

# Handwritten Character Recognition Using Deep-Learning

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**Abstract**—In this paper we present an innovative method for offline handwritten character detection using deep neural networks. In today world it has become easier to train deep neural networks because of availability of huge amount of data and various Algorithmic innovations which are taking place. Now-a-days the amount of computational power needed to train a neural network has increased due to the availability of GPU's and other cloud based services like Google Cloud platform and Amazon Web Services which provide resources to train a Neural network on the cloud. We have designed a image segmentation based Handwritten character recognition system. In our system we have made use of OpenCV for performing Image processing and have used Tensorflow for training a the neural Network. We have developed this system using python programming language.

**Keywords**—Neural Networks, Deep Learning, Tensorflow, Python, OpenCV, Android, JAVA.

## I. INTRODUCTION

As we All know , in today's world AI(Artificial Intelligence) is the new Electricity. Advancements are taking place in the field of artificial intelligence and deep-learning every day. There are many are many fields in which deep-learning is being used. Handwriting Recognition is one of the active areas of research where deep neural networks are being utilized. Recognizing handwriting is an easy task for humans but a daunting task for computers. Handwriting recognition systems are of two types: Online and Offline. In an online handwriting recognition system the handwriting of the user is recognized as the user is writing. The information like the order in which the user has made the strokes is also available. But in offline handwriting recognition system, the handwriting of user is available as an image. Handwriting recognition is a challenging task because of many reasons. The primary reason is that different people have different styles of writing. The secondary reason is there are lot of characters like Capital letters , Small letters , Digits and Special symbols. Thus a large dataset is required to train a near-accurate neural network model. To develop a good system an accuracy of atleast 98% is required. However even the most modern and commercially available systems have not been able to achieve such a high accuracy. Our system comprises of two parts:

1)An Android application: This is the frontend of our system. The android application helps the user to click a picture of text which is to be recognized , using their smartphone camera. This picture is passed on to a python script running on a server which further processes this image to extract the relevant information

2)A server: This is the backend of our system. This server is a computer which is capable of executing a python script. It is needed because an android smart phone does not have the computation power required for running neural networks and performing image processing operations. Also the use of server for performing computationally intensive tasks enables users of older smart phones to make use of our system.

We used the Convolutional Neural Network Model in our system. We used the publicly available NIST Dataset which contains samples of handwritten characters from thousands of writers. The neural network model which we have used is Convolutional Neural Network. CNN's are State-of-Art neural networks which have huge applications in field of Computer Vision. The neural network model was trained using Tensorflow which is an open source library used for Machine learning applications. OpenCV was used to perform various image processing operations like segmentation , thresholding and Morphological Operations. OpenCV is an open source library which is used for Image processing.

## II. RELATED WORKS

Immense research is going on in the field of handwritten character recognition. Many people have developed systems for handwritten character recognition. We have studied some of the systems:

A character recognition system has been designed using fuzzy logic[1]. The system developed by them can be created on a VLSI structure. Their character recognition system is immune to distortion and variations in shift. They have made use of hamming neural network in their system.

An innovative method for recognition of handwritten tamil characters using Neural Networks has been developed[2]. They have made use of Kohonen Self Organizing Map(SOM) which is an unsupervised neural network. The system developed by them can be used for recognition of tamil characters as well

as for the recognition of other indic languages. Their system produces near accurate results but sometimes produces errors if the handwritten characters are not properly segmented.

One of the Authors has presented a unique method for authenticating a person based on their handwriting[3]. The author has used the Multi layer feed forward neural network in their system. The author has proposed in this paper that the height and width of a handwritten alphabet is unique for each and every person. The author has presented a method for recognition and identification of a person from their handwriting.

A novel method for handwritten character recognition has been designed which does not use feature extraction[4]. They have implemented their system in Matlab. Their system uses a feed forward neural network with backpropagation.

One of the authors have proposed an unique method for handwriting recognition[5]. Their system uses Self Organizing Map[6] for feature extraction. They have used a Recurrent neural network[7] for learning. They conducted their experiment on recognition of Japanese characters.

### III. VARIOUS TOOLS USED

To design this offline handwritten character recognition system , we have used various tools like Python, Android, OpenCV and Tensorflow

### IV. IMPLEMENTATION

In this section we discuss how our system has been implemented. Let us first discuss the Android application that we developed for our system. Using this application the user clicks a photo of the handwritten document to be digitalized using the camera of the android phone. Shown next are the screen-shots of the developed application.

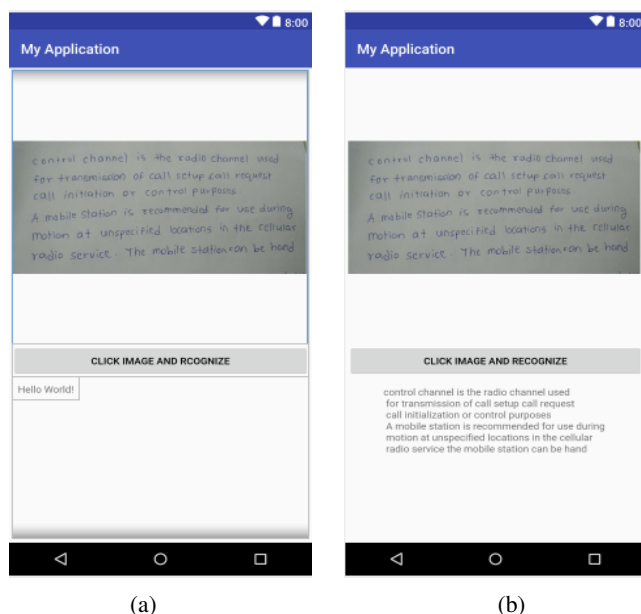


Fig. 1: Homescreen of The application and Results displayed to the user

An Android application was developed using which the user can click a photo of handwritten text using their camera. The clicked picture is sent to our server for processing at the backend. A neural network runs on this server which can recognize the handwritten text from image. The recognized text is sent back as a response to the android application which is displayed to the user as shown in Fig.1(b).

Now let us discuss how the backend of our system works. The backend of our system performs two important things. The first thing is hosting the pre-trained neural network model to serve predictions. The second thing is performing image processing operations on the image of handwritten text which is to be recognized. At the backend we have Neural network model trained using Tensorflow and a python script which is equipped with OpenCV library. We have used the Convolutional Neural network model.

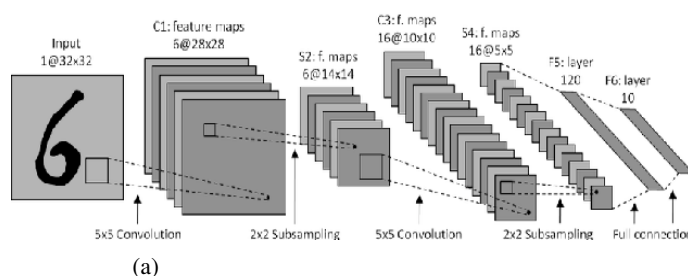
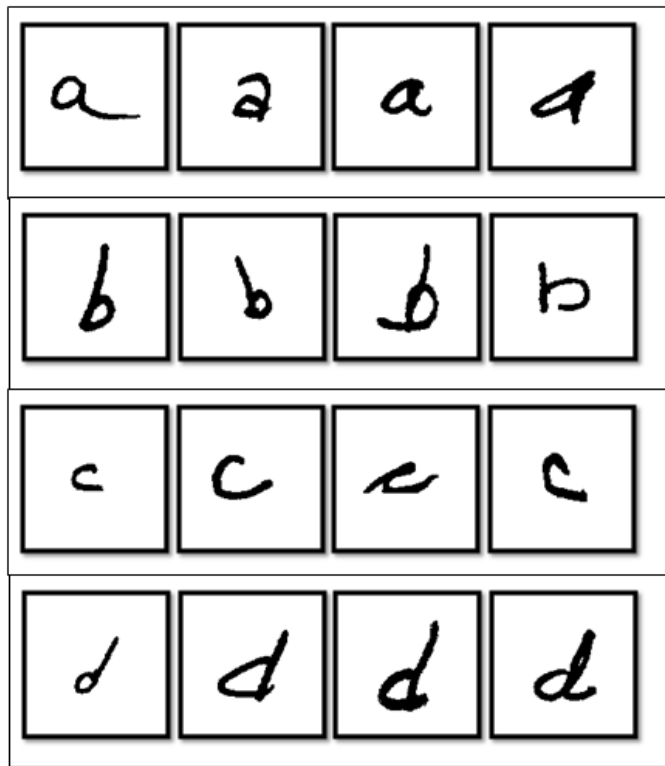


Fig. 2: A Convolutional Neural Network[15]

Convolutional neural network(CNN) is the current state-of-art neural network which has wide applications in feilds like Image and Video Recognition , Natural Language Processing , Recommender systems. CNN's are biologically inspired neural networks. CNN's are very good at image recognition. In case of CNN the input is a multi-channelled image(Often an image having Red,Green and Blue channels). A CNN comprises of a stack of Convolutional layer and a Max-pooling layer followed by a fully connected layer. The convolutional layer is the most important layer of network. It performs the convolution operation. The pooling layer comes after the convolutional layer. This layer is needed because in case of larger images , the number of trainable parameters can be very large. This increases the time taken to train a neural network and is not practical. The pooling layer is used to reduce the size of image. We used the NIST database which contains thousands of images of handwritten characters. Some of them are shown below. However these images were originally of size 128x128 pixels. The images in the training set were cropped to a size of 28x28. Reducing the size of images decreases the overall time taken to train the neural network model.

After the training the Neural network model, an accuracy of upto 94% was obtained.

Now let us discuss the various image processing operations which are performed on the image to be recognized. Following steps are involved in processing of images:



(a)

Fig. 3: Some of the images used for Training Neural Network

#### 1) Pre-processing:

This is the first step performed in image processing. In this step the noise from the image is removed by using median filtering. Median filtering is one of the most widely used noise reduction technique. This is because in median filtering the edges in image are preserved while the noise is still removed.

#### 2) Conversion to Gray-Scale:

After the pre-processing step, the image is converted into grayscale. Conversion into grayscale is necessary because different writers use pens of different colours with varying intensities. Also working on grayscale images reduces the overall complexity of the system.

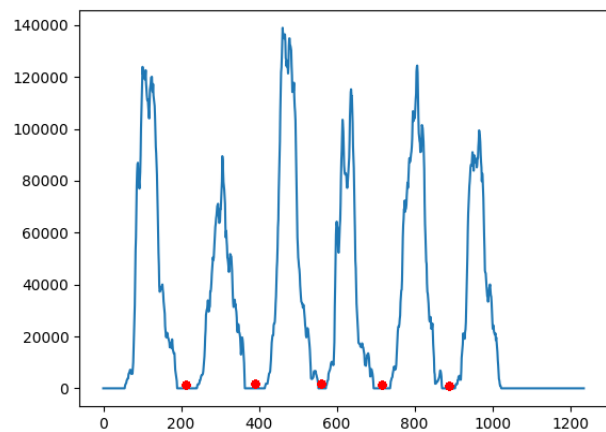
#### 3) Thresholding:

When an image is converted into grayscale, the handwritten text is darker as compared to its background. With the help of thresholding we can separate the darker regions of the image from the lighter regions. Thus because of thresholding we can separate the handwritten text from its background.

#### 4) Image Segmentation:

A user can write text in the form of lines. Thus the thresholded image is first segmented into individual lines. Then each individual line is segmented into individual words. Finally each word is segmented into individual

characters. Segmentation of image into lines is carried out using Horizontal projection method[16]. First the thresholded image is inverted so that background becomes foreground and vice-versa. Now the image is scanned from top to bottom. While scanning, the sum of pixels in each row of image is calculated. The sum of pixels will be zero if all the pixels in one particular row are black. The sum will be non-zero if some white pixels are present in a row. After this a horizontal histogram is plotted in which the X-axis represents the Y-coordinate of image (Starting from Top to Bottom) and the Y-axis represents the sum of pixels in the row corresponding to the Y-coordinate. The horizontal histogram is plotted using Matplotlib and is as shown in Fig.4(a).



(a)

Fig. 4: Horizontal Histogram of Image

The points marked in red are the points corresponding to the rows where sum of pixels are zero. After identifying all such rows we can easily segment handwritten text into lines at these points.

Now once the image is segmented into lines, each line must be further segmented into individual words. Segmentation of a line into words can be performed using the Vertical projection method. For segmenting line into words, we can make use of the fact that the spacing between two words is larger than the spacing between two characters. To segment a single line into individual words, the image is scanned from left to right and sum of pixels in each column is calculated. A vertical histogram is plotted in which the X-axis represents the X-coordinates of image and Y-axis represents the sum of pixels in each column. The vertical histogram is as shown below:

As we can see the points which are marked as red in Fig.5(a) are the points corresponding to the columns where sum of pixels is zero. The region where the sum of pixels is zero is wider when it is a region separating two words as compared to the region which is separating two characters.

After segmenting a line into words, each word can be

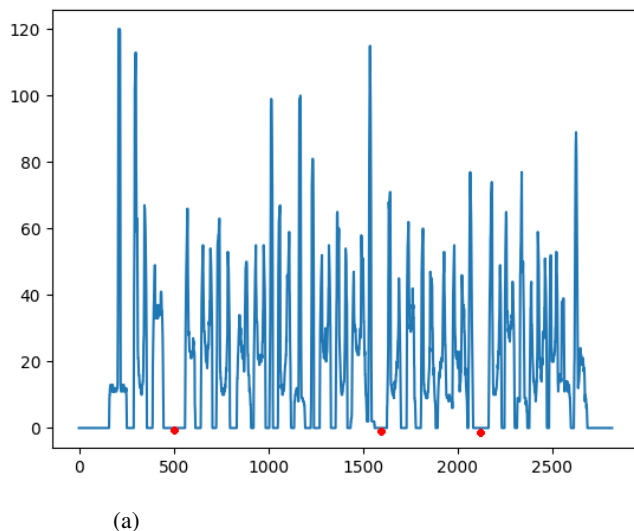


Fig. 5: Vertical Histogram of Image

seperated into individual character using similar technique as explained earlier. Now these individual characters are given to the pre-trained neural network model and predictions are obtained. Using this the final predicted text is sent back as a rersponse to the user.

## V. CONCLUSION AND FUTURE SCOPE

There are many developments possible in this system in the future. As of now the system cant recognize cursive handwritten text. But in future we can add support for recognition of cursive text. Currently our system can only recognize text in English languages. We can add support for more languages in the future. Presently the system can only recognize letters and digits. We can add support for recognition of Special symbols in the future. There are many applications of this system possible. Some of the applications are Processing of cheques in Banks , Helping hand in Desktop publishing , Recognition of text from buisness cards , Helping the blind in recognizing handwritten text on letters.

## VI. ACKNOWLEDGMENT

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