

Smart Zebra Crossing System with Automated Barricade and Violation Detection Using IoT

Prof M.B. Nigade¹, Amarnath Gupta², Aditya Gunjal³, Sahil Bhagat⁴, Sharvari Haldekar⁵,
Vaishnavi Hirmukhe⁶

¹Assistant Professor, Dept. Of Mechanical Engineering AISSMS IOIT, Pune, India

^{2,3,4,5,6} Student, Dept. Of Applied Sciences and Engineering, AISSMS IOIT, Pune India

Abstract—Recent developments in intelligent transportation systems have focused on improving pedestrian safety at road intersections using automation and smart technologies. Various researchers have proposed solutions using Internet of Things (IoT), computer vision and sensorbased systems to reduce accidents at zebra crossings. Study published in 2023 introduced an IoT based-smart pedestrian crossing architecture that integrates sensors and communication modules to manage pedestrian movement efficiently. The system was designed to detect pedestrian presence and control traffic signals accordingly. However, the proposed model mainly focused on signal automation and lacked a physical mechanism to restrict vehicle from violation crossing rules. From the existing literature it is evident that while many systems provide smart monitoring and signal control, there is lack of integrated solutions that combine pedestrian safety, traffic regulation and physical enforcement mechanisms. Most existing approaches depend on driver behaviour rather than enforcing compliances. To address these limitations the proposed system introduces and IoT based smart zebra crossing integrated with an automated barricade mechanism, which physically prevents vehicles from crossing during pedestrian movement. The system also ensures sensor-based detection and emergency vehicle prioritization.

Index Terms—Smart Zebra Crossing, Internet of Things (IoT), Pedestrian Safety, Traffic Management System, Automated Barricade, Violation Detection

I. INTRODUCTION

Road safety has become a major concern worldwide due to the increasing number of vehicles and frequent traffic rule violations. According to recent reports, a significant number of road accidents occur at intersections and pedestrian crossings, where both

vehicles and pedestrians interact in an unregulated manner. Zebra crossings are specifically

designed to provide safe passage to pedestrians; however, in many real-world situations, drivers fail to follow traffic rules and often stop beyond the designated line or ignore red signals. This creates unsafe conditions and increases the risk of accidents. In urban areas, the lack of coordination between pedestrian movement and vehicle flow further

worsens the situation. Pedestrians may attempt to cross roads without proper signal awareness, while vehicles may continue moving even when pedestrians are present. Existing traffic management systems primarily rely on signal control and manual enforcement, which are not always effective in ensuring compliance. Although modern intelligent transportation systems have introduced automation and monitoring features, many of them still depend on driver behavior rather than enforcing strict safety measures. With the advancement of Internet of Things (IoT) technology, it has become possible to design smarter and more responsive traffic control systems. Sensor-based solutions using devices such as ultrasonic sensors, infrared sensors, and sound sensors can detect vehicles, pedestrians, and emergency situations in real time. These technologies enable dynamic control of traffic signals and improve decision-making processes. However, most existing solutions focus on monitoring and alerting rather than physically preventing traffic violations. To overcome these limitations, this paper proposes a smart zebra crossing system with an automated barricade and violation detection mechanism. The system is designed to ensure pedestrian safety by physically

restricting vehicle movement during crossing periods. It integrates multiple sensors with a microcontroller to monitor real-time conditions and control traffic accordingly. Additionally, the system includes an emergency vehicle detection feature that overrides normal operation to provide immediate clearance when required. The proposed approach aims to create a safer and more efficient traffic environment by combining automation, real-time sensing, and physical enforcement. This system not only improves pedestrian safety but also enhances overall traffic management, making it suitable for implementation in smart city infrastructure.

II. LITERATURE REVIEW

Several studies have focused on improving pedestrian safety and traffic management through IoT and automation systems: -Research published in 2023 introduced an IoT-based smart pedestrian crossing architecture that integrates sensors and communication modules for efficient pedestrian movement and automatic traffic signal control.

-Various intelligent transportation studies proposed sensorbased zebra crossing systems using ultrasonic sensors and infrared sensors for vehicle and pedestrian detection.

-Several researchers examined automated traffic signal management systems to reduce accidents and improve pedestrian safety at road intersections.

-IoT-based traffic management models focused on real-time monitoring and dynamic control of vehicle movement using microcontrollers and communication technologies.

-Recent smart city transportation projects emphasized automation techniques for regulating traffic flow and prioritizing emergency vehicles.

-Existing research works mainly concentrated on monitoring and signal automation but lacked a physical barricade mechanism to prevent vehicle violations during pedestrian crossing.

These efforts collectively highlight the need for an integrated approach that combines real-time sensing, automated signal control, pedestrian safety systems, and physical barricade enforcement for effective traffic management and accident prevention.

III. OBJECTIVES

- To improve pedestrian safety at zebra crossings using IoT-based automation systems.
- To detect the presence of vehicles and pedestrians using ultrasonic and infrared sensors.
- To develop an automated barricade mechanism that physically restricts vehicle movement during pedestrian crossing.
- To implement automatic traffic signal control and emergency vehicle prioritization for efficient traffic management.

IV. METHODOLOGY

The methodology for this study includes the following steps:

Step 1: System Design

The overall smart zebra crossing system architecture was designed by integrating sensors, traffic signals, automated barricades, and a microcontroller-based control unit.

Step 2: Component Selection

Components such as Arduino UNO, ultrasonic sensor, infrared sensor, sound sensor, servo motor, LEDs, and buzzer were selected based on system requirements and operational efficiency.

Step 3: Sensor Integration and Programming

All sensors and actuators were connected to the Arduino UNO. The control logic was programmed to detect pedestrian movement, vehicle presence, and emergency vehicle sirens. Step 4: Traffic Control and Barricade Operation

The system was tested for automatic traffic signal operation and barricade movement during pedestrian crossing conditions. The servo motor controlled the barricade mechanism based on sensor inputs.

Step 5: Emergency Vehicle Detection

A sound sensor was used to detect emergency vehicle sirens. When detected, the system automatically overrode normal traffic operation to provide immediate vehicle clearance. Step 6: System Testing and Validation

The complete setup was tested under different traffic scenarios to evaluate pedestrian safety, traffic regulation, sensor response, and automated barricade performance.

Experimental Setup:

(Include details on your experimental setup, such as apparatus, materials, methods used for testing, etc. This section would typically contain photographs, diagrams, or tables to support the description.)

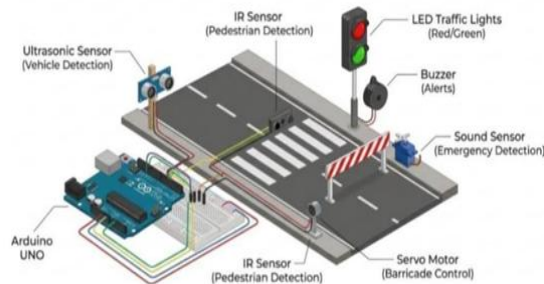


Fig. 1. Circuit Diagram

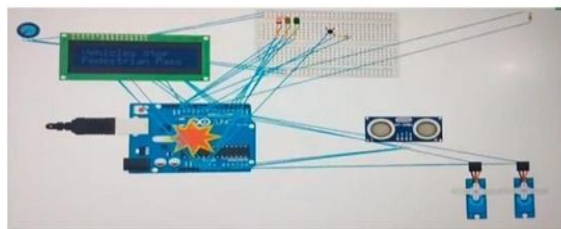


Fig. 2. Simulation Diagram

V. CONCLUSION

The proposed IoT-based smart zebra crossing system with an automated barricade and violation detection mechanism provides an effective solution to improve pedestrian safety at road intersections. By integrating sensor-based detection with a physical enforcement system, the model overcomes the limitations of traditional traffic signals that rely heavily on driver compliance. The automated barricade ensures that vehicles are physically restricted during pedestrian crossing, thereby reducing the chances of accidents. The system demonstrates reliable performance in detecting vehicles, pedestrians, and emergency situations through the use of ultrasonic, infrared, and sound sensors. The integration of automated traffic signals, pedestrian gates, and emergency vehicle prioritization enhances both safety and traffic management efficiency. Experimental testing on the prototype model confirmed that the system responds effectively under different traffic conditions and improves coordination between pedestrians and vehicles. From a practical perspective, the system offers a cost-effective and scalable solution for urban traffic management. It can be implemented in high-

risk areas such as school zones, hospitals, and busy intersections. Future enhancements, such as integration with computer vision and cloud-based monitoring, can further improve system efficiency and reliability.

REFERENCES

- [1] "Smart Pedestrian Crossing System Using IoT and Machine Learning" (2024) Uses sensors + ML to detect pedestrian intent and control signals automatically.
- [2] "IoT-Based Intelligent Traffic Management System for Smart Cities" (2023) Covers smart signals, pedestrian prioritization, and real-time traffic control.
- [3] "Automated Zebra Crossing with Vehicle Detection and Alert System" (2022) Focuses on ultrasonic + IR sensors to stop vehicles at crossings.
- [4] "Deep Learning-Based Traffic Violation Detection System" (2024) Uses cameras + AI to detect red-light and zebra crossing violations.
- [5] "Smart Crosswalk Safety System Using Computer Vision" (2023) Detects pedestrians using cameras and controls traffic lights dynamically.
- [6] "IoT -Based Smart Traffic Light Control with Emergency Vehicle Priority" (2022) Includes siren detection similar to your project idea.
- [7] "Edge AI-Based Road Safety Monitoring System" (2025) Uses edge computing for real-time violation detection without cloud delay.
- [8] "Design of Smart Pedestrian Crossing System Using Arduino and Sensors" (2021) Very close to your hardware-based model (Arduino + IR + ultrasonic).
- [9] "Vision-Based Intelligent Transportation System for Pedestrian Safety" (2023) Combines AI vision + traffic analytics for safer crossings.
- [10] "Smart Traffic Control System Using IoT and Cloud Integration" (2022)