



# HANDWRITTEN CHARACTER RECOGNITION USING MACHINE LEARNING

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## Abstract

The paper we are presenting is Offline Handwritten Character Recognition using Machine Learning. Because accessibility of a large amount of data as well as numerous algorithm upheavals has led to training machine learning effortlessly. The image segmentation is built on handwritten character recognition. We have used OpenCV for image processing, Tensorflow for training the Neural Network and used python programming language to develop this system. Machine Learning takes out concealed details that lie in the data. Machine Learning can be used to attain and foresee output for unrevealed data by which we are putting some mathematical functions and notions to reveal unrevealed details. One main application of Machine Learning is Pattern Recognition. Because of the large image data set, patterns are perceived by others. By utilizing these ideas, we have to a train computer to read alphabets and numeric characters in any language existing in an image dataset. There exist various methods using handwritten character recognition with which it can be recognized.

**Keywords:** CNN, OpenCV, Tensorflow, Python, Pattern Recognition, Handwritten Character Recognition, Feature extraction.

## 1. Introduction

Machine Learning has become a more useful technology to recognize objects. Some examples are Face Recognition and Handwritten Character Recognition. These things can be done by using a large set of the image datasets. The dataset has two perspectives regarding that domain one is positive and the other is negative. The unknown data can be classified in better ways with the help of algorithms. Nowadays, handwritten recognition is a new technology and it is very convenient in this century. As it is a build component so new demands will take place. A Handwritten algorithm helps to identify the characters in the image and then convert them into text. Handwritten Recognition is a type of Optical Character Recognition. OCR is automation that helps to identify

the text which may be in printed or handwritten form. It can capture the document through a camera and convert it into applicable formats. This can reduce human involvement in such scenarios. There are two approaches to Optical Character Recognition first is Printed Character Recognition and the second is Handwritten Recognition. Printed Character Recognition is the character which recognizes the image of a newspaper or from any other sources. Handwritten character recognition presupposes human involvement i.e. one is written by a human. Handwritten Recognition is divided into two modes, first offline character recognition and the second one is online character recognition. Offline Character

Recognition involves images of documents or words. Online Character Recognition needs special writing pads and an electric pen which are used to recognize characters at the time of writing in the online process [1][2][3].

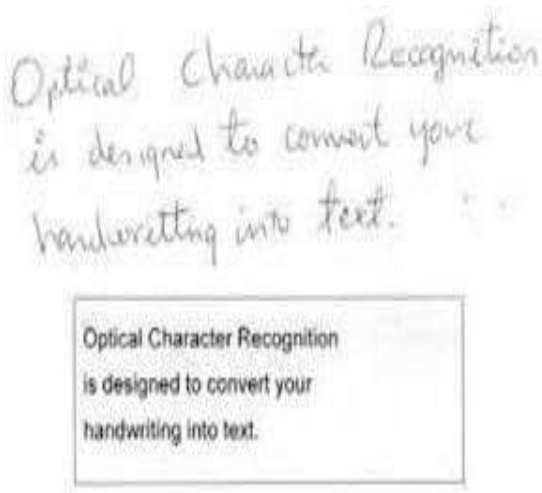


Figure 2.1. Describes Handwritten Character Recognition

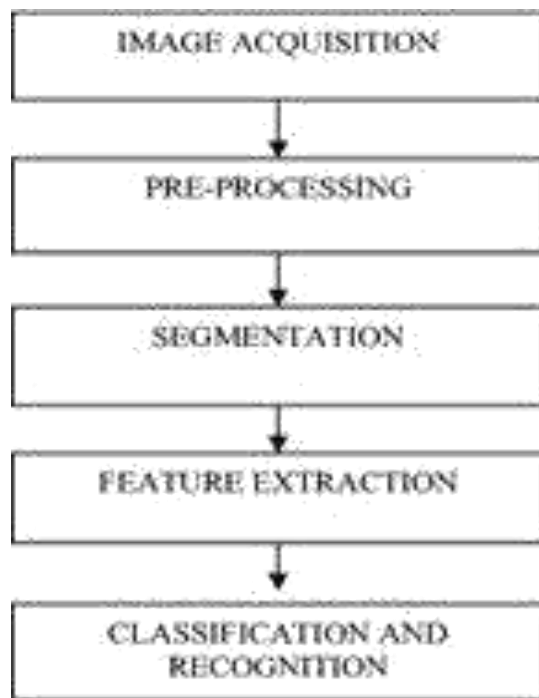


Figure 2.2: Stages in OCR

**i) Image Acquisition-** This is the first phase of handwritten character recognition in which we can take the image from any digitized tool or we can capture the image which is already handwritten and then send it to the next phase [4][5].

**ii) Pre-processing-** It is a process in which we can improve the quality of the image and that can increase the accuracy of the image. The following pre-processing techniques are as follows: [6].

**a) Noise removal-** It is a pre-processing technique in which we can remove the noise so that the smoothening of the image will increase and also decrease the unnecessary indicators from the image. There are several methods to remove noise such as Gaussian Filtering Method, Min-max filtering method, Median filter and many more [7].

**b) Binarization-** This is a technique which can convert the coloured images into a binary image. Binary image contain the image only in 0's and 1's format. The pixels in images can be partitioned into zeros and one's construct on a few persistent value i.e. if the values is less than persistent then it should be replaced with 0 or else with 1 [8].

**c) Morphological Operation-** This operation performs the increment and decrements of the size of an image. It can be done because the algorithm would look for the persistent image size. If we want to enlarge the size of an image we could put on pixels to the boundary otherwise if we want to decrease the image we have to decrease the pixels of the boundary of an image [9].

**iii) Segmentation-** It is a feature that extracts the individual character in the image. Segmentation is of two types one is implicit which involves words

recognized without the segmentation process and the other one is explicit which involves words are recognized with segmentation [10][11].

**iv) Feature Extraction-** The algorithm starts from here and it is also a very important part of this character recognition process. It contains several rules to define the feature of the character and also each character can contain its features. This phase can be done with the extraction of features [12][13].

**v) Classification And Recognition-** After all the steps, the training is completed and testing will take place. In testing, we would pass the input data to action and differing probabilities to similar rules. The rule with inflated possibility is chosen and correlated with the class label is made to identify the character [14] [15].

## 2. Literature Review

CNN's full form is Convolution Neural Network. Convolution is referred to as coiled. A neural network works in the close way of the human brain and their design is inspired by a human brain. CNN's main use is for image classification. CNN has many layers. There are two learning algorithms one is the Scaled Conjugate Gradient algorithm and the other is the Resilient Back-propagation algorithm. The scaled Conjugate Gradient algorithm work well in preciseness and training in contrast to the Resilient Back-propagation algorithm. There are three layers in [16][17].

CNN. These are:-

- i) Convolution Layer
- ii) Polling Layer
- iii) Fully Connected Layer

### Convolution Layer

Pattern detection has given the proposal for image classification in the convolution layer. To increase the rate of every single character, we use Machine Learning (ML). The input given to the convolution layer is in the matrix form of width\*height\*depth. Depth refers to a various numbers of channels in an image. The number of the channel is one for grayscale images and Three for RGB images. CNN operation is performed after the RGB image is converted to gray scale image [18][19][20].

The matrix used in the convolution layer is the kernel or filter. The pattern will be recognized with the help of kernel. Computation takes place in this layer. The second layer can accompany the first layer of convolution. The kernel inside moves across the responsive field of the image and inspect the feature there in the image. After many iterations, the kernel moves in the entire image. A dot product is calculated between the input pixel and filter after every iteration. The final output is called a feature map or convolved feature. The image converted to numerical value allows CNN to convert the image and draw out suitable patterns from it [21][22].

### Pooling Layer

The algorithm used works well with accuracy and time complexity. Offline handwritten digit recognition is based on some ML techniques such as Support Vector Machine, Naïve Bayes, Bayes Net, Multilayer perception, WEKA, Random tree, Random forest and J48. Dimensionality reduction is the result of using layers. The output given by the convolution layer can be (200\*200) which cannot be taken input for the further layer as it is already a fully connected layer. If we want to avoid this matrix size should be decreased.

This dominant submissive feature is extracted from the image in the pooling layer which is known as max-pooling, min - pooling and average pooling. Max pooling can be used for handwritten character recognition. A fastened size of vacant batch  $m*n$  size comes along the image in pooling. The max, min or avg value of every pixel is taken into a batch overlap on a specific part of that convoluted matrix and by filling the pooling value, a new matrix is formed [23][24].

### Fully Connected Layer

The fully connected layer gets hold of the output of the pooling layer which is mostly a matrix and distributes the image into a tag. Matrix gets to change into a single dimensional array which is known as flattening. Some features of the object show the probability of value in vectors. The flattened value pass by many layers of a perceptron. Then the input is expanded by weight and goes to the activation function which is likely to be ReLU that removes the negative in input. The equation of ReLU is shown as  $f(x) = \max(0, x)$  which states that if input given to ReLU is -ve, it will give zero else it will return input. Normally CNN experience various iterations which is known as Epochs. There are a number of epochs and accuracy is directly proportional to each other. If there increases the number of epochs, the accuracy increase and if the threshold is crossed, the accuracy decreases [25][26].

### Handwritten recognition using ML

To recognize handwritten character recognition many algorithms are made. OCR (Optical Character Recognition) is a technique accustomed to identifying the handwritten characters and printed documents. Handwritten documents are referred to as those written by hand. There are two recognition methods which is:-

i) Offline handwritten recognition ii)

Online handwritten recognition

#### Offline Handwritten Recognition

It is the method by which documents are already stored and written to make it easier to recognize the character in them. These characters are alphabetical or numerical or they can be present in another symbol which is used to recognise mathematical expression. It can be used in various phone applications which helps freshers inspect the paper and provide the solution.

#### Online Handwritten Recognition

Online handwritten recognition is used in real time. In this, the data is not inspected from paper. It uses the electric pen to write the characters and then those characters are identified in existing times. Strokes are contemplated for character identification [27][28].

## 3. Proposed Methodology

The project we have to use a convolution neural network to determine character recognition so that the given is preprocessed successfully. The Neural network is explained in detail along with character segmentation. The first step to collect data we have to use EMNIST dataset to train the proposed model. The dataset may contain several handwritten character which are small and capital alphabets and that may train and test the handwritten EMNIST dataset. It helps to perform handwritten identification and verification experiments thoroughly. The EMNIST dataset is a collection of a handwritten digit characters which are taken from the NIST special [29][30].

Database 19 can be turned into a  $28*28$  pixel image layout and dataset design. Now, data is collected successfully next step is to preprocess the collected

data. There are some techniques to preprocess the data i.e. thresholding, resizing, blurring, reshaping, etc. in which input image can be processed. OpenCV is used to preprocess the user's input images. Thresholding is a very useful technique in which the pixels of an image is used to change easier to interpret of an image. Thresholding is used to convert coloured image into the binary image which is simply black and white coloured. Thresholding is a good technique to select areas of interest in an image. A Gaussian blur (Gaussian smoothening) used to affect in fading of an image. Also, the Gaussian function can take place in image processing. To minimize image noise we have to use common effects in graphics software. In this proposed model we can resize the image to 28\*28 pixels. Binarization can transform the coloured image to a white and black coloured image effectively. This can reduce the information of an image which are having 256 shades of coloured or gray into two shades that are black and white. The CV2 library is used to recognize the word or given text after the preprocessing had done. The next step is to design and train the model. The model consists of three layers of a convolution neural network. CNN is used to take out the quality of an image. It is used by several layers by applying the filters. To concentrate on the number of features extracted we have to use the maxpool layer which is followed by the convolution layer and the output is ultimately the max pool layer. The fully connected network is taking the input from the convolution layer which one flattened and can be converted into a vector of a single dimension. The model has an input image of size 28\*28 pixels and it is gray-value image. We have to use three layers of CNN. The first layer is the convolution layer with 32 filters of scale (3, 3). Relu activation function can be achieved by the negative value of normalization. A pooling layer of size (2, 2) is

used to pick the maximum element of the feature section. The output is forwarded to the second convolution layer with 64 filters of scale (3, 3) and then send back to the pooling layer. The output of the second convolution layer sends to the third convolution layer with 128 filters of scale (3, 3) and then again send back to the pooling layer. To avoid overfitting we need to set the dropout function to 0.2. After all, process had done then we need to apply batch normalization which reduces training time and accelerate training which is used to make deep networks trainable.

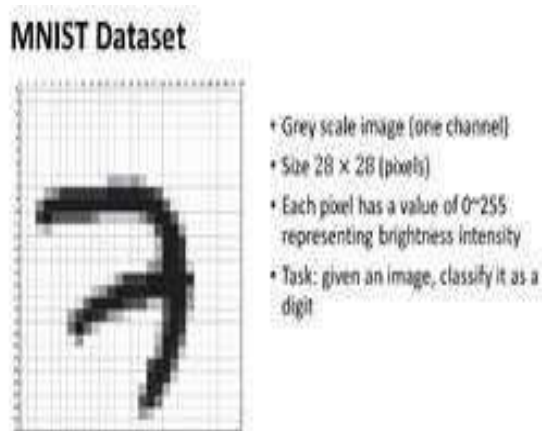


Figure 4.1: MNIST dataset

#### 4. Experimental Result Discussion

In this result, a new partition is made to solve the influence of the dataset. The Experiment data processing is used to decrease the influence of character similarity. The dataset can be trained and validated on three sets of data and may show different results also the results can be analyzed to compare which dataset is more accurate for the experiment.

- i) The First dataset contains 62 characters which may include numeric characters i.e. 0 to 9 and also the English alphabet i.e. small and capital letters.

ii) The Second dataset contains 36 characters which are containing alphabets (upper case or lower case) grouped. The influence of the result can be observed that are used to verify the existence of capitalization and letter similarity.

iii) The Third dataset consists of 49 characters. According to the first dataset, the similar character (O, o, 0), (R, r), (V, v), (Q, q), (D, d) are classified and processed i.e. (O, o, 0) are classified into one class and likewise others.

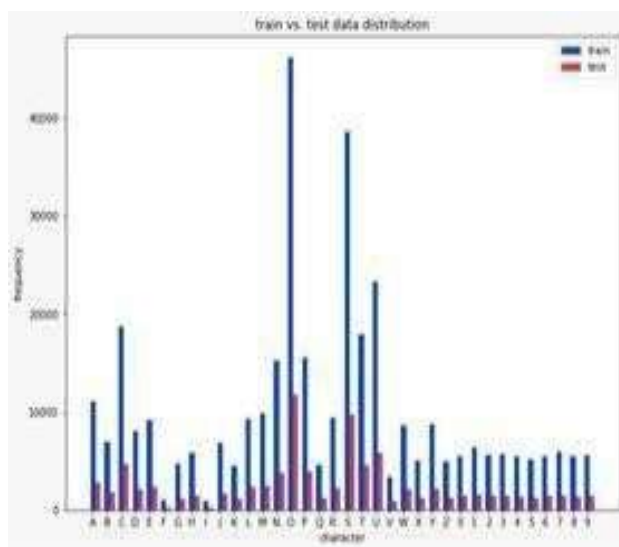


Figure 5.1: It describes the data which are containing alphabets (lowercase and uppercase) and also numeric characters.

## 5. Conclusion

The preciseness and competence of handwritten character recognition have extended to a high level as its recognition rate is nearly around 100%. This paper on handwritten character recognition firstly challenges more datasets of handwritten character types and enhances the convolutional neural network model. Secondly, it seeks diverse categorization process for the dataset, and confirm the effect of comparable

preciseness based on experiments to choose a better classification effect. To adopt more appropriate optimization algorithm, different optimizers are being compared to influence the experimental result. Lastly, with the TensorFlow framework, handwritten recognition has reached a cognition rate of 88%. Some approaches of handwritten recognition are Convolution Neural Network (CNN), Zoning, incremental, Semi incremental segmentation, Slope and Slant Correction. Convolution Neural Network (CNN) has the highest accuracy and the minimum correctness comes from Slope and Slant correction method that is mentioned above. We will attain good accuracy when the dataset of an image is trained with CNN as it is the successful method for handwritten recognition. The disadvantage with CNN is that its training time for model is huge as there are many image samples incorporated.

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