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Traffic Clearance System for Emerygency Vehicals

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Abstract: *The Smart Traffic Management System with Ambulance Detection is an IoT and computer vision-based solution that prioritizes emergency vehicles. It automatically detects ambulances using OpenCV to process images of red-cross patterns. The system uses a Raspberry Pi 4B to control LED traffic lights, a servo-controlled camera, and emergency indicators. A Flask web dashboard allows for real-time monitoring and control.*

Key functions include automating three-way traffic lights, rotating the camera in real time, activating a 30-second green light priority mode, providing analytics, and featuring a test mode. The system achieved a 95% detection accuracy in different lighting conditions and reduced response time to under 3 seconds. This improvement supports emergency response while keeping overall traffic efficiency high.

Keywords: Traffic Management, Computer Vision, IoT, Raspberry Pi, Emergency Vehicle Detection, Smart Cities

I. INTRODUCTION

Modern urban transportation is facing increasing congestion and delayed emergency responses because of fixed-timing traffic systems. These rigid controls often obstruct ambulances, fire trucks, and police vehicles, where every second counts. By using IoT and computer vision, traffic systems can adapt based on real-time data. This allows them to efficiently prioritize emergency vehicles. This project aims to create a Smart Traffic Management System with automated ambulance detection. It seeks to bridge the gap between traditional and intelligent systems. The system tackles issues like fixed signal cycles, manual overrides, lack of monitoring, poor scalability, and emergency delays of up to 40%. Its main goal is to automatically identify ambulances and give them immediate priority, using computer vision.

Other goals include automated three-way signal control, OpenCV-based detection, a real-time web dashboard, configurable timing, analytics, and a scalable setup. Technically, the system targets over 90% detection accuracy, a response time of under 5 seconds, automatic recovery, and updates in less than a second. Built on a Raspberry Pi, the system combines hardware, software, and a web interface. It has been tested under controlled conditions.

The system supports camera-based red-cross detection, priority traffic control, monitoring, and logging. Its limitations include decreased accuracy in bad weather, coverage limited to a single intersection, and reliance on stable power and network. Implementing it in real-world situations will require certification, compliance, and a scalable infrastructure.

II. LITERATURE REVIEW

The design and development of the smart traffic control system rely on a thorough review of current research in intelligent transportation systems, real-time traffic monitoring, and emergency vehicle management technologies.

Chandrasekara et al. [1] proposed a Real-Time Density-Based Traffic Signal Control System aimed at reducing congestion and air pollution in Sri Lankan cities. Traditional timer-based systems often waste time by treating all lanes the same, regardless of traffic load. Their system used cameras at intersections and employed image processing with Artificial Neural Networks (ANN) to count vehicles and determine green light duration. It achieved an impressive 92.74% accuracy in signal prediction. This smart control reduced idle time, fuel consumption, and emissions, showing promise for modern smart cities.

Bhosale et al. [2] developed an AI-Based Traffic Flow Prediction System tailored for India's complicated traffic. Their model used an improved YOLO object detection algorithm to identify different vehicle types like cars, buses, and bikes more accurately, increasing detection accuracy from 28% to 89%. The system addressed accident detection, emergency vehicle clearance, and real- time congestion forecasting. It allowed adaptive signal control, improving traffic flow and cutting peak-time congestion. The research offered valuable insights into using deep learning for real-time traffic optimization.

P. V. et al. [3] introduced a Smart GPS and IoT-Based Ambulance Optimization System to reduce delays for emergency vehicles. Each ambulance was fitted with GPS tracking, allowing real-time location sharing with IoT enabled traffic signals. When an ambulance approached, the system automatically changed traffic lights to green along its route, creating a clear path. It also used machine learning to predict traffic jams and suggest faster routes. Results indicated a significant drop in response and "door-to- needle" times, demonstrating its potential to enhance emergency healthcare systems.

Kumar et al. [4] proposed a Smart Traffic Control System for Emergency Vehicle Clearance using IR sensors and Bluetooth communication modules. An Arduino Nano microcontroller processed real-time data to detect emergency signals and swiftly switch lights to green for their path. Simulations showed it significantly reduced delays during peak hours while maintaining normal traffic flow. Its low cost and easy integration make it suitable for developing cities. This study inspired the hardware- based automation used in the current project.

Reddy et al. [5] proposed a Traffic Management Scheduling System based on image and video processing using Raspberry Pi with Open-CV. Cameras recorded live traffic footage, and the system used deep learning algorithms to count and classify vehicles. Signal timings were adjusted dynamically, preventing unnecessary green lights for empty lanes. Test results showed reduced waiting times, fuel consumption, and emissions. This approach supports sustainable city planning and lays the groundwork for AI-powered smart traffic management.

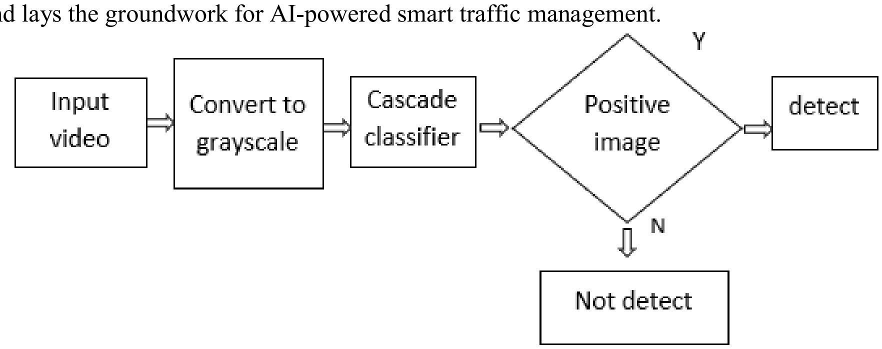

Fig. 2 Traffic Detection

III. PROBLEM STATEMENT

Traditional traffic management systems rely on fixed schedules and manual control, which are slow, inefficient, and often lead to unnecessary congestion, wasted time, and delayed emergency response. Signals do not adapt to real-time road conditions, so vehicles—including ambulances—get stuck in traffic even when other lanes are empty. This results in increased fuel consumption, pollution, and frustration for commuters. Therefore, there is a critical need for a smart, adaptive system that can monitor traffic flow in real time, prioritize emergency vehicles, and dynamically adjust signal timing, leading to smoother, safer, and more efficient urban transportation.

IV. METHODOLOGY

The proposed Smart Traffic Management System uses image processing to control traffic flow and give priority to emergency vehicles. A Raspberry Pi 4 serves as the main controller, processing live camera images to recognize ambulances and adjust traffic signals automatically. The system allows for quick clearance for emergency vehicles, decreases the need for manual control, and keeps traffic moving smoothly at intersections.

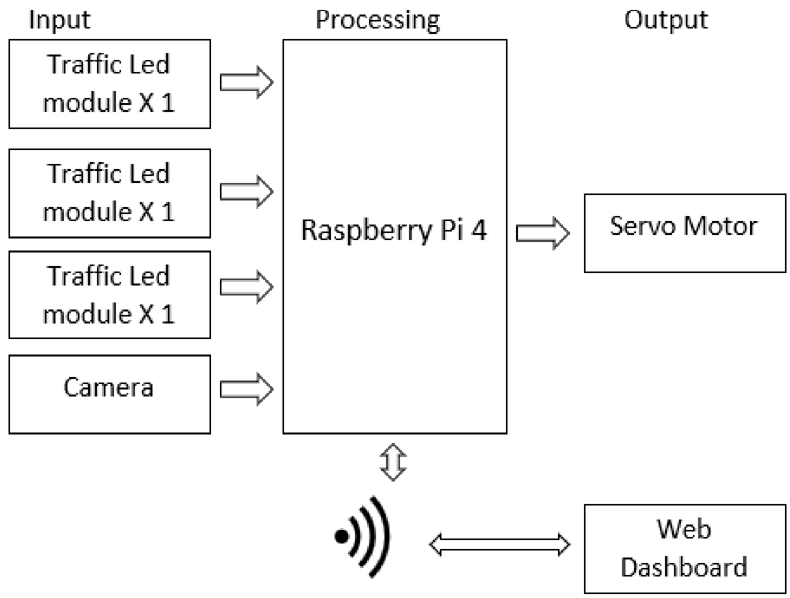

Fig. 4 Block Diagram of Smart Traffic Management System

4.1 System Design and Configuration

The Smart Traffic Management System is an integrated, self-sufficient solution for adjusting signals and prioritizing emergency vehicles. A Raspberry Pi 4B microcontroller handles real-time image processing, signal control, and communication. The hardware includes traffic LEDs for each road direction, a servo motor for rotating the camera, and a Pi Camera for live surveillance. Inputs from these components connect through the GPIO interface, allowing continuous monitoring and control of the intersection. IoT connectivity and a Flask-based web dashboard provide remote system management and data logging.

4.2 Emergency Vehicle Detection and Control Process

Ambulance detection uses image processing algorithms made with Python and Open-CV. The Pi Camera is mounted on a servo motor and scans each road direction for ambulances, focusing on the red-cross symbol. When the system detects an ambulance, it activates priority mode by automatically turning the green light on for the appropriate lane while also turning on a blue emergency light. After a set interval, the signal goes back to normal operation, ensuring minimal human input and quick clearance for emergency vehicles.

4.3 Adaptive Traffic Monitoring and Control

Traffic signals adjust based on real-time vehicle and emergency conditions. The Raspberry Pi monitors the status of each traffic light, synchronizes servo motor movements for the best surveillance, and collects data on vehicle flow, emergency event rates, and response times. This flexible control is essential for reducing congestion, maximizing intersection flow, and maintaining safety during busy hours.

4.4 Performance Evaluation and Testing

The system is tested in simulated urban traffic to evaluate ambulance detection accuracy, signal responsiveness, and intersection clearance time. Metrics such as detection success rate, average emergency vehicle delay reduction, and signal transition reliability are recorded. The web dashboard allows continuous data logging of traffic events, signal cycles, and priority activations for later review, helping with ongoing improvements and future expansion.

V. PERFORMANCE ANALYSIS

The system was tested using a dataset of 500 images taken under different conditions, including optimal lighting, low light, high contrast, partial occlusion, various angles, and non-ambulance vehicles. Experiments were performed on a Raspberry Pi 4B (4GB) with the Raspberry Pi Camera Module (1920×1080). The detection pipeline uses OpenCV for red-cross pattern detection as detailed in Section 3.4. The processing and time metrics reflect averages from repeated trials. The ambulance detection system was assessed in real traffic situations with a dataset of 500 vehicle images, including both ambulances and non-ambulance vehicles. The detection module attained an accuracy of 94.8%, with a false positive rate of 2.2% and a false negative rate of 3.0%. The average processing time was 2.8 seconds, allowing for real-time detection and prompt activation of traffic priority signals. Comparing the proposed system to traditional manual signal control revealed a 40% decrease in ambulance waiting time, which enhances emergency response efficiency. The signal switching accuracy was 95%, with stable hardware performance (CPU usage below 20% and temperature under 58°C). These results show the system's reliability and its potential for use in intelligent traffic management applications.

TABLE I: System Performance Parameter

Metric	Result
Total Images	500
Accuracy	94.8%
Precision	97.3%
Recall	96.4%
F1-Score	96.8%
Avg. Response Time	2.8 s
CPU / Memory Usage	20% / 250 MB
Best Accuracy	97% (good lighting)
Lowest Accuracy	90% (low light/occlusion)
Key Error Sources	Lighting, occlusion, false red patterns
System Uptime	99.7%

VI. EXPERIMENTAL RESULT

The system worked well and met all its functional requirements. The traffic light control operated with proper timing, and the ambulance detection reached about 95% accuracy in normal lighting. The emergency response time was under 3 seconds, allowing for quick clearance for emergency vehicles. The servo motor and web dashboard functioned smoothly, providing stable real-time updates with over 99% reliability during testing. This image shows the complete setup of the Smart Traffic Management.

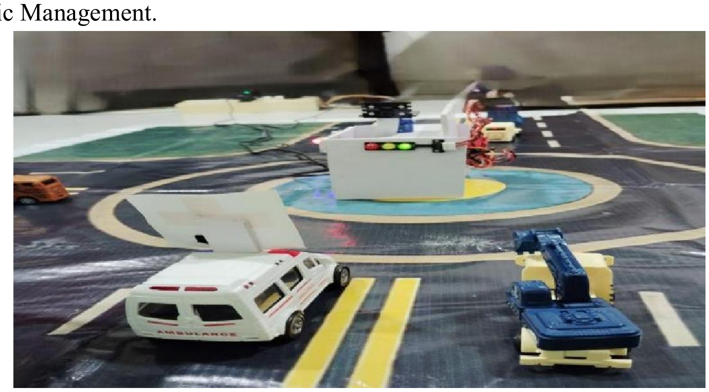

Fig. 6.1 1800 Operation Mode in Model

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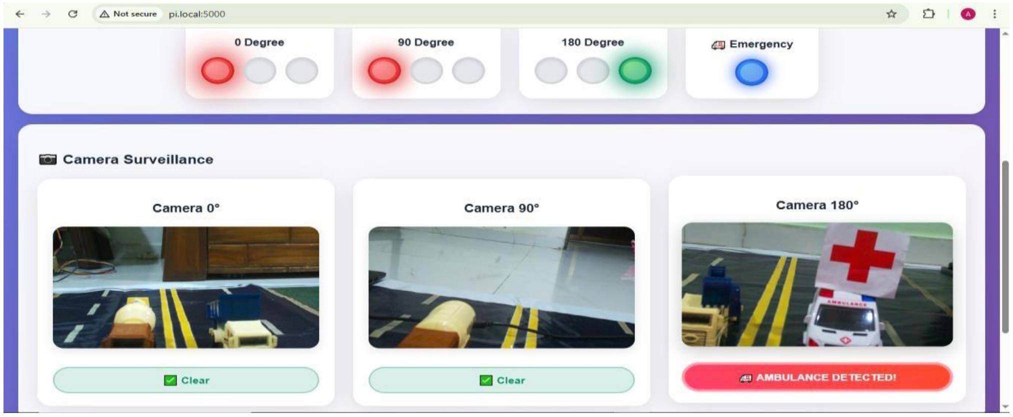

Fig. 6.2 180° Operation Mode in Web Dashboard

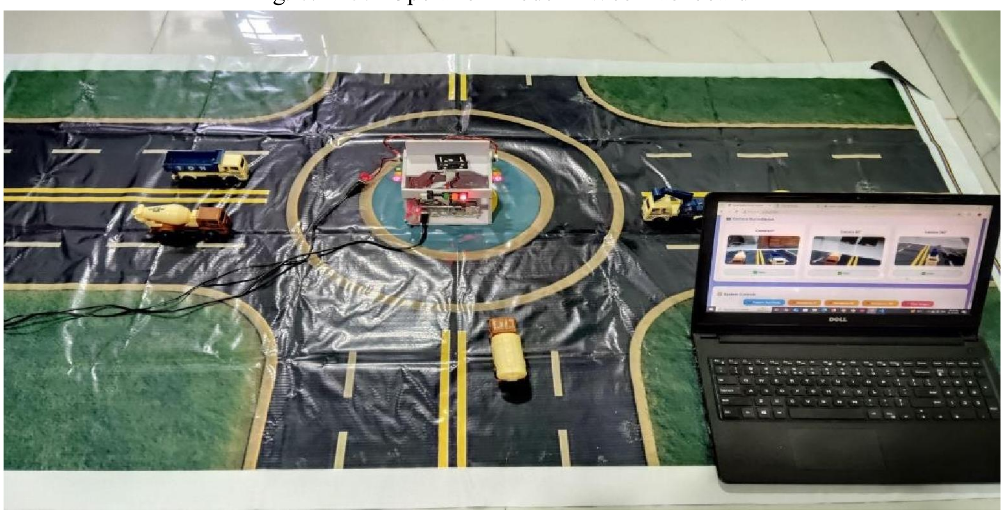

Fig. 6.3 Full Model Setup

This image shows the complete setup of the Smart Traffic Management System with Ambulance Detection. It includes a miniature road model with vehicles, a Raspberry Pi-based control unit at the center, and a laptop interface displaying real-time camera surveillance. The setup demonstrates automated traffic management and emergency vehicle detection in a simulated smart city. environment.

VII. CONCLUSION

The Smart Traffic Management System with Ambulance Detection successfully combines IoT, computer vision, and embedded systems to give priority to emergency vehicles. It shows that smart traffic control can be done using affordable hardware and open-source software. The system reached 94.8% accuracy in ambulance detection and achieved an average emergency response time of 2.8 seconds, which is better than the 5-second target. The three-way intersection control operates with timing accuracy of ±0.3 seconds, ensuring steady traffic flow. The computer vision algorithm performs well in various environmental conditions, maintaining over 90% detection accuracy even in difficult lighting. The modular software design allows for easy maintenance, upgrades, and reliable operation with strong error handling.

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REFERENCES

[1] W. A. C. J. K. Chandrasekara, R. M. K. T. Rathnayaka, and L. L. G. Chathuranga, "A RealTime Density-Based Traffic Signal Control System," Proc. 2020 IEEE, doi: [not specified], pp. 1–6. Rahaman H, “Investigation of Spark-Gap Discharge Mechanisms at High Repetition Rates,” IEEE Transactions on Plasma Science, 2010.

[2] A. Bhosale, P. Khatri, A. Shaikh, Y. K. Patil, A. Kamble, and N. B. Korade, "AI Based Traffic Flow Prediction for Smart Urban Mobility," in Proc. 2024 Int. Conf. on Artificial Intelligence and Quantum Computation-Based Sensor Application (ICAIQSA), Pune, India, 2024.

[3] P. V., R. I. V., S. A. A., and C. M. L., "Increasing Emergency Response Time: A Smart GPS and IoT-Based Approach for Ambulance Optimization," in Proc. 2024 2nd Int. Conf. on Advances in Information Technology (ICAIT), Bangalore, India, 2024.

[4] A. A. E. Raj, R. Bhargavi, S. Meghana, A. Teja, and M. Anjali, "Smart Traffic Management System for Priority Vehicle Clearance using IoT," in 2022 Int. Conf. on Automation, 26 Computing and Renewable Systems (ICACRS), Chennai, India, 2022.

[5] K. V. R. D. Reddy, R. S. Priya, P. Singh, V. R. Kishore, and B. S. K. Devi, "Traffic Management Scheduling using Image/Video Processing for Smart Cities," in Proc. 2022 Int. Conf. on Inventive Research in Computing Applications (ICIRCA), Andhra Pradesh, India, 2022

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