A License plate recognition system based on HSV space in natural lighting

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Abstract. In recent years, with the development of modern traffic demand, the automobile license plate recognition technology has obtained more and more attentions. In this paper, the license plate in the vehicle image is located by extracting the color feature in HSV color space. And after binarizing the license plate image, the vertical scanning procedure is used to segment the license plate characters, and the template matching procedure are used to recognize the characters according to the similar degrees. Experimental results show that the system designed in this paper can effectively recognize the license plate in natural lighting, with the accuracy up to 95% for the Chinese characters, 90.4% for the numbers, 84.4% for the letters, and the time consumption being second level.

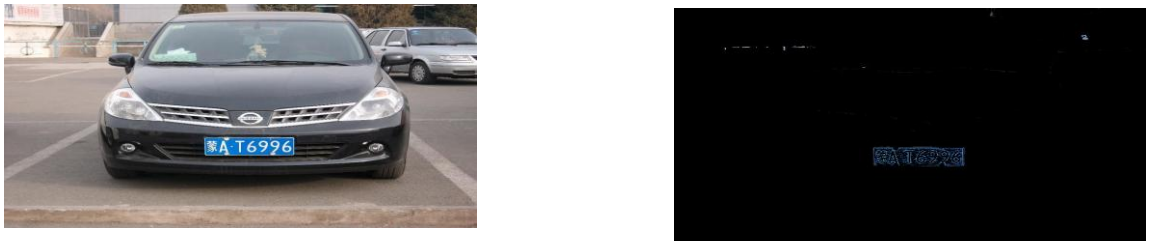
1. Introduction

License Plate Recognition (LPR) is important and fundamental in Intelligent Transportation System (ITS). It's the integrated application of several disciplines such as Computer Vision, Image Processing, Neural network [1]. And furthermore, the positioning accuracy of the LPR, smart characters segmentation and precise characters recognition are three main issues [2]. In recent years, many LPR methods have been developed, including the textures-based approach for license plate location presented by Guo and Shi [3]. Later, Hongliang and Changping proposed a location method based on edge statistics and morphology [4]. In [5], Chen and Luo proposed an improved prewitt arithmetic operator to locate the license plate edge. However, the backgrounds of license plates in practice are relatively complicated, especially, for Chinese characters recognition, and these methods based on edge to locate the plate are limited. In the license plate segmentation, the connected domain method and template matching were chosen [6], and in literature [7], Ye etc. proposed a configurable method for multi-style license plate recognition, however, their time consumptions were also costly. In this paper, a license plate recognition system based on HSV space in natural lighting are designed, in which the color feature is extracted to position the plate area in HSV space, and for reducing the time consumption of the characters segmentation, a vertical projection procedure is used to divide the characters of the plate, and then the template matching is used to recognize the characters composed of Chinese characters, letters and numbers.

2. License plate location in HSV space

2.1 Feature extraction of license plate in HSV space

The RGB model is widely used in electronic devices and image processing. The shortcoming of RGB is that its three components have high relativity. The other way round, the color information of the license plate can be easily confirmed in HSV space by its hue. And this is important for the LPR because of most of the license plate are blue background. However, the color information of the license plate can not be extracted by Hue alone due to the complex of illumination variations. For most blue license plate, the Hue vector varies from 100 to 250, and the Saturation vector from 100 to 360, and the Value vector from 50 to 360. And the blue area in the license plate image can be extracted according to the combination of the Hue, Saturation and Value of the license plate in natural lighting, the result processed shown as in Fig.1.(b).



a) The original vehicle image b) After extraction color feature

Fig.1 The color feature extraction of the license plate in natural lighting

2.2 License plate area location

As shown in Fig.1.(b), the image containing the license plate has many isolated noises after locating it using the color feature in HSV space. The noise pixels can lower the accuracy of the license plate recognition. In this section, two steps have to be finished: firstly, eliminating the isolated noise pixels using the open operator; secondly, segmenting the license plate area from the binary vehicle image using the projection procedure, the result processed shown as in Fig.2.(b).

a) After removing the isolated noise pixels b) License plate area image c) Binary license plate area image

Fig. 2 The license plate area image after removing noises

The projection procedure to segment license plate area as follows:

1) Scan horizontally the pixels in Fig.2.(a), counting the non-black pixels in each scanning line, and record these numbers;
2) Using the histogram technique to confirm the top and bottom boundaries of the license plate.
3) Scan vertically pixels in Fig.2.(a), counting the non-black pixels in each column scanning line, and record the numbers;
4) Using the histogram technique to confirm the left and right boundaries of the license plate.

3. Character Segmentation and normalization

The characters segmentation is an important stage in LPR, where the license plate image located is divided into several individual character images. Generally, there is a gap between characters.

Therefore, the vertical projection approach can be adopted to separate them in this paper, in which, the histogram technique is used to find the gaps between characters. The vertical projection algorithm:

1) Vertically scan the plate image processed Fig.2(c), and record the white pixels in each column scanned to find the maximum, and store it in Vmax.
2) Scan from left to right, the first value greater than Vmax/pixel is stored in PL.
3) Scan from PL to right, the first value lower than Vmax/pixel is stored in PR.
4) Extract the area between PR and PL in combination with the histogram technology, and store it as an individual character image.
5) Repeat steps 2)-4), until all character are separated, as shown in Fig.3.

During the process, there may be some disturbances regarded as characters. For example, some isolated noises, or boundaries in the image are unwanted, which must be eliminated before the character recognition. Therefore, the validity test procedure must be done after the completion of the characters division. According to the prior knowledge, the proportion of the character's Height and Width is a certain value when the distance between the camera of the system and the license plate is known. Therefore, the validity of the license plate characters is implemented:

1) Get the maximum height of all characters, denoted as Hmax, and the maximum width, denoted as Wmax.
2) Get the width (W) and high (H) for each character.
3) If H/W>scale (Experiments show that scale is 1.5 best), and H>0.7*Hmax, W>0.2*Wmax, and then, it is considered as a character image and save it, otherwise reject it.
4) Repeat 2) and 3) steps, until all the character image be checked.

Fig.3 The divided individual characters of the license plate

After the character division, the characters do not always accord with the each standard template. The characters normalization process is implemented to obtain the same size images with the standard templates. And in this system, the standard template resolution is (20*40), shown as in Fig.4 and Fig.5. There are 37 characters composed of some special Chinese characters, letters and numbers.

Fig.4 The Chinese characters in license plate

Fig.5 The numbers and letters in license plate

4. Characters Recognition

The license plate character recognition is also an important step in LPR system, and the last step of

the whole system. The characters matching with the standard template is adopted because there are only 37 different characters in all license plates. However, the template matching is poor in the similar characters recognition, such as character 8 and B, Q and D, I and 1, etc. In order to solve this problem, the template matching based on the region feature is used.

4.1 General Template Matching

The general template matching procedure was to match each character with the corresponding template. This procedure compares the similar degrees of the matching pairs, and the higher one can be confirmed as the right character recognized according to Eq. (1).

$$T(x_1 - x_2, y_1 - y_2) = \iint f(x,y)F(x+(x_1-x_2), y+(y_1-y_2))dxdy \tag{1}$$

In Eq. (1), f(x,y) is an input image function, and F(x,y) is a template function. The coordinate (x1,y1), (x2,y2) correspond to f(x,y) and F(x,y), respectively. When x1=x2, y1=y2, and f(x1,y1)=F(x2,y2), we can conclude the two point are same. In practice, the similar degree C_i, shown as in Eq. (2) [8], and threshold λ_i are introduced to overcome the effect factors such as illumination, noises, etc.,

$$C_i = \frac{\sum_{a=1}^{A}\sum_{b=1}^{B}(Y \times T_i)}{\sum_{a=1}^{A}\sum_{b=1}^{B} T_i} \tag{2}$$

In Eq. (2), Y is the individual license plate character image, Ti is the template，and they are all the same size, A*B. When $C_i \geq \lambda_i$ (In this paper, $\lambda_i \approx 65$), the ith template is confirmed as the right one recognized.

4.2 Template Matching based character region feature

The general Template Matching is poor in complex backgrounds, especially, for these approximate characters above mentioned. In this section, the feature-region-based template matching (FRTM) is adopted to improve the accuracy of the general template matching by using the character region differences in the image.

The individual character images are grouped into two groups according to the similar degrees obtained by the general template matching, and those which hold of the high similar degrees are confirmed as the right characters recognized, the rest are further processed using the FRTM. The specific steps as follows:

1) Place the character images into the Cartesian coordinates;
2) Compare the part in each quadrant with the template;
3) Count the character pixels in the corresponding quadrant for the character image or template image.

For example, while recognizing the B with 8 template, the quadrant 2,3 should be selected as the feature regions, shown as in Eq.(3) [8].

$$\tau_k = \sum_{i=1}^{n}\sum_{j=1}^{m}\frac{f_I(i,j)T_{I,K}(i,j)}{\Delta T_K} \tag{3}$$

In Eq.(3), $f_I(i,j), T_{I,K}(i,j)$ correspond to input image function, template function, respectively, in which, I is the feature region, K is the template, (i, j) is pixel coordinate. And if the pixel is target point, record "1", otherwise, record"0". ΔT_K is the 1's numbers in template K, τ_k is the new similar degree. And if the similar degree of the template is equal to τ_k, the character is confirmed.

5. Experiment results and discussions

In this section, the experimental results demonstrate that the time consumption is small, and the accuracy of the license plate recognition is high using the system designed in this paper. The images of these license plates were taken randomly by using a general digital camera by hands, or copied from some Webs, up to 35 images. And the experiments were performed on the Intel CPU E8400 Processor with 3.0GHZ and 2GRAM. The operating system is MS-Windows XP and the programming environment is Matlab 7.6.

As shown in Fig.6, the results of the license plate location, characters division and characters recognition were shown on the GUI of the system, respectively, as well as their time consumptions. In addition, the effective license plate division from vehicle images improves the accuracy of the system, some easily confused characters such as D-0, B-8, 2-Z, 5-S, 1-L can be identified easily through using FRTM and the general template matching. The accuracy of the system is up to 95% for the Chinese characters, 90.4% for the numbers, 84.4% for the letters, with the time consumption being second level. However, some characters recognition rate is not high due to the great skewed license plates in the vehicle images. Further research needs to improve the system in correcting the license plate.

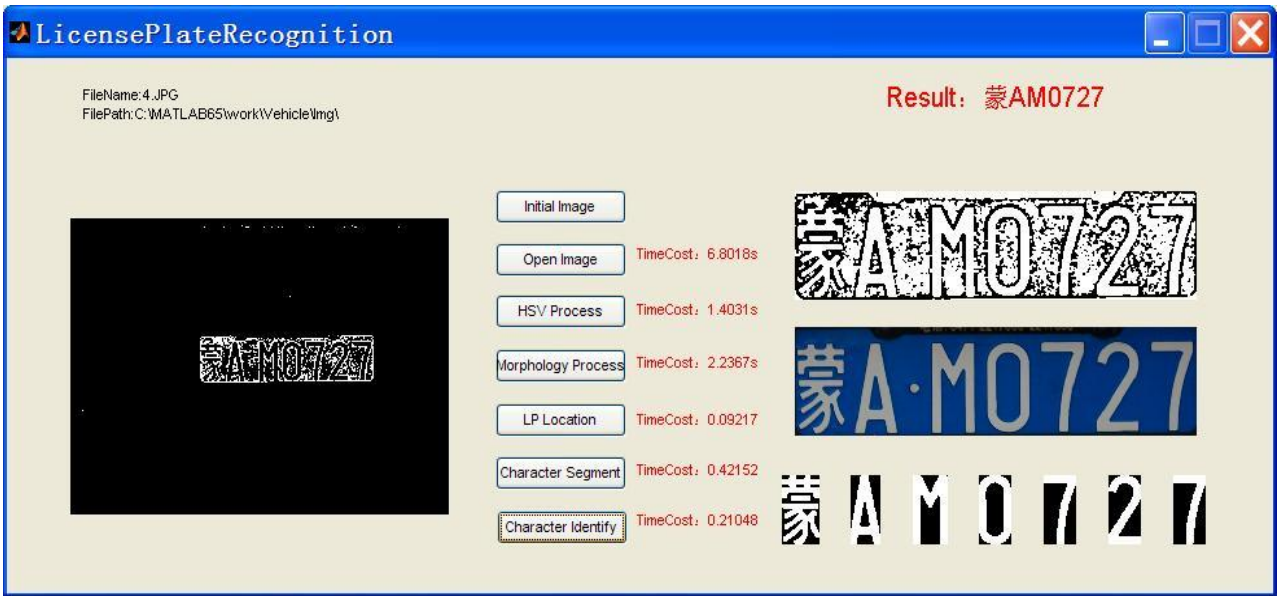


Fig.6 The recognition result of the LPR

6. Conclusions and Future work

HSV color space was used to locate LPR to improve its location accuracy. And the vertical and horizontal projection procedure could ensure the validity of the license plate region. The general template matching and FRTM were used to improve the accuracy of the characters recognition. Based on the images taken in natural lighting, the experimental results demonstrate that the system designed can improve the accuracy and reduce the time consumption, with the accuracy of recognition up to 95% for Chinese characters, 90.4% for the numbers, 84.4% for the letters, the time consumption being second level. In the future, we will process the license plate images grasped at different angles to improve the suitability of the system.

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