Handwritten Digit Recognition

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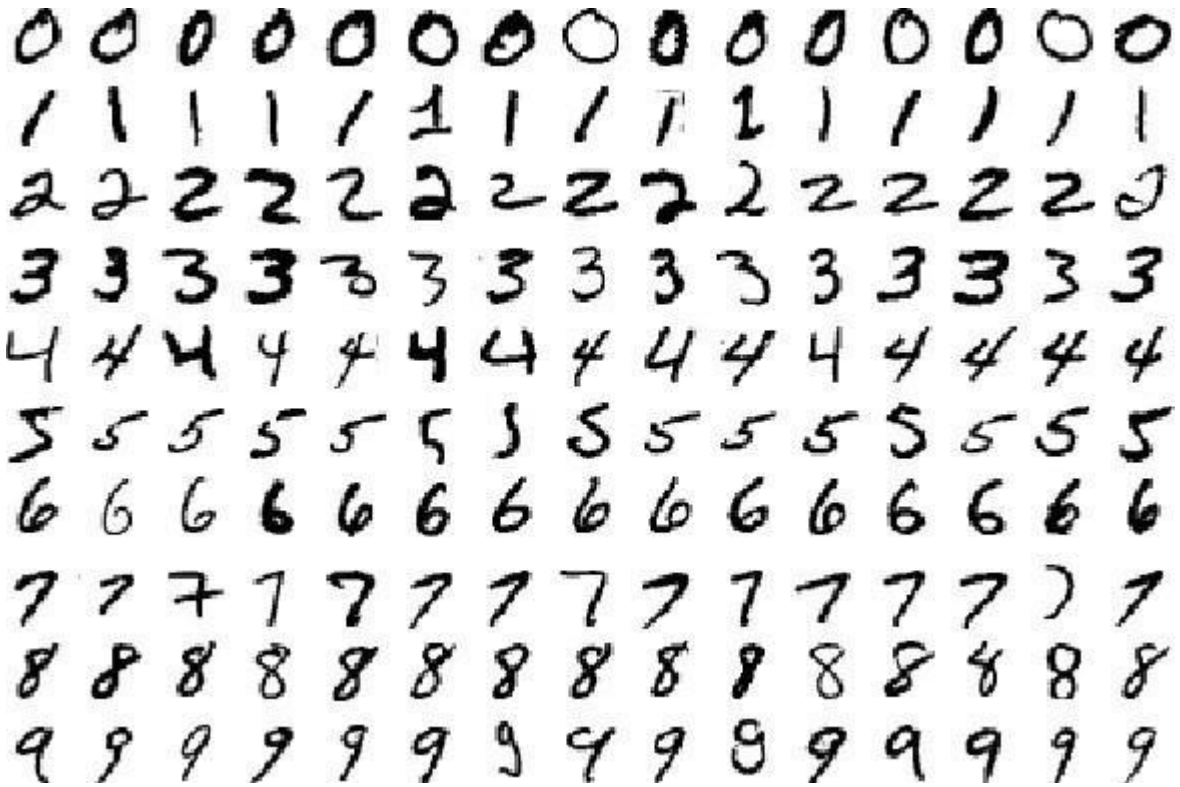
The MNIST Database



60,000 images for training

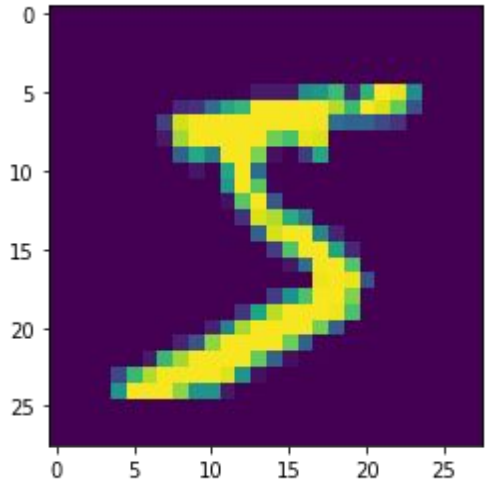
28x28

10,000 images for testing

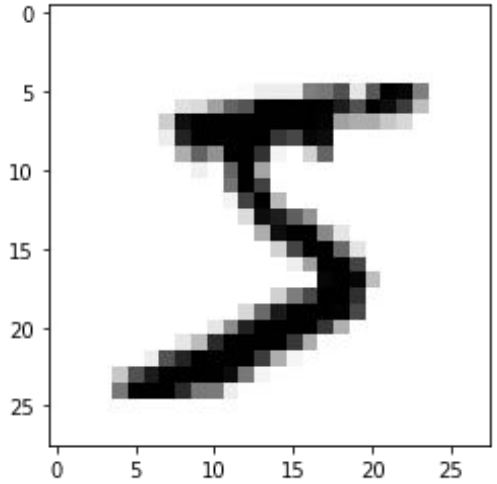
10 layers

Source: https://medium.com/@afozbek_/how-to-train-a-model-with-mnist-dataset-d79f8123ba84

The MNIST Database



Original Color Image



Grayscale image after converted

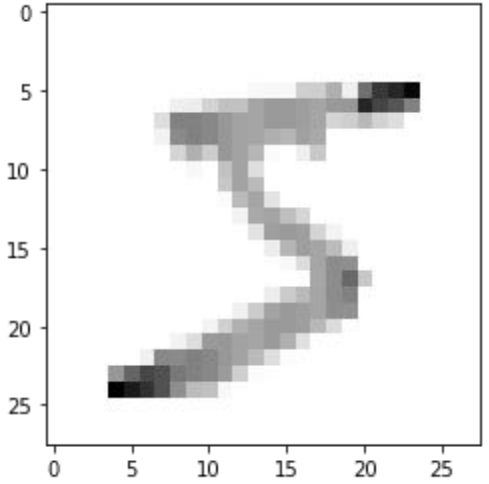
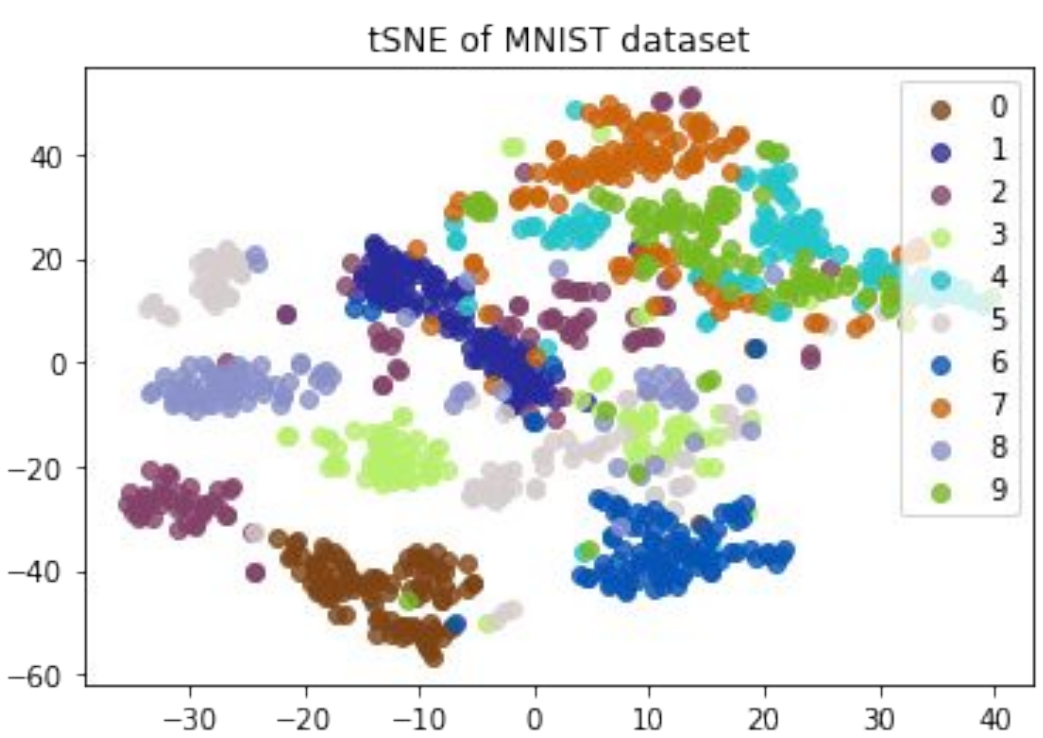


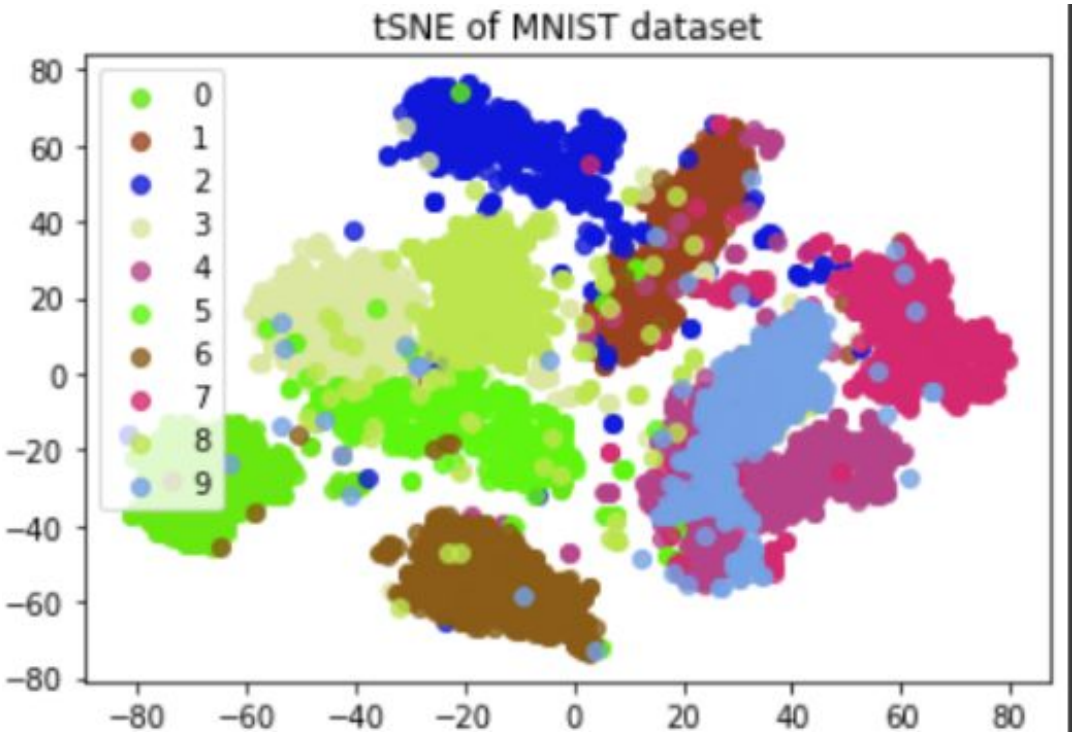
Image After Normalization

Source: https://www.milindsoorya.com/blog/handwritten-digit-classification-using-cnn

t-SNE Exploratory Data Analysis



1000 datasets



5000 datasets

Our Approach: CNN Models

1. Multi-Layer Perceptron
2. LeNet
3. ResNet-18

The Results

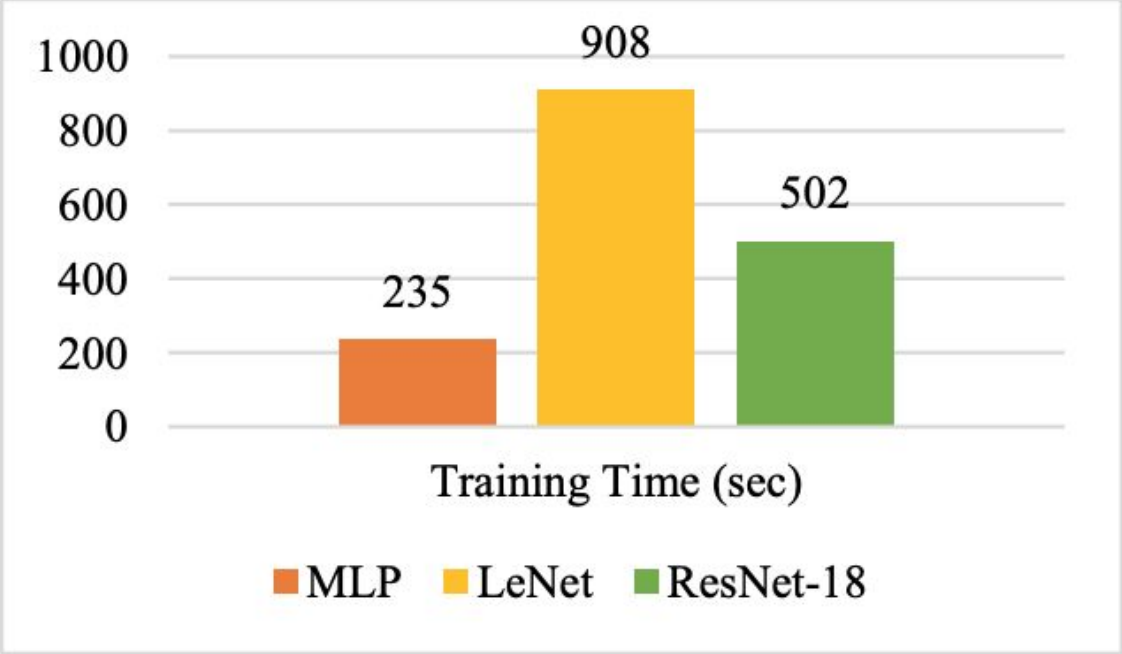


Figure 27. Training Time Comparison

Model	Training accuracy	Validation accuracy	Testing accuracy	Training Time	Cross Entropy Loss
ResNet-18	98.9%	99.0%	99.1%	502s	1.4%
LeNet	98.1%	98.7%	99.2%	908s	0.6%
MLP	98.4%	98.6%	97.3%	235s	4.2%

Table 4. Comparison of Extracted Results

MLP Hyperparameter Tuning

Learning Rate	Training Accuracy	Validation Accuracy	Testing Accuracy	Validation Loss
1e-4	97.1%	97.3%	96.6%	4.3%
2e-4	97.2%	97.3%	96.7%	4.1%
1e-2	97.2%	97.1%	97.1%	6%
2e-2	97%	96.7%	97.1%	5.5%

ResNet Hyperparameter Tuning

Learning Rate	Training Accuracy	Validation Accuracy	Testing Accuracy	Validation Loss
1e-4	98.1%	97.2%	99.4%	2.2%
2e-4	98.2%	98.3%	99.2%	1.2%
1e-2	98%	97.8%	99.2%	1.5%
2e-2	98.2%	97.8%	99.1%	7.8%

LeNet Hyperparameter Tuning

Learning Rate	Training Accuracy	Validation Accuracy	Testing Accuracy	Validation Loss
1e-4	96.2%	97.1%	99.2%	1.3%
2e-4	96.3%	88%	98.1%	5.2%
1e-2	95.3%	91.7%	99.2%	1.5%
2e-2	95.3%	96.9%	99.3%	1.2%