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Moving Vehicle Recognition and Feature Extraction From Tunnel Monitoring Videos

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Abstract

In recent decades, many government agencies and famous universities are researching the intelligent traffic video monitoring system. According to the tunnel monitoring video, this paper uses the combination of background subtraction method and three frame differencing method for moving vehicle detection , and designs the geometric parameters and combined parameters for vehicle classification, finally makes up a vehicle classifier, based on these characteristics parameters.

Keywords*: ITS, Surendra, background subtraction, three frame differencing, vehicle classifier*

1. Introduction

With the social economy develops quickly, the speed of life is also increasing, which is inseparable from the rapid transport, especially the car. Vehicles not only bring the convenience to the human, also the social problems(traffic jam, frequent traffic accidents, air pollution, etc). In recent decades, the infrastructure of transportation system is almost saturated by the increasing number of cars, so the traffic demand is growing. In the intelligent traffic video monitoring system, feature library is made up of moving object recognition, feature extraction, classification and recognition and tracking moving targets. The feature library serves directly in the behavior understand module of target to complete the advanced intelligent analysis capabilities.

Vehicle recognition is very important for the traffic monitoring and regulation of highway, tunnel, highway, as well as the large parking management. And it is an important part of the intelligent transportation system. At home and abroad, the feature extraction and recognition of vehicle type is mainly focused on the electromagnetic induction feature extraction method, the physical feature extraction method, the vehicle logo recognition method, axle load and total weight identification method and the prior classification recognition method [2-4]. At this stage, based on the original tunnel monitoring system, the classification and recognition of video based on image recognition is a promising method [1] . According to the tunnel monitoring video, this paper designs geometric parameters and combined parameters for vehicle classification, finally sets up a vehicle classifier based on these characteristics parameters.

2. Related Work

2.1. Popular Detection Algorithms of Moving Objects

Processing speed and reliability are the two basic problems that need to be solved in the moving target detection, and the two important index to measure the quality of algorithm. Popular detection methods of moving object are mainly divided into 3 categories, including the frame differencing method, background subtraction method and optical flow segmentation method [2], each have their own advantages and disadvantages:

Frame differencing method: is a method to obtain the outline of moving object by computing the difference between the two adjacent frames in the sequence of video images, it can be well applied in the case of multiple moving targets and camera's movement. When the moving objects appear in the monitoring scene, the difference between frames will be obvious.

Two frame subtraction, get the absolute brightness difference value between frames of image, judge it whether it is larger than the threshold to analyze the motion characteristics of the

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video or image sequence, and determine whether the image sequence has object motion. This algorithm is very easy and the complexity of program design is low ;Less sensitive to the changes of light and other scenes and able to adapt to dynamic environment with good stability. It can extract boundary ,not the full area of object; depends on the time interval between frames. For the fast-moving objects, it is necessary to select a smaller time interval, and if the choice is inappropriate, when the object is no overlap in the two frames, will be detected as two separate objects; while, for the slow-moving objects, should select bigger time interval, if the selection is inappropriate, will not detect any objects, when the object is almost completely overlap between frames. It is generally difficult to obtain the complete outline of the moving target, the "Double Shadow " and "empty" phenomenon are easily generated in the target internal, resulting in inaccurate information of the detected target.

Background subtraction method is an effective detection algorithm of moving object. The basic idea is to approximate the background image pixels using a parametric model of background. By the image difference between current frame and background detect moving region, the larger distinction between pixel area is regarded as a moving region, and the small difference between the pixel area is considered as the background region. Background subtraction method must have a background image, and the background image have to update with the change of the light or the external environment , so the key of background subtraction is modeling and updating the background . This method is simple, easy to implement, can efficiently extract the feature data of the target, but is very sensitive for the change of the external environment ,and suitable for the known background .

Optical flow segmentation method: The optical flow segmentation method detects the motion area using the time-varying vector feature of a moving target in the image sequence[7]. The main task of the optical flow segmentation method is to calculate the optical flow field. In the conditions of appropriate smoothness constraints, according to spatial-temporal gradient of the image sequence gradient estimates motion filed by analyzing the changes of motion field ,detects and segments the moving target and scene. In general, the optical flow method does not need to know any information of the scene in advance, it can detect the moving object. It can handle the moving background, but the noise, light, shadow and occlusion and other factors will have a strong impact on the computing the calculation of the optical flow field; and optical flow method with complex calculation, large amount of computation and need special hardware support, is difficult to meet the demand of real-time processing of video streams.

2.2. Image Feature

The image features is the original characteristics or attributes of the image. Some of them are the directly felt natural features , such as the regional brightness, edges, texture or color; Some are the human characteristics that obtained by transformation or measurement, such as transform spectrum, histogram, moment and so on [11]. The common image features can be divided into the gray (density, color) characteristics, texture characteristics, geometry features, etc [3] [4] [5]. Gray features and texture features belong to the internal characteristics, and be measured them with the help of the segmented image from the original image. Geometry features belong to the external characteristics and can be measured from the segmented image.

One of the key based on the video image recognition technology is the extraction of the feature parameters of the vehicle. Observable parameters for vehicle characteristics described three categories:

(1) geometric parameters: vehicle length, width, height, wheelbase, etc;
(2) weight parameters: vehicle axle load, load, total weight or carrying staff, etc ;
(3) text parameters: license plate number, vehicle signs, vehicle models, etc.

Because of the difficulties in system integration, not all above parameters is applied to vehicle characteristics recognition[6][7][8]. Weight parameters is mainly detected in induction detection. In the video detection, it focuses on geometric parameters and the text parameters (that vehicle recognition and license plate recognition). Any class of vehicle has a certain external shape features, and these features can be quantitatively described by its geometric characteristics.

3. Recognition

According to the lack of the frame differencing method and background subtraction method, we use adaptive Surendra algorithm to obtain the background, then do the background subtraction operation to extract the moving target, and then combine with the improvement of inter-frame differencing algorithm to a simple and effective moving target detection method.

The algorithm is mainly composed of three frame differencing, background extraction and updating, background subtraction, motion detection, Subsequent operation and so on. First, handle the source image with the three frame differencing and background subtraction, and then make the two binary template images of these two methods do "or" operation, get the intermediate template image, and then update the background based on a certain model. Finally, the template needs necessary post-processing, including the connected component analysis and morphological filtering (such as opening and closing operation) to remove the small noise region in the template, smoothes and segments the boundary of the object. Background updating model and three frame differencing is the core and key of the algorithm.

We use Surendra background updating algorithm, the idea of the algorithm is to find the moving region of the object by the current frame frame differencing image.Remain the background in the motion area unchanged, and replace the background of the no moving area by the current frame, so after, the background image can be extracted.

In image processing, the frame differencing obtains a motion area by calculating the difference between the adjacent images. The difference image can quickly detect the range of movement caused by a moving object in the adjacent image. But the moving target it extracts is usually larger than the actual, often with the phenomenon of "double shadow". In addition, since the detected object is the relative change between the two adjacent frames, cannot detect the overlap part, lead to the detected target of "empty" phenomenon. Three frame differencing method is improved on the inter-frame differencing. It takes the adjacent three images as a group, then does subtraction. Three frame differencing method can detects better the shape of the in between moving target.

4. Feature Extraction

Our extracted geometric parameters of vehicles video images can be divided into three categories, overall parameters, the length parameters and the combined parameters. The definition and description of these parameters are given in Table 1.

Table 1. The Definition and Description of Basic Geometric Parameters Describe Vehicles

type	parameter	symbol	definition
overall parameters	contour area	S	contour area of the vehicle
	minimum bounding rectangle area	MS	Minimum bounding rectangle area of the vehicle
length parameters	length	L	The distance between the protruding parts of the outermost end of the front and rear
	width	W	The distance between the protruding parts of the outermost end of the left and right
combined parameters	length-width ratio	LW	The vehicle length and vehicle width ratio , different types of vehicles have a more significant length-width ratio, often used to distinguish large, medium and small cars, is defined as the LW = L / W
	space occupancy	CR	The vehicle features have complicated boundary, such as a small car, has a regular changed boundary; such as a bus and van, characterized by the vehicle contour area and its external rectangle area ratio to describe the space occupancy rate,is defined as CR=S / MS

5. Vehicle Models

Usually the platform of various types car can provide the vehicle length, vehicle width and contour information. Because the position and angle of tunnel camera are not fixed, and the

car is moving, that is to say, the distance between the camera and the vehicle, are constantly changing. The above-mentioned parameters values of the same vehicle in the video image sequence cannot be absolutely equal, so it cannot use the absolute parameters (length, height, etc) as the feature parameter identification.

Combined parameters can better reflect the models' contour feature than the sample parameters, such as the space occupancy duty can be well differentiate motorcycles, turk or car and bus or van, and the ratio parameters do not depend on dimensionless characteristic, no need to know the intrinsic parameters of the camera or the location of the shoot[10]. The calculated parameters of the same or similar models is relatively stable, and changes in a certain range. So, the final selected classification parameters in this paper are also ratio parameters.

Vehicle recognition accuracy rate depends on the reliability of the characteristic parameter extracted from the contour curve and the separable degrees of characteristic parameters itself on the categories . So appropriately select classification features and the combined parameters, can be more desirable to achieve the vehicle classification[9]. The past, many vehicle classification system uses efficiency parameters such as top-longer ratio, top center-length ratio, tail length ratio -length ,etc. But these systems require vehicle image have to be a side view[1]. Now, whether tunnels, roads, highways and other surveillance video, almost are the top view, which requires to be looking for some new classification feature parameters. Although these parameters have a very good degree of separable, but due to the randomness of the distance and angle between the camera and the vehicle, so the scope of the combined parameters is difficult to define.

Based on the above analysis, the basic parameters of this article need to be obtained from the video image ,such as vehicle length, vehicle width, minimum bounding rectangle area and contour area[10], the final selected classification of parameters are length-width ratio and the space occupancy. These parameters have good character, such as high identify efficiency, good combination, weak correlation, easy extraction and regardless of the image ratio.

In order to realize the automatic vehicle classification, we need to determine the classification parameters' range of all types of vehicles. Through statistical analysis of more than 400 various types vehicles in the tunnel video data, give the range of the length-width ratio and the space occupancy, as shown in Figure 1.

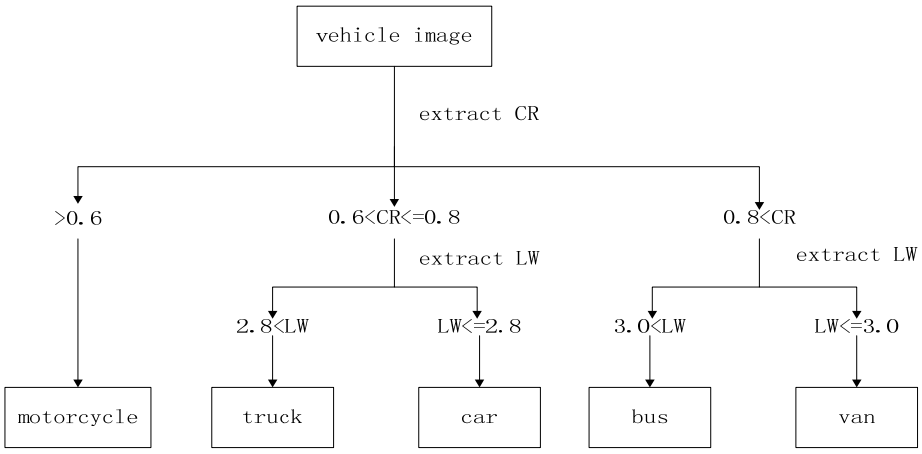

Figure 1. The design of vehicle classification

6. Experiment

6.1. Video & Image Preprocessing

Our tunnel monitoring video is sdv format, while MATLABR2009a programming software we use can only read avi format video. Before the processing of the video, we must convert sdv video into avi format. After a query and a series of experiments, ultimately, we use this winavi software to transform video into avi format, selecting ZJMedia Uncompress RGB24 video format .

During the image recognition, there are often noise interference. In order to get a more clear and complete target, we have to remove the identified images noise. Popular used denoising methods are corrosion, expansion, linear filtering, wavelet change, median filter, etc. We mainly use the corrosion and expansion operation.

The corrosion processing of the image can remove some small noise. The expansion processing of the image is carried out ,in order to fill some small holes in the image. Doing the corrosion and expansion can make the image more clear and complete .

6.2. Recognition of the Moving Vehicles

In this paper, we use the MATLABR2009a software as the development tool to handle the tunnel monitoring video. Respectively, we did experiment about the background subtraction method, the frame differencing method and the method we use, then compare them .We detected the 160th frame of a video ,and results are shown as follows:

Figure 2. Current image

Figure 3. The detected moving objects by background subtraction

Figure 4. The detected moving objects by three frame differencing

Figure 5. The detected moving objects by the combination of the background subtraction and three frame differencing

From the experiment result, we find that background subtraction demands very high on environment. The changed light will affect the test results. The light of video we select is very dark, so the identification of the vehicle is not complete. The detected vehicles by frame differencing method had some empty. Because we choose two adjacent frames and the time interval is very short, "double shadow" almost does not appear. But moving object position will be overlap between the two adjacent frames, which will lead to the "empty". The combination of

background subtraction with the three frame differencing we use, can detect moving object more clear and complete. The background subtraction makes up the lack of three frame differencing method which produces empty easy, three frame differencing method makes up the lack of background subtraction which is sensitive to the environment, the combination of the two makes test results more ideal.

6.3. Feature Extraction

We use the C61_6.avi video to test, get random a vehicle of in the video and extract the feature parameters (data in pixels), the main data is given in Table 2.

Table 2. The Data of Vehicle Feature Parameters

frame	L	W	LW	S (×103)	MS (×103)	CR
1	120.4377	96.0029	1.2545	7.5916	11.5623	0.6566
2	108.5346	91.5261	1.1858	6.4895	9.9337	0.6533
3	103.2450	85.0485	1.2140	6.0954	8.7808	0.6942
4	103.7358	89.5974	1.1578	6.3305	9.2944	0.6811
5	101.0932	80.9503	1.2488	5.8354	8.1835	0.7131
6	98.8038	76.6099	1.2897	5.2293	7.5693	0.6908
7	93.7329	78.7516	1.1902	4.9301	7.3816	0.6679
8	94.1454	76.1791	1.2358	4.9503	7.1719	0.6902
9	86.7286	74.2869	1.1675	4.5093	6.4427	0.6999
10	88.5265	69.1769	1.2797	4.1713	6.1239	0.6811
15	89.7266	63.4270	1.4146	4.2465	5.6910	0.7462
16	86.5814	63.3908	1.3658	3.9218	5.4884	0.7145
17	78.5568	67.7329	1.1598	3.8191	5.3208	0.7178
18	82.4873	67.0671	1.2299	3.7036	5.5321	0.6695
19	80.8843	61.4852	1.3155	3.5441	4.9731	0.7126
20	73.8559	60.0703	1.2295	3.3073	4.4365	0.7455

Seen from Table 2, with the constant movement of the vehicle, the length (L), width (W), contour area (S) and minimum bounding rectangle area (MS) are also changing; while the length-width ratio (LW) and space occupancy (CR) are always in a certain range, and the variation range is very small. The variation range of length-width ratio (LW) is 0.3 and the variation range of space occupancy (CR) is only 0.1. Thus, the LW and CR have great feasibility in the vehicle classification.

6.4. Classification of Vehicle Models

In order to verify the efficiency and accuracy of the classifier, we use the vehicle image in different environments to experiment. We do something including the image preprocessing and the characteristic parameters extraction; finally decide the model of vehicle and evaluate the results. The following is the test of different video. The results are as Figure 6 to Figure 9.

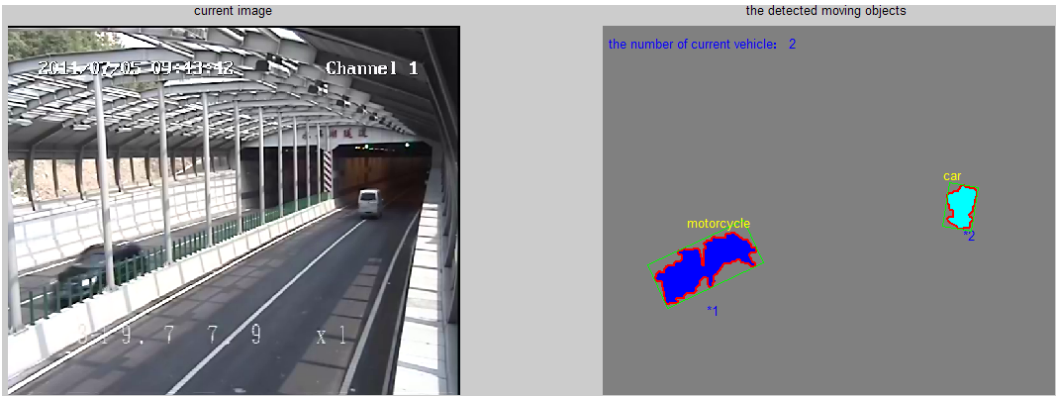

Figure 6. Test results using C61_15.avi

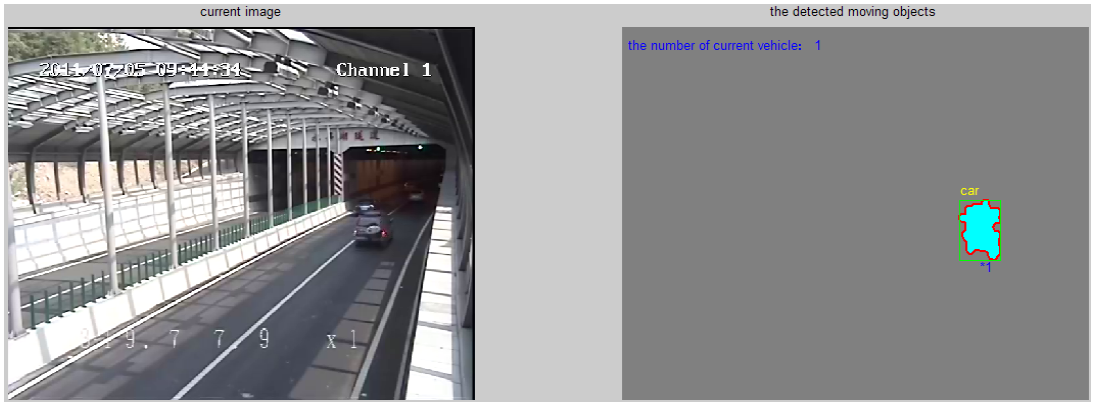

Figure 7. Test results using C61_27.avi

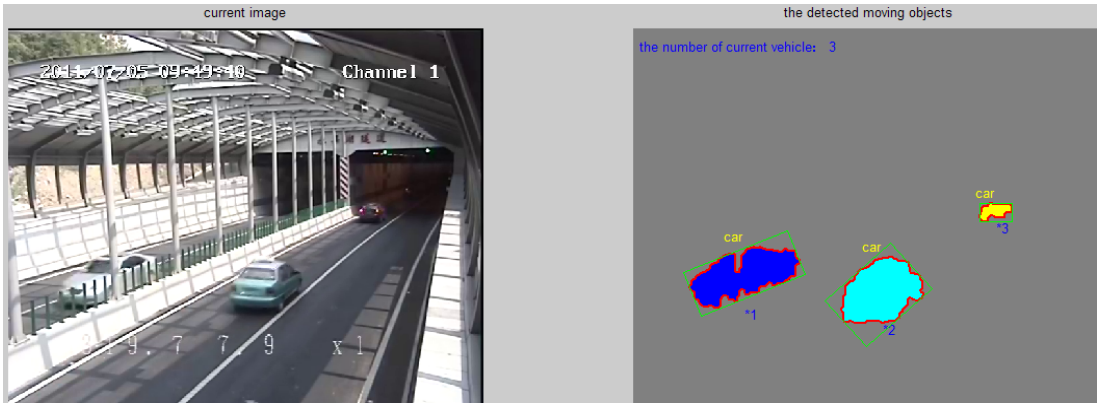

Figure 8. Test results using C61_99.avi

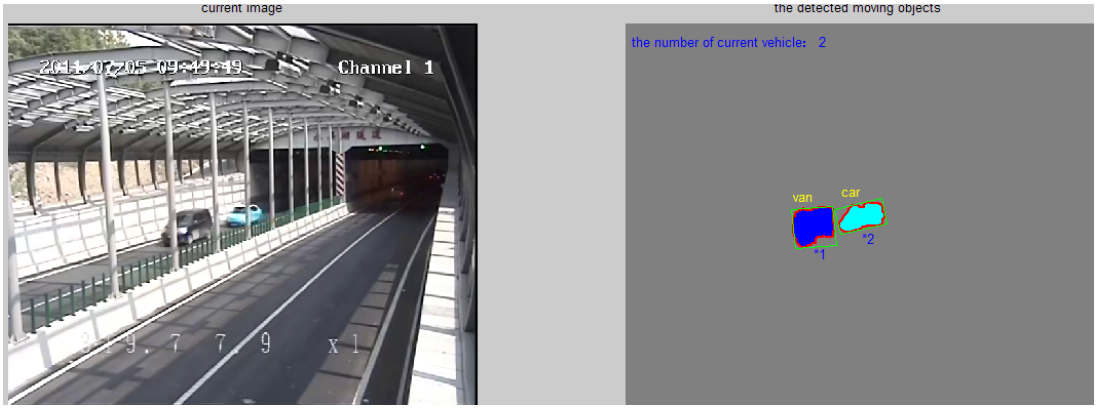

Figure 9. Test results using C61_101.avi

Can be seen by the test results of the models, when the vehicle images is blocked (Figure 6), the identified image is not complete, so that the values of the characteristic parameters are wrong and the judgment models will appear error; When the vehicle images overlap (Figure 7), the identification of the vehicle is the superposition of several vehicle images and will also determine error; But in normal case, the accuracy of the vehicle models determination is very high. Doing vehicle identification under the above special cases, is also our key research content.

7. Conclusion

The video contains rich geometric characteristics information of vehicle. We obtain a more complete moving target by using the combination with background subtraction and three frame differencing method, identify moving objects from a video sequence, extract the vehicle characteristic parameters of the moving object and classify them by the vehicle classifier. The experimental results show that the classification method has higher accuracy and the selected parameters and classification scheme are feasible. Used in tunnel monitoring, traffic monitoring, etc can reduce the human and material investment, and have better economic benefits.

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