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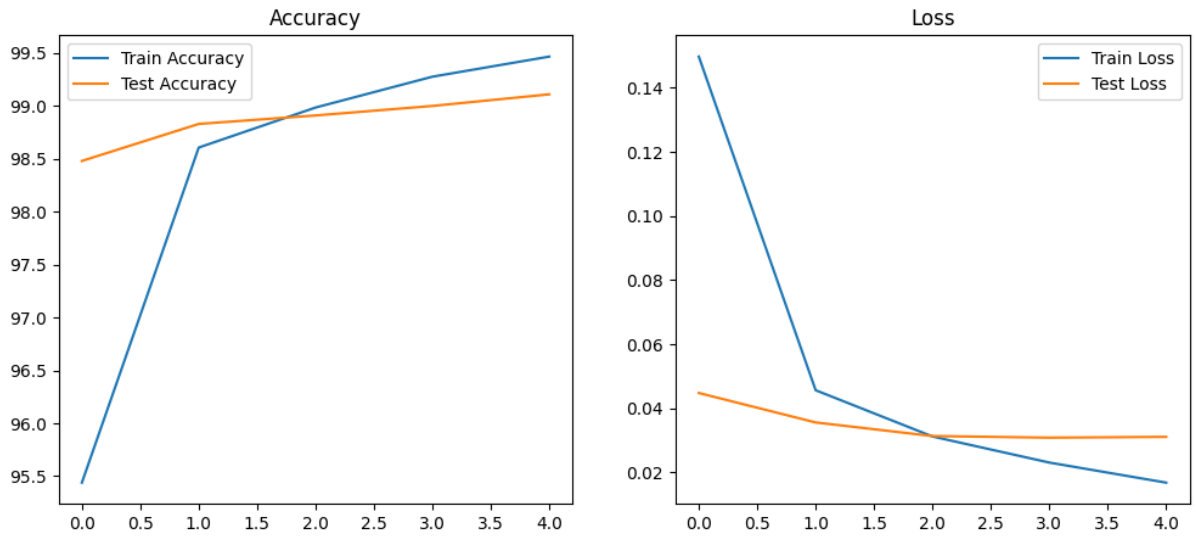
Assignment no.: 04

1. Handwritten Digit Recognition using CNN on the MNIST Dataset: Objective: Build and train a Convolutional Neural Network (CNN) to classify handwritten digits (0–9) using the MNIST dataset. Evaluate model performance, analyze errors, and experiment with architectural or training variations.

Output:

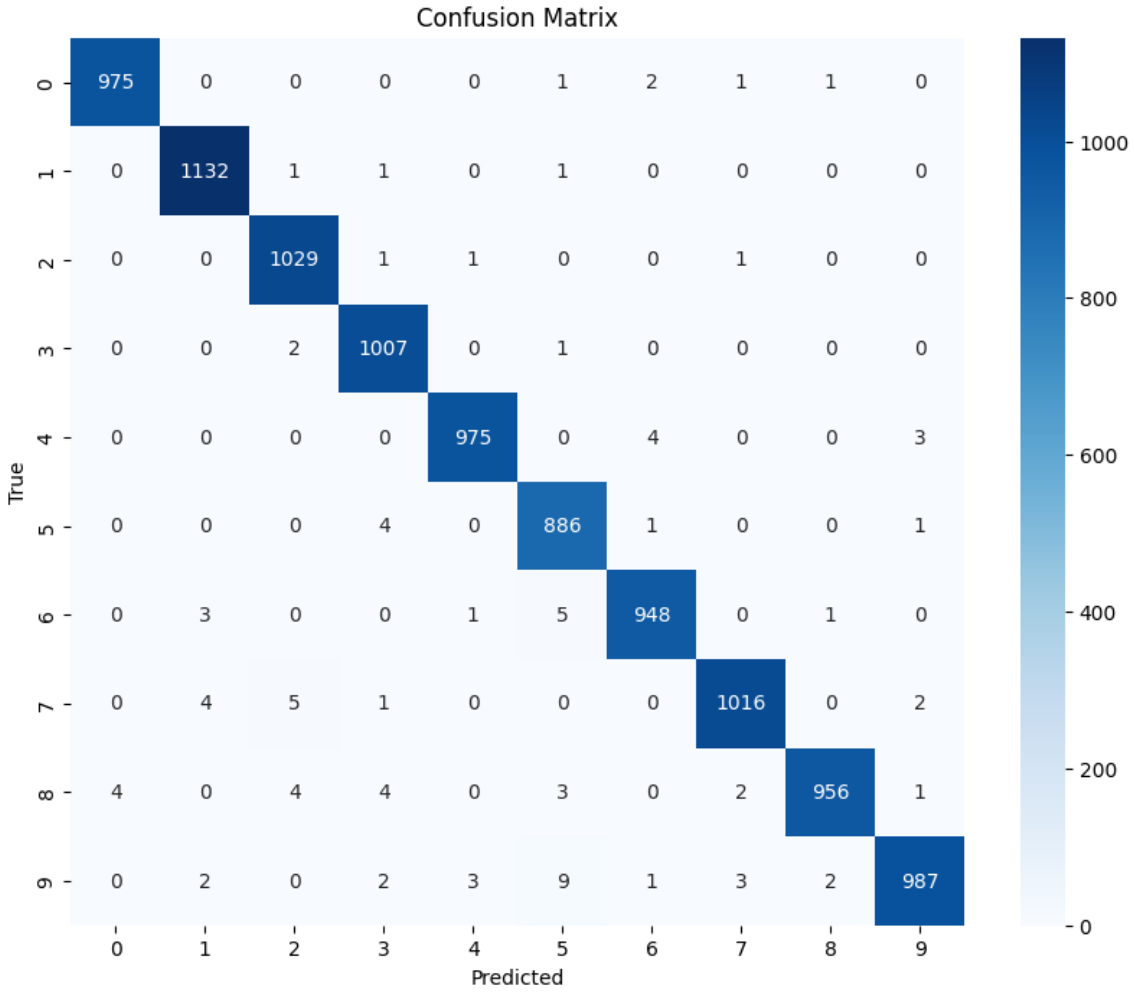
```
Epoch [1/5], Train Acc: 95.44%, Test Acc: 98.48%
Epoch [2/5], Train Acc: 98.61%, Test Acc: 98.83%
Epoch [3/5], Train Acc: 98.98%, Test Acc: 98.91%
Epoch [4/5], Train Acc: 99.28%, Test Acc: 99.00%
Epoch [5/5], Train Acc: 99.47%, Test Acc: 99.11%
```

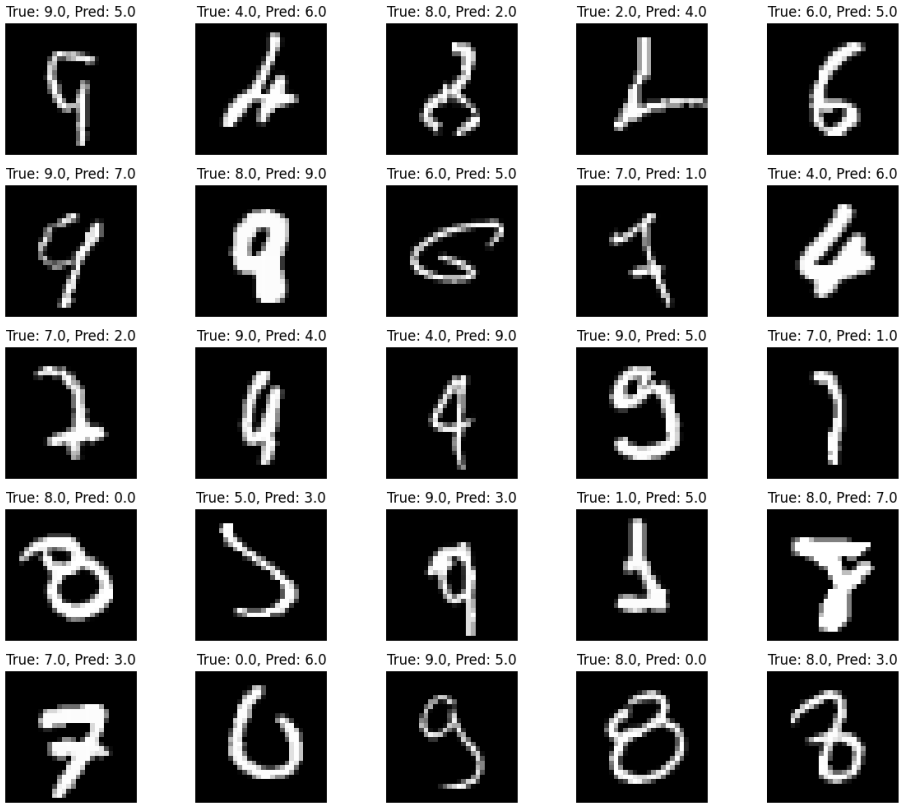



```
Classification Report:
              precision    recall  f1-score   support

         0.0       1.00      0.99      1.00       980
         1.0       0.99      1.00      0.99      1135
         2.0       0.99      1.00      0.99      1032
         3.0       0.99      1.00      0.99      1010
         4.0       0.99      0.99      0.99       982
         5.0       0.98      0.99      0.99       892
         6.0       0.99      0.99      0.99       958
         7.0       0.99      0.99      0.99      1028
         8.0       1.00      0.98      0.99       974
         9.0       0.99      0.98      0.99      1009
```

accuracy			0.99	10000
macro avg	0.99	0.99	0.99	10000
weighted avg	0.99	0.99	0.99	10000





Handwritten Digit Recognition with CNN on MNIST + Dropout + Data Augmentation

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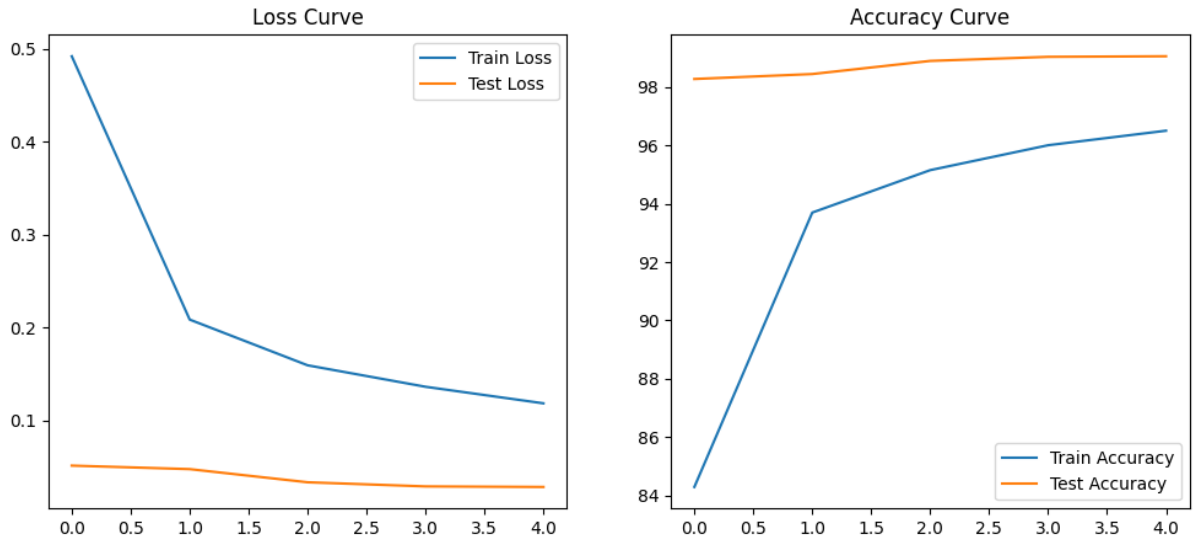
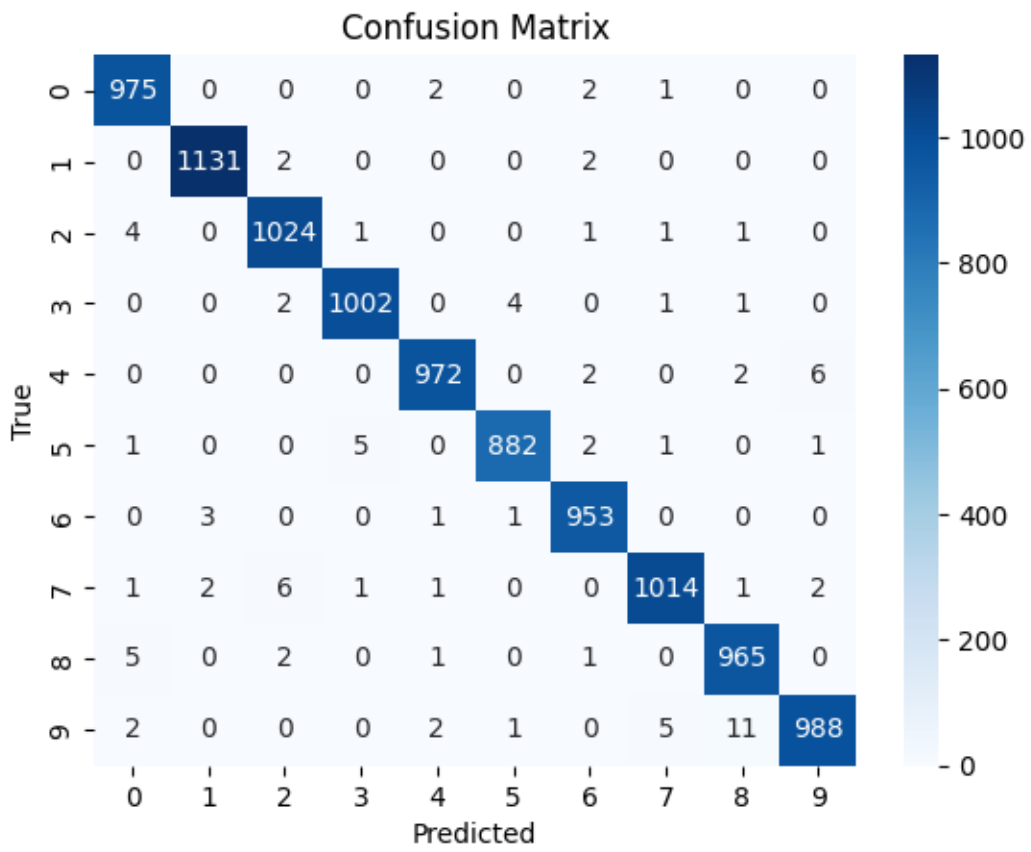
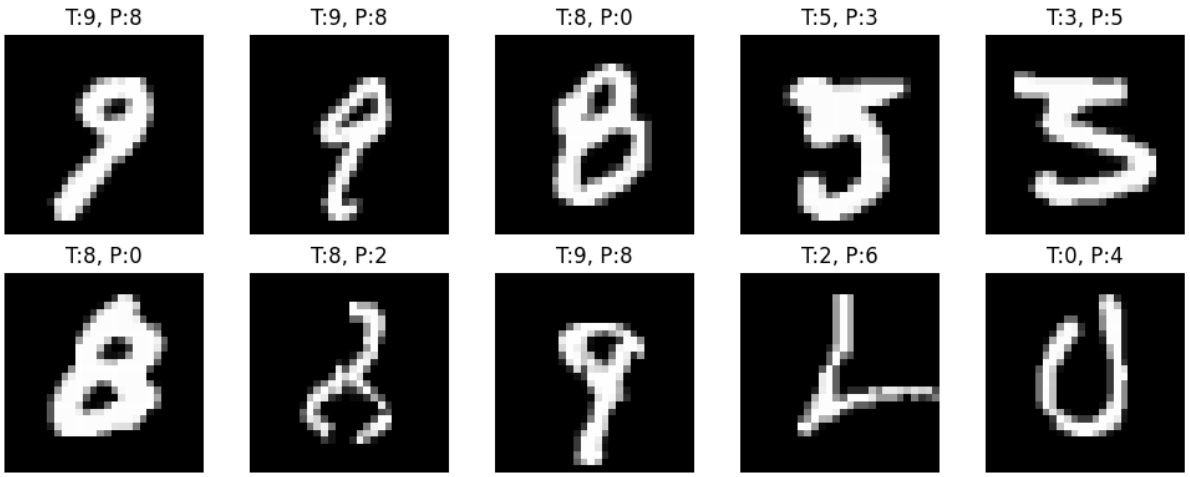
Epoch [1/5], Train Acc: 84.29%, Test Acc: 98.28%
Epoch [2/5], Train Acc: 93.70%, Test Acc: 98.45%
Epoch [3/5], Train Acc: 95.15%, Test Acc: 98.90%
Epoch [4/5], Train Acc: 96.01%, Test Acc: 99.04%
Epoch [5/5], Train Acc: 96.51%, Test Acc: 99.06%
```





Classification Report:

	precision	recall	f1-score	support
0	0.99	0.99	0.99	980
1	1.00	1.00	1.00	1135
2	0.99	0.99	0.99	1032
3	0.99	0.99	0.99	1010
4	0.99	0.99	0.99	982
5	0.99	0.99	0.99	892
6	0.99	0.99	0.99	958
7	0.99	0.99	0.99	1028
8	0.98	0.99	0.99	974
9	0.99	0.98	0.99	1009
accuracy			0.99	10000
macro avg	0.99	0.99	0.99	10000
weighted avg	0.99	0.99	0.99	10000

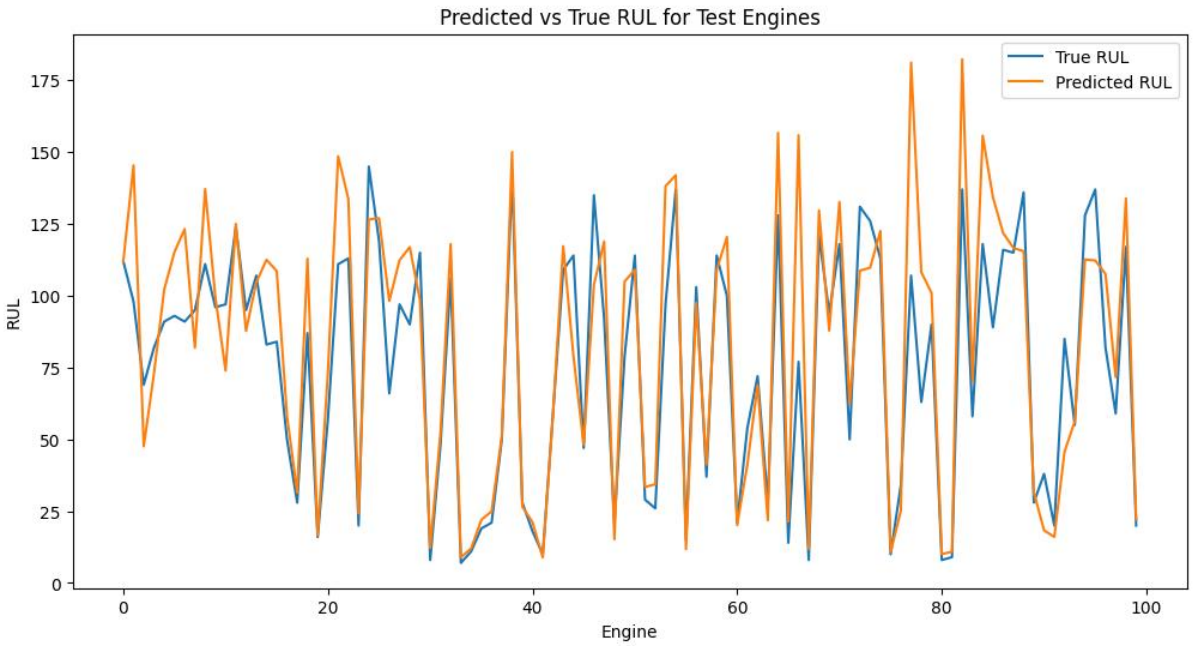


2. Remaining Useful Life (RUL) Prediction of Engine Using Recurrent Neural Networks (RNN):

Objective: To develop, train, and evaluate a Recurrent Neural Network (RNN)-based model for predicting the Remaining Useful Life (RUL) of turbofan engines.

RMSE: 21.38

MAE: 14.99




```
Engine 1: True RUL = 112, Predicted RUL = 111.95
Engine 2: True RUL = 98, Predicted RUL = 145.39
Engine 3: True RUL = 69, Predicted RUL = 47.57
Engine 4: True RUL = 82, Predicted RUL = 72.98
Engine 5: True RUL = 91, Predicted RUL = 102.16
```

```
Engine 6: True RUL = 93, Predicted RUL = 115.19
Engine 7: True RUL = 91, Predicted RUL = 123.21
Engine 8: True RUL = 95, Predicted RUL = 81.90
Engine 9: True RUL = 111, Predicted RUL = 137.10
Engine 10: True RUL = 96, Predicted RUL = 99.47
```