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License Plate Recognition Using Convolutional Neural Network

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Abstract: *In this world of new upcoming technologies which leads to our ease and comfortable life style, we also demand a comfortable traveling life, be it private or public vehicle. With increasing number of vehicles every day, it is very difficult to keep track of every vehicle manually to keep check on law enforcement, traffic control, stolen cars etc. Using OCR technology, we can automate the manual work of noting down the license plate number and then verifying it later which is time consuming and a tedious job especially with the ever increasing number of vehicles. This system first will capture the image of the car, then it will pass on the image to OCR software which firstly recognizes the location of license plate in the image and then extracts the license plate from it. After extracting the license plate, we will do a number of image processing steps to enhance the image to get better results later on. Then we will perform character segmentation so that we can recognize each character individually. After getting the segmented character, we will recognize the characters using CNN (Convolutional Neural Networks) which is trained on large number of data sets. Artificial Neural Networks increases the success rate more than the template matching technique of recognizing the character being used earlier.*

Keywords: *ALPR, Character Segmentation, Convolutional Neural Networks, Edge Detection, License Plate Extraction, Morphology, OCR.*

I. Introduction

Optical Character recognition (OCR) is a technology that is mainly used for recognizing machine printed or human written text in scanned documents, images and then converting into editable form. Expanding its application, we can use OCR in computer guided traffic system i.e. an intelligent traffic system that can work on its own with little or no human intervention. License plate recognition will play an important role for building any intelligent traffic system. Due to increase in number of vehicles, the major problem that arises is the traffic management issue and the ever increasing vehicle information which is required to be processed for stolen cars as in [1], traffic rule violation. Hence it is necessary to have a system that reduces the load on human operators.

II. Background

We input an image of a car that goes through the image pre-processing stages that enhances the image quality for better results in later stages. Then it converts the RGB image into grayscale and further binarization is done to restrict the color shades to 2 colors only (viz. Black & White). Then with the help of Sobel's edge detection algorithm or Smearing algorithm, we extract the license plate from the binarized image. After getting the license plate now, the system will segment the character on the license plate by horizontally scanning the image. Then with the help CNN, we recognize the characters. After recognizing the characters, we can use them for verification of license number or extracting the information about the vehicle owner based on the license plate number. The whole process is shown in Fig. 1.

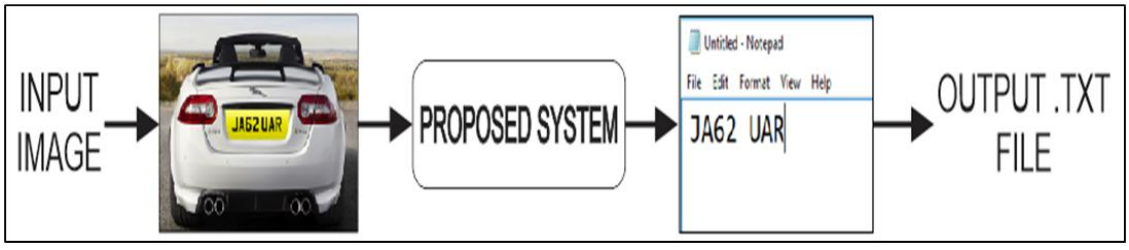

Fig. 1. Input-Output of the system

III. Related Work

In previous papers, there were many proposed techniques for developing ALPR system. Since these papers include many advantages and disadvantages, we tried to use all the best methods being used in different papers to build up our system, thus making our system more reliable and time efficient. Reference [2][3][4] gives some of the trivial method used in the field of character recognition using various methods that made the system unreliable and time complex. The below given references gave methods which further made the previous system more advanced and reliable.

As per the paper [5], the proposed algorithm used feature extraction to extract the license plate from the given image. In the last stage, ANN was used for recognizing extracted characters. As per the paper [6], mathematical morphology concept was introduced for extracting plate region from the input image. Segmentation of license plate was done using digital image labeling and character recognition was done using template matching. As per the paper [7], edge detection algorithm and vertical projection method was used for extracting the plate region. For segmentation, there were several steps of filtering, thinning, vertical and horizontal projection. As per the paper [8], the system which was designed for Indian plates used feature-based number plate localization for locating the license plate from image and for character segmentation image Scissoring technique was used and statistical feature extraction was used for character recognition. As per the paper [9], for locating the license plate within the image, salient features were used. Feature projection was used to segment the characters in the license plate.

IV. Proposed System

The proposed system for license plate recognition is presented in this section. Input to the system is a vehicle image that has been acquired through image acquisition device and output is the editable form of license number.

The flowchart of proposed system is shown in Fig. 2. which consists of the following main steps:

1. Acquired Input Image
2. Image Pre-processing:

a. RGB to grayscale conversion
b. Noise removal by Iterative Bilateral Filtering
c. Image binarization

3. License plate extraction using Sobel's edge detection algorithm/Smearing algorithm
4. Character Segmentation
5. Recognition of License number using convolution neural network

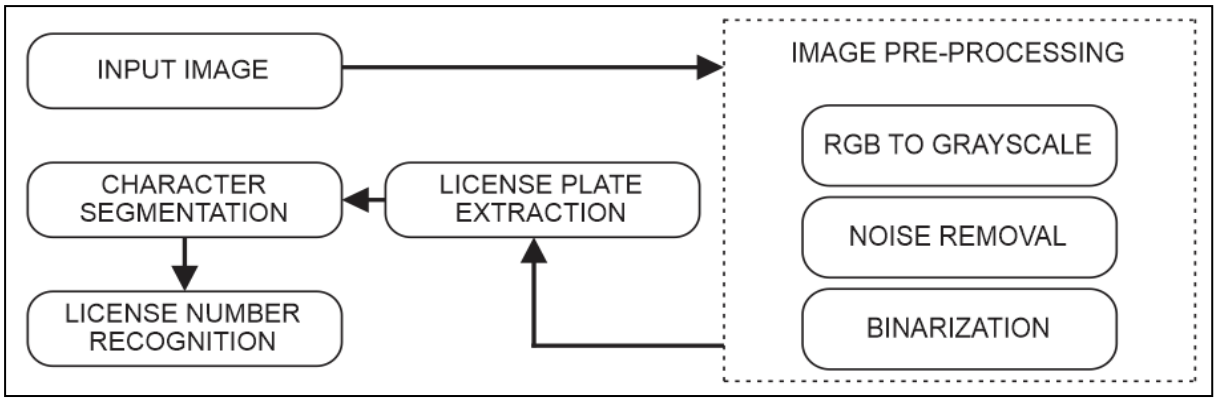

Fig. 2. Proposed ALPR system

2.1 ACQUIRED INPUT IMAGE

The first step is to acquire the image of the vehicle with license plate which in our case is taken from an already existing set of images been acquired with the help of various devices (viz. high speed cameras etc.) as shown in Fig. 3(a).

2.2 IMAGE PREPOCESSING

Image pre-processing is an important step in any image analyzing system. Without a proper pre-processing, the recognition will be ineffective or may give improper results in later stages. The main motive of pre-processing is to enhance the quality of the image that will be processed for recognition.

Various processes that we are going to apply are converting RGB image to Grayscale, noise reduction and binarization of image.

2.2.1 RGB to Gray Scale Conversion

The inputted image is in RGB format. Main purpose of this conversion is to reduce the number of colors as shown in Fig. 3(b).

Fig. 3(a). Input image

Fig. 3(b). Converted to grayscale

2.2.2 Noise Reduction

Image noises are distortion in the image that arises due to fault in camera or result of poor visibility due to changing weather conditions. Noises are also the random variation in the intensity levels of the pixels. Noise can be of various types like Gaussian noise, Salt and pepper noise. In this proposed method, we use iterative bilateral filter for noise removal. It provides the mechanism for noise reduction while preserving edges more effectively than median filter. Fig. 4(a). and 4(b). shows the images with noise and reduced noise respectively.

Fig. 4(a). Image with noise

Fig. 4(b). Image with reduced noise

2.2.3 Binarization

Binarization is the process of converting an image into an image with two pixels value only i.e. containing white and black pixels. Performing binarization process before detecting and extracting license plate from the image will make the task of detecting license plate easier as edges will be more clearly in binary image.

Binarization is performed by selecting a threshold value. After selecting the value, we analyze the pixel values in the image. If it's greater than threshold, then make that pixel fully white or black accordingly. This is simple thresholding method which may not yield proper result by selecting a global threshold value. Hence to overcome this, we use an adaptive thresholding method in which instead of selecting a global threshold value we calculate threshold of smaller region in the image which gives better result.

2.3 LICENSE PLATE EXTRACTION

In license plate extraction, it is important to take in mind the boundaries of the plate in the image as in [10]. For doing so, we have many methods such as Sobel's edge detection method and Hough's Line detection method. Now the connected component method helps us to find out what the shape actually is by the grouping method of intersection points of the shapes.

Further by getting the intersection points of the shapes, we come to known whether it is a rectangle or not depending upon the number of points in that respective group. Since now we have got the points of rectangles, we can successfully extract the rectangular parts from the image out of which we can get the license plate depending upon some properties of the license plate such as major axis length, minor axis length, area, bounding box etc. as shown in Fig. 5(a).

Now the extracted plate is actually an inverted binary image of it from the actual image of the car as shown in Fig. 5(b). Further steps cannot be applied on such an image. Thus we convert the image into binary image for further operations as shown in Fig. 5(c).

Fig. 5(a). Extracted license plate

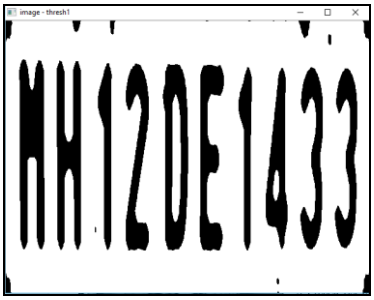

Fig. 5(b). Inverted binary image of LP

Fig. 5(c). Binary image of LP

2.4 CHARACTER SEGMENTATION

Character segmentation is done on the binary image of the extracted license plate. The algorithm used for the same is horizontal scanning which makes use of a scanning line which finds the conditions satisfying the start and end position of the character as in [11]. The pseudo code for the same is given below in Fig. 6. The segmented characters are shown in Fig. 7.

```
global var start_pos
global var end_pos

function start_of_char(img)
{
increment the scan_line
start_pos=position(scan_line)
until(finds(any_one_pixel(scan_line)),1)==true)
else goto function end_of_char(img)
}

function end_of_char(img)
{
increment the scan_line
end_pos=position(scan_line)
until(finds(all_pixel(scan_line),0)==true)
else exit
}
```

Fig. 6. Pseudo-code of character segmentation

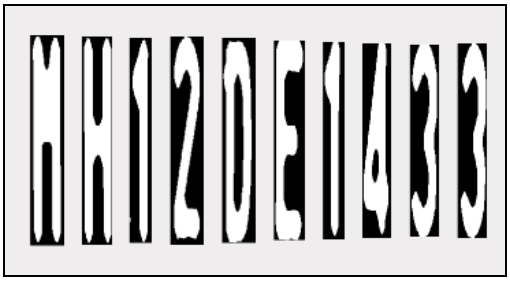

Fig. 7. Segmented characters

2.5 CHARACTER RECOGNITION USING CNN

In order to recognize the segmented characters efficiently, we used artificial neural network training to train our system over a dataset downloaded from [12]. After this training, we used the same neural model to recognize the characters.

We used a CNN with 2 convolution layers at the beginning and 2 fully connected layers at the end. We used a dataset to train the CNN as referred from [15][16][17]. The dataset consists of 1,000 sample images for each of the 36 characters. Out of the 36,000 samples, we used the first 30,000 samples as training data and remaining 6,000 samples as test data. We first trained the model with the number of training steps being 100 followed by testing.

The CNN has 784 input nodes. The first convolution layer has 5x5 kernels followed by a pooling layer of size 2x2. Output layer has 36 nodes. We used tensorflow to train and test our model. We used gradient descent algorithm to minimize cross-entropy with having a learning rate of 0.5.

V. Result

Our proposed system gave an excellent results as far as the training and recognition of the characters is concerned. The accuracy of the system was measured and it is presented in the below given tables respectively. Table I shows the accuracy maintained while training the neural network:

TABLE I. TRAINING ACCURACY

CONTENTS	**TRAINING CHARACTERS**	**TESTING CHARACTERS**
COUNT	30000	6000
PERCENTAGE	97%	

Table II shows the accuracy maintained while recognizing the characters:

TABLE II. RECOGNITION ACCURACY

STAGES	**LICENSE PLATE EXTRACTION**	**CHARACTER SEGMENTATION**	**CHARACTER RECOGNITION**
OUTPUT/TOTAL	94/100	96/100	980/1000
PERCENTAGE	94%	96%	98%

Table III shows the errors while recognizing the characters from the license plate:

TABLE III. ERRORS IN REGONIZED CHARACTERS

CONTENTS	**CHARACTERS**	**ERRORS**
TOTAL	1000	20
PERCENTAGE	2%	

VI. Conclusion & Future scope

Automatic license plate recognition is a wide field which can be implemented using many different algorithms and techniques. Every method has its own advantages and disadvantages. Our proposed methodology initially does the pre-processing steps which includes RGB to grayscale conversion, noise removal, and binarization of the image. After which the license plate is extracted using Sobel's edge detection algorithms. Then the characters are segmented using horizontal scanning which is given as input to the CNN in order to recognize the character correctly. Training our system with the help of ANN made our system more reliable and efficient in order to recognize the characters correctly.

Although we can see that so many algorithms have been implemented in various previous projects, in order to make a robust system for automatic license plate recognition, there are still many loop holes left in the system which can be filled in order to make the system more future-proof and reliable.

Our project however works on the simple font styles which is being used normally on license plates of the cars as per the rules made by the governing bodies of traffic department as in [18]. But in order to handle the cases where people don't follow these rules, it can be handled in future projects being implemented in this field of license plate recognition.

Some of the various fields which can be explored in this project are as follows:

- Car model recognition
- Multi-lingual character recognition
- Fancy character recognition etc.

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