Vehicle Detection and Counting using Haar Feature-Based Classifier

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***Abstract*— In this paper we would describe a vehicle detection technique that can be used for traffic surveillance systems. An intelligent traffic surveillance system, equipped with electronic devices, works by communicating with moving vehicles about traffic conditions, monitor rules and regulations and avoid collision between cars. Therefore the first step in this process is the detection of cars. The system uses Haar like features for vehicle detection, which is generally used for face detection. Haar feature-based cascade classifiers are an effective object detection method first proposed by Viola and Jones. It's a machine learning based technique which uses a set of positive and negative images for training purpose. Results show this method is quite fast and effective in detecting cars in real time CCTV footages.**

Keywords— traffic surveillance, computer vision, automatic car detection, Haar features, transportation systems, OpenCV

I. INTRODUCTION

In recent years there has been an increase in the number of motor vehicle resulting in problems like traffic congestion, accidents resulting in death and injuries. Developing countries bear a large amount of burden due to lack of proper infrastructure and traffic surveillance system. It has been noted that increase in preliminary transportation infrastructure system like more number of roads or flyovers can't solve these problems completely. An automated traffic surveillance system equipped with sensors can reduce these problems by a large margin.

The first step in traffic surveillance is recognizing vehicles in surveillance video cameras. Here, we are going to propose a system that is capable of detecting vehicles at a steady rate.

Automatic detection of vehicles from videos is a challenging task. But then vehicle detection and counting is crucial to decrease traffic congestion and increase security. Preferably video should be recorded from CCTV cameras placed at the top of traffic signals. Data recorded from traffic flow can be recorded directly and can be communicated as needed. This paper specifically focuses on automatic car detection process. The process described here uses Haar like features previously introduced by Viola and Jones. The rest of the paper is organized as follows. Section I presents related work an i.e. different vision based surveillance systems that were proposed. In section II we discuss the implementation of the proposed system and present the results. Finally we conclude the paper in section III.

II. RELATED WORK

There have been proposals to use parallel computing for storage and faster processing of videos. Previously we have proposed a system where Hadoop Map reduce can be used for faster processing of surveillance videos [14]. The process described here uses Haar like features which have been introduced by Viola and Jones [15].

The problem of vehicle detection is a challenging one, mostly because there are lots of different models and dimensions of cars. Also detecting them in uncontrolled environment with varying backgrounds and low processing time makes it difficult. As vehicle recognition is the most important step in traffic surveillance, there has been a lot of research done. In this portion we would discuss different vehicle traffic image analysis and vehicle tracking approaches.

A. Moving object detection based approach

The Moving object detection technique can be used to detect vehicles. Here subsequent image sequences are compared to detect moving objects. Large number of applications is deployed based on this technique like video surveillance, healthcare, remote sensing, and underwater sensing. Though various research papers have been proposed, it's still a tough task to detect and segment vehicles in a dynamic environment. Here we would present a few related papers describing different approaches.

1. Fast Vehicle Detection and Counting Using Background Subtraction Technique and Prewitt Edge Detection [1]

Here authors proposed a highway vehicle detection model using image processing techniques, such as background subtraction, Prewitt filter and various morphological operations. First step is edge detection followed by adaptive background subtraction technique to extract the moving objects; next morphological operations are used to remove the unrelated objects to the vehicles. The accuracy of the system is dependent on the edge detection and segmentation technique used. A better accuracy might lead to more computational complexity too.

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2. Moving vehicle detection based on fuzzy background subtraction

Background subtraction is a method typically used to segment moving regions in image sequences taken from a static camera by comparing each new frame with a model of the background scene. In the paper [2] authors propose a moving vehicle detection which uses fuzzy background subtraction algorithm and achieves high detection rates.

3. Background subtraction for vehicle detection

The method proposed in [3] can be considered as a hybrid of two existing methods. The background is modeled per-pixel with a collection of pixel values. The foreground/background decision is based on whether the current pixel value finds a match with the samples in the model. The evaluation is based on public CDnet dataset in highway scenarios.

4. Real-time Vehicle Detection using Information of Shadows underneath Vehicles

In the paper [4] authors have proposed a vehicle detection from video camera footage using the shadow underneath the cars. The method actually works by calculating the distance between front and rear tire from shadows. Results show that the proposed algorithm can detect vehicles with high speed using low-complex calculations.

5. Reliable moving vehicle detection based on the filtering of swinging tree leaves and raindrops

In the paper [5] authors proposed a background subtraction method to extract moving objects. Here two back to back filters are used to remove swinging tree leaves and raindrops respectively. In addition, a shade removal method is combined with a versatile background deletion approach to take out the mobile vehicles in background images.

6. Tracking multiple vehicles using foreground, background and motion models

The authors in [6] have presented an approach for tracking vehicles by integrating traits such as volume, location, color dissemination, speed of a group of the forefront entity and Gaussian Mixture based background form.

B. Feature Based Method

In feature based method, moving objects are detected using some sub features like edges and corners of objects. Here we would discuss a few feature based methods proposed previously.

1. Automation of Traffic Flow Measurement Using Video Images

The research article [7] focuses on automating the task of vehicle detection on motorway. The system caches a sequence of images from a video camera mounted above a motorway. Background subtraction is applied to perform motion segmentation on images and then apply image processing techniques such as statistical methods and solving systems of equations to estimate traffic parameters. The system has been designed to handle inconsistencies caused by occlusion of vehicles, by predicting the motion of vehicles using the derived parameters of motion.

2. A Trainable System for Object Detection in Images and Video Sequences

The paper [8] focuses on training set of images for detecting objects. Examples have been given on detecting face, car or people.

3. Vehicle Classification System with Local-Feature Based Algorithm Using CG Model Images

The authors in [9] have proposed a vehicle classification system using local-feature configuration. In this work, the Eigen-window approach is used. It has several advantages such as detection of vehicles even if it changed its path due to veering out of the lanes and also if parts of the vehicles are occluded.

4. A Detection Method of Traffic Parameters Based on EPI

In the paper [10] authors have presented a vehicle detection technique based on pattern recognition methods. The Epi-polar Plane Image method is used to measure the movement and characteristics of the vehicle. Finally, based on the EPI, it is given about the detection methods of mean velocity and length of the vehicle, traffic flow.

C. Vehicle Tracking

Vehicle tracking means identifying the physical movements of the object and tracking its position in a dynamic scene. In video based surveillance system object tracking is a challenging task. Here we would present a few ideas highly related with proposed method on Vehicle tracking.

1. Detection and classification of vehicles

The proposed method in [11], regions of the object is used for tracking purpose. Vehicles are modeled as rectangular patches with certain dynamic behavior. The proposed method is based on the establishment of correspondences between regions and vehicles, as the vehicles move through the image sequence. The model provides position and speed of each vehicle from video captured through stationary camera.

2. Efficient Vehicle Tracking and Classification for an Automated Traffic Surveillance System

This paper [12] introduces a traffic surveillance model to track vehicles in real time. The authors in this paper have proposed a novel real time traffic supervision approach which employs optical movement and non-calibrated camera parameter knowledge to detect a vehicle pose in the 3D world. In this paper, the proposed approach uses two new techniques: color contour based matching and gradient based matching, and it showed well accepted results when it tested for real tracking environment.

3. Detection of vehicle occlusion using a generalized deformable model

The authors in [13] have presented an occlusion detection approach based on generalized deformable model. In this paper, the occlusion of vehicles detection process used a 3D

solid cuboid form with up to six vertices, and this cuboid used to fit any different types and sizes of vehicle images by changing the vertices for a best fit. Therefore, vehicle detection, segmentation and tracking can be achieved efficiently due to changes in the region proportion, prototype width and height with consideration to previous images

III. Proposed System

Voila and Jones previously suggested Haar feature technique for face detection purpose. It's a machine learning based technique where a positive and negative dataset is required for training purpose. Algorithm extracts features from these images.

To understand how feature extraction is used, let's say each feature is a single value obtained by subtracting sum of pixels under white rectangles from sum of black rectangles. That way, there can be 20000 features resulting in huge calculation. To simplify it they introduced integral images to reduce the calculation to an operation involving four pixels.

But among these large no of features most are irrelevant. We need to select the features that classify the object to be detected. For each feature, it finds the best threshold which will classify the objects to positive and negative. But obviously, there will be errors or misclassifications. We select the features with minimum error rate, which means they are the features that best classifies the objects.

Here we propose a framework to combine several features into a cascade, i.e. a sequence of tests on the image or on particular regions of interest, organized into several stages, each based on the results of one or more different Haar features. When the object passes through all stages of classifiers, it gets recognized.

To implement the framework, we have used OpenCV along with a python wrapper called cv2. Here we would describe the steps one by one.

1. Asset Preparation: Asset preparation means the training of image classifier to detect objects. Images can be occupied from car image datasets available online. Negative images are the one that doesn't contain cars. Here, we have collected images by manually cropping from video frames. No of negative images can be increased by rotating cropped images.

2. Creating metadata: Metadata is a file containing number of objects, position and dimensions of the objects within each image. This metadata invoked by openCV library would be used to train the classifier.

3. Testing the classifier: Here OpenCV along with a python wrapper CV2 to invoke the classifier and detect objects from the video. Vehicles within the frame are highlighted with a rectangle.

First we need to create a Video Capture object to access the video. The name of the video file must be passed as an argument. We would also need a Cascade Classifier object with the name of the trained classifier as an argument. Now we can use a loop to read the video and detect cars using the detectMultiScale function. Once the objects are detected we can print the no of vehicles or use cv2.rectangle function to draw a rectangle surrounding the detected vehicles.

This concept is applied for the entire image and the final count of objects is present in variable count. A fairly good accuracy of count is achieved. Table 1 presents the results. 2nd column presents the no of frames in a video. Column 3 and 4 respectively represent no of cars and no of detected cars. Last column denotes the percentage of accuracy.

TABLE**1** Testing of the proposed method

Accuracy	**Detected no Cars**	**Actual no of Cars**	**Frames**	**Input Video**
93.75%	45	48	30	**Video1**
90.03%	28	31	20	**Video2**
97.1%	34	35	20	**Video3**

Here are some video snapshots showing how the cars get marked with a rectangle:

Video snapshot 1.

Fig. 1. Image1

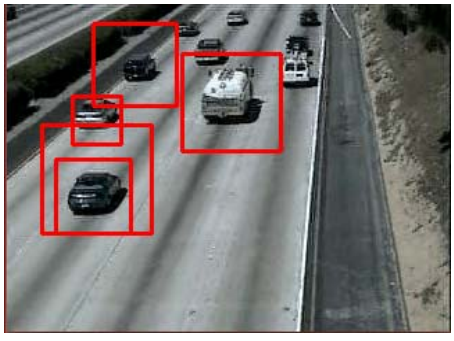

Fig. 2. Image1 with cars in a rectangle

Video snapshot 2.

Fig. 3. Image1

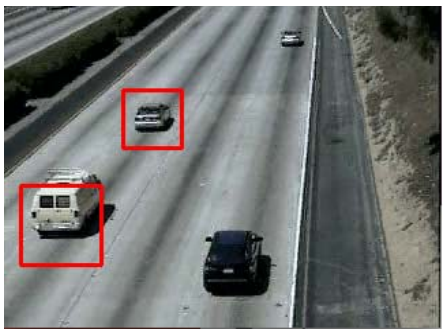

Fig. 4. Image1 with cars in a rectangle

It is clearly observed in Fig. 2 and Fig. 4, some cars that are obscured because of distance and aren't detected either. Still this is a very useful technique for detecting vehicles from images or video frames.

IV. CONCLUTION AND FUTURE SCOPE

The paper presents a way to detect vehicles using Haar cascades. First we presented different vision based vehicle detection systems. Following that we presented a machine learning based technique to detect cars from video frames. The haar feature based solution is faster and capable of detecting cars at a rapidly changing environment. Experimental results show that the accuracy of counting vehicles is above 90%. The cost of sensors, processors and CCTV cameras are decreasing rapidly. This continued with increased image resolution provides the basis for a continuous growth of this field.

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