

# HANDWRITTEN DIGIT RECOGNITION FROM MNIST DATASET

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**ABSTRACT** - The ability to a computer to detect digits written by human is achieved by this handwritten digit recognition project. This project uses Keras for importing the datasets from MNIST or NIST which consist 60,000 images of digits for extensive training and 10,000 images for testing which are obtained from various scanned documents that are used to evaluate the models, these models also helps the recognizing algorithm to detect the given digit. Digit recognizing task predicts and produces the output within 10 digits (0 - 9). Results are exhibited by using inverted classification accuracy, which is also known as prediction error method. This algorithm uses Convolutional Neural Network (CNN) to train and detect the digit and come up the most efficient output.

**Key words** - Keras, TensorFlow, SciKit-Learn

## 1. INTRODUCTION

CNN is a model that converts the set of inputs to outputs through hidden layers. This type of approaches are generally used in Deep learning algorithms which are part of machine learning in order to train the computers by using various models and resources as inputs. There are various CNN layers in order to train the module, they are convolution layers, pooling layers, flatten layers and classification layers. By using these layers of neural network computer mimics the functionalities of human brain and behavior of identifying objects and patterns in this case digits.

## 2. RELATED WORK

Y. Le Cun, L. D. Jackel, B. Boser, J. S. Denker, H. P. Graf, I. Guyon, et al.[1], with the title "Handwritten Digit Recognition: Applications of Neural Network Chips and Automatic Learning", published on *NATO ASI series F: Computer and system sciences*, vol. 68, pp. 41-46. This paper proposes a transfer learning based deep learning method. This work is based on different convolutional neural networks (CNN). This work identifies only images.

T Siva Ajay[2], who's work goes with the name "Handwritten Digit Recognition Using Convolutional Neural Networks", which is presented in "International Research Journal of Engineering and Technology (IRJET)", vol. 04, no. 07, pp. 2971-2976, on the year 2017. This paper mostly focuses on the image detection algorithms based on deep convolutional neural networks (DCNN).

Deng Li[3], which is entitled as "The MNIST Database of Handwritten Digit Images for Machine Learning Research", presented in "Best of the web series IEEE signal processing magazine", pp. 141-142, on November 2012. This project uses the help of MNIST to accomplish the requirement of the dataset and utilizes optical digit recognition and machine learning research.

Ma Caiyun and Zhang Hong[4], the title of the project is "Effective Handwritten Digit Recognition Based on Multi-feature Extraction and Deep Analysis", which is published in *12th International Conference on Fuzzy Systems and Knowledge Discovery (FSKD)*, pp. 297-301, on 2015. In this project author uses DCNN with Multi-feature Extraction and Deep Analysis of the dataset imported from NIST. Here the final result is obtained based on K-nearest neighbor algorithm.

Y.W. Matthew[5], the title is "Understanding Convolutional Neural Networks Using A Minimal Model for Handwritten Digit Recognition", published in *Teow Artificial Intelligence Lab on 21 October 2017*, pp. 167-172. This project on the whole works on the Minimal Model for Convolutional Neural Network for presenting the repercussion.

## 3. PROPOSED SYSTEM

The proposed system explains us how the handwritten digit is recognized with the help of the model that is trained with the help of MNIST dataset. It identifies the loaded image in 28x28 pixel square (784 pixel total) from the dataset using dense CNN layers and the resultant quotient is achieved with approximately 0.2% error. In this process we come across various Deep Learning libraries such as Keras to import essential datasets, TensorFlow, matplotlib to import pyplot module, SciKit-Learn and more.

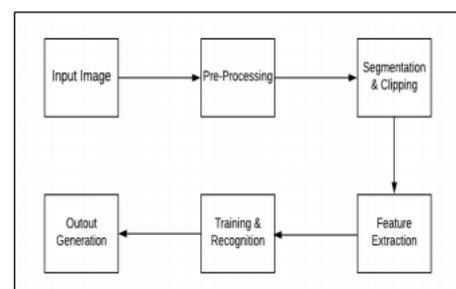


Fig 1:- Architecture of the Proposed System

### A. Importing MNIST dataset

The process of creating a working algorithm is started by importing the dataset which consists labeled handwritten digit images gathered from the scanned documents from MNIST or NIST(National Institute of Standards and Technology). Keras library which is used for Deep Learning provides an advantageous way for loading MNIST dataset.

- Keras is a high-level library in Python that is a package of TensorFlow, CNTK and Theano. TensorFlow is the default package for Keras and it is also used for training the module.
- Matplotlib is used to import pyplot module and uses its methods to import and display images from MNIST dataset.

### B. Structuring the data

- In order to utilize the Keras API effectively, we are supposed to reshape each and every image that is imported from dataset and normalize the image value data by split up each pixel by 255. Here we split the image data to 255 pixel because of the RGB value varies from 0 to 255.
- In the following step conversion of the dependent variable in integer to binary form is done.

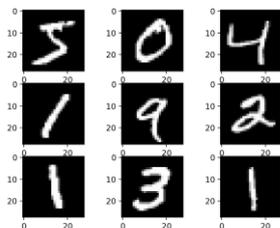


Fig 2: Digits after bifurcation

### C. Designing the model

In the whole working process model design task is the most tedious task, faults in this task may impact on the performance of the model. In this step we use design from Keras.

- In the way of creation of the model firstly initialize a sequential model.
- Then add the Convolutional layer to intake the input and run them through certain filters. And activation of 'relu' rectifies linear units.
- Pooling layer is the followed convolution layer, which helps in feature detection by combining Convolutional features.
- Common problem while creating a neural network, which are trained on large resources is "overfitting", To avoid this the next Convolutional layer is Dropout layer. This layer drops the units with 20% probability.
- Next, Flattening layer that converts data into a 1 dimensional array followed by another dropout layer in

advance to a final dense layer which helps in the classification of the data.

- Finally the data is classified into various pre-decided classes with the help of softmax, followed by a loss layer.

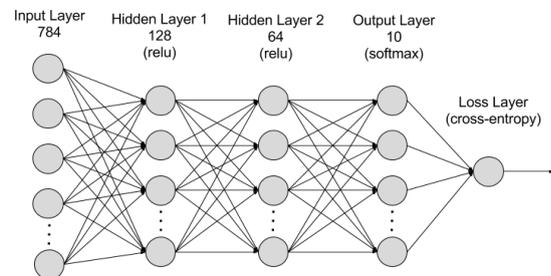


Fig 3: Convolutional layers of CNN

### D. Compilation and Training of the model

- During the compilation we specify loss function and create an empty model without an object function. Model performance can be assessed by metric and optimized function.
- If any integer dependent variable then the usage of this loss function exist. Then the epoch and batch size is specified when model is training.
- One Forward and backward pass respectively of a training example is known as epoch and number of training examples in one forward and backward pass is called as batch size.
- General specification of a batch is around 10. At the end of the training save the model for the later usage.

### E. Prediction of the handwritten digit

Once the model is ready for the usage import the handwritten image from the model by using imageio method from SciKit-Learn library, followed by the normalizing the values and reshape the image and then loading the model and prediction of the digit is done by the methods from the SciKit-Learn library.

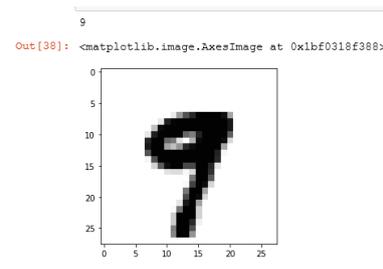


Fig 4: Prediction from handwritten digit

### F. Application of GUI

An interactive window is created in order to write the hand written digit and a handy control is created to recognize the digit drawn. Now the Thinker library which is a standard library in python is used to take the input and produce the output as digit by training the model. The writing of the app class (GUI APP) is captured by the mouse moment and a click on the button created in the window produces the predicted digit.

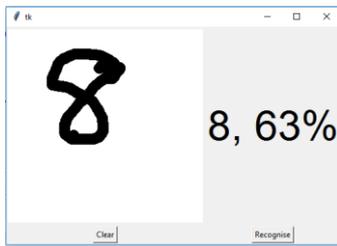


Fig 5: Recognition of handwritten digit

#### 4.CONCLUSION

This project involves in the recognition of the handwritten digit by using high level dense convolutional neural network. To get the classified and refined data from the dataset and to get the accurate recognition of the digit of the standard libraries provided by the python and rest of the essential methods are imported from the library such as keras, matplotlib, SciKit-Learn. With the help of all these libraries a model is created with complex hidden layered convolutional neural network with the accuracy of 98%. Even after the high probability of accuracy there are still chances for the enhancement and improvement of the handwritten digit recognizing models.

#### 5.REFERENCES

- [1] R. Ting, S. Chun-lin and D. Jian, "Handwritten character recognition using principal component analysis", *MINI-MICRO Systems*.
- [2] R. Walid and A. Lasfar, "Handwritten digit recognition using sparse deep architectures. in Intelligent Systems: Theories and Applications (SITA-14)".
- [3] Z. Li et al., "Handwritten digit recognition via active belief decision trees", Control Conference (CCC) 2016 35th Chinese.
- [4] J. Schmidhuber, "Deep learning in neural networks: An overview", *Neural Networks*
- [5] Y. LeCun, Y. Bengio and G. Hinton, *Deep learning. Nature*, no. 7553, pp. 436-444, 2015.
- [6] G.E. Hinton and R.R. Salakhutdinov, "Reducing the dimensionality of data with neural networks".
- [7] K. Yu et al., "Deep learning: yesterday today and tomorrow", *Journal of computer Research and Development*,
- [8] Z.-J. Sun et al., "Overview of deep learning", *Jisuanji Yingyong Yanjiu*,
- [9] Y. Bengio, *Learning deep architectures for AI. Foundations and trends® in Machine Learning*.
- [10] Y. LeCun, C. Cortes and C.J. Burges, *The MNIST database of handwritten digits*.

#### 6.FUTURE ENHANCEMENTS

Handwritten digit recognition can be used in various task of work and in various aspects of the daily routine, by the further development of the proposed model also emphasizes the merits of CNN concepts and SVM classifiers for the further enhancements in handwritten digit recognition. This model can also be upgraded into a fully automatically regenerated features and recognition of handwritten characters in various styles and languages such as English, German, Arabic, Urdu, French and in many other languages can be achieved. This enhancement in the project can also be used to optimize the techniques to uplift the classification performance and can be utilized to create personalized font style, which bring down the needs of actual writing for entering the essay form speech. Digit recognition and also be used in traffic surveillance to take down the Number plate information from surveillance cameras with the help of object recognition algorithms. Handwritten digit recognition is the basic CNN project which can be used to enhance various fields of Machine learning such as speech recognition, video surveillance, security systems and many. By utilizing the help of SVM-CNN model the improvement in the initial stages of the model can be achieved.