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Review of Vehicle Detection Technologies

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***Abstract*— This paper reviews various approaches and technologies used in vehicle detection especially using their license plates. The objective of this is to shed some light on different aspects involved in such methods. There are myriad of propositions that have been worked upon. Some of these use sensors, embedded systems, some are fully software based like programs in matlab, python etc. Moreover, there are also examples of both software and hardware going hand in hand for detecting vehicles.**

Keywords: CNN (Convolution Neural Network), Features, Sensors, Traffic surveillance, Vehicle detection, YOLO (You Only Look Once).

I. INTRODUCTION

The most important aspect of urban planning is the identification and monitoring of vehicles. Vision-based traffic monitoring devices have received a lot of attention over the past ten years. Vehicle detection & speed monitoring could assist with this. The monitoring system collects numerous data, including vehicle count, traffic density, vehicle speed. Speed is one of the primary factors in traffic collisions. To evaluate whether the car is driving above the legal limit or not, it is able to derive frames from the video and compare the speed across two places. There are numerous methods that may be used to remove automobiles from their background. Traditionally radar systems were used for such applications but had some limitations. So to overcome the limitations in existing methods, various techniques have been developed for vehicle speed determination using image processing [1].

This paper discusses various ways which are used to detect as well as track the vehicles. Some techniques use GPS, RFID, intelligent transport system while some use sensors on board , CCTV surveillance and what not. All these approaches are described here to give a streamline viewpoint to users about the progress in this field so far.

Figure 1: Example images from a surveillance system [1]

The paper is divided into five sections. Section 1 covers the introduction, while Sect. 2 includes approaches used for vehicle detection with Section 3 covering the different vehicle detection techniques. Section 4 talks about scope of application and lastly, sect. 5 summarizes the review of work discussed.

II. APPROACHES USED FOR VEHICLE DETECTION

The primary step of video processing is the picture localization or object tracking. Vehicle detection includes tracking, behavior analysis, or representation of motion, which serve as the foundation for additional processing to obtain classification accuracy [2]. The other type is motion-based. For an appearance-based strategy, factors including a vehicle's texture, color, and shape are taken into account. With contrast, in a motion-based method, the moving properties are exploited to set the cars apart from the still background sceneries.

2.1 Motion-Based Features

The task of motion recognition is important in computer vision approach. Only moving vehicles are of interest in traffic scenes, which is a key feature of interest. The moving foreground items in an image are distinguished from the still backdrop by the motion detecting approach. Motion signals are used to distinguish moving traffic from stationary backdrop, and they can be categorized into: The optical flow method uses the current pixel speed on the image surface, whereas the temporal frame differencing approach [3] takes into account the previous two or three frames. Background subtraction method is utilized to build background models by employing frame history.

2.2 Appearance Based Features

One can categorize an object's stereo vision based on its color, texture, shape. The majority of the time, models built using these methods employ historical information. Utilizing

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the feature extraction approach, it compares the resulting two-dimensional image features to the three-dimensional features found in the real world. In contrast to motion-based methods, appearance-based methods may identify & recognize fixed objects [4].

2.3 Neural Networks

The vehicle identification process using neural networks is divided into six main steps. They are importing the data set, creating the convolutional neural network, setting up the training parameters, utilizing Faster R-CNN to teach the object detector, & assessing the trained detector.

Vehicle Classification Scheme is focused on classifying vehicles into several groups, such as cars, vans, trucks, buses, etc. A variety of geometry, texture, & appearance-based feature extraction techniques are created in conjunction with various classification strategies.

III. VEHICLE DETECTION TECHNIQUES

The paper in [5] discusses a technique for object detection & tracking in highway surveillance footage and established vehicle detection from the perspective of surveillance cameras. Some of practical Python libraries that can be utilized to count automobiles and categorize traffic include NumPy, Matplotlib, and Scipy. The technique proposed in this paper is low-cost and stable compared to conventional hardware-based traffic monitoring, so it does not require extensive construction or installation work on current tracking devices. Vehicles can be detected by the device even at night. Foreground objects must be present for the algorithm to gather contour attributes or features [12].

Meanwhile in [6] a method for counting traffic that makes use of both still photos and a multi-task, multi-channel CNN network is used. In addition to passing vehicles, this will enable the identification of parked or possibly broken-down cars in the center of the road. This idea is great since parked cars or cars that might crash in the center of the road could slow down both the amount of traffic passing by a road and the speed at which it moves. The fundamental shift in the method's details occurs when the RGB image input is split into two distinct images, namely grayscale & illumination invariance. The procedure of categorization, generation of the vehicle calculation data, and establishment of density level thereafter follow. The classification of camera images was used in this study to improve the effectiveness of the strategy. Investigations on removing images from a range of city movies, where the sample data is always composed of images and then traffic on generally straight roads.

Vehicle detection methods using the intrusive and non-intrusive sensors are being studied in [7]. The vehicle detection system gives detailed information about the type of vehicle, whether it is a car, truck, bus, or heavy vehicle. The driver details can also be saved and shared through the server. The speed and traffic are estimated to avoid speed violations and traffic congestion by giving alerts to drivers. Drivers get the alarms so they can avoid congestion or reduce the speed or take the alternate path available on the route. The radio frequency identification (RFID) [8] is frequently being used for tracking the vehicles at certain checkpoints. Various types of technologies are used for detecting and tracking the vehicles with devices like Light Detection and Ranging (LiDAR), Global System for Mobile (GSM), Geographic Information System (GIS), etc. The sensor nodes used for these methods are sometimes prone to damage and there is cost factor in their installation. Each has their benefits and disadvantages.

The idea in [9] demonstrates a reliable & effective real-time method for autonomous vehicle detection and tracking in aerial films that uses both detection & tracking characteristics to improve the judgment. In the detection phase, the usage of Top-hat and Bottom-hat transformations assisted by the morphological procedure has been utilized. After identification, background regions are removed using a combination method of KLT tracker and K-means clustering to analyze motion feature points of the resulting object regions. Based on their motion characteristic, acquired object characteristics are grouped into distinct items. Finally, a powerful connecting method is shown to link the vehicle labels to the cluster trajectories that correspond to them. The detection & tracking processes were combined in this manner to obtain the robust feature points when they were updated consistently per predetermined amount of frames. Grayscale morphological-based detection, optical flow, & K-means clustering are all incorporated in the extraction and analysis of these feature points. A traffic flow detection scheme based on deep learning on the edge node is proposed in the article [10]. It has YOLOv3 (You Only Look Once) model trained with a great volume of traffic data.

Enhanced bat optimization is used to select features in [11]. This selection is done by combining sample's class label and feature value. Confidence level between two thresholds of tracking rectangles is used for classification. Support vector machine (SVM) classifier is combined with local binary pattern to perform this classification. The interference areas between moving objects and vehicles are removed by Enhanced Convolutional Neural Network (ECNN) classifier.

Table 1: Comparsion table of Vehicle Detection

Method	Strength	Weakness
The authors [12] proposed Vehicle Detection system is depends on local-binary-pattern (LBP).	As shown in some instances and experiments results of vehicles database that this system has an improved performance.	The system is focusing on a simple set of features to detect vehicles, while ignoring the complex features. Besides, there is no vehicle counting and classification in this system.

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The authors [13] proposed (VD) system is based on linking the ARMA model and the AdaBoost algorithm.	The method effectively decreases time complexity. The average time for each image costs less using ARMA + AdaBoost.	Vehicle detection can only be done from frontal & side perspectives, which limits the image that the system can use as input.
A video-based vehicle counting system suggested using virtual loop system [14].	The technology accurately counts the number of vehicles in a variety of daytime lighting situations.	The accuracy of the system depends on the visual angel besides the position of the camera.
The authors [15] suggested an automatic VD for vehicle parking in security, which includes three stages: VD, detecting the face of the driver, and recognizing the face of the driver.	The trials demonstrate the likelihood that the cutting-edge technology will be applied to any location for car parking, such as open parking lots.	This method restricts the input video to the method to detection from front and sideways vision only.
The authors [16] proposed VD and counting system based on computer vision.	The accuracy of the suggested system is about 96%.	First, the cars must be clear of obstructions and be within the virtual detecting zone. Second, the virtual sensing area's breadth needs to be sufficient to count the number of vehicles.

IV. SCOPE OF APPLICATION

The vehicle detection can sort out many problems one can face in dense traffic areas. Real time traffic monitoring can keep reckless driving in check especially when in recent times deaths due to traffic accidents is on the rise. If done efficiently, tracking and detection of vehicle can help solve many problems.

4.1 Theft deterrent

With an efficient vehicle detection and tracking system in place, thieves can be deterred from stealing vehicles. It has been seen, in recent times, a stolen vehicle usually gets tracked easily because they can be detected efficiently due to license plate tracking.

4.2 Traffic Management

The volume of traffic on raods has increased a lot. People try to change lanes in order to reach their destinations quickly. They risk not only their lives but everyone around them faces a risk. Real time monitoring of vehicles can help manage the traffic. Automatic challan generation is an example that demotivates people from breaking the traffic rules.

4.3 Tracking vehicle bombs

When authorities investigate terrorists and they get intel about any suspicious vehicle that may have been stranded for the purpose of bombing; it can be easily tracked using this application.

4.4 Smart Traffic system

Vehicle tracking can help make the job of Traffic police easier. The alignment and tracking of vehicle along the roads can lead to reduction of congestion on roads.

4.5 Reduce Accidents

When people have knowledge that their driving movement can be tracked, they will try to drive correctly in their lanes. This will go a long way in decreasing road mishaps.

4.6 Better Driving

Vehicle movement being monitored for automatic challans will motivate people to drive rightly and follow the traffic rules.

4.7 Smart Parking

To avoid parking problem in densely populated areas, a map can be drawn and updated simultaneously as vehicles are getting parked. The faulty parking can be detected easily and be removed.

V. CONCLUSION

In this paper, we have reviewed various vehicle detection and classification techniques that are mainly focused on deep learning. There is another aspect to this which includes various hardware techniques using sensors, etc. One of them is the RFID tags which have become a common norm especially for toll taxes. It makes the movement on highways automatic and seamless. From this paper, readers can get an idea about vehicle detection , tracking and classification using Convolution neural networks, various classifiers etc. It sheds light on the software side of detection and tracking integrated with CCTVs. Various state of the art techniques aids this application and can go a long way in promoting smart city projects.

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