

A License Plate Recognition System Based on Machine Vision

Jian Yang¹, Bin Hu²

¹ Dongguan Research Institute of CASIA
Cloud Computing Center, Chinese Academy of Sciences
Dongguan, China
² The State Key Laboratory of Management and Control for Complex Systems
Institute of Automation, Chinese Academy of Sciences
Beijing, China

JieHan Yu³, Jianqi An⁴, Gang Xiong¹

³ Guang Zhou Communication Infomation Construction
Investment and Operation Co.Ltd,
Guang Zhou, China
⁴ School of Information Science and Engineering, Central
South University
Changsha, China

Abstract—License Plate Recognition based on machine vision has been widely used in ITS(Intelligent Transportation System) and Smart Parking System. In this paper, we developed a system which included the image acquisition, license plate location, character segmentation and character recognition. To improve the accuracy of the license plate location, we improved the effect of the binary image positioning method. In character segmentation, we solved several typical license plate characteristics. In order to improve the accuracy of segmentation, we have taken a variety of methods to deal with their respective characteristics. In character recognition, we use template matching method and considered whether to consider the background matching. In the system, we just adopted the image recognition to recognize the characters. With no significant exposure, the area of license plate is more than 1/5 of the total images, we can get a good recognition.

Keywords—*License Plate Location ; Template matching ; Character Recognition ; Machine Vision*

I. INTRODUCTION

LPRS(License Plate Recognition System) is one of the most important part of the ITS(Intelligent transportation System). With the help of Digital Image Processing, Computer Vision and Pattern Recognition, we can get an only license number from the photos, which is come from a video or a camera. Combined with other technologies, we can apply it in Parking Management System, the Traffic Flow Control Measurement, Auto-guard, Electronic Police, Toll Highway and so on.

At present, the characteristic recognition based on machine vision mostly focused on the plate recognition in the ITS. Generally, we use electronic eye to identify the license plate automatically.

But how could we acquire the license plate number accurately and efficiently is a hotspot problem. That is, on the one hand, we must develop a new arithmetic to shorten the problem run time, on the other hand, our arithmetic must acquire a high recognition accuracy though in a complex environment or the image quality is poor.

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YingWen^[1], ZhigangXu^[2], BoLin^[3], Moghassemi^[4], Jian-XiaWang^[5] and HuaXu^[6]'s works help developed the recognition efficiency.

ChanghuaLu^[7], FengZhifan^[8] have do the research of the image segmentation. And Jian-XiaWang^[5] had proposed an image segmentation based on the neighborhood information.

Based on the Ostu method, Lu gives an improved two-dimensional Otsu segmentation method which changes the coordinate system of the two-dimensional histogram to strengthen resistance to noise and improve the computing speed.

Blaschke^[9] built on a discussion of different approaches to image segmentation techniques and demonstrates through several applications how segmentation and object-based methods improve on pixel-based image analysis/ classification methods. He addressed the concepts of object-based image processing, and presented an approach that integrates the concept of object-based processing into the image classification process.

In this paper, we developed a license plate recognition system. In the next parts, we'll introduce you the license plate location, character segmentation, and character recognition. PartV is the experimental analysis of the system and the last is our conclusion.

II. LICENCE LPATE LOCATION

In the system, plate is located from a binary image. As we acquired images contain plenty of outline, we need do some preprocessings.

With the edge detection, we can get the outline of the images. Then image erosion and close operation will fill the outlines. As the license plate area is more than 1/5 of the total area, removing small objects will decrease the interface.

Figure1 is the original images, by the processing of locating, we acquire the binary images showed in figure2. We can find that most of the blank area is the object region, as a result, we can do the next step.

At last, we cut the license plate from the color image as shown in figure 3.



Fig. 1. The original images

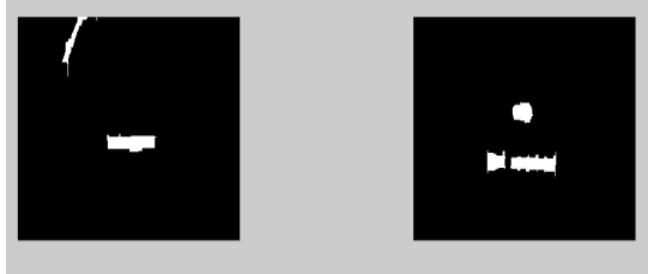


Fig. 2. The binary images

From figure 3, we find some problems we should deal with. First, as show in the first plate and the third one, we still find some frames need to delete. Secondly, the size of the plates is different from the original images. These two must process well before we do the character segmentation.

III. CHARACTER SEGMENTATION

From figure 3, we have three kinds of license plate after we located. That is the edge cutting in order, existence of the upper and lower edge and existence of the left and right edge. Consequently, we must erase the edge before we segment characters. And for a better effect, we should normalize sizes as some references notified.

There are plenty of methods for normalization of the image sizes. But the most important is interpolation normalization and splitting and merging. In our system, we adapt the splitting and merging. The rationale is as follows:

Consider our original image's size is $M \times N$, after normalization, the size is $I \times J$. In splitting, every pixel is copied magnified $I \times J$ times. That is copy the pixel to the array of $I \times J$. Then the original matrix size become $M \times N$. In merging, the matrix is divided into $I \times J$ parts and the size of every part is $M \times N$. We average the $M \times N$ pixels and narrow it to be a pixel. Then an $M \times N$ matrix is become an $I \times J$ matrix.

We segment character in a binary image, but what we get is a color image. Then we need repeat the operation of graying and binarization.

Gray-scale map just has the information of intensity. A two-dimensional matrix could save a gray-scale map. In a color image, every pixel is represented by $RGB(r,g,b)$, while in a gray-scaled one is $RGB(r,r,r)$. The value of r , g , and b range

from 0 to 255, so the gray value is 256. Generally, the graying method is weighted average: consider the index's importance, we give r , g and b difference weight and make them equal the weighted average. That is:

$$r=g=b=(R*WR+G*WG+B*WB)/3 \quad (1)$$

where WR, WG, WB represent the weight of R, G, B . In our system we set them the empirical value 0.30, 0.59 and 0.11.



Fig. 3. The images of license plate

Our input, a color image is a three-dimensional array. Every dimensional represent one of the color value R, G, B . Every pixel multiply the empirical value in the two dimensional array. Then we sum the three arrays, and get a grayscale image.

The binarization means that we get a picture only have white and black. The algorithm is choosing a suitable threshold. When the pixel number is higher in the array of the gray image, we set it 1. Otherwise we set it 0. That is,

$$B = \begin{cases} 0, & L < \theta \\ 1, & L > \theta \end{cases} \quad 1.(2)$$

Where B is the pixel value, L is gray value, θ is the threshold.

The threshold is decided by

$$\theta = g_{\max} - (g_{\max} - g_{\min}) / 3 \quad (3)$$

where g_{\max} is the max gray value, g_{\min} is the min one. If the answer is not an integer, we should round it.

Comparison experiment results show that the cutting effect from a filtered binary image is better than one without filtered. So the next process is filter.

The mean filtering, whose window length can also be modified adaptively and pattern is selective, is used to remove the noises step by step. In fact, it is just a low pass filter.



Fig. 4. The license plate of binary image



Fig. 5. The images of license plate

After these processing, fig.3 became fig.4. As showed in the two figure, we should cut the edge before the segmentation. We have met three types of edge, that is continuous, jumping and none. As we have normalized the size, we can scan the jump times of the black and white to cut the edge. If the times

is upper than the threshold we set, we think it is edge and should cut it. Figure5 is the result after the processing. We can find the style is approximately all the same.

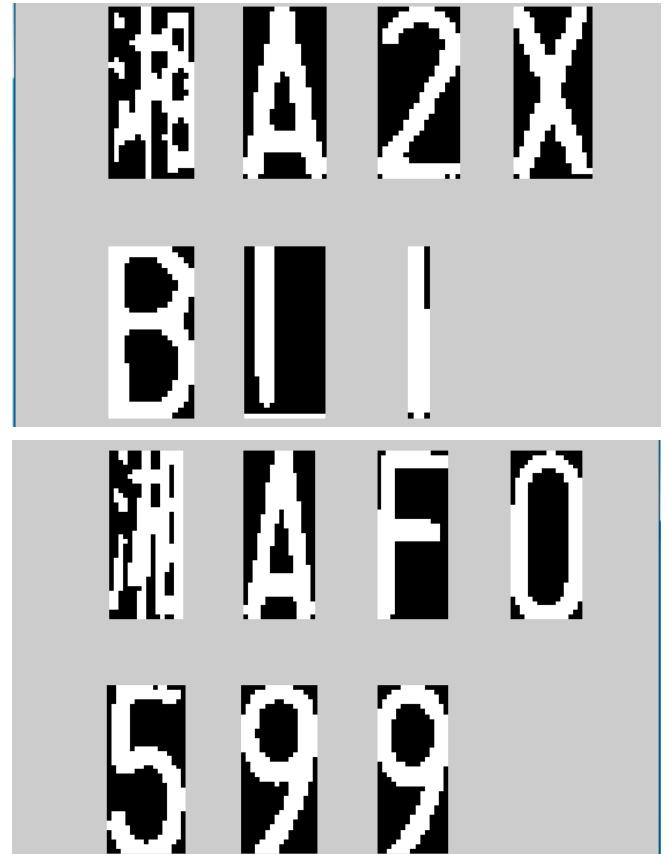


Fig. 6. Character blocks after segmentation

As the segmentation method is same, we package two subprograms “getword” and “cutting”.

“cutting” will erase a great quantity of background around the character. The program will remove unnecessary black background and prepare for “getword”.

The main idea of “cutting” is move from the edge to the central. When this row is all 0, we move to the next row. If not, mark the current position. Then we use the function imcrop crop the image with background.

In addition, the subprogram “cutting” is embedded into the program “getword”.

IV. CHARACTER RECOGNITION

We use template matching to recognize character. There are two algorithm to be considered. One is matching both foreground and background. The other is calculating the related coefficient.

The first method is resize the character block to the same size with template P and match the foreground. That is,

$$S_k = \frac{\sum_{i=1}^I \sum_{j=1}^J X(i,j) P_k(i,j)}{\sum_{i=1}^I \sum_{j=1}^J P_k(i,j)} \quad (4)$$

Next we reversal the character and template and match the background. That is,

$$B_k = \frac{\sum_{i=1}^I \sum_{j=1}^J X'(i,j) P'_k(i,j)}{\sum_{i=1}^I \sum_{j=1}^J P'_k(i,j)} \quad (5)$$

With (4) and (5), we get the overall matching,

$$M_k = 1 - S_k - B_k \quad (6)$$

If M_k is smaller, the probability of X is plate k is higher.

The second method is calculate the related coefficient R ,

$$R = \frac{\sum_{m=1}^M \sum_{n=1}^N S(m,n) \times T(m,n)}{\sqrt{\sum_{m=1}^M \sum_{n=1}^N [S(m,n)]^2} \sqrt{\sum_{m=1}^M \sum_{n=1}^N [T(m,n)]^2}} \quad (7)$$

where M, N represent the image size, S represents the image, T represents the template, m and n represent the current position of S and T , R represents the related coefficient. The larger R is, the more similar the two character blocks.

Consider experiment result, we adopt the second method.

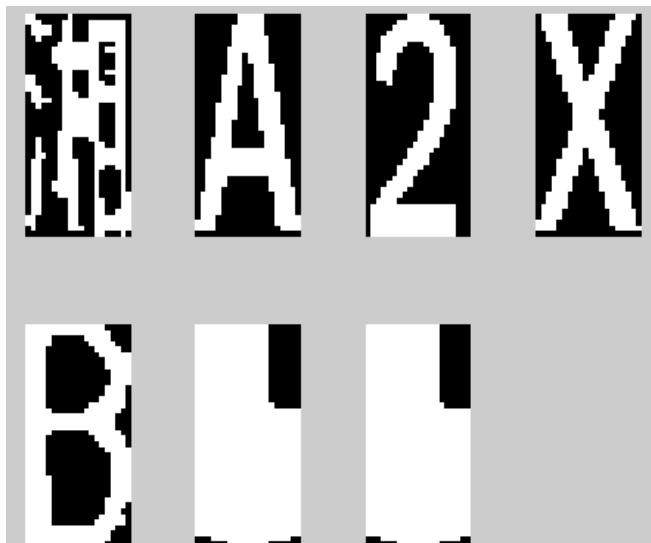


Fig. 7. Character recognition

Figure 7 is the result of the recognition. Here, the character blocks are from the template. So the output is irregular. But in the system, the output is text.

V. ANALYSIS AND CONCLUSIONS

One of our system's feature is we just use images to recognize character compared with other systems. So we also have some limits. The license plate in the image must be blue background and white character. Also the image should uniform illuminance, at least in the object region.

To improve the accuracy rate, we can large the plate area in the image. This could decrease the difficulty of location, increase the pixel number of the plate and the related coefficient.

To test the performance, we collect 30 images around the teaching building and download 100 images included only a vehicle.

Table.1 SYSTEM PERFORMANCE

The number of accurate location	The number of accurate segmentation	The number of accurate recognition
97	73	64

From table 1, we can find the accurate rate of segmentation and location is well. The number is 73 and 64 from 97 images. In addition, the recognition could be higher as we larger the template library.

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