A Real-time Vehicle Recognition Method based on Video Sequence Images

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Abstract *—This paper describes a real-time vehicle recognition system in which the basic components of road vehicles are first located in the video sequence images based on background subtraction and then Harris corner of moving vehicles are abstracted. At last, we calculate the Hausdorff distance between the Harris corner of which need to be recognized and that of standard samples of car, bus and truck. The two whose Hausdorff distance is the smallest could be judged as the same type. Because of vehicle detection and recognition in real, cluttered road images, a new vehicle recognition approach is proposed in order to better deal with vehicle variability, illumination conditions, partial occlusions and rotations. The experimental results show that the system can accurately detect and recognize the vehicles on the urban multi-traffic road, while satisfying the real-time requirement.*
Keywords *— Harris corner, Hausdorff distance, vehicle recognition*

Ⅰ. INTRODUCTION

Intelligent Transportation Systems (ITS) is the newest research in the field of transportation [1]. With the development of digital image processing techniques and computer technology, Automatic vehicle identification based on video images has become an important part of ITS [2][3]. This paper describes a Harris Corner Detector-based Vehicle Recognition System in the framework of ITS technologies. In our approach, the basic components of road vehicles are first located in the image and then combined with a Harris Corner Detector. In order to achieve a low cost final solution that meets the requirements needed to undertake serial production. Vehicle detection should perform robustly under variable illumination conditions, variable rotated positions, and even if some of the vehicle parts are partially occluded. The traditional category is represented by model-based systems in which a model is defined for the object of interest and the system attempts to match the model to different parts of the image in order to find a fit. Unfortunately, road vehicles can be regarded as quite a variable class that makes it impossible to define a model that represents the class in an accurate, general way. In consequence, model-based systems are of little use for vehicle recognition purposes. In order to detect objects in real images, we propose a vehicle recognition approach which is based on Harris corner and Hausdorff distance.

978-1-4244-3864-8/09/$25.00 ©2009 IEEE

Ⅱ.ABSTRACTION OF HARRIS CORNER

Corner feature is an important feature of the image. In all kinds of image characteristics, the corner feature has the advantage of rotation invariance and less influence of illumination change. The corner feature can reduce the amount of calculating data without loss of significant image information. It also improves the matching speed in the image matching using corner feature. So a fast, effective corner feature extraction method to improve the speed and the rate of image matching is of great significance in the way of improving the speed of vehicle identification. In this paper, Harris corner to abstract corner feature of image are used.

Corner is a point of intersectoin or combinaton of line segments. Harris corner detector can abstract the corners of objects in pictures as feature points. Corner detection is mainly used in grey-level images. In a piece of image every pixel in 2D images is defined by (x, y) coordinates. Then, an image is described by function f(x,y). The local texture around pixel (x, y) is characterized by:

$$\mathbf{C} = \mathbf{G}(\sigma) \otimes \begin{bmatrix} f_x^2 f_x f_y \\ f_x f_y f_y^2 \end{bmatrix} \tag{1}$$

$\mathbf{G}(\sigma)$ is a Gaussian function with standard deviation σ and is the convolution operator. f_x, f_y is the first derivatives of $f(x, y)$. Two big eigenvalues for matrix $\mathbf{C}$ indicate a feature point. For more efficiency, the function R is used to get rid of edge points:

$$R = Det(\mathbf{C}) - \alpha Tr^2(\mathbf{C}) \tag{2}$$

$0.04 \le \alpha \le 0.06$

Interest points are found at local maxima of R above a user-defined threshold *T* (*T*>0). In practice, *T*= 9000 and $\alpha = 0.05$.

The characteristics of Harris corner are followed as:

(a)Harris operator only uses first-order gray-level difference, so it is easy to operate.

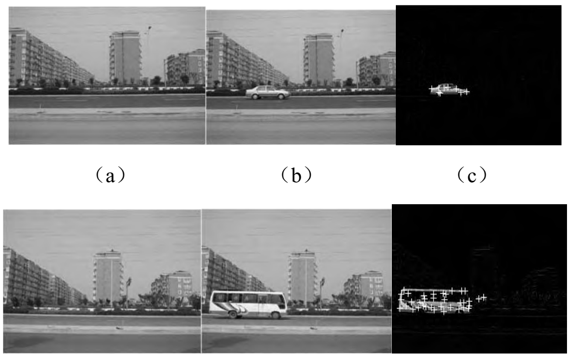
(b)The extraction of corner feature is well-proportioned and in reason. Harris operator can calculate for each point of image the value of its interest in, and then choose the optimal point from adjacent domains. Harris operator can extract a lot of important feature points in the area of more texture Information and a little of important feature points in the area of less texture Information.

(c)Quantitative extraction of the corner feature is used.

(d)Even if the existence of the rotation of images, gray-scale changes, noise impact and the transformation point of view, it is one of most stable algorithm for corner feature extraction.

So we choose to detect features with the Harris corner detector because Harris corner detectors work quite well under varying mean lightness, rotation or zooming. The basic idea of this detector is to use the auto-correlation function in order to determine locations where the signal changes in two directions, the correlation between images can be calculated by Normalized Cross Correlation algorithm. When the result value equals 1, the degree of similarity between images will reach the maximum.

There are three kinds of conventional approaches to moving object detection: temporal differencing, background subtraction, and optical flow. Temporal differencing is the simplest method, which comprises the differencing of two successive frames, but generally gets a poor performance of extracting all relevant feature pixels. Optical flow methods are computationally complex, and therefore not practicable for real time systems. The most suitable algorithm for detecting and extracting moving objects from a real time video stream is one that is based on the subtraction between the current frame and an estimate of the background image [6].



（a） （b） （c）

（d） （e） （f）

Fig.1. result of the detection of moving objects:（a）,（d）background;（b）,（e）frame;（c）,（f）result

III. AUTOMATIC VEHICLE CLASSIFICATION

A variety of vehicles with the goal of the more obvious differences corner, based on this, first of all, can be used in the way the side installation of the CCD camera movement to obtain the video side of the vehicle image, and then abstract the video and framing sequence based on the background of the differential access to methods of moving object. Finally, moving vehicles are detected and identified by using the recognition approach which is based on Harris corner and Hausdorff distance.

Hausdorff distance is a maximum - minimum distance, mainly for calculation of degree of match between two point set. The shape- match based on the Hausdorff distance is different from the other match. Hausdorff distances do not need to establish the one-to-one relationship of points which are from two points and it has good robustness in noise and shaking of the image.

The Hausdorff distance is a shape comparison method [7] [8], which is based on a distance measure of the edge maps of two objects. Given two finite point sets A = {a1, a2, ..., am} and B = {b1, b2, ..., bn}. The Hausdorff distance is defined as

$$H(A, B) = \max(h(A, B), h(B, A)) \tag{3}$$

Which, h (A, B) from point A-B-counting of the Hausdorff distance, h (B, A) can be used on and so forth.

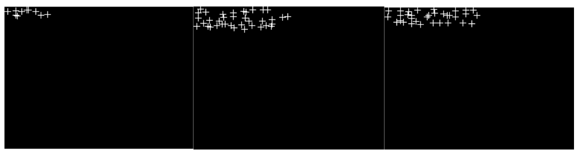
$$h(A,B) = \max_{a\in A}\min_{b\in B}\|a-b\| \tag{4}$$

$$h(B,A) = \max_{b\in B}\min_{a\in A}\|a-b\| \tag{5}$$

$\|\cdot\|$ is the norm of a vector. In the case of images, point sets are pixel sets containing the coordinates of feature pixels. The directed Hausdorff distance $h(A, B)$ finds the point $a \in A$ which is farthest from any point in B, and gives the distance between a and its nearest point in *B*. Thus if h(A,B) = d, then each point of A must be within distance d of some point of B, and there also is some point of A that is exactly distance d from the nearest point of B (the most mismatched point). The Hausdorff distance, H(A,B) can estimate the dissimilarity between the point sets A and B by finding the maximum of the directed Hausdorff distances between A and B (h(A,B) and h(B,A)). Hausdorff distance measures the degree of mismatch between two point sets and can be used as a measure for shape comparison. In the case of images, edges can be the features. The Hausdorff distance differs from many of the shape comparison methods in the sense that there is no explicit pairing between the points of A and B.

The steps of vehicle recognition based on Harris corner and Hausdorff distance are as follows:

(a) According to the function of vehicle, the vehicle will be simply divided into three models: car, bus and truck. Namely, select three standard Harris corner images of car, bus and truck as standard samples, as depicted in figure 2.



（a） (b) (c)

Fig. 2. the standard sample for three types of vehicles: （a） standard sample 1 – car; (b) standard sample 2 - bus; (c) standard sample 3 - truck

(b)A moving vehicle is detected and located in the image based on background subtraction, then Harris corner of the moving vehicle is abstracted.

(c) The Hausdorff distances between the Harris corner of which need to be recognized and that of standard samples of car, bus and truck are calculated.

(d) The two whose Hausdorff distance is the smallest could be judged as the same type.

As the variability of video sequence in the object vehicles, so Harris corners of standard samples are set in the upper-left corner of the image.

Ⅳ. EXPERIMENTAL RESULT

Matlab-based simulation platform, based on the vehicle Harris corner and Hausdorff distance of the identification process simulation models. Table 1 gives recognition to be the standard vehicle with three samples of Harris corner match between the calculated values, Table 2 gives the results of the identification of categories of vehicles. As can be seen from the table of this method to identify effective and better real-time.

Table 1. vehicle identification with the Hausdorff distance

model	match	Ho	H1	H2
car	sample1	5（car）		
	sample 2		24（not bus）	
	sample 3			20（not truck）
bus	sample 1	28（not car）		
	sample 2		1（bus）	
	sample 3			3（not truck）
truck	sample 1	16（not car）		
	sample 2		12（not bus）	
	sample 3			8（truck）

Table 2 vehicle classification results of the identification

models	Total number	error	Recognition rate	The average time of each vehicle simulation
car	100	0	100%	0.247s
truck	120	5	95.83%	0.286s
bus	90	3	96.67%	0.263s

This experiment is run on MATLAB7.0 platform, the Frequency of CPU is 1.6GHz, the memory is 1GB.

Ⅴ. CONCLUSION

In this paper, a vehicle recognition method based on the Harris Corner and Hausdorff distance was proposed. Its advantages are as follows:

(a)The algorithm is simple, and easy to carry out.

(b) Using the method based on Harris corner, the searching and matching of whole image is not needed, so the calculation is greatly reduced. This method is able to overcome the shortage of traditional methods, and automated highway toll booths and so on occasions of high practical value.

Ⅵ. ACKNOWLEDGMENT

This research is supported by the National Natural Science Foundation of China under Grant No. 60875004.

The author wishes to thank the IEEE for providing this template and all colleagues who previously provided technical support.

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