Handwritten Digit Recognition using Machine Learning

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Introduction

Handwritten digit recognition is the computer's ability to read and accurately classify the human handwritten digits from different sources like photographs, papers, mobile displays.

From number plate detection to sorting postal mails, digit recognition has numerous applications. Due to other peoples' different writing styles, it is a challenging task to perform digit classification.

This research brings up a comprehensive comparison between many known classifiers available in Machine Learning and Deep Learning.

This poster aims to provide a good understanding of many classifiers available in ML and DL for handwritten digit classification.

Dataset

MNIST
The data initially has 60k samples of size 28*28. Converted it to 784*1.

EMNIST
Extended version of MNIST dataset and has similar features. Along with digits, it has letters in the class labels.

Data Pre-processing
We checked for data-imbalance using frequency plots and performed dimensionality reduction of input features using PCA and SVD. We have used max-pooling to reduce the computation time.

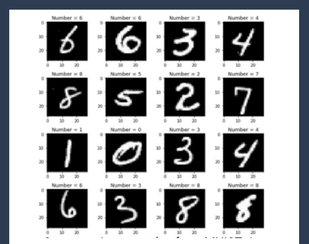


Figure 1. Samples from MNIST dataset

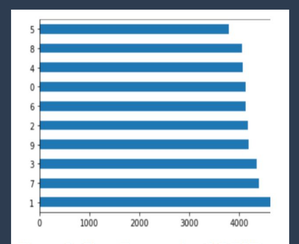


Figure 2. Class Frequencies (MNIST)

Methodology

We have used MNIST and EMNIST dataset to train and test our model.

- Building up the model using the processed data.
- Training our model for appropriate number of epochs and avoiding overfitting of our model. K-fold CV can be used here as well.

We have implemented following ML algorithms-

KNN
K-Nearest Neighbour is one the ML Algorithm based on Supervised learning technique which can be used to solve classification and regression problem. KNN is a lazy learning algorithm; it does not perform much while training and do the real computation while testing.

SVM
SVM is used to fit to the data we provide. It returns a hyperplane that divides or categorize our data.

MLP
In Multi-Layered Perceptron, we create a neural network which consists of an input layer, hidden layers and an output layer.

CNN
Convolution Neural Network consists of input layer, output layer and hidden layers. Layers perform Convolution layer, pooling layer for classification.

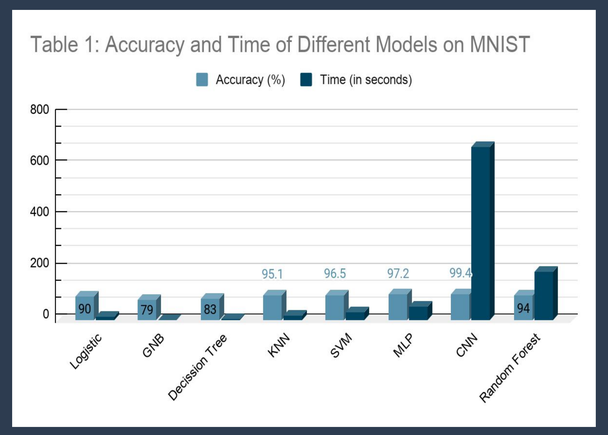
Decision Trees
Decision Tree is a flowchart-like tree structure where internal nodes represent features; the branch tells us the decision rule and leaf gives the outcome.

Random Forest
This is an ensemble technique. Many decision trees (uncorrelated) are trained on various subsets of data and averaging and voting is done on the outputs of each D.T.

- Once we've trained our model, we can predict the labels for the testing data.
- After that we'll measure the accuracy of different models and will benchmark our model on kaggle platform.

Results

After training eight different classifiers in Machine Learning and Deep Learning, our research compares all these algorithms' testing accuracy and training time. It has been found that CNN has the best accuracy and Gaussian Naive Bayes has the worst accuracy. The execution time for CNN was moderate and was the highest for Random Forests.
The running time of the algorithms depends on the number of operations performed.



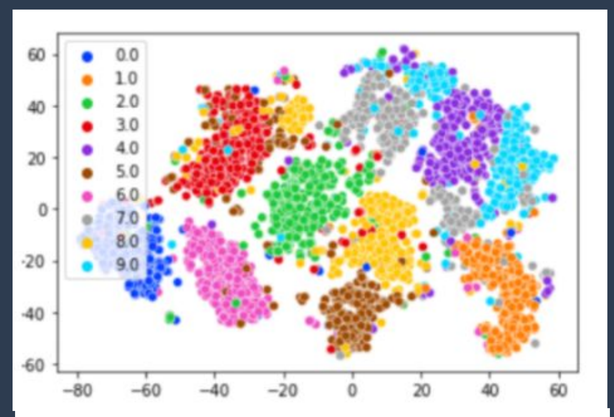


Figure 3: Dataset visualization using t-SNE

Conclusion

This research paper has implemented eight different models for classifying handwritten digits using both MNIST and EMNIST datasets and compared all these algorithms based on testing accuracy and training time to find the accurate model. Owing to its simplicity, SVM is one of the best classifiers, but when it comes to more complex real-world scenarios, MLP and CNN have an edge.
CNN is the best candidate among all the models we tested based on the accuracy of rate and learning capabilities.

Model	Accuracy	Time(sec)
Logistic Regression	92.7 %	138.78
Gaussian Naive Bayes	75.08 %	0.144
Decision Tree	86.66 %	26.86
Random Forest	96.2 %	1550.15
K - Nearest Neighbours	97.4 %	325.54
Support-Vector Machines	98.3 %	389.35
MLP	98.58 %	325.67
CNN	99.1 %	689

Table 2. Accuracy and time of Different models on EMNIST

References

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