

### PROJECT PART- 3

#### CONVOLUTIONAL NEURAL NETWORKS

##### SETUP:

The project implements the Convolutional Neural Network on Handwritten Digit Recognition MNIST dataset. The dataset was divided into training and testing data. The following parameters were set for the neural network (in the particular order):

1. Input size of image = 28x28
2. First Convolutional Hidden Layer: Feature Maps = 6, kernel size = 3x3, stride = 1
3. Max Pool Layer: size= 2x2, stride =1
4. Second Convolutional Hidden Layer: Feature Maps = 16, kernel size = 3x3, stride = 1
5. Max Pool Layer: size= 2x2, stride =1
6. First Fully connected Layer: 120 nodes, activation function- ReLU
7. Second Fully connected Layer: 84 nodes, activation function- ReLU
8. Softmax Layer: 10 output nodes (corresponding to 10 classes)

Testing error and accuracy were calculated for the above-mentioned setting of parameters.

##### REQUIRED TASKS:

1. **Plots for learning/testing errors and final classification accuracy for the baseline code:**

The CNN model uses the setup to report the testing error and accuracy of the model:

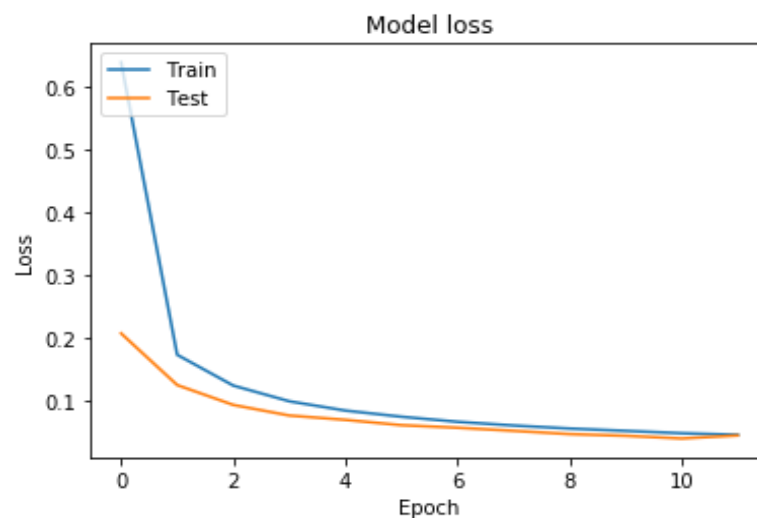
##### Hyperparameters:

- Kernel size: 3x3
- Number of feature maps in the first convolution layer: 6
- Number of feature maps in the second convolution layer: 16

##### Final classification results:

- **Test loss:** 0.06745879888087511
- **Test accuracy:** 0.9787

The graph in Fig 1 illustrates the results:



**Fig 1: Learning/Testing error v/s Number of Epochs for baseline code**

## 2. Plots for learning/testing errors and final classification accuracy after changing the kernel size:

The CNN model uses the following parameter setting to report the testing error and accuracy of the model:

### Hyperparameters:

- Kernel size: 5x5
- Number of feature maps in the first convolution layer: 6
- Number of feature maps in the second convolution layer: 16

### Final classification results:

- Test loss: 0.05676895530931651
- Test accuracy: 0.9816

The graph in Fig 2 illustrates the results:

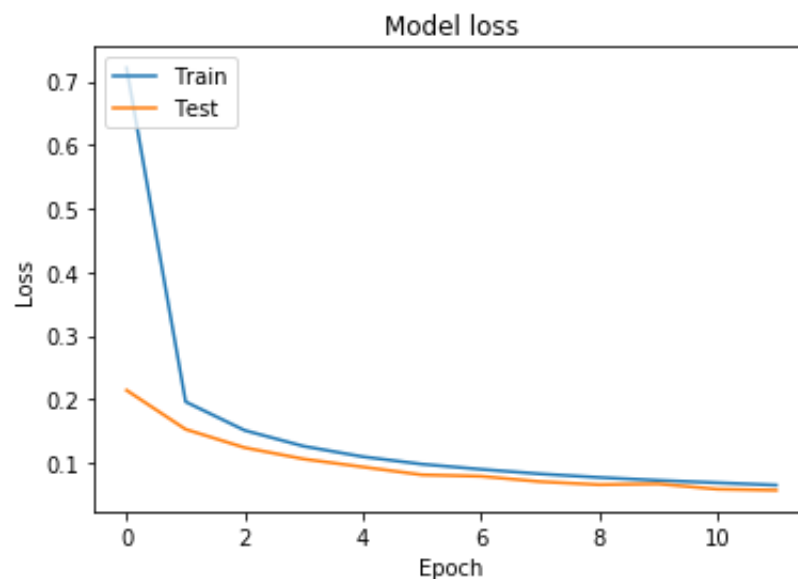


Fig 2: Learning/Testing error v/s Number of Epochs for 5x5 kernel size

## 3. Plots for learning/testing errors and final classification accuracy after changing the number of feature maps for the first and second convolutional layer:

The CNN model uses the following parameter setting to report the testing error and accuracy of the model:

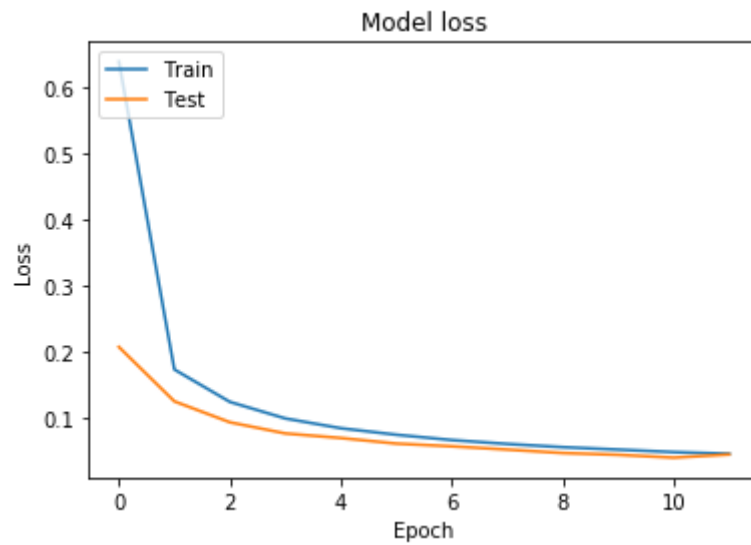
### Hyperparameters:

- Kernel size: 5x5
- Number of feature maps in the first convolution layer: 12
- Number of feature maps in the second convolution layer: 32

**Final classification results:**

- Test loss: 0.04587676397231408
- Test accuracy: 0.9854

**The graph in Fig 2 illustrates the results:**



**Fig 3: Learning/Testing error v/s Number of Epochs for different number of feature maps**