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ORIGINAL ARTICLE

Improved CNN license plate image recognition based on shark odor optimization algorithm

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Abstract The recent development in the domestic economy has increased the number of private vehicles leading to the issue of road congestions and traffic accidents. The diversity and severity of traffic problems leads to the requirements of modern intelligent transportation systems. In case of vehicle license identification, plate positioning plays a very vital role and this is the key factor affecting the accuracy of the system. In order to alleviate traffic pressure, solve the problem of road congestion, this paper is based on Convolutional Neural Network (CNN) license plate character identification. This article adopts the license plate character identification employing the CNN model and uses the neural network optimization principles for the improved construction. By adopting neural network principles, it is improved, and the license plate identification model is constructed. The results show that based on CNN-based license plate character identification model, the identification of license plate characters is completed, and the license plate recognition has been significantly improved, accurate rate of 99%.

Keywords Modern intelligent transportation · Convolutional neural network · License plate image recognition · Optimization · Character identification

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1 Introduction

In recent years, with the continuous development of the domestic economy, the number of private cars has increased rapidly, leading to problems such as road congestion, traffic accidents. In order to alleviate traffic issues, the intelligent traffic management system is installed in each city. The most important part of this system is the license plate identification module. The license plate identification is mainly to determine the information of illegal vehicles, and the license plate information of all vehicles is used and the public security. The network database is compared to analyze which vehicles are suspicious vehicles, which can reduce illegal acts, can also control, reduce road traffic accidents, apply road monitoring equipment combined with modern information network technology. This forms the road monitoring intelligent network systems for better improving the road's dynamic management, control and meet the business needs of new sites such as public security, criminal investigation, transportation management. A basic optimized license plate recognition system is depicted in Fig. 1.

The most critical in the vehicle license identification system is the license plate positioning link and license plate character identification. The label positioning system is mainly, because the license plate photos obtained in the natural environment will have the tilt of the image, the image is unclear, the image is damaged, etc., these are key issues affecting the accuracy. In recent years, a lot of positioning methods have been proposed, and a good positioning effect is made, and the foundation is laid on the late license plate identification. However, with the diversity and severity of traffic problems, the requirements of modern intelligent transportation systems are getting

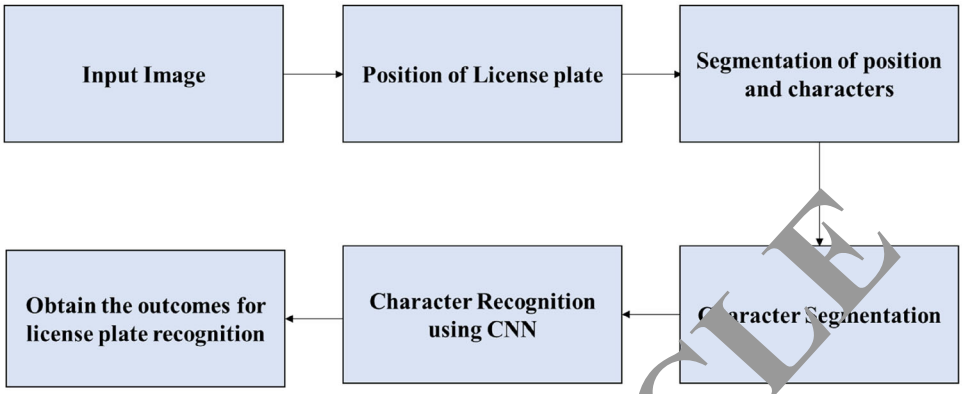

Fig. 1 Basic optimized license plate recognition system

higher and higher. The license plate character recognizes the identification of characters such as numbers, letters and Chinese characters extracted on the license plate, and guarantees accurate identification, but due to the sharpness of the license plate image, the exterior environment and human factors such as weather, light and camera perspective. The process is therefore a big challenge. In order to study a license plate identification technology with a wide range of applications, a new license plate identification system based on convolutional neural network is proposed, mainly related to convolutional neural networks and license plate identification methods (Zhang et al. 2020).

The major contribution of this research are:

- This article adopts a Convolutional Neural Network (CNN) based approach for license plate character identification in order to diversify the severe traffic problems.
- The research work uses the plate positioning concept in order to serve the requirements of modern intelligent transportation systems.
- The article alleviates the traffic pressure in order to solve the road congestion problem.
- This article adopts the license plate character identification employing a CNN model and uses the neural network optimization principles for the improved construction.
- By adopting neural network principles, it is improved, and the license plate identification model is constructed.
- The results show that based on CNN-based license plate character identification model, the identification of license plate characters is completed, and the license plate recognition has been significantly improved.

The rest of this article is organized as: Sect. 2 presents the literature review, followed by the presentation of improved traditional neural network license plate character identification model design depicted in Sect. 3. Section 4 further depicts the design of license plate character recognition model based on improved CNN and the simulation results and analysis of license plate character identification are provided in Sect. 5. Section 6 concludes the outcomes of the entire research work.

2 Literature Review

In a conventional license plate recognition system, the processing on the image is generally divided into two parts of license plate positioning and character recognition. Image identification. The target is to enable the computer to obtain the ability to cognition among the ambient content from the given multiple images or videos, which covers a perception, identification and understanding of the three-dimensional environment. Target recognition is usually divided into the following stages: image pretreatment, feature extraction and selection, design model, identification detection; its research method can summarize two categories: image recognition based on traditional image processing and machine learning algorithm and in recent years Comparison of image recognition based on deep learning algorithms; research on fish image recognition algorithms at home and abroad is based on both methods.

The initial fish recognition algorithm is implemented by traditional image processing, by artificially designed features, such as SIFT (scale constant feature transformation), HOG (direction gradient histogram feature), etc., based on this feature selection classification Identify the target. In the early years, the engineer Zhang of the US BYU University proposed a contour match, he designed a model of fish image acquisition, contour extraction, sample classification, and data stored, the model extracted the profile of fish, and based on this feature The fish in the fish tank is classified, and Fourier transform, linear fitting, and other methods are used in feature extraction(Zhang et al. 2019). Aberdeen's Cao et al., Based on machine vision, identifies fish transmitted on the conveyor belt under digital camera, the authors are positioned with fish on the conveyor, and judge the shape of the fish, extract the color of the fish and

the contour as characteristics Choice; experiments identified 7 categories of fish under the clear background, reaching 99.8% identification (Cao et al. 2020). In 2009, Geng sent a shape and texture characteristic from the antique model of the fish, and also manually labeled the characteristics of the fish's eyes and the spine outline, and the characteristics added to the classifier, and test the restricted conditions (from The three fishs under the ocean capture: squid, stonehead fish and black rods, and test in data concentration containing 108 images, reaching 76% identification (Geng and Lu 2020). In 2010, the CAT University's Yang, W. also combines fish's shape outline and texture characteristics, and tested 360 images of ten fish in a database, reaching 92% of the identification rate (Yang et al. 2019a). 2012, Yang, et al. Based on color and texture characteristics, the fish is classified by the fish, using the HSV color space to extract the color of the fish, using the wavelet function to extract the texture characteristics, and constitute six groups of feature vectors; then use multiple types of support vector machines (MSVM) as classification The classifier after training has achieved a good classification effect (Yang et al. 2019b). In 2014, Arefnezhad, S. could calculate the surface of the five fish grayscale images and the KrawTchouk torque invariant shape., Change to high-dimensional feature vectors into the multi-core support vector machine (LS-SVM), through training, the difficulty accuracy of the parameter M is more than 83.33% (Arefnezhad et al. 2020). In 2017, Rehman, S. U. has designed a fish image identification and classification system based on convolutional neural network for complex neural networks, and uses dataset amplification, add DropOUT layers, which effectively reducing the pediment. The neural network is optimized, and 8 kinds of fish have been identified by this classification system, and the results show the accuracy rate 96.24% (Rehman et al. 2020a). ur Rehman, et al. presented a deep learning based retrieval methodology for reducing the challenge of multimodal approaches like the representation and its translation (Rehman et al. 2020). The authors evaluated various supervised and unsupervised approaches for bridging the gap between the actual potential solutions and the researchers. Authors in ur Rehman et al. (2019) presented an unsupervised pre-trained effective CNN based approach for validating the experimentation for face detection. Liu, et al. (2019) et al. 2019) presented a robust approach incorporating fraction order for reducing the deviation in gradient direction. The CNN approach was adopted for obtaining the recognition rate and various databases were exploited for validating the robustness of image processing. A learning opportunity was proposed for optical character recognition (OCR) and comprehensive computation of performance for various subspace-learning methods (ur Rehman et al. 2019). The experimental outcomes are demonstrated for identifying the efficiency of the retrieval method. Some authors have investigated the model based reasoning algorithms for integrating the diagnostic activities in medicine on the basis of natural language processing enabled electronic medical records (Geng et al. 2020). The algorithm performance is improved while enhancing the sample size and pattern efficiency. An evolutionary CNN based approach was proposed for optimizing the particle swarm optimization approach (Tu et al. 2021). This method involves dynamism for improving the convergence and creating a balance in computational cost and accuracy. Several surveys were conducting for analyzing the medical records in the health condition monitoring of the patients for revealing the medical status of human brain control (Ramakuri et al. 2019), EEG analysis in healthcare (Sravanth et al. 2018; Ramakuri et al. 2017) and various other medical ailments (Finnegus and Sathik 2020). The challenges of existing cross media correlation models were combatted using the reinforced cross-media correlation approach for bidirectional translation (Peng and Qi 2019).

All these literature works on the traditional neural network based applications for improving their model designing in order to improve their performance. The challenges of the traditional methodology are overcome using various strategies in literature, however, the proposed approach in this research work aims at improving the performance of license plate recognition which could be useful in various smart city based applications.

3 Improve traditional neural network license plate character identification model design

3.1 Introduction to license plate character identification

The license plate recognition system (LPR) includes three parts of license plate positioning, character segmentation, and character identification, which combines pattern identification, machine learning, machine vision, image processing and other technologies.

3.2 Character identification process

Traditional license plate characters identify mainly including image character pretreatment, image character feature extraction, and character identification classification. In the character pretreatment, it is mainly to first process the character samples, binarization, and normalization; character feature extraction, main structure characteristics, texture characteristics, moment constraint characteristics, projection histogram characteristics, etc.

method. The RBF network license plate character identification flow design designed herein is shown in Fig. 2.

3.3 Image pretreatment

Traditional license plate character data extraction includes three phases of license plate image pretreatment, license plate positioning, and character segmentation. As the basis of image analysis, image recognition, the main purpose of image pre-operation is to better extract data in the image, restore useful information in the image, reduce the error rate of classification identification. The pre-processed image is then positioned, and the positioned image is segmented. The extracted character data is normalized and related feature extraction, and finally the data is classified by clustering with genetic hybrid optimized character identification of the RBF network. Due to the large amount of information, the amount of information of the grayscale image is relatively small, the complexity is relatively low, so in order to reduce the amount of information in the amount of information without changing the image information, it is generally grayscale processing. Thus, giving grayscale images.

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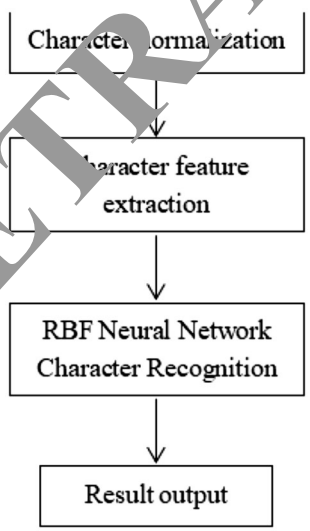

Fig. 2 RBF network license plate character recognition flow chart

3.4 License plate character positioning extraction

The license plate positioning method is based on edge detection method, and the license plate positioning is achieved in conjunction with mathematical morphology, and the edge detection is to scan the edge of the gradular image, and the edge of the digital image is obvious. Reduce the amount of calculation data while maintaining image characteristics. The common edge detection method includes a first-order differential calculator and a second-order differential operator, wherein the algorithm used in one stage differential operator has an algorithm of Sobel, Robert, Prewitt, first pass the Sobel operator to the edge of the pre-processed image. Scan

The Sobel operator is composed of two edge detection templates shown in Fig. 3.

The license plate area is detected by the Sobel operator edge, and the number of license plate edge images horizontally horizontal the position of the label area is labeled, and finally the license plate area is used as a threshold to obtain a license plate area that satisfies the threshold condition. Through this method, the license plate area after screening is obtained, and then mathematically morphological formation after screening license plate area, morphological processing is to do some specific logic operations for binary images, such as expansion, corrosion, open operation, closed operation, etc. That is, the structural model in the image is logically operated in the image in each element position, and finally the license plate is positioned (Liu et al. 2019).

4 Design of license plate character recognition model based on improved CNN

4.1 Convolutional Neural Network Features

The depth learning algorithm is first applied to image processing, with convolutional neural network, CNN, is a wide range of depth network models, and can process large data images. The CNN network structure is mainly connected by a convolution layer and a cellification layer, and

-1	0	+1
-2	0	+2
-1	0	+1

+1	+2	+1
0	0	0
-1	-2	-1

Fig. 3 Sobel gradient detection operator

finally connects the full connection layer, and at least 5 hidden layers are connected (ur Rehman et al. 2019; Geng et al. 2020).

At present, convolutional neural networks have been applied to handwritten character identification, face recognition, pedestrian testing and other aspects. In a conventional character identification method, character is required to be extracted. Therefore, the quality of the feature extraction affects network identification performance, and the convolutional neural network is a process of obtaining a feature detection by data, and therefore, CNN is considered directly from Extraction features in the original image, the method also improving the accuracy of image recognition while avoiding pre-processing of the image, making the online operation efficiency greatly increase.

Convolutional Neural Network Le Net-5 has the characteristics that can directly input images as a network input, so there is a good application in handwriting digital identification to avoid the pre-complex image feature extraction process. The license plate character identification is different from handwritten digital identification. There will be a large number of image tilt, license plate image damage, and environmental factors such as illumination. These will affect the identification rate of license plates, so for traditional convolutional nerves. The network has been improved.

4.2 Data acquisition

The conventional convolutional neural network ensures that even if the object shape or position changes, it is still correctly identified, and therefore, the convolutional neural network has good translation, rotation and zoom uncapmeal during recognition. But a depth network, if the amount of data is small, there will be a prediment and other phenomenon, so that the test phase in the network cannot achieve a good effect. Therefore, in order to verify the improved convolutional neural network performance, it is collected to include 5200 40 × 40 license plate data. In the depth study of the image, in order to enrich the image training set, better extract image features, generalization model, will The image is enhanced, and the common method has rotating image or flip image, randomly rotates flips an angle; zoom transformation, the image is enlarged or reduced by an image according to a certain scale; translation transform, within or within a certain range The image is translated in the horizontal or vertical direction; enhanced image noise, usually adding pretzo noise and Gaussian noise. The original image is expanded by the above method, and finally the original 5200 picture is expanded to 13,000 pictures.

4.3 Image preprocessing

Second, in order to improve the identification, the collected image data can be prepared before training and testing. The main component analysis (PCA) is a method of representing a high dimensional vector by a low dimensional vector, which is realized by reconstructing the low dimensional vector matrix, which not only compresses the data to the descending purpose, but also various features of the data. The amplitude on the axis is normalized, and data compression can be realized, while data dropping, the correlation between features and some potential feature variables are found. Since the data that needs to be processed during the training deep network is high-dimensional data, it is necessary to perform certain denoising and reduction processing by PCA before training testing (Tu et al. 2021; Ranakumar et al. 2019, 2017; Sravanth et al. 2018).

The PCA reduction calculation process is as follows:

(1) First, the average value of the training and test data is summarized, and then the corresponding mean is subtracted for all data. Assume that the sample set is {× 1, × 2, …, xn}, the average vector of the sample is as shown in the formula Eq. (1),

$$\overline{X} = \frac{1}{N}\sum_{i=1}^{N} X_i \tag{1}$$

(2) Then ask the solution to the covariance matrix, the formula is as follows,

$$\sum = \frac{1}{N}\sum_{i=1}^{N} (X_i - \overline{X})(X_i - \overline{X})^T \tag{2}$$

(3) Then sort the above in the above formula, to be sorted, resulting,

$$\lambda_1 \geq \lambda_2 \geq \ldots \lambda_d \geq \lambda_{d+1} \geq \ldots \tag{3}$$

(4) Finally selecting the largest K feature vector to form a new feature vector matrix as the column vector, constitute a master component. According to the feature vectors larger than the characteristic value, most of the image information is characterized, and therefore, the main component obtained can not only achieve design, but also reserved information as much as possible.

$$U = (u_1, u_2, \ldots u_d) \tag{4}$$

After obtaining the reduction data, the original data can be reduced according to the reduced data, and the maximum acquisition characteristics can be maximized. The data is multiplied by the transfers that the desired mean is added to complete the reconstruction data.

5 License plate character identification simulation results and analysis based on improved CNN

Through the MAT CONV NET framework, construct and training with 4200 images, using 4200 pictures to train the network structure, tested the training good parameters with 1000 images, and finalize the model learning rate setting by adjusting the network model parameters. To 0.001, it is not only too long that the model convergence costs will not be too long, and the model accuracy is improved; set the sample batch capacity to 20; set the weight attenuation to 0.005, and update the weight in reverse communication and offset; the number of training is set to 20 (Firthous and Sathik 2020; Peng and Qi 2019; Sharma et al. 2017).

The proposed improved convolutional neural network is compared with the conventional initial volume neural network to obtain 13,000 pictures, and then the label data has been introduced by 20 items after 20 items after 20 iterations. The identification results of the three network structures are shown in Table 1 and the respective graph is formed in Fig. 4.

Table 2 and respective Fig. 5 shows that compared with the traditional BP neural network and the RBF neural network, the shallow network will appear in the training big data, low training accuracy is achieved while deep networks can better train big data.

It can be seen from Table 2 and respective Fig. 5 that the test recognition rate of the BP neural network is on... about 93%, and the test recognition rate of the RBF neural network is about 97%, while the improved CN... test recognition rate has reached 99%. Training accu...y and character recognition accuracy are significantly higher than shallow neural networks. Compare... to shallow neural networks, the accuracy of deep lea...g license plate recognition is significantly in...d, and the shallow neural network is training in a single character during the license plate character train...g identification, and the CNN network can directly i...t the picture as a network input. Avoid the pre-character ...traction, greatly reduced the training time. D...g the training of deep network, the training dat... used is ...ge, while shallow networks are not only slow in training in large data, but also low precision, and the i...roved CNN network can effectively avoid pre...ion d...g training thus, yielding higher recogni... ac...y.

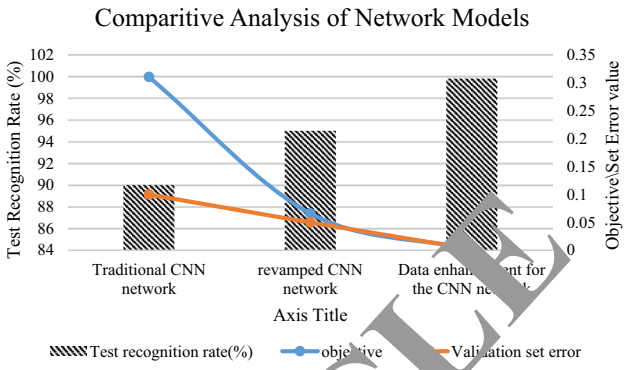

Fig. 4 Comparative analysis of th... three network structures

Table 2 Comparison of ident...tion results

Network model	Test recognition rate (%)
Traditional CNN ...etwork	90.0
revamped CN... ne...ork	95.0
Add data enha... ...ment	99.8
BP neural network	93.3
RBF ne... ...rk	97.6

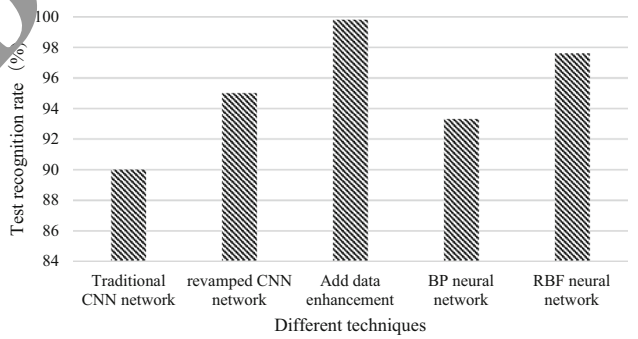

Fig. 5 Comparative Analysis of Identification outcomes

6 Conclusion

The license plate identification technology is a key part of the intelligent transportation system. The major technological advents included in this article are license plate positioning, character segmentation, and character identification involving the license plate identification. The research work is majorly focused on the principle and

Table 1 Comparison of network parameters before and after improvement

Network model	Objective	Validation set error	Test recognition rate (%)
Traditional CNN network	0.311	0.100	90.0
revamped CNN network	0.066	0.050	95.0
Data enhancement for the CNN network	0.002	0.002	99.8

algorithm of the neural network The relevant improvement and optimization is done to analyze the license plate character identification process including license plate image pretreatment, focusing on the license plate character identification method. The model simulation is performed for realization of license plate identification function which yields the test recognition rate of the BP neural network is only about 93%. The test recognition rate of the RBF neural network is about 97%, while the improved CNN has achieved a high-test recognition rate of 99%. This work finds its application in license plating for image recognition which is further applicable in smart city applications.

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Declarations

Conflicts of interest The authors have no Conflict of interest.

Research involving Human Participants and/or Animals This research has not involved any Human Participants and/or Animals.

Informed consent Not applicable as all the material is publically available.

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