Chinese Character Recognition Based on Character Reconstruction*

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***Abstract*—A completely new and effective algorithm for Chinese character recognition is proposed in this paper. The recognition is based on character reconstruction. And then we can obtain a new normalized character. Through character reconstruction we can reduce the error brought by the blur and the tilt of the original image. We first obtain the structure information of the original character and then we reconstruct a new character according to our rules. The structure information includes the information of the horizontal lines, the vertical line, the bias lines and dot. Then we compare the sample character and the template character and obtain the recognition result. A large number of experiments prove the robustness and high performance of the algorithm. The recognition rate of this algorithm is 96%. It can bear image's blur and tilt.**

I. INTRODUCTION

CAR license plate recognition is the key technique of intelligent traffic system. Plate recognition is widely used in traffic control, in parking lot management, in automobile surveillance. To recognize the plate license, there are several steps: you first should extract the plate from the complex background. Second transfer the image from RGB to gray and segment each character from the plate. And transfer the image from gray to binary image and then recognize each character. So recognition is the final step and it is also the most important step. Plate characters are varied from countries to countries, and number and letter characters are the most widely used. Number and letter characters can be easily recognized for the reason that they are simple. There are a large number of papers discussing about it while there are few papers discussing about the recognition of the Chinese characters appearing in Chinese license plate. In this paper we care about the Chinese character recognition. This paper proposes a completely new method to recognize them. We first get the segmented character normalized. And we compare the distance between the sample image and the template image. Of course both the sample image and the template image are the reconstructed character. Then we choose the first six characters which have the smallest distance with the sample image, and then we consider the structure information between the sample character and the chose template characters. The template which has the most similar character structure with the sample character is the final recognition result.

This paper is organized as follow. In section II, the method of obtaining isolated character is presented. The algorithm of recognition is discussed in details in section III. The result of this experiment is presented in section IV. Section V is conclusion..

II. OBTAIN ISOLATED CHARACTERS

A. Extracting Plate License

There are several ways to extract license plate from the original image [1]-[2]. Some are based on gray image and some are based on RGB image. In our algorithm we choose the method described in [1].This algorithm is based on the color space. For Chinese car plate license only have six collocations of plate's background and character. We first find the candidate location of the plate using color information and then exclude some candidate using plate's structure and texture. Then we obtain license plate and rectify it using Hough Transform. And we convert it to gray image using formula (1).

$$Gray = 0.212 * R + 0.715 * G + 0.072 * B \quad (1)$$

B. Segmentation Of The License Plate

When we get the license plate in gray, we use the method described in [3] to segment the image. Firstly, we set the standard value of the height and width of a character according to the license plate obtained. Secondly we stretch the image and use Laplacian Transform to look for character edges. Finally region growing can merge every character together and the Boundary Rectangle of the merged area with standard value of height and width is the character area. And then we can resize the isolated characters to 32*16.

C. Binarization Of The Characters

There are many methods to transfer the gray character to binary character. Some are based on self-adapt threshold, some are based on Ostu. In this algorithm we use the algorithm mentioned in [4].

III. RECOGNITION OF THE CHINESE CHARACTER

Now there are many way to recognize character [5]-[10]. To Chinese character, most scholars use SVM or BP network. They let it find character's feature by itself and get the appropriate separate line. And some scholars draw the character's features including line number information and line place information and recognize the sample character. In [8], it employs SVM to recognize both the number character

978-1-4244-4888-3/09/$25.00 ©2009 IEEE

and Chinese character. If the sample image is blurring, the result can not be so ideal. And if the image is tilt, the object pixel is not at its original place or the line width is not the same among the training set, so the predict result will not be so accurate. In our algorithm, firstly we reshape the image object to 32*16. And then we scan the whole image and get the character's structure information including the information of the horizontal lines, the vertical line, the bias line and the dot. We get their place and length and width. And now we can reconstruct the character according to the original character structure information and our rules. Finally we can recognize the sample using the reconstructed character and the reconstructed template character. During this process we have two steps. First we compare the distance between the reconstructed sample character and the reconstructed template character and choose the first six template characters with the smallest distance. And then we use some structure information to get the final recognition result.

A. Extract The Boundary Rectangle Of The Object And Resize It

The object is not always occupy the whole image, some are in the upper part of the image, some are in the lower part of the image and some are in the middle. To make the line place information more accurate and accordant, we extract the contour of the image object and resize it to 32*16. Thus we can eliminate the error cased by different size of objects to some extent. We scan the image row by row and then can obtain the first row index of non zeros and the last row index of non zeros. This row indexes are the contour's upper limit and lower limit. When we scan the image along the column using the same method, we can get the contour's left limit and right limit. Then we resize this rectangle to 32*16 using bilinear interpolation.

B. Drawing Character's Structure Information

When we have processed the image according to step 1, then we can say the image object occupy the whole image. So we can diminish error to some extent.

There are four kinds of structure information we will draw. First we must know the character's structure. There are four kinds of character structure in Chinese: up-down structure, left-right structure, and the whole structure and half-encircled structure. But we suppose Chinese character has the first three kinds of structure. The second structure information is the information of the horizontal lines and vertical lines. The third structure information is the information of the bias lines. And the fourth structure information is the information of the dot. In our algorithm, we adopt a simple way to decide character's structure. We scan the image and get the longest horizontal line and the longest vertical line. The character's structure is decided as formula (2).

$$structure=\begin{cases} up-down & if: l1/c>0.8 \,\&\, l2/r<0.8 \\ left-right & if: l2/r>0.8 \,\&\, l1/c<0.8 \\ whole & if: l1/c>0.8 \,\&\, l2/r>0.8 \end{cases} \quad (2)$$

In the formula, l1 is the length of the longest horizontal line, l2 is the length of the longest vertical, c is the column number of the image and r is the row number of the image.

Here we label the image first using 4-connection and dispose the area one by one. We first decide whether the area is a dot. If the length and the width of the area are similar and they are less than a threshold which is set at 5 pixels and the distance of them is less than a threshold which is set at 3 pixels then we believe it is a dot and we record their information. If an area is a dot then we continue to scan the next area and record our structure information. If the area has no dot then we continue to search for horizontal line and vertical line.

Now we began to scan the area to get our line information. Searching for horizontal line and vertical line has the same algorithm. For the reason that some image is tilt and so the horizontal line is not so horizontal and the vertical line is not so vertical, so when searching for the lines we must take it into consideration. And for the reason of binaryzation, some pixels in the line have value of 0, and the algorithm must tackle it. We suppose that the line length is the number that have longest continuous pixel with value one. And if the line length we obtained is less than a threshold which is decided by the actual image and then we believe it should be noises or part of a vertical line. When searching for horizontal line we discard it. When we count one continuous pixels length we use algorithm as follow:

$$\begin{aligned} &continuoun\quad umber\quad = continuous\quad number\quad + 1 \\ &if\ : image\ (i, j) = 1\ \&\ image\ ((i+m), (j+1)) = 1 \end{aligned} \quad (3)$$

Here we suppose we reach pixel image(i, j) and its pixel value is one and when we search for the next pixel we will take pixel image((i+m),(j+1)) into consideration. Here m is a measure of tilt angle. It is determined by your image. We measure image's tilt angle by pixel number. When the line is completely horizontal its tilt angle is 0 pixel. If your image's tilt angle is 0 pixel then we give m value 0. The value of m is in proportion to image's tilt angle. In our algorithm the value of m is 1. And finally we can obtain the information of the line including the row index, the column index, the length, and the width.

To obtain the information of the bias line, we scan the whole image. We first look for a seed. If we search for left bias line, the seed should satisfy the condition that its pixel value is 1 and its left pixel has value of 0. And we continue to search left bias line at the direction of -135 degree. We can search for our right bias line using the same method.

C. Reconstruct Characters

So far we have got all the information we wanted. The following thing we will do is to reconstruct our character.

According to our statistics, we suppose the width of the horizontal line and the vertical line is 2 pixels. If the width of one line is more than 5 pixels, then we believe two or more line is stuck each other. Then we divided them into two or more lines base on rules that the width of line is 2 pixels and the interval of adjacent lines is 2 pixels. And most of the characters have no more than five horizontal lines and four vertical lines. So we suppose all of the characters have no more than five horizontal lines and four vertical lines. And both the horizontal line and the vertical line are located in the permanent place. To our image of 32*16, we suppose all horizontal lines are located in row 3, row 11, row 16, row 23 and row 28 while all vertical lines are located in column 3, column 8, column 12, and column 15. If one horizontal line is not in the extra row then we suppose it is cause by image preprocessing or noises. And we will adjust the row place of the line to the nearest horizontal line's place determined by our hypothesis. We suppose the beginning and the ending of one horizontal line are at one vertical line's column place. If the beginning or ending column index of one horizontal line is not at the given column, then we will also adjust them to the nearest vertical line's column place determined by our hypothesis. Thus we complete the reconstruction of horizontal line. We can reconstruct vertical line using the same method.

Now we will reconstruct the dot and the bias line. According to our dot information, we know the place of the dot. We may obtain many dots, but some of the dots may be noises. So we must tell them. We can do this from the statistics of dot place. If the place of the dot may exist a dot, then we consider the dot as part of the character otherwise we consider it as noises. Then we reconstruct the dot at the extra place with permanent size. With the same method we can reconstruct bias line. But when we reconstruct the bias line we reconstruct the bias line as a horizontal line. So we can reduce error caused by the fact that some horizontal line may be judged as a bias line.

And now we finish reconstructing one character. Fig. 1. is parts of characters of the original templates and their reconstruct characters.

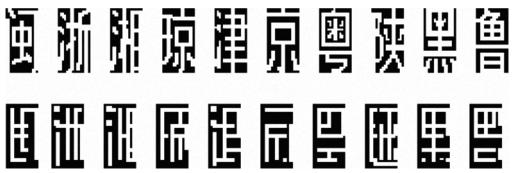

Fig. 1 Part of templates and their reconstructed characters

D. Recognize The Sample

Now we employ template matching to recognize sample character. Both the template character and the sample character are the reconstructed character. So they are more standard, and the error caused by image tilt, image noises, and some other causes is reduced, however, the reconstruct character can not replace the original character for the reason that they loss some information in standardization. We will recognize our sample character through two steps. Firstly we transform the character matrix into vector along column, and then calculate the Euclidean distance between the sample vector and the template vector and get the six candidates that own the minimal distance. Secondly we use the structure information to get the final recognition. We will describe how we use the structure information to obtain the final recognition result in details.

Although the reconstruct characters are more standard, they loss part of information. So the result obtained through vector matching of reconstruct character is not so reliable, but the correct result is always in the first six candidates. So we choose the first six candidates to carry out our second recognition. We dispose them as follow: we compare the structure information between the sample and the template, and the template which own the most similar structure information are our recognition result

IV. Experiment Results

In our experiment, we use real 24-bit 800*600 color images captured at varied background including parking lot and freeway and some other places. According to the Standard for Vehicle License Plate in the People's Republic of china, there are about 60 Chinese characters and 34 character of the abbreviation of province. In our experiment, we recognize the 34 character. We employ 800 numeric and alphabetic images. In following table, we compare our method with SVM method mentioned in [8]. The traditional template matching result is reported in [9].

TABLE I Accuracy Comparison

Methods	Character
SVM	95.7%
Traditional template matching	92.7%
Our method	96%

Fig. 2. Parts of sample characters

From the table we can conclude that our algorithm have slightly advantage over SVM method and is better than traditional template matching method. Our algorithm recognizes character through structure information so our algorithm can recognize it only if the character's structure is complete. Our algorithm can tolerate the adherence of the image and can tolerate the tilt of the image. So on the whole our algorithm has advantage. Figure 2 the part of our test sample image.

V. CONCLUSIONS

In this paper we present a complete new method to recognize the Chinese character in License plate. Our recognition is based on Chinese character reconstruction. And we use the reconstructed character and its structure information to obtain recognition result. The algorithm performs well on recognizing character which has complete structure. And our algorithm can tolerate the adherence of the image and the tilt of the image. Our algorithm perform well on robustness.

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