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Visualization of License Plate Recognition System

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Abstract

The image of the license plate is located and segmented by some digital-image processing technologies such as gray-scale processing, gray-scale stretching and filtering, edge detection, morphological processing, Hough transformation etc. According to the characteristics of the license plate, binary matrix of character image sets the fuzzy matrix, and based on the principle of proximity computing space of closeness to get the fuzzy pattern recognition of characters. On the basis of the data of image pixels, the samples which are randomly selected under noisy condition and which are treated by morphological processing are randomly selected, and then the samples are used to test the simulation and identification of Back Propagation (BP) Neural Networks. With the mathematical software-Matlab programming, the license plates are recognized. The aim is to develop the Visualization of user interface in License Plate Recognition System.

Keywords: *license plate recognition, image processing, fuzzy pattern recognition, BP neural network, GUI*

1. Introduction

License plate recognition system is a special computer vision system which takes license plate for a specific target, is the usage of computer vision and pattern Recognition technology in the field of Intelligent transportation, License Plate Recognition System is one of the most important part of Intelligent Transport System, ITS, as a research hotspot in the field of modern transportation, it plays an important role in the management of turban transportation, highway, and parking lot etc.

Automatic license plate recognition technology [1, 2] can be divided into: radio frequency identification technology, bar code recognition technology and vehicle license recognition technology. The former two techniques are accurate and reliable, but it still needs to install related devices and to establish background management in the vehicle license plate recognition system; License plate recognition system is based on video technology hardware so that you can identify and monitor the vehicle directly.

At the beginning of the 1980s, foreign researchers had wide concern about the license plate recognition technology. In the 1990s, along with the development of computer vision technology and improvement of the computer performance, license plate recognition system has been systematically researched. However, the system can not recognize the Chinese characters in the Chinese license plate. At present, there are some more mature products to solve the issue of recognizing Chinese characters in China such as HW eye-the Chinese Academy of Sciences Institute of Automation HW company, Huiguang plate number automatic identification system-ASIA Vision Technology Ltd., some relevant recognition products developed by Shenzhen Ke An Xing Industrial Company Limited and the Sino-Chilean traffic Electronics Company Limited under the ministry of China Information industry. In addition, some University Departments' laboratories, such as artificial-intelligence State Key Laboratory of Tsinghua University, Shanghai Jiao Tong University computer science and Engineering Department, the Department of automation of Zhejiang University, have devoted the scientific research strength into recognition technology area. What's more, Zhiyong Liu, who is from the Automation Institute of Chinese Academy of Sciences, has also published related articles, and Aiming Hu, one of the researchers from Beihang University, developed a license plate recognition system on the basis of the template matching technique, and this system can be applied in the toll stations.

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The standard-small cars have a wide range of users in China so the aims of this article are to research the license plate recognition system in Chinese standard-small car, to realize the image of license plate location cutting, and then to identify the character by fuzzy model and neural network selective concurrent operations. Other types of cars can also choose recognition database in accordance with the license plate features and specifications, to complete license plate recognition.

2. Summary of License Plate Recognition System

2.1. Chinese License Plate Features and Specifications

In China, the license plates of standard-small cars are white letters on blue, 440mm in width and 140mm in length, Ratio between the width and the height is about 3.14:1. There are seven characters in the license plate. The first character is a Chinese character standing for the Abbreviation of all provinces and municipalities; the second character is one of the 24 capital letters except the letter "I" and "O", which represents the code name of the issuing authority. Those letters, from the third letter to the seventh, consist of 24 English letters and numbers. Each character in License plate is centered in a width of 45mm and 90mm in height rectangular range. The space between two characters is 12mm. There is 10mm interval symbol "●" between the second and the third character, so the actual interval is 22mm. The general style is "某A·12345".

2.2. The Composition of License Plate Recognition System

License plate recognition system is based on video image acquisition technology, and the system is using computer technology to search and judge vehicle license plate. The three main parts of this recognition system are license plate image location, license plate character segmentation and license plate character recognition.

Figure 7 shows the system makes the license plate location cutting on the image for user to read. Figure 8 shows the system makes fuzzy pattern recognition on the cutting license plate character and display results. Figure 9 shows the system identification results based on user needs to save text as txt format, and provides three results for each character in accordance with the size of the possibility of fuzzy pattern recognition, for example, "E:\LPRS\Example1.jpg" is recognized to be the license plate by the fuzzy pattern. The first character is "苏豫吉"; the second character is "DQC"; the third character is "V97"; the fourth character is "0QD"; the fifth character is "086"; the sixth character is "085"; the seventh character is "172". Thus, the entire license plate is most likely to be "苏DV0001".

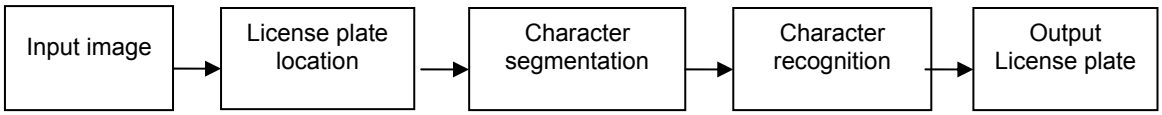

Figure 1. Flowchart of System Identification

3. Image Preprocessing

Image enhancement [3, 4] is one of the most basic methods of digital image preprocessing, which also becomes a quite valuable technology to be used. Image enhancement technology is often used to improve the gray level image quality, and to increase the ratio of signal and noise. This technology can make some features of the image be recognized easily.

3.1. Gray Image

Gray image is the basic step for the pretreatment of license plate images. The original image contains a large number of color information which occupies the storage space. Different illumination intensity results in recognition problems, so gray processing should be made for color images. In the gray processing, R, G, B are given different weight values ω_R, ω_G, ω_B.

The gray value is $I=(\omega_R \cdot R+\omega_G \cdot G+\omega_B \cdot B)/(\omega_R+\omega_G+\omega_B)$. In general, when $\omega_R=0.299$, $\omega_G=0.587$ and $\omega_B=0.114$, we can get the best gray image.

3.2. Gray Stretch

Gray stretch is a kind of image enhancement technology. The image gray value is mapped to the entire range of gray level by gray stretch transformation in order to increase the contrast of the image. Extending the range of gray level makes the character features more obvious [5-7] and it is more conducive to further processing. In the image which the pixel is $m \times n$, the histogram is $h(i)$. Gray stretch transformation functional formulation:

$$f(x)=\begin{cases}\dfrac{c}{a}x & x<a\\ \dfrac{d-c}{b-a}(x-a)+c & a\le x\le b\\ \dfrac{255-d}{255-b}(x-b)+d & x>b\end{cases} \quad (1)$$

Get a which satisfies the smallest positive integral of $\sum_{i=0}^{a} h(i) \ge \frac{mn}{10}$, and b values the largest positive integral of $\sum_{i=0}^{b} h(i) \le \frac{9}{10}mn$, and set the values of c and d.

3.3. Median Filtering

The outstanding merit of Median Filtering is that it can not only eliminate noise but also prevent blurred edges. Median Filtering is a kind of practical non-linear image smoothing method, and this method has a good effect on eliminating noise in processing license plate image.

The basic principle of the median filter is to substitute the average value of the various points in an area of the point for the value of point in digital sequence, that is to say, a_1, a_2, $\cdots$, a_n are in descending order $a_{i_1} \le a_{i_2} \le \cdots \le a_{i_n}$.

And let $b=med\{a_1,a_2,\cdots,a_n\}$, then b is the average value of sequence. Two-dimensional sequence $\{a_{ij}\}$ is the gray value of each image point. Window 2-d median filter is $b_i=med_A\{a_{i+s,j+r}|(s,r)\in A\}$.

4. License Plate Extraction

First of all, license plate location needs to make edge extraction for gray image by using Canny, and then eliminating noise through morphology processing, the two processes are to make the images form a connected area. According to the characters and specifications of license plate and photographic angle, given that the fast change of frequency is in edge graphics of the license plate, and selecting the length and width ratio and the size of the connected region at the same time, we extract license plate binary image.

4.1. Binary

OSTU threshold segmentation is a very classic automatic threshold segmentation algorithm. Its basic principle is that the histogram is divided into two groups from a certain threshold. When the variance between the two groups is the maximum then the corresponding threshold considered to be the best threshold. OSTU the threshold segmentation avoid some disadvantages such as long computation time, low efficiency, high cost. It is very effective way in solving single threshold segmentation of grayscale images. OSTU binary is based on OSTU threshold segmentation; it processes the image with accordance to optimal threshold limits.

4.2. Edge Detection

Edge detection takes advantage of edge enhancive operator to underline the edge of the part of the image. After the intensity of pixel edge is defined, the point set can be extracted

by the set limits. The common detection algorithms are Canny operator, Roberts operator, the LOG operator, Wallis operator, edge detection methods based on fractal theory etc. Based on Canny operator, the gradient and direction Angle of boundary are:

$$\nabla f = \sqrt{G_x + G_y}\ ,\ \phi(x,y) = \arctan\frac{G_y}{G_x},\ (G_x = \frac{\partial f}{\partial x}\ ,\ G_y = \frac{\partial f}{\partial y}\ ) \tag{2}$$

Canny operator is to seek local maximum value of the image gradient, so to smooth the image is necessary. Using 5×5 Gaussian filter and the Sigma parameter control the filter, and using two threshold segmentations enhances image segmentation. Canny method can better balance the edge detection and noise suppression. It is the most effective detection method provided by Matlab Image Processing Toolbox functions. It is based on the optimization algorithm and it is less susceptible to noise interference.

4.3. Mathematical Morphology Processing

Corrosion and inflation are two of the most fundamental operations in mathematical morphology [8]. They can be defined as:

$$A \otimes B = \{a | \forall a \in A, b \in B, b + a \in A\},\ A \oplus B = \{c | \forall a \in A, b \in B, c = a + b\} \tag{3}$$

The process of Corrosion before Inflation is called open operation, which can eliminate small objects. This process can also separate the boundary of object and can smooth objects in delicate places. The process of operation inflation before Corrosion is called closed operation that can fill a tiny hollow of the object. It not only can connect the adjacent objects but can smooth the boundary of the object, which enable the fracture of contour line to be made up.

5. License Plate Character Segmentation

5.1. Hough Transformation

After the license plate image is located, it sometimes has different degree of tilt phenomenon. In such case, it needs to make geometric correction on the plates by classical Hough transform. In the Hough, the curve or straight line with given shape in the original image space is converted into a point in the Hough space. Hough is to transform the detection problem of curve or straight line in the Original image space to the peak point of the transform space. Hough transform linear polar equation is expressed as $\rho = x\cos\theta + y\sin\theta$, $\theta = \arctan\frac{y}{x}$. (ρ,θ) refers to polar coordinates vector perpendicular to the line, ρ is the length of the vector, θ is the angle between the vector and the axis positive direction.

5.2. Vertical Projection Method

In fact, the quality of the original image, the camera angle, the effect of the Hough transform and other factors will cause a certain degree of influence on the divided character. In the image processing, the noise can not be completely eliminated. So it is more effective to detect the character position with vertical projection method.

After image preprocessing, license plate location and extraction, and rotation transformation, the image of license plate is treated by morphology processing. Then it needs to record the vertical projection of the value of the binary image column highlights in turn. According to the priori knowledge of the license plate area and projection methods, the license plate is scanned based on a certain threshold. After the previous process, we check the beginning and the end position of each character. The average of each character width is used to be the width of character and to reduce noise impact. Finally, the seven characters are got throng cutting from the start of the character to the end of the average width of the character.

6. License Plate Character Recognition

6.1. Character Template

This article takes a 24 x 48 JPG format character image as template ,then respectively set up Chinese characters (the color character image as shown in Figure 2), English letters (as shown in Figure 3), and the Arabic numeral (as shown in Figure 4) character database.

Figure 2. Chinese Characters

Figure 3. English Alphabetic Characters

Figure 4. Arabic Numeral Characters

6.2. Fuzzy Pattern Character Recognition

Fuzzy pattern recognition, it is mainly classified by direct methods according to maximum membership principle for individual identification. For the group model, it is identified by indirect methods and is classified according to "choose the nearly principle".

When the identified object is not a specific pattern, but is a fuzzy set of domain. the identification problem becomes a problem of solving close degree between the fuzzy set .Obviously, set character template as a category, and awaiting recognition character as object, the characters may be used to determine a fuzzy matrix. Then, based on the principles of choosing nearly, the closeness is computed and categorized.

According to the character features, giving each calculated point of binary image some weight (as shown in Figure 5 to provision fuzzy matrix collections, and the formula is:

$$\tilde{A}(i,j) = 0.4 \cdot BW(i,j) + 0.1 \cdot [BW(i,j-1) + BW(i,j+1) + BW(i-1,j) + BW(i+1,j)] + 0.05 \cdot [BW(i-1,j-1) + BW(i-1,j+1) + BW(i+1,j-1) + BW(i+1,j+1)] \quad (4)$$

	0.05	0.1	0.05	
	0.1	0.4	0.1	
	005	0.1	0.05	

Figure 5. Fuzzy Matrix Calculation Weight Diagram

Providing that $\tilde{A}_i$ refers to known category fuzzy subset within the universe of discourse, if object to be identified meet the Formula $N\left(\tilde{A}_k, \tilde{B}\right) = \max_{1 \le j \le t}\left\{N\left(\tilde{A}_j, \tilde{B}\right)\right\}$, then we consider that $\tilde{B}$ is closest to $\tilde{A}_k$, $\tilde{B}$ is classified to $\tilde{A}_k$ pattern. Combined with fuzzy matrix formula by using the hamming approach degrees its calculation formula is:

$$N\left(\tilde{A}_k, \tilde{B}\right) = 1 - \frac{1}{mn}\sum_{j=1}^{n}\sum_{i=1}^{m}\left|\tilde{A}_k(i,j) - \tilde{B}(i,j)\right| \quad (5)$$

6.3. Neural Network Character Recognition

The application of neural network [9] in image recognition according to data processing type can be divided into the neural network algorithm based on pixel data and feature data. Neural network recognition technology based on the image pixel data takes the high dimension of the original image data as a neural network training samples.

Some algorithm, such as forward feedback adaptive neural network, Hopfield neural net work, RAM neural network, SOFM neural network, cellular neural network, are based on the pixel to identify images. First, to construct a training sample set which also constitutes the input vector and the target vector of the training required. According to the needs of identification to, the image pixel is processed by binary figure, random noise interference and morphological processing. The image pixel value is 0 or 1, as neural network input vector to establish corresponding training set.Second, to establish a three-layer feed-forward network. The feed forward and backward BP neural network is tested on the basis of the input and the target vector formed by training samples.Third, to test the recognition of character database plus noise image, then to realize the recognition of character of positioning cutting.

7. Visualization of Identification System

Graphical User Interfaces (GUI) [10-12] is a way of human-computer interaction operation provided by the Matlab. It not only can facilitate the user's operation, but also can generate executable file without installing Matlab running on Windows operating systems.

Interface of license plate recognition system consists of the image, positioning segmentation and pattern recognition three parts. It provides image and display which the users select to recognize, image license plate positioning segmentation, and fuzzy pattern recognition and neural interface network respectively. The recognition results can be output as shown in Figure 6, the initial interface.

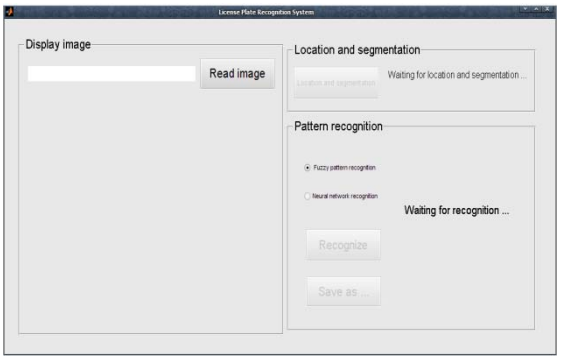

Figure 6. Initial Interface of Recognition System

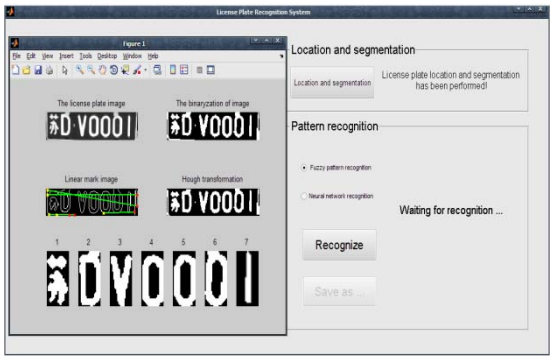

Figure 7. The Positioning Cutting Interface of License Plate Recognition System

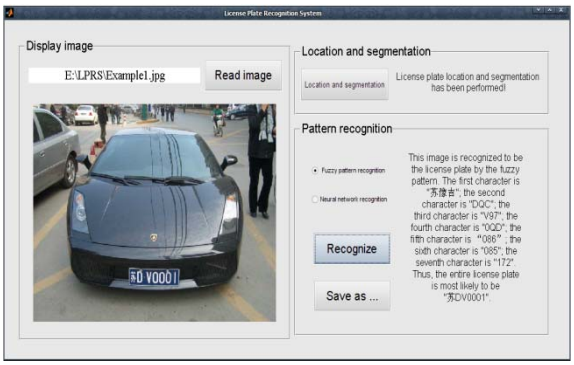

Figure 8. Recognition System Interface

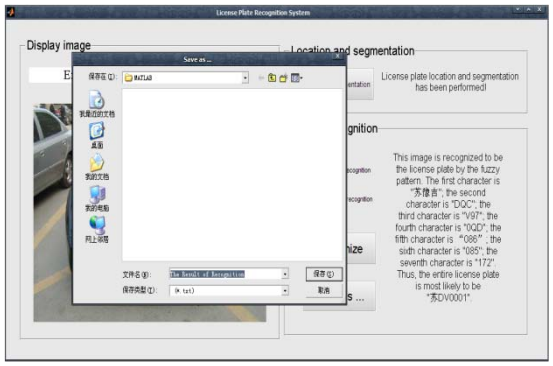

Figure 9. The Result Saving Interface of Recognition System

Figure 7 shows the system makes the license plate location cutting on the image for user to read. Figure 8 shows the system makes fuzzy pattern recognition on the cutting license plate character and display results. Figure 9 shows the system identification results based on user needs to save text as txt format, and provides three results for each character in accordance with the size of the possibility of fuzzy pattern recognition, for example, "E:\LPRS\Example1.jpg" is recognized to be the license plate by the fuzzy pattern. The first character is "苏豫吉"; the second character is "DQC"; the third character is "V97"; the fourth character is "0QD"; the fifth character is "086"; the sixth character is "085"; the seventh character is "172". Thus, the entire license plate is most likely to be "苏DV0001".

8. Conclusion

In this paper, it just pays attention to the license plate of the standard-small cars. Through digital image technology such as the image gray level, the edge detection, morphological processing and Hough transform, to realize the image of license plate location and character segmentation. Using the data of character template and selectively operate concurrently between fuzzy model and neural network to recognize Chinese, English, and English and numbers of the license plate respectively. To make license plate location, segmentation and recognition experiments by 16 images collected, but because of the big difference in background image, there are one cannot positioning, 2 pieces positioning mistake, and the rest of the image is able to successfully locate and cut. We just get the characters after the fuzzy pattern recognition and the characters are within the three results provided.

For other types of motors, the recognition system can also realize license plate positioning cutting, and specifications. In accordance with the license plate characteristics and choosing the corresponding character database, the license plate can also completely be recognized. For some other types of car such as the license plate of the coaches "某A·1234学", A large container trucks license plate "某A·1234挂" license plate license plate of consulate "某O·1234领", we just need to identify the specific characters in differences.

As the system discussed in this paper can not only realize the images of license plates positioning, segmentation, but also can facilitate the recognition of Chinese character. What's more after amended, the system can also achieve the character positioning, cutting and recognition cutting and recognition of license plate in Japanese and Russian, by aiming at the license plate specifications specific improvement system in Japan, Russia and other countries.

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References

[1] Shan Ding. The Research of License Plate Character Recognition Based on Neural Network Ensemble. Master's degree thesis of Shandong Normal University. 2011: 1-5 (in Chinese).
[2] Xiaojing Zhang. Research of Video Based Vehicle Detection and License Plate Recognition System. Master's degree thesis of Taiyuan University of Technology. 2011: 1-6 (in Chinese).
[3] Ibaa Jamal, M Usman Akram, Anam Tariq. Retinal Image Preprocessing: Background and Noise Segmentation. *TELKOMNIKA Indonesia Journal of Electrical Engineering.* 2012; 10(3): 537-543.
[4] Xinghua He, Yuanyuan Zhou, Jiyang Wang, etc. Image Processing about MATLAB7.X. Beijing: People's Posts and Telecommunications Press. 2006 (in Chinese).
[5] Yongchao Chen. The Research of License Plate Recognition Based on Digital Image Processing. Master's degree thesis of Wuhan University of Technology. 2006: 9-10 (in Chinese).
[6] Jingjiao Li, Lihong Zhao, Aixia Wang. Pattern Recognition. Beijing: Publishing House of Electronics Industry. 2010 (in Chinese).
[7] Jinming Su, Yongli Wang. Graphic Image about MATLAB. Beijing: Publishing House of Electronics Industry. 2005 (in Chinese).
[8] Peiyou Han, Guiyun Dong. Image Technology. Xi'an: Northwestern Polytechnical University Press. 2009 (in Chinese).
[9] Patricia Melin, Victor Herrera, Danniela Romero, etc. Genetic Optimization of Neural Networks for Person Recognition based on the Iris. *TELKOMNIKA Indonesia Journal of Electrical Engineering*. 2012; 10(2): 309-318.

[10] Chao Chen. Application Examples Succinctly about MATLAB: Image Processing and GUI Design. Beijing: Publishing House of Electronics Industry. 2011 (in Chinese).
[11] Zhengjun Liu. Scientific Computing and Simulation about MATLAB. Beijing: Publishing House of Electronics Industry. 2004 (in Chinese).
[12] Huanjin Liu, Hui Wang, Peng Li, etc. N Tips about MATLAB. Beijing: Beijing University of Aeronautics and Astronautics Press. 2011 (in Chinese).