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OFFLINE HANDWRITTEN CHARACTER RECOGNITION SYSTEM – A REVIEW

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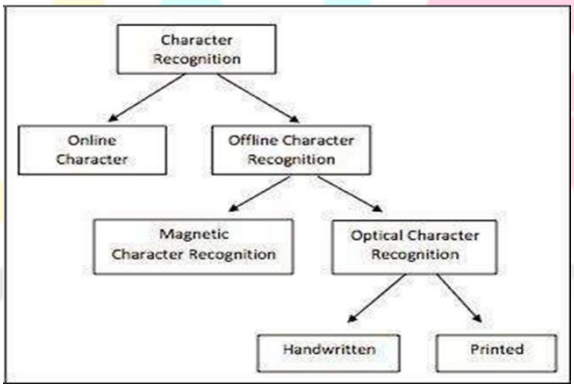
Abstract: In this paper we present an innovative method for offline handwritten character detection using deep neural networks. In today world it has become easier to train deep neural networks because of availability of huge amount of data and various Algorithmic innovations which are taking place. 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 loud 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 Jupyter, Tensorflowlite and Keras for training a the neural Network with the. We have developed this system using python programming language.

IndexTerms **- Handwritten Character Recognition, Neural Network, OpenCV, Android, Jupyter, Tensorflowlite, Keras, Python, OCR, Image Processing, Feature Extraction**

I. INTRODUCTION

INTRODUCTION

OCR- Offline 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 at least 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.

II. PHASES OF SYSTEM

PHASES OF RECOGNITION OF CHARACTER

Handwritten recognition is usually split into six stages: picture acquisition, pre - processing, segmentation, extraction of features, classification, and post-processing.

A. Acquisition of Image: The first stage of HCR is the acquisition of images. Ac- quirking an picture from a camera or scanner is a technique. The picture is in a defined file format, say JPEG, PNG. The picture input may be colored, grey, or binary. The acquisition stage comprises input image-processing, compression, depot and display. The user submitted picture will have certain limitations to adhere to. The limitations may differ to improve the precision rate of character recognition for distinct algorithms.
B. Pre-Processing: With vision to improve a picture for further processing. the pre-processing stage includes distinct operation phases. Preprocessing involves reducing noise, binarizing, detecting edges and thresholding.
You can remove unwanted noise signals from an image by using suitable filters. This filter may be a medium filter, a max filter or a Gaussian filter, etc. for removing noise from an image.
C. Reducing Noise: Noise is the haphazard variation in a picture's brightness or color intensity that is not present in the picture's initial object. The scanned input picture includes noise and may even be of reduced quality which might not result in a required consequence being adequate. The preprocessing stage involves the removal undesirable noise signals and enhancing image quality for the next following processing stages. If noise signals between sections of the lines are not removed, great gaps will arise; these noises should be removed to obtain all the significant data. In a bunch of pictures, one of them might have many noises.
D. Segmentation: The precision of the effective identification of personality depends on the precision of the segmentation carried out. The words are divided into single letters. A character is segmented from the beginning to the end of the character. It is possible to further classify segmentation into external-internal segmentation. External segmentation is described as the de-composition into logical units of the page layout. A significant aspect of document analysis is external segmentation. Internal Segmentation is described as the decomposition of a picture into sub- image sequence of characters.

E. Feature Extraction: The technique of collecting significant materialistic in- formation from the content of raw information. Important materialistic information is the accurate and effective depiction of characters. The set of characteristics obtained from raw information is referred to as feature extraction to maximize the character recognition rate including the least quantity of components.

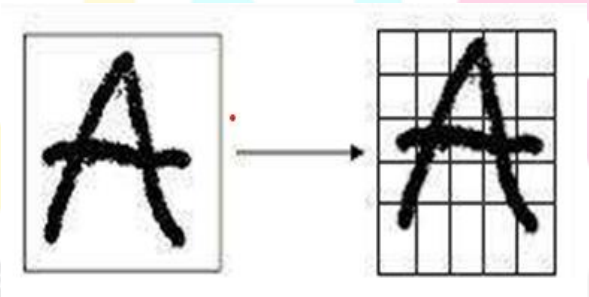


Fig. 1. Feature Extraction A

Extraction of features is not only an significant stage in the recognition of characters but also in any application for pattern recognition. Techniques such as Scale Invariant Feature Extraction (SIFT), Linear Discriminant Analysis (LDA). Histogram, Principle Component Analysis (PCA). Chain Code (CC), Extraction-based Gradient are used to obtain needed and helpful information characteristics. To train a system for executing pattern recognition jobs, these characteristics are essential

F. Diagonal Feature Extraction: Extraction of diagonal-oriented characteristics is a fresh technique introduced to extract handwritten alphabet characteristics. It primarily operates to acknowledge handwritten characters offline. For example, consider a size 80x50 pixel character picture that is further split into 54 areas, each area having a size of 10x10 pixels. The characteristics are obtained in each area by shifting across the area diagonal. Each area has D amount of diagonal rows and to extract a single function, the foreground pixels on the diagonal are added up. Extracting D number of sub- functions from every area.

G. Neural Network: To conduct duties of recognition and classification, an Artificial Neural Network (ANN) is used. The Artificial Neural Networks is now counted among the finest instruments for classification and strong character recognition in offline sys-terms. Neural networks are split into two designs that are primarily feed-forward and feed-back networks. Depending on the algorithm used, the feed-forward network has one or more concealed layers. Multiple neuron layers with transfer features

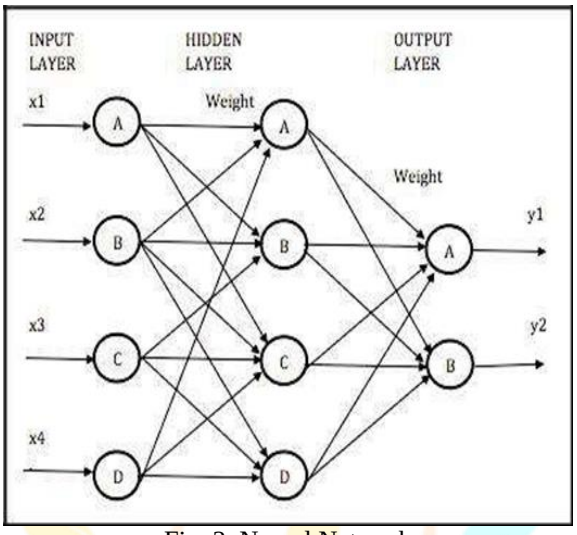


Fig. 2. Neural Network

allow the network to understand and recognize various linear and nonlinear I/O vector interactions. To obtain pattern recognition of handwritten characters, the NN architecture is used here. The classifier includes several smaller sub-networks, a 3-layer subnetwork.

III. VARIOUS TOOLS USED

To design this offline character recognition system, we have used various tool like Python, TensorFlow, Android Studio, OpenCV, Java, Jupyter, Keras.

IV. IMPLEMENTATION

Using jupyter we develop backend of application first we host neutral network model to server then we provide training to that neutral network model

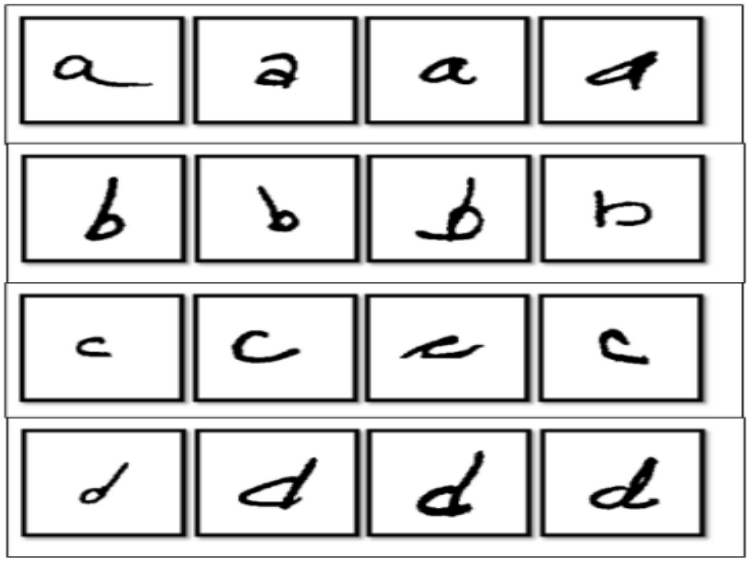


Fig. 3. Some of images used for Training Neural Network

And perform image processing operation on image of hand written text which is to be recognized. At backend we trained Neural Network model using python script with OpenCV library and keras. We have used convolutional Neural network model.

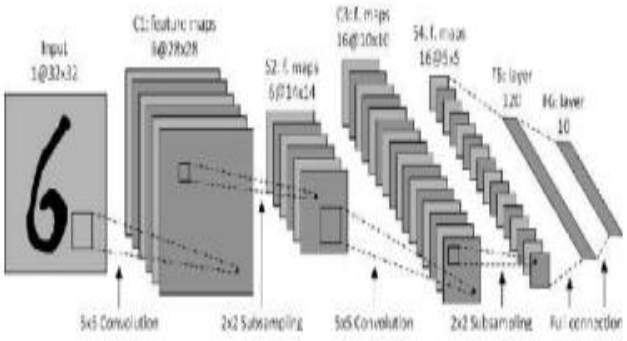


Fig. 4 : Convolutional Neural Network

Convolutional neural network (CNN) is the current state-of- art neural network which has wide applications in fields 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-channeled 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 up to 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:

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 preprocessing step, the image is converted into gray scale. Conversion into gray scale is necessary because different writers use pens of different colors with varying intensities. Also working on gray scale images reduces the overall complexity of the system.

3) Thresholding: When an image is converted into gray scale, the handwritten text is darker as compared to its background. With the help of thresholding lee 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. 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

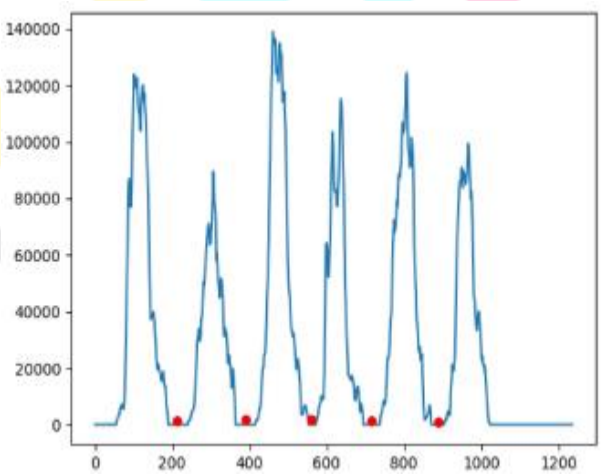


Fig. 5 : Horizontal Histogram of image

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 between two characters. To 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.

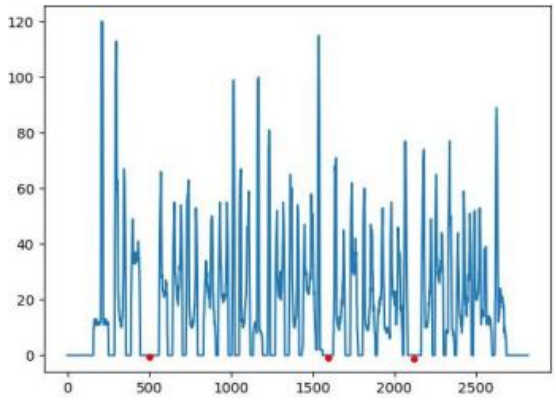


Fig. 6: Vertical Histogram of Image

As we can see the point which are marked as red 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 separated 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 response to the user.

V. CONCLUSION

There are many developments possible in this system in the future. As of now the system can't 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 business cards. Helping. the blind in recognizing handwritten text on letters.

VI. REFERENCES

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