International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Real Time Smart Traffic Management System using AI

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ABSTRACT :

This project proposes a real-time Smart Traffic Management System using a Raspberry Pi and camera module, with a primary focus on the implementation of an intelligent traffic control algorithm. Traditional traffic lights operate on fixed time cycles, which are in efficient during fluctuating traffic conditions. To overcome this,the system captures live video feeds using a camera module and processes the images using real-time computer vision techniques. The algorithm performs gray scale conversion, Gaussian blur, background subtraction, and contour detection to accurately identify and count vehicles in each lane. Based on the vehicle count, the algorithm calculates the traffic density and dynamically adjusts the green signal duration for each direction, giving higher priority to lanes with more traffic. To ensure fairness, the algorithm includes control logic that prevents starvation of less congested lanes by setting minimum and maximum time limits for each signal. The entire process is executed locally on the Raspberry Pi, ensuring low latency and eliminating the need for cloud connectivity. This approach provides a cost-effective, adaptive, and scalable solution for managing urban traffic efficiently making it suitable for smart city applications.

KEYWORDS: Traffic Management, Reducing Congenstion, Pollution Control

INTRODUCTION

To solve the growing problem of traffic jams in cities, a Smart Traffic Management System has been developed. This system works by adjusting traffic lights based on the real-time traffic conditions instead of using fixed timers. In this project, we use a camera module and image processing techniques to watch how many vehicles are present at road intersections. The system works by capturing live video from a camera placed at a traffic intersection. It uses computer vision techniques to analyze the video and count the number of vehicles present in each lane. These techniques help the system understand which direction has more traffic at

any given moment. After counting the vehicles, the system compares traffic on all sides and decides where the signal should stay green for a longer time. By doing this, the system gives priority to busy lanes and reduces unnecessary waiting on empty or less crowded roads. This method helps reduce long queues and improves the overall flow of traffic. It also saves fuel by minimizing the idle time of vehicles. The goal is to make traffic movement faster and smoother. Overall, the system adjusts itself automatically and works better than fixed-timer traffic lights.

The system incorporates automated control mechanisms that dynamically adjust signal timings based on vehicle count and flow direction. For example, during peak hours or employs vehicle detection algorithms and real-time video analysis to dynamically adjust signal timings, leading to smoother traffic flow and reduced waiting times. This study underscores the potential of distributed computing models in building scalable, efficient, and responsive smart traffic systems.

Patel and Verma, in their 2023 publication in the International Journal of Transportation and Smart Technologies, conducted an in-depth analysis of security and privacy vulnerabilities in camera-based traffic surveillance systems. Their study emphasizes how the growing reliance on video feeds and AI algorithms for traffic management also brings significant concerns related to data integrity, unauthorized access, and surveillance ethics. To address these issues, they propose a multi-layered security framework aimed at protecting sensitive traffic data while ensuring compliance with privacy regulations.

unexpected traffic build-ups, the smart controller can allocate longer green light durations to lanes with higher traffic, thus reducing waiting time and minimizing congestion. The integration of computer vision and decision-making algorithms makes this system scalable and applicable in real-world urban environments.

LITERATURE REVIEW

Kumar and Singh, in their 2023 study published Through comprehensive evaluations of encryption protocols, access control mechanisms, and anomaly detection systems, the researchers highlight the critical need for strong cyber security practices within intelligent traffic management infrastructures. Their work establishes an essential foundation for securing data-driven transportation systems against

in IEEE Transactions on Intelligent evolving digital threats. Chen and Wang, in their 2024 study presented at the International Conference on Smart Cities and Intelligent Infrastructure, introduced an artificial

Transportation Systems, present an innovative real-time traffic control framework that combines camera-based computer vision with edge computing. Their work tackles the critical issue of latency in video data processing, which is vital for real-time traffic management. By deploying computational resources closer to traffic junctions, their edge-based architecture significantly improves system responsiveness. They also critically evaluate the limitations of intelligence-based system for traffic flow prediction and adaptive signal control. Their proposed model combines deep learning with real-time video analysis to assess vehicle density, predict congestion patterns, and optimize signal timings accordingly. This proactive approach goes beyond traditional reactive signal adjustments, offering a more fluid traditional time-based traffic signals, demonstrating their inability to adapt to varying traffic conditions. The proposed hybrid system

and efficient traffic management strategy. The AI system developed by the researchers processes visual data from multiple intersections and generates predictive models capable of anticipating traffic buildup, adjusting green light durations, and rerouting vehicles in real time. Their findings show a significant reduction in results in more efficient traffic flow, minimizingvehicle idling time, reducing congestion, and improving overall intersection performance. A stable power supply unit is integrated into the system to ensure that the Raspberry Pi and all connected components, including the camera and LED signals, operate smoothly without average travel time and vehicle idling, interruptions. The model leverages the
emphasizing the practical benefits of AI in managing urban mobility. The study highlights the transformative potential of machine learning in developing future-ready traffic systems.

METHODOLOGY

The proposed model for the Real-Time Smart Traffic Management System using AI is designed around the Raspberry Pi 4 Model B, which serves as the central processing unit responsible for controlling and coordinating the entire operation. A USB camera is connected to the Raspberry Pi, continuously capturing live video feeds of traffic conditions at an intersection. These video feeds are processed in real-time using computer vision algorithms implemented on the Raspberry Pi, which are capable of detecting, tracking, and counting the number of vehicles in each lane. This vehicle count data is crucial for analyzing traffic density and making informed decisions about traffic signal timings. Based on the real-time analysis, the Raspberry Pi intelligently controls four independent sets of traffic lights, with each set comprising red, yellow, and green LEDs that correspond to four different directions at the intersection. Instead of relying on fixed-time cycles like traditional traffic signals, the system dynamically adjusts the duration of green lights depending on the vehicle density in each direction, giving more time to heavily congested lanes and reducing unnecessary waiting for lighter traffic. This adaptive control strategy
processing capabilities of edge computing by performing all computations locally on the Raspberry Pi, reducing latency and making the system highly responsive to changing traffic conditions. By combining artificial intelligence, computer vision, and embedded systems technology, this smart traffic management solution offers a practical, scalable, and cost-effective approach for modernizing urban traffic control infrastructures.

Figure 1:Block Diagram

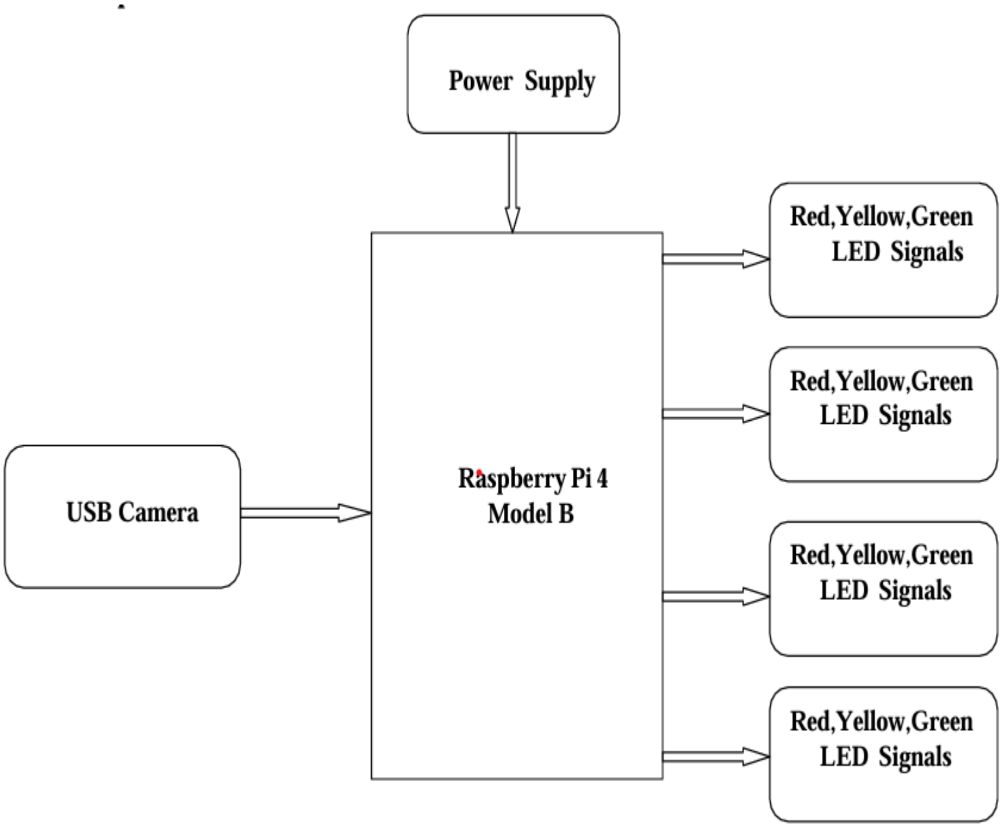
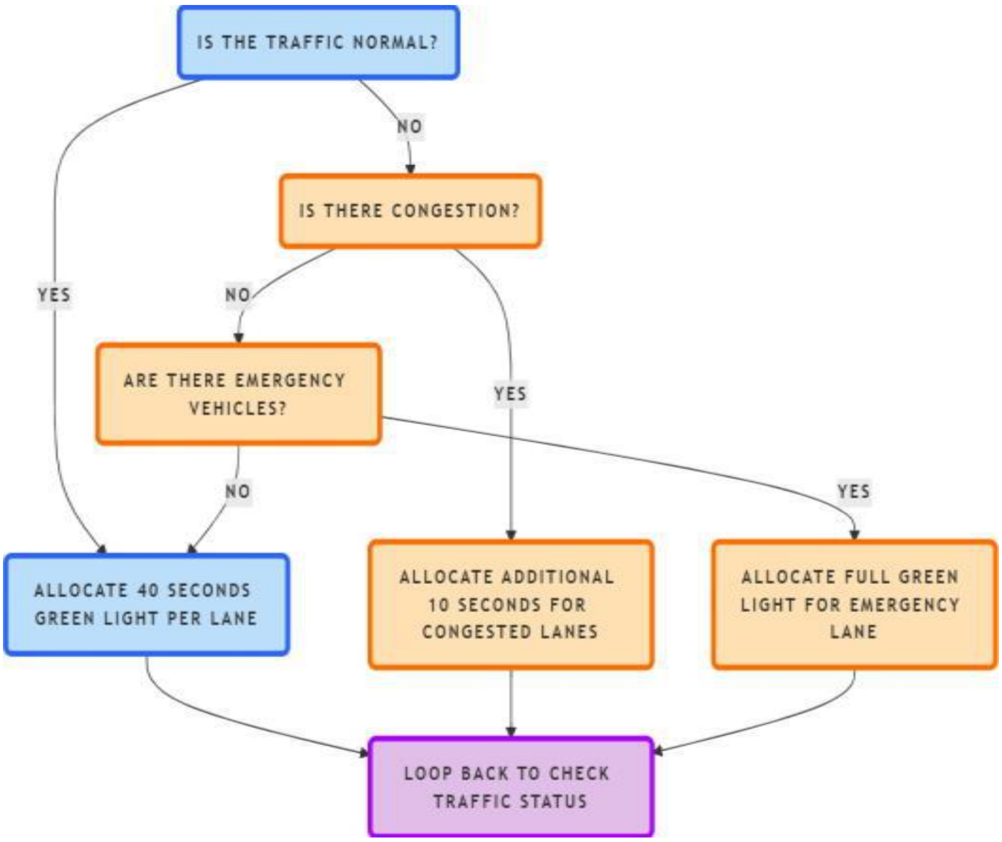


Figure 2:Flow Chart



The flowchart outlines a smart traffic management system that integrates real-time congestion, it then checks if there are anyemergency vehicles like ambulances or fire trucks that need to pass quickly. But if it does find a traffic jam in any lane, it immediately focuses on clearing that lane first by giving it more green light time.

STEP 4: When an emergency vehicle, like an ambulance or fire truck, is detected on the road, the system will immediately give a green light to the lane the emergency vehicle is in. This ensures that the vehicle can pass through the intersection quickly without any delays. Once the emergency vehicle has cleared the intersection, the system will switch the traffic lights back to normal, allowing regular traffic to continue. The system helps make sure that emergency vehicles can get through traffic without causing disruption, while also keeping other drivers safe.

STEP 5: If there are no emergency vehicles but traffic congestion is detected, the system will automatically extend the green light by 10 seconds for the lanes with heavy traffic. This extra time helps reduce the congestion by allowing more vehicles to pass through the intersection. Once the traffic clears, the system will return to its regular cycle, ensuring that traffic flow is smooth and efficient. This decision- making using congestion and

emergency vehicle detection. The System uses video input and logib based flow to control traffic signals dynamically, improving road efficiency and prioritizing critical movement .below is a step-by-step breakdown of the flowchart, explaining how the system adjustment helps manage traffic more component interact:

STEP1: The system continuously monitors traffic conditions through a camera and vision-based processing.

STEP2: The system first checks if the traffic is normal. If the traffic is normal, it gives 40 seconds of green light to each lane. If the traffic is not normal, it studies the traffic more carefully to decide how to adjust the green light time, so that crowded lanes get more time and traffic moves smoothly. effectively and prevent long delays during busy times.

STEP 6: After executing the necessary action, the system loops back to monitor the traffic status again, ensuring continuous and adaptive control.

STEP3: The system looks at each lane to see if

there's any traffic jam. If it doesn't find any

RESULT

The smart traffic management system was successfully designed and implemented using Raspberry Pi, OpenCV, and the YOLOv8n affordable, using common components like aRaspberry Pi, camera, and LEDs, and works without needing the internet, making it reliable even in areas with poor network coverage. It also includes emergency vehicle detection, allowing quick passage for these vehicles, which could save lives. The system is flexible and can be used at one intersection or scaled to cover multiple areas with minimal changes. It reduces the need for manual control, lowers the chance of human error, and helps save energy by reducing vehicle idling, which also cuts down on pollution.

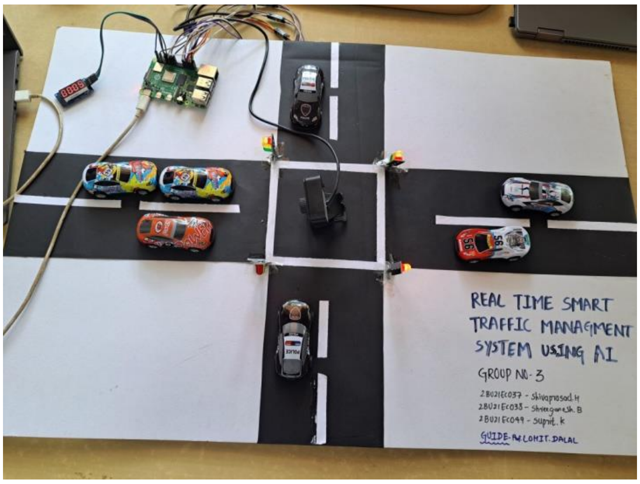


Fig 3 Result

CONCLUSION

The proposed Smart Traffic Management System is a big step forward in improving how traffic is Image Processing," Journal of Transportation Technology, 2023, Vol. 11, pp controlled in cities. Unlike traditional systems that use fixed timers, this system uses a Raspberry Pi and camera to monitor traffic in real-time. It detects the number of vehicles in each lane and adjusts traffic signals accordingly, helping reduce wait times on empty lanes and easing congestion in busier lanes. This system is

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detected vehicles in real-time from live video feeds and dynamically controlled the traffic lights based on the congestion level at each lane. Congested lanes were provided 30 seconds of green light, normal lanes 20 seconds, while empty lanes were skipped to improve traffic efficiency. A TM1637 display module was used to show countdown timers synchronized with the OpenCV video output. Overall, the project achieved its goal of creating an intelligent, cost effective, and efficient traffic control solution.

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