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Indian License Plate Number Detection Using Convolution Neural Networks

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Abstract - *In this modern era, several technologies have been implemented for the identification of the number plate. License Plate Number Detection Using Convolution Neural Networks (LPND-CNN) is a method to identify the number plates of Indian Vehicles. There are different background colors that are used in the number plates to categorize the vehicle. In Indian vehicles, backgrounds are either white or yellow and this application will help to detect and recognize characters of number plate. This method uses the Single Shot Detection (SSD) Trained Model for Image Segmentation, Open CV Functions for Morphological Operations, and Convolutional Neural Network Model for Character Recognition and there are many applications that can be implemented by using this method. For example, traffic violation handling and traffic maintenance, for parking maintenance purposes to reduce the human efforts and efficient usage of technology. The Convolution Neural Network Model is trained with 45,000+ images and tested with 1,000+ images.*

Key Words: License Plate, Open Source Computer Vision Library (OpenCV), Convolutional Neural Networks, Deep Learning, TensorFlow.

1. INTRODUCTION

The world that we see today shows clear signs of drifting towards an easy and comfortable life for everyone. We live in a world where technology gets updated and upgraded at a very fast pace, all due to a constant research and development by a perennial flow of technocrats, providing a plethora of innovations and developments. This innovative mindset provides a drive to seek smarter solutions for the existing problems, promising a better and safer tomorrow. In this fast-developing world, vehicular commute is increasing at an alarming rate and is leading to many problems due to congestions and also due to irresponsible riding leading to accidents and mishaps. It may be needed to identify the people responsible for such deeds for the successful implementation of the law and making our roads safer. Hence automated vehicle plate detection will prove to be a handy and smarter solution to identify such vehicles and also to implement smarter parking facilities.

There are large number of approaches that are defined and implemented for the Number Plate Detection and Character Recognition and we have studied some of those analysis, and these are mentioned in the following survey. In [1], Real Time License Plate Recognition from Video Streams using Deep Learning done and License Plate Detection done through Morphological operations and other Adaptive threshold operations using Open CV and Optical character Recognition from License Plate through Convolution Neural Network model. In this paper to achieve High Accuracy, they worked with Convolutional Neural Network-CNN and K-Nearest neighbor model with several parameter changes and processing speeds of given Automatic License Plate Detection system is slow and could be further improved by using the parallelization approach for various stages of development. In [2], for License Plate Detection pre-processing is done through OpenCV and then CNN Model for License Plate Confirmation and Recognition will be done using another CNN Model. And Proper application of morphological operations, adaptive thresholding, fine contours and geometric filtering done in the pre-processing operations. And Detection process through CNN for knowing whether it is a License Plate or not a License Plate. But the problem with this paper is the Model is trained with a smaller number of Data Sets and Accuracy is low. For this reason, this Application to Real Time System fails. In [3], the application is developed for the specific country like Bangladesh and the pre-processing for the upper part and lower part done separately. In the process, Contour Detection, Filtering Contours, cropping of the lower Part and upperpart will be done. But in this model the system fails because of the diversity of the number plates in Bangladesh. And the paper must concentrate on the Making available for vehicles of all classes, night mode detection, and detection rate. In [4], This paper only concentrates on the License Plate Detection, there is no recognition will be done in this paper. This paper allows the system with the Convolution Neural Network Model and the License Plate Detection under different lighting conditions and also based on different camera orientations. In [5], License plate detection through Single Shot Detection for Object Detection, Character Segmentation with Vertical projection method and Recognition using Convolution Neural Network Model. In this paper the character segmentation based on the vertical projection and this process is a challenging phase for the implementation procedure. In this paper Detection accuracy is best among the featured but recognition accuracy lacks prediction of exact number of characters. In [6], A Review Paper on Automatic Number Plate Recognition System using Machine Learning Algorithms is done with the machine learning algorithms , in this the system is embedded with the camera Module and the system is processed with the N number of number plates with recorded in the database and

these are used for the training and testing of the developed system and plate detection will be done with the different OpenCV libraries (morphological operations) and recognition will be done through the Artificial Neural Network-ANN model and in this paper the author uses the KNN algorithm for the classification of the characters and it is very necessary that focus on the condition of the recorded images from the camera.

With the help of the survey of these papers, the understandability of the concept and ideas towards the concept comes into picture and this helps to move with the ideas and identification of the models with the pros and cons making it an easy task. And this provides a picture of the overall concept of their implementation ideas and how they have approached it with a problem domain and what are our challenges towards this project and what are the necessary things to be learned and what are the necessary technologies that needs to be used and this will in turn provides an overall view of our application.

2. Proposed System

Here, in this section, several phases to automatically detect and recognize the license plate and its respective number from the video input will be discussed. The complete procedure has been divided into different steps and the same are discussed here.

In this model, plate localization and pre-process of the image is initially executed and the input is provided in a video file for which we want the prediction to be conducted. This then breaks down the video into several frames. Then the frames which are obtained as the intermediate results are sent to the main function which will return the predicted image and the cropped license plate from the frames of images present. Then detection of the license plate number is undertaken, then comes in the segmentation of characters for the respective license plate and then the final phase which would be the recognition phase where the concluding characters and numbers that is been extracted with the help of convolutional neural network will be printed respectively.

2.1 Split Input Video into Frames

The initial steps that needs to be taken is to load the input video as a series of images. One of the advantages in this process is that we can control splitting of the frame rate, therefore in the video, if the speed of the respective vehicle is high, split the video into 60-80 frames to get better results. If the speed of the vehicle is quite slow, then 10-15 frames will be satisfactory. The phases described further are applied on each of these split frames obtained.

2.2 LP Extraction and Pre-processing of the Input Image

This step includes image segmentation which means to capture the license plate from the image or also called as plate localization. To achieve this, SSD trained model is been used. This is the actual model that is used for object detection. Next, frozen inference graph of tensor flow is been used to achieve the image segmentation. Once the plate localization is done, that respective image will be further passed onto the next steps which is pre-processing of the obtained image.

Now, the pre-process of the image is been conducted using OpenCV platform functions by initially converting the RGB image into a grayscale image, and the reason for this conversion is to achieve better detection of the plate and reduction of size of the image. Now the resulting grayscale image will in turn be transferred to high contrasted image. Contrast is the difference between light and dark image, high contrast images will have bright highlights and dark shadows, bold colours, and texture in the subject. Next, gaussian blurring is applied on the image to basically clear out the noise present and reduce the image detail. Blurring is used to reduce the edge content and makes the transition from one color to the other very smooth. After saving the intermediate image, finally adaptive threshold to eliminate any grey areas and this in fact clears the image more by removing all the unknown noise from it and the same is applied on the saved image. Then, we return the grayscale and the threshold image onto the next phase which is LP detection which is discussed in the next phase.

2.3 LP Detection

The main intention of this phase is to extract all the contours from the number plate image and group relevant contours into a list and return the list. Grayscale and thresholded image of the number plate from the previous step is been taken as the input. The first move in LP detection is to find all contours in the number plate. Contours can be explained simply as a curve joining all the continuous points (along the boundary), having same color or intensity. The contours are a useful tool for shape analysis and object detection and recognition. Here, for each contour that is present, this detection function, in the 'first pass' does a rough check on a contour to see if it could be a character and if it is then that particular character will be appended to the list. Now, the resulting contour image will be drawn associated with the possible characters in the plate. Therefore, the final output here will be list of all possible characters present in the number plate and this be further forwarded as the input to the next phase.

2.4 LP Character Segmentation

In this character segmentation function, it starts with all the possible characters and numbers (A-Z 0-9) in one big list. The purpose of this function is to re-arrange the one big list of characters into a 'list of lists' of matching characters, and here if any of the character that is not be found in the group of matches is not considered for further process. Here, a recursive call is made which helps in finding all the matching groups of characters present. One of the computations made to check to see if the characters are a match and are in order is by calculating the distance between characters, angle between characters, change in the area, change in width and height are considered. Once done, all the matching characters are retuned and respective contour for that is also

been drawn. The next step in this character segmentation is to remove all the inner overlapping of characters (if there are two characters overlapping or too close to each, then remove the inner(smaller) character, this is to prevent the existence of the same character twice if two contour are found for the same character). Once down, respective contour is drawn for the same and displayed. A Basic outline of the methodology is been displayed fig ure-1 below.

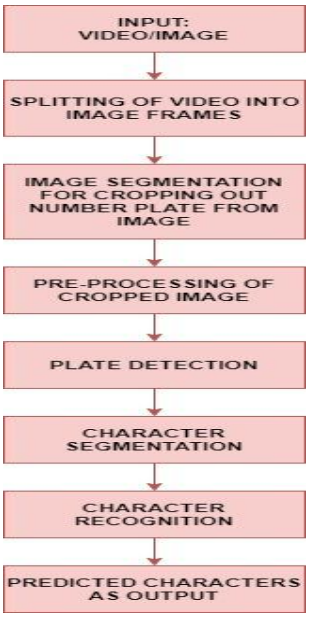

Fig-1: Flow chart

2.5 Character Recognition and CNN Model Architecture

To recognize characters in a plate, CNN Model is Used. From the Threshold Image of the number plate and with the list of single line text contours, A full length text of the number plate will be collected and provide it as output. The output is the String of all Characters from the plate. The Steps that are done in Character recognition before sending the image to predict from the CNN Model are a) Binary inverting the Threshold Image, b)Getting RGB form of Threshold Image ,c)String recognized from each line of Number plate ,d)Characters Cropped out of Threshold Image ,e)Resizing the Image. After Resizing, Number of Channels are chosen from the current model and then sent it to prediction with Input Image of 64 X 64.

A Convolutional neural network is a neural network comprised of convolution layers which does computational heavy lifting by performing convolution. Convolution is a mathematical operation on two functions to produce a third function**.** Convolution over an image f (m, n) using a filter h (m, n) is defined in equation (1):

$$G[m,n] = (f * h)[m,n] = \sum_{j} \sum_{k} h[j,k] f[m-j, n-k]$$

CNN is the best suited for image recognition tasks since they are able to capture spatial features of the inputs due to their large number of filters. To choose the best performing network architecture for the task of character recognition on the given dataset, a comparison of many pre-trained models and novel architectures was carried out. After taking into consideration the accuracies and learning obtained through different models, a novel CNN architecture was designed for this research. The structure of the proposed CNN architecture is given at Table-1 below:

Table -1: CNN Architecture

Layer type	Description
First Convolution Layer	32 Filters of Size 3 X 3, ReLU
First Max Pooling Layer	Pool Size 2 X 2
	32 Filters of Size 3 X 3, ReLU
Second Max Pooling Layer	Pool Size 2 X 2
Flatten Layer	Making it into a Single Column
First Dense Layer	Kernel:6272 X 128, ReLU
Dropout Layer	Dropout:0.5
Second Dense Layer	Kernel:128 X 36, SoftMax
Dropout Layer	Dropout:0.07
Output Layer	36 Classes Ranging from 0-9 and A-Z

The Input to the network is a pre-processed 64 X 64 Characters Plate. The network consists of two convolution layers, two max pooling layers, two dense layers and output layer. Number of filters used in two Convolution Layers are 32 with ReLu as the Activation function. Max pooling Layer follows each of the Convolution Layer with the pool size of 2 X 2 .Dense Layer with the Dimensions of 6272 X 128(First Dense Layer) and 128 X 36(Second Dense Layer) with the Dropout having 0.5 after First Dense Layer and 0.07 after Second Dense Layer were chosen with the Activation functions of RelU and SoftMax for the final output layer. Output Layer with 36 Nodes for 36 alphabets (A-Z) and digits (0-9) were chosen.

Hyper -parameters are all the parameters which can be arbitrarily set by the user before starting the training process. The table below shows the Hyper parameter set. The Neural Network was built using the Python Keras Module. Below at the Table-2 is the Hyper Parameter Table:

Table-2: Hyper Parameter Table

Hyper parameter	Value
Number of Epochs	5
Loss Function	Categorical _Cross Entropy
Optimizer	Adadelta
Learning Rate	0.01
Convolution Kernel Size	3 X 3
Max Pooling Kernel Size	2 X 2

3. Results and Discussion

For the Experimental Results, we created our own dataset consisting of 45,000+ Images for Training and 1,000+ Images for testing. This dataset was used in the Character Recognition phase where the Final Characters of Number

plate would be extracted. In the below Table we have provided the Hardware requirements for the Convolution Neural Network Training and also for the Entire Process.

3.1 Hardware Requirements

Table-3: Hardware requirements

Model	Lenovo-CFJBJBOP
Processor	Intel Core i7 CPU-2.8GHz
RAM	16 GB
System Type	64 Bit Windows OS
Memory	Minimum 100 MB Free Space
Graphics Card Version	Nvidia 1060 DDR5

Below at figure-2 shows the Results in each phase that we have obtained after execution.

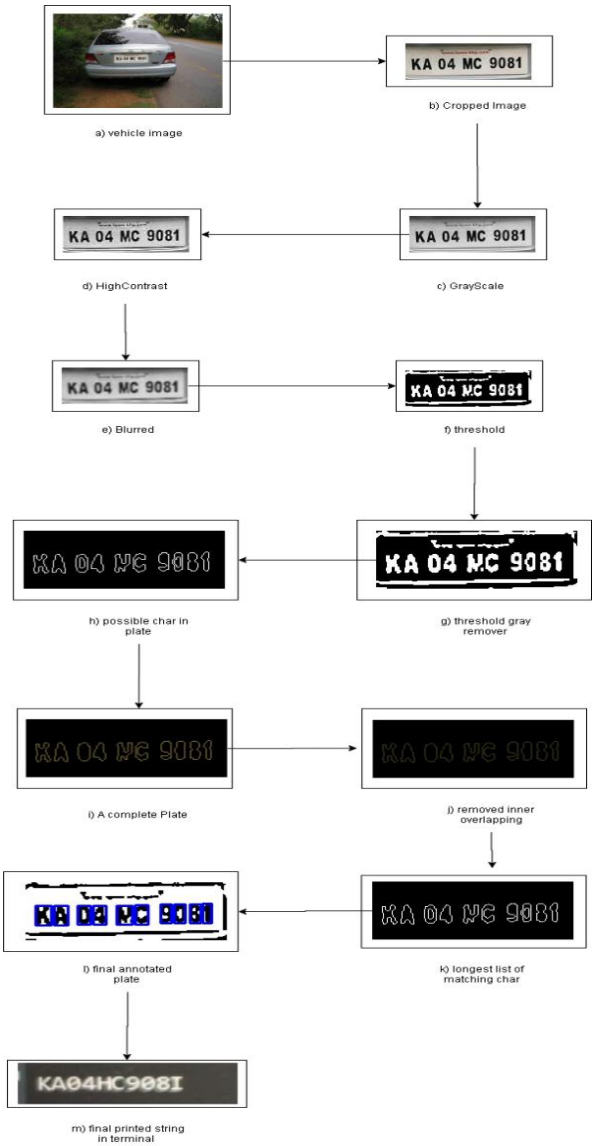

Fig-2: Flow & results produced at each stage

After several testing using several inputs are done, we can convey that the Prediction of Characters came quite good it recognized up to 8 Character in the total of 10 Character Number Plate.

4. Conclusion

In this project, we have developed a method for License Plate Number Detection and Recognition using OpenCV Tools and CNN Model. The final Result that we have provided is a String, so this could further be stored in some database along with the resultant cropped image and can be used depending on the application of work. We have made sure that the approach will give best results in Realtime and provide a research base to other researchers to carry further work in the field of Image Processing and Deep Learning. Our System could also Integrate with other things like Smart Parking, Recovery of Stolen Cars, Catching Drivers who Over Speed their Vehicles on Roads. There can be further improvement that can be done in Recognition Phase by improving the Dataset and also in the process of applying Morphological Operations.

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