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# Handwriting Recognition by MNIST

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## Abstract

*Digital documents are easier to store and process. The task of taking a decision to identify the character can be accomplished by using Optical Character Recognition. The chief purpose of Optical Character Recognition is to make editable documents from the existing paper documents or image files by employing automatic classification methods to so that various operations can be implemented on the document with ease. It reduces human efforts to a large extent, making work more reliable and time-efficient. A research was taken on to identify the gaps in the existing methodologies to come up with a solution. 'Recognito' identifies isolated integral values by making use of Convolution Neural Network and Supervised Learning algorithms. Each layer of the neural network filters the input data by identifying the pixels in the image which are lit-up more than the threshold value, taking us closer to the expected output. These pixels are identified by nodes and layers of the neural network. Each node of a layer is responsible for detecting various patterns like loops, number of loops, lines, position of the lines, number of lines and curves. These factors are further used to differentiate a number from the other. These nodes process the input and send the result to all the nodes of the next layer for further processing and decision making, eventually leading to the expected output. The novelty of this approach is that, along with making use of MNIST database, it learns from the regular training of database by inputs provided to it and, thus increasing the reliability and accuracy gradually. The beneficiaries- government officials, data analysts, accountants and exam evaluators can gain access to this by free online and subscribed offline distribution which will gradually and eventually generate revenue.*

***Index Terms:*** *Optical Character Recognition, Neural Network, Convolutional Neural Network, Number Identification, MNIST database etc.*

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## 1. INTRODUCTION

Handwritten character recognition is a combination of two fields namely image processing and pattern recognition. There are two approaches involved in Optical Character Recognition for hand written numbers which can be classified as structural approach and statistical approach. In structural approach, a character is identified on the basis of interrelationship and interconnection of various features whereas in statistical approach, data in generated based on input and is assigned to one of the n classes. Since all handwritten aren't the same, building a general recognition system which can identify a number which can identify a number with high accuracy is needed. Hence, such systems are developed keeping in mind maximum reliability and need for high performance. In particular, hand written digit recognition for isolated integral number is helpful wherever there is a need to process data without having to invest in manual labour, which saves time, resources and increases efficiency. Thus, it has found applications in various avenues like banking, data analysis, exam evaluation, accounting etc.

Hand written digit recognition can be divided in four stages:

- Acquisition of data.
- Pre-processing the data

- Extracting features
- Classification

These operations are performed by various machine learning algorithms. The task of classifying the number can be accomplished by Convolutional Neural Network, each layer of which is responsible for taking a decision based on some parameter. A neural network consists of nodes or neurons which are essentially classifiers. Each neuron makes a decision based on the features it identifies in a digit, for instance number of loops and lines. These factors are further used to differentiate a number from the other. These nodes process the input and send the result to all the nodes of the next layer for further processing and decision making, eventually leading to the expected output. Along with making use of MNIST database which consists of 6000 samples of hand written numbers, this algorithm learns from the inputs provided to it and its regular training. This helps in increasing the accuracy and efficiency over the time. Out of the four stages of handwritten digit recognition, these samples have already been through acquisition and pre-processing stages, leaving feature extraction and classification to algorithms. Since we are making use of existing database, supervised learning algorithm becomes useful.

The pipeline architecture of entire process is as follows:

1) Pre-processing
2) Import data set
3) Building and implementing software regression model
4) Training and evaluating the model
5) Classifying the digit.

In upcoming sections, we give detailed explanation of methodology, Experimental setup and result, conclusion and references in Section 3, section 4, section 5 and section 6 respectively.

## 2. ARCHITECTURE

### 2.1 Input Data Set:

We are going to take the MNIST datasets for training and recognization. We have 60,000 images are used to train a model and a separate set of 10,000 images are used to test it. Every image is a 28of 28 pixel square (784 pixels total). This standard spit of the dataset is used to evaluate and compare models. There are 10 digits (0 to 9) or 10 classes to recoginze. Results are noted using prediction error, which is indirectly known as inverted classification accuracy. We are going to use Keras deep learning library for loading the MNIST dataset in our project.

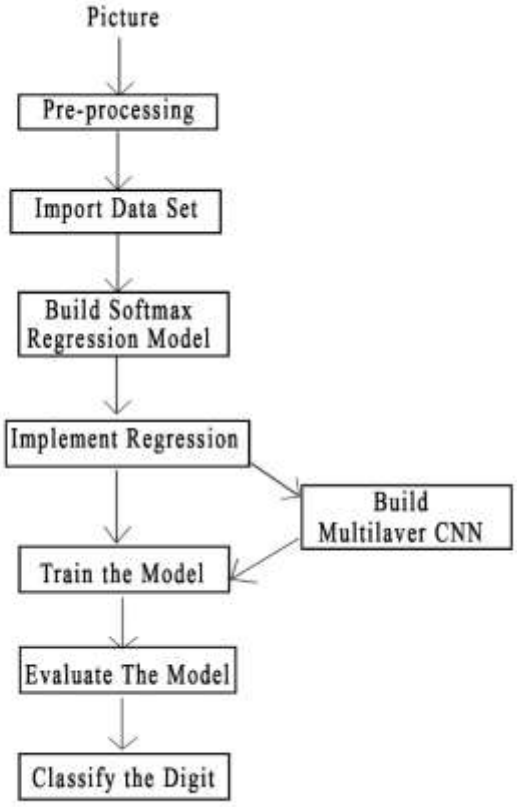


**Fig 1:** pipeline architecture of entire process

### 2.2 Preparing CNN Model:

CNNs are a special type of neural networks. In CNN, Neural Networks receive an input, and transform it through a series of hidden layers. Each hidden layer is made up of a set of neurons, where each neuron is fully connected to all neurons in the previous layer. The last connected layer is called the output layer.

CNN can be divided into two parts:

i) Feature learning part: Feature learning is done by combining two types of layers: Convolution layers and pooling layers. ii) Classification: performance is based on the learned features through dense layers. We need the following python libraries to build our neural network.Numpy – It is use perform matrix/vector operations as we are working with Images. Matplotlib – Use to visualize what's happening with our neural network model.Tensorflow, Keras - It is use to create the neural network model with neurons, layers.

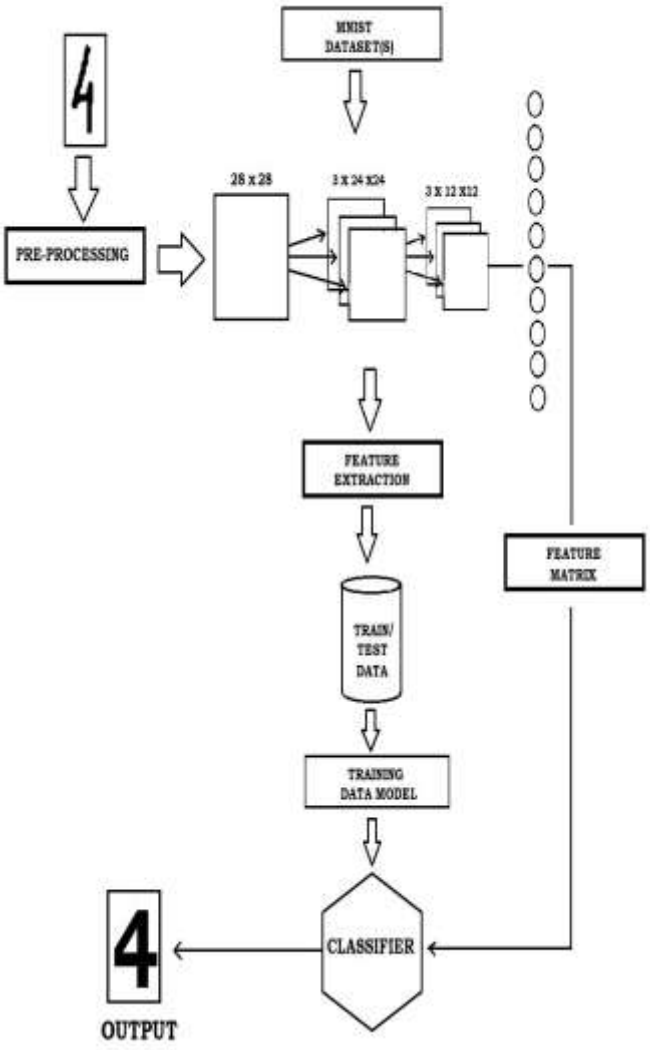


**Fig 2:** Block diagram of entire process

### 2.3 Training the Model:

After creating the model, we have to compile the model for optimization and learning process. Adam (gradient descent algorithm) act as the optimizer and accuracy as our performance metric.
After compiling, we have to fit the model with the MNIST dataset. Using model fit function. And for analyse how our model gets trained with the dataset, we can use history object provided by Keras.

### 2.4 Testing the Model:

In order to test the model, we cuse some images from the testing the dataset. These are taken from the testing dataset because these images are unknown or new to model, so that we can test our model's performance easily. We will gatherer few images from those 10,000 test images and make predictions using **model.predict_classes** function which takes in the flattened raw pixel intensities of the test image.

### 2.5 MNIST:

Basically MNIST dataset consist of about 70000 images out of which 60000 are of training set and remaining are of test set. Each image is 28 pixels by 28 pixels. This array can be flattened into a vector of size 28 pixels * 28 pixels = 784. It will now have a shape of [60000, 784]. The x-coordinate is an index of the images in the data set and the y-coordinate is an index of the each pixel in an image.

### 2.6 Regression Model:

We know that every image in the data set is a digit between 0 to 9.We want to be able to give probabilities for it being each digit. For example, our model might look at a picture of a nine and be 80% sure it's a nine but give a 5% chance to it being an eight and a bit of probability to all the others because it isn't sure. This is a classic case where a regression is a natural, simple model, to assign probabilities to an object being one of several different things.

## 3. DATASETS

The dataset which is used in the MNIST database of handwritten digits. It nearly content training set of 60,000 examples, and 10,000 examples. The digits has been size-normal and minimized and change in a fixed-size image. The images are of size 28 by 28 pixels.

## 4. ADVANTAGES

[1]. Aim to learn and practically apply the concepts of Machine Learning and Neural Networks.

[2]. Moreover, digit recognition is an excellent prototype problem for learning about neural networks and it gives a great way to develop more advanced techniques like deep learning.

## 5. FEATURE EXTRACTION

Since many classifiers cannot process the raw images or data efficiently, extracting the relevant information of the data is needed. Feature extraction is the step that aims to extract relevant information reducing the dimension of the data. The

performance of the classifiers depends on quality of the feature extracted from the data. In character recognition the commonly and eventually used features are statistical, structural, moments and global transformations.

For extracting the features knowledge and executing the classification steps, the frame of digit is required to narrow them. This frame includes the important and compulsory data of input digits and the unnecessary data is removed. For finding the narrowed frame of digits, the coordinates of pixels of foreground in farthest as left, right, up and down side are found. In such conventional feature extraction technique if a line passes through a pixel (foreground), then corresponding pixel will be given value one (1). If line does not pass a pixel (background), then it is consider as zero (0).

## 6. RESULT AND CONCLUSION

The application display or give the results of the processing of an image, and feeds it into the network. There has been hardly any rare cases where the CNN model gives wrong prediction for any image.

| Models | Accuracy |
|---|---|
| K Nearest Neighbour (KNN) | 71.28 |
| Multilayer Perceptron (MLP) | 87 |
| Convolution Neural Network (CNN) | 91.2 |

In this model we implemented a neural network for offline recognition of handwritten isolated digits. The normalized and skeletonize binary pixels of digits are used as inputs of multilayer perceptron network. The experimental result shows conventional features with the back propagation network which yields good classification accuracy of 100% and recognition accuracy of 91.2%.The work can be extended to increase the results by using or adding some more relevant features.

## 7. ACKNOWLEDGEMENT

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## 8. REFERENCES

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