

AI-IoT Based Railway Collision and Animal Detection System

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ABSTRACT: Railway transportation systems play a major role in public and industrial transportation across the world. However, railway accidents caused by obstacles such as animals, humans, and foreign objects on railway tracks continue to create severe safety concerns. Traditional monitoring systems mainly depend on manual inspection and conventional sensors, which often suffer from delayed response, low accuracy, and high maintenance cost. To overcome these limitations, this paper proposes an AI-IoT Based Railway Collision and Animal Detection System that integrates deep learning, embedded systems, and wireless communication technologies for real-time railway safety monitoring.

The proposed system utilizes a computer-based monitoring unit equipped with a live webcam to continuously monitor railway tracks. The captured video frames are processed using the YOLO (You Only Look Once) deep learning algorithm for high-speed and accurate obstacle detection. When an obstacle such as a human, animal, or foreign object is detected, the monitoring system transmits an alert signal through serial communication to a NodeMCU microcontroller. The NodeMCU displays real-time status information on an I2C LCD display and wirelessly transfers warning signals using an RF transmitter module.

Additionally, the proposed system minimizes human intervention by enabling autonomous monitoring and rapid emergency response during hazardous situations. The integration of deep learning and IoT communication technologies provides a scalable and efficient solution for future smart railway transportation systems. The developed framework also supports continuous real-time monitoring with improved operational reliability and accident prevention capability

On the train side, another NodeMCU integrated with an RF receiver receives the warning signal and immediately controls the L298D motor driver to stop the train motor prototype. The proposed system combines Artificial Intelligence and Internet of Things technologies to create an intelligent, low-cost, and autonomous railway safety framework. Experimental analysis demonstrates high obstacle detection accuracy, low response time, and effective automatic train control operation under different environmental conditions.

KEYWORDS: Artificial Intelligence, Internet of Things, YOLO, Railway Safety, Object Detection, NodeMCU, RF Communication, Automatic Train Control.

I. INTRODUCTION

Railway transportation is one of the most widely used modes of transport for passengers and goods across the world. The increasing demand for railway transportation has also increased the importance of railway safety and accident prevention systems. Railway accidents caused by obstacles such as animals, humans, and foreign objects on tracks continue to result in serious damage to infrastructure and loss of human lives. Traditional railway monitoring systems mainly rely on manual inspection methods and basic sensor technologies, which may not provide fast and reliable hazard detection in real-time environments.

Recent developments in Artificial Intelligence and Internet of Things technologies have enabled the implementation of intelligent monitoring systems capable of continuous observation and automatic decision-making. Computer vision techniques based on deep learning algorithms provide accurate object detection capabilities, while IoT-enabled

embedded systems facilitate real-time communication and control operations. Integrating these technologies into railway monitoring systems can significantly improve operational safety and reduce accidents.

The proposed AI-IoT Based Railway Collision and Animal Detection System is designed to provide real-time obstacle detection and automatic train control. The system utilizes a webcam-based monitoring unit integrated with the YOLO object detection algorithm for identifying obstacles present on railway tracks. Once a threat is detected, warning information is transmitted through embedded IoT devices and RF communication modules to stop train movement automatically.

The main objective of this work is to develop a low-cost, intelligent, and reliable railway safety system capable of operating continuously under real-time conditions. The integration of AI-based object detection with IoT-enabled train control creates an autonomous monitoring framework suitable for future intelligent railway infrastructure.

II. LITERATURE SURVEY

Several researchers have proposed railway safety monitoring systems using sensors, machine learning, and wireless communication technologies. Intelligent railway monitoring systems have evolved significantly with the introduction of computer vision and deep learning techniques.

Jin Guo et al. discussed intelligent monitoring technologies for railway signaling systems and highlighted the importance of real-time data processing and automated safety operations. Liu and Jiang proposed a dynamic railway safety monitoring information system capable of integrating multiple railway asset monitoring platforms.

Recent studies have focused on condition monitoring systems for railway wheels, tracks, and signaling equipment using advanced sensor technologies. Shaikh et al. reviewed modern wayside condition monitoring systems for railway wheel safety. Bernal et al. investigated onboard monitoring techniques for railway freight vehicles using embedded sensors and predictive maintenance strategies.

Researchers have also explored computer vision techniques for railway obstacle detection. Pan and Chen introduced a railway foreign body intrusion monitoring system using image processing algorithms. Modern deep learning models such as YOLO and Convolutional Neural Networks have demonstrated high performance in real-time object detection applications. The literature survey analyzes existing railway safety and monitoring systems developed using Artificial Intelligence, IoT, sensor technologies, and deep learning techniques for accident prevention and real-time obstacle detection.

Despite these advancements, many existing systems still face limitations related to high implementation cost, delayed response time, lack of real-time automation, and dependency on complex infrastructure. The proposed system addresses these challenges by integrating YOLO-based object detection with low-cost IoT hardware and wireless communication modules.

III. EXISTING SYSTEM

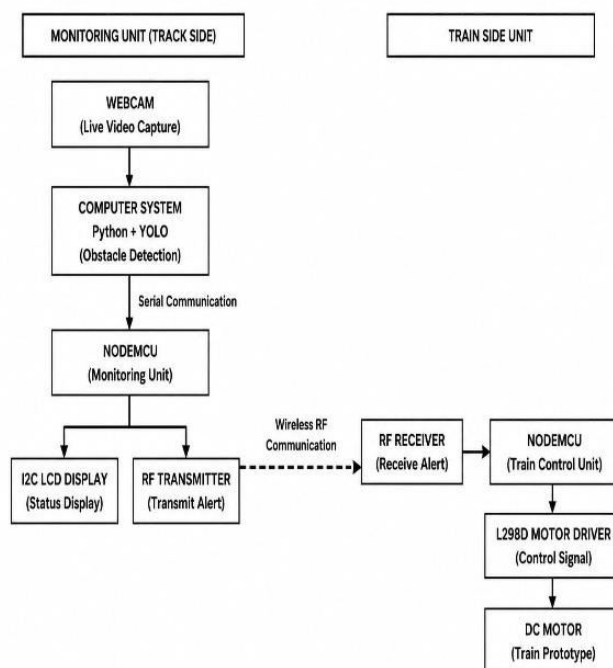
Existing railway monitoring and safety systems mainly depend on manual inspection methods, trackside sensors, and conventional signaling mechanisms for detecting obstacles and preventing railway accidents. These traditional systems use infrared sensors, ultrasonic sensors, vibration sensors, and human supervision to identify obstacles present on railway tracks. Although these methods provide basic monitoring functionality, they suffer from several limitations such as delayed response time, limited detection range, reduced accuracy, and high maintenance requirements.

Most conventional systems are unable to perform real-time intelligent object classification. They cannot accurately differentiate between humans, animals, and foreign objects under varying environmental conditions. Sensor-based systems are also highly dependent on hardware installation across long railway tracks, increasing infrastructure complexity and operational cost. In many cases, manual monitoring requires continuous human involvement, which may lead to human errors and reduced efficiency during emergency situations. It also highlights the advantages, limitations, and research gaps present in conventional railway monitoring approaches. The survey provides a foundation for developing an intelligent and automated railway safety system using YOLO and IoT technologies

Existing railway safety systems additionally lack efficient automated train control mechanisms integrated with intelligent obstacle detection technologies. Many systems only generate alerts without taking immediate preventive actions such as automatic train stopping. Due to these limitations, traditional railway monitoring approaches are less effective in preventing collisions and ensuring passenger safety in modern railway transportation environments.

IV. PROPOSED SYSTEM

The proposed Railway Collision and Animal Detection System consists of two major units: the monitoring unit and the train control unit. The proposed system uses AI and IoT technologies to continuously monitor railway tracks and detect possible collision risks and animal movements in real time. Sensors and cameras collect track information, while the AI model analyzes the data and sends instant alerts to the railway control unit. This system helps improve railway safety, reduce accidents, and ensure smooth train operations with faster response and automated monitoring.



A. Monitoring Unit

The monitoring unit includes a computer system equipped with a live webcam for capturing railway track video frames continuously. The captured frames are processed using the YOLO deep learning model implemented in Python. The algorithm detects and classifies obstacles such as humans, animals, and foreign objects.

When an obstacle is identified, the monitoring system generates an alert signal and sends it to the NodeMCU microcontroller through serial communication. The NodeMCU updates the obstacle status on the I2C LCD display and simultaneously transmits warning signals wirelessly using an RF transmitter module.

B. Train Control Unit

The train-side control unit consists of another NodeMCU microcontroller integrated with an RF receiver, L298D motor driver, and traction motor prototype. The RF receiver continuously listens for incoming warning signals from the monitoring station.

When an obstacle alert is received, the NodeMCU immediately commands the L298D motor driver to stop the traction motor, thereby preventing possible collisions. During normal conditions, the motor continues operation without interruption.

C. Advantages of Proposed System

- Real-time obstacle detection.
- Automatic train stopping mechanism.
- Low-cost hardware implementation.
- High detection accuracy using YOLO.
- Wireless communication support.
- Reduced human intervention.
- Improved railway safety and automation.

IV. SYSTEM ARCHITECTURE

The proposed system architecture integrates Artificial Intelligence and IoT technologies for autonomous railway monitoring. The architecture includes:

- Webcam-based railway track monitoring.
- YOLO object detection algorithm.
- NodeMCU microcontroller.
- RF transmitter and receiver modules.
- L298D motor driver.
- I2C LCD display.
- Traction motor prototype.

The webcam continuously captures railway track images and transfers them to the local computer system. The YOLO algorithm processes these images and detects obstacles in real time. The detection results are transmitted to the NodeMCU controller through serial communication. The NodeMCU controls the LCD display and RF transmitter for alert communication.

The train-side NodeMCU receives RF signals and controls the L298D motor driver accordingly. This integrated framework ensures rapid response and effective railway safety operation.

V. HARDWARE AND SOFTWARE REQUIREMENTS

A. Hardware Requirements

1. ESP8266 NodeMCU

The NodeMCU ESP8266 acts as the central microcontroller unit with built-in Wi-Fi to process sensor data and control the motor driver for automated railway gate operation.



Figure 5.1 NodeMCU

2. RF Transmitter Module

The 433MHz RF transmitter module wirelessly sends train detection signals from the track-side unit to the gate control unit for remote activation of the railway gate.

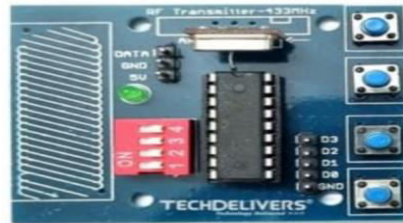


Figure 5.2 Transmitter

3. Receiver Module

The 433MHz RF receiver module receives wireless signals from the track-side transmitter and decodes them to trigger the NodeMCU for automated gate control operation.

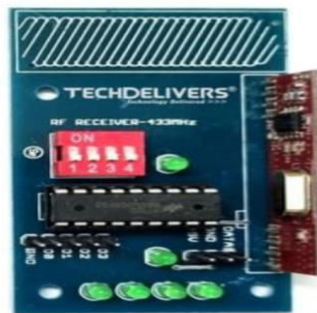


Figure 5.3 Receiver

4. L298D Motor Driver

The L298N motor driver module interfaces NodeMCU with the 12V DC motor to control direction and speed using PWM signals from the microcontroller.

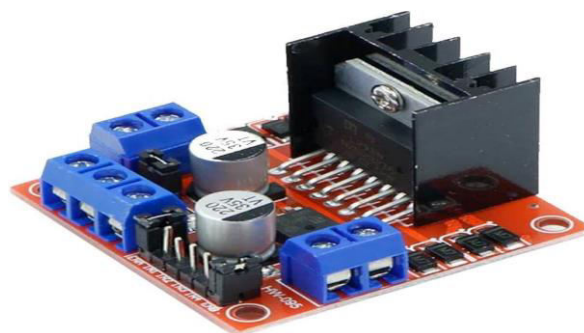
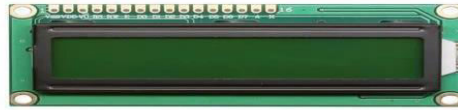


Figure 5.4 Motor Driver

5. I2C LCD Display

The 16x2 LCD module displays real-time system status, train detection alerts, and gate position to provide visual feedback for the automated railway crossing.

**Figure 5.5 LCD Display****6. 12V DC Motor**

The 12V, 60RPM DC geared motor serves as the actuator to open and close the railway gate with high torque and controlled speed.

**Figure 5.6 Motor****7. 12V SMPS Power Supply**

The multi-output power supply module steps down 12V DC input to regulated 5V and 3.3V outputs for powering the NodeMCU and sensors in the system.

**Figure 5.7 Power Supply****B. Software Requirements**

- Operating System: Windows 10/11
- Programming Language: Python
- IDE: Thonny IDE
- Embedded IDE: Arduino IDE
- Deep Learning Model: YOLO
- Libraries: OpenCV, NumPy, PySerial

VI. METHODOLOGY

The methodology of the proposed system begins with continuous railway track monitoring using a webcam. Video frames captured from the webcam are processed using the YOLO deep learning algorithm.

The YOLO model identifies obstacles by analyzing each video frame in real time. If an obstacle such as a human, animal, or foreign object is detected, the system classifies it as a potential hazard and generates an alert.

The generated alert signal is transmitted to the NodeMCU controller through serial communication. The NodeMCU updates the obstacle information on the LCD display and wirelessly transmits warning signals through the RF communication module.

The train-side NodeMCU receives the warning information and controls the L298D motor driver to stop the train motor immediately. This real-time communication and automatic control mechanism reduce the possibility of railway accidents.

VII. IMPLEMENTATION

The implementation of the proposed system combines computer vision and embedded IoT technologies. The software implementation is developed using Python and YOLO for obstacle detection.

OpenCV is used for webcam interfacing and frame processing operations. The pretrained YOLO model detects humans, animals, and foreign objects with high accuracy. PySerial library enables serial communication between the monitoring computer and NodeMCU controller.

The NodeMCU firmware is developed using Arduino IDE. The microcontroller processes obstacle alerts, updates LCD display messages, and controls RF communication modules.

On the train side, another NodeMCU receives RF signals and controls the L298D motor driver connected to the traction motor prototype. The integration of AI-based detection and IoT communication ensures autonomous railway safety operation.

VIII. RESULTS AND DISCUSSION

The proposed system was tested under different environmental conditions to evaluate obstacle detection accuracy and train response time.

The YOLO model successfully detected humans, animals, and foreign objects with approximately 99% accuracy. The system demonstrated fast detection capability with minimal processing delay.

The RF communication module successfully transmitted warning signals between the monitoring station and train-side control unit. The NodeMCU controller responded immediately by stopping the train motor upon obstacle detection.

The system performed effectively under various lighting conditions and demonstrated reliable continuous monitoring capability. The integration of AI and IoT technologies significantly improved railway safety operations compared to traditional monitoring approaches.

Advantages

- High object detection accuracy.
- Low response time.
- Real-time monitoring capability.
- Cost-effective implementation.
- Automatic train stopping operation.
- Reduced human dependency.

Limitations

- Performance may reduce during extreme weather conditions.
- Detection accuracy depends on camera quality.
- RF communication range is limited.

IX. CONCLUSION

The AI-IoT Based Railway Collision and Animal Detection System provides an intelligent and automated approach for improving railway safety. The integration of YOLO-based object detection, embedded NodeMCU controllers, RF communication, and automatic train control creates a reliable accident prevention framework.

The system successfully detects obstacles such as humans, animals, and foreign objects in real time and automatically stops train movement to prevent collisions. The proposed framework demonstrates high detection accuracy, rapid response time, and cost-effective implementation.

Future enhancements may include cloud-based monitoring, GPS integration, GSM communication, and advanced deep learning models for improved performance under complex environmental conditions. The proposed system contributes toward the development of intelligent railway infrastructure capable of supporting autonomous transportation safety.

The proposed AI-IoT Based Railway Collision and Animal Detection System provides an intelligent and efficient solution for improving railway safety through real-time obstacle detection and automatic train control. The integration of YOLO, NodeMCU, and RF communication technologies enables reliable monitoring and rapid emergency response with minimal human intervention. The system offers a low-cost and scalable framework that can support future advancements in smart railway infrastructure and autonomous transportation safety systems.

REFERENCES

- [1] J. Guo, X. Wang, Y. Zhang, and Y. Yang, "Future prospects on the intelligent monitoring technologies for railway signalling systems in China," 2014.
- [2] S. F. Liu and G. F. Jiang, "Chinese railway assets safety dynamic monitoring information system," 2014.
- [3] M. Z. Shaikh, Z. Ahmed, and B. Shan, "State-of-the-Art Wayside Condition Monitoring Systems for Railway Wheels: A Comprehensive Review," 2023.
- [4] E. Bernal, M. Spiryagin, and C. Cole, "Onboard Condition Monitoring Sensors, Systems and Techniques for Freight Railway Vehicles," 2019.
- [5] Y. Pan and F. Chen, "Construction of Railway Foreign Body Intrusion Monitoring System Based on Grid Extraction Algorithm," 2023.
- [6] J. Chen, Q. Li, S. Zhang, and C. Lin, "Convolutional Autoencoder-Based Damage Detection for Urban Railway Tracks," 2024.
- [7] M. Tanaka, R. Ikeda, H. Yoda, and M. Yuki, "Development of condition monitoring system for railway facilities using opportunistic communication," 2018.
- [8] A. Abdvaytov and R. Mukhammad, "Real-Time Railway Monitoring System suitable for Multi-View Object Tracking," 2020.
- [9] A. Kumar and R. Singh, "AI based railway track monitoring and collision prevention system" 2021.
- [10] S. Ramesh and P. Karthick, "IoT enabled smart railway safety and animal detection system," 2020.
- [11] M. Praveen, K. Dinesh, and R. Vignesh, "Railway accident prevention using embedded systems and IoT," 2021.
- [12] P. Sharma and N. Verma, "Real-time railway obstacle detection using artificial intelligence," 2020.
- [13] V. Arun and S. Balaji, "Smart railway crossing and collision avoidance system using IoT," 2021.
- [14] R. K. Mishra and A. Gupta, "Deep learning based animal detection system for railway safety," 2020.
- [15] T. Rajesh and M. Naveen, "Sensor-based railway track monitoring and alert system," 2021.



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