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COMPUTER-VISION: PROMISING METHOD OF REAL-TIME TRAFFIC CONTROL AT THE ROAD INTERSECTION

Swati N. Divatankar*1, Dr. Magan P. Ghatule*2

*1Research Scholar, Dept. Of Electronic Science, R & D Center, Modern College Of Arts, Science And Commerce, Pune, Maharashtra, India.

*2Principal And Prof. Sinhgad College Of Science, Ambegaon (Bk.), Pune, Maharashtra, India.

ABSTRACT

Due to the increase in the number of vehicles on the road day by day, traffic anomaly detection and traffic control are some of the active research areas. Vehicle detection and classification in real-time are one of the difficult tasks of intelligent traffic management systems. With different types of vehicles, and with high density it becomes a challenging task to make accurate vehicle detection and classify it correctly with real-time speed. Based on the accuracy of the detection and classification of vehicles traffic can be controlled on a real time basis at the road intersection.

In this research paper, the drawbacks of the existing methods of road traffic control at the intersection and the need of the computer vision- based method are discussed. Further, the computer vision-based method is discussed along with the steps involved. Different evolutionary algorithms are proposed by researchers which can be used for real time traffic control at the intersection using computer vision. The steps needed to be followed for the same are discussed and the paper concludes with the advantages of the computer vision-based method.

Keywords: Computer Vision, Real Time Traffic Control, Vehicle Detection, Intelligent Traffic Management.

I. INTRODUCTION

Due to an increase in the population, an increase in the number of private vehicles, insufficient road infrastructure, synchronized road traffic signals, and insufficient green signal time, the number of vehicles on road has been increased at the intersection as well as on highways. The popular methods of traffic management and control used at the road intersection are traffic police , use of navigation apps and traffic signals. Although the traffic signals and service provided by the traffic police at the intersection decrease average traveling time, these methods have no emphasis on actual traffic situations, which results in ineffective traffic management techniques. These methods have the following disadvantages that explains the need for vision- based methods of traffic control.

- In traffic signals, the timing is repeated continuously, it has no connection with traffic and could lead to significant delays at particular intersections.
- For the purpose of estimating the time of the traffic light, traffic data collection must be performed.
- In case of a traffic control with traffic police, a trained officer is needed. Since this system is not automated and the method is insufficient in cases of heavy traffic, one person will be needed continuously to operate it.

These disadvantages can be overcome by using vision-based methods. The computer vision will direct traffic and determine the number of vehicles on the road in real time. Based on the traffic condition; the required green signal time can be allotted for the roads of the intersection. Vision based methods will be automatic and real-time based therefore it will control the traffic congestion at the road intersection to some extent.

Nowadays, in many cities low-cost video surveillance systems have been installed, commonly known as closed-circuit television systems (CCTV). CCTV cameras are a unique and practical application of video surveillance technology. The recordings from the camera can be used to analyze traffic patterns for future study and also for monitoring & controlling traffic, which will help to build adaptive traffic light control systems.

Instead of limiting the camera's features, the camera can be used for real-time traffic measurement and control. This traffic monitoring system eases traffic congestion and offers intelligent signaling, which greatly reduces pollution and time delays while providing emergency vehicles with faster service.

The cameras are crucial for incident and accident detection, vehicle monitoring, license plate recognition, and ensuring that traffic rules are being followed. Additionally, the traffic data can be made available for additional

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data analysis or for real-time traffic monitoring, both of which are helpful for identifying traffic violations including speeding and running red lights.

Figure 1.1 shows a comparison of human vision systems and computer vision systems. Computer vision is an interdisciplinary study that studies how to help computers read complex data from images or videos [1].

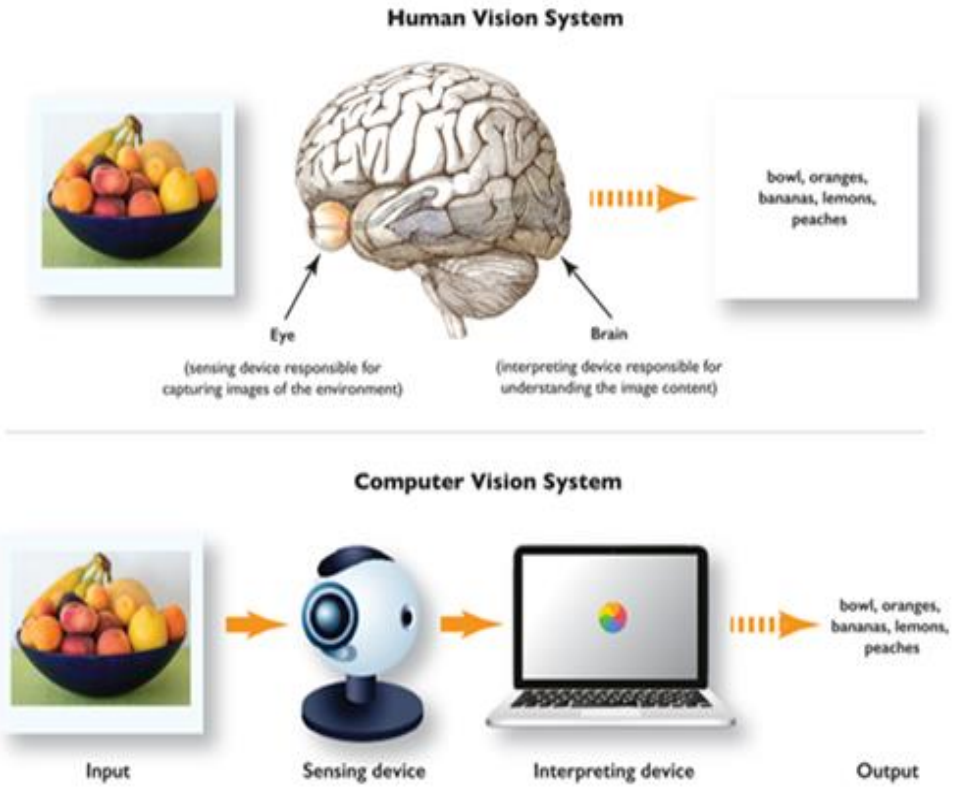

Figure 1: Comparison of human vision system and computer vision system

The fundamental aim of computer vision research is to simulate some of the complexity of the human visual system. Computers are capable of identifying and analyzing objects in images and videos in a manner similar to that of humans. Computers can identify and evaluate objects from images and videos similarly to how humans do it.

Computer vision-based method performs following tasks:

Identification of objects: The system analyzes visual data. It determines a particular object in a picture or video. Motion-based and appearance-based object detection are the two categories. While motion-based methods use the object's velocity, acceleration, direction, and trajectory, appearance-based methods concentrate on features like color, edge, shape, size, and any other static characteristics.

Object classification: The next step after object detection is object classification. The system analyzes visual information to assign an object in an image or video to the appropriate category. Four characteristics set an object apart from others: size and shape, color, texture, and motion.

Object tracking: The system examines video, finds objects that match the search criteria, and keeps track of moving objects. Object tracking is the process of constructing the route and trajectory of an object in the image plane by identifying and determining the position of the object in subsequent frames. It only identifies the location of the object in each frame. The association between the object's positions in different frames is then established [2].

II. ALGORITHMS OF VISION BASED METHOD FOR REAL TIME TRAFFIC CONTROL

Over the past ten years, there has been an increase in research on vision-based traffic monitoring systems in advanced countries. A prominent application of computer vision is in the monitoring and management of traffic. By estimating traffic density close to traffic signals, a dependable system known as a vision-based traffic control system manages real-time traffic.

Artificial intelligence (AI field) enables computers and other systems to extract relevant information from visual inputs such as images, videos, etc. and to take appropriate action in response to that data. Artificial intelligence (AI) approaches have been used to improve the intelligent transportation system. Artificial neural network (ANN) technology has been applied to traffic control and traffic flow prediction [3]. Machine learning and deep machine learning are two groups of artificial intelligence. Advanced models and techniques called machine learning allow computers to provide data that may be used to create AI applications. Deep machine learning uses multiple-layer artificial neural networks to do tasks like speech recognition and object detection with incredibly high accuracy.

For the vehicle detection challenge, convolutional neural networks, a Deep Learning technique, have been frequently used. A region-based convolutional neural network (RCNN) was utilized after CNN to extract features, and then SVM was used to do classification. Fast RCNN has gained popularity since RCNN training takes a huge amount of time. Fast RCNN employs a selective search, which takes a while to locate a region of interest. As a result, a faster R-CNN approach was developed, which finds regions of interest using a region proposal network. Higher detection quality can be achieved with faster R-CNN techniques [4].

The faster R-CNN (Region Convolutional Neural Network) object detection algorithm used in the researchers' proposed method accurately detects vehicles in low light [5]. Faster RCNN is better suited for vehicle detection and classification. Additionally, vehicles can be precisely recognized in low-light situations [6]. Mask RCNN is an extension of faster R-CNN in which the bounding box and score were used to find the mask of the identified item. Deep learning techniques can be used to detect vehicles accurately at night and in low light conditions.

The problem is entirely solved, not just partially, via deep learning. With machine learning algorithms, features must be extracted in order to identify the object, but with deep machine learning employing the YOLO technique, the object can be quickly identified by location and name. Deep learning techniques have the capacity to independently build new features. In contrast to previous vision-based systems, convolutional neural networks and deep learning provide the best combination for a traffic monitoring system that correctly detects and precisely counts the vehicles at the intersection [7]. Using video surveillance data, a convolution neural network is employed to categorize road traffic. Convolution Neural Networks are known for their accuracy and require the least amount of preparation. The video is categorized based on a rating of the traffic to its content. After initial training, the convolution neural network is evaluated and updated using a validation set.

For traffic control, a trained model can process the real-time streaming video, detect each frame, and rate how much traffic is in each lane [8]. Real-time traffic analysis on CNN is done by computing mobility matrices using Mask R CNN and a pretrained model [9]. It has been recommended to use videos to count vehicles. Tracking, counting, and object detection utilizing YOLO are the three stages of video processing. A system that concentrates on tracking moving items, identifying and preventing traffic congestion, and suggesting alternatives to the moving objects was proposed. The YOLO algorithm's convolutional neural network was employed for the training process. The first input for the majority of tracking techniques is the spatial detection of the objects in a video frame [10]. A quick, precise, and immediate object recognition system called You Only Look Once (YOLO) was released [11].

Before creating YOLOv3 in 2018 [12], it underwent a lot of significant modifications. Performance of deep convolutional neural network (DCNN), support vector machine (SVM), and fundamental YOLO approach was assessed [13] in identifying traffic congestion from CCTV photos. They show the best accuracy of 91.4, attained by the YOLO method.

A comparable work compares the effectiveness of YOLOv3, faster R-CNN, and mask-RCNN for object detection using a dataset of CCTV images to determine traffic flow [14]. It is demonstrated that YOLOv3 displayed the best speed and accuracy for their image dataset, which had a precision value of 0.96. YOLOv3-tiny version was pre-trained on COCO datasets for real-time traffic counting [15].

III. OVERVIEW OF THE METHOD

Humans are capable of quickly detecting and identifying real-time vehicles on the road, as well as controlling traffic based on the level of congestion created at each lane. The same can be accomplished by utilizing computer vision algorithms to identify and count vehicles. The coordinates of vehicles in motion are recorded

by an algorithm, which then forms a box around that specific vehicle. Making precise vehicle recognition and correctly classifying it with real-time speed becomes a difficult issue when there are many various types of vehicles and a high arrival flow.

Many parameters, including average vehicle speed, driver behavior, traffic law violations, vehicle count, and vehicle flow, can be computed from the effective identification and classification of vehicles. To calculate the required parameters from the real-time traffic video, accurate vehicle identification and categorization of moving and stopped vehicles is crucial. [16] . The video-based techniques offer traffic data, are simple to install, and offer surveillance, security, and traffic management techniques. In addition to monitoring and controlling traffic, cameras mounted at road intersections are also used for identifying incidents, accident detection, vehicle tracking, license plate recognition, and enforcing traffic regulations, among other things [17].

The following steps need to be taken to manage traffic at the road intersection:

1) Vehicle detection:

a) Camera placement: The first step in employing a vision-based technique to identify automobiles is to position the camera in an appropriate location. Videos taken by stationary cameras have been employed in the research that has been proposed.

b) Detection: Vehicle detection is the process of identifying and locating vehicles from images or videos.

2) Vehicle classification:

Vehicle classification is used to identify different kinds of vehicles. It is possible to identify one or more trained or per-specified vehicles or vehicle classifications. Vehicles of all kinds, including trucks, buses, cars, motorcycles, bicycles, etc., can be seen.

3) Tracking vehicles:

Once a vehicle is recognized, it is followed or tracked. As the vehicle drives through the scene or across the particular frame, the system must record the data with real-time tracking updates.

4) Vehicle counting:

It is important to count the vehicles in order to estimate the density or arrival flow of the vehicles, which will be used to manage signaling, in order to control traffic at road intersections.

5) Traffic management:

A formula for the duration of the green light for a particular road can be generated from the vehicle count to control traffic.

IV. CONCLUSION

Currently, traffic signal controllers operate on a predetermined timer and do not respond immediately to the volume of vehicles on the route. A computer vision-based traffic light system that can automatically adapt to the traffic scenario at the traffic signal has been created to reduce congestion and improve traffic flow.

The following are **advantages of computer vision-based methods** used for real time traffic control at the road intersection.

1. The computer vision will direct traffic and determine the number of vehicles on the road in real time. It is more accurate in identifying the presence of vehicles when real-time data is used.

2. In order to pass through heavy traffic safely, a side of the junction with a larger traffic flow occasionally needs a longer green period than the usual allotted time. The employment of a vision-based traffic control system can make this possible.

3. The system will only give necessary green time to empty roads, rather than wasting additional green light time for them.

4. Since signal timing will be determined in real time, there is no requirement for observers or autonomous equipment to collect traffic data.

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