International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 01 | Jan -2021 ISSN: 2582-3930

Vehicle Analysis Techniques

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Abstract - Vehicle analyzer applications play a very important role for various civilian and military applications such as in urban traffic planning, highway traffic surveillance control and management. Vehicle detection processes have many uses like vehicle tracking, vehicle counts, average speed, traffic analysis, calculation of each vehicle and may be implemented under different environments.
In this paper, we are presenting a brief overview of various image processing methods and analysis tools that are used in building these previously mentioned applications that are involved in developing traffic surveillance systems. We have classified the processing methods under three main categories for more description to explain the traffic systems.

Key Words: OpenCV, Haar-Cascading, vehicle, analysis, detection

1. INTRODUCTION

One of the compelling applications of video-based supervision systems is traffic surveillance. Therefore, for many years the researches have been investigating the Vision-Based Intelligent Transportation System (ITS), transportation planning and traffic engineering applications so that they can extract useful and precise traffic information for traffic image analysis and traffic flow control for example vehicle count, vehicle trajectory, vehicle tracking, vehicle flow, vehicle classification, traffic density, vehicle velocity, traffic lane changes, license plate recognition, etc. [1-4]. In the past, the vehicle detection, segmentation and tracking systems have mainly been used for the determination of the charge for various kinds of vehicles for the automation of toll levy system [5]. Recently, vehicle recognition systems are being used to detect (the vehicles) or detect the traffic lanes [6-10] and classify the type of vehicle class on highway roads like cars, vans, motorbikes, heavy goods vehicles and etc. [5, 7, 11-15].

However, the traditional vehicle systems are declining and are not at all being recognized well due to the vehicles being occluded by other vehicles or by background obstacles such as trees, road signals, weather conditions, etc., and the performance of these systems is mainly dependent on good traffic image analysis approaches for the detection, tracking and classification of the vehicles.

In this paper, the traffic image analysis mainly comprises of three different parts:

1. Motion Vehicle Detection and Segmentation Approaches
2. Camera Calibration Approaches and
3. Vehicle Tracking Approaches.

2. TRAFFIC IMAGE ANALYSIS TECHNIQUES

2.1 Motion vehicle detection and segmentation approaches

The detection of moving object's regions of change in the same image sequence which captured at different intervals. This is one of the interesting fields in computer vision world.

To change the detection in its work, a certain number of applications in various disciplines have been employed, such as video surveillance etc. [16]. An essential video surveillance branch is the traffic image analysis which includes the detection of the vehicle's motion and various other segmentation approaches even though various research papers have mentioned for vehicle detection systems (background subtraction, frame differencing [17-22] and motion-based methods) but it is still a difficult task to detect and segment the vehicles in dynamic scenes. There are three main approaches that are used to detect and segment the vehicle, such as:

• Background Subtraction Methods

In various computer vision applications, background subtraction technique is a "fast and easy" way of constraining moving objects in a video recorded by a static camera. In this perspective, motion detection is considered as the first step of a multi-stage computer vision system [8, 20, 24, 25] (person recognition, car tracking, wild-life monitoring, etc. Therefore, most BS methods "in motion" to every pixel at a time t whose colour is naturally different from the ones in its background [34].

It is not always as easy to detect motion through background subtraction as it may appear. There could be many reasons for false positives like, some videos with poor signal-to-noise ratio caused by a low-quality camera, a noisy environment,

etc. False positives can also be caused by gradual illumination changes, camera jitter, or an animated background, etc. On the other hand, false negatives can also occur when the object that is in motion contains colours similar to its background. In order to cope with those challenges, numerous background models and distance measures with different optimization schemes have been proposed in the past decade.

a. Background Subtraction Algorithms

Most BS techniques share a common denominator: they make a main assumption that the observed video sequence I is made of a static background B in front of which moving objects are observed.

A BS technique namely basic motion detection is presented below.

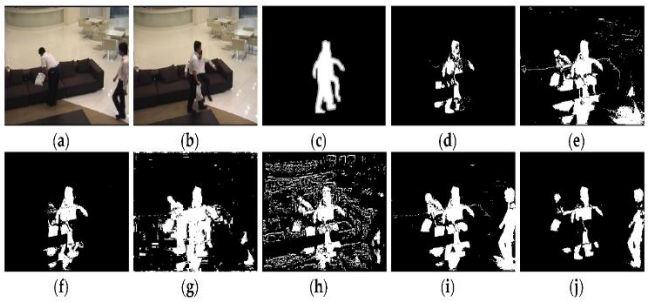


Fig. 1.1 BS technique

b. Basic Motion Detection

The simplest way to model the background B is through a single grayscale/colour image void of moving objects. This image can be a picture taken in absence of motion or it can be estimated via a temporal median filter [12, 17, 34].

• Feature Based Methods

Nowadays, the applications of object classification and detection became one of the most leading uses in many fields such as, mobile, industries, robotics, security and internet services. In robots the object localization and classification are commonly used to recognize a certain object within a scene, furthermore, facial recognition plays a vital role in the security issues. Object detection methods are essentially for further tasks (i.e. classification, categorization, analysis, etc). Yilmaz [1] categorized the object detection methods into four categories, point-based, segmentation-based, background-based and, supervised based to detect the object. Mean-shift [2], Graph-cut [3], and Active contour [4] are example of segment-based to detect the object. While, background

modelling that is used to detect the object within a scene may vary; mixture of Gaussian [5], Eigenbackground [6] and Dynamic texture background [7] are the common models based on modelling the background. In the other hand, Support Vector Machine [8], Neural Network [9] and Adaptive boosting [10] used to detect the object as supervised techniques Point-based detector is used to search for points that demonstrate quick changes in both the horizontal and vertical orientation of their intensity. Such points are called the key points or interest points.

• Motion Detection Using Frame Difference Methods

An important stream of studies within a computer vision, that has been gaining a lot of highlight in the last few years, is the understanding of human activity from a video. This growing interest in the analysis of human motion has been strongly motivated by recent improvements in computer vision with the availability of a variety of new promising applications such as personal identification and visual surveillances and of low cost hardware such as video cameras. The primary goal of motion detection is to recognize motion of objects found in the two given images. Furthermore, finding objects motion can also contribute to objects recognition. Thus, the main objective of the research is to recognize pixels belonging to the same object. However, some assumptions have been made during the recent researches:

- A well-fixed camera – stability is key when we want to isolate motion.
- Stable light, no flickering
- High Contrast background
- High camera frame rate and resolution

Detection of moving object from a sequence of frames captured from a static camera is widely performed by frame difference method. The main objective of this approach is to detect the moving objects from the difference between the reference frame and the existing frame. This method is the most common method of motion detection. This method adopts pixel-based difference to find the moving object.

- Difference of two consecutive frames
- Transform absolute differential image to gray image
- Filtering and binarizing transformed gray image

2.2 Camera calibration approaches

We are implicating surface extraction and segmentation using image processing methods [28], such as Gaussian mixture modelling, which is using for better vehicle detection results when using the object detection method. The highway surveillance video image has a large field of view. The vehicle is the focus of attention in this study, and the region of interest in the image. At the same time, according to the camera angle, the road surface area is concentrated in a specific range of the image [29]. With this feature, we are extracting the highway road surface areas in the video. The process of road surface extraction is shown in Fig. 2.1.

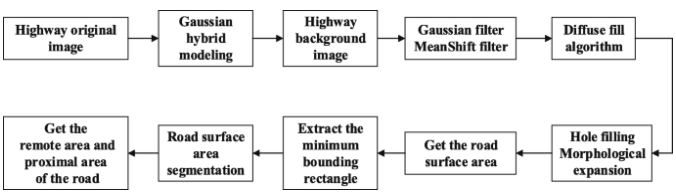


Fig. 2.1 Overall flow of road surface extraction

As shown in Fig. 2.1, to eliminate the influence of vehicles on the road area segmentation, we are using the Gaussian mixture modelling method to extract the background in first 500 frames of the video [31]. The value of the pixels in the image is Gaussian around a central value in a time range, and each pixel in each frame of the image are been counted. If the pixels are far from the centre, the pixel belongs to the foreground. If the value of the pixel point deviating from the centre value within a certain variance, the pixel point is considered to belong to the background.

After the extraction, the background image will be smoothed. We are segmenting the road surface area to provide accurate input for vehicle detection. For the extracted road surface image, a rectangle is generated for the image without rotation. The processed image will be divided into five equal parts, the 1/5 area adjacent to the origin of the coordinate axis is defined as the near remote area of the road surface, and the remaining 4/5 area is defined as the near proximal area of the road surface.

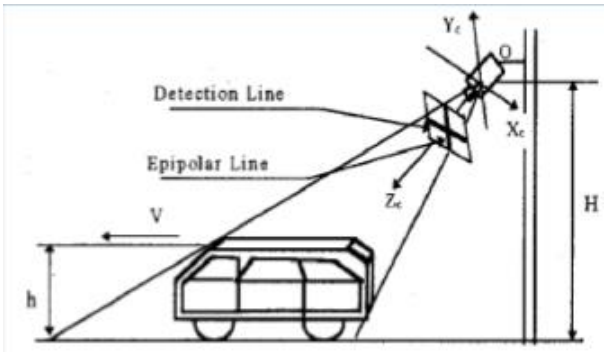
• Algorithm for Camera Calibration Approaches

A motion detection algorithm begins with the segmentation part where foreground or moving objects are segmented from the background. The Simplest way to implement this is to take an image as Background and take the frames obtained at time t, denoted by I(t) to compare with the background Image denoted by B. Here using simple arithmetic calculations, we can segment out the objects simply by using image subtraction technique of computer vision meaning for each pixel in I(t), take the pixel value denoted by P[I(t)] and subtract it with the corresponding pixels at the same position on the background image denoted as P[B]. In mathematical equation it is written as:

$$P[F(t)] = P[I(t)] - P[B]$$

A threshold is put on this difference image to improve the subtraction,

$$|P[F(t)] - P[F(t+1)]| > \text{Threshold}.$$



2.3 Vehicle tracking methods

• Automatic Vehicle Location

An AVL system is a very advanced method which helps in tracking and monitoring remote vehicles with a device that receives and sends signals through GPS satellites.
This method makes use of Global Positioning System (GPS) and Geographic Information System (GIS) to provide the real time location of the vehicle. This method consists of PC-based tracking software to dispatch, a radio system, GPS receiver on the vehicle and GPS satellites.

- This system provides vehicle location with an accuracy of around 5m to 10m.
- This system can provide more services like the ability to replay vehicle route, external sensor data.

This system cannot get a very accurate and complete satellite data in dense urban areas or when the transmission is blocked by natural obstructions like a building or tree cover.

• Assisted GPS

In an AGPS system, a terrestrial RF network is utilized to improve the performance of GPS receivers as helps in providing valuable information about the satellite constellation directly to the GPS receivers. An AGPS makes use of both mobiles and cellular networks to locate an accurate positioning information.

- This method uses GPS satellites to track vehicles. In this method a receiver in vehicle is always connected to around 4 satellites where three of them determine latitude, longitude and the elevation and the fourth satellite provides the element of time.
- The accuracy in this method is around 3m to 8m and the speed of 1 kilometre.
- This method can provide Accurate Time Assistance. There is a panic button present which when pressed can connect you to an operator and he/she can help you or get you to safety in the event of an accident.

• RFID System

Radio-Frequency Identification is an automatic identification method that works using devices called tags to store and remotely retrieve data. This method uses radio waves to capture the data from tags.

- This method consists of three components which are:
- Tags that can be passive, semi passive or active
- Reader that can be the antenna or the integrator
- Software i.e., the middleware
- This method has an accuracy of 4m to 6m at providing the location of the vehicle

The main limitation of RFID is its short range. This system is only available in short distances.

• Region-Based Tracking Method

In this method, the region of the moving objects is tracked and is used for tracking the vehicles. This region is segmented from the subtracting process between the input frame image and prior stored background image. A proposed research paper introduced a model-based automobile recognizing, tracking

and classification which is efficiently working under most conditions [33]. This model provided the position and the speed knowledge for each and every vehicle as long as it is visible, and in addition, this model also worked on series of traffic scenes that were recorded by a stable camera for automobiles monocular images. The processing algorithms of this model represented three levels: the raw images, region level, and vehicle level. A traffic criterions assessment such as the vehicles numbering and classification involving with a suggested traffic observation scheme have been suggested by [34]. The proposed scheme demonstrated in its work the feature ratio and density to classify vehicles, also, it made use of the geometric traits to eliminate the false regions and also for more accurate segmentation processes the shades elimination algorithm is used (fig 3.1).

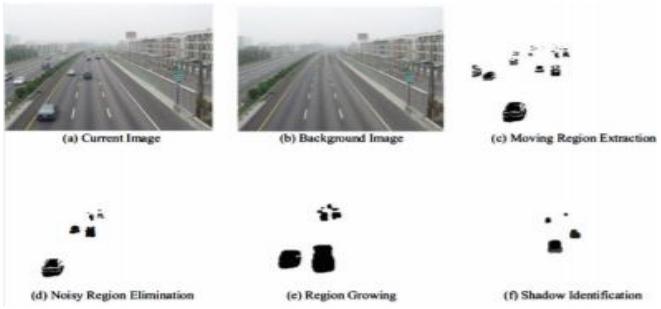


Fig. 3.1 Region Based Tracking Approach

3. CONCLUSIONS

Some important conclusions can be made from our results. Firstly, by using modern methods like frame difference methods, we can vastly improve the accuracy of vehicle detection and by using camera calibration methods we can use different approaches when the environment is not suitable for conventional methods.

Secondly, Region based tracking approach has been one of the most effective approaches in traffic analysis. This method is suitable as it is cost effective and is an adaptive approach for the false positive test cases.

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