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# Research and Implementation of License Plate Recognition Based on CNN Algorithm Under Low Illumination

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**Abstract.** In view of the image information collected by hardware devices under low-light conditions, the signal and noise are relatively low, which will lead to the inability to accurately analyze and process image details and colors in the future. In order to explore the license plate recognition technology based on CNN, this paper improves some recognition steps to strengthen the license plate recognition technology in low-light conditions. The authors use histogram correction and histogram equalization methods in the image pre-processing stage to enhance the image and improve the image quality, and applies the algorithm is applied in low light conditions, which can solve the related problems of low license plate recognition accuracy due to weather or environmental influence, and make the license plate recognition algorithm more suitable for low light environments.

**Keywords.** Convolutional neural network, low light, image enhancement, license plate recognition

## 1. Introduction

In the past five years, license plate recognition technology has developed rapidly at home and abroad. [1,2] In the process of consulting many related literatures, the author found that most of the researchers are studying the fundamental recognition principle of license plate recognition technology, such as A. Hendry and R.-C [3] , X. Zhou [4] ,X. Qin [5], L. Du [6], D. V. Niture [7] , R. Gomes [8] ,S. Zherzdev and A. Gruzdev[9], A. Khan[10], K. Abebe[11] and other authors proposed a variety of efficient license plate recognition techniques and methods, and discussed the application of neural convolution network technology in the field of license plate recognition from different perspectives. These provide many improvement ideas for the author's research in this paper.

In recent years, the concept of a smart city has flourished, and the status of smart transportation has gradually increased. At present, the comprehensive development of intelligent transportation is facing many technical challenges, such as image recognition and data processing. In this paper, the authors focus on the license plate recognition technology under low illumination, one of the complex environments. When processing images of driving or entering and leaving the parking lot, the quality of the obtained images may be poor due to weather conditions or inadequate lighting at the time of capture. Such images are generally dark, have low contrast, fewer overall details, a low

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signal-to-noise ratio, and low brightness contrast, which is not conducive to later detection and recognition. In this paper, the authors use image enhancement technology in the spatial domain to enhance the license plate image under low illumination. The license plate recognition technology, based on convolutional neural network, is used to identify and analyze the license plate image.[12] The size of the vehicle image after image enhancement will be compressed, which will improve the running rate of the subsequent system. After the image contrast is improved, the subsequent image processing will be more efficient and fast. It can be applied to the road section with large traffic flow to improve the overall system efficiency and reduce the equipment burden.

## 2. Convolutional Neural Networks

### *2.1. Basic Techniques of CNN*

The Convolutional Neural Network (CNN) is a deep neural network with a convolutional structure that can be specifically used to process grid-structured data. It uses convolution, rather than matrix multiplication, in at least one layer of the network. Through three key operations of local perception, weight allocation, and pooling layer, the number of network parameters can be effectively reduced. The memory utilization of the deep network can be greatly reduced, and the problem of model overfitting can be well solved. It has good fault tolerance, parallel processing ability, and self-learning ability.

License plate recognition is one of the effective applications of convolutional neural networks. The precise positioning algorithm of license plate recognition based on CNN can improve the traditional license plate recognition algorithm, thereby enhancing the accuracy and stability of license plate recognition. The license plate recognition system consists of a positioning module, segmentation module, and recognition module. The license plate location module extracts license plate information through gray processing, fuzzy processing, and accurate edge detection of the license plate image. The character segmentation module combines gray image averaging processing, adaptive binarization, license plate boundary detection, and license plate character distribution features to segment license plate characters.

### *2.2. Improve Technical Methods*

The authors use 8 million pixel high-definition CMOS image sensor, high-performance DSP as the core of image processing, built-in STM32F767 CPU as the core, in which a number of technologies are designed to play a major role in image coding, processing and analysis. The authors complete the design of the core algorithm in six steps: First, capture and collect vehicle images during driving. Second, the histogram correction is performed on the collected image to reduce the image memory size and enhance the information contained in the image. Third, locate the license plate in the image. Fourth, character segmentation is performed on the extracted license plate image ( the basic characteristics of China 's domestic license plate are that the first character is the abbreviation of provinces, autonomous regions and municipalities directly under the central government, the second character is the license issuing agency code, the third character is the interval character '. ', and the fourth to eighth characters are serial

numbers). Fifth, character recognition of the segmented string. Sixth, output the license plate recognition results and perform subsequent operations.

According to a large number of investigations, the authors found that the images presented by shooting equipment on cloudy days or at night were relatively dark. This is not conducive to license plate recognition and tracking. In the early stage, the author carried out 200 license plate recognition of driving vehicles in different environments. As shown in Figure 1, it is obvious that the accuracy of license plate recognition under low illumination conditions is low. Therefore, the authors suggest that the obtained image should be improved first, and then the subsequent license plate recognition should be continued.

The authors use image enhancement technology in the spatial domain to enhance the license plate image, identify it, and output the license plate. Image enhancement techniques usually highlight or improve some features of the image, such as edge information, contour information, contrast, etc. In order to better display the basic information contained in the image and significantly improve its usability and value.

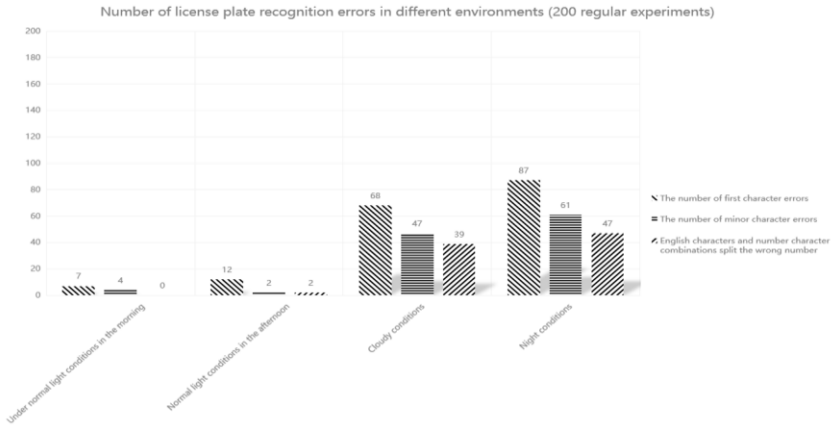


**Figure 1.** Number of license plate recognition errors in different environments (200 regular experiments).

## *2.3. Comparative Analysis of Histogram Correction Method and Other Methods*

### *2.3.1. Histogram correction method.*

After using the algorithm, the change in image gray value will be displayed intuitively. The gray value of the bright area is lower, while the gray value of the dark area is higher, which makes the difference between the bright area and the dark area clearer and easier to distinguish. The histogram is evenly segmented after correction, which can clearly reveal the changes in gray values of the image under different lighting and shading conditions, making image analysis easier. Image information increased significantly. In addition, histogram equalization also has some shortcomings. If the grayscale of the converted image is reduced, some extremely high or low grayscale values will be deleted, and some details will be weakened. Some images, such as histograms, may increase (decrease) unnaturally at maxima.

Gray scale transformation can expand the dynamic range of the image, enhance the contrast between light and shade, which makes the image more intuitive and distinctive, and is an important means of enhancing image information. This is mainly to use the

point operation to correct the gray level, the gray value of the output pixel and the gray value of the corresponding input pixel are determined one by one, without changing the spatial relationship in the picture, which is essentially transformed from one pixel to another.

*2.3.2. The rest of the algorithm analysis.*

The neighborhood averaging algorithm is simpler than other algorithms. However, this algorithm will lead to distortion of the target image when reducing noise, and the edges and details will lose a large amount of data, which is not conducive to subsequent algorithm research.

Median filtering involves sorting the gray values of each pixel in a sliding window and replacing the original gray value of the central pixel with the median. Therefore, it is a nonlinear image smoothing method. It has a good suppression effect on impulse interference and salt and pepper noise, effectively protecting the edge from blurring and suppressing random noise. [13] However, this algorithm is not suitable for images with more details such as points and lines.

Compared with the above methods, the authors choose the histogram correction method to realize the image enhancement technology.

## 3. Improved Technical Approach to License Plate Recognition Applications in Low-light Situations

*3.1. License plate recognition process*

In the process of research and design, the author introduces image enhancement technology, puts forward the flow chart of license plate recognition as shown in Figure 2, and carries out practical research in this project.

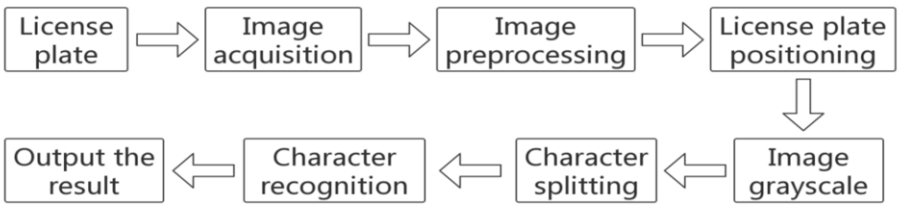


**Figure 2.** License plate recognition flowchart

*3.1.1. Image preprocessing.*

The authors use histogram correction and histogram equalization methods to enhance the obtained license plate image. After processing, the vehicle image with high contrast, rich overall details, high signal-to-noise ratio, and high brightness can be obtained, as shown in Figure 3 and Figure 4.

(1) Histogram correction method: The gray histogram of the image reflects the distribution of the image's gray values, which also indicates the number of gray pixels.

[14]The histogram can accurately reflect the basic information of the image. It can be seen from the output results of the following programs that the histogram for bright images is mainly located in the area with high gray values, while the histogram for dark images is mainly located in the area with low gray values. It can also be seen from the histogram that the contrast of the balanced image is relatively high, while the contrast of the unbalanced image is relatively low, as shown in Figure 5 and Figure 6.


**Figure 3.** Original license plate image


**Figure 4.** Corrected license plate image

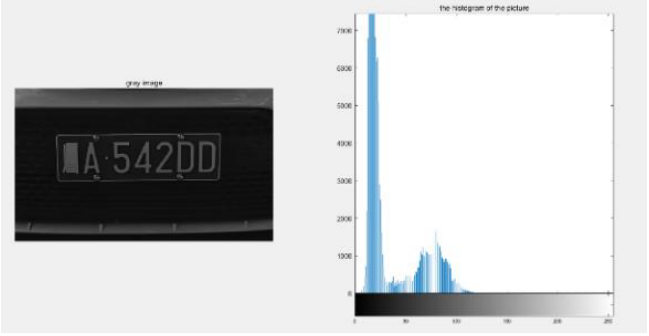


**Figure 5.** Grayscale histogram of the original output

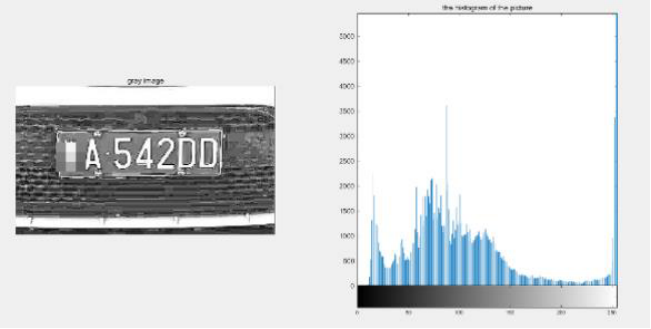


**Figure 6.** Corrected output grayscale histogram

(2) Histogram equalization: Histogram equalization is closely related to the gray histogram. For nonlinear stretched images, the pixel distribution of the image will change so that there are an equal number of pixel values within a certain range. [15]Based on the original image, the contrast of the middle is enhanced, while the contrast of the two sides is reduced. This results in a smoother gray histogram and achieves the purpose of image equalization. The purpose of image correction is to improve the contrast of the image. For images with a concentrated gray distribution (overexposed or underexposed images), adjusting the balance can make the image more balanced, as shown in Figure 7.

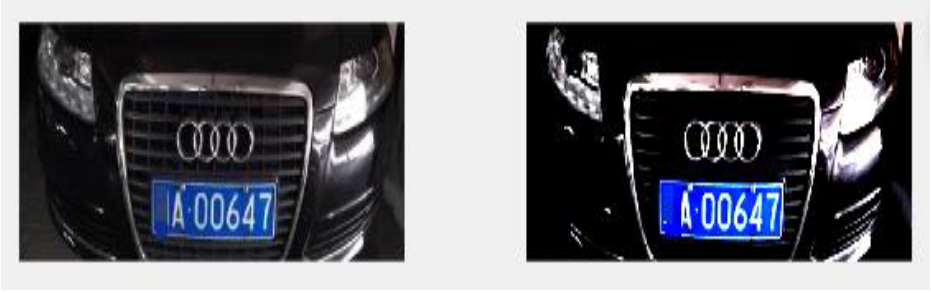


**Figure 7.** Equalization renderings

*3.1.2. License plate positioning.*

Under the condition of low illumination, the background of the collected automobile image is complex and the illumination is uneven. How to accurately determine the license plate area in the low illumination background is the key to the whole recognition process.

Firstly, the proportion of collected automobile images is adjusted, Gaussian denoising is performed, and the images are converted into grayscale images. Then the morphological changes are carried out, and the two images of the changed image and the grayscale image are synthesized into an image. The image is thresholded, and then the correlation function is used for edge detection.

After the first image processing operation, part of the license plate information can be extracted. However, under the influence of the vehicle's background environment, various information may also be mixed. Therefore, the authors extract the blue part of the image, based on the feature of the blue background and white license plate, to further filter out the noise.

Considering that the image may have a blue part other than the license plate, or a non-license plate part that meets the code judgment conditions, it will cause interference in image segmentation and subsequent character recognition. For this purpose, a secondary image processing process is set up which uses the function of the first image processing, selects specific parameters according to the actual situation, and makes subtle changes to make the results more accurate.

Finally, a large-scale correlation search is performed on the collected video images to find several regions that meet the characteristics of the vehicle license plate as candidate regions. Then, these candidate regions are further analyzed and evaluated. Meanwhile, an optimal region is selected as the license plate region and separated from the image.

As shown in Figure 8, 9, the license plate is located.

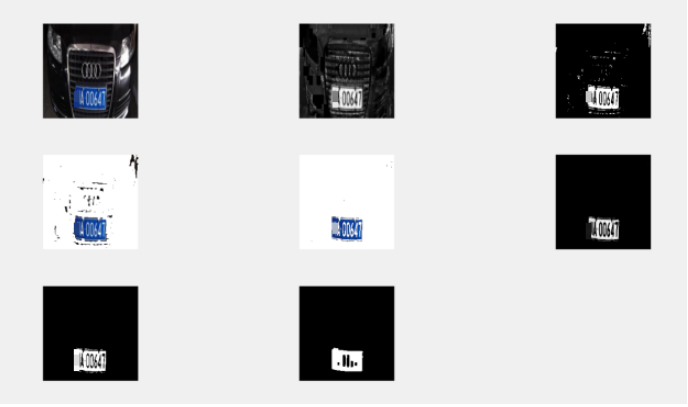

**Figure 8.** The effect of license plate positioning in sufficient light

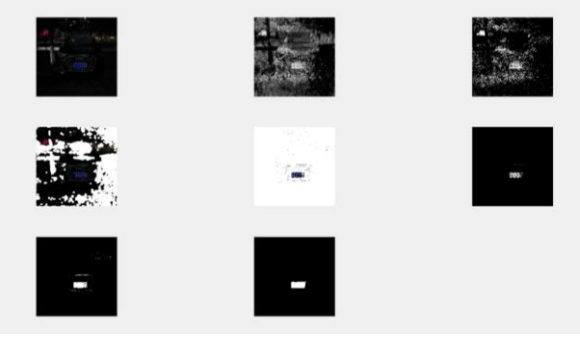

**Figure 9.** License plate positioning effect in low lighting

*3.1.3. Character segmentation and character recognition.*

The function of this part of the system is to locate and segment the license plate based on preprocessing the image. After preprocessing, the license plate position is displayed as white, and the rest is displayed as black, as shown in Figure 10. However, in some cases, white areas may also appear in unmarked locations. The judgment conditions are set for the license plate segmentation part, and the

pixel coordinate values that meet the judgment conditions are recorded into the array. Record the data of all pixels, and then search the required data in the array to determine the location of the segmentation point and segment the characters. Use the above logic to find and segment the upper left and lower right corners of the license plate in the image, as shown in Figure 11.

**Figure 10.** Image preprocessing results

**Figure 11.** Character segmentation diagram

This system uses pattern matching methods to realize character recognition. The main task of pattern matching is to create a symbol pattern library. When recognizing characters, the range of the search template is set according to the characteristics of the image. The first is Chinese characters; the second is the English sign; pictures three to seven are letters or numbers. By comparing the character image to be recognized with the patterns in the symbol pattern library, the number of matching pixels is inputted and saved in the appropriate array position. The pattern corresponding to the maximum value in the array is likely to be the real feature of the image. Repeat at least five times to obtain the license plate data in the image, and finally output the identified license plate data, as shown in Figure 12.

**Figure 12.** Character recognition result diagram

*3.2. Main Code*

Figure 13 shows the core code part of the author's development.

*3.3. Enhanced Technical Analysis*

In this paper, a smooth two-dimensional target histogram is obtained by minimizing the sum of the differences between the histogram and the uniform distribution histogram. Then, the relevant elements of the input histogram and the chart unit of the target histogram are analyzed and processed one by one. [16]For image noise, the convolutional

neural network is used to reduce processing, and finally, the improvement of low-illumination images is completed. It is found that when the image is dark, the contrast is low, and the noise in this area is stronger. The key point in enhancing image brightness is to suppress noise in a reasonable manner to generate high-quality images.

```
%% Load the picture
I=imread('D:\vehicle license.jpg');
figure(1),imshow(I);title('original image');

%% RGB converted to Gray
I1=rgb2gray(I);
figure(2),subplot(121),imshow(I1);title('gray image');
figure(2),subplot(122),imhist(I1);title('the histogram of the picture');

%% Using roberts operator for edge detection
I2=edge(I1,'roberts',0.18,'both');% select the threshold=0.18
figure(3),imshow(I2);title('roberts operator edge detection image');

%% Erosive operation
se=[1;1;1];
I3=imerode(I2,se);
figure(4),imshow(I3);title('corrosion image');

%% Smooth pictures
se = strel('rectangle',[25,25]);
I4 = imclose(I3,se);

%% Pick out the small objects
I5=bwareaopen(I4,2000);%remove the part smaller than 2000
```

```
%% Locate the license plate
[y,x,z]=size(I5);
myI=double(I5);
tic % begin timing
Blue_y = zeros(y,1); % generate a zero matrix of y*1
for i=1:y
    for j=1:x
        if(myI(i,j,1)==1)
            Blue_y(i,1)=Blue_y(i,1)+1;
        end
    end
end
[temp, MaxY]=max(Blue_y);
PY1=MaxY;
while((Blue_y(PY1,1)>=5&&(PY1>1))
    PY1 = PY1-1;
end
PY2 = MaxY;
while((Blue_y(PY2,1)>=5&&(PY2<y))
    PY2 = PY2+1;
end
IY=I(PY1:PY2, :, :);
```

```
Blue_x=zeros(1,x);
for j=1:x
    for i=PY1:PY2
        if(myI(i,j,1)==1)
            Blue_x(1,j)=Blue_x(1,j)+1;
        end
    end
end

PX1 = 1;
while((Blue_x(1,PX1)<30&&(PX1<x))
    PX1=PX1+1;
end

PX2=x;
while((Blue_x(1,PX2)<30&&(PX2>PX1))
    PX2=PX2-1;
end

PX1=PX1-1;
PX2=PX2+1;
dw=I(PY1:PY2-8,PX1:PX2);
t=toc;
figure(5),subplot(121),imshow(IY),title('line direction area');
figure(5),subplot(122),imshow(dw),title('positioning color images');
```

**Figure 13.** Core code

## 4. Application in Low Light

Image enhancement technology is closely related to machine vision. Images are inevitably affected by various factors such as sensor sensitivity, noise interference, and quantization problems during analog-to-digital conversion during the acquisition process, resulting in images that cannot achieve satisfactory visual effects. In order to achieve the purpose of human eye observation or machine automatic analysis and recognition, the improvement behavior of the original image is called image enhancement. Through a large number of experimental statistics, it is concluded that the accuracy of license plate recognition under low illumination conditions is greatly improved by image enhancement technology, as shown in Figure 14.

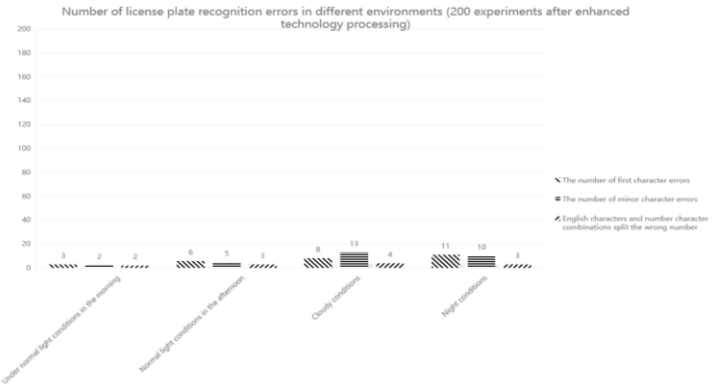


**Figure 14.** Number of license plate recognition errors in different environments (200 experiments after enhanced technology processing)

By improving the license plate recognition method, the authors enhance the effectiveness of the algorithms involved in license plate recognition at night intersections

or low-light areas, automatic driving at night, and driving recorders. Compared with the license plate recognition error data without image enhancement technology, the improved recognition accuracy has significantly increased. In the case of low illumination, vehicle images with rich overall details, high signal-to-noise ratio, and suitability for software processing can be obtained. This provides improved algorithm ideas for individuals learning license plate recognition technology in the future.

In addition, a major application scenario in low-light environments is the underground parking system. The algorithm system designed by the author takes in the dynamic video image containing the license plate by collecting the camera, and intercepts a frame for subsequent operation. Then the captured image is enhanced to overcome the image interference and improve the recognition effect. The license plate position in the image is selected and segmented by edge monitoring. The license plate image is binarized and the sorted characters are input into the character recognition system for final recognition output. Finally, the parking lot system performs subsequent processing.

## 5. Conclusion

At present, the iteration of automobiles is faster, and the competition among automobile enterprises is increasingly fierce, resulting in a sharp increase in the number of vehicles. As a result, related problems, such as automobile management, have gradually intensified. For intelligent transportation, license plate-related processing technology is very important. This paper focuses on the situation of low license plate recognition rate in low illumination environment. After collecting the license plate image of the moving vehicle, the authors first perform histogram correction image enhancement technology in the image preprocessing stage to enhance the collected image three times. After the image is enhanced, the authors will get an image with obvious light-dark contrast and clear license plate contour. Based on this image, the license plate location, character segmentation and character recognition in the license plate image will improve the license plate recognition rate and accuracy under low illumination to a certain extent. The authors ' improved design technology has certain application promotion for license plate recognition in night or cloudy road traffic. The image volume after image enhancement will be compressed, which can save background storage and improve running speed. It has a certain technical promotion effect on promoting the intelligentization of domestic license plate recognition. In this paper, the authors only consider the causes of insufficient lighting caused by environmental factors, and there are other factors that have not been carefully considered. In the next research, the authors will further improve the algorithm optimization of license plate image recognition to enhance the accuracy of license plate recognition.

## Acknowledgments

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