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Deep Learning Based Image Recognition for Vehicle Number Information

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Abstract: A number plate contains a sign affixed to the front and rear of a vehicle for displaying its registration number. This registration number is used for the official identification purposes by the authorities. Most regular Optical Character Recognition (OCR) techniques perform well in recognizing printed characters on documents but cannot make out the registration number on the number plates. Besides, the existing approaches to number plate detection require that the vehicle is stationary and not in motion. To address these challenges to Number plate detection we make the following contributions: i. Use Neural Networks based Number plate character recognition, ii. Create a database of captured vehicle number plate's images, iii. Provide a client-server solution for quickly getting the details of a vehicle's ownership.

Index Terms: Optical Character Recognition (OCR); Image Recognition; Neural Networks; Deep Learning

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I. INTRODUCTION

All the motorized vehicles in India are tagged with a registration or license number. The vehicle number plate also called as registration plate is issued by the district level Regional Transport Officer (RTO) of respective states which is the chief authority on road issues. Every vehicle can be unambiguously placed with its registration number. The Indian number plates follow a specific format. The current format of the registration number consists of four sections. The first two characters indicate whether the vehicle belongs to a state or Union Territory. The following two-digit numbers are the sequential numbers of a district within the land. The third part consists of one, two or three alphabetic characters which announce the ongoing series of RTO and or vehicle classification. The fourth part is a four-digit number unique to each plate. Oftentimes, single or two letters are prefixed when all the four-digit numbers are used up. A typical Indian number plate appears as pictured in the below image:

Fig. 1: Sample Number Plate

Convolutional Neural Networks (CNNs) [1] or simply ConvNets are inspired by visual cortex. The visual cortex is the part of the cerebral cortex that processes visual information which it receives from the optic nerves. The advent of CNNs has made tasks like image classification, image recognition and other cognitive tasks easier and unchallenging. In our study, we have used the CNNs to recognize the alphabets and numeric digits of the number plates. For this purpose, we have captured images of two-wheeler and four-wheeler vehicles of Telangana and Andhra Pradesh states of India. This dataset is used to train a CNN architecture that is capable of effectively recognizing number plate characters.

Absence of a powerful Deep Learning based number plate detection system is what propelled us to go on one. Given the large number of classes involved (36, A-Z and 0-9) and their within class variability, the character recognition and classification is a complex task to address. Nonetheless, our CNN architecture performed well on the collected data set. Our contribution to Deep Learning based number plate recognition includes the following:

1. We make a big collection of dataset containing 11894 images for training and 7407 test images.

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2. We present a single convolution layer CNN architecture that gives best results on our dataset.
3. We created an Android app to get pictures of vehicles deploy the model and use it to distinguish the number plate.

The remaining portion of the composition is structured as follows in section 2 we will discuss the existing work in the field of number plate detection. Section 3, describes the novel approach that we proposed. Subsection 3.1 talks about the dataset used to train the CNN and sub-section 3.2 describes the CNN architecture that we employed for character recognition and classification task. Section 4, summarizes the performance of our model and Section 5 gives a brief conclusion and remarks.

II. RELATED WORK

The early approaches in the field image processing included the morphological operations where a structured element is taken as a reference and performed operations on an image. Such an approach was employed by W. Devapriya, C. Nelson Kennedy Babu and T. Srihari [2] which consisted of four major operations like erosion, dilation, opening and closing. It requires RGB image to be converted into a Gray scale image and then obtain binary image from it. The aforementioned operations were performed for detecting license plate and then segmentation of characters is followed by character recognition. Many classical approaches were taken into consideration for character recognition and the one which was used in their work was template matching.

Furthermore, the OCR (Optical Character Recognition) system was likewise utilized for reading text from the scanned pictures. There are two basic types of core OCR algorithms, which may produce a ranked list of characters. For all the approaches, there is a need to perform feature extraction separately by the developer and this might be a complex task. Different feature extraction methods exist for different representations of characters such as solid binary characters, character contours, or gray level sub-images for each individual character [3]. Neural Network based OCR [4] was proposed to provide a better and faster algorithm to recognize the characters.

Appending to the list of related works, the next approach purely focused on using HMM (Hidden Markov Model) [5] which is doubly stochastic process with an underlying stochastic process which is not visible but observed through another stochastic process which brings forth a succession of reflections. The hidden process consists of a sequence of states connected by transitions with probabilities and the observed process consists of values obtained by using the PDF (probability distribution function). For every input image a feature vector is and this vector is used to compare the images which arrive during testing to assign their classes. It is also to be noted that this approach also had a feature extraction which is done manually by using moment-based features which help in computing features like centroid, total mass, skewness, eccentricity etc.

Using CNNs for character classification is not something novel. Over the past few years there are several works relating to CNNs. The MNIST dataset used for handwritten digit recognition is what inspired many of the further projects in deep learning. Convolutional Neural Networks for Isolated Character Recognition proposed by Yann LeCun and others [6] suggested how CNNs can be used to effectively recognize characters by making non-linear mappings from a large number of examples.

Several works [7] suggested how CNNs can be used to improve the performance during solving image recognition problems. Back-Propagation Neural Networks have also been proposed [8] through which satisfactory results have been obtained. But CNNs however outperformed the back-propagation Neural Network.

III. PROPOSED APPROACH

Our approach to number Plate detection is simple and straight forward. We have collected images of over 5000 vehicles which includes two-wheelers and four-wheelers from the states of Telangana and Andhra Pradesh. Each of these images are then used to extract the number plate and furthermore the characters from these number plates. The characters so collected are used to train the CNN model. The trained CNN model can then be deployed in an android application. Through this application a user can capture an image of a vehicle or import from the gallery and process this image to get the textual format of the registration plate.

A. Dataset

Like any Deep Learning Algorithm, CNNs also require a huge a collection of datasets. Most of the existing preprocessing techniques work well for our number plate character dataset. But the characters are directly fed to the model without much processing except for rescaling the image to make them appropriate for training.

Before being used to train the model, the images of each number plate are loaded into an image processing software and its constituent characters are extracted by slicing action on the image. The characters so obtained are stored in their respective classes. This process resulted in a collection of 34 classes of characters (number plate collection do not include alphabets I and O) which summed up to 19301 images. These are further divided into train and test sets which are essential for training a CNN model.

B. CNN Architecture

We propose CNN architecture with a single Convolutional Layer followed by a single pooling layer that showed good results on our dataset. Furthermore, dropout regularization has been applied to randomly drop out neurons in the network to avoid overfitting. RELU (Rectifier Linear Unit) Activation function is used to adapt to variations in the output. Below is the CNN architecture diagram (as shown in fig. 2) pertaining to our study:

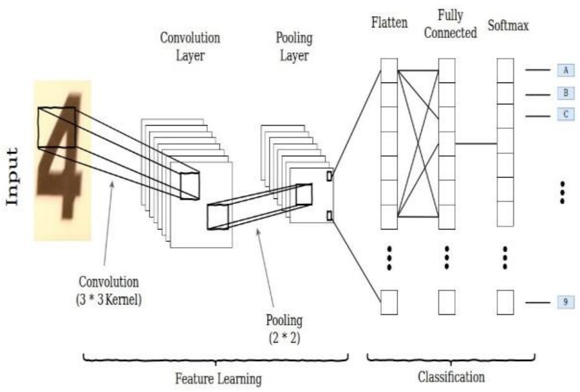


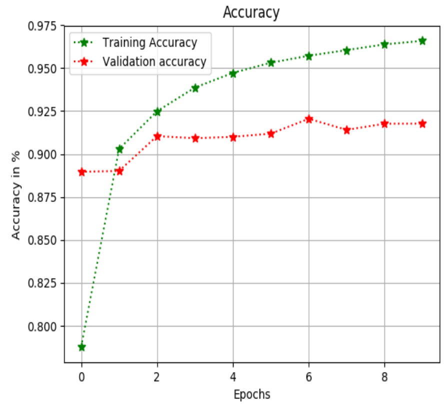
Fig.2. CNN Architecture

As can be seen, the architecture bear a single convolution layer, a single pooling layer, a flatten layer and two dense layers and finally an output layer. Thirty-two learnable filters have been used and each of these filters produces an activation map, which will be used by the network to ascertain from. A pooling layer is applied after the convolution layer. Its role is to progressively cut down the spatial size of the representation and to reduce the amount of computation in the network [8]. As a consequence of the pooling layer we obtain multiple pooled feature maps. The network sends these feature maps to a flattening layer. Flattening is a simple procedure of converting all the resultant two-dimensional arrays into a single long continuous vector. Next in the architecture, we have three fully connected layers which are simply layers of artificial neural networks. The purpose of these fully connected layers is to combine the features into a wide variety of attributes and assist the convolution layer in properly classifying the images.

Finally, we have an output layer with a many nodes as there are output classes (34 classes) in our dataset. Because we are dealing with categorical variable, we have used SoftMax Activation function which is a generalization of sigmoid function for multi-class classification. To model is then compiled using Adam optimizer to update the network weights iteratively. Categorical Cross Entropy loss function is used which is proven to work well for multi-class classification tasks [9-10].

IV. RESULTS

We trained our model on a training set of 11887 images and then the model is validated against 7307 images. Initially the model did not furnish a satisfactory result (around 75%), but once dropout regularization is used to start showing improved results. We found the model to be 96.7% accurate on the training set and the validation accuracy was around 91.5%. This model has promised for good classification and its performance can be varied by parameter tuning and finding out the best values for the optimizers and epochs. Below are the images related to our model performance and its summary.



(a)

```
>>> classifier.summary()
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 18, 18, 32)        896
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 9, 9, 32)          0
_________________________________________________________________
flatten_1 (Flatten)          (None, 2592)              0
_________________________________________________________________
dense_1 (Dense)              (None, 100)               259300
_________________________________________________________________
dense_2 (Dense)              (None, 100)               10100
_________________________________________________________________
dense_3 (Dense)              (None, 34)                3434
=================================================================
Total params: 273,730
Trainable params: 273,730
Non-trainable params: 0
_________________________________________________________________
>>> |
```

(b)

Fig. 3. Performance measurement of CNN Model (a) Training and validation accuracy graph (b) Summary of Classifier parameters used for model.

It is our opinion that a more comprehensive dataset containing a greater number

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of images will give great results. Also, the architecture can be made robust by including few more convolution operations and using better regularization techniques like simple data augmentation [4] or batch regularization [5].

V. CONCLUSION AND FUTURE WORK

Through our work, we have proposed a Deep Learning based character recognition for vehicle number plates. We have attained a good performance and promising results. The advantage of the proposed method over the existing method is that much preprocessing can be overcome in neural networks-based approach. Furthermore, we have developed a comprehensive dataset to facilitate training of machine learning [11-13] based models for number plate detection.

Our dataset and architecture can be further expanded and used to hold the text format of registration number. Such system can be linked to repositories that hold details of the vehicle owner and can be used for Automated Toll collection, theft detection, speed limit exceeding, etc.

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