An Efficient and Flexible Automotive Vehicle Management System

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ABSTRACT

In recently, the high security and high safety is the necessary requirement in the building parking management and restaurant parking management. The automotive vehicle management system is essential and its technologies include image capture, vehicle plate recognition, and the confirmation and the record of the vehicle behaviors. The proposed method can process the input images from different image capture methods. Many vehicle plate recognition researches have advantage of identification accuracy but have high computation complexity. Therefore we propose the simple and fast vehicle management system in real time system. The proposed methods use vertical and horizontal projection to segment the character blocks, flexible reserve and valley cut to eliminate the annoying unnecessary data and pattern matching to recognize the character blocks. That is fast and accurate enough in the practical applications. Finally the recognized vehicle plate is compared with the database of the legal parking vehicle. The vehicle management system decides automatically if lock the guard gate and record the vehicle behaviors in the database. The simulation results demonstrate that the proposed system is efficient and feasible in vehicle management system.

Keyword: Vehicle Management System, Vehicle Plate Localization, Character Segmentation, Character Recognition

INTRODUCTION

In modern parking management system, the vehicle management is the most important. In recently, the high security and high safety is the necessary requirement in the building parking management and restaurant parking management. The disallowed vehicle is not entered to park. The vehicle management system decides the parking access. In order to reduce the human cost and improve the working efficiency, the vehicle management automation is imperative. The automotive vehicle management system includes three main technologies: the first is the image capture, the second is the vehicle plate recognition, and the third is the confirmation and the record of the vehicle behaviors. The automotive vehicle management system shows in Fig. 1.

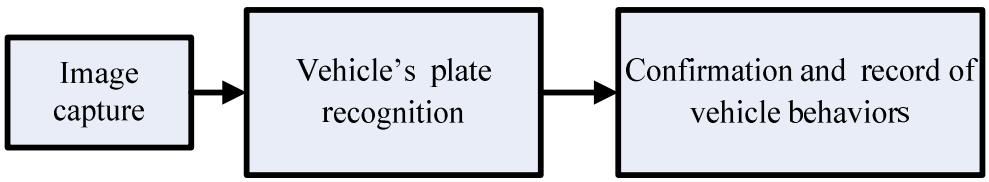


Fig. 1: The automotive vehicle management system

The two ways of image capture methods: one is the image capture from the video sequence of the surveillance system and the other is the image capture by automotive monitor camera. In the application of traffic monitoring, intersection control …etc, the image capture from the video sequence of the surveillance system is used in common. And the image capture by automotive monitor camera is used in parking management, restaurant entrance management…etc. the capture method choice depends on the frequency of the abnormal event. The image capture from the video sequence of the surveillance system is used in high frequency of the abnormal event while the image capture by automotive monitor camera is used in low frequency of the abnormal event. Anyway, whether what kind of the capture method one image is captured and processed in vehicle plate recognition step. There are a number of techniques used so far for recognition of vehicle plates such as fuzzy/neural network character recognition (S. L. Chang, L. S. Chen, Y. C. Chung, and S. W. Chen 2004). But the computing complexity of fuzzy/neural network model is the barrier of the real time vehicle management system. Therefore we suppose the simple and fast method to recognize the vehicle and decide the parking access. The techniques use in the proposed system is based on pattern matching, which is fast and accurate enough for real time applications and is developed for recognition of vehicle plates with prior knowledge of ciphers and capitals. Finally the vehicle plate is compared with the database of the legal parking vehicles. If the vehicle plate is not confirmed with the allowable vehicles in the database the guard gate will lock. And if the vehicle license plate is confirmed with the allowable vehicles in the database the guard gate will unlock and the accessing behavior will record in the database.

The rest of the paper is organized as follows: Section II discusses about the system architecture and the steps involve in image capture, vehicle plate recognition, and the confirmation and record of the vehicle behaviors. Section III explains the proposed algorithm for real time detection of vehicle in automotive vehicle management system. Section IV shows the experimental results and finally Section V concludes.

BACKGROUND

The proposed system architecture contains three distinct parts: monitor cameras, server to recognize and record the vehicle behaviors, and the guard gates. The architecture of the automotive vehicle management system shows in Fig. 2. The outdoor part includes the cameras that are installed in different intersections of interest for capturing images and the guard gates to control the access vehicles. The indoor part is the central control server that receives stores and analyzes the captured images from all these installed cameras. Communication link can be high speed cable or fiber optic connecting all these cameras to the central control station.

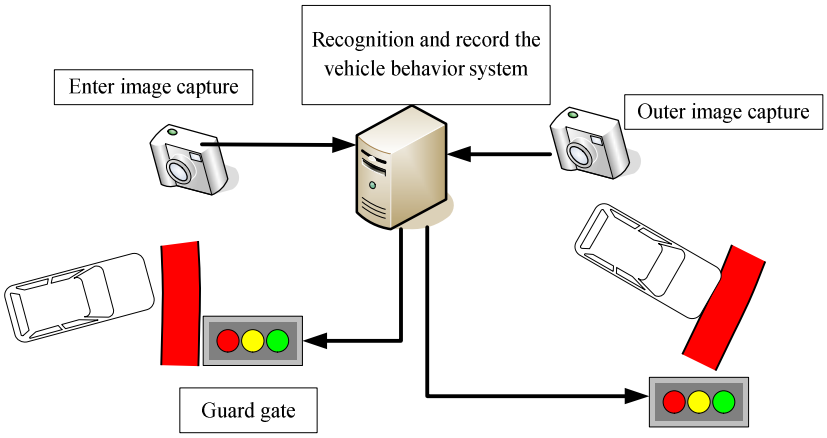


Fig. 2: The architecture of automotive vehicle management system

Almost all the algorithms are developed so far work by following similar steps. The three general processing steps have been identified as being common to all vehicle plate recognition algorithms. The vehicle plate recognition algorithm steps as follows: the first is vehicle plate localization and the second is character segmentation. Finally, the third part is character recognition.

Relative researches of vehicle plate detection are described. As far as extraction of the plate region is concerned, techniques based on combinations of edge statistics and mathematical morphology (D. Zheng, Y. Zhao, and J. Wang 2005) featured very good results. In these methods, gradient magnitude and their local variance in an image are computed. They are based on the property that the brightness change in the license plate region is more remarkable and more frequent than otherwise. In (H. J. Lee, S. Y. Chen, and S. Z. Wang 2004), the author proposed that regions with a high edge magnitude and high edge variance are identified as possible license plate regions. Since this method does not refer to the license plate boundary, it can deal with unclear license plate boundary in the image. The disadvantage is that edge-based methods can hardly be applied to complex images, since they are too sensitive to unwanted edges, which may also show high edge magnitude or variance. Fuzzy logic has been applied to the problem of locating license plates (Y. K. Ki and D. K. Baik 2006). But these methods are sensitive to the license plate color and brightness and need longer processing time from the conventional color-based methods. In (C. T. Hsieh, Y. S. Juan, and K. M. Hung 2005), a wavelet transform-based method is used for the extraction of important contrast features used as guides to search for desired license plates. The major advantage of wavelet transform, when applied for license plate location, is the fact that it can locate multiple plates with different orientations in one image. Nevertheless, the method is unreliable when the distance between the vehicle and the acquisition camera is either too far or too close. Symmetry is also used as a feature for car license plate extraction. The generalized symmetry transform (GST) produces continuous features of symmetry between two points by combining locality constraint and reflectional symmetry. This process is usually time-consuming because the number of possible symmetrical pixels in the image is huge.

In addition, various neural-network architectures (K. K. Kim, K. I. Kim, J. B. Kim, and H. J. Kim 2000) are proposed and implemented for plate identification. The above mentioned methods have these advantages but all of them have high time consuming this is a serious troubling problem in real time system. Therefore, we propose a simple and fast vehicle plate detection method to decrease the time complexity.

The vehicle plate area that is determined in the previous stage is analyzed in the identification step. The two major tasks involved in the identification phase: character segmentation and character recognition. A number of techniques to segment each character after localizing the plate in the image have also been developed. In (S. Nomura, K. Yamanaka, O. Katai, H. Kawakami, and T. Shiose 2005), the author proposes an adaptive approach for character segmentation and feature vector extraction from seriously degraded images. An algorithm based on the histogram automatically detects fragments and merges these fragments before segmenting the fragmented characters. The results are very promising and encouraging, indicating that the method could be used for character segmentation in plates with not easily distinguishable characters during off-line operation, but since the algorithm is computationally complex, it cannot be proposed for real time system.

For the recognition of segmented characters, numerous algorithms exploited mainly in optical character recognition applications utilized neural networks (Christos Nikolaos E. Anagnostopoulos, Ioannis E. Anagnostopoulos, Vassili Loumos, and Eleftherios Kayafas 2006). Multilayer perception neural networks were used for license plate character identification. The network has to be trained for many training cycles in order to reach a good performance. This process is rather time consuming, since it is not certain that the network will learn the training sample successfully. Moreover, the number of the hidden layers has to be defined after a trial and error procedure. And the other advance relative neural network researches have excellent recognition result ratio up to 95.7%~99.5%(C. Anagnostopoulos, T. Alexandropoulos, S. Boutas, V. Loumos, and E. Kayafas 2005). This outstanding feature comes with the drawbacks of larger memory requirements and slightly slower execution speed compared to conventional neural networks.

A similar application is described in (P. Comelli, P. Ferragina, M. N. Granieri, and F. Stabile 1995). The authors use a normalized cross correlation operator. The recognition process was based on the computation of the normalized cross correlation values for all the shifts of each character template over the subimage containing the license plate. The main computation time of this algorithm spend on the cross correlation measures between the various templates and the relative subimage. As the subimage is a small image, the problem of computational time is overcome. The recognition result ratio of this method is up to 90% that is inferior to that by the neural network based method but the results is acceptable. Therefore, unlike the neural network based method, the template matching techniques is used for character recognition in real time system. The automotive vehicle management system is the real time implementation therefore lower computing complexity and acceptable recognition effect in character recognition is necessary in the proposed method.

PROPOSED METHOD

A. Vehicle plate localization

Vehicle plate localization technology in the automatic vehicle plate identification system is an extremely important part. The main goal of the vehicle plate localization is the ROI (region of interesting) capture in the input image. The camera capture image is color image. If the vehicle plate localization process in RGB channel separately, it is not gain to reduce the time costing. Therefore, the proposed method first transforms the color image to gray level image and then erodes the edge of the gray level image. And mostly the position of the car license plate is located in the underneath of the input image, the proposed method only process the below part in the image. This procedure has two advantages: one is reducing the disturbance of the miscellaneous edges; another is reducing the computation time.

Generally, the Sobel filter is simple and fast edge detection technology. There are many horizontal edges, like bonnet, ground edge and radiator cap and so on. After using the Sobel horizontal filter, the unnecessary edges are detected. Therefore, the proposed method uses the Sobel vertical filter to detect the vehicle plate edges. Because the vehicle plate edges are composed by a succession of strong intensity change in gray level image, therefore the severe change region in vertical edge image possibly is the correct vehicle plate location.

All of the Taiwan vehicle plates have the same height (15 cm) and length (32 cm), so the ratio of height to length is invariable (2.133). The height and length of the Taiwan vehicle plate in the test image is the reduced multiple of the height and length of the actual Taiwan vehicle plate. Therefore the ratio of height to length in the Taiwan vehicle plate in the test image approximates to that in actual one. According to this vehicle plate characteristic, the proposed method uses flexible reserve to eliminate the annoying regions and edges. The flexible reserve can detect the unlike regions in all of the constructs that are composed by edges. The flexible reserve limits the ratio between 2 and 2.5. And then the proposed method uses vertical projection to find the correct vehicle plate region position. The vehicle plate localization flowchart shows at the Part A in Fig. 5.

B. Character segmentation

The vehicle plate localization segments the vehicle plate in the input image and then the character segmentation divides the character blocks in vehicle plate. The main two types of the vehicle plate in Taiwan show in Fig. 3.

(a) (b)

Fig. 3: The two types of the vehicle plate in Taiwan

The common character segmentation method is mask, but this method is inflexible. The two types of vehicle plates must have two masks. If the location of dash line "-" is varied, a new mask must be produced. One vehicle plate type needs one mask that is impracticable. Therefore, we propose an adaptive method to segment the character blocks. First, the display type of the vehicle plate segmentation is transformed from gray level to

binary. And then the proposed method removes the nonessential information in vehicle plate segmentation by valley cut. The valley cut finds the valley point between two mountain peaks in row-major histogram in Fig. 4. First, the proposed method finds all the zero points and one of them maybe become the valley point. And then the proposed method detects if the zero point between two peaks. While the two peaks are found the zeros point is the candidate as valley point, otherwise not. Finally, the maximum in all valley point candidates is choice as valley point and cut the binary segmentation with the unnecessary information.

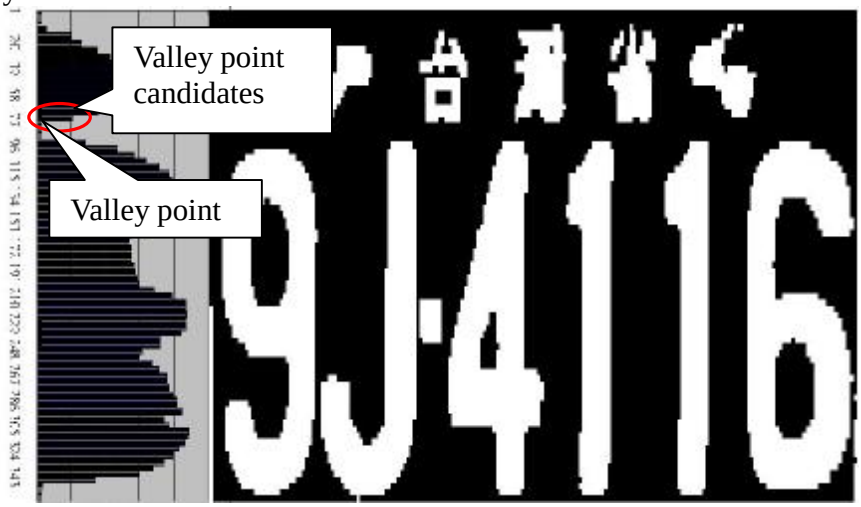


Fig. 4: The valley cut between two mountain peaks in row-major histogram

And the binary vehicle plate segmentation is projected vertically and the characters are found independently. No matter the distance between neighbor characters, there must be one zero column between neighbor characters. Therefore, it's easy to segment the character blocks independently. Each of the character blocks is projected horizontally and the heights of character blocks are found. Finally, each of the character blocks resizes of 200x100. The character segmentation flowchart shows at the Part B in Fig. 5.

C. Character recognition and validity decision

The seven independent character blocks are captured and then recognized. Initially, we make 36 binary patterns that size of 200 x 100 and use XOR operation to comprise the character blocks with all of these patterns. Exclusive disjunction (XOR) of a pair of propositions, (p, q), means that p is true or q is true, but not both. The kind of vehicle plate can be detected. If $\min\sum(a_3 \oplus b) > \min\sum(a_5 \oplus b)$ then the vehicle plate type is type 1, such as Fig.3(a), otherwise type 2, such as Fig.3(b). $\oplus$ is XOR operation, a_i is the independent character block pattern (i=3 and 5), b is the dash line pattern "-". In type 1, the dash line "-" is the third independent character block and that in type 2 is the fifth independent character block. Type discrimination can reduce the XOR operation numbers. And the difference $D = \min\sum(c \oplus g_i)$, c is the independent character block pattern, g_i is the all patterns, and i= {1.2.3…36}. If the independent character block is different from the pattern, the difference D is large. Oppositely, the independent character block is the same with the pattern, the difference D is small. Therefore, the pattern matching is that the minimum capture in the all differences. We recognize the six independent character blocks and then compare this string (vehicle plate) with the database of the legal parking vehicle. If the vehicle plate is not confirmed with the allowable vehicle in the database the guard gate will lock. And if the vehicle plate is confirmed with the allowable vehicle in the database the guard gate will unlock and the accessing behaviors will record in the database. The character recognition and validity decision flowchart shows at the Part C in Fig. 5.

SIMULATION RESULTS

The proposed system has been prototyped using Matlab 7.0 and Microsoft Excel 2003. The architectures of this simulation test include that the capture camera is Fujifilm F11, CPU is Pentium 4 and memory is 256 MB in the server. We simulate ten vehicles in the automotive vehicle management system. The capture image size is 1024x768 and the flowchart shows in Fig. 5. The automotive vehicle management system has two databases: one is the record of the legal person names, vehicle plates, and person phones and the other is the record of the vehicle behaviors, such as enter accessing time, outer accessing time, and the total parking time. Because the computing operation in this system is simple, this automotive vehicle management system is an efficient and real-time system.

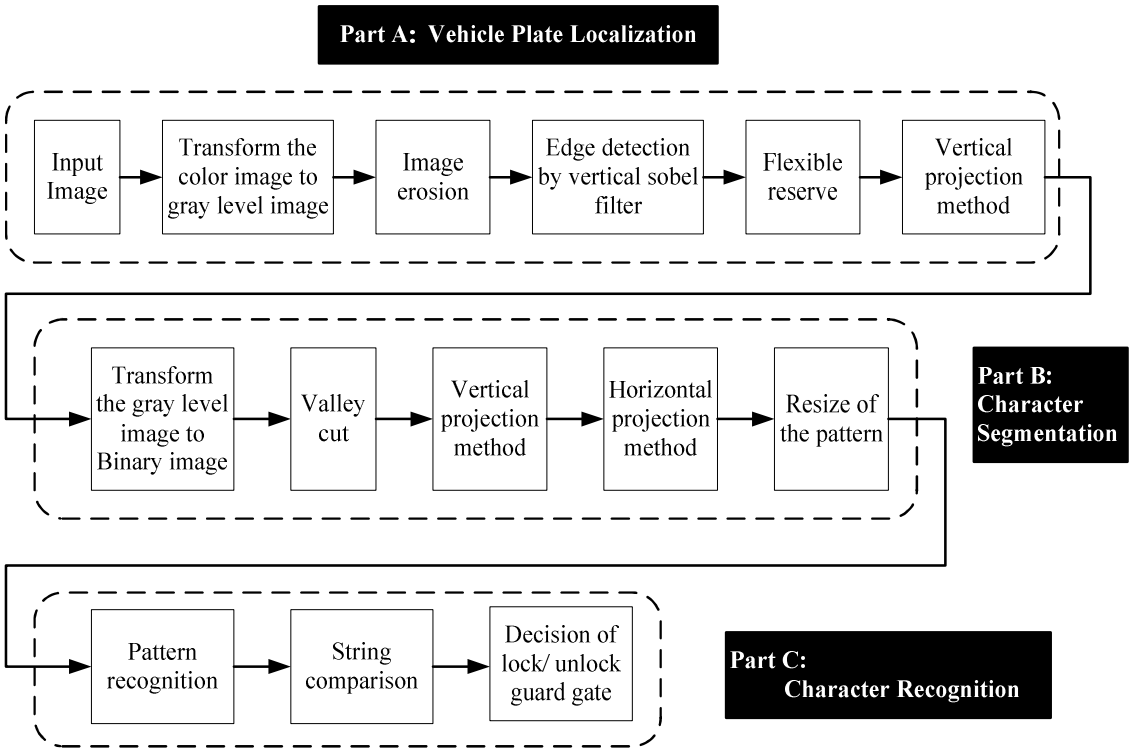


Fig. 5: The flowchart of automotive vehicle management system

A. Vehicle plate localization

A sample of Taiwan vehicle plate is test image and its gray level image shows in Fig. 6.

Fig. 6: The gray level image

Generally, the Sobel filter is simple and fast edge detection technology. After using the Sobel horizontal filter, the unnecessary edges are detected in Fig. 7. Therefore, the proposed method uses the Sobel vertical filter to detect the vehicle plate edges in Fig. 8. The annoying edges are not detected.

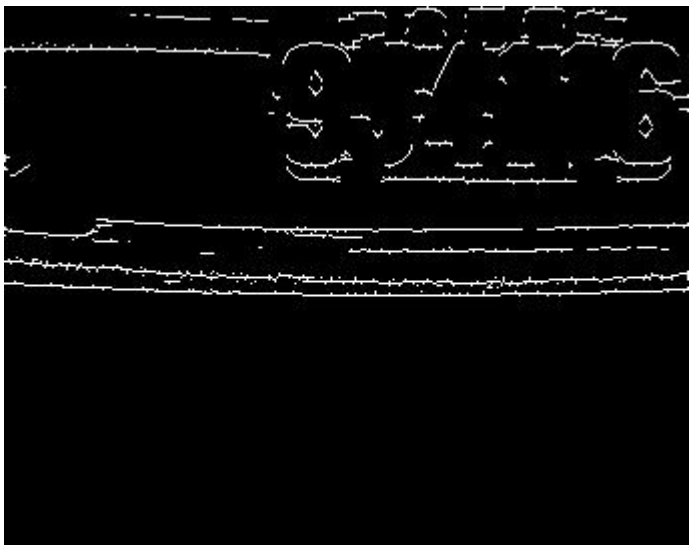
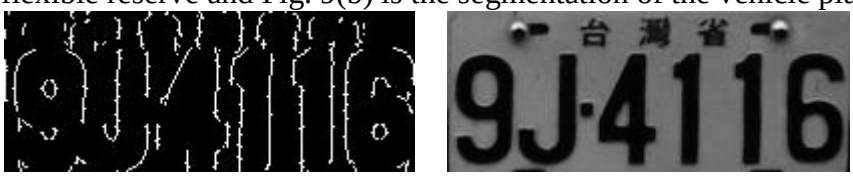


Fig. 7: The results of the edge detection by Sobel horizontal filter

Fig. 8: The results of the edge detection by Sobel vertical filter

In order to eliminate the annoying regions and edges, the proposed method use the flexible reserve to detect the unlike regions and then the proposed method uses vertical projection to find the correct vehicle plate region position. Fig. 9(a) is the results of flexible reserve and Fig. 9(b) is the segmentation of the vehicle plate.



(a) (b)

Fig. 9: The segmentation of vehicle plate

B. Character segmentation

The proposed method segments the character blocks. First, the gray level vehicle plate segmentation transforms to binary one. And then valley cut removes the nonessential information of the vehicle plate in Fig. 10. Furthermore, the vertical

projection and horizontal projection segment the seven independent character blocks in Fig. 11. Finally, these independent character blocks resizes of 200x100.

Fig. 10: The binary segmentation image

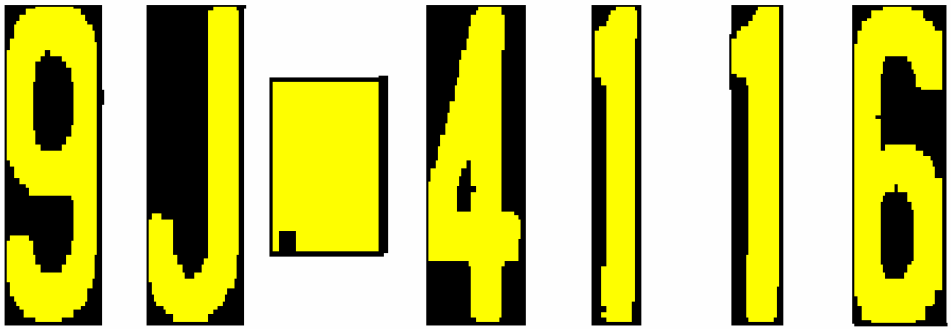


Fig. 11: The results of the character segmentation

C. Character recognition and validity decision

The seven independent characters are captured and then recognized. Initially, we make 36 binary patterns that size of 200 x 100. The 36 binary patterns included ciphers “0~9”, dash line “-” and capitals “A~Z”. The capital “O” is not used in vehicle plate, because the capital “O” is similar to the cipher “0”. Therefore the binary patterns also not include the capital “O”. The proposed method uses pattern matching to find the independent character block meaning. Each of the dependent character blocks compares with all of the binary patterns and the best match is found. Fig. 12 shows that the independent character block “2” compares with the patterns “A” and “2”. Figure 12(a) shows that the difference D is 111,106 between the independent character block “2” and the pattern “A” and Fig. 12(b) shows that the difference D is 4,711 between the independent character block “2” and the pattern “2”. Table 1 shows the difference D between the independent character block and all the patterns. Because of type discrimination the independent character blocks “4”, “1”, ”1” and ”6” are not XOR with the ciphers patterns “A~Z”. Table 2 shows the difference D between the independent character block and all the patterns in the other vehicle plate type. After recognizing the six independent character blocks, the proposed method compares this string (vehicle plate) with the database of the legal parking vehicle in Fig. 13. And if the vehicle license plate is confirmed with the allowable vehicle in the database the guard gate will unlock and the accessing behavior will record in the database. In Fig. 14, the simulation results of the automotive vehicle management system: the householder is B3, the number of vehicle plate is 9J4116, the enter guard gate is unlocked, and the record of accessing behavior shows.

(a) (b)

Fig. 12(a): The difference D is 111,106 between the character block “2” and the pattern “A”
Fig. 12(b): The difference D is 4,711 between the character block “2” and the pattern “2”

Tab. 1: The difference D between independent character block and all the patterns

Pattern plate	9	J	4	1	1	6
A	17431	16512				
B	6594	12858				
C	9641	12581				
D	7795	11327				
E	10203	16154				
F	11790	18452				
G	7847	11528				
H	10958	12451				
I	16368	19164				
J	10375	1832				
K	13912	19100				
L	14130	15394				
M	12851	15885				
N	10605	13960				
P	8926	16772				
Q	9145	11594				
R	10884	17409				
S	6644	11424				
T	18005	19282				
U	9028	8411				
V	14631	14675				
W	13914	15059				
X	17366	16490				

Z	13195	13939				
0	200000	200000	15181	6854	6804	7336
1	11082	11900	13041	4279	2728	14810
2	9668	12542	16897	5220	5608	11919
3	8341	8857	13856	4835	4712	9066
4	16596	13381	4696	5196	5589	15578
5	8147	11744	14028	5760	6117	8636
6	7962	13265	13058	6530	7012	5260
7	15769	17058	16087	5188	5799	16777
8	7221	12854	12504	4854	5250	6226
9	3803	11106	16681	5723	5610	7765

Tab. 2: The difference D between independent character block and all the patterns

Pattern plate	0	9	1	0	L	E
A					18850	15596
B					15689	7273
C					11342	9673
D					13161	9542
E					13699	3608
F					13944	5191
G					13737	10692
H					14255	9587
I					21339	16071
J					16746	15358
K					16096	10285
L					6894	5866
M					17273	13468
N					18754	13110
P					16339	13977
Q					12284	11523
R					14010	8129
S					17298	10461
T					17177	12985
U					11237	10737
V					15397	14281
W					16291	13965
X					18362	15196
Y					16280	14094
Z					18841	10094
0	4105	11412	5902	5063	2000000	2000000
1	12786	14571	2330	12730	21693	17875

2	10827	14734	4579	11034	18251	11326
3	8283	12178	3869	8490	17896	12645
4	14715	17253	4374	15104	18030	16804
5	8401	12178	5183	8453	17161	10592
6	6203	12919	5931	6935	14961	9428
7	16190	15899	4775	15955	18623	13108
8	8220	13037	4740	8411	19580	12131
9	6335	5650	5010	6885	18037	12794

	A	B	C	D
1	Name	Plate	phone	
2	Bill	OF1243	3869574	
3	Ken	9J4116	3869575	
4	Mary	9J3229	3869576	
5	Helen	1035LB	3869577	
6	Bob	0910LE	3869578	
7	Lena	QG7608	3869579	
8	Linda	ZB8907	3869580	
9	John	QU9157	3869581	
10	Andy	B35719	3869582	
11	Peter	8Q2820	3869583	
12				

Fig. 13: The simulation results of the automotive vehicle management system

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Plate	in_Year	in_month	in_day	in_hour	in_miniute	in_second	out_Year	out_month	out_day	out_hour	out_miniut	out_second
2	OF1243												
3	9J4116	2007	1	23	13	41	50.109						
4	9J3229							2006	5	30	12	59	11.99999
5	1035LB												
6	0910LE												
7	QG7608												
8	ZB8907												
9	QU9157												
10	B35719												
11	8Q2820												

Fig .14: The record of accessing behavior

CONCLUSIONS AND FUTURE WORKS

The automotive vehicle management system includes three main technologies: the first is the image capture, the second is the vehicle plate recognition and the third is the confirmation and the record of the vehicle behaviors. We mainly propose the vertical sobel filter and fixable reserve to avoid the annoying edge and locate the vehicle plate. Furthermore, vertical/ horizontal projection and valley cut segment the character blocks and then pattern matching to recognize the character blocks. Finally the recognized vehicle plate is compared with the database of the legal parking vehicle. The experimental results demonstrate the system is simple and efficient. And

if the vehicle plate in the capture image is distorted that maybe cause by the imaging angle, the image must be reformed before character segmentation. But if the legal vehicle plate is malice spoiled such as Fig. 15, the automotive vehicle management system maybe not distinguishes the vehicle plate and lock the guard gate. This challenge is our future work to overcome. In the while, the automotive vehicle management system is excellent and practical.

Fig.15: The malice spoiled image

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