

# REAL TIME TRAFFIC SIGNAL OPTIMIZATION USING ARTIFICIAL INTELLIGENCE

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**ABSTRACT-** Traffic congestion is a major problem in urban areas due to the increasing number of vehicles and inefficient traffic signal management. This project proposes a Real Time Traffic Signal Optimization system using Artificial Intelligence (AI) to improve traffic flow at road intersections. The system uses video input from traffic cameras to monitor vehicle density in different lanes. Using Convolutional Neural Networks (CNN) and deep learning techniques, the system analyzes real-time traffic conditions and dynamically adjusts signal timing based on the number of vehicles present in each direction. This adaptive approach helps reduce waiting time, minimize traffic congestion, and improve overall road efficiency. The proposed system provides a smart and automated traffic management solution that can support modern intelligent transportation systems (ITS) and contribute to safer and more efficient urban traffic control.

Rapid urbanization and the continuous increase in the number of vehicles have led to serious traffic congestion in many cities. Traditional traffic signal systems operate with fixed time intervals and often fail to adapt to real-time traffic conditions. This project presents a Real Time Traffic Signal Optimization system using Artificial Intelligence (AI) to manage traffic more efficiently. The proposed system uses video cameras to capture live traffic data from different lanes at an intersection. By applying Convolutional Neural Networks (CNN) and deep learning techniques, the system detects vehicle density and automatically adjusts signal timings according to traffic flow. This dynamic signal control helps reduce vehicle waiting time, improve traffic movement, and decrease congestion at busy intersections. The system aims to provide an intelligent and automated traffic management solution for modern smart cities.

**Key Words:** Artificial Intelligence (AI), Traffic Signal Optimization, Convolutional Neural Network (CNN), Real-Time Traffic Monitoring, Vehicle Detection, Traffic Congestion Control, Intelligent Transportation System (ITS), Deep Learning.

## I. INTRODUCTION

Traffic congestion has become a major problem in many urban areas due to the rapid increase in the number of vehicles on the road. Traditional traffic signal systems usually operate with fixed timing schedules that do not change according to real-time traffic conditions. Because of this, some roads may experience heavy congestion while others remain relatively empty, leading to increased waiting time, fuel consumption, and frustration among drivers. Therefore, an intelligent traffic management system is needed to improve traffic flow and reduce congestion at road intersections.

Artificial Intelligence (AI) has emerged as an effective technology for solving complex real-world problems, including traffic management. AI techniques can analyze large amounts of data and make quick decisions based on current conditions. In this project, an AI-based system is proposed to optimize traffic signal timing by analyzing real-time traffic density.

The system uses video cameras installed at intersections to capture live traffic footage. With the help of Convolutional Neural Networks (CNN), a deep learning technique, the system detects and counts vehicles present in each lane. Based on the vehicle density, the traffic signal timing is automatically adjusted to allow smoother traffic movement.

This real-time traffic signal optimization approach helps reduce congestion, minimize waiting time, and improve overall road efficiency. The proposed system also supports the development of smart cities by providing a more intelligent and automated traffic control solution. Through this project, the application of AI in traffic management demonstrates how technology can be used to address everyday transportation challenges effectively.

## II. LITERATURE REVIEW

Traffic congestion is a common issue in many urban areas and several researchers have proposed intelligent traffic management systems to solve this problem. Many studies have focused on using Artificial Intelligence (AI) and machine learning techniques to improve traffic signal control and reduce congestion at road intersections.

Kumar et al. (2020) proposed an AI-based traffic signal control system that dynamically adjusts signal timing

according to real-time traffic density. Their study used traffic cameras to capture vehicle movement and applied machine learning algorithms to analyze traffic patterns. The results showed that adaptive signal control significantly reduced vehicle waiting time and improved traffic flow at busy intersections.

Li and Sun (2019) introduced a deep learning-based traffic flow analysis system using Convolutional Neural Networks (CNN). Their research focused on detecting and counting vehicles from real-time traffic video footage. The system was able to accurately identify different types of vehicles and estimate traffic density, which helped in making better traffic signal decisions.

Another study by Smith et al. (2021) developed a smart traffic management system that used sensors and AI algorithms to monitor traffic conditions. The system collected data from multiple lanes and optimized traffic signal timing to reduce congestion. Their results demonstrated improved road efficiency and reduced travel time.

From these studies, it is clear that AI and deep learning techniques play an important role in modern traffic management systems. These technologies help analyze real-time traffic data and make intelligent decisions. The proposed project builds upon these ideas by using AI and CNN techniques to optimize traffic signal timing and improve traffic flow at intersections.

### III. METHODOLOGY

The proposed system uses Artificial Intelligence (AI) and Computer Vision to analyze traffic videos and control traffic signals based on vehicle density. The system works in several simple steps such as video input, vehicle detection, traffic density calculation, and signal timing control.

Video Input → Frame Extraction → Vehicle Detection →  
Traffic Density Calculation → AI Signal Decision → Traffic  
Signal Output

#### 3.1 DATA COLLECTION

Data collection is an important step in this project. Traffic data is collected using traffic cameras installed at road intersections. The cameras capture live video of vehicles such as cars, bikes, buses, and trucks moving on different lanes. The recorded video frames are used as input for the system. These video frames help the model to detect vehicles and analyze traffic density. The collected data is then processed using Python and OpenCV to identify the number of vehicles present on the road. This information is used to understand the traffic condition and adjust the signal timing accordingly.

- Traffic Cameras
- Video Capture
- Image Frames
- Vehicle Detection

- Vehicle Counting
- Traffic Density
- Data Input to AI

#### 3.2 VIDEO UPLOAD MODULE

The Video Upload Module is the first step of the system. In this module, the traffic video is uploaded to the system. The video may come from CCTV cameras or recorded traffic videos.

This video is used as the input for traffic analysis. After uploading, the video is sent to the next step for processing and vehicle detection.

Traffic Video



Video Upload



Video Processing

#### 3.3 VIDEO PROCESSING MODULE

The Video Processing Module processes the uploaded traffic video.

In this step, the video is converted into frames (images) so that the system can analyze each frame easily.

Basic operations like resizing and noise removal are done to improve the video quality. After processing, the frames are sent to the vehicle detection module.

Uploaded Video



Video Processing

(Frame Extraction)



Vehicle Detection

#### 3.4 VEHICLE DETECTION MODULE

The Vehicle Detection Module identifies vehicles from the video frames.

The system uses Artificial Intelligence (AI) to detect vehicles like cars, buses, trucks, and bikes.

After detecting the vehicles, the system counts the number of vehicles in each frame. This information is sent to the traffic density calculation module.

Video Frames



Vehicle Detection



Vehicle Count

### 3.5 TRAFFIC DENSITY ESTIMATION

The Traffic Density Estimation module calculates the number of vehicles on each road lane.

After detecting the vehicles, the system counts them to know how much traffic is present.

If the number of vehicles is high, it means high traffic.

If the number of vehicles is low, it means low traffic.

This information is sent to the signal optimization module to decide the signal timing.

Vehicle Count



Traffic Density

Calculation



Traffic Level

(High / Low)

### 3.6 AI-BASED SIGNAL OPTIMIZATION

The AI-Based Signal Optimization module decides the traffic signal timing using Artificial Intelligence.

The system uses the traffic density data (number of vehicles) to control the signal.

If a road has more vehicles, the system gives more green signal time.

If a road has less vehicles, the system gives less green signal time.

This helps to reduce traffic congestion and waiting time.

Traffic Density



AI Decision



Signal Timing

(Green Time Control)

### 3.7 SIGNAL TIMING OUTPUT:

The Signal Timing Output module shows the final traffic signal time decided by the AI system.

Based on traffic density, the system gives the green signal time for each road.

This helps reduce traffic congestion and waiting time.

AI Signal Decision



Signal Timing Output



Traffic Signal Control

## IV.IMPLEMENTATION ALGORITHM

The implementation of the proposed real-time traffic signal optimization system follows a sequence of steps to analyze traffic conditions and dynamically adjust signal timings. The algorithm processes traffic video input, detects vehicles using artificial intelligence techniques, and calculates traffic density to determine optimal signal timing for each lane.

### Algorithm: AI-Based Traffic Signal Optimization

**Step 1:** Start the system.

**Step 2:** Input the traffic video captured from a traffic junction or uploaded by the user.

**Step 3:** Convert the input video into multiple frames for frame-by-frame analysis.

**Step 4:** Perform image preprocessing operations such as resizing, noise removal, and normalization to improve image quality.

**Step 5:** Apply a deep learning-based vehicle detection model to identify vehicles in each frame.

**Step 6:** Detect different types of vehicles such as cars, buses, motorcycles, and trucks.

**Step 7:** Count the number of vehicles detected in each lane of the traffic junction.

**Step 8:** Calculate traffic density based on the vehicle count and queue length.

**Step 9:** Compare the traffic density across all lanes.

**Step 10:** Allocate optimal green signal timing to each lane based on the calculated traffic density.

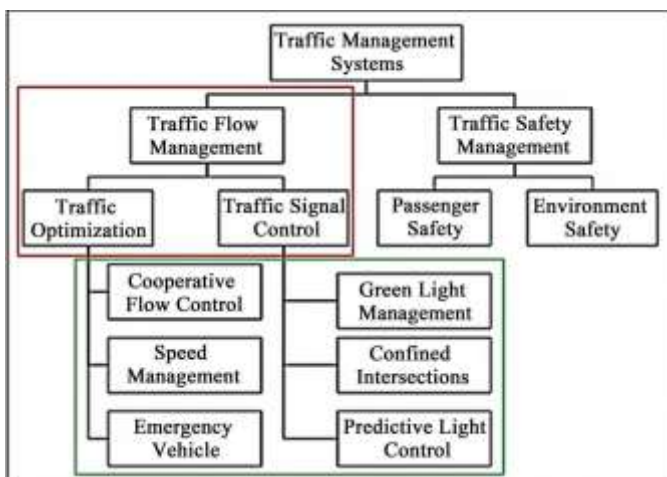
**Step 11:** Display the optimized traffic signal timings for all lanes.

**Step 12:** End the process.

#### 4.1 MODULES LIST

1. Video Input Module
2. Video Preprocessing Module
3. Vehicle Detection Module
4. Vehicle Counting Module
5. Traffic Density Estimation Module
6. Signal Timing Optimization Module
7. Signal Output Module

#### V. ARCHITECTURE SYSTEM



- ❖ Traffic Camera – Captures traffic video.
- ❖ Video Input – Video is given to the system.
- ❖ Video Processing – Video is converted into frames.
- ❖ Vehicle Detection – AI detects vehicles.
- ❖ Traffic Density Analysis – System calculates traffic level.
- ❖ AI Signal Controller – AI decides signal timing.
- ❖ Traffic Signal Output – Final signal timing is given.

#### VI. PROPOSED SYSTEM

The proposed system uses Artificial Intelligence (AI) and Computer Vision to improve traffic signal control. Instead of using fixed signal timing, the system analyzes traffic videos to detect vehicles and measure traffic density.

In this system, the traffic video is first uploaded and processed. The system then detects vehicles such as cars, buses, trucks, and bikes using AI techniques. After detecting the vehicles, the system calculates the traffic density for each road lane.

Based on the traffic density, the AI system automatically decides the signal timing. Roads with more vehicles receive longer green signals, while roads with fewer vehicles receive shorter green signals.

This proposed system helps to reduce traffic congestion, decrease waiting time, and improve traffic flow at road intersections. It also supports the development of smart transportation systems in modern cities.

#### VII. RESULTS AND DISCUSSION

The proposed system was tested using traffic videos to analyze vehicle movement and traffic density. The system successfully detected vehicles such as cars, buses, trucks, and bikes using Artificial Intelligence techniques.

After detecting the vehicles, the system calculated the traffic density for each road lane. Based on the number of vehicles, the AI system automatically adjusted the traffic signal timing.

The experimental results show that roads with higher traffic density received longer green signal time, while roads with lower traffic density received shorter green signal time. This helped to reduce vehicle waiting time and improve traffic flow at road intersections.

Compared to traditional fixed-time traffic signals, the proposed AI-based system performs better because it adapts the signal timing according to real-time traffic conditions. This makes the traffic management system more efficient and intelligent.

#### VIII. FUTURE SCOPE

The system can be expanded to manage traffic for multiple intersections across the city.

AI can be improved to predict traffic patterns and adjust signals automatically for smoother flow.

Emergency vehicles like ambulances, fire trucks, and police can get signal priority to reach quickly.

It can help reduce fuel consumption and vehicle emissions, contributing to a cleaner environment.

Integration with public transport can give buses and other services priority, improving travel efficiency.

In the future, the system can connect with smart vehicles and IoT devices for real-time traffic management.

Traffic data collected can be used by city authorities for better planning and reducing congestion.

The model can be scaled for larger regions or multiple cities to improve overall traffic management.

## **IX. CONCLUSION**

In this project, a real-time AI-based traffic signal system was developed to optimize traffic flow at intersections. The system adjusts signal timings automatically based on vehicle density, reducing waiting time and congestion. By using AI and sensors, it improves traffic efficiency, supports emergency vehicles, and helps reduce fuel consumption and pollution. This project shows that intelligent traffic management can make urban roads safer, faster, and more environmentally friendly.

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