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Traffic Signal Scheduling using Machine Learning

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Abstract: ***Within the past few years the number of vehicles increased drastically and therefore the traffic of vehicles became a major issue in urban as well as in rural areas. Major traffic is happening in the area where many roads do intersect with each other. Our existing traffic signal is not real-time and it is run according to how it is programmed earlier irrespective of traffic. To avoid traffic, traffic signals should give the priority to the road that has the maximum density of vehicles. By doing this we can pass the maximum number of vehicles in a certain period of time. This type of signal acts according to the real-time situation, and take a decision smartly. Hence this system is also called a smart traffic light system. The purpose of this study is to get the traffic situation on the roads in real-time and acts accordingly. Using a web camera that should be mounted on the signals, we can get real-time footage of the roads and by using image processing methods, we can determine the densities of vehicles on each road. Signals which are programmed priorly or wrong signal scheduling was found to play the greatest role in causing vehicle traffic. This smart traffic signal scheduling system is definitely a better option in comparison with existing traffic signal scheduling as it is taking the decision according to the traffic situations.***

Keywords: ***Image recognition, Machine Learning, Image Processing***.

I. INTRODUCTION

The objective of the project is to design and implement a dynamic traffic signal system that adjusts its temporal order based on the real-time traffic density at the junction. The current challenge with the traditional fixed-time traffic signals is that they are unable to respond to changes in traffic flow, leading to 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 that are plagued by congestion and provide a smoother and more efficient experience for commuters. An object detection technique will be employed in combination with video analysis to accurately count the number of vehicles within a certain space. 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 optimized to work 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 causing an increase in traffic-related problems. 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 and 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.

The effective management of roads is crucial to ensuring their proper usage and maintenance. Gathering traffic information and updating it for road users is an important aspect of this. To this end, various sensors will be deployed to gather relevant data on traffic parameters. Image processing is a key aspect of capturing traffic density, which can be used to determine traffic patterns at different times of the day. In India, traffic lights play a critical role in regulating traffic flow and ensuring compliance with traffic rules. The three colors 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.

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 road 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 density of vehicles 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. Used a deep reinforcement learning model for controlling the traffic light. In this, he breaks down the complex schemes as states and divides them into small grids. The reward got was the cumulative waiting time difference between the two cycles. He used a convolutional neural network to map the states to rewards. There are several components for improving the performance, like target network, dueling network, double Q-learning network, and prioritized experience replay. He evaluated the model using simulation in the Simulation of Urban Mobility (SUMO) in an interconnected network of vehicles, and the simulation results showed the efficiency of the model of 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 which is based on the canny operator. After that, the full image was classified using a support vector machine and various spectral, spatial, and texture attributes to form a road image. At last, the quality of detecting the 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 true adaptive signal control. They presented a paper containing Q-learning, a simple and powerful reinforcement learning algorithm, and displayed a case study that involves the application of traffic signal control. The main objective of the project is to take control of a highly congested area. [4] In this paper, the authors presented a system in order to increase the visibility of drivers in bad conditions. The classification method is used to identify the variety of optical characteristics for vision enhancement algorithms to make them 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-dimension feature matrix. then, classifiers are trained using five supervised learning algorithms. He shows that extracted features could describe the image semantics accurately. This method gives the basis for further study of the detection of vehicles at nighttime or when there is foggy weather where objects or vehicles cannot be seen 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 main purpose of the automatic detection of traffic panels is to support maintenance and help the driver. He proposed the language model which is partially based on the dynamic dictionary. [6] In this paper, a real-time smart traffic light system is constructed. In this, the main element is the Arduino board(open-source electronic board for educational purposes). created a real-time smart traffic light system demo model to show how the system will work. This project is mainly based on image processing and machine learning. Created the C++ code for finding the density of vehicles on the road and take the action accordingly. They divided the densities into 3 parts namely less 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 used for number plate reading, and obstacle detection. This is operated by using an Android app so that signal can manage manually if needed.[7] Life is precious. They developed the system using AI and machine learning. The emergency vehicles like ambulances and fire fighting vehicles should reach the destination at a specific time.to save time and avoid congestion all the traffic lights which are in the way of emergency vehicles and delayed by 1 min so that emergency vehicles can pass the congestion easily and reach the desired position in a particular time. Arduino UNO as well as Mega with 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 matcher algorithm is used. Matcher algorithm uses a geometric and algorithmic template to convert the 3D images into 2D images in real-time. The camera which is mounted in the smart vehicle is used to recognize the traffic light. Once the spotlight is detected the control is go to the Adaptive Template Macher 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 go into the moving state. They used image processing for developing the system. it is very useful in urban and rural areas.

III. PROPOSED SYSTEM

From the above section we come to know that, to deal with the highly increasing traffic, we need a real-time traffic signal scheduling system. Real-time traffic signal scheduling system is a little expensive and do a greater amount of work in a shorter period of time. More precisely, the few advantages of a real-time Traffic signal scheduling system are as follows1. Many types of situations arise in day-to-day life due to which congestion is happened on the road. 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 in a much better way according to the real-time situation. 2. It reduces the average waiting time of the vehicles 3. It also reduces the emission of harmful gases. In shorter words, it can reduce the pollution level as well.

The system is divided into two parts namely web service and traffic signal scheduling according to the density of vehicles. On the web service, all the traffic signal-related activities will be shown. For this project, we have the database to store a high amount of data generated per second. The main aim of the system is to identify the congestion of vehicles due to accidents or any other external event happening on the road and schedule the traffic signal accordingly. The system will detect a traffic-related event in real time.

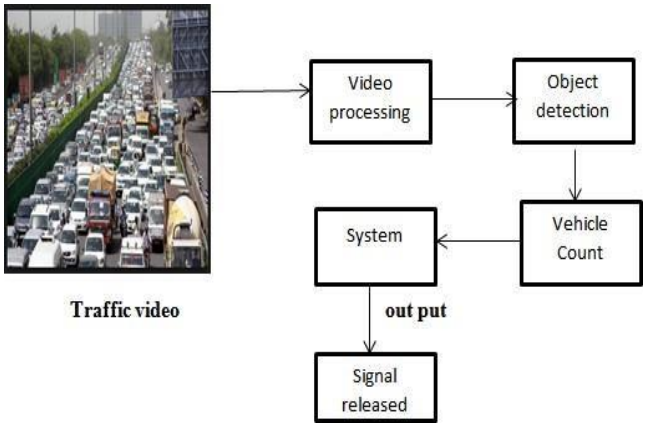

Fig.1 Proposed System

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

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 work well without traffic police.

a. Image Acquisition-

In this work, we capture the image through a webcam. The real-time images of roads and vehicles are captured every 1 second through a webcam. Then we make sure that the webcam is properly connected to the system and captured images are previewed on the system before moving to the further process. Fig. 2 shows the flow of image acquisition.

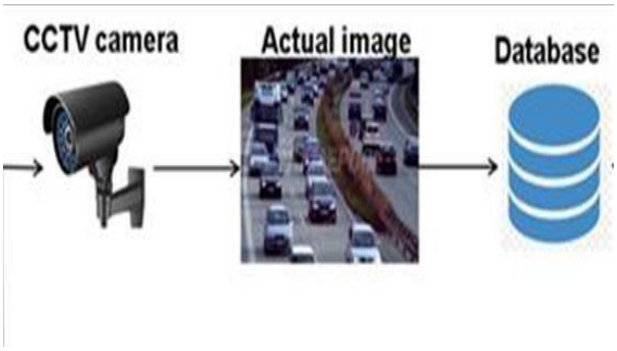

Fig. 2 Image Acquisition Flow Diagram

As the above figure shows, the real-time images are captured through the web camera and stored the real-time images for further use.

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

b. Image Processing-

Images are captured through the webcam fitted are the junction of the road. Four cameras are placed for four roads that are meeting at a particular junction. Cameras are placed at the respective position from which a particular whole road can be clearly visible. Then as discussed in the previous section these images are stored in the database for further use. Then these images are converted into greyscale images to eliminate the complexities related to the 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 so that it can suitable for further use. This involves Image enhancement, Image resizing, edge detection, and image matching. The following diagram shows the basic steps which are followed during image processing.

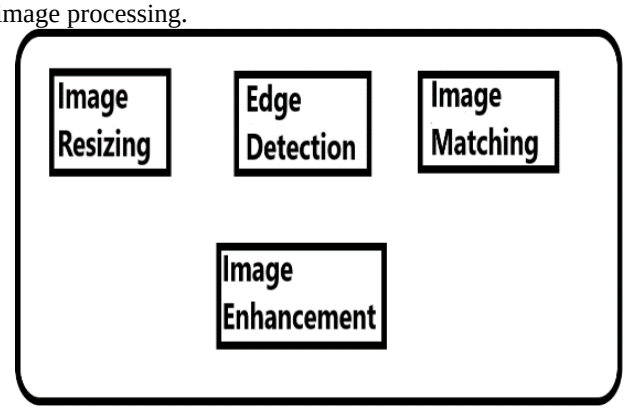

Fig. 3 Basic Image Processing Techniques

b) Image resizing-

Image resizing is done on the captured images in order to increase or reduce the number of pixels.

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 black-and-white image to detect the blob, eliminate the background other than the object i.e., in this case, vehicles, and reduce computational complexities.

d. Applying 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.

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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-
A convolutional neural network is used to extract image feature pixel by pixel.
Step 4-
Matrix factorization is performed on the pixel, the matric is of m*n.
Step 5-
Max pooling is performed where the maximum value is selected and again fixed 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 as the required object and it is counted as the vehicle.

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 which is captured by the web camera.

Fig. 4 Original image

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

Fig. 5 Greyscale image

Fig. 6 shows how the system is detecting the objects

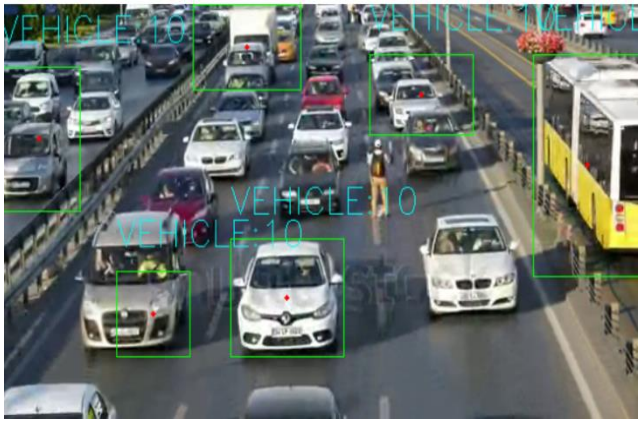

Fig. 6 An image that detects the vehicle

Fig. 7 shows the dialed image of the original image. The purpose behind converting the original image into a dialed image is to detect the 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 in order 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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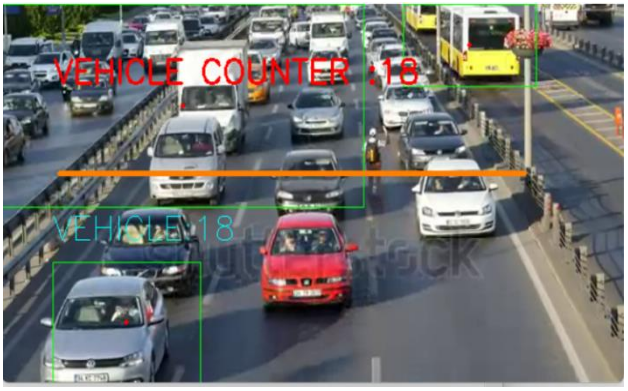

Fig. 9 Final output

After implementing the algorithm for one lane it will be implemented for all four lanes. After getting the real-time vehicle count of all four-lane traffic signals is scheduled according to the vehicle density. The lane which has the highest density of vehicles will be given the highest priority. By doing this we can reduce congestion to great extent.

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

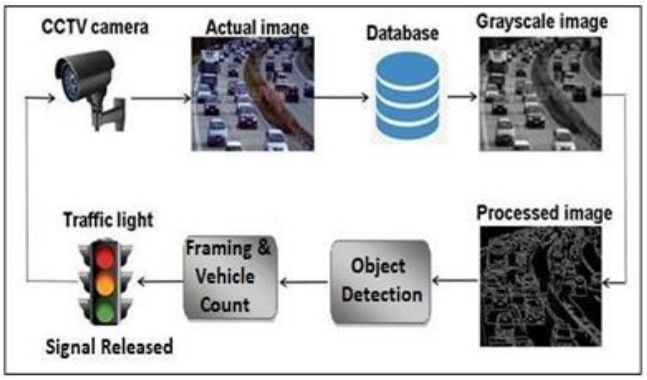

Fig. 10 Basic architecture of the system

VI. CONCLUSION

The traffic of vehicles is a drastically growing problem in the world. In the cities where the population is more, traffic is the major issue. Crowded conditions, poor management, and lack of advanced traffic control facilities are the major factors contributing to increasing traffic. Our system will detect the traffic densities in real time and schedule the traffic light according to the condition. Also, it will show the corresponding result on the website. Despite new efforts to control the traffic in real-time, more research is needed in order to increase its accuracy and implement it worldwide.

DECLARATION

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Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors have equal participation in this article.

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