Design of license plate recognition system based on capsule network

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Abstract. With the development of automobile industry, the license plate, as the unique identifier of the vehicle, plays an important role in vehicle management. License plate recognition technology is mainly realized by image processing technology. It mainly includes image preprocessing, license plate positioning, character segmentation and other processes. In the actual process of license plate recognition, it is often impossible to accurately recognize the license plate due to the positional relationship such as angle. Therefore, this paper proposes a license plate recognition program based on the capsule network. First, through image preprocessing, license plate positioning, and character segmentation, and then use capsule neural network for training and simulation in order to achieve the object of accurate character recognition.

1. Introduction
With the development and application of computers, automatic identification technology has made rapid progress. At the same time, since the viewpoint of deep learning was proposed, the license plate recognition technology has always been one of the issues that people are more concerned about. However, as the number of motor vehicles has accumulated over the years, the huge motor vehicles have brought great challenges to the construction of intelligent transportation systems. The identification of motor vehicles is an important part of the intelligent transportation system, so the automatic license plate recognition technology has developed into the core technology of the intelligent transportation system. Nowadays, the application range of automatic license plate recognition technology is very wide, including the intelligent construction of highways, community entrances and so on, which not only saves a lot of human resources, but also optimizes the public transportation environment and provides convenience to people. Therefore, it is necessary for the license plate to be recognized as a motor vehicle quickly and accurately.

This paper first performs image preprocessing on vehicle license plates, and then realizes vehicle license plate recognition through license plate positioning, character segmentation, and character recognition[1]. In the process of vehicle license plate recognition, it is often impossible to perform accurate recognition due to problems such as angles. The current license plate recognition is realized by BP neural network or convolutional neural network.

BP neural network[2] is a multi-layer feedforward network trained by error back propagation algorithm. The BP network can learn and store a large number of input-output pattern mapping
relationships without revealing mathematical equations describing such mapping relationships in advance[2]. Its learning rule is to use the steepest descent method. The weights and thresholds of the network are continuously adjusted through back propagation to minimize the sum of squared errors of the network and achieve higher learning efficiency. However, the selection of the network structure in the BP neural network has no normative theoretical guidance. It is often selected based on personal experience. There must be some errors leading to inaccurate recognition results. At the same time, the essence of BP neural network algorithm is gradient descent method, and the optimized objective function is complex, which leads to slow algorithm convergence and long training time. Not only that, the prediction result of BP neural network is closely related to the typicality of training samples, but it is especially difficult to collect typical samples to form the training set.

Convolutional neural networks[3-5] are an important part of deep learning, especially in terms of images. Its excellent learning ability has attracted more and more people, and many models have gradually appeared, including LeNet as an example. The convolutional neural network is essentially a multi-layer perceptron. Many license plate detection and recognition algorithms based on convolutional neural networks have been proposed [6-16]. It has excellent learning in the form of local connection and weight sharing. On the one hand, it reduces the number of weights, reduces the complexity of the network, and is easier to optimize the network. On the other hand, it also reduces the possibility of overfitting[3-5]. The convolutional neural network involves a convolutional layer and a pooling layer. There is a set of matrices in the convolutional calculation layer, also known as filters. Convolution product operations are performed on the matrix and filters output from the previous layer to obtain certain features and pass them to the pooling layer. There are many types of pooling layers, including maximum pooling, average pooling and so on. Currently the most commonly used is the largest pooling layer, which can not only achieve translation invariance, but also achieve dimensionality reduction output at no cost. For translation invariance, once the experimenter changes the position or angle of the image, the neurons that recognize the image may not be activated. The maximum pooling layer slides from the left to the right in the matrix through the set window to select the maximum value of the area as the output, so a lot of small data information is also lost. Therefore, due to the existence of the pooling layer, the convolutional neural network not only loses a lot of small valuable information, but also loses the related relationship between the whole and the part, which makes it impossible to accurately recognize the image after the posture change. Of course, the experimenter can expand the database by collecting various poses of the image to improve the accuracy of recognition, but the workload is large and cannot solve the fundamental problem. It can be seen that the two methods still have defects.

The capsules in the capsule network are not composed of a single neuron, but a small group of neurons. The output is a vector, where the length of the vector represents the estimated probability of the existence of the object, and the direction records the detailed attitude parameters such as the precise position and attitude of the object, which just makes up for the shortcomings of the convolutional neural network. Therefore, this paper proposes a license plate recognition method based on capsule network.

2. Composition of license plate recognition system
The system includes the process of reading vehicle license plate images, image preprocessing, license plate positioning and cutting, frame trimming, separating characters, character recognition and so on [17]. The general process is shown in Figure 1. First input the vehicle license plate image, and then pre-process the motor vehicle license plate. The pre-processing process is to convert the color image into a grayscale image, and then perform image enhancement and median filtering, then use Canny operator to perform edge detection[18-19] and corrode the image to reduce the effects of other disturbances in the image. Secondly, the position of the license plate in the image is located, the frame is cropped, and the characters in the license plate image are segmented. Finally, the system use capsule neural network to achieve the purpose of accurate character recognition [20-21].
3. image preprocessing

Vehicle license plate images are usually collected by hardware equipment, and the collected image information is transferred to a computer for further processing. During the acquisition process, the vehicle license plate is affected by various factors such as light and weather. Therefore, the collected image is not satisfactory. There is always more or less interference, which causes the characters in the image cannot be segmented correctly, and the characters of the image cannot be read directly. Therefore, the image needs to be processed before the license plate positioning and segmentation.

In this paper, the grayscale processing of the input image is first performed by using the weighted average method. The graying effect of this method is very good, which can reduce the original image data. Image enhancement processing is then carried out to improve the parts with low gray contrast, thereby emphasizing and highlighting the local or overall characteristics of the image. In addition, the grayscale stretching can also play a role in enhancing the image contrast. Next, the image median filtering process is used to improve the image quality and achieve the purpose of suppressing noise. Finally, the optimal threshold is determined and the image is binarized to retain more and more accurate information. The image pre-processing process is shown in Figure 2.

4. License plate positioning and License plate border cropping

4.1. License plate positioning

After processing the collected pictures, it is necessary to find the position of the license plate in the area, that is, the location of the license plate. In the process of license plate location, the processed image is first morphologically processed, including edge detection, disconnection of the H-shape connection in the image, removal of burrs, corrosion expansion, and image smoothing. Then, by extracting the area of the figure, determining and comparing the area characteristic parameters, the position of the license plate is determined and the license plate area is extracted. At the same time, contrast enhancement processing is performed on the basis of preprocessing to better perform image edge detection. Edge detection provides an important foundation for later license plate recognition and image segmentation. In the process of license plate recognition, a large amount of edge information is hidden in the license plate area in the collected image. This kind of information is different from other information in the image. Therefore, edge detection is particularly important in the license plate recognition system. Not only that, the tilt correction of the obtained license plate area provides the basis for the later license plate recognition. The license plate positioning process is shown in Figure 3.
4.2. License plate border cropping

By preprocessing the obtained images and positioning the license plate, a color image of the license plate can be obtained. After the license plate tilt correction is performed, it is necessary to further tailor the positioned vehicle license plate. First, the frame of the vehicle license plate is cropped, and then it is further cropped close to the characters. Among them, the upper and lower and left and right borders are determined through continuous adjustment of the threshold, thereby eliminating the influence of the vehicle license plate border. Not only that, the vehicle license plate image after removing the frame needs to be further cropped. Try to make the upper and lower and left and right borders of the cropped image close to the characters to eliminate the influence of the rivets. The trim of the license plate frame is shown in Figure 4.

5. License plate character segmentation

In order to facilitate the separation of the characters, the cropped license plate is converted into a binary image. After the license plate is converted into a binary image, in order to reduce the interference elements in the image, we perform mean filtering on it. Due to the differences in different original images, the characters may be discontinuous or connected together after processing here. At this time, we need to perform corrosion treatment or expansion treatment on the filtered image again. The judgment structure is used here to determine the use of corrosion or swelling based on the area of the white part in the figure.
For the license plate image after filtering, the vertical projection method is used to segment the characters of the license plate on the basis of the binary image. The segmentation is performed based on the calculated character spacing and the width of a single character. Then the horizontal projection is used to determine the upper and lower boundaries of the character. The spacing between the second character and the third character is different from the rest, so special space treatment is performed separately. The license plate characters are divided as shown in Figure 5.

![Figure 5. After the license plate character is divided.](image)

6. **License plate recognition based on capsule network**

In the capsule network\[22\], the capsule is a group of neurons. First, it is different from the convolutional neural network. Each neuron contains various attributes of a specific entity in the image. These attributes represent many instantiation parameters, such as position, size, orientation, deformation and so on, which are similar to vectors in mathematics. The output of a convolutional neural network is similar to a scalar, so it is often impossible to accurately recognize images that change in angle. Secondly, the biggest charm of the capsule network lies in the use of a consistent routing algorithm. The overall shape of the image and the relationship between the overall and some features are learned during training, so even if the image changes in posture, it can be accurately identified.

First save each of the above divided characters separately, and then establish a database of Chinese characters, characters, and numbers used for vehicle license plates. The database created is shown in the Figure 6. The first step in the process of using a capsule network is to use a convolutional neural network, because the convolutional neural network is still very good for the extraction of primary features. After training through the capsule neural network, the test is required to recognize the license plate information composed of Chinese characters, English letters and numbers, respectively. The recognition result is shown in the Figure 7.

![Figure 6. database.](image)
7. Summary
This paper uses the capsule neural network to recognize the vehicle license plate, which can be found. Different from the generally collected license plate photos, the license plate photos taken by this article take a small proportion of the license plate area, which increases the difficulty of license plate positioning. For the license plate photos at the non-positive position, we performed pre-processing of image preprocessing, license plate positioning and so on, and used the capsule network for recognition and found that the recognition results are accurate.

With the advancement of intelligent footsteps, image processing and recognition has been receiving attention from people as a hot spot. License plate recognition technology, as the focus in today's traffic management, also provides great convenience to staff. For a long time, the license plate recognition technology has been continuously improved and improved. In order to realize accurate recognition of vehicle license plates, this paper proposes a license plate recognition scheme based on capsule network. First, we perform image preprocessing, license plate positioning, and character segmentation processing, and then use capsule neural networks for training and simulation to achieve the purpose of accurate character recognition. The experimental results show that the system has a high accuracy in license plate recognition. However, there are still some problems, such as the uneven quality of the images collected or captured by vehicles in complex environments, such as haze and heavy snow environments, which seriously affect the recognition results. This requires us to continuously learn new technologies, improve new methods, and combine various technologies to conduct more in-depth research.

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