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Study of Deep Learning Algorithms for Automatic License Plate Recognition (ALPR)

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Abstract: Automatic License Plate Recognition (ALPR) systems obtain a vehicle's license plate and recognize the license plate number and other required information from the image. ALPR systems have number of significant applications: law enforcement, public safety agencies, toll gate systems, etc. The goal is to recognize the characters on the license plate with high accuracy. ALPR has been implemented using various techniques. In traditional recognition methods, features are obtained from the image manually. Unlike conventional methods, deep learning techniques automatically select features and are one of the significant technologies in the field of computer vision, automatic recognition tasks and natural language processing. In this paper we have discussed some of the character recognition methodologies like Convolutional neural network (CNN), feedforward Artificial Neural Network (ANN), Back Propagation Neural Network (BPNN) and their performance is compared.
Keywords: Automatic License Plate Recognition (ALPR), Convolutional Neural Network (CNN), Artificial Neural Network (ANN), Back Propagation Neural Network (BPNN).

I. INTRODUCTION

Automatic license plate recognition (ALPR) is a mass surveillance method that uses optical character recognition on images to recognise license plates on vehicles on highways and parking lots, traffic violations detection and surveillance applications. ALPR can be used to store the images as well as text captured from the license plate. ALPR technology tends to be region-specific, owning to plate variation from place to place. Automatic License Plate Recognition (ALPR) systems capture a vehicle's license plate and recognize the license number and other required information from the captured image. ALPR systems are used in various applications. The goal of these systems is to recognize the characters and state on the license plate with high accuracy. ALPR has been implemented using various techniques. In traditional recognition methods, features are obtained from the image manually. Manually designed features are often over-specified, incomplete and take a long time to design and validate. Learned features are easy to adapt, fast to learn. Deep learning provides a very efficient framework for representing world, visual and linguistic information.

II. WORKING

Automatic License Vehicle Plate Recognition (ALPR) is an image processing problem which plays a vital role in traffic surveillance systems. It is a technique which is used to identify license plate numbers of the vehicles. Applications of such systems range in parking areas, highways, bridges and tunnels, which can help a human operator and improve overall quality of a service. Automatic number plate recognition is a surveillance method that uses various character recognition methods on images to read vehicle registration plates. The main use of ALPR is security. This technique is very helpful in toll collection, parking management, access control, radar-based speed control, border control and road patrolling.

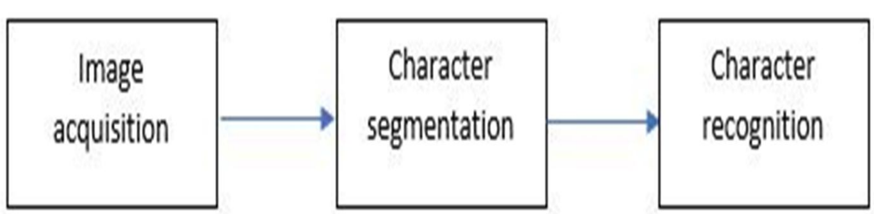

Fig. 1 Steps in ALPR

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Initially, the frames of the video are acquired and the key frames are selected. Then, the license plate is detected and extracted. Later the characters are segmented from the license plate. Finally, the characters are recognised. Various recognition algorithms used here are Convolutional neural network(CNN), feedforward Artificial Neural Network (ANN), Back Propagation Neural Network (BPNN).

III.ALPR PHASES

Fig. 2 shows the flowchart of ALPR phases. It consists of image acquisition, image pre-processing, plate localisation, character segmentation and character recognition.

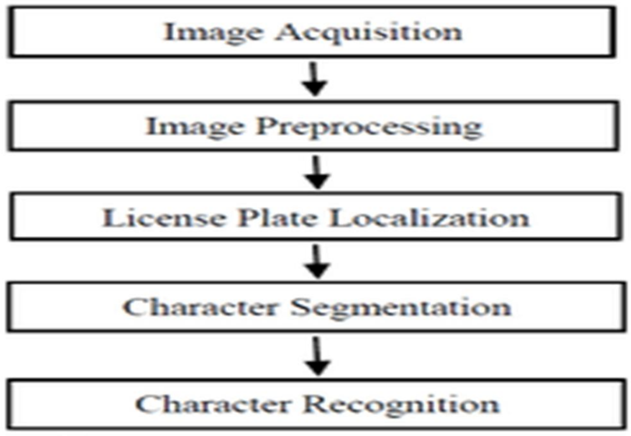

Fig. 2 Flowchart of ALPR system

A. Image acquisition

Acquire images of different vehicles is the first step of the image processing for this system. To capture vehicle license plates, cameras is located in many different locations belong to ANPR system. Still or video cameras is used in ANPR system, this camera must be specialized for capturing a high-resolution image.

B. Image Pre-Processing

This step enhances the input image and makes it more suitable for the next processing steps. Applying minimum filter to the image is the first step done in the pre-processing in order to enhance the dark values in the image by increasing their area. The goal is to make the characters and the plate edges bold, and to eliminate the effect of the light diagonal strips that appear in the characters and edges of the license plates.

C. License Plate Localization

The goal of this stage is to identify the location of the license plate of the vehicle and the result of this stage will be a sub-image that contains only the license plate.

D. Character Segmentation

This stage segments the characters from the plate. This stage results in a set of monochrome images for each candidate character in plate.

E. Character Recognition

In this stage, the goal is to recognize and classify the binary images that contain characters received from the previous one. The characters of the license plate are recognised here. After this stage every character must have a label and an error factor. If the error factor is greater than a predefined value, it will be used to reject false characters accidently passed from the previous steps.

IV.METHODS USED FOR CHARACTER RECOGNITION

Here we discuss the character recognition algorithms used in Automatic License Plate Recognition (ALPR) system. The character recognition techniques include Convolutional neural network(CNN), feedforward Artificial Neural Network (ANN), Back Propagation Neural Network (BPNN).

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A. *Convolutional Neural Network*

An automatic system for LP detection and recognition based on deep learning approach is presented in [1], which is divided into three parts: detection, segmentation, and character recognition. Many pre-treatment steps should be made before applying the first CNN model for the classification of plates / non-plates. Subsequently, a few pre-processing steps are applied to segment the LP and finally to recognize all the characters in upper case format (A-Z) and digits (0-9), using a second CNN model with 37 classes.

1) *License plate detection:* In this stage, possible various boundary boxes that can be considered as LP are extracted. But to decide whether an LP from several boundary boxes is correct, we integrate the deep learning architecture represented by the CNN model to filter and distinguish between LPs and non LPs. This CNN model is implemented with tensorflow framework which is composed of four layers: two convolutional layers for feature extraction and two fully connected layers.

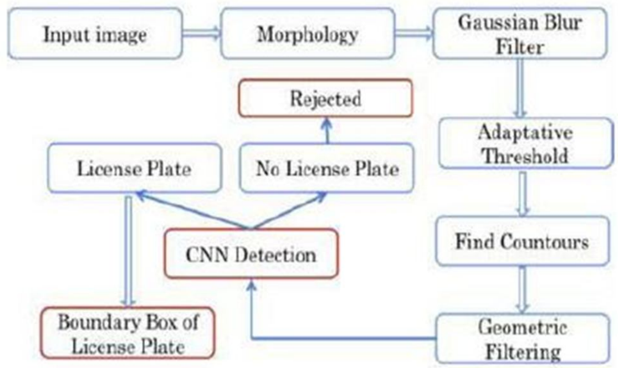

Fig. 3 Flowchart of LP detection

First of all, all the images are resized to 100 * 36 in gray level, as an input of our model. The first convolution layer C1 consists of 16 feature maps calculated using a 5 x 5 filter kernel for the image.

The layer C1 provides 96 x 32 feature maps. At the level of the first subsampling layer S2, we have 16 maps of on a maxpooling using a 2 × 2 kernel of the output of the layer C1. For the second convolution layer C3, there are 32 feature maps calculated using a 5 x 5 filter kernel on the output of the layer S2. It produces 44 x 12 feature maps. At the second subsampling S4, we have 32 characteristic maps of size 5 x 5, calculated by sub-sampling based on the maxpool using a 2 x 2 kernel on the output of the layer C3, which produces 22 x 6 feature maps. Thus, we get a first fully connected layer that contains 4224 of features. To reduce overfitting our model, we apply a dropout, which is a regularization technique, with a ratio equal to 0.5. Finally, we obtain the second fully connected layer that produces 2 neurons, which are values of softmax whose output is 2 classes.

2) *Character recognition:* The final stage in this system is the character recognition. There are currently a lot of techniques applied to the character and number recognition, such as the syntactic, the statistical and neural networks. In this system, to recognize the characters on an LP, the Tensorflow framework will be reused to classify the characters with a second CNN model with 37 classes. For training, 36 entry classes (10 classes of digits (0 to 9) and 26 upper case characters (A..Z)) and another non-character class are considered. The configuration of the CNN model is presented in Table I. The second CNN model contains four convolutional layers and two fully connected layers for 37 classes. The input image is resized to 32 x 32 in gray-scale. It firstly utilizes a 5x 5 kernel and secondly modifies it by 3 x 3. The subsampling is based on maxpooling using a 2 × 2 kernel, except the fourth convolution layer, which respects the same output size of the third convolution layers but we modify the number of features maps. The dropout is involved within a set of fully connected layers having a 0.5 in the aim of preventing overfitting. Finally, it follows this softmax layer to predicate every class probabilities. Besides, this CNN model is used to eliminate a false positives element.

B. *Feed Forward Artificial Neural Network*

Feedforward Neural Networks are artificial neural networks where the connections between units do not form a cycle.

The processing of input patterns by machine to produce meaningful outcomes is referred to as character recognition. A character recognition procedure contains the steps of pre-processing, feature extraction, and classification. Considering the input pattern to be a point in feature space after feature extraction, the recognition problem becomes one of classical classification. In the current work, we prefer to use an ANN that was been widely applied to pattern recognition.

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Therefore, in this work [2], a three-layer feedforward ANN that uses a backpropagation learning algorithm is constructed and the characters are determined using this ANN.

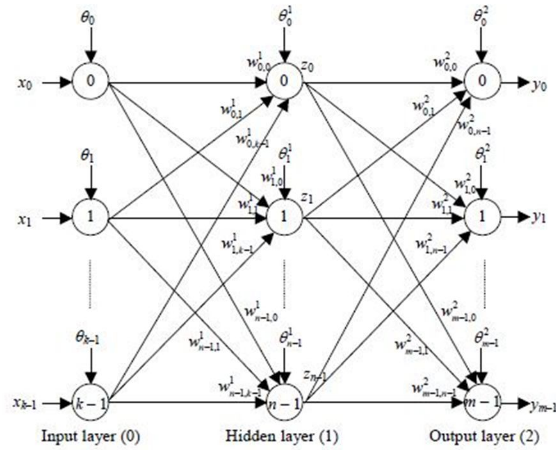

Fig. 4 Architecture of 3-layer feedforward ANN

In feedforward ANNs, nerve cells (neurons) are organized into layers and the outputs of one layer are given as input to the next layer through weights. The input layer receives information from the external environment and transmits it to the nodes (processing units) in the hidden layer without any alteration. Network outputs are determined by processing information in the hidden and output layers. The architecture of a three-layer feedforward ANN that is used in the character recognition phase of the current system is shown in Fig 4.

C. Back Propagation Neural Network

Backpropagation is a method that is used in ANN to calculate a gradient that is needed in the calculation of the weights to be used in the neural network. It is commonly used in training deep neural networks, a term used to explain neural networks with more than one hidden layer. In this work [3], each character is set to the window size of 50x30 black and white image. This is done before the image data are sending set to neural network for training purposes. Increasing the training dataset images is crucial for neural network and will improve method efficiency and accuracy for the neural network. Architecture of a simple neural network is made up from an input layer, at least one intermediate hidden layer, and output layer. Each node from input layer is connected to a node from the hidden layer and then each node from the hidden layer is connected to a node in output layer. With BPNN, learning occurs during a training phase. Back Propagation is one of the most important and popular neural network methods. This method can be divided into four steps : 1) Feed forward computation 2) Back propagation to the output layer 3)Back propagation to the hidden layer 4) Weight updates. This method is stopped when the value of the error function becomes accurately small.

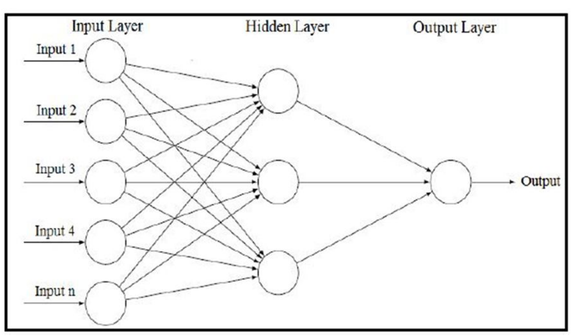

Fig. 5 Basic block of BPNN

V. RESULTS AND DISCUSSION

Several studies have been conducted on LP detection and recognition. In fact, various researchers have developed several methods and techniques for the application of this process. However, all the techniques have their own advantages and disadvantages. Moreover, every country has its own system of numbering the LP, background, size, colours and language of characters.

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Approximate accuracy of the recognition algorithms is shown below:

Algorithm	Accuracy (%)
Convolutional Neural Network	96.2
Feedforward Artificial Neural Network	96.92
Back-propagation Neural network	95

Table 1: Algorithms accuracy

VI. CONCLUSIONS

Here we have discussed various algorithms for character recognition in Automatic License Plate Recognition (ALPR). Character Recognition is the final stage of ALPR system. Convolutional neural network(CNN), feedforward Artificial Neural Network (ANN), Back Propagation Neural Network (BPNN) are widely used methods to recognize the characters on the vehicle plate detection. It is clear that ALPR is difficult system because of much number of phases and presently it impossible to achieve 100% accuracy of character recognition as each phase is dependent on previous phase. Some factors like shadow and non-uniform size of license plate characters, varying illumination conditions, different font and background colour affect the performance of ALPR system. For an effective ALPR system we have to improve the recognition algorithms by increasing the accuracy of the plate recognition.

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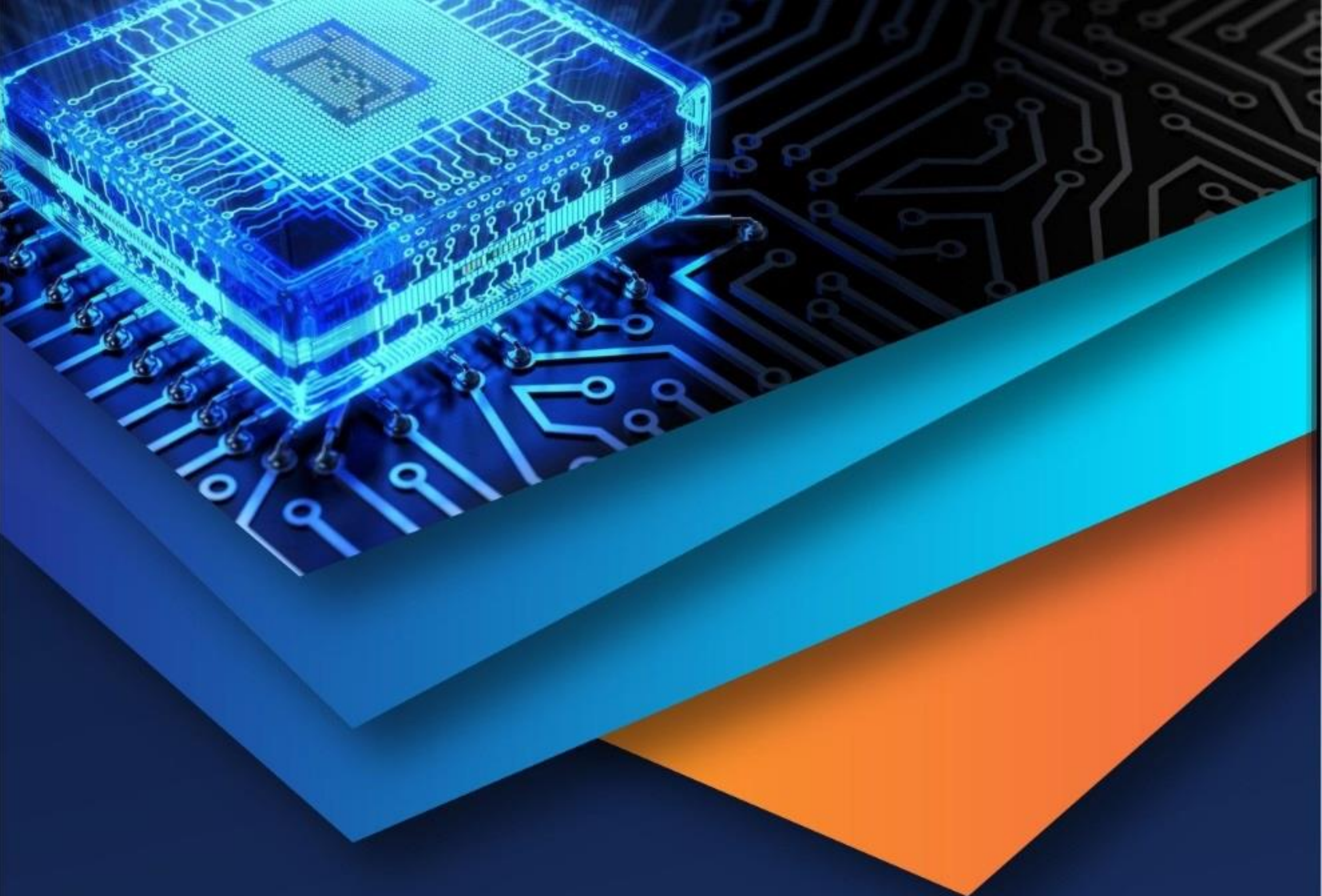

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