Low Resolution License Plate Recognition Based on Intelligent Data Processing and Prediction Algorithm

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Abstract. Aiming at the problems of low accuracy of low resolution license plate recognition and long time consuming of recognition and registration in traditional methods, this paper proposes a low resolution license plate recognition method based on intelligent data processing and prediction algorithm. Firstly, the low resolution license plate is located, and the low resolution digital image of license plate is defined by the principle of image registration; Secondly, the doc scale space is constructed to determine the Gaussian pyramid and Gaussian difference pyramid model of low resolution license plate, and the RANSAC prediction algorithm is used to eliminate the mismatching of low resolution license plate and realize low resolution license plate recognition. The experimental results show that the proposed method can achieve fast recognition accuracy and recall rate of low resolution license plate, and the recognition time is low.

Keywords: RANSAC prediction algorithm · Low resolution license plate recognition · Image registration · Gauss pyramid · Gauss difference pyramid

1 Introduction

The research on license plate recognition technology abroad began in the 1980s. At that time, it was usually only used some of the simplest image processing technologies to process a module of license plate recognition process, without a complete process system, and no real-time automation. In 1990, lotufo and others developed a license plate recognition system, which consists of three parts: extracting character features, building character template library, character segmentation and character template matching, which was of epoch-making significance at that time. But after the 1990s, the complete license plate recognition system was formed slowly, all of which was due to the rapid development of computer vision and image processing technology [1–3]. China's license plate recognition technology is from the 1990s, due to the particularity of Chinese characters in China's license plate, can not fully learn from foreign technology, so the gradual rise of the domestic license plate recognition system. At present,

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the better license plate recognition systems include Hanwang eye developed by Hanwang company, license plate communication developed by Automation Department of Zhejiang University, Institute of automation of Chinese Academy of Sciences, and national key laboratories in domestic universities. They are all studying license plate recognition related algorithms and have achieved good results [4, 5].

Generally, when the car body color is different from the license plate color, the license plate detection method based on color is better. Relevant scholars use HSI color model to detect the candidate area of license plate, and then verify it by position histogram. The image is divided into different regions according to different colors by means of mean shift algorithm, and then the license plate is distinguished according to the characteristics of rectangle, aspect ratio and edge density. Domestic scholars propose to first generate the gray image of the license plate, remove the non license plate area according to the color accompanying attributes of the character area and the background area, retain the real license plate, and then use the color information to get more accurate positioning results [6]. Color based method can detect slanting or deformed license plate, but it can't distinguish other objects with similar color and size, and is very sensitive to various lighting changes.

In order to solve the above problems, this paper proposes a low resolution license plate recognition method based on intelligent data processing and prediction algorithm.

2 Low Resolution License Plate Location

2.1 Principle of Image Registration

License plate location can also be called license plate detection. The existing methods can be divided into two categories: traditional license plate location method and license plate location method based on deep learning. Traditional license plate location methods can be divided into texture features, edge features, character region features and color features; The deep learning method is mainly based on the deep learning detection network. Because the license plate is a rectangular region with a specific aspect ratio, and its edge density is richer than other positions in the image, the edge information is widely used for license plate detection. Generally, the edge detector and some morphological operations are combined to generate the candidate license plate rectangular region. Then Hough transform is used to find the vertical and horizontal lines as the license plate boundary. Although edge based methods are fast in detection speed, they are not suitable for complex or blurred license plate images. They are too sensitive to useless edges in images [7–9]. Image registration is the best matching process of two or more images obtained by different imaging equipment and under different conditions, such as climate, camera angle and position. That is to find out the relative position parameters such as scaling factor, relative rotation angle and relative displacement between these images, and then use the method of geometric transformation to classify these images into a unified coordinate system.

2.2 Definition of License Plate Low Resolution Digital Image

Sample a simulated license plate image, set up a data, arrange these data into a data matrix according to the relative position of the sampling points, and then quantify the amplitude of each element, so as to obtain the digital matrix of the license plate image. The elements of the matrix are called pixels or pixels [10, 11].

Let the coordinate value of the origin be (1, 1), then an $M \times N$ size digital image, $f(x, y)$ can be represented by a matrix:

$$f(x,y) = \begin{bmatrix} f(1,1) & f(1,2) & \cdots & f(1,N) \\ f(2,1) & f(2,2) & \cdots & f(2,N) \\ \cdots & \cdots & \cdots & \cdots \\ f(M,1) & f(M,2) & \cdots & f(M,N) \end{bmatrix} \tag{1}$$

It can be seen from the above that digital image $I_1(x, y)$ can be represented by a two-dimensional matrix, let $I_1(x, y)$ represent the gray value of the image to be registered at point (x, y), and let $I_2(x, y)$ represent the gray value of the reference image at point (x, y), then the registration relationship between the reference image and the image to be registered is expressed as follows:

$$I_2(x,y) = g(\mathrm{I}_1(\mathrm{f}(\mathrm{x},\mathrm{y}))) \tag{2}$$

In formula (2), f is a two-dimensional geometric transformation function and g is a one-dimensional gray scale transformation function. The coordinate mapping relationship between reference image and image to be registered is established. Image registration can be considered as the matching of two images in gray and spatial geometry. So the main purpose of image registration is to find the best gray transformation relationship and spatial transformation relationship.

3 Low Resolution License Plate Recognition Based on Intelligent Data Processing and Prediction Algorithm

3.1 License Plate Image Registration Algorithm Based on Intelligent Data Processing

The full name of sift is scale invariant feature transformation one, which is a feature matching operator based on scale space and keeping the scale and rotation of license plate image unchanged. The local features of the image are extracted by the registration algorithm, which has good anti noise performance and fast processing speed. Therefore, in the field of registration, the registration algorithm is a common registration algorithm [12, 13]. Registration algorithm includes three aspects: content feature detection, feature description and feature matching (Fig. 1):

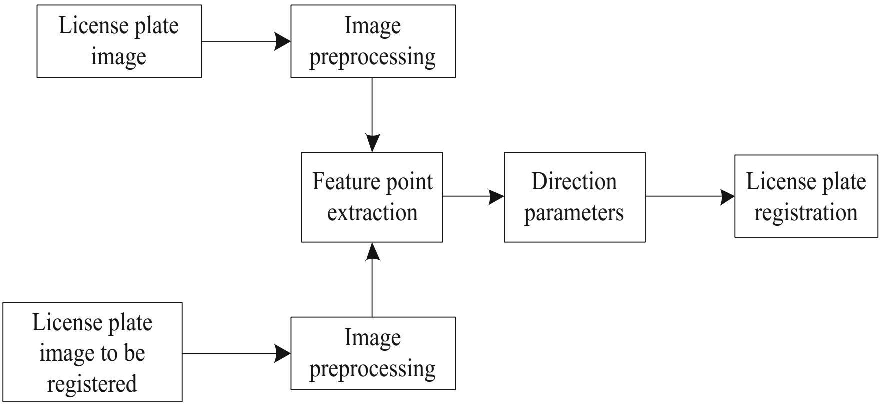

Fig. 1. Steps of license plate image registration algorithm

In this paper, the feature registration algorithm is used. Before two images are registered, the feature points of the two images must be found first, and these feature points are the extreme points in the scale space of the image, so the scale space of the image must be constructed first [14–16].

The principle of scale space. The concept of scale space was first proposed in the field of computer vision, mainly to describe the scale characteristics of license plate image. By proving that the transform kernel of scaling transform is Gaussian convolution kernel, and it is unique. Later, Gaussian convolution kernel is proved to be linear kernel, and it is unique. The scale space of a two-dimensional image is obtained by convolution of the image and Gaussian function. Suppose that the two-dimensional image of license plate is represented by $I(x, y)$, and $G(x, y; \sigma)$ is the Gaussian function, then the scale space of the two-dimensional image is represented by:

$$L(x, y; \sigma) = I(x, y) * G(x, y; \sigma) \tag{3}$$

Gauss function $G(x, y; \sigma)$ is expressed as:

$$G(x, y; \sigma) = \frac{1}{2\pi\sigma^2} e^{-(x^2 + y^2)/2\sigma^2} \tag{4}$$

In formula (3), $L(x, y; \sigma)$ is the scale space obtained by Gaussian convolution, σ is the scale factor, that is, the variance of Gaussian function distribution, and the value of σ directly affects whether an appropriate image scale space can be established. It can be seen from Eq. (3) that when $\sigma = 0$ is set:

$$L(x, y; 0) = I(x, y) * G(x, y; 0) = I(x, y) \tag{5}$$

At this time, $G(x, y; 0)$ is a two-dimensional pulse function. Therefore, the value of σ can not be too large. The image data described in this way is too rough to reflect the details of the image. The value of σ can not be too small. The image data described in this way is too fine to reflect the image information completely.

3.2 Establishment of DOC Scale Space

In order to extract more stable feature points of license plate image, the Gaussian difference scale space model doc is constructed based on the Gaussian scale space model. Take different values for σ, and then according to Eq. (3), $I(x, y)$ and σ are different. By convoluting the Gaussian function of $G(x, y; \sigma)$, the Gaussian pyramid model of the image can be obtained, and more feature points of the license plate image can be extracted from different scale spaces. In general, the Gaussian pyramid model has order, and each order takes the layer image. In the Gaussian pyramid model, the scale space of DOC can be obtained by subtracting the functions of two adjacent scale spaces.

$$D(x, y; \sigma) = I(x, y) * (G(x, y; k\sigma) - G(x, y; \sigma)) = L(x, y; k\sigma) - L(x, y; \sigma) \quad (6)$$

In Eq. (6), $D(x, y; \sigma)$ is the Gauss difference function. In the Gaussian pyramid model, there are layers of images in each order, and the scale difference between each layer is a constant k times. By subtracting two adjacent layers of images, $D(x, y; \sigma)$ can be obtained. Thus, the model is formed, as shown in Fig. 2.

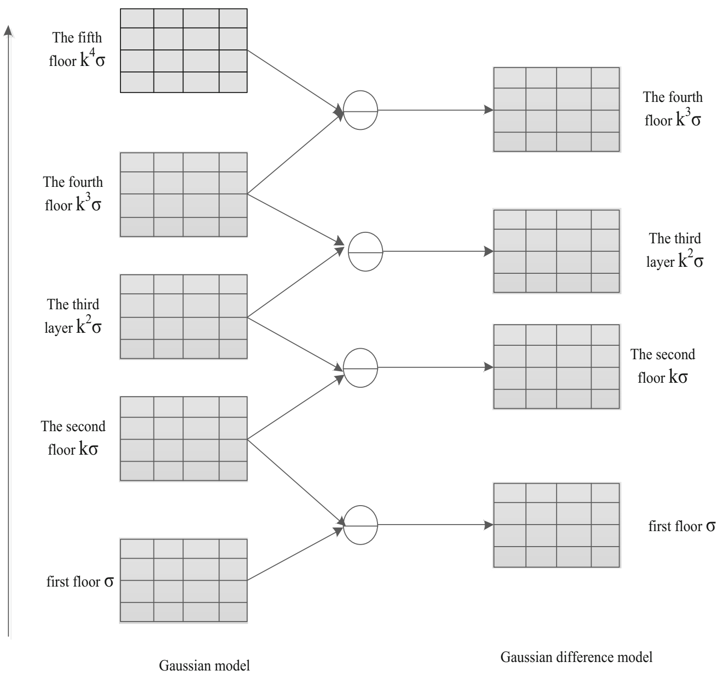

Fig. 2. Gaussian pyramid and Gaussian difference pyramid

3.3 Eliminating Mismatching Based on RANSAC Prediction Algorithm

The parameters of the mathematical model of RANSAC algorithm are estimated by iterative method. When the error rate of data exceeds, the algorithm can also deal with it. Moreover, the model is relatively simple and has strong adaptability. It is one of the most robust algorithms. Because of these advantages, it is often used in the field of registration. In this paper, the algorithm is added to the original method to better eliminate the mismatched point pairs and improve the accuracy of license plate image registration.

The idea of RANSAC algorithm is simple and ingenious. Its input value is the collection of measurement data, which is called data point. In the data point set, some data points can satisfy the pattern of some unknown parameters. These data points are called interior points, and all data points except interior points are exterior points. The set of matching points is sampled for many times, and a set of allowable error range is set. All the points are in the range and match with the model, while most of the outer points fall outside the allowable error range, so the model determined by the inner point is close to the actual model, so the parameters of the model can be determined. RANSAC algorithm is to carry out many random sampling experiments, eliminate all the feature points that are not in the error range, and optimize the parameters of the model.

In this paper, based on the Euclidean distance method, the algorithm is added to better eliminate the mismatching point pairs and improve the accuracy of license plate image registration:

(1) The threshold value of Euclidean distance method is given a dis value, the range of which is selected from one to another, and the dis value is adjusted according to the needs of the experiment. If the value of NN/SCN is smaller than the set closed value, the point is retained, otherwise the point is deleted.
(2) In the last step, among the remaining pairs of matching points, randomly sampled pairs of matching points are obtained as samples of data points.
(3) The transformation matrix H is calculated by using the m matching points;
(4) According to the transformation matrix, the error values of the remaining pairs of matching points are calculated. Let (x, x') be the feature points in two images corresponding to the same position, that is, a pair of matching points. If δ is a threshold, then there is a threshold:

$$\|Hx - x'\|^2 \leq \delta \tag{7}$$

(5) Judge whether (7) is true. If it is true, then the corresponding feature points are interior points, and the number of interior points is n. If it is not true, then the corresponding feature points are exterior points and are eliminated.
(6) The new transformation matrix H is solved by n interior points in, and the new number of interior points n' is obtained by performing (4) and (5).
(7) Judge the size of n and n'. If $n' > n$, then repeat (2)–(7). If two values are equal, then the number of interior points tends to be stable, and exit ends.

After repeated execution for many times, more than 90% of the outliers can be removed, which improves the accuracy of RANSAC algorithm to solve the geometric transformation model of license plate image.

4 Experiment

In order to verify the practical application effect of the proposed low resolution license plate recognition method based on intelligent data processing and prediction algorithm, the simulation experiment is carried out. The image data used in this experiment comes from MySQL database, and 500 images are selected from the database for the experiment. Due to the space limitation of the experiment, only one image is displayed (Fig. 3).

Fig. 3. Experimental image

4.1 Experimental Design

At present, there is no unified index to evaluate the performance of license plate location in various natural scenes. In this paper, we use the accuracy (P) and recall (R) to quantify the results of license plate location. The accuracy is defined as the ratio of the number of license plates correctly detected to the total number of candidate regions generated. The more candidate regions generated by the location network, the lower the accuracy of the model.

$$P = \frac{T_p}{T_p + F_p} = \frac{T_p}{N} \tag{8}$$

where T_p is defined as the total number of candidate regions for the correct detection of license plate, F_p is the total number of candidate regions for the wrong detection of license plate, and N is all candidate regions generated by the network.

Recall rate is defined as the ratio of the number of license plates correctly detected to the total number of real frames marked by the license plate. The specific formula is as follows

$$R = \frac{T_p}{T_p + F_n} \tag{9}$$

where F_n is the total number of undetected license plate label real boxes. The more the number of license plates detected correctly, the higher the recall rate.

4.2 Experimental Analysis

Low Resolution License Plate Recognition Accuracy

In order to detect the accuracy of low resolution license plate recognition, the paper adopts the methods of literature [7], literature [8], literature [9] and the method in this paper to test the accuracy of low resolution license plate recognition. The results are shown in Table 1.

Table 1. Accuracy of low resolution license plate recognition under different methods

Iterations/time	Low resolution license plate recognition accuracy/%			
	Methods in literature [7]	Methods in literature [8]	Methods in literature [9]	Method of this paper
5	76	66	72	99
10	75	69	54	96
15	54	73	59	89
20	63	75	64	94
25	73	79	67	96
30	70	72	63	93
Mean value	68.5	72.3	63.2	94.5

Analysis of Table 1 shows that there are differences in the accuracy of low resolution license plate recognition under different methods. When the number of iterations is 5, the low resolution license plate recognition accuracy of literature [7] is 76%, the low resolution license plate recognition accuracy of literature [8] is 66%, the low resolution license plate recognition accuracy of literature [9] is 72%, and the low resolution license plate recognition accuracy of this method is 99%. When the number of iterations is 20, the low resolution license plate recognition accuracy of the method in literature [7] is 63%, the low resolution license plate recognition accuracy of the method in literature [8] is 75%, the low resolution license plate recognition accuracy of the method in literature [9] is 64%, and the low resolution license plate recognition accuracy of the method in this paper is 94%. The low resolution license plate recognition accuracy of this method is much higher than other methods.

Time for Low Resolution License Plate Recognition

In order to verify the low resolution license plate recognition efficiency of this method, the time-consuming detection experiments of low resolution license plate recognition are carried out by using the methods of literature [7], literature [8], literature [9] and this method, and the results are shown in Table 2.

Table 2. Time consumption of low resolution license plate recognition under different methods/s

Iterations/time	Time for low resolution license plate recognition/s			
	Methods in literature [7]	Methods in literature [8]	Methods in literature [9]	Method of this paper
5	35	62	76	4
10	42	67	74	6
15	52	60	72	5
20	46	57	73	7
25	55	52	75	5
30	58	49	70	7
Mean value	48	57.8	73.3	5.7

According to the analysis of Table 2, the time of low resolution license plate recognition is different under different methods. When the number of iterations is 10, the low resolution license plate recognition time of reference [7] is 42 s, the low resolution license plate recognition time of reference [8] is 67 s, the low resolution license plate recognition time of reference [9] is 74 s, and the low resolution license plate recognition time of this method is 6 s. When the number of iterations is 30, the low resolution license plate recognition time of reference [7] method is 58 s, the low resolution license plate recognition time of reference [8] method is 49 s, the low resolution license plate recognition time of reference [9] method is 70 s, and the low resolution license plate recognition time of this method is 7 s. The low resolution license plate recognition time of this method is far less than the other two methods.

4.3 Recall Rate of License Plate in Different Ways

In order to verify the efficiency of low resolution license plate recognition in this paper, the paper adopts the methods of literature [7], literature [8], literature [9] and this method to detect the recall rate of low resolution license plate recognition. The results are shown in Fig. 4.

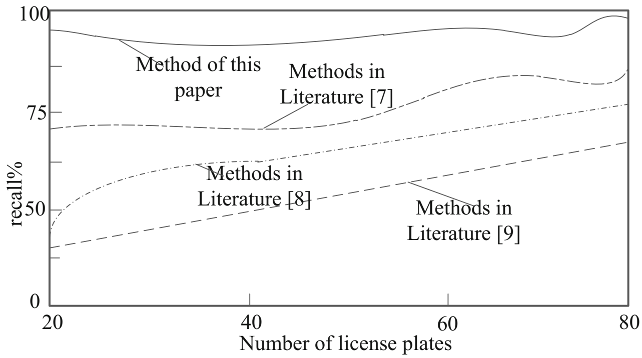

Fig. 4. Recall rate of low resolution license plate recognition under different methods

Analysis of Fig. 4 shows that the recall rate of low resolution license plate recognition is different under different methods. When the number of vehicles to be identified is 40, the low resolution license plate recognition recall rate of literature [7] method can reach 73%, the low resolution license plate recognition recall rate of literature [8] method can reach 62.5%, the low resolution license plate recognition recall rate of literature [9] method can reach 49%, and the low resolution license plate recognition recall rate of this method can reach 87.5%. When the number of vehicles to be identified is 60, the recall rate of low resolution license plate recognition of literature [7] method can reach 77%, the recall rate of low resolution license plate recognition of literature [8] method can reach 74%, the recall rate of low resolution license plate recognition of literature [9] method can reach 60%, and the recall rate of low resolution license plate recognition of this method can reach 90%. This method has higher recall rate of low resolution license plate recognition, which shows that the license plate recognition effect of this method is better.

5 Conclusion

This paper proposes a low resolution license plate recognition method based on intelligent data processing and prediction algorithm. The low resolution digital image of license plate is defined by the principle of image registration; The Gaussian pyramid and Gaussian difference pyramid models of low resolution license plate are constructed, and the false matching of low resolution license plate is eliminated by RANSAC prediction algorithm to realize low resolution license plate recognition. The results are as follows:

(1) When the number of iterations is 20, the low resolution license plate recognition accuracy of this method is 90%. The low resolution license plate recognition accuracy of this method is much higher than other methods.
(2) When the iteration times are 30, the time of low resolution license plate recognition in this paper is 89s. The low resolution license plate recognition time of this method is far less than the other two methods.

(3) When the number of vehicles to be recognized is 60, the recall rate of low resolution license plate recognition can reach 90%. This method has higher recall rate of low resolution license plate recognition, which shows that the license plate recognition effect of this method is better.

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