IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, January 2026
Impact Factor: 7.67

Vision-based Intelligent Traffic Light System

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Abstract: *Traffic congestion has become a serious problem in urban areas due to the rapid increase in the number of vehicles. Traditional traffic signal systems operate on fixed time intervals and fail to adapt to real-time traffic conditions, resulting in unnecessary delays, fuel wastage, and increased pollution. To overcome these limitations, this paper presents a Vision-based Intelligent Traffic Light System that dynamically controls traffic signals using real-time video processing.*

The proposed system uses a camera to monitor traffic density on each lane. Computer vision techniques implemented using OpenCV are applied to detect and count vehicles. Based on the detected vehicle density, traffic signal timings are adjusted automatically. The system also includes pedestrian crowd detection for safe crossing, emergency vehicle prioritization, and accident detection with automatic alert generation. An Arduino UNO is used to control traffic lights based on commands received from the processing unit. The proposed system aims to improve traffic flow efficiency, enhance road safety, and provide a low-cost and scalable solution for smart city traffic management.

Keywords: Computer Vision, Intelligent Traffic System, OpenCV, Machine Learning, Arduino UNO, Traffic Density

I. INTRODUCTION

Urban traffic congestion is one of the major challenges faced by modern cities. With the increasing number of vehicles, conventional traffic management systems are becoming inefficient. Most existing traffic signals operate on predefined time cycles, regardless of the actual traffic conditions on the road. This often leads to longer waiting times on less congested roads and traffic jams on busy roads.

Recent advancements in computer vision and machine learning have opened new possibilities for intelligent traffic management systems. Vision-based systems can analyze real-time traffic conditions and make dynamic decisions accordingly. Such systems help in reducing congestion, improving fuel efficiency, and enhancing overall road safety.

This paper focuses on the design and implementation of a Vision-based Intelligent Traffic Light System that adapts signal timings based on real-time traffic density. Additional safety features such as pedestrian detection, emergency vehicle prioritization, and accident detection are also integrated to improve the effectiveness of the system.

II. LITERATURE REVIEW

Several researchers have proposed intelligent traffic management systems using image processing and machine learning techniques. Traditional traffic control methods based on fixed timers have been proven to be inefficient in handling dynamic traffic conditions. Studies show that adaptive traffic signal systems significantly reduce congestion and waiting time.

Computer vision-based approaches use object detection techniques to identify vehicles and pedestrians from live video feeds. Machine learning models, including convolutional neural networks (CNNs), have been widely used to improve vehicle detection accuracy. Integration of such systems with microcontrollers like Arduino enables real-time signal control.

Some recent studies have also explored accident detection and emergency response systems using vision-based technologies. These systems help in providing faster medical assistance and improving road safety. The proposed

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system builds upon these existing works by integrating vehicle density detection, pedestrian safety, emergency vehicle prioritization, and accident alert mechanisms into a single unified system.

III. PROPOSED SYSTEM

The proposed Vision-based Intelligent Traffic Light System uses a camera to capture live video footage of traffic at an intersection. The video feed is processed using OpenCV to detect and count the number of vehicles present on each lane. Based on the traffic density, the system dynamically adjusts the green signal duration for each lane.

If a lane has a higher number of vehicles, it is given a longer green signal time. In case an emergency vehicle such as an ambulance, police vehicle, fire brigade, or school bus is detected, the system immediately provides priority by switching the signal to green for that lane. Pedestrian crowd detection is also implemented, where both road signals are turned red to allow safe pedestrian crossing.

In addition, the system is capable of detecting accidents using abnormal motion patterns and visual cues. Once an accident is detected, an alert is automatically generated and sent to the nearest hospital for quick emergency response.

IV. SYSTEM ARCHITECTURE AND METHODOLOGY

The system architecture consists of both hardware and software components. A camera module is installed at the traffic junction to capture live traffic video. The video feed is processed on a computer system using Python and OpenCV libraries. Vehicle detection and counting algorithms analyze the frames and calculate traffic density.

The processed data is sent to an Arduino UNO through serial communication. The Arduino controls the traffic lights using LEDs representing red, yellow, and green signals. A buzzer is used for alert notifications. The overall workflow of the system ensures real-time adaptability and efficient traffic management.

Algorithm Steps:

- Capture live video using the camera.
- Extract frames and preprocess the images.
- Detect vehicles and pedestrians using computer vision techniques.
- Count the number of vehicles in each lane.
- Allocate green signal time based on traffic density.
- Detect emergency vehicles and provide priority.
- Detect pedestrian crowds and allow safe crossing.
- Identify accidents and generate emergency alerts.
- Control traffic lights using Arduino UNO.

V. RESULTS AND DISCUSSION

The proposed system demonstrates improved traffic flow compared to traditional fixed-time traffic signals. By dynamically adjusting signal timings based on real-time traffic density, unnecessary waiting time is reduced. Emergency vehicle prioritization ensures faster response times, while pedestrian detection improves safety at intersections.

The system is cost-effective and suitable for real-world implementation, especially in urban areas. Although the current implementation is a prototype, the results indicate that vision-based traffic control systems can significantly enhance traffic management efficiency.

VI. CONCLUSION AND FUTURE SCOPE

This paper presented a Vision-based Intelligent Traffic Light System that dynamically controls traffic signals using real-time video processing. The system addresses major limitations of conventional traffic signal systems by adapting to actual traffic conditions. Integration of pedestrian safety, emergency vehicle prioritization, and accident detection further enhances the reliability of the system.

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In the future, the system can be extended by incorporating advanced deep learning models for improved detection accuracy. Integration with IoT and cloud-based platforms can enable centralized traffic monitoring and data analytics. The system can also be scaled to manage multiple intersections in smart city environments.

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