Research on Key Technologies of Night Detection of License Plate Recognition System

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Keywords: graphic image technology; image noise reduction; license plate recognition system; edge detection; image feature expression

Abstract: In order to study the application of computer graphics technology in license plate recognition system, the image pixel feature representation in computer graphics technology and image denoising technology are applied to license plate recognition, which is convenient for license plate image processing in license plate recognition system. The basic principles of the system, image edge detection preprocessing, license plate image feature expression and license plate image denoising combined to improve the accuracy of night license plate recognition, can provide technical support for night detection of license plate recognition system.

1. Introduction

In recent years, with the development of economy and society, image processing technology, covering a wide range of areas, has been widely used in medical, transportation, industrial manufacturing, virtual reality and other fields.

Reference [2] proposed a pretreatment method for license plate recognition system, and studies the algorithm. But it does not denoise the recognition image. Reference [3] proposed a dynamic mathematical model of the license plate recognition system, which is validated and analyzed by MATLAB simulation platform. The dynamic mathematical model is applied to character segmentation and recognition module. Reference [4] proposed a license plate recognition algorithm, but it did not establish a dynamic mathematical model, nor did it perform simulation analysis. However, the image processing of license plate recognition system in [2-4] is relatively simple and the control strategy is single. Reference [5] proposed a new type of recognition detection system, which carries out end-to-end processing of license plate images, and used simulation experiments to analyze and compared them. However, the extraction of pixel feature values of license plate images is not studied. At present, there are many types of license plate detection methods, but they are not mature.

It is more difficult to identify license plate recognition at night, compared with daytime. How to effectively detect and recognize license plate has become an important issue. Supported by image processing technology, this paper proposes a method of night license plate recognition and beautification, which greatly improves the accuracy of license plate recognition [6].

2. License Plate Recognition System Image Acquisition Preprocessing

The license plate recognition system is widely used in high-speed toll collection systems, with suitable daytime lighting conditions and high recognition accuracy. Due to the limitation of nighttime lighting conditions, the image recognition of the license plate recognition system is easy to be distorted. How to enhance the reliability of the night license plate recognition system has become an important issue for us. The system identification process is shown in Figure 1.

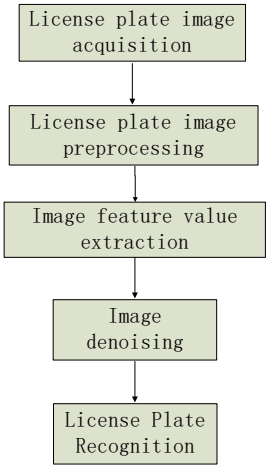

Fig. 1. System identification process

The license plate recognition system collects complex information of color license plate image through edge detection. The system uses color segmentation, gray processing and preliminary extraction of license plate image. When the recognition rate of the system is not high at night, it needs further extraction of image pixel eigenvalues and image denoising to beautify the license plate image to improve the reliability of license plate acquisition.

3. License Plate Acquisition Image Pixel Feature Expression

Feature extraction is to extract features that are different from other images in a specific image, such as the shape features of the object shape, etc. [7]. In order to achieve the accuracy of vehicle license plate recognition at night, it is necessary to decompose and express image pixel features of the images recognized by the system. The image acquired by the license plate recognition system is output as follows:

$$I(x) = J(x)t(x) + A(1 - t(x)) \quad (1)$$

where A is scale information of the license plate image in the x direction; t(x) is light intensity at night; J(x)t(x) is noise figure of image area of license plate.

Under the multi-scale illumination fill light, the color subspace and brightness feature space of each pixel of the nighttime image are calculated. The digital image processing method is used to weigh the acquired image adaptively and extract the edge contour features. The constrained optimal solution vector of the image is defined as:

$$\begin{aligned} &min \quad f(\vec{x}), \vec{x} = (x_1, x_2, \ldots x_n \in \Omega) \\ &s.t. \begin{cases} g_j(\vec{x}) \le 0, \; j = 1, 2, \ldots l \\ h_j(\vec{x}) \le 0, \; j = l+1, l+2, \ldots p \end{cases} \end{aligned} \quad (2)$$

Where $x \in \Omega$ is feasible domain of uniform pixel traversal for nighttime images.

When the illumination background is weakened, the mathematical model of license plate image output by the system is set as follows:

$$g = \left\{ g_j(i) i \in \Omega \right\} \quad (3)$$

After the license plate image extracted at night is detected by edge detection, the pixel feature vector of the license plate gray image is constructed, its expression as follows:

$$L = J(w, e) - \sum_{i=1}^{N} a_i \left\{ w^t \varphi(x_i) + b + e_i - y_i \right\} \quad (4)$$

The constrained optimization evolutionary method is used to image fusion, and the collected night image is decomposed and stabilized in the wavelet domain. In order to improve the beautification

ability of images, the characteristics of night image acquisition pixels are analyzed in the pixel template m×n by template matching [8]. The expressions are as follows:

$$I(\vec{x},y) = (G,x,y,\delta_i)\sum L \bullet I(x) - f(\vec{x})\vec{x} \tag{5}$$

$$S(\vec{x},y) = (G,x,y,\delta_i)\sqrt{g_j(\vec{x}) \bullet h_j(\vec{x})} \tag{6}$$

where G(x,y,σ_i) is spatial orientation of image sequence.

Template matching of 3×3 in each gradient direction can solve the gradient magnitude information of the image, so as to realize night image acquisition and pixel feature expression.

4. Vehicle License Plate Image Denoising Processing

At night, the illumination intensity is insufficient, and the background is easily blurred. Under such background conditions, the license plate image recognized by the system often has image distortion and large noise. On the basis of image pixel feature expression, in order to improve the clarity of night license plate recognition, noise reduction has become an important part of license plate image recognition, which can further beautify the license plate image. The set of noise points is:

$$W = \{m_i \,|\, i = 1,2\cdots n\} \tag{7}$$

Wavelet noise reduction is currently popular image denoising processing technology. The mother wavelet function is:

$$fitness(\vec{x}) = \begin{cases} f(\vec{x}), \ feasible \\ 1 + rG(\vec{x}), otherwise \end{cases} \tag{8}$$

In the continuous distribution feature space of continuous image, wavelet ridge transform is used to decompose time-frequency. The time-frequency composite weighting function family $\varphi_{a,b}$ of image is the eigenvector obtained by φ(t) through wavelet ridge transform, which is expressed as:

$$\varphi_{a,b}(t) = [U(a,b)\varphi(t)] = \frac{1}{\sqrt{|a|}}\varphi(\frac{t-b}{a}) \tag{9}$$

where $U(a,b)$ is the Euclidean distance; $1/\sqrt{|a|}$ guarantees the normalization of the amplitude of the ridge transform. In a complex environment with low visibility at night, let $t(x) = e^{-\beta d(x)}$, in which 0<t(x)<1. t(x) represents the neighborhood of the feature point i of the image. Through wavelet denoising, the gray-scale pixel features of the image are obtained as follows:

$$c = \sum_{j=1}^{m} P\left(z(k)/m_j(k), z^{k-1}\right) P\left(m_j(k)/z^{k-1}\right) = \sum_{j=1}^{m} \Lambda_j(k)\overline{c_j} \tag{10}$$

In the complex background of nighttime illumination chromatic aberration, the white balance enhancement of the night scene blurred license plate image by wavelet denoising is:

$$M = \min P_1 \bullet \frac{W}{c^3}\sqrt{fitness(\vec{x})} + \max P_2 \bullet \varphi_{a,b}(t) \tag{11}$$

where P_1 is time-domain characteristic components of pixels in neighborhood; P_2 is frequency-domain characteristic components of pixels in the neighborhood.

Through the above processing, the noise reduction of license plate image is realized. Then, using binary processing, we can get a clear and beautified license plate image.

5. License Plate Character Segmentation

After the license plate image recognition is beautified, the system recognizes the license plate characters. Traditional license plates are mainly composed of letters, Chinese characters and numbers. The system is based on neural network algorithm for segmentation and recognition of

license plate characters. It adopts gradient descent algorithm and has strong robustness. It is suitable for segmentation and recognition of license plate characters in complex background environments [9]. The gradient descent algorithm is the most commonly used optimization algorithm for neural network model training. For the deep learning model, the gradient descent algorithm is basically used for optimization training. Principle of gradient descent algorithm: the gradient of objective function with respect to parameters will be the fastest rising direction of objective function [10]. For minimizing the optimization problem, it is only necessary to advance the parameter by a step in the opposite direction of the gradient to achieve the drop of the objective function. The gradient descent algorithm is as follows [11]:

$$\begin{aligned} &Want\min_{\theta} J(\theta) \\ &\text{Re } peat \\ &\{ \\ &\theta_j := \theta_j - \alpha \frac{\partial}{\partial \theta_j} J(\theta) \\ &simul\tan eously \quad update \quad all\theta_j \\ &\} \end{aligned} \tag{12}$$

6. Analysis of Experimental Results

Under different background, the vehicle license plate beautified by image feature extraction and image denoising is tested. The experimental results show that the test accuracy and reliability of the system in this paper is better than that of the traditional license plate recognition system. The test results show that the performance of the optimized system is better than that of the traditional license plate recognition system. The accuracy of character segmentation and license plate recognition is 100% and 99.9% respectively. As shown in Table 1.

TABLE I. Comparison Of Test Results

recognition system	Character segmentation correct rate	License plate recognition accuracy
Traditional system	98%	98%
Optimization system	99.9%	100%

7. Conclusion

This paper introduces the image acquisition and preprocessing of license plate recognition system. Based on the limited background conditions of night illumination, this paper proposes the extraction of pixel feature expression values of license plate image, and uses wavelet denoising technology to reduce the noise of license plate image to improve the beautification of license plate and provide character segmentation. The favorable support greatly improves the character segmentation rate and recognition accuracy of the license plate recognition system, which provides a favorable foundation for the research of the next license plate recognition system.

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