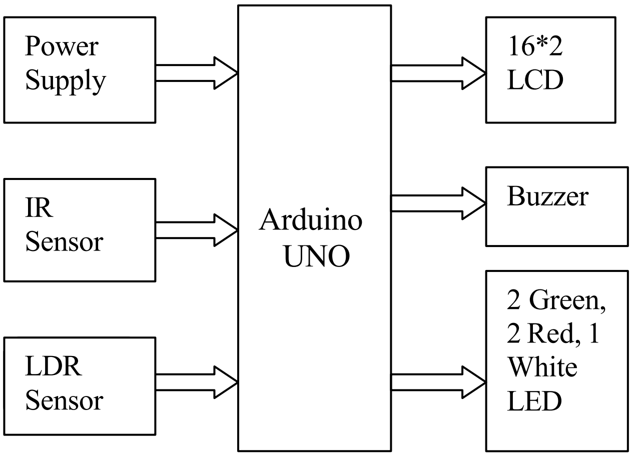
While advanced surveillance systems like radar-based monitoring or CCTV cameras exist, they are expensive, require a continuous power supply, and demand regular maintenance, making them unsuitable for remote and less developed regions where infrastructure is minimal and resources are scarce.

The lack of a cost-effective and efficient accident prevention system results in frequent accidents, injuries, and fatalities.

The proposed IR Sensor-Based Accident Prevention System addresses these issues by providing real-time vehicle detection, dynamic warning signals, and energy-efficient lighting, ensuring safer and smarter road conditions in hilly and accident-prone areas.

C. BLOCK DIAGRAM:

Below is the block diagram representing the working of the system:



The block diagram represents an IR Sensor-Based Accident Prevention System designed for hilly areas, with the Arduino Uno as the central control unit.

The system is powered by a power supply, which ensures that all components receive the necessary voltage to operate. IR sensors are placed on either side of a curve to detect approaching vehicles.

When a vehicle is detected, the sensor sends a signal to the Arduino. Simultaneously, an LDR sensor monitors the ambient light conditions. In low-light or dark situations, it signals the Arduino to activate the white LED to improve visibility on the road.

The Arduino Uno processes the inputs received from both the IR and LDR sensors. Based on the data, it controls the outputs accordingly. If a vehicle is detected, it turns on the red LED to warn the approaching driver to slow down, and also triggers the buzzer to provide an audible alert.

If no vehicle is present, the green LED lights up, indicating safe passage. The white LED is automatically turned on by the Arduino during low visibility conditions as detected by the LDR sensor. Additionally, a 16×2 LCD display is used to show real-time status updates such as vehicle detection and lighting condition.

This system is energy-efficient, automated, and provides timely visual and audio warnings to reduce accidents on sharp curves in hilly roads.

IV. RESULTS

A. SYSTEM PERFORMANCE ANALYSIS:

The proposed IR Sensor-Based Accident Prevention System was successfully implemented and rigorously tested under varying environmental and traffic conditions, specifically targeting blind curves in hilly terrains.

The system integrates IR sensors for vehicle detection, RGB LEDs and buzzers for real-time alerts, and LDR sensors for smart lighting control. During testing, the system consistently provided accurate detection of approaching vehicles from both directions. The real-time warnings through visual and audio indicators allowed drivers to react proactively, thus mitigating collision risks.

The smart lighting mechanism, controlled by LDR sensors, automatically activated illumination during low-light and night-time conditions. This not only ensured enhanced visibility for drivers but also optimized energy usage by switching off lights during daylight. The use of RGB LEDs allowed for clear and distinct visual signalling, improving driver awareness.

This comprehensive approach not only improves road safety but also aligns with sustainable engineering practices, making the system suitable for implementation in remote and resource-limited hilly regions where accidents are frequent due to sharp curves, low visibility, and inadequate infrastructure.

B. COMPARISON BETWEEN EXISTING AND PROPOSED:

Compared to traditional systems that rely on static signs and continuous lighting, the proposed model introduces real-time, sensor-based alerts and smart lighting controls. It enhances driver awareness and conserves energy, providing a cost-effective and efficient solution suited for hilly terrains.

TABLE 3
Comparison Between Existing System & Proposed System

Feature	Existing System	Proposed System
Real-Time Alerts	Relies on static road signs, convex mirrors, and manual signals	Uses IR sensors and LEDs for real-time vehicle detection and alerts
Real-Time Alerts	Relies on static road signs, convex mirrors, and manual signals	Uses IR sensors and LEDs for real-time vehicle detection and alerts
Energy Consumption	High; streetlights operate continuously	Low; LDR sensors activate lights only when needed
Weather Adaptability	Limited effectiveness in foggy or low-visibility conditions	Works effectively in all weather conditions
Cost Efficiency	High installation and maintenance costs for CCTV/radar-based systems	Affordable and requires minimal maintenance
Accident Prevention	Passive methods with limited impact	Proactive warning system that significantly reduces accident risks
Sustainability	No energy generation; inefficient power use	Optimized lighting control using LDR sensor

C. POWER CONSUMPTION COMPARISON GRAPH:

The graph below illustrates the power consumption of the existing and proposed systems. The proposed system significantly reduces power usage by utilizing LDR sensors to activate lights only when necessary, optimizing energy efficiency.

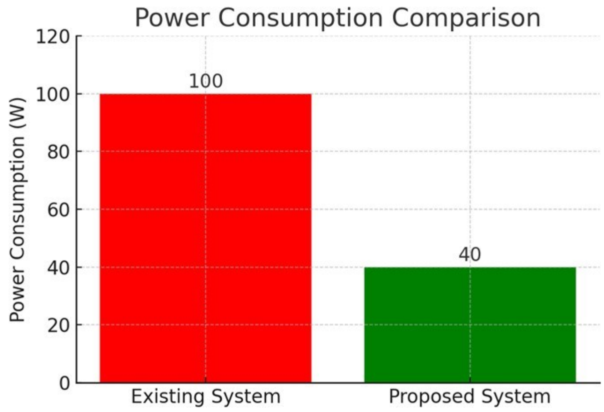


Figure 1: - Comparison of power consumption in Existing system and Proposed system.

The Power Consumption Comparison Graph clearly shows a significant reduction in energy usage by the proposed system:

- The Existing System consumes around 100 watts, primarily because streetlights stay on throughout the night regardless of necessity.
- The Proposed System consumes only 40 watts, thanks to the use of LDR sensors which activate lighting only during low-light conditions.

This optimization contributes to both energy savings and system sustainability, especially in remote hilly areas with limited power resources.

D. EXPERIMENTAL RESULTS:

When a vehicle is detected on the opposite side of a curve, the red LED turns on to warn the driver to slow down and proceed with caution. If there is no vehicle, the green LED lights up, indicating that it is safe to move forward.

Additionally, a white LED controlled by an LDR sensor switches on automatically during night or low-light conditions to improve visibility. This colour-based indication helps drivers make quick decisions and reduces the risk of accidents on blind curves.

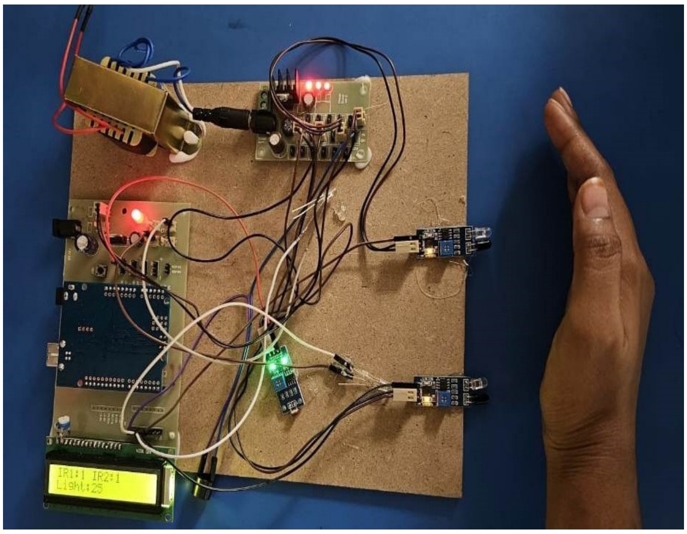


Figure 2: - Checking the presence of vehicle.

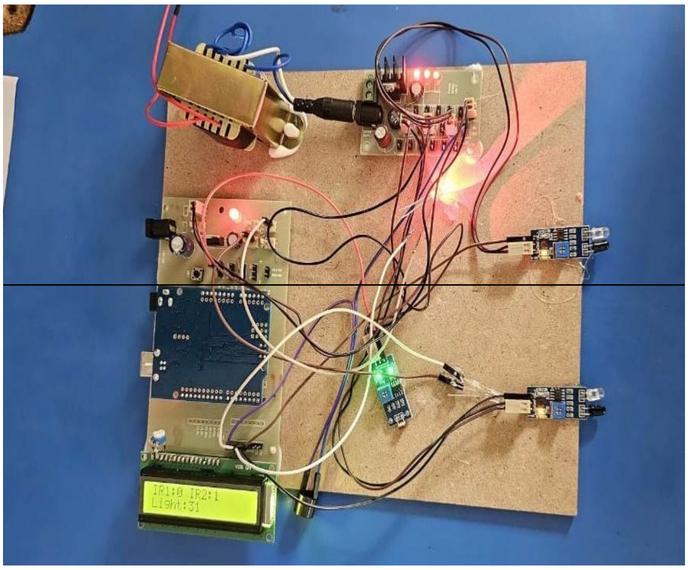


Figure 3: - RGB Indication and Buzzer to alert the drivers.

V. CONCLUSION

The objective of this model is to enhance road safety in curved hilly areas. Accidents at curves can be reduced by alerting drivers on both sides using infrared sensors, LED indicators, and an alarm system controlled by an Arduino microcontroller. The model also ensures energy efficiency by using LDR sensors to optimize streetlight operation based on ambient light conditions. This cost-effective solution aims to prevent accidents and improve road safety, ultimately saving numerous lives in hazardous hilly regions.

VI. REFERENCES

[1] SmDwaipayan Saha1*, Indrani Mukherjee2, Jesmin Roy3, Sumanta Chatterjee4, “Smart Safety and Accident Prevention System for Mountain Roads” International Journal of Computer Sciences and Engineering Research Paper Vol.-8, Special Issue-1, pp. 16-18(Feb 2020).

[2] Deepthi Jha, Harshit Sharma, Priyanshu, “Smart Road Safety and Automatic Vehicle Accident Prevention System for Mountain Roads” International Journal of Engineering and Technical Research (IJETR) ISSN: 2321-0869 (O) 2454-4698 (P), Volume 10, Issue 6, pp. 17-19 (June 2020).

[3] Aravinda B1, Chaithralakshmi C1, Deeksha1, Ashutha K2, “Sensor Based Accident Prevention System’’ INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING(IJIREEICE) Vol. 4, Issue 6, pp. 14-17 (June
4 2016).

[4] Shubham Verma1, Umesh Kumar Singh2, Vivek Kumar3, Aakansha Singh4, “SMART ROAD SAFETY AND VEHICLE ACCIDENT PREVENTION SYSTEM FOR MOUNTAIN ROAD’’ National Conference on Industry 4.0(NCI-4.0), Pp. 134-140(2020).

[5] Mrs. Y. Lavanya, M. Monika Rani, M. Sai Swaroop, P. Raja, Y. Rajesh, Dr. L. Bharathi, “Smart Road Safety and Vehicle Accident Prevention System for Mountain Roads’’ JAC: A Journal of Composition Theory Volume XIV, Issue VIII, pp. 201-207 (AUGUST 2021).

[6] Y. A. Badamasi, “The working principle of an Arduino,” in 2014 11th International Conference on Electronics, Computer and Computation (ICECCO), pp. 1–4 (2014).

[7] Assist. Lec. Karrar S. Faraj, “printed circuit board manufacturing’ ’Al-Israa University College Computer Techniques Engineering Department, Workshops Report, First Stage (2019- 2020).