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Programming Assignment-6 (Lab-11&12)
CSL2050 - Pattern Recognition and Machine Learning

Neural Network MNIST Classification

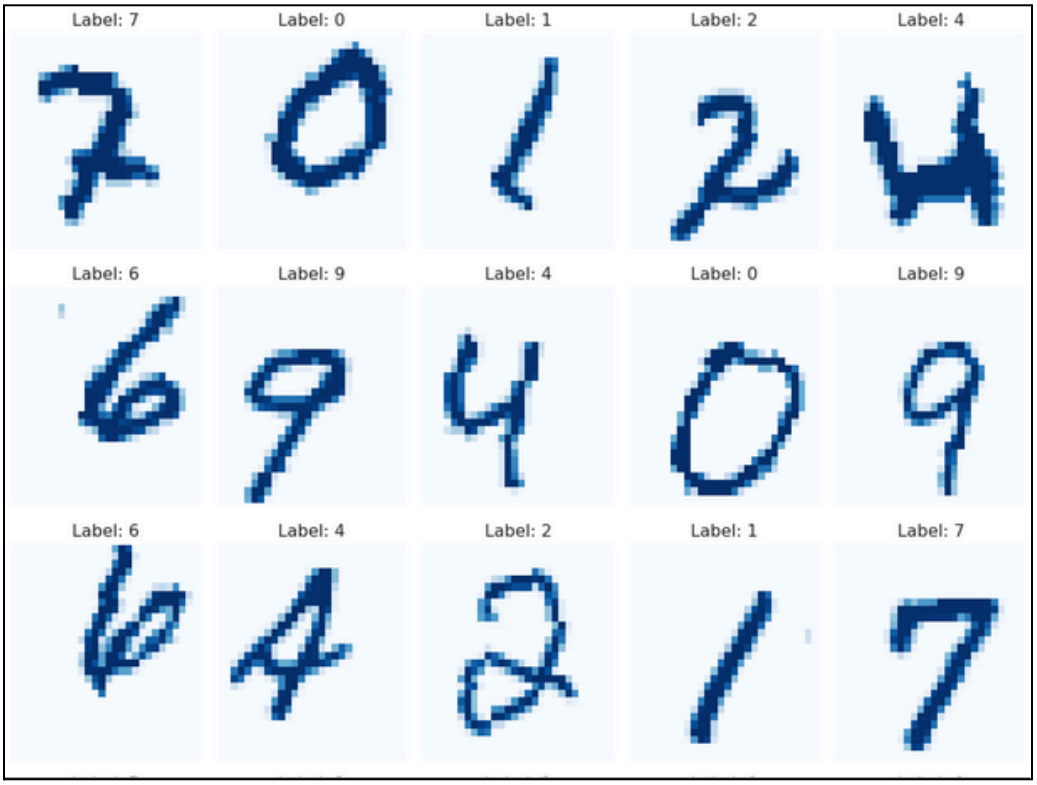
Task-0: Data Preparation

- Downloaded the MNIST dataset using torchvision.
- Split the data into train, test, and validation sets.
- Applied augmentations to images: RandomRotation, RandomCrop, ToTensor, and Normalize.

Data	Size
Training Data	*36000*
Validation Data	*12000*
Test Data	*12000*

Task-1: Data Visualization and DataLoader Creation

- Plotted a few images from each class along with its labels.



- Created data loaders for the training, validation and testing datasets.

Task-2: 3-Layer MLP Model

- Implemented a 3-Layer MLP model using PyTorch, with all layers using Linear functions with relu activation in both cases.
- Printed the number of trainable parameters of the model.

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Number of trainable parameters: 109386
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Task-3: Model Training

- Trained the model for 5 epochs using Adam optimizer and CrossEntropyLoss as the loss function and with the learning rate of 0.001.
- Evaluated the model on the validation set after each epoch.
- Saved the best model and logged the accuracy and loss of the model on training and validation data at the end of each epoch.

Epoch	***Training loss***	***Val. loss***	***Training Acc.***	***Val. Acc.***
1/5	*0.81*	*0.43*	*0.74*	*0.87*
2/5	*0.37*	*0.34*	*0.88*	*0.90*
3/5	*0.31*	*0.28*	*0.91*	*0.91*
4/5	*0.27*	*0.25*	*0.92*	*0.92*
5/5	*0.24*	*0.24*	*0.92*	*0.93*

- Calculated the test accuracy of the model.

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Test Accuracy: 0.9331666666666667
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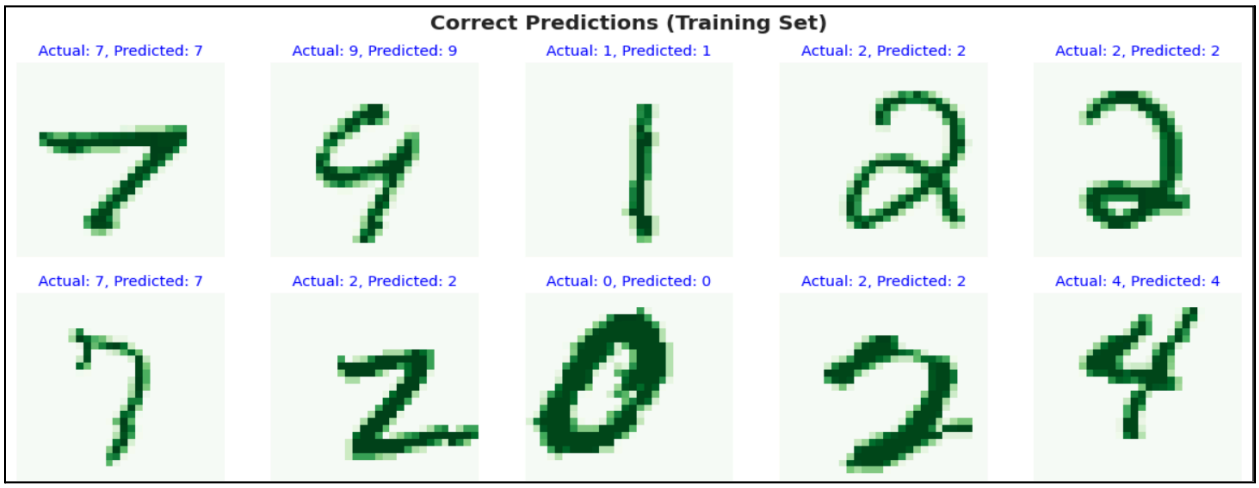
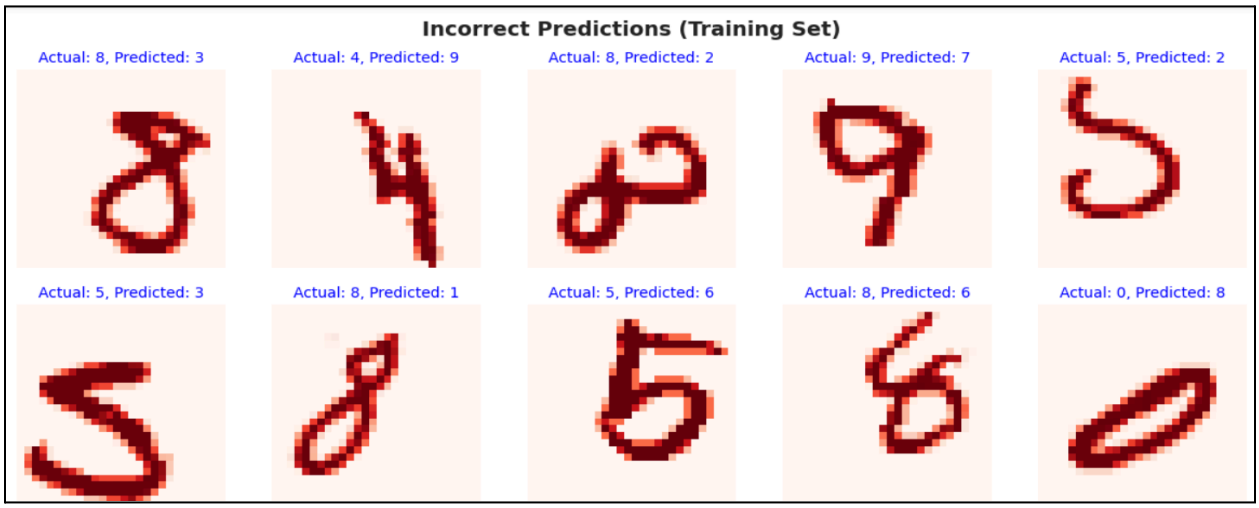
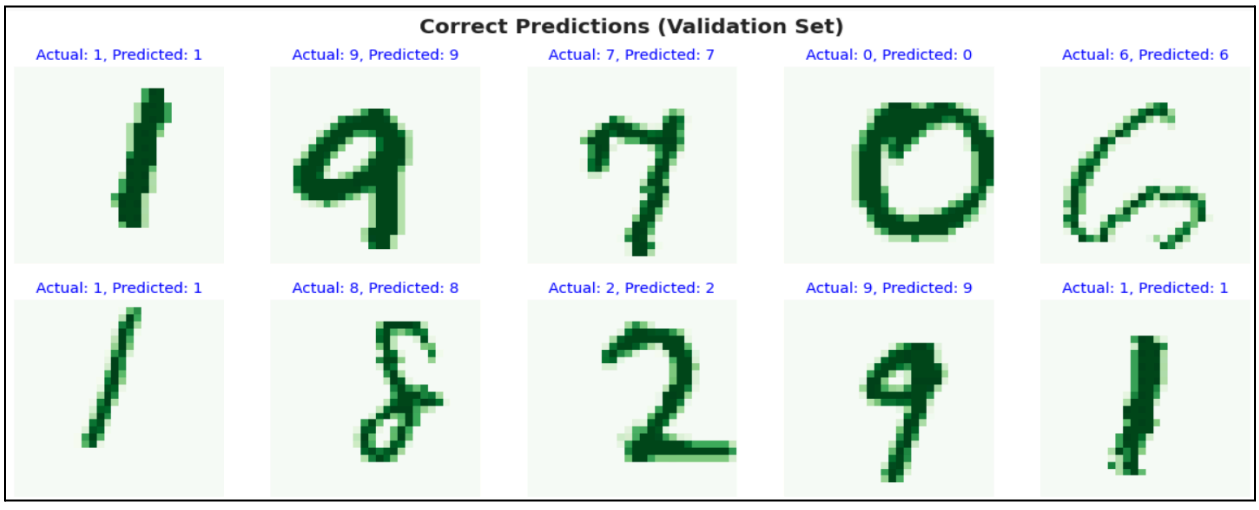
Task-4: Visualization of Results

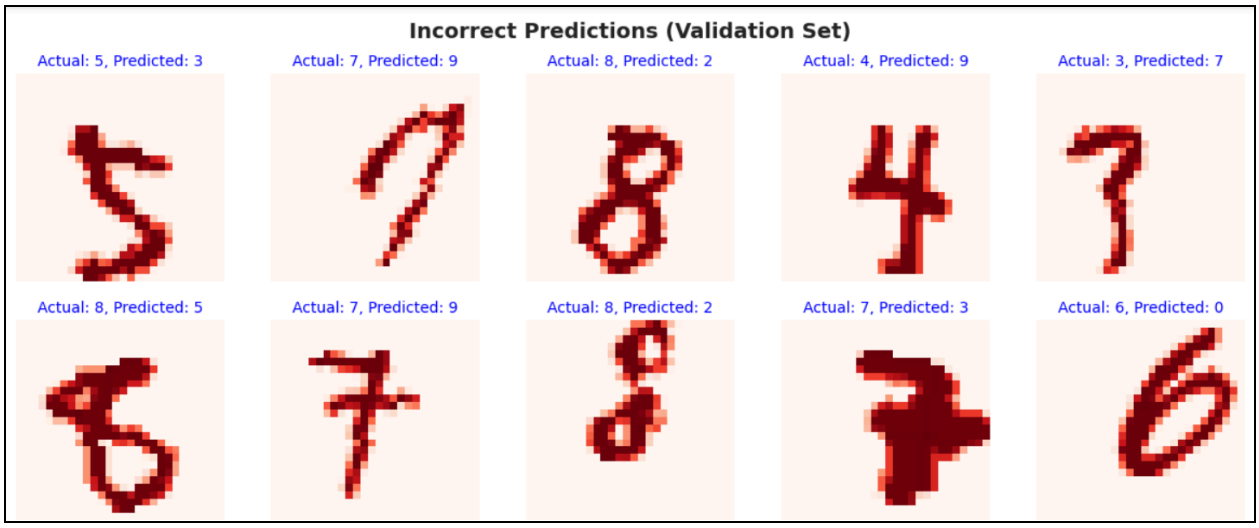
- Visualized correct and incorrect predictions with both actual and predicted labels on the data printed. I have used the seaborn library to visualize the prediction for training and validation data. I have used cmap ‘Greens’ and ‘Reds’ for the correct and incorrect labels

predicted by the model, respectively. This trick makes it easy to visualize predictions accurately.

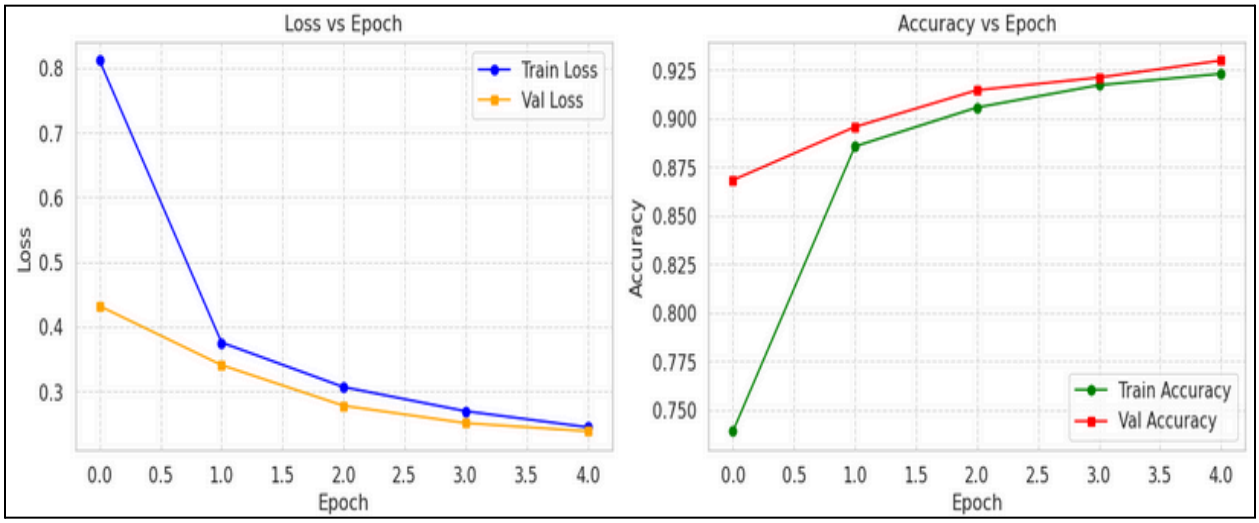








- Plotted Loss-Epoch and Accuracy-Epoch graphs for both training and validation data.



- Here is the classification report for both training and testing data-

Training Data →

Digit	***Precision***	***Recall***	***F1-score***	***Support***
0	*0.95*	*0.96*	*0.96*	*3554*
1	*0.98*	*0.96*	*0.97*	*4000*
2	*0.86*	*0.95*	*0.90*	*3594*
3	*0.93*	*0.89*	*0.91*	*3724*

4	*0.94*	*0.93*	*0.93*	*3514*
5	*0.94*	*0.91*	*0.92*	*3255*
6	*0.95*	*0.96*	*0.96*	*3561*
7	*0.92*	*0.95*	*0.93*	*3729*
8	*0.92*	*0.89*	*0.90*	*3524*
9	*0.91*	*0.89*	*0.90*	*3535*
accuracy			*0.93*	*36000*
Macro avg	*0.93*	*0.93*	*0.93*	*36000*
Weighted avg	*0.93*	*0.93*	*0.93*	*36000*

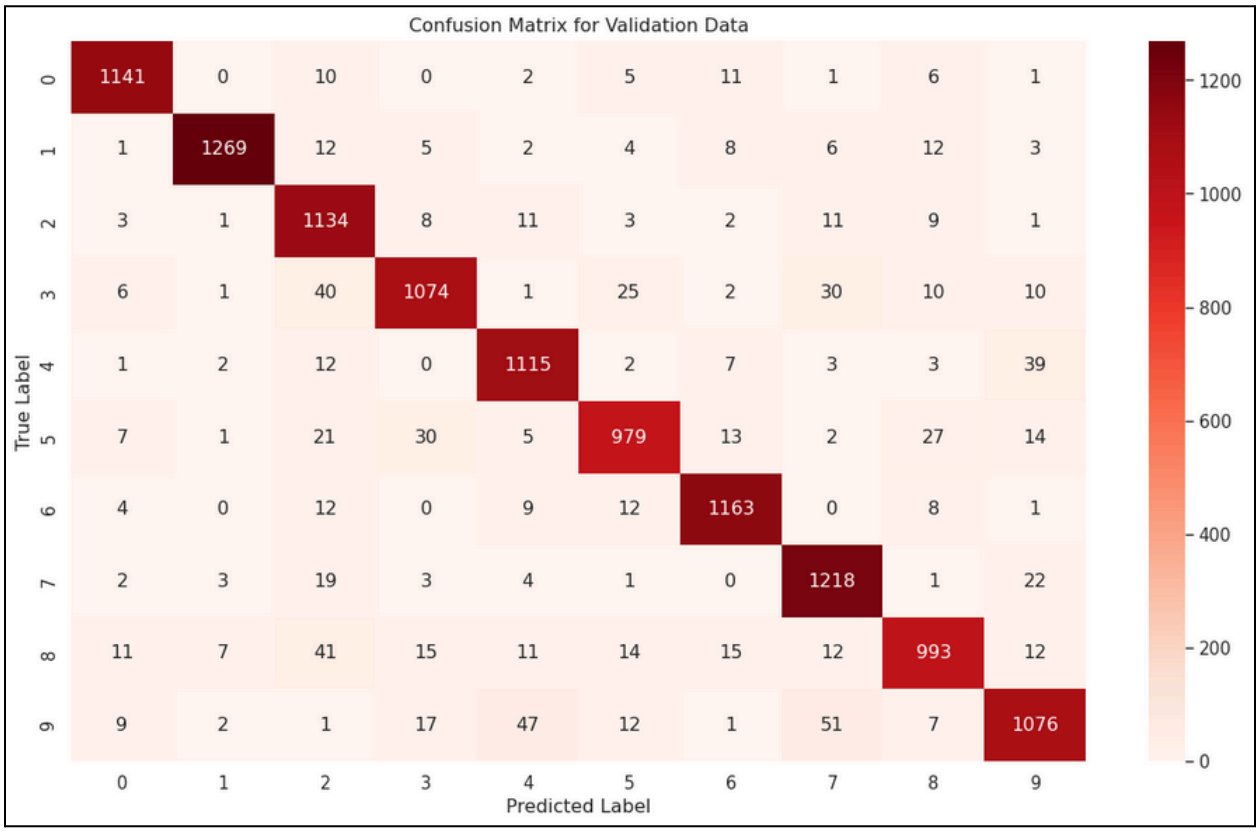
Validation Data →

Digit	***Precision***	***Recall***	***F1-score***	***Support***
0	*0.96*	*0.97*	*0.97*	*1177*
1	*0.99*	*0.96*	*0.97*	*1322*
2	*0.87*	*0.96*	*0.91*	*1183*
3	*0.93*	*0.90*	*0.91*	*1199*
4	*0.92*	*0.94*	*0.93*	*1184*
5	*0.93*	*0.89*	*0.91*	*1099*
6	*0.95*	*0.96*	*0.96*	*1209*
7	*0.91*	*0.96*	*0.93*	*1273*
8	*0.92*	*0.88*	*0.90*	*1131*
9	*0.91*	*0.88*	*0.90*	*1223*
accuracy			*0.93*	*12000*
Macro avg	*0.93*	*0.93*	*0.93*	*12000*
Weighted avg	*0.93*	*0.93*	*0.93*	*12000*

This classification report shows that -

- ➢ This model predicts the digits- 0,1 and 6 most accurately. These digits have very high precision, recall and f1-score.
- ➢ This model has lowest precision, recall and f1-score in case of the digits 8 and 9.
- ➢ Digit 2 has low precision and f1-score.
- ➢ Digit 3 has a low f1-score.
- ➢ Digit 5 has a low f1-score.
- ➢ Digit 7 has a low precision score.

- Plotted the confusion matrix that can further help us evaluate and visualize the model results.



Conclusion

This report presents the implementation of a 3-Layer MLP model for classifying the MNIST dataset. The model was trained and evaluated using various metrics, including accuracy and loss, to assess its performance. Visualizations were used to understand the model's behavior and performance over the training epochs. The results demonstrate the effectiveness of the model in accurately classifying handwritten digits from the MNIST dataset.