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Survey on Vision Based On-Road Vehicle Detection

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Abstract

To alert drivers about driving environments on-board automotive driver assistance systems are developed. This paper presents a review on the various techniques of On-Road Vehicle detection systems. When vehicles are fully stopped for epoch of time, this condition is known as a traffic jam. For this, we must need an efficient traffic control system. In this paper a Survey of previous and recent works is presented on vision-based vehicle detection using sensors and also gives a detailed discussion on two steps of vehicle detection which are hypothesis generation and hypothesis verification. In the first step, all vehicles are hypothesized and in the second step, all hypotheses are verified and classified into vehicle and non-vehicle classes. The Both stages are important and challenging.

Keywords: *Vehicle detection, Sensors, Hypothesis Generation, Hypothesis Verification, Driver assistance, intelligent vehicles*

1. Introduction

Now a day Traffic accidents are the major problem in which 1.2 million people die and our (1 to 3) % gross domestic product is spend on the medical cost and property damage [1]. To prevent the peoples from day to day accidents one option is to increase the capacity of transportation system by increasing the number of lane miles and second option is developed on-board automotive driver assistance systems. Aim of on-board automotive driver assistance systems to alert a driver about driving environments and possible collision with other vehicles. In these systems robust and reliable vehicle detection is the first step [2]. The on-road vehicles detection has been a topic of great interest to researchers over the past decade. Several national and international projects have been launched over the past several years to investigate new technologies for improving safety and accident prevention [3]. Vehicle detection is an integral part of Intelligent Transportation Systems (ITS) that include sensor and traffic control technologies [4]. In vision-based on-road vehicle detection systems camera is mounted on the vehicle rather than being fixed such as in traffic/driveway monitoring systems [5]. A variety of sensors modalities has become available for on-road vehicle detection, including active and passive sensors such as radar based, lidar based, acoustic based and normal cameras based. There are at least three reasons for the increasing research in this area: (1) the statistics show that most deaths and loss in vehicle accidents caused by vehicle accidents,(2) improved machine vision algorithms and feasible technologies, 3) availability of low cost high computational power and the exponential growth in processor speeds [6].

Almost every vehicle detection system includes two basic stages: (1) Hypothesis Generation (HG) Which hypothesized the locations of possible vehicles in an image and (2)

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Hypothesis Verification (HV) which verifies the hypotheses [7, 8]. These methods can be measures using various techniques. This figure shows that how a camera detect vehicle in various positions.

Figure 1. The Variety of Vehicle Appearances Poses a Big Challenge for Vehicle Detection [9]

2. Sensors

There are two types of sensors:

2.1. Active Sensors- These sensors are that sensors which transmit and detect at the same time. The reason that these sensors are called active is because they detect the distance of objects by measuring the travel time of a signal emitted by the sensors and reflected by the objects. Their main advantage is that they can measure certain quantities directly without requiring powerful computing resources. When a large number of vehicles move simultaneously in the same direction, interference among sensors of the same type poses a big problem. Moreover, active sensors have, in general, several drawbacks, such as low spatial resolution and slow scanning speed [10].

Active sensor can describes using three categories.

2.1.1 Radar Based- Radio (Radio Detection and Ranging) waves are transmitted into the atmosphere, which scatters some of the power back to the radar's receiver. Radar-based systems can "see" at least 150 meters ahead in fog or rain, where average drivers can see through only 10 meters or less [11].

2.1.2. Laser Based (Lidar) – Lidar (Light Detection and Ranging) waves are also transmits and receives electromagnetic radiation, but at a higher frequency. It operates in the ultraviolet, visible, and infrared region of the electromagnetic spectrum. Lidar is less expensive to produce and easier to package than radar; however, with the exception of more recent systems, lidar does not perform as well as radar in rain and snow. Laser-based systems are more accurate than radars; however, their applications are limited by their relatively higher costs [12].

2.1.3. Acoustic-based - Acoustic sensors measure vehicle passage, presence, and speed by de tecting acoustic energy or audible sounds produced by vehicular traffic from a variety of sources within each vehicle. When a vehicle passes through the detection zone, an increase in sound energy is recognized by the signal-processing algorithm and a vehicle presence signal is generated [13].

2.2. Passive Sensors- Optical sensors, such as normal cameras, are usually referred to as passive sensors because they acquire data in a nonintrusive way. Nonintrusive sensors can be mounted above the lane of traffic [14]. They are monitoring or on the side of a roadway where they can view multiple lanes of traffic at angles perpendicular to or at an oblique angle to the flow direction [15]. The technologies currently used in nonintrusive sensors are video image processing, passive infrared, ultrasonic, passive acoustic array, and combinations of sensor technologies such as passive infrared. Camera is best example of passive sensor.

2.2.1. Cameras- With the introduction of inexpensive cameras, we could have both forward and rearward facing cameras on a vehicle, enabling a nearly 360 degree field of view. One advantage of passive sensors over active sensors is cost. Optical sensors can be used to track more effectively cars entering a curve or moving from one side of the road to another. Also, visual information can be very important in a number of related applications, such as lane detection, traffic sign recognition, or object without requiring any modifications to road infrastructures.

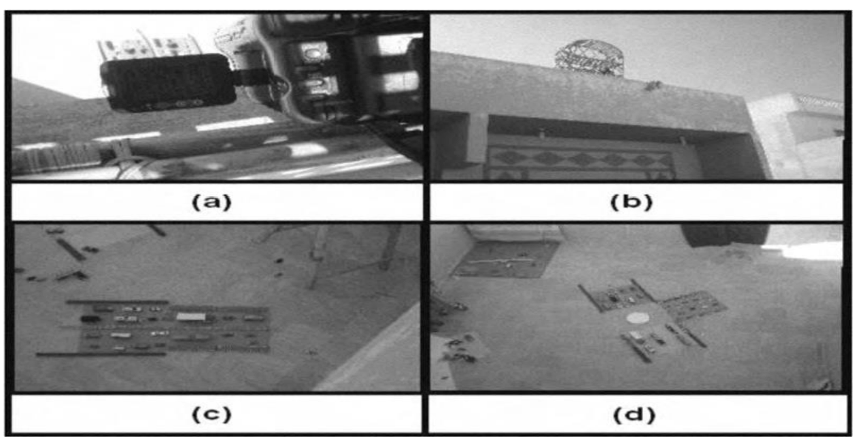

Figure 2. Camera Position from Different Heights

3. Methodology

On-board vehicle detection systems have high estimation requirements as they need to process the captured images at real-time or close to real-time to save time for driver reaction [16]. When an image is captured then searching the whole image to locate potential vehicle locations is prohibitive for real-time applications. Vision based vehicle detection systems are particularly interesting for their low cost and for the high-devoted information.

The majority of methods reported in the literature follow two basic steps:

A. Hypothesis Generation (HG) Method

B. Hypothesis Verification (HV) Method

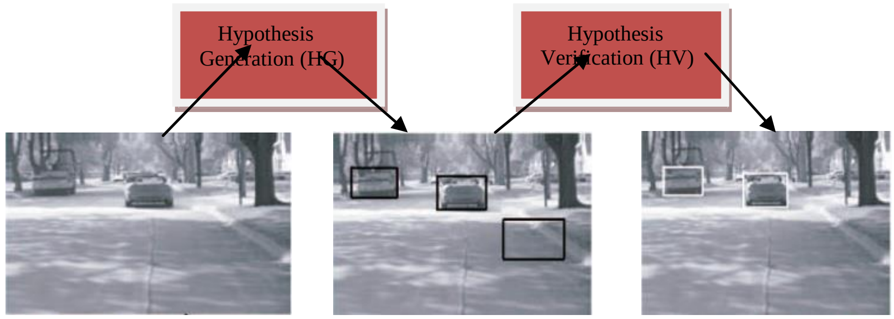

Figure 3. Illustration of the Two-Step Vehicle Detection Strategy

4. HG Methods

HG method is used to hypothesize the locations of possible vehicles in an image. Various HG approaches can be classified into one of the following three categories: (1) knowledge-based (2) stereo-based and (3) motion based. The objective of the Hypothesis Generation step is to find vehicle locations in an image quickly for further exploration.

4.1 Knowledge-Based Methods: Knowledge-based methods used a previous knowledge to hypothesize vehicle locations in an image. Some representative approaches are used some information about symmetry, color, shadow, geometrical features (*e.g.*, corners, horizontal/vertical edges), texture, and vehicle lights [17].

Some approaches used in the knowledge based method:

S.NO	Approach	How to find out the information about vehicle
1.	Symmetry	By taking rear or frontal views in the horizontal and vertical directions.
2.	Color	By object representation and feature selection
3.	Shadow	By setting appropriate threshold values for darkness
4.	Corners	By matching four corners (upper-left, upper-right, lower-left, And lower-right) of object.
5.	Vertical/Horizontal Edges	By constellation of vertical and horizontal edges of heavy vehicles.
6.	Texture	By measuring the intensity changes in environment due to presence of vehicle.
7.	Vehicle Lights	By detecting vehicle light pairs in a narrow inspection area.

4.2. Stereo-Vision-Based Methods: To find out the locations of vehicles and obstacles in image Stereo-based approaches using Inverse Perspective Mapping. Camera parameters have already been computed through calibration.

Two approaches used in the Stereo-Vision based method:

S.No	Approach	How to find out the information about vehicle
1.	Disparity Map	By comparing left and right sides pixels of captured images, creating disparity map and find out the peak using Histogram [18].
2.	Inverse Perspective Mapping	By transforming and reprojecting left side image as right side image using IPM technique and then comparing it to the right side actual image [19]. On the basis of mismatch between IPM based image and actual image the presence of vehicle is decided.

4.3. Motion-Based Methods: These methods calculating the presence of vehicle by employing relative motion between sensor and scene obtained by calculation of optical flow. Approaching vehicles at an opposite direction produce a diverging flow, which can be easily distinguished from the flow caused by the car ego-motion as shown in below diagrams.

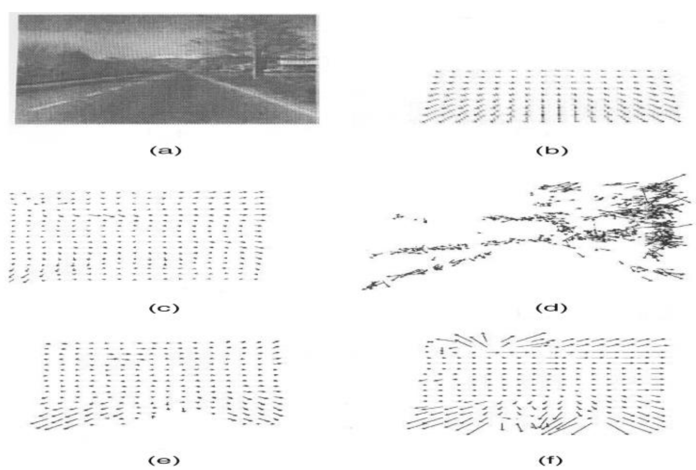

Figure 4. Different Stages of Optical Flow in the Presence/Absence of Vehicles

5. HV Method

Hypothesized locations output of the HG step is works as an input to the HV step. In this method, various tests are performed to verify the correctness of a hypothesis. HV method can be classified mainly into two categories: (1) Template-based and (2) Appearance-based.

S. No	Approach	How to find out the information about vehicle
1.	Template-	By using predefined patterns of the vehicle class and perform

	based	correlation action between the HG image and the stored template [20].
2.	Appearance-based	Firstly the decision boundary between the vehicle and nonvehicle classes is defined using multiple training images or probability distribution [21].

6. Integrating Lane and Vehicle Tracking

Tracking mechanism is used to hypothesize the location of vehicles in future frames. Vehicle location can be hypothesized using past history and a prediction mechanism [22]. When tracking performance drops, common hypothesis generation techniques can be deployed to maintain performance levels. Basically in this hypothesis “detect-then-track” approach (vehicles are first detected and then turned over to the tracker) is used. This approach aims to resolve detection and tracking sequentially and separately. Vehicle detection is based on template matching while tracking uses dynamic filtering [23].

7. Discussion

On-road vehicle detection is so challenging, that none of the methods reviewed can solve it alone completely. Various sensors and algorithms should be used to improve overall robustness and reliability [16]. Generally vehicles can be classified into three categories according to their relative position to the host vehicle: (1) close-by vehicles (2) midrange/distant vehicles (3) overtaking vehicles. In close-by regions (A1), we may only see part of the vehicle. In this case, there is no free space in the captured images. In the overtaking regions (A2), only the side view of the vehicle is visible while appearance changes fast. Detecting vehicles in the midrange/distant region (A3) is relatively easier since the full view of a vehicle is available and appearance is more stable.

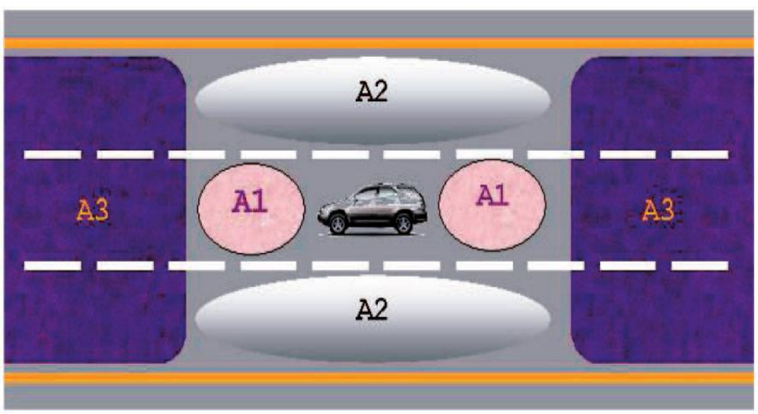

Figure-5. Detecting Vehicles in Different Regions Requires Different Methods.[16]

8. Conclusions

In this paper a review is presented on vision based on-road vehicle detection. Firstly we discussed recent and traditional techniques of the vehicle detection. Rapidly falling costs for the sensors and processors combined with increasing image resolution provides the basis for a continuous growth of this field .Sensors play an important role to detect the vehicle location. Major motor companies, government agencies, and universities, are all expected to work together to make significant progress in this area over the next few years. In our perspective, the future holds promise for driver assistance systems that can be tailored to solve well-defined tasks that attempt to support, not replace the driver.

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