A Chinese License Plate Recognition System

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Abstract : As one of the hot issues of studying in the field of modern traffic engineering, the license plate recognition (LPR) has attracted more and more attention. In this paper, an experimental system for the LRP of China-style license plates is presented. The proposed system consists of four phases: license plate location, which is based on colour character and vein character to locate the plate; image pre-processing, which is included gray processing, binary processing and **wiping off** the side frame and the Upper and Lower rivets of license plate; character segmentation, which is based on the improved horizontal projection; and character recognition, which is proposed to use artificial neural networks for recognizing of' license plate characters. This system is effective for solving the problems which are Chinese character unconnected, cement of the character, illumination variance, interference of the noise and space mark. From the results of experiment, we can see the proposed approach is robust. Yet there are still some images failed to detect in the experiment (especially skew images). We will improve the performance of the algorithm through skew correction of license plate further.

Key-Words: License plate recognition, License plate location, Character segmentation, Character recognition, Artificial neural network.

1. Introduction

License plate recognition(LPR) system plays an important role in traffic surveillance systems, such as traffic law enforcement[1], real-time monitoring and parking systems [2]，road monitoring and security systems. Recognizing the license plate of a vehicle from a natural image is a complicated process that involves the detection of the license plate and recognition of character on the plate. Many techniques have already been suggested as in [3,4]. However, these systems are very viable in developing China LPR. In this paper, an experimental system for the LRP of China-style license plates, which is based on colour character and vein character to locate the plate, is presented. The proposed system consists of four phases, license plate location, image pre-processing, character segmentation and character recognition, whose functions are briefly described as following:

- License plate location.

This phase extracts license plate candidate regions from a complex scene. We adopted the license plate location method, which is based on colour character and vein character. At first, coloured picture is changed from RGB space into HSI space. The thick location of the license plate has realized by using the character of blue colour degree and value of saturation degree. Finally, according to the character of license plate

image's high-frequency of changing black-and-whitely, we realized the accurate location of the license plate.

- Image pre-processing.

The pictures of license plates are generally colourful. If the colourful pictures are processed directly, it will lower the processing speed of system. Therefore, the colourful information of license plates should be processed to obtain greyscale pictures. In fact, because the side frame and the Upper and Lower rivets of license plate will interfere with the recognition of license plate, we will remove the side frame and the Upper and Lower rivets.

- Character segmentation.

Segmentation was carried out using the improved horizontal projection, then the segmented characters are scaled. This method is effective on solving the problems which are Chinese character unconnected, cement of the character, interference of the noise, space mark and illumination variance.

- Character recognition.

The improved BP neural network is proposed to use recognition of' license plate characters. The training vector of neural network consists of 256 elements. It can be created by vectors of image rows of the license plate characters in binary format.

The rest of this paper is organized as following: section 2 discusses the system architecture and explains each step in details; section 3 shows the experimental results and has a conclusion remarks on the work.

2. System Implementation

2.1 License plate Location

2.1.1 Revise the color model of plate regions

We adopt the license plate location method, which is based on colour character and vein character. In order to extract the license plate from the image, the main characteristic of the license plate should be seized accurately. A pixel of 24-bit BMP images takes three bytes in memory, which contents red, green, blue color information. The image we get from common computers is described using RGB model. In this model, we use the value of red, green and blue to denote each one color. This model is affected by illumination. So we translate RGB model into HSI model to get plate color information under the condition of various illumination .The color pictures of HSI model are described using Hue, Saturation and Intensity. The hue denotes the attribute of every pure color. The saturation is measurement of the degree which a pure color is diluted by white light. The intensity denotes the value of image gray scale [5]. RGB model translated to HSI model as follow:

$$I = \frac{1}{3}(R+G+B) \quad , \qquad (1)$$

$$S = 1 - \frac{3}{R+G+B}[\min(R,G,B)], \qquad (2)$$

$$\theta = \arccos\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-G)(G-B)]^{1/2}}\right\}, \qquad (3)$$

where $\theta \in [0,2\pi)$, $S \in [0,1]$, $I \in [0,255]$. If $B \le G$, $H = \theta$; if $B > G$, $H = 360° - \theta$. Blue degree is about 240°and S value of saturation degree is bigger.

According to the characteristic we can rough locate the license plate in the license plate of blue plate and white characters. We give an example in blue car and blue plate and white characteristic

showed in Fig. 2.1. Fig. 2.1 is a RGB image. First we translate RGB image into HSI image. Then we filter blue range of the car by taking into account the values of H and S. The result is showed in Fig. 2.2.

Fig. 2.1：Original image

Fig. 2.2：the filtered image

2.1.2 Accurate location of license plate

The texture of license plate is mainly contour of plate characters. Obviously an edge is composed by a set of conjoint pixels, which lie on the region of gray scales break. So we usually use the derivatives to detect the edge pixels in the image. Actually there are a lot of the methods of edge detection. Here we use Canny filter to process [5]. The edge image of Fig.2.2 is shown in Fig 2.3 after Canny operator filtering.

Fig. 2.3 Edge image of Canny operator filtering

The image of Canny operator filtering is the binaries image. According to Fig. 2.3 we can see that the plate regions have more edge information than other regions on the image. It is owing to the great contrast of characters and plate. And the plate region characters arrange in a certain interval level. The characters have a certain width. The colors of characters and plate are comparatively single. So we can use these characteristics to locating the plate regions by line scaning algorithm. The line scanning algorithm as followig:

1. Scanning every horizontal lines of the image;
2. Getting the value of changing times between white and black pixel every line;
3. Up and down Scanning from the line that the change value of pixel is more than other lines.
4. If the change times of white pixel and black pixel is less than a threshold, we will stop scanning. The upper and lower horizontal lines of stopping scanning are upper and lower borders of the plate license.

The results of horizontal line scan are shown in Fig. 2.4 and Fig. 2.5:

Fig 2.4 the binary **image of up and down location**

Fig 2.5 the color **image of upper and lower location**

Similarly, we scan every vertical line of the image showed in Fig 2.4. By using same method, we can get the left and right borders of the plate license. The results of accurate location are shown in Fig. 2.6 and Fig. 2.7.

Fig. 2.6 **he** binary edge detecting image of accurate location

Fig. 2.7 the color image of accurate location

It can be seen from Fig. 2.7 that the effect of plate location is satisfactory, although color of car and plate is same.

2.2 Image pre-processing:

2.2.1. Gray processing

Because colourful pictures contained thousands of bits information, when the colourful pictures are processed directly, the execution speed of processing system decrease. Therefore, colourful information of the located plate pictures should be processed to obtain greyscale pictures.

A pixel of 24-bit BMP images takes three bytes in memory, which content red, green, blue color information. We denote red, green and blue with R, G and B. The grey value is showed by g. We can use following three formula to turn the images into gray images:

1. $g = \max(R, G, B)$ (4)
2. $g = \frac{R + G + B}{3}$ (5)
3. $g = \frac{0.3R + 0.59G + 0.11B}{3}$ (6)

Because eyes are more sensitive to green, the parameter of green is the maximum [6]. We will use this type of convention in this paper. The corresponding gray image of the color images Fig. 2.7 is shown in Fig. 2.8.

Fig 2.8 gray image of Fig. 2.7

2.2.2 Binary processing

From the image which has been processed by edge detection, we can see that the gray scale of the extracted edges is higher than the gray scale of other areas. In order to predigest the succeeding treatment, we usually binarize the images. The classical method of Otsu is common to adopt the simple algorithm of binarization in the location of the license plate. So we use the method of Otsu to obtain binary image. The corresponding binary image of the gray images Fig. 2.8 is shown in Fig. 2.9.

Fig. 2.9 binary image of Fig 2.8

2.2.3. Wiping off side frame and upper and lower rivets of the license plate

There are four rivets on upper and lower edge frames of the license plate. In fact, because side frame and upper and lower rivets of license plate interfere with recognition of license plate. In this phase we will remove the side frame and upper and lower rivets of the license plate. We can see that the change times of white and black pixel on edge frame are less than characters of license plate. According to this characteristic, we can wipe off the side frame and upper and lower rivets. Fig.

2.10 shows the modified image of Fig. 2.9 after wiping off the side frame and upper and lower rivets of license plate.

Fig 2.10 binary image wiped off the side frame and rivets

2.3 Character segmentation:

There are many factors that cause the character segmentation task difficultly, such as image noise, plate frame, rivets, space mark, and illumination variance. Our algorithm, the improved horizontal projection, overcomes the difficulties mentioned above. This method is effective on solving the problems, which are Chinese character unconnected, cement of the character, illumination variance, interference of the noise and space mark. In order to segment the individual characters, we project license plate images vertically using grey level values. Then we introduce the thresholds for segmentation.

The improved horizontal projection as following:

1. Scan the pre-processing image from left to right, and record the white pixel(the pixel of character is white);
2. On Chinese license plate, first letter is Chinese character. According to the feature of Chinese characters, we set two thresholds to segment first Chinese character. We scan the pre-processing image from left to right. When white pixel value of the first vertical line is more than first threshold, the vertical line is starting position of Chinese character, Then continuing scan, when white pixel value of the vertical line is less then first threshold, we compare the width between the two vertical lines with second threshold. If the width is less then second threshold, continuing scan until finding the vertical line that the width between two vertical lines is more then second threshold. Then the vertical line is end position of Chinese character. This method is effective on solving the unconnected problems of some Chinese characters.
3. Next seventh characters of license plate are English letters and numbers. There is not unconnected problem. So we just use first threshold to segment. When first Chinese character is segment, we continue scan. When white pixel value of the vertical line is more than first threshold, the vertical line is starting position of next letter. When white pixel value of next vertical line is less than first threshold, the vertical line is end position of the letter. And so forth, until all letters and number are segmented.

Two examples of segmentation are shown in Fig.2.11 and Fig. 2.12.

Fig.2.11 two original image of located plate

Fig. 2.12 segmented image of Fig. 2.11

Characters segmented from different car plates have different sizes. We use a linear normalization algorithm to adjusting the input image into a uniform size (in our implementation, 16×16 pixels).

2.4 Character recognition:

So far there are a number of techniques is used the recognition of license plates, such as vector quantization, template matching and neural network etc [7,8,9]. It is proposed to use artificial neural networks for recognizing of' license plate characters. In general, the BP algorithm includes the forward course and the backward course. The BP neural network contains inputs, neurons of the hidden layer and neurons of output layer. The outputs of every intermediate layer are the inputs of the next layer. The images of characters (16x16 pixels) form the training set of neural network. The BP neural network is used for character recognition. The training vector of neural network consists of 256 elements. It can be created by vectors of image rows of the license plate characters in binary format. The algorithm can be fond in reference [10].

3. Experimental Result and Conclusion

The system is implemented with MATLAB. The implementation process are shown in Fig.3.1, Fig. 3.2 , Fig. 3.3 and Fig. 3.4. In the paper, 260 images are employed for experiment. All of them were taken by CCD camera from various scenes and under different conditions of the real world, including diverse angles, different lightening conditions. The results show that the average speed is 3ms time-consuming for a license plate. The success detection rate of characters is up to 76%. Because of character recognitions are generally very sensitive to skew plate.Therefore, skew detection affect recognition rate of license plate. If the images of license plate employed experiment do not have skew, the recognition rate will greatly be improved. From the result of the experiment, we can see the proposed approach is robust. Yet there are still some images failed to detect in the experiment (especially skew images). We will improve the performance of the algorithm through skew correction of license plate further.

Fig.3.1 Location result of license plate

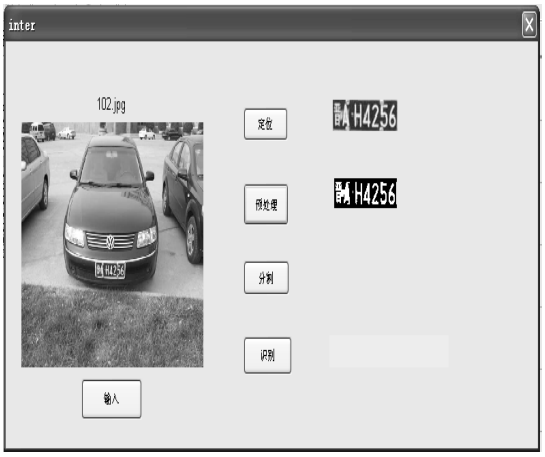

Fig. 3.2 Pre-processing result of license plate

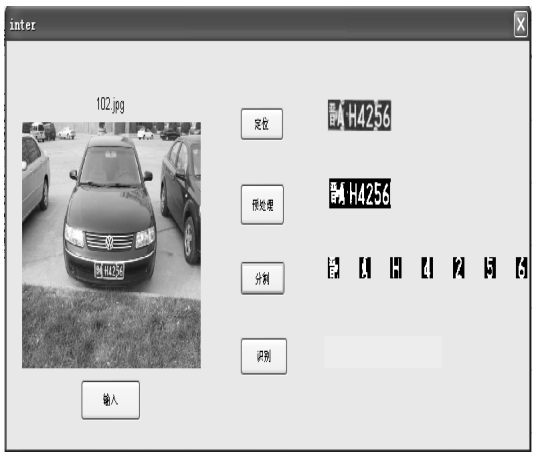

Fig. 3.3 Character segmentation result

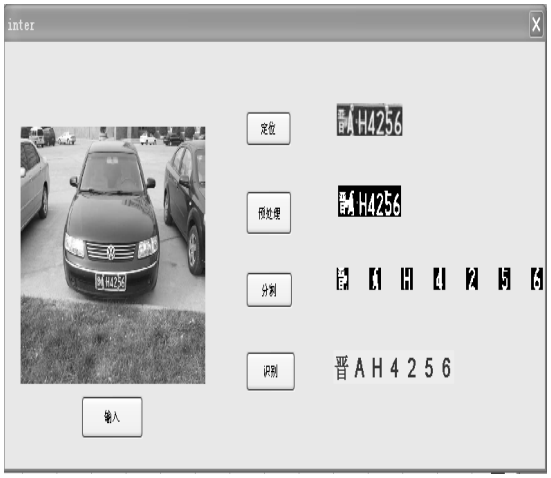

Fig. 3.4 Character recognition result

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