

# Traffic Signal Scheduling using Machine Learning

## Onkar Nichat, Suraj Kulkarni, Aditya Mane, Siddhesh Naik, Shubham Bhandari



Abstract: Within the past few years, the number of vehicles increased drastically, and therefore, the traffic of cars became a significant issue in urban as well as rural areas. Considerable traffic is happening in the area where many roads intersect with each other. Our existing traffic signal is not real-time and operates according to its pre-programmed settings, regardless of traffic conditions. To avoid traffic, traffic signals should give priority to the road with the highest vehicle density. By doing this, we can accommodate the maximum number of vehicles within a specific period. This type of signal responds to real-time situations and makes informed decisions in response. Hence, this system is also known as an intelligent traffic light system. The purpose of this study is to get the traffic situation on the roads in real-time and act accordingly. Using a web camera that should be mounted on the signals, we can obtain real-time footage of the streets. By applying image processing methods, we can determine the vehicle densities on each road.

Signals that are programmed priorly to or incorrect signal scheduling were found to play the most significant role in causing vehicle traffic. This innovative traffic signal scheduling system is a superior option compared to existing systems, as it makes decisions based on real-time traffic conditions.

Keywords: Image recognition, Machine Learning, Image Processing.

### I. INTRODUCTION

 $\mathbf{T}$  he objective of the project is to design and implement a dynamic traffic signal system that adjusts its temporal order in response to real-time traffic density at the junction. The current challenge with traditional fixed-time traffic signals is that they are unable to respond to changes in traffic flow, resulting in increased congestion and longer wait times for commuters. This new system will utilize sensors to measure the density of vehicles at the junction, and the signal timings will be adjusted accordingly to ensure an optimized flow of traffic.

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The aim is to improve the traffic situation in cities plagued by congestion and provide a smoother, more efficient experience for commuters. An object detection technique will be employed in conjunction with video analysis to count the number of vehicles within a specified area accurately. This will enable us to determine which areas of the intersection have high traffic density. Based on this information, the signal timings will be adjusted to accommodate the density levels of each part of the intersection. Traffic accidents are a persistent problem, particularly in low-visibility conditions such as nighttime, overcast days, rainy nights, and foggy conditions. Existing driver assistance systems are optimised to operate effectively in good weather conditions. However, there is a need to improve their performance in challenging weather conditions. One approach to achieving this is through the use of classification algorithms, which help to identify the type of visual characteristics and improve the effectiveness of vision enhancement algorithms. Traffic signal management is a critical technical challenge in urban areas worldwide, and improving the performance of driver assistance systems in these conditions is a key step toward reducing traffic accidents. The constant growth in the number of vehicles is leading to an increase in traffic-related issues. A system incorporating current technology and artificial intelligence needs to be developed to address these issues. The objective of this project is to create a dynamic traffic signal system that adjusts the sequence of the signals based on traffic density. This will help to reduce wait times and improve the overall flow of traffic.

To address the challenges posed by increased traffic volume, we aim to implement a system that combines real-time traffic detection with dynamic traffic signal management. The system will be based on a Deep Convolutional Neural Network. It will utilize both social and road networks as sources of information to detect road traffic events such as blockages, congestion, and accidents. This will result in a more efficient and effective traffic management system.

Effective management of roads is crucial to ensuring their proper use and maintenance. Gathering and updating traffic information for road users is an essential aspect of this. To this end, various sensors will be deployed to collect relevant data on traffic parameters. Image processing is a crucial aspect of capturing traffic density, which can be used to identify traffic patterns at various times of the day. In India, traffic lights play a critical role in regulating traffic flow and ensuring compliance with traffic rules. The three colours of the traffic signals - red, yellow, and green - indicate to drivers to stop, wait, and proceed, respectively. Drivers are instructed to wait until the signal turns from red to yellow and then from yellow to green.

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The current traffic signal system is set to wait for a fixed amount of time between signal changes, regardless of the number of vehicles on the road. However, this may not always be the most efficient approach. In some cases, a particular route may be more congested than others and require more time to allow for the flow of traffic. To address this issue, an intelligent system can be designed that adjusts the signal change time based on the real-time vehicle density on the road. This can help reduce traffic congestion and improve the overall traffic flow. In this paper, we will review various methods used for monitoring and managing traffic through image acquisition and processing.

#### **II. RELATED WORK REVIEW**

Xiaoyuan Liang [1] conducted the study and manage the duration of traffic signals from the data which is collected from the various sensors and interconnected network of the vehicles and used a deep reinforcement learning model for controlling the traffic light. In this, he breaks down the complex schemes into states and divides them into small grids. The reward obtained was the cumulative difference in waiting time between the two cycles. He used a convolutional neural network to map the states to rewards. Several components can improve performance, including the target network, duelling network, double Q-learning network, and prioritised experience replay. He evaluated the model using simulation in the Simulation of Urban Mobility (SUMO) framework, which simulates an interconnected network of vehicles. The simulation results demonstrated the model's efficiency in traffic control. [2] In this paper, the Author proposed a semi-automatic approach for extracting different road types from remote-sensing images. This was based on edge detection and a Support vector machine. The outline of the road was detected based on the Canny operator. After that, the whole image was classified using a support vector machine, along with various spectral, spatial, and texture attributes, to form a road image. Ultimately, the quality of detecting roads was improved using morphological operators. [3] In this paper, authors used the reinforcement learning which is a very popular learning algorithm in machine learning for accurate adaptive signal control. They presented a paper that featured Q-learning, a simple yet powerful reinforcement learning algorithm, and showcased a case study involving the application of traffic signal control. The primary objective of the project is to manage a highly congested area. [4] In this paper, the authors presented a system to increase the visibility of drivers in bad conditions. The classification method is used to identify the variety of optical characteristics, enabling vision enhancement algorithms to become more efficient. He used a multi-class classification algorithm based on multiple weather features and supervised learning in order to improve visibility in bad weather. First, underlying visual features were extracted from traffic images, and after that, the feature was expressed as an eight-dimensional feature matrix. then, classifiers are trained using five supervised learning algorithms. He demonstrates that extracted features can accurately describe the image semantics. This method provides the basis for further study of vehicle detection at nighttime or in foggy weather, where objects or vehicles are not visible clearly. [5] This study is based on detecting traffic notations and symbols. The method will recognize the traffic panels and capture all the information contained in them. The primary purpose of automatic traffic panel detection is to support maintenance and assist the driver. He proposed the language model which is partially based on the dynamic dictionary. [6] In this paper, a real-time innovative traffic light system is constructed. In this, the main element is the Arduino board(an open-source electronic board for educational purposes). created a realtime innovative traffic light system demo model to show how the system will work. This project primarily focuses on image processing and machine learning. Created the C++ code for finding the density of vehicles on the road and taking action accordingly. They divided the densities into three categories: low density, medium density, and high density, using image processing, and set the duration of signals accordingly. This system is not only used for congestion detection but also for number plate reading and obstacle detection. This is operated using an Android app, allowing the signal to be managed manually if needed.[7] Life is precious. They developed the system using AI and machine learning. Emergency vehicles, such as ambulances and fire trucks, should arrive at their destinations on time. To save time and avoid congestion, all traffic lights that impede the passage of emergency vehicles are delayed by 1 minute, allowing emergency vehicles to pass through the congestion easily and reach their destination within a specific time frame. Arduino UNO as well as Mega with a network shield (ZigBee) were used in this project.[8] In this paper, a traffic light recognition system is created for the smart vehicle. In this project, a matcher algorithm is used. The matcher algorithm utilises a geometric and algorithmic template to convert 3D images into 2D images in real-time. The camera, mounted in the smart vehicle, is used to recognise traffic lights. Once the spotlight is detected, control is passed to the Adaptive Template Maker and then to the validation process. After recognizing the traffic light if it is red smart vehicle will stop moving state. If it is yellow, it will prepare for a stop, and if it is green, it will enter the moving state. They utilised image processing to develop the system. It is instrumental in urban and rural areas.

#### **III. PROPOSED SYSTEM**

From the above section, we learn that to address the increasing traffic, a real-time traffic signal scheduling system is needed. A real-time traffic signal scheduling system is a little expensive, but it can accomplish a greater amount of work in a shorter period. More precisely, the few advantages of a real-time Traffic signal scheduling system are as follows. Many types of situations arise in day-to-day life, causing congestion on the roads. This type of situation cannot be handled using the existing traffic signal scheduling system. Real-time traffic signal scheduling can handle these types of situations more effectively, depending on the real-time situation. 2. It reduces the average waiting time of the vehicles 3. It also reduces the emission of harmful gases. In simpler terms, it can also reduce pollution levels.

The system is divided into two. parts: web service and traffic signal scheduling, based on vehicle density. On the web

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service, all the traffic signal-related activities will be shown. For this project, we have a database to store a large amount of data generated per second. The primary objective of the system is to detect congestion of vehicles due to accidents or other external events on the road and adjust the traffic signal accordingly. The system will detect traffic-related events in real-time.



#### **Fig.1 Proposed System**

Fig. 1 above shows the high-level view of the proposed system. As shown in the figure, the real-time video is captured through the webcam, and the object detection algorithm is applied to the video. Then, by using the algorithm, the number of vehicles is counted, and the traffic signal is scheduled according to the density of cars.

#### **IV. METHODOLOGY**

Traffic signal congestion is a serious issue in day-to-day life. Delays, parking issues, unwanted waiting time, pollution, and global warming are some of the disadvantages of the existing traffic signal scheduling system. Real-time signal scheduling systems can reduce waiting time, congestion issues, and pollution problems and maximize the total number of vehicles that can pass through the intersection. Our real-time traffic signal scheduling system is based on image processing and can operate effectively without the need for traffic police.

#### a. Image Acquisition-

In this work, we capture the image through a webcam. Realtime images of roads and vehicles are captured every second through a webcam. Then, we ensure that the webcam is correctly connected to the system and that captured images are previewed on the system before proceeding to the following process. Fig. 2 shows the flow of image acquisition.



Fig. 2 Image Acquisition Flow Diagram

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As shown in the figure above, real-time images are captured through the web camera and stored for future use.

The actual image captured by the web camera every second is stored in the database.

#### b. Image Processing-

Images are captured through the webcam fitted at the junction of the road. Four cameras are placed for four roads that meet at a particular junction. Cameras are placed at the respective positions from which a specific part of the road can be visible. As discussed in the previous section, these images are stored in the database for further use. These images are then converted into greyscale photos to eliminate the complexities related to computational requirements. Also, converting RGB images to greyscale images reduces the image's size.

#### a) Image processing techniques-

In this process, the image is adjusted to make it suitable for further use. This involves Image enhancement, Image resizing, edge detection, and image matching. The following diagram illustrates the basic steps involved in image processing.



Fig. 3 Basic Image Processing Techniques

#### b) Image resizing-

Image resizing is performed on the captured images to increase or decrease the pixel count.

#### c) Edge detection-

The image detection technique is applied to the captured images to get the accurate boundaries of the desired objects.

#### c. Converting the greyscale image into a black-and-white image-

In this process, the greyscale image is converted into a blackand-white image to detect the blob, eliminate the background other than the object (in this case, vehicles), and reduce computational complexity.

#### d. Applying the CNN algorithm-

CNN is widely used in image recognition, object detection, image classification, face recognition, and emotion recognition. In our system, CNN has been used to detect objects, i.e., vehicles.

#### Step 1-

The dataset containing images along with reference vehicle names is fed into the system.

## Step 2-

Now import the libraries and build the model.

### Step 3-

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A convolutional neural network is used to extract image features pixel by pixel.

## Step 4-

Matrix factorization is performed on the pixel, the matric is of m\*n.

## Step 5-

Max pooling is performed by selecting the maximum value and then fixing it into the matrix.

## Step 6-

Normalize the matrix where every negative value is converted into zero.

## Step 7-

The hidden layer takes the input values from the visible layer and assigns the weights after calculating the maximum probability.

## e. Counting the objects-

The objects with closed boundaries are considered the required objects and are counted as vehicles.

## V. IMPLEMENTATION

Up till now, we have discussed the detailed methodology of the system. Now we are moving toward the actual implementation part. Firstly, vehicles are counted for the single lane.

Fig. 4 shows the original image captured by the web camera.



Fig. 4 Original image

As shown in Fig. 5, the RGB image is converted into a greyscale image.



Fig. 5 Greyscale image Fig. 6 illustrates how the system detects objects.



Fig. 6 An image that detects the vehicle

Fig. 7 shows the dial image of the original image. The purpose of converting the original image into a dialled image is to detect objects. Pixels that are very close to each other make the close boundary, and figures make the close boundary considered as an object.



Fig. 7 Dilated Image

Fig. 8 shows the imaginary reference line, which is drawn on the image to count objects.



Fig. 8 Image with a Reference line

Fig. 9 shows the final output. The object which crosses the reference line is counted and sent to the system as input for further processing.



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Fig. 9 Final output

After implementing the algorithm for one lane, it will be implemented for all four lanes. After obtaining the real-time vehicle count for all four-lane traffic signals, they are scheduled according to vehicle density. The lane with the highest vehicle density will be given the highest priority. By doing this, we can significantly reduce congestion.

Fig. 10 shows the Basic architecture of the system, in which an image is collected through CCTV and then stored in the database. After that, it is converted into a greyscale image. Then it is transformed into a processed image, and objects are detected according to that signal schedule.



Fig. 10 Basic architecture of the system

## VI. CONCLUSION

The traffic of vehicles is a rapidly growing problem worldwide. In cities with larger populations, traffic is a significant issue. Crowded conditions, poor management, and a lack of advanced traffic control facilities are key factors contributing to the increase in traffic. Our system will detect traffic densities in real-time and schedule the traffic light accordingly. Also, it will show the corresponding result on the website. Despite new efforts to control traffic in real-time, further research is needed to enhance its accuracy and implement it on a global scale.

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## DECLARATION

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	evidence that is already publicly available.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors have equal participation in this article.

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Mr. Onkar Nichat is currently pursuing a Bachelor of Engineering in Computer Science and Engineering from the Imperial College of Engineering and Research, Wagholi, Pune, India. He has an interest in machine learning, data science, web development, and artificial

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## **Traffic Signal Scheduling using Machine Learning**



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