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License Plate recognition in fog weather based on deep learning

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Abstract. The traditional license plate recognition is generally carried out under normal conditions, but there is little work to carry out license plate recognition in fog. With the deterioration of the global environment, the probability of winter fog increases. Therefore, efficient and accurate license plate recognition under fog conditions is the research focus of this paper. This paper introduces the defogging of license plate images in foggy weather and the detailed work of license plate recognition through deep learning, which can improve the accuracy of license plate recognition in foggy weather and is conducive to ensuring the driving safety of vehicles in foggy weather.

1. Introduction

With the progress of the society, the improvement of people's living standards, and people's rich material life at the same time, more and more people choose the way of private car travel. at the same time, vehicle proliferation brings about the problem of intelligent and efficient license plate recognition. Nowadays, in the information age, license plate recognition has become one of the important research directions in the field of computer vision. The traditional recognition methods include template matching, support vector machine and so on. The recognition method of template matching is simple, but the corresponding recognition rate is low, especially for Chinese characters.

Nowadays, with the gradual deterioration of the environment, serious air pollution and frequent occurrence of haze, the chances of driving in the haze or fog are greatly incased. Traditional license plate recognition is basically based on license plate recognition in normal weather. Due to good light, the recognition rate is relatively high. However, due to the uncertainty of the environment, we have to recognize license plates under the conditions of abnormal light, such as fog. Due to the significant reduction in visibility in foggy days, people's line of sight and cameras cannot normally collect clear image data, which makes it more difficult to recognize license plates [1].

With the development of deep learning, deep learning has been applied more and more widely in various fields. In particular, the application of convolutional neural network emerging in recent years in image processing has made the field of image processing develop rapidly. Compared with the traditional character recognition technology, the convolutional neural network based on deep learning can overcome the technical difficulties such as low character recognition rate and slow recognition speed, and its recognition rate can reach about 99%.

2. Related work

The license plate recognition technology related to the corresponding introduction, so that they have a corresponding understanding of the technology.



2.1. Template matching method is briefly introduced

Template matching[2,3] way is through the license plate positioning, through a series of processing, character segmentation, at the same time establish a license plate character library, after segmentation of license plate characters normalization, one by one after the split after the plate with the license plate character library pixel matching, finally choose the best matching of matching results as to predict the output. Formula (1) for calculating the matching coefficient is as follows:

$$R(x, y) = \frac{\sum_{ij} (T(i, j) I(x+i, y+j))}{\sqrt{\sum_{ij} T(i, j)^2 \sum_{ij} I(x+i, y+j)^2}} \quad (1)$$

The value range of threshold value[4] of $R(x, y)$ is $[0, 1]$. When $R(x, y)$ is set to 0.88, the matching effect is the best; when $R(x, y)$ is greater than 0.88, the matching effect is poor.

2.2. Support vector machine (SVM) method is briefly introduced

Support vector machine[5,6] is a method in machine learning to classify license plate characters through a high-dimensional spatial mapping mechanism. Support vector machines can be divided into interval and support vector, dual problem, kernel function, linear inseparability knowledge points. This method is a binary classification model problem and a linear classifier with the maximum interval in the feature space. The learning strategy is to maximize the geometric spacing and finally to solve a convex quadratic programming problem.

In license plate recognition, SVM is required to be applied to license plate recognition. After license plate positioning, we segment license plate characters, and then use SVM module in the visual library in Open CV[7,8] for training. CV SVM is a SVM module of libsvm library, which has a complete SVM machine learning function.

When using SVM modules in the Open CV, use of reshaping the SVM methods is matrix vector drawing, reoccupy predict method to forecast. In the process of data processing, we divide the data sets according to the proportion. If there are more and larger data sets, 80% of the data will be used to train the SVM model, and 20% of the data will be used to verify the model.

2.3. The deep learning method is briefly introduced

The concept of deep learning[9,10] originated from the study of artificial neural network, which is intended to be extended to the processing of computer problems through the structure of artificial neural network. Through the deep neural network, people extend the hidden layer in the network, so as to carry out the generalization treatment of the problem, and realize to carry out the problem solving by characterizing the complex problem.

Convolutional neural network is a neural network specially designed for image processing. Compared with the fully connected network, its main advantages lie in parameter sharing and sparse connection. The neurons of the convolutional neural network can respond to the surrounding units in a partial coverage area, showing that the output of its coverage part is not affected by other pixels. The more important layers in a convolutional neural network are convolutional layer, pooling layer, full connection layer, activation function layer, loss function layer and full connection layer. Where, the convolution layer is expressed as Formula (2) as follows:

$$f_{rc} = \sum_{ij}^{kernelsize} W_{ij} \times X_{r+i, c+j} + b \quad (2)$$

Where W_{ij} is the weight of the i row and the j column of the convolution kernel; $X_{r+i, c+j}$ are the $r+i$ row and $c+j$ column of the convolution layer input. b is the deviation; f_{rc} is the element in row r and column c of the convolution layer.

By constructing the network model, constructing the input layer, hiding layer and output layer for model training and sample prediction, its simple model architecture is shown in Figure 1 below:

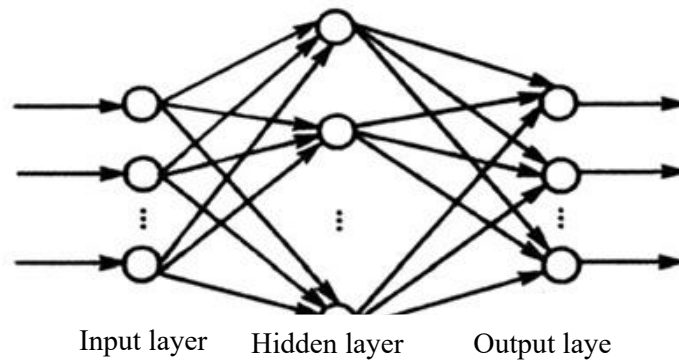


Figure1. Simple neural network model architecture diagram

In this paper, the neural network is mainly used by convolution neural network[11,12], the simple neural network model for changes in the hidden layer in the architecture to match the convolution and pooling layer in the middle of the hidden layer is used, for later use full connection layer will be in the process of convolution and pooling layer classify image to extract the characteristics of the task, the final classified mainly use Softmax layer, layer Softmax can get the current sample belong to different classification probability distribution. The classification model in the convolutional neural network is shown in Figure 2 below:

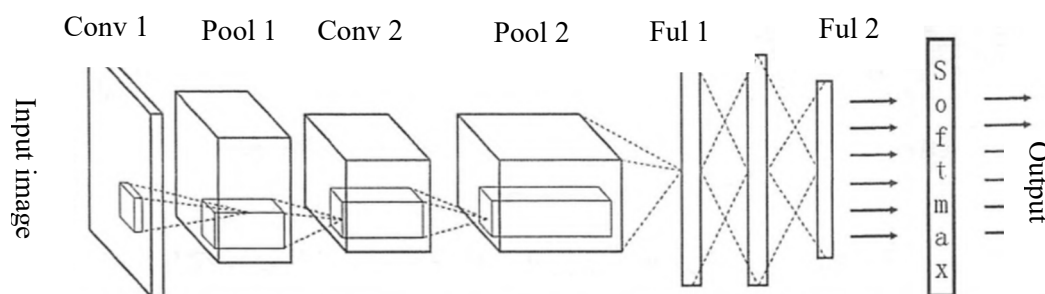


Figure2. Classification architecture diagram of convolutional neural network

The diagram vividly depicts the process of classification through neural networks.

3. System implementation

The whole realization process of the system includes image defogging, image sharpening, initial location of license plate, accurate location of license plate, correction of license plate deformity, character segmentation and single character recognition through neural network.

3.1. Image defogging

The main idea of image defogging in this paper is the dark channel prior [13]. In most non-sky local areas, some pixels always have at least one color channel with a very low value. In other words, the minimum intensity of light in that region is a very small number. The mathematical expression of its dark channel is shown in formula (3) below:

$$J^{dark}(x) = \min_{y \in \Omega(x)} \left(\min_{c \in \{r,g,b\}} J^c(y) \right) \quad (3)$$

J^c said color images in the formula of each channel, $\Omega(x)$ as the center of a window in pixels. The purpose of this formula is to find the minimum value of each position on different channels, and then filter the grayscale image in a certain window. In computer vision, the model describing the fog map is shown in formula (4) below:

$$I(x) = J(x)t(x) + A(1 - t(x)) \quad (4)$$

Where, $I(x)$ is the image we have now (the image to be fog-free), $J(x)$ is the fog-free image we want

to recover, A is the global atmospheric light component, and $T(x)$ is the transmittance. In this formula, the purpose is to obtain the image $J(x)$ of fog removal through known conditions. We need to find A transmittance $t(x)$ and the value of atmospheric light A , so as to complete the image after fog removal. The comparison of the defogging effect of the license plate under natural conditions is as follows. Figure 3 is the original image without defogging operation, and Figure 4 is the image after the defogging operation.



Figure3. Original image with fog



Figure4. Post-fog image

As shown in the comparison between Figure 3 and Figure 4, the clarity effect of license plate after fog removal is significantly increased, which is conducive to the subsequent processing of license plate recognition.

3.2. License plate pretreatment

The license plate pretreatment includes image enhancement, license plate positioning, license plate tilt correction, character segmentation and so on. The output image of the former part of the image after defogging operation as the input of license plate pretreatment, first through the image adding technology, make the image sharpen, facilitate the subsequent processing. In the image enhancement section, follow these steps:

1. Scale accordingly to change the size of the image to the specified size.
2. Gaussian blur (3*3) is carried out to remove the noise in the image and smooth the image.
3. Carry out corresponding open operation on the grayscale map, and at the same time carry out weighted operation on the original and the grayscale map after the open operation.
4. Perform threshold operation to binarize the image.
5. At the same time, the corresponding morphological operation is carried out to make the license plate position of the image become a regional block.

After the above operation, we can locate the block position in the image, including the license plate area and other block areas, and then we need to select the precise location of the license plate for subsequent operation. The pretreatment effect of license plate is shown in Figure 5 below:



Figure5. Map of the area to be selected after license plate pretreatment

3.3. Positioning of license plate

After the above operation, we need to accurately locate the license plate from the waiting selection field of the license plate, judge the contour area of the pre-processed image area, directly exclude the area less than a certain area threshold, and further screen the area blocks in the area meeting the conditions. In China, the license plate is made in accordance with a certain proportion. The aspect ratio of the license plate is 3.5, so it can be further screened in accordance with the width and height ratio of the contour, and the screening range is 2~5. After accurately locating the license plate, the license plate may be tilted [14] due to the long installation time of the license plate, or the shooting Angle of the camera and other

problems, which is not conducive to subsequent character segmentation. Therefore, the operation before character segmentation should also check whether the license plate is tilted to correct its irregular shape. There are a variety of license plate correction processes. Here, we detect the tilt Angle of the license plate through Hof line, and then conduct malformation correction through affine transformation. The correction effect is shown in Figure 6 below:

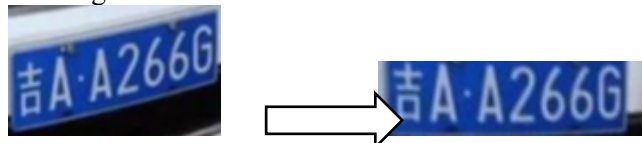


Figure6. License plate correction variation diagram

3.4. License plate character segmentation

Character segmentation [15] of license plate is a key step before character recognition. Excellent character segmentation algorithm and results can effectively improve the accuracy of character recognition. In the segmentation of license plate characters, the main methods are vertical projection segmentation and template matching character segmentation. Vertical projection segmentation method is used in this paper. On the basis of horizontal projection, the upper and lower edges are removed, and then the pixels of the binarized license plate image are added vertically. Due to some characteristics of the license plate itself, some characters of the license plate are stuck or disconnected. Therefore, the vertical projection method needs to be restricted under certain conditions. Its specific description is as follows:

1. After binarization, the color license plate is morphologically closed to make it connect some disconnected Chinese characters, so as to avoid misclassification in the segmentation process.
2. Add pixels in the vertical direction to obtain the projected array in the vertical direction of the license plate.
3. Set an appropriate threshold for the projection direction to avoid the influence of some character adhesion or non-character noise.
4. Traverse the array of vertical projection to determine whether the value of the digital element is a crest and whether it is greater than the threshold. If both conditions are met, record the starting and ending points of the crest rise.
5. Add the traversal character start and end points as tuple data to the list.

In the process of character vertical projection segmentation, character adhesion may still occur, so it is necessary to check the number of separated characters again. When the number of characters is greater than 7, there will be multiple marks of characters. At this time, a lower limit of width should be set. Only when the width of a character is greater than the threshold, will be considered it as a character; otherwise, it will be considered as a wrong mark. When the number of characters is less than 7, the phenomenon of character adhesion will occur. At this time, a wide threshold value should be set. Only when the character width is less than the threshold value, a character will be considered as a character. The vertical projection of license plate is shown in Figure 7, and the segmentation of license plate characters is shown in Figure 8:

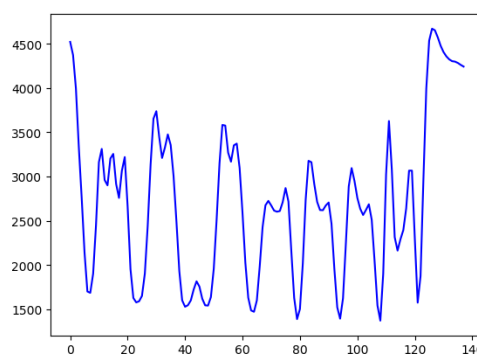


Figure7. Vertical projection

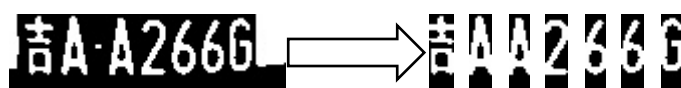


Figure8. Character segmentation diagram

3.5. License plate character recognition

The last key step of license plate recognition is recognition, and the accuracy and speed of recognition are very important. In the traditional recognition method, the recognition rate is low, and it is easy to be affected by the external environment factors, which leads to the decrease of its accuracy. This paper adopts the deep learning method for license plate recognition, which has strong generalization ability, and its generalization ability comes from the final training parameters of the network model built. Having a large number of training samples is one of the most important ways to achieve good generalization ability. Secondly, the loss function value of the model can be reduced through regularization of network structure parameters and dropout random deletion of nodes, so as to better fit the results of sample set classification.

In this paper, a network model is built by means of convolutional neural network. Its main network model structure is shown in Table 1 below:

Table1.Main structure of network model

| | |
|-----------------------|-----------------|
| Convolution layer | f:32,k:5×5,s:1 |
| Activation layer | relu |
| Maximum pooling layer | k:2×2 |
| Regularization | dropout(0.25) |
| Convolution layer | f:32,k:3×3,s:1 |
| Activation layer | relu |
| Maximum pooling layer | k:2×2 |
| Regularization | dropout(0.25) |
| Convolution layer | f:512,k:3×3,s:1 |
| Flat treatment | |
| Full connection layer | 756 |
| Activation layer | relu |
| Regularization | dropout(0.5) |
| Full connection layer | 75 |
| Activation layer | softmax |

This network mainly adopts Adam algorithm to optimize the loss function, so that the loss function can better fit the sample set.

4. Conclusion

In this paper, the license plate recognition in foggy weather is carried out. The license plate recognition rate in foggy weather is greatly improved by improving the realization of the phenomenon that the license plate may not be recognized or the recognition effect may be poor under the original conditions. In the process of license plate defogging, the dark passage in the process of license plate defogging can be better optimized to make it more natural and smooth, which is conducive to better fog removal. In the future improvement, the deep learning method can also be combined into the defogging, which is more likely to be conducive to the improvement of license plate recognition accuracy in foggy days. In the recognition module of license plate characters, Dropout can be used in the optimization of convolutional neural network to optimize the network well and avoid the phenomenon of overfitting, resulting in the decrease of loss value. In a word, the method proposed in this paper can better identify the license plate in foggy days, but it still needs to be further improved.

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