



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



Impact Factor: 8.699

Volume 14, Issue 5, May 2025

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www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025 |DOI: 10.15680/IJIRSET.2025.1405030|

Real Time Video Monitoring of Vehicular Traffic and Adaptive Signal Change Using Raspberry PI

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ABSTRACT: The "Real-Time Video Monitoring of Vehicular Traffic and Adaptive Signal Change Using Raspberry Pi" project aims to enhance traffic management by dynamically adjusting signal timings based on vehicle density. A Raspberry Pi serves as the central processing unit, utilizing a USB web camera to monitor traffic flow at an intersection. The system analyses video input to count vehicles and determines appropriate signal changes, activating red, green, and yellow LEDs accordingly. A motorized camera setup enables multi-directional monitoring for improved accuracy. However, real-time video processing poses challenges in object detection accuracy due to streaming limitations. This cost-effective and automated solution aims to optimize traffic efficiency while reducing congestion.

KEYWORDS: OpenCV, Python, Raspberry Pi, Traffic analysis, Traffic control, Vehicle detection.

I. INTRODUCTION

Urban areas are increasingly facing the challenge of traffic congestion, which leads to significant delays, excessive fuel consumption, and heightened pollution levels. Conventional traffic signal systems operate on fixed timing schedules, making them incapable of responding effectively to changing traffic conditions, thereby causing inefficient vehicle movement. To overcome this limitation, the proposed project titled "Real-Time Video Monitoring of Vehicular Traffic and Adaptive Signal Change Using Raspberry Pi" introduces an intelligent traffic management system. This system dynamically adjusts signal durations based on the real-time density of vehicles. A Raspberry Pi acts as the core processing unit, paired with a USB web camera to continuously monitor traffic flow at intersections. By analyzing the live video feed, the system calculates vehicle counts and adjusts the red, green, and yellow light durations for optimal traffic control. Additionally, a motorized camera mount allows for multi-directional surveillance, enhancing the precision of vehicle detection.

II. LITERATURE SURVEY

A. Real-time video monitoring of vehicular traffic and adaptive signal change using Raspberry Pi

Ayushi Gupta; Charu Gandhi; Vartika Katara; Stuti Brar

Published in: 2020 IEEE Students Conference on Engineering & Systems (SCES)

This paper presents a method to use live video feed from the cameras at traffic junctions for real-time traffic density estimation. It also focuses on providing an effective traffic light switch timer according to the vehicle density, thereby aiming at reducing the traffic congestion on roads.

B. Real-time traffic control and monitoring

Mimansha Gupta; Harsha Miglani; Pradnyesh Deo; Alka Barhatte

This paper demonstrates how to utilize real-time live video feeds from cameras at intersections to perform instantaneous traffic bulkiness calculations using image processing and vehicle detection using EfficientDet architecture and TensorFlow lite. It also aims to reduce traffic jams and accidents by focusing on algorithms that switch signal lights on the basis of density of vehicles on the road and the priority set for specific emergency vehicles





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C. Intelligent Traffic Signal Management using Raspberry Pi and OpenCV

Dr. Ch. Rambabu; J. Divya Madhuri; M. Vamsi; D. Tharun Nayak; L. Pavan Prasad

This project centers on real-time vehicle detection and intelligent signal control to adapt dynamically to fluctuating traffic conditions. By consolidating data from traffic sensors, cameras, and IoT devices into a unified management platform, the system delivers valuable insights that enable traffic authorities to make informed, data-driven decisions.

III. METHODOLOGY

A. Existing method:

Conventional traffic control systems typically rely on fixed-timer signal operations, which are not capable of adapting to real-time traffic fluctuations. While some modern systems incorporate inductive loop sensors embedded within road surfaces to detect vehicles, these setups involve high installation and maintenance costs. Alternative technologies such as infrared and ultrasonic sensors are also utilized; however, their performance can be compromised by environmental conditions like rain, fog, or dust, making them less dependable. Due to their limited adaptability, these traditional methods often result in suboptimal traffic management, leading to increased congestion, inefficient flow, and extended vehicle wait times.

B. Disadvantages in existing model:

- Lack of real time adaptability
- Not efficient
- Traffic congestion and increased travel time
- Higher Fuel Consumption and Pollution

C. Proposed method:



Fig.1. Block Diagram of the proposed system





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The proposed system utilizes a Raspberry Pi in conjunction with a USB web camera to monitor vehicular traffic density in real time. The camera captures continuous video footage, which is then processed to estimate the number of vehicles and dynamically adjust the duration of traffic signals accordingly. Traffic lights are simulated using LEDs in red, green, and yellow, while a motorized camera mount allows for multi-directional surveillance, enhancing detection accuracy. This automated solution enhances traffic flow efficiency, alleviates congestion, and presents a cost-effective alternative to conventional traffic control methods. Nevertheless, implementing real-time video processing poses challenges in maintaining accurate object detection due to limitations in video streaming quality.

D. Advantages in proposed model:

- Real time traffic monitoring.
- Improved Traffic Flow and Reduced Congestion
- Multi-Directional Monitoring

IV. IMPLEMENTATION

- E. Hardware Requirements:
- Raspberry Pi
- Memory card
- USB web camera
- Red, green, and yellow LEDs
- Motor driver
- DC motor
- Wheel
- Connectors
- Power supply
- Adapter

F. Software Requirements:

- Python
- Raspbian
- Computer Vision Libraries
- Operating System

The primary objective of this project is to deliver an automated traffic management system based on real-time vehicle detection and traffic density estimation. A camera module is interfaced with a Raspberry Pi, which, along with a connected motor setup, is used to monitor traffic from multiple directions. The camera continuously captures video frames of the traffic scenario, which serve as input for vehicle detection.

The motor is operated using the L293D motor driver, and the Raspberry Pi's GPIO (General Purpose Input/Output) pins are utilized to interact with external devices such as LED traffic lights. These pins enable the Raspberry Pi to control the LED states based on real-time traffic conditions detected in each direction.

Captured video frames are processed using OpenCV, an open-source computer vision library, to detect vehicles present in the scene. The vehicle detection process relies on various image processing techniques provided by OpenCV to accurately identify and locate vehicles within each frame.

This detection is essential for estimating traffic density, which in turn is used to dynamically control the traffic lights. The control logic functions as follows:

High Traffic Density: When the number of vehicles in a particular direction exceeds a predefined threshold, the system switches the traffic light to green in that direction, allowing the congestion to clear.





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Low Traffic Density: If the traffic in a direction is below the threshold, the system turns the traffic light red for that path, thereby prioritizing directions with higher congestion.

V. RESULTS

G. Hardware Implementation:

The motorized camera rotates in 360 degrees and gives the captured video input to the Raspberry Pi. Raspberry pi processes the data and controls traffic signals based on the vehicle density.



Fig.2. Hardware implementation of the proposed system

H. Software Implementation:

The code is related to control the overall processing of system to give proper output and uses YOLOv3-tiny (You Only Look Once, version 3 - tiny variant) computer vision technology implemented using OpenCV's DNN (Deep Neural Network) module to detect the vehicles from the video input.



Fig.3. Simulation view of the proposed system





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VI. FUTURE SCOPE

The proposed system has significant potential for further development and real-world implementation. Future enhancements can include the integration of machine learning algorithms to improve vehicle detection accuracy and enable classification of different vehicle types. This would allow for more precise traffic signal control based on the type and number of vehicles present.

Additionally, incorporating cloud-based data storage and analytics could enable long-term traffic pattern analysis, aiding urban planners and traffic authorities in infrastructure development and congestion management. Integration with GPS and real-time traffic apps could also provide drivers with alternate route suggestions, further enhancing traffic flow.

Expanding the system to cover multiple intersections and enabling intercommunication between them could lead to the creation of a fully automated and synchronized smart traffic network. Finally, deploying solar-powered modules and wireless communication could make the system more sustainable and easier to install in remote or developing areas.

VII. CONCLUSION

In conclusion, the project "Real-Time Video Monitoring of Vehicular Traffic and Adaptive Signal Change Using Raspberry Pi" offers a smart and cost-efficient approach to contemporary traffic management. Through the use of a Raspberry Pi and a USB web camera, the system continuously monitors vehicle density and dynamically adjusts signal timings to optimize traffic flow. The inclusion of a motorized camera setup enables comprehensive, multi-directional monitoring, thereby enhancing the accuracy of real-time vehicle detection. While certain challenges—such as video streaming limitations and environmental conditions—can affect system performance, the application of effective image processing techniques helps ensure dependable operation. This adaptive traffic control strategy not only eases congestion and boosts efficiency but also promotes fuel savings and reduces emissions. By showcasing the potential of embedded systems in intelligent transportation, the project lays a foundation for more sustainable and smarter urban mobility solutions.

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