A Video Surveillance System for Traffic Application

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Abstract—Traffic surveillance is an important topic in intelligent transportation systems associated with traffic management center and traveler in urban areas. Vehicle detection and tracking method based on different methods like multiple vehicle salient parts or background subtraction or active contour or Region based method is one of the challenging problem for complex urban traffic surveillance. In this paper different traffic states like congested, slow and smooth are detected based on traffic flow speed and road space occupancy. Road areas extraction is the root of road occupancy calculation. Optical flow field analysis is a common method that obtains the motion vector based on the distribution of apparent velocities of movement of brightness patterns in sequential images. The Road Space Occupancy estimated using sobel edge detection algorithm and Traffic Flow Speed estimated using Horn and LK (Lucas-Kanade) algorithms.

Keywords—Road Space Occupancy; Traffic Flow Speed Estimation; Traffic State Detection; Video Surveillance System.

Abbreviations—Histogram of Oriented Gradients (HOG); Lucas-Kanade (LK); Line Of Sight (LOS); Macroscopic Velocity (MOFV); Support Vector Machine (SVM).

I. INTRODUCTION

VIDEO surveillance is the word surveillance comes from a French phrase for “watching over” (“sur” means “from above” and “veiller” means “to watch”), and is in contrast to more recent developments such as video surveillance.

With, Rapid development of urbanization, Traffic problems increase day by day and pose great challenges for with traffic management center and traveler in urban areas. Surveillance systems are use full for handling this type of situations. Vision, as an information collection access of world environment, has attracted much important in transportation system. Video surveillance systems provide quick practical information resulting in increased safety and traffic flow. For example, objects are defined as vehicles moving on freeways. Video surveillance system use cameras which are much less disruptive to install than loop detectors and other pneumatic sensors. These were the main factors that motivated us to design the traffic surveillance system.

Most of detection and tracking method based on multiple vehicle salient parts using a stationary camera. The vehicle is treated as an object composed of multiple salient parts, including the license plate and rear lamps. These parts are localized using their distinctive color, texture, and region feature [Tian et al., 1]. Traffic state based on accurate parameters of each individual vehicle, which can be achieved using kinds of vehicle detection or/and tracking methods [Kopf, 9]. The other one uses Histogram of Oriented Gradients (HOG) of extracted frames is used as features for classification (vehicle frame and non vehicle frame). The classifier is designed based on Support Vector Machine (SVM) [Mudoi & Parismita, 2].

A system that detects the vehicle in real time in highway is done by using image processing. The implementation includes algorithms used for real time vehicle detection, which is based on background differencing and morphological operations [Prutha & Anuradha, 3]. Background subtraction is used which improves the adaptive background mixture model and makes the system learn faster and more accurately, as well as adapt effectively to changing environments [Kaстринаки et al., 8; Kumari & Rathore, 13].

One of the techniques is geometric relationships inherently available in the image, some common-sense assumptions that reduce the problem to a one-dimensional (1-D) geometry, frame differencing to isolate moving edges and track vehicles between frames, and parameters from the distribution of vehicle lengths, to estimate speed [Dailey et al., 7].

In Traffic state detection one method use Headlight segmentation and detection, headlight pairing, vehicle tracking, vehicle counting and detection. First, a fast segmentation process based on an adaptive threshold is applied to effectively extract bright objects of interest [Salvi, 4]. To compute traffic density, we place a colored strip, either painted or taped, horizontally across the surface on the road.
II. DIFFERENT TECHNIQUES TO DERIVE TRAFFIC STATE

We review a number of well-known methods and their algorithm’s and based on this we derive below.

2.1. Background Subtraction Method

This method is one of the widely used methods to detect moving vehicle as an object in regions. It subtracts the generated background which has little change in image from the input image frame to detect the moving vehicle regions. This difference in image is to extract the vehicle regions. The disadvantage is the stored background frame is that they are not adaptive to the environment changes which may create non-existent vehicle regions and also works for stationary background.

2.2. Active Contour based Method

This method characterize vehicle by bounding contour of the object and dynamically update it during the tracking. The advantage of this tracking method over region-based tracking is the reduced computational complexity. But the disadvantage of the method is their insufficiency to accurately track the occluded vehicles and tracking need to be initialized on each vehicle separately to handle occlusion better.

2.3. Region based Method

This method subtracts image frame containing vehicles from the background or previous frame which is then further processed to obtain vehicle regions. After that these vehicle regions are tracked. It can work well in free flowing traffic conditions, but it has difficulty in handling shadows and occlusion.

2.4. Feature based Method

This method extracts suitable features from the vehicle regions and these features such as rear lamps, license plate etc. are processed to track the vehicles correctly. The method has low complexity and also can handle occlusions well. But the recognition rate of vehicles using tow-dimensional image features is low, and the problem that which set of sub features belong to one object is complex.

III. TRAFFIC STATE DETECTION TECHNIQUE

The process of traffic state detection system is based on two traffic parameters, traffic flow speed and road space occupancy, are estimated using image features extraction and analysis at first. Then traffic state detection algorithm is being introduced.

3.1. Motion Detection and Road Areas Extraction

Road areas extraction is the basis of road occupancy calculation, and also helpful to get parameters and the calculation work. In traffic surveillance video, it can be supposed that the road areas are regions where vehicles move on and background are regions which has few changes. So the road areas can be extracted by motion accumulation.

Frame difference is usually used to detect vehicle movement in a consecutive sequence of frames. The movement in image can be extracted through the equation:

\[ \Delta F_t(x,y) = F_t(x,y) - F_{t-1}(x,y) \]

Where \( F_t(x,y) \) is the current frame at time \( t \), \( F_{t-1}(x,y) \) is the previous frame, and \( \Delta F_t(x,y) \) is the difference image. To discard noise and simple calculation, binary image is obtained and with gray value describe motion information.

The white pixels in Fig. denote the points within road regions White points on the top of images caused by camera shaking because there are some words on the video. A tunnel cross under the road there are some white regions on the left bottom. So, more image processing are doing to subtract the...
road areas we are interested in, and the road structure of straight or approximately straight roads are modeled by a group of lines which are shown in Fig.

Figure 2: Road Areas Extraction

3.2. Road Space Occupancy Estimation

Sobel algorithm is being used for extract the vehicle edge map in the road areas. Then binary image of edge map is used to count the amount of edge pixels $N_E$ and the amount of pixels in each direction’ road area $N_{RA}$. Edge density $O_E$ is calculated by following equation:

$$O_E = \frac{N_E}{N_{RA}}$$

The value region of $O_E$ is in the range of [0, 1], and bigger value means higher road space occupancy.

3.3. Traffic Flow Speed Estimation

Most vehicles on road areas have similar direction and speed, thus the optical flow vector essentially meets traffic flow vector. A macroscopic velocity, MOFV, is presented to estimate whole traffic flow speed.

Horn algorithm and LK algorithm are two classic and faster gradient-based algorithms with simple principles and low computational complexity. Horn algorithm can calculate motion vectors in any scale, and make the background’s optical flow very small under suitable index. LK algorithm is limited in local motion. The MOFV are calculated using the feature optical flow vectors.

The MOFV are calculated using the feature optical flow vectors. MOFV’s value $V$ of each main direction can be calculated as follow:

$$V = \sqrt{\hat{u}^2 + \hat{v}^2}$$

Where the average optical flow vector value $(\hat{u}, \hat{v})$ of feature points.

IV. Conclusion

The presented method can detect traffic different states automatically using traffic surveillance videos with high accuracy and high speed in daytime. Individual vehicle detection is not use full for this method, and two important traffic flow parameters, the traffic flow speed and road space occupancy, are estimated easily. The presented system is easy to use because of no individual vehicle detected. It provides a tool to collect traffic state information based on freeway traffic surveillance video system. This method is efficient for straight freeway or approximate straight freeway.

References


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