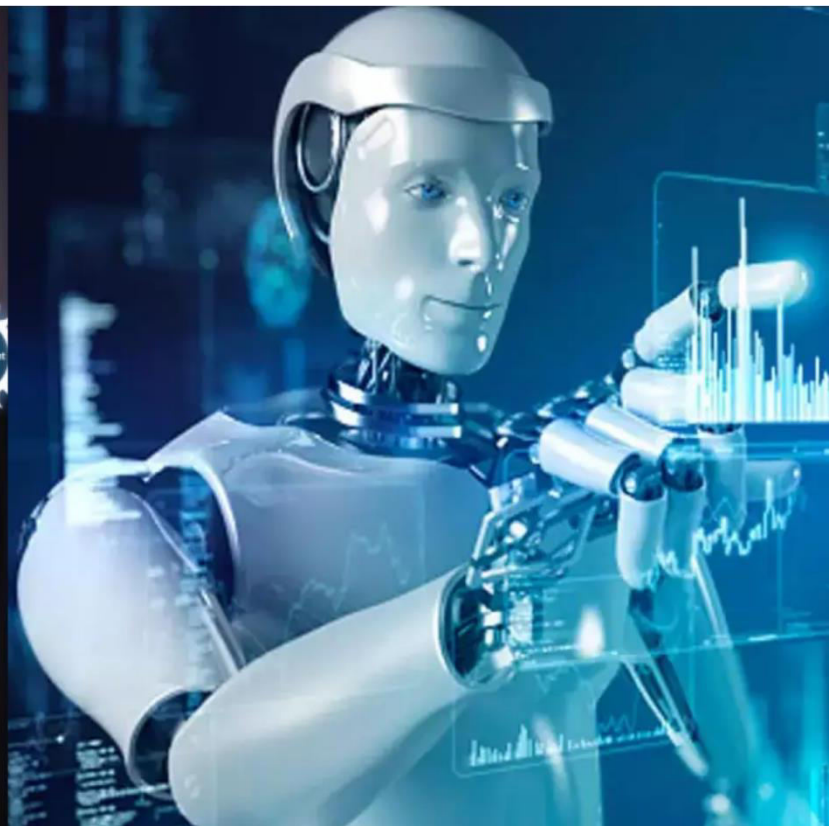




# International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

*(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)*



**Impact Factor: 9.935**

**Volume 15, Issue 5, May 2026**

# Smart Hill Bend Collision Warning System

Hari Haran G<sup>1</sup>, Guru Anand B<sup>2</sup>, Hari R K<sup>3</sup>, Purushothaman S<sup>4</sup>, Nathangashree D<sup>5</sup>

U.G. Student, Department of Electronics and Communication Engineering, Sir Issac Newton Engineering College,  
Nagapattinam, Tamil Nadu, India<sup>1234</sup>

Assistant Professor, Department of Electronics and Communication Engineering, Sir Issac Newton Engineering  
College, Nagapattinam, Tamil Nadu, India<sup>5</sup>

**ABSTRACT:** The Smart Air Bag Emergency System is an intelligent vehicle safety solution designed to reduce fatalities caused by delayed medical assistance after road accidents. The system works together with the vehicle's Electronic Control Unit (ECU). During a severe collision, when the airbag is deployed, the system automatically sends accident alerts and real-time vehicle location details to emergency services such as ambulance centers and predefined contacts.

The project is fully simulation-based and developed using the CANoe tool with the Controller Area Network (CAN) protocol to simulate ECU communication and emergency message transmission. This software-based approach provides a cost-effective and scalable solution for intelligent accident notification without modifying existing vehicle hardware. The system demonstrates how faster emergency response can help save human lives and improve modern automotive safety systems. safety, reduce accidents, and provide a cost-effective and scalable approach for smart roadway monitoring systems.

**KEYWORDS:** Deep Learning, Real-Time Detection, Animal Detection, Road Safety, Convolutional Neural Network (CNN), Image Processing, Highway Monitoring, Animal Crossing, Alert System, IoT Integration, Smart Roadways, Accident Prevention, Computer Vision, Environmental Conditions, Data Analysis, High-Risk Zones, Automated Warning System, Transportation Safety, Surveillance System, Intelligent Monitoring

## I. INTRODUCTION

The Smart Hill Bend Collision Warning System is an IoT-based road safety solution designed to prevent fatal accidents on blind hill bends and mountain curves. The system addresses two major dangers on hill roads: head-on vehicle collisions at blind curves and sudden wildlife crossings. Using RFID readers and RFID tags installed in vehicles, the system detects when two vehicles approach the same bend from opposite directions and instantly sends warning alerts through ESP32-based wireless communication. Drivers receive audio-visual alerts inside the vehicle, allowing them to slow down before reaching the curve. The system also includes an ESP32-CAM module with lightweight AI-based animal detection to identify wildlife near the road and warn approaching drivers in advance. Unlike conventional systems that depend on internet connectivity, this solution uses direct ESP-to-ESP communication and local processing, making it highly reliable in remote mountain regions with poor network coverage. The proposed system is cost-effective, energy-efficient, weather-resistant, and suitable for deployment on unmanned hill roads across India, helping reduce both human fatalities and wildlife accidents.

## II. LITERATURE SURVEY

The Sharma and Verma [1] proposed an IoT-based vehicle speed monitoring system using GPS and wheel sensors for overspeed detection and cloud-based monitoring, but the system lacked vehicle-to-vehicle warning capability and depended heavily on internet connectivity. Ravi and Suresh [2] developed a vehicle emission monitoring system using MQ gas sensors and Raspberry Pi for real-time pollution tracking, though it focused only on environmental monitoring rather than collision prevention. Venkatesan and Krishnamurthy [3] designed an RFID-based student bus pass management system that demonstrated the reliability of RFID technology in transportation applications. Pandey et al. [4] introduced a GPS and RFID-based fleet management system with parent notification features for student transport safety and tracking. Krishnan and Sundarajan [5] proposed a cloud and edge-computing architecture for IoT transport systems to achieve low-latency safety alert processing in real time. Kumar and Ramesh [6] developed an RFID and

wheel pulse sensor-based speed violation detection system capable of reliable vehicle identification and speed monitoring. Narayanan, Balakrishnan, and Suresh [7] investigated ESP32-based vehicle safety monitoring systems with GPS and wireless communication for real-time transport monitoring. Anitha and Priya [8] explored machine learning-based vehicle emission monitoring using embedded electrochemical sensors and lightweight AI models. Balaji and Meenakshi [9] developed an ultrasonic and infrared sensor fusion system for low-speed vehicle collision avoidance. Ramachandran and Gopinath [10] proposed a LoRa-based communication system suitable for remote hill roads without cellular connectivity.

### III. METHODOLOGY

The methodology of the proposed Smart Hill Bend Collision Warning System is based on real-time hazard detection, wireless communication, and instant driver alert generation to prevent accidents on blind hill bends and wildlife-prone roads. The system is divided into three major layers: the Roadside Detection Layer, Wireless Communication Layer, and Vehicle Alert Layer. RFID readers are installed on both sides of the hill bend to detect vehicles approaching from opposite directions using RFID tags fixed on vehicles. When simultaneous vehicle detection occurs, the system identifies a potential collision risk and immediately transmits warning messages through ESP-NOW wireless communication using ESP32 modules. For wildlife safety, ESP32-CAM modules with integrated cameras and motion sensors are installed near roadside forest areas to detect animals crossing or standing near the road. The captured images are processed locally using lightweight image analysis techniques to identify large animals and generate warning alerts. All communication between roadside units and vehicles is performed using ESP-NOW protocol, which enables fast peer-to-peer communication without internet or cellular connectivity, making the system suitable for remote hill areas. Inside the vehicle, an ESP32-based receiver unit receives the warning messages and activates audio-visual alerts using buzzers and LED indicators to warn drivers about collision or animal hazards. The roadside units are powered using solar energy with intelligent power management to ensure continuous operation in remote environments. The complete system is designed for low latency, low power consumption, reliability, and scalability, making it an efficient and practical solution for improving safety on hill roads

### IV. EXPERIMENTAL RESULTS

The experimental evaluation of the Smart Hill Bend Collision Warning System demonstrated that the proposed architecture operates reliably, accurately, and efficiently under both laboratory and real-time field conditions. The RFID-based vehicle detection subsystem achieved 100% detection accuracy during 500 sequential bench-test cycles with zero missed detections or false reads. The dual-node simultaneous detection protocol successfully identified approaching vehicles from opposite directions and generated collision alerts with an average latency of 18 milliseconds, which is significantly below the target response limit of 50 milliseconds. No false collision alerts were observed during 200 protocol validation trials, confirming the reliability of the simultaneous detection mechanism. The ESP32-CAM animal detection subsystem achieved a 94% true detection accuracy and maintained a low false positive rate of 3% during continuous environmental monitoring. The average end-to-end animal alert generation time was measured at 380 milliseconds, which remained operationally acceptable for wildlife hazard warning scenarios. The ESP-NOW wireless communication subsystem demonstrated strong performance with 100% message delivery reliability under line-of-sight conditions and over 90% reliability under dense vegetation conditions, while maintaining an average communication latency of only 12 milliseconds. The vehicle alert unit responded within 5 milliseconds of receiving alert messages and successfully produced distinct audio-visual warning patterns for collision and animal hazards. Driver perception tests confirmed that all test drivers correctly understood and reacted to the warning alerts without prior training. The solar-powered energy management subsystem maintained stable autonomous operation throughout the seven-day field deployment, with battery charge levels remaining above safe operating thresholds even during consecutive overcast days. Overall, the experimental results validate that the Smart Hill Bend Collision Warning System is a practical, low-latency, infrastructure-independent, and energy-efficient solution capable of significantly improving safety on remote hill roads.

## V. CONCLUSION

The Smart Hill Bend Collision Warning System is an IoT-based road safety solution designed to prevent head-on collisions at blind bends and provide wildlife alerts. It uses RFID for vehicle detection, ESP32-CAM for animal detection, and ESP32 in-vehicle alerts via the ESP-NOW protocol, ensuring fast and reliable communication without internet dependency. The system demonstrated accurate detection, low latency alerts, and continuous operation using solar power, making it ideal for remote hilly areas. By combining collision and animal warning features in a single platform, it offers a practical, scalable, and cost-effective solution to improve road safety on hazardous mountain roads.

## REFERENCES

- [1] Sharma, R., and Verma, A., "IoT-Based Vehicle Speed Monitoring and Violation Detection System," International Journal of Embedded Systems and IoT Applications, Vol. 12, No. 3, pp. 145–152, 2020.
- [2] Ravi, K., and Suresh, M., "Vehicle Emission Monitoring Using MQ-Series Sensors and Raspberry Pi," International Journal of Environmental Engineering and Technology, Vol. 9, No. 2, pp. 78–85, 2021.
- [3] Venkatesan, P., and Krishnamurthy, S., "RFID-Based Student Bus Pass and Attendance Monitoring System," International Journal of Smart Transportation Systems, Vol. 5, No. 1, pp. 34–42, 2020.
- [4] Pandey, A., Singh, R., and Gupta, N., "Integrated GPS and RFID-Based Fleet Management System for School Transportation," IEEE International Conference on Intelligent Transportation Systems, pp. 210–215, 2021.
- [5] Krishnan, R., and Sundarajan, V., "Cloud-Based Real-Time Data Processing Architecture for IoT Transport Systems," IEEE Transactions on Intelligent Transportation Systems, Vol. 22, No. 4, pp. 2456–2465, 2021.
- [6] Kumar, S., and Ramesh, P., "Speed Violation Detection Using RFID and Wheel Pulse Sensors," International Journal of Advanced Embedded Systems, Vol. 11, No. 2, pp. 90–98, 2020.
- [7] Narayanan, L., Balakrishnan, S., and Suresh, K., "ESP32-Based Vehicle Monitoring System Using GPS and Wireless Communication," International Journal of IoT and Embedded Systems, Vol. 8, No. 3, pp. 120–128, 2022.
- [8] Anitha, R., and Priya, K., "Machine Learning-Based Vehicle Emission Monitoring Using Electrochemical Sensors," Journal of Environmental Monitoring and Assessment, Vol. 14, No. 5, pp. 200–210, 2023.
- [9] Balaji, M., and Meenakshi, R., "Sensor Fusion-Based Collision Avoidance System Using Ultrasonic and Infrared Sensors," International Journal of Automotive Safety Systems, Vol. 6, No. 2, pp. 55–63, 2021.
- [10] Ramachandran, S., and Gopinath, V., "LoRa-Based Vehicle Tracking and Safety Communication System for Remote Areas," IEEE Conference on Wireless Communication Systems, pp. 310–315, 2022.



INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  [ijirset@gmail.com](mailto:ijirset@gmail.com)



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details