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Convolution Neural Network Based Automatic License Plate Recognition System

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Abstract**—** For the past few years, the automatic license plate recognition system has gained more importance in the development of smart cities for vehicle management, investigation of stolen vehicles, and traffic monitoring and control. In this paper, we propose an efficient Automatic License Plate Recognition system (ALPR) for the Indian license plate. ALPR first localizes the license plate by using an adaptive sliding window technique with the help of a convolution neural network classifier. Then, the characters are segmented from the license plate by using the morphological operations. Segmented characters are converted into text upon using Transfer learning techniques on Mobilenet. ALPR was tested and has outperformed traditional license plate recognition system. Also, the performance of ALPR was satisfactory in variation in illumination condition, text style, uncanny and skewness of the license plate. The ALPR system can be integrated with the Speed Calculation System so that the authority can notify the traffic offender.

Keywords**—** Automatic License Plate Recognition system(ALPR), convolution neural network classifier(CNNC), Optical character recognition(OCR), adaptive sliding window technique(ASW), MobileNet.

I. INTRODUCTION

For the past few years reducing road accidents and controlling traffic by limiting the speed of vehicles has been done. Whereas informing the driver of over-speeded vehicle in real time is still a challenging task. In this paper ALPR system is proposed which is an extension of Camera-based Speed Calculation System(CSCS) for speed calculation of vehicles[8]. Since ALPR system is an extension of CSCS, input for ALPR system is derived from CSCS. The ALPR was invented in 1976 at the Police Scientific Development Branch in the UK. However, it has gained more interest during the last decade along with the improvement of digital cameras and the increase in computational capacity. Our ALPR system is robust as compared to the other ALPR system. The earlier methods use a feature based approach using edge detection or Hough transform which are computationally expensive. The ALPR is a system designed to help in the recognition of license plates of vehicles. The ALPR is used in many applications such as controlling the gate access of a parking lot, traffic control, tracking of stolen cars, red light violation detection, border control, parking management, and many others. This paper will explore and elaborate on the proposed algorithm for ALPR.

The proposed ALPR system works in four steps, the first step is the image acquisition. The second step is the localization of the number plate in which convolution neural network classifier was created for classification of the license plate which was then used by adaptive sliding window technique for localization of number plate. The third step is character segmentation with the help of morphological operations. The fourth step is Optical character recognition in which convolution neural network classifier for prediction of characters was created with the help of MobileNet. This methodology shows the superiority in both performance and accuracy in comparison with the traditional license plate recognition systems.

II. THE PROPOSED ALGORITHM

Automatic License Plate Recognition system is divided into four steps:

1. Image Acquisition
2. License plate localization
3. Character segmentation
4. Character recognition

A. Image Acquisition

Figure 1(a) shows the instance when vehicle first appeared in the video stream. Figure 1(b) shows the frame when speed was calulated with the help of CSCS[8]. Since we know the speed of the vehicle we can find which frame number will be best suitable for vehicle license plate localization. Figure 1(c) shows the most suitable frame for vehicle license plate localization.

The frame number is calculated from the below expression:

$$Frame\ number = \frac{Distance\ *\ FPS}{Speed}$$

where,

Distance= Distance between ROI and the point which is most suitable for vehicle license plate localization.

FPS= Frame per second of the camera.

Speed= Speed of the vehicle estimated by CSCS.

(a)

(b)

(c)

Figure 1- (a) Image when vehicle first appeared (b) Image when vehicle speed was found (c) Image to be considered for license plate localization

B. License Plate Localization

For localizing the license plate first data set[20] was collected which consist of 1537 positive license plate and 3589 negative license plate. Figure 2(a) shows samples of the positive license plate and figure 2(b) shows samples of the negative license plate. For classifying positive and negative license plate, the License Plate Convolution Neural Network based classifier(LPCNNC) was used. LPCNNC consist of convolution-2D which takes input image of size 150*150 with a single channel. LPCNNC uses the max-pooling layer, flatten layer, dense layer, drop out layer. Relu was used as the activation function in each layer of LPCNNC and in the output layer softmax function is used for predicting two classes of the positive and negative license plate. For training the data set 'Adam' is used as the optimizer. Training accuracy was found to be 85% in 10 epoch. Figure 3 shows the architecture of LPCNNC used in our study. This trained LPCNNC was used for localizing the license plate. For achieving this Adaptive sliding window technique(ASW) is used. The size of the sliding window will vary according to the end application of the ALPR system hence ASW. Figure 4(a) shows the original image, figure 4(b) shows the starting point of the sliding window while scanning from left to right, figure 4(c) shows the snapshot of the instance when the license plate was detected. The proposed ASW technique is more robust than a conventional sliding window technique as it provides better 'Intersection Over Union' (IOU) and 'Mean Average Precision' (MAP).

(a)

(b)

Figure 2-(a) Samples of positive license plate (b) Samples of negative license plate

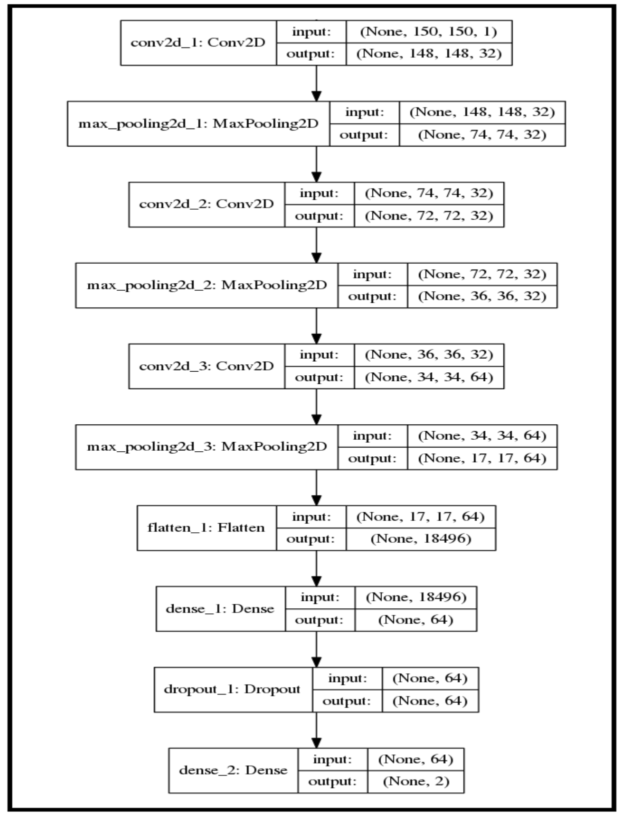


Figure 3 - LPCNNC architecture

(a)

(b)

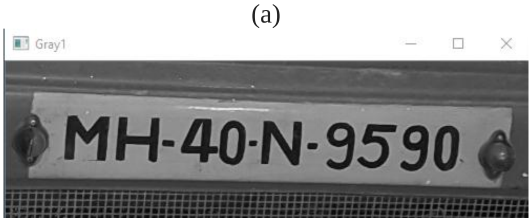
(c)

Figure 4- (a) Original image (b) Starting point of sliding window(in red) while scanning from left to right (c) Instance when the license plate was detected

C. Character Segmentation

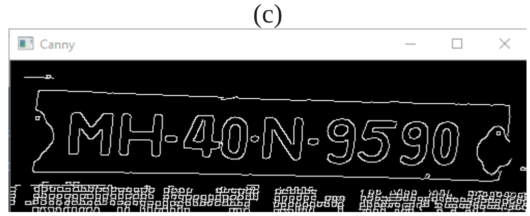
The extracted license plate from ASW needs not to be necessarily closely cropped as shown in figure 5(a). In order to get the exact boundary of the license plate, canny edge detection is performed by first blurring using a gaussian blur as shown in figure 5(c) and then performing canny edge detection as shown in figure 5(d). In order to close the small opening in the detected edge, the image needs to be dilated. After dilation, different contours are identified and the one whose area is found to be comparable with the output image(from ASW technique) is selected. Figure 5(e) shows the closely cropped Gausian Blurred image. On the blurred image, adaptive thresholding is done shown in figure 5(f). On the binary image morphological operation is performed as shown in figure 5(g). Finally, contours are identified shown in figure 5(h) to get characters from the license plate shown in figure 5(i).

(a)



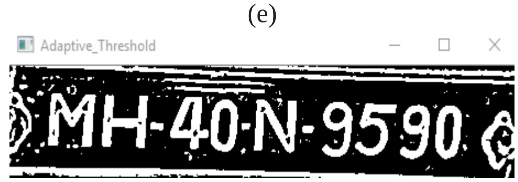
(b)

(c)

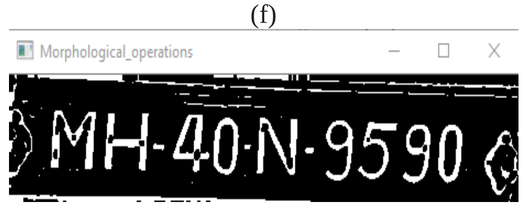


(d)

(e)



(f)



(g)

(h)

(i)

Figure 5 - (a) Output from ASW technique (b) BGR to gray converted image (c) Blurred image (d) Output after canny edge detection (e) Closely Cropped Blurred image (f) Output after adaptive thresholding (g) Output after performing morphological operation (h) Different contours identified (i) Segmented characters

D. Character Recognition

For predicting the segmented characters of license plate Character recognition convolution neural network based classifier(CRCNNC) is used. Data set[21] for CRCNNC is prepared which consists of 37 classes where each class denotes characters from A to Z and from 0 to 9 and the last class is for those which are neither alphabets nor digits(void). Figure 6 shows a sample of the data set. The initial layer of CRCNNC comprises of MobileNet (224*224). MobileNet[18] is originally trained from the ImageNet data set. Some initial layers of MobileNet are set to non-trainable for using it in CRCNNC. Fine tuning of the MobileNet model is done because the data set is not quite large and also our data set is quite different from ImageNet. Before fine tuning, the MobileNet model extra four layers are added which consist of a dense layer. Dense layer is added so that the model can learn from more complex functions and classify for a better result. We require 37 output classes from CRCNNC but MobileNet provides us with 1000 output classes, that's why in the output layer softmax function is used for predicting 37 classes. Figure 7 shows the architecture of CRCNNC. The training accuracy of CRCNNC was found to be 93%. The trained CRCNNC is used for predicting the characters. Figure 8 shows the final output in which characters are predicted whereas others are ignored.

Figure 6 - Sample data set

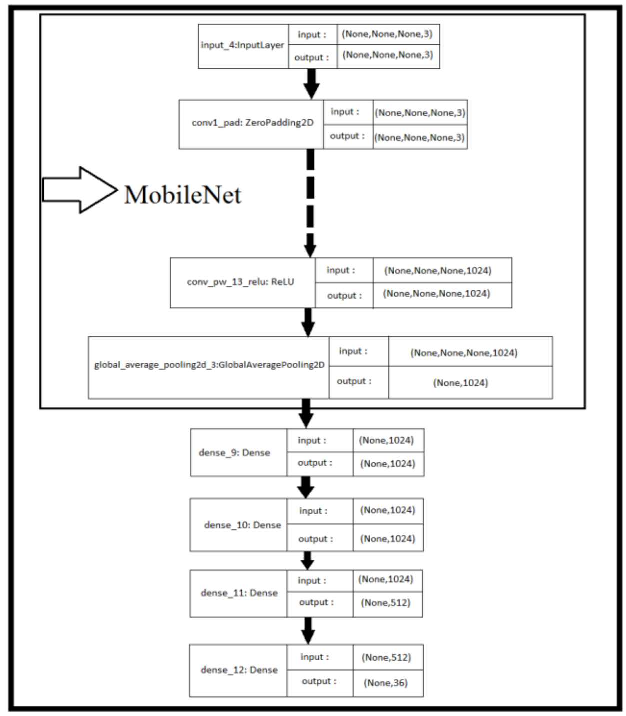


Figure 7 - CRCNNC architecture for character recognition.

Figure 8 - OCR output

Table 1 shows the integration of data generated from ALPR system with CSCS. CSCS has set a speed limit of 75Kmph. Vehicles who were found over-speeding are highlighted in red.

S.NO	SPEED (Kmph)	TIME	LOCATION	NUMBER PLATE
1.	20	10:14:51	NAGPUR1	MH29LA4072
2.	47	11:15:09	NAGPUR2	MH39QR1078
3.	70	11:15:24	NAGPUR1	MH40N9590
4.	77	12:02:19	NAGPUR3	MH31KR5967
5.	80	12:02:40	NAGPUR4	MH34BC0765
6.	35	12:40:30	NAGPUR5	MH40AR5078

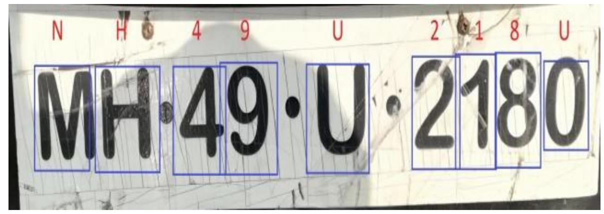
Table 1- Data generated after processing the video through CSCS and ALPR system

III. RESULTS

The proposed system was tested with a set of sample images, some of them are shown from figure 9(a) to 9(d) having a wide variation in illumination condition, written style, uncanny and skewness of the license plate. The ALPR system was found to have achieved satisfactory performance. However, it still faces the challenges of recognizing similar characters such as "D" and "0", "U" and "0", and "B" and "8". The training accuracy for license plate localization is found to be 85% and for character recognition, it was 93%. Figure 10 shows the True Positive and True Negative percentage of the classes(0-9,A-Z,Void) when model is tested over 2500 images[19].

(a)

(b)



(c)

(d)

Figure 9-(a) Test sample output for variation in illumination. (b) Test sample output for different styles of the license plate. (c) Test sample output for the uncanny license plate. (d) Test sample output for skewed characters of the license plate.

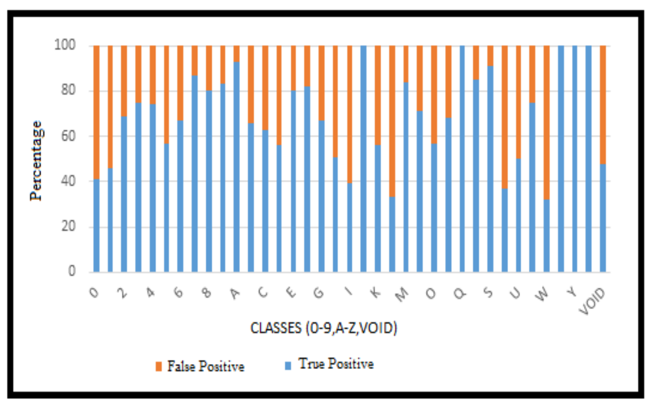


Figure 10- Accuracy Graph

IV. CONCLUSION

In this paper, we have proposed an efficient and automated license plate recognition system. The LPCNNC model has high accuracy in capturing the license plate. Also, the integration of the MobileNet model with CRCNNC for predicting characters of license plates has high accuracy. Experimental results show the superiority of the proposed automatic license plate recognition system in both performance and accuracy. The ALPR system can be further integrated with the Speed Calculation System for finding the speed of the vehicle and extracting the license plate of the vehicles so that further action can be taken by the respective authority.

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