License Plate Recognition System Based on Deep Learning

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***Abstract*—In the Internet plus era, artificial intelligence has developed rapidly. Some repetitive mechanized manual operations are gradually replaced by artificial intelligence. License plate recognition is a classic case which applies deep learning knowledge to reality. However, many license plate recognition methods are limited to obtaining the license plate in a fixed area, rather than locating the license plate information. License plate character recognition is a process of effective recognition of Chinese characters, letters and numbers on the basis of accurate license plate location. At present, there are many existing methods, but the effect is far from the actual requirements, so it is difficult to adapt to the requirements of high speed and fast rhythm of modern transportation system. Therefore, further research on character recognition is also urgent and necessary. The improvement of this paper is that it can accurately locate the license plate of the vehicle in the picture, so as to realize license plate recognition.**

Keywords—license plate location, character segmentation, character recognition, target detection, deep learning

I. RESEARCH STATUS OF RELATED PROJECTS

The appearance of automobile has changed the times of hiking and horse riding, greatly changed people's life style, expanded people's activity scope, and strengthened the communication between people. The car ownership in the world is increasing explosively. Although the car is convenient for our travel, it also causes the urban traffic pressure. Applying modern technology to solve the traffic problems caused by the growing car has become an important research topic, and the intelligent transportation system should come out.

Intelligent transportation system (ITS) is a kind of transportation management system which makes full use of various advanced high-tech to realize real-time, accurate and efficient traffic management system, making traffic more smooth and safe. It is also a kind of transportation information service system, making people travel more convenient and faster. With the rapid development of intelligent transportation system, intelligent transportation system has been integrated into people's daily life, making people's life more and more convenient. Vehicle is the key research object in intelligent transportation system. Each vehicle has its own unique license plate number. The license plate number reflects the vehicle information and related owner information. Through the license plate number, the traffic behavior of the corresponding vehicle can be recorded. Therefore, license plate recognition technology is one of the most core and basic technologies in intelligent transportation system, which determines the development speed of intelligent transportation system Degree and technical level.

In this paper, on the basis of literature [1], the neural network technology is applied to the field of deep learning, and the license plate recognition algorithm is improved. In order to improve the accuracy of license plate recognition, the structure of convolution neural network is adopted in reference [1]. The network parameters are set reasonably, and the weights of each layer are optimized by error back propagation. After training and testing, the system accuracy in the final reference [1] is more than 97%. The disadvantage of literature [1] is that vertical projection is used to avoid license plate tilt, which is not ideal. Based on the method of literature [1], this paper adopts overflow filling algorithm to optimize the license plate filtering and correction, and reduces the time consumption of 1 second compared with literature [1].

II. METHODS ADOPTED IN THIS PAPER

In this paper, license plate recognition is divided into three parts: location, cutting and recognition. This paper hopes to show you the process of license plate recognition intuitively through three specific split license plate recognition tasks.

In this paper, OPEN CV is used to locate the license plate area, the characters are cut by projection, and the characters are recognized by convolution neural network. Next, this paper will show the specific implementation of each functional module one by one, and string it into the whole identification system process.

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A. Location of License Plate

In this paper, we only need to analyze and study the license plate area, so we need to locate the license plate area first. The license plate is relatively single. The whole character area of the license plate is the target to be located.

1) Image preprocessing

In reference [2], end-to-end technology is adopted, but the article mentions that end-to-end recognition is a little inefficient in time efficiency, so this paper uses Open CV to detect the target to improve the detection efficiency.

First, we load the image, then convert the RGB image to grayscale image, so as to reduce the amount of data, and then we blur the image mean, so that we can soften some small noise points. Because there are many vertical edges of license plate, this paper uses Sobel to get the vertical edge. The background color of license plate is generally blue or yellow. First, transfer the original picture from RGB to HSV, and then find the blue or yellow area from the picture processed by Sobel, that is, take out the blue or yellow area from HSV, and multiply with the picture processed by Sobel. Finally, use binarization. The effect is as Fig. 1:

Fig.1 After pretreatment

Finally, the paper use the idea of literature [3] for reference, some parameters in the loaded image are adjusted to make the model more robust.

2) Location of License plate

First of all, in view of the positioning in literature [4], the positioning of the system is realized.

It can be seen from the above Fig. 1: that although the license plate has been found relatively completely, there are too many interference items in the whole picture. The next step is to eliminate the interference items and keep only the license plate area as much as possible.

First, obtain the contour, obtain the contour circumscribed rectangle, and exclude part of the contour of non-license plate through the length, width and length width ratio of the circumscribed rectangle. The green in the Fig. 2 below is the suspected license plate area.

Fig.2 Get contour

Next further excluding non-license plate area by background color. Here, we mainly use the diffuse filling algorithm (similar to PS magic wand) to generate seed points in the rectangular area. The color of seed points must be blue or yellow. Draw an external rectangle on the filled mask, then judge whether the size of the external rectangle meets the requirements of the license plate in turn, and finally do affine transformation to calibrate the position of the rectangle. There are two purposes to fill the overflow. The first one is that the license plate outline may be incomplete when preprocessing. After filling the overflow, the remaining part can be completed. The second one is to further exclude the non-license plate area.

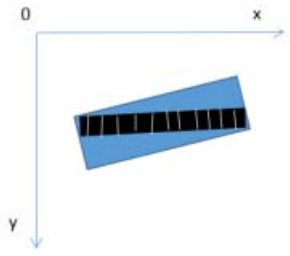

Fig.3 Slightly tilted

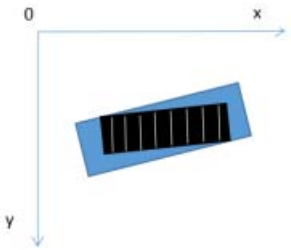

Fig.4 Severe tilted

The above overflow filling algorithm is more critical for the selection of seed points, because once the front efforts are wasted, the back also don't want to get the license plate area. In general, the number of license plates obtained will be inclined. As shown in Fig. 3, I sort the X and Y values of the four vertices of the rectangle, and take the middle two values of X and y as the horizontal and vertical upper and lower limits to generate random seed points, which can better cover the whole license plate area. In another case, the license plate tilt is too serious, as shown in Fig. 4. In this case Besides, I think of a stupid way to generate seed points directly on two diagonal lines of the rectangle, which can also cover the whole license plate area better. In addition, the adjustment coefficient can be added when generating seed points, so as not to make the generated seed points too close to the rectangular edge. The final result is as follows Fig. 5:

Fig.5 Result of Overflow filling algorithm

There are still two suspected license plate regions Fig. 6 and Fig. 7 after background color removal by water filling, but the distance to extract the real license plate target seems very close.

Fig.6 Suspected 1

Fig.7 Suspected 2

Finally, the purpose of license plate filtering is to select the real license plate from the above two suspected license plate images. Here, I use convolutional neural network to deal with whether it is two types of license plate. The dataset is owned by others and is used for license plate filtering. Here refer to the support vector machine in [5]. It should be noted that the smaller the standard deviation setting of model parameters, the faster the model convergence, and the better the effect. Of course, this pattern can also be misjudged. For example, if the model determines that two suspicious license plate images are license plates, then the image with the highest similarity to the license plate is finally selected.

Convolutional neural network is one of the most representative neural networks in the field of deep learning technology. It has made many breakthroughs in the field of image analysis and processing. On the standard image annotation set Imagenet commonly used in academia, it has made many achievements based on convolutional neural network, including image feature extraction and classification, scene recognition, etc. Compared with the traditional image processing algorithm, one of the advantages of convolutional neural network is to avoid the complex pre-processing process of image, especially the artificial participation in the image pre-processing process. Convolutional neural network can directly input the original image for a series of work, which has been widely used in various image related applications.

B. Character Segmentation

According to the paper [6], firstly, the binary license plate image is projected horizontally to the y-axis by using the horizontal projection technology, and the longest segment of continuous projection is obtained as the character area, because there are white edges around the license plate, the continuous white lines in the horizontal direction can be filtered out.

Then use vertical projection, because there is always a distance between characters, so it can be used as the basis for horizontal segmentation. In this paper, the method of reference [7] is used to calculate the width of the divided character as a character only when it reaches the average width. The "." between the second and third characters of the license plate can be excluded here.

Finally, we can get the separated characters as follows Fig. 8:

Fig.8 Segmentation results

C. Character Recognition

The purpose of this step is to identify the character image block above and output the license plate text character. Reference [8] here I still use convolutional neural network. There are many kinds, including numbers, letters and Chinese characters. But this method is similar to the two classification methods of license plate filtering. The network outputs 67 dimensional vector with the maximum probability as the output result. The final recognition results are as follows Fig. 9:

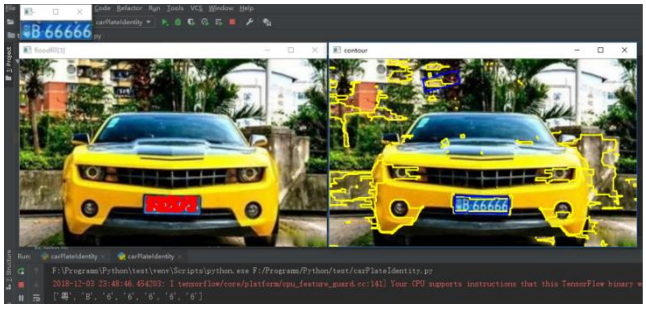

Fig.9 Recognition result

D. Discussion

For the convolution neural network of license plate recognition described in this paper, the training set needs to include 31 Chinese characters and 34 letters and numbers of 31 province abbreviations. After sorting out the segmented images, 20 training sets of each category are obtained. Randomly select 8 / 10 of the images as the training set, and the training mode is random batch sample training. A certain amount of samples are taken from the training set each time, and the gradient is reduced. Take the remaining 2 / 10 images as the test set, complete the convolution neural

network test, and the final recognition accuracy is 98%. The comparison between the accuracy and the training time corresponding to the reference [1] is shown in Fig. 10 below.

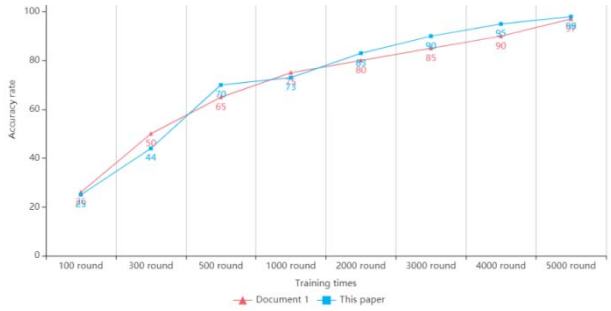

Fig.10 Training accuracy comparison

III. Conclusion

Compared with the traditional fixed shooting area, the fixed shooting area can only be used in the car park license plate recognition system, which has limitations. And using image detection to locate the target can be used not only in the parking lot recognition system, but also in such aspects as monitoring system, traffic light illegal photographing and so on. So it will be widely used in the future.

One of the benefits of Open CV is that it provides many built-in basic elements for image processing and computer vision related operations. If you need to write something through scratch, you will have to define something, such as images, points, angles, etc., which are the basis of almost any computer vision algorithm. Open CV provides these out of the box infrastructure data structures, which are all contained in the core module. Another advantage is that these data structures have been optimized for speed and memory, so you don't have to worry about implementation details.

Support vector machine (SVM) is a two classification model. Its basic model is to define the linear classifier with the largest interval in the feature space, which makes it different from the perceptron. Support vector machine also includes kernel technology, which makes it essentially a nonlinear classifier. The learning strategy of SVM is to maximize the interval, which can be formalized to solve the convex quadratic programming problem, and also equivalent to the minimization of the regularized hinge loss function problem. The learning algorithm of support vector machine is the optimization algorithm of convex quadratic programming, which can be applied to the problems such as license plate filtering.

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