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Length Based Vehicle Classification Using Digital Image Processing

Priya.K
Assitant Professor/Department Of ECE Ultra College Of Engineering And Technology For Women, Madurai

Jayanthi rajee.R.B,
Assitant Professor/Department Of EEE, Velammal College Of Engineering And Technology, Madurai.

***Abstract*— Vehicle classification information is one of the important measurements that need to obtain in practice, which is invaluable for various aspects of transportation including engineering and planning. In our paper, we have proposed a technique through which the vehicles are detected and classified based on their sizes. The proposed algorithm is based on morphological operations. It also uses thresholding, filtering, edge detection for vehicle detection and vehicles are classified by their length. Finally, the performance of our classification approach is illustrated and discussed.**

***Keywords*— Vehicle classification, Morphological operations. Vehicle detection, Throsholding technique, Sobel filter**

I. INTRODUCTION

It is important to know the road traffic density real time especially in megacities for signal control and effective traffic management. In recent years, video monitoring and surveillance systems have been widely used in traffic management. Hence traffic density estimation and vehicle classification can be achieved using video monitoring systems. Extracting useful information such as traffic density and vehicle types from these camera systems has become a hassle due to the high number of cameras in use. Manual analysis of these camera systems is now inapplicable. So the development of intelligent systems that extract traffic density and vehicle classification information from traffic surveillance system is crucial in traffic management.

An initial step for traffic control is vehicle detection and classification using traffic measuring techniques. This objective is achieved by using image processing based techniques. Many algorithms were proposed to detect and classify the vehicles. In [13], features extraction using Gabor wavelet and BP neural network algorithm for the classification of vehicle types based on the texture model is proposed. In[8], the detection of moving vehicles using image tracking methods e.g. background and foreground (BG/FG) detection and blob tracking are employed.

The vehicle detection can be achieved with the help of vehicle shadows [10]. This approach becomes difficult if shadows of other objects like overhead bridges overlap with the shadows of vehicles. In [12],support vector machines is used to identify if the detected moving object is a vehicle or not. Support vector machine is a two class classification method and requires modification for multi class classification. The vehicles are detected using mathematical modeling in [13]. The expected parameters of a moving vehicle is mathematically modeled using the position of the camera, vehicle, and sun; it is compared with the values obtained from the video. However, this model requires very sensitive calibration of the camera and it works for cases with short distance between camera and vehicles. The traffic videos used in Istanbul do not satisfy these needs.

In [5], rule based reasoning is used for vehicle detection, in which the results highly depend on the rules decided by humans. In [6], the feature information is extracted by the seed-filling-based method and is presented to the input of neural network for vehicle detection and classification. the issues associated with feature based tracking, presents the real-time implementation of a prototype system, and the performance of the system on a large data set [4]. In [9], a vehicle tracking and classification system is described that can categorize moving objects as vehicles or humans. However, it does not further classify the vehicles into various classes.

In [7], an object classification approach that uses parameterized 3D models is described. The system uses a 3D polyhedral model to classify vehicles in a traffic sequence. The system uses a generic vehicle model based on the shape of a typical sedan. The underlying assumption being that in typical traffic scenes, cars are more common than trucks or other types of vehicles.

The proposed algorithm consist of two modules.1) vehicle Detection 2) vehicle classification based on size. This paper is organized as follows: Section II deals with the actual

algorithm based on edge detection and morphological process is proposed along with vehicle detection. Section III describes the vehicle classification and Section IV illustrates the experimental results. Section V presents conclusions.

II. VEHICLE DETECTION ALGORITHM

Video cameras are placed at common congestion points on highways, freeways, inter states and major arteries to monitor a road for a specific duration. Normally, traffic flows do not vary much from day to day, but in the event of a severe accident or road closure, a traffic alert can be extremely valuable for a time-crunched commuter. The video is broken into frames at fixed intervals. The resultant images are processed individually to obtain information regarding the number of vehicles and their classification at a particular instant of time. The Figure 2a shows the schematic diagram of proposed work.

Video cameras are used to monitor a road for a specific duration. The obtained video is broken into frames at fixed intervals. The resultant images are processed individually to obtain information regarding the number of vehicles and their classification at a particular instant of time.Initially the frames are passed through pre processing phase and then it passed through vehicle detection phase.

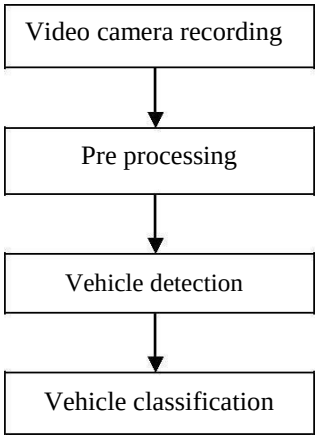


Figure 2a. Schematic Diagram of proposed work

2.1 Pre processing algorithm

The video frames are passed to the pre-processing phase, after that vehicle extraction phase. The flow diagram of the pre processing algorithm is shown in Figure 2b. The traffic video is taken as input. In pre processing phase, two images are taken. one without vehicles and the other with vehicles. We call the former image the reference image and the latter one the current image. Both images are converted into grayscale images.

The gray scale images are converted into black and white images by using series of throsholding technique. The threshold value is chosen according to the brightness of the image to be processed. After applying the threshold, image differencing is takes place which is shown in Figure 2d. The median filter is applied on the image to remove the noise generated by image differencing. The median filter is smoothing filter. All smoothing filter are effective at removing noise in smooth regions of a image, but affect the edges. Median filter preserve the edges of the image. The output of the median filter image is fed into the vehicle detection system and then classified. Finally the filtered image is fed into the vehicle detection system and further classified. The output image obtained from the pre processing system is shown in Figure 2e.

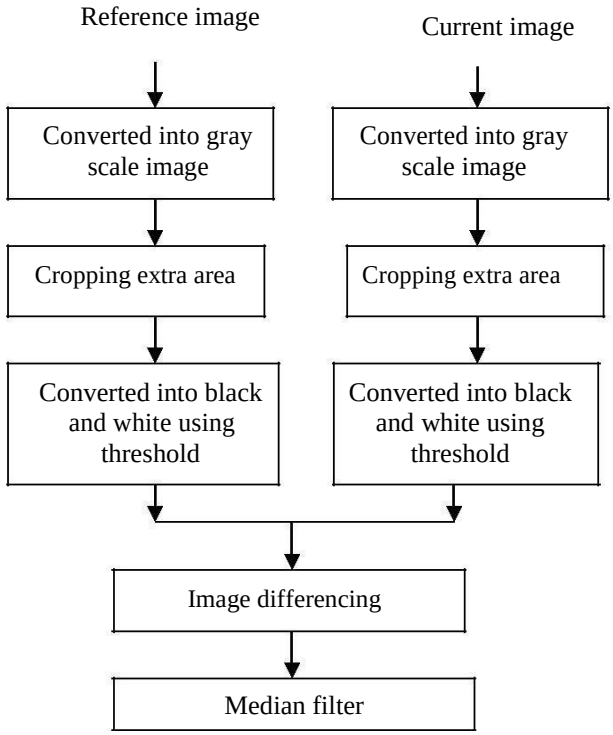


Figure 2b. Block diagram of pre processing algorithm

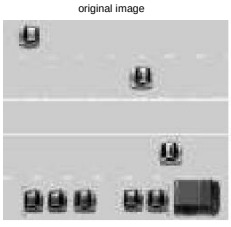


Figure 2c. Current image

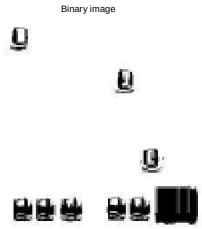


Figure 2d. Binary image

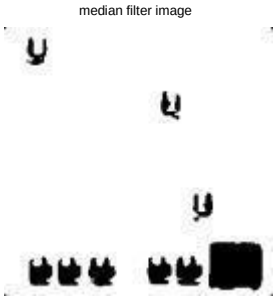


Figure 2e. Median filter image

2.2Vehicle detection algorithm using morphological operations

In vehicle detection algorithm, initially the edges on the preprocessing output image is detected by using sobel edge detector. The sobel detector is sensitive to noise in image, it effectively highlight them as edges (Figure 2g). Then the binary morphological dilation takes place in three direction such as vertical, horizontal and 45 degree. The effect of the dilation operator on a binary image is to gradually enlarge the boundaries of the region which are shown in Figure 2(h,i,j). Furthermore the binary hole filling is performed as shown in Figure 2k.

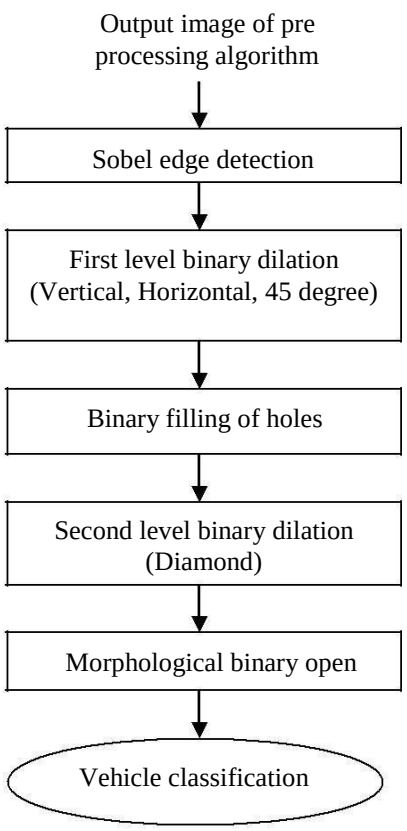


Figure 2f. Block diagram of vehicle detection algorithm

Second level binary dilation is performed on the hole filling image. In some cases, when a single vehicle is broken into adjacent parts due to the previous processing steps, it is required to connect them otherwise they could be detected as separate vehicles and gives false detection. Thus, a second level dilation ensures the connectivity of such disconnected parts. The structure element used for this dilation is the diamond structure which is one of the most efficient structures in morphological dilation and erosion. This is shown in Figure 2l**.** Then if there is any unwanted region presents in the dilated image binary open operation is performed which shown in Figure 2m.

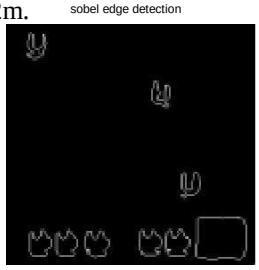


Figure 2g. Sobel edge detection

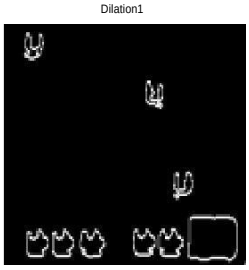


Figure 2h. Dilation in vertical direction

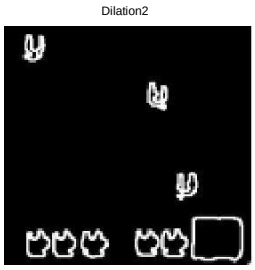


Figure 2i. Dilation in horizontal direction

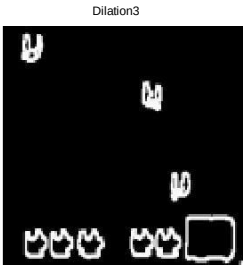


Figure 2j. Dilation in 45 degree direction

The operation we have used to remove small unwanted objects is the binary open operation based on the size of the objects. The range of sizes of such objects depends on the camera height. For different heights we have selected different opening sizes. Objects that are 8-connected neighborhood and having sizes smaller than the defined threshold are removed using binary opening. At this point the vehicle objects are prominent without noise or unwanted objects and ready to be classified.

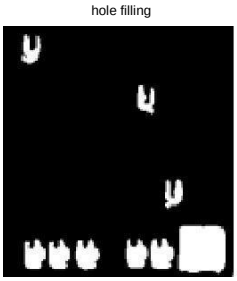


Figure 2k. Hole filling image

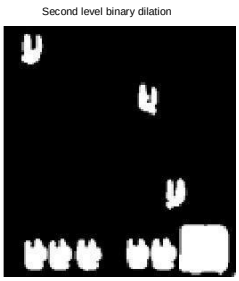


Figure 2l . Second level binary dilation

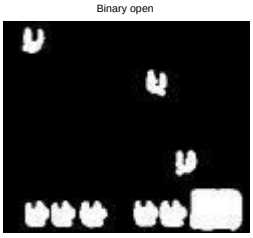


Figure 2m. Binary open

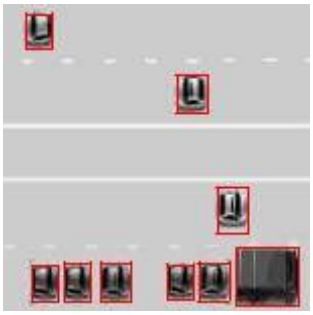
I. VEHICLE CLASSIFICATION

Vehicle classification process starts with isolating each object and reshaping it into a near polygon shape so that it reflects the actual vehicle's dimensions from an aerial camera. The objects are isolated using 8connectivity neighborhood. Each detected object is assigned a label indicating the location of each vehicle. Further, the Convex Hull of each object is calculated and the objects are reshaped into near polygon shape. To perform classification, each vehicle type (e.g. small, medium and big) is assigned a measurement range of sizes. This measurement is based on the area and length of the vehicles. The object falling within any of these ranges will be classified as small, medium or big vehicle .The standard vehicle length is shown in Table 1. The final result is shown in Table2 after detection and classification of the vehicles.

Table 1: Passenger Vehicle Classification Criteria

Vehicle Type	Size	Criteria
Passenger Cars	Sub compact	Wheelbase: Under 100 in
	Compact	Wheelbase: Under 100 – 104 in
	Midsize	Wheelbase: Under 105 – 109 in
	Full- size	Wheelbase > 109 inches
Vans	Mini Vans	Unibody Vans
	Large Vans	Frame based Vans
SUV"s	Midsize	Wheelbase > 88 inches Width: 66 – 75 inches
	Full size	Wheelbase > 88 inches Width: 75+ inches
Pickup Trucks	Compact	Under 4.500 lbs
	Standard	Over 4,500 lbs

In our research, the vehicles are grouped into three categories: Small, Medium and Large. If a vehicle length is within 75% to 125% of the standard length of certain type, this vehicle is belonging to the type.



Large : 1
Medium : 8

Figure 3a. Detected vehicle image

Table 2. Result of vehicle detection and classification for Figure 3a

Total number of vehicles	Detected vehicles		Accuracy
9	Size	No of vehicles	100
	Small	0	
	Medium	8	
	Large	1	

IV RESULTS

EXPERIMENTAL SETUP

The system requirements for the proposed work are processor, camera and memory unit. The proposed work is simulated using the Matlab software on the Intel processor of 2GHz frequency and 5GB RAM. The required images for the proposed work are acquired with the help of digital camera. The images acquired have the resolution of 3008×2000 and the size of the images used for processing is 256 x256. In order to check the efficiency of the proposed algorithm, the experiment is performed repeatedly with few traffic images.

original image

Figure 4a. Original image

Figure 4b. Vehicle detected image

Detected vehicles			
27	Size	No of vehicles	96.2
	Small	0	
	Medium	25	
	Large	1	

V CONCLUSIONS

In this paper, we have proposed a novel algorithm for vehicle detection and classification based on image processing.
By combining methods of thresholding, image differencing, edge detection and various morphological processes, with the advent of camera calibration result the proposed algorithm gives a success rate of more than 85% in both vehicle detection and classification which in turn can be very useful for traffic analysis and management.

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Author's Profile

Ms.R.B.Jayanthi rajee received the B.E.degree in Electronics&communication Engineering from Sethu Institute of Technology in 2007 and M.E. degree in Communication systems from thiagarajar college of Engineering in 2011. Currently working as assistant professor in Electrical &Electronics Engineering department in Velammal college of Engineering and Technology , Madurai (TN), India.

Mrs K.Priya, received the B.E. degree in Electronics & communication Engineering from Sethu Institute ofTechnology in 2007 and M.E. degree in Communication systems from thiagarajar college of Engineering in 2011. Currently working as assistant professor in Electronics & communication Engineering department in Ultra College of Engineering and Technology for women, Madurai (TN), India.