ML Offline 3

Dataset : mnist

Batch Size: 32
Learning rate: 0.001
Validation accuracy :

Epoch	Loss	Validation Accuracy	f1-score(macro)
1	.0984	97%	97%
2	.0739	98%	98%
3	.0594	98%	98%
4	.0508	98%	98%
5	.0458	98%	98%

Test Loss: 0.0589
Test Accuracy: 98.06%
Test f1-score(macro): 98.04%

```
(ml) cse@user-UCSC-C240-M5SX:~/Desktop/ML offline 3$ python3 1605026_1.py
Epoc 1, Batch 100  loss= 1.5570 Accuracy = 43.75% f1(macro) = 51.33%
Epoc 1, Batch 200  loss= 0.2595 Accuracy = 93.75% f1(macro) = 86.87%
Epoc 1, Batch 300  loss= 0.3866 Accuracy = 87.50% f1(macro) = 78.47%
Epoc 1, Batch 400  loss= 0.3546 Accuracy = 84.38% f1(macro) = 78.33%
Epoc 1, Batch 500  loss= 0.3112 Accuracy = 87.50% f1(macro) = 86.79%
Epoc 1, Batch 600  loss= 0.2871 Accuracy = 96.88% f1(macro) = 94.67%
Epoc 1, Batch 700  loss= 0.0606 Accuracy = 96.88% f1(macro) = 94.67%
Epoc 1, Batch 800  loss= 0.1551 Accuracy = 93.75% f1(macro) = 93.57%
Epoc 1, Batch 900  loss= 0.2250 Accuracy = 93.75% f1(macro) = 93.46%
Epoc 1, Batch 1000  loss= 0.0830 Accuracy = 96.88% f1(macro) = 96.57%
Epoc 1, Batch 1100  loss= 0.1630 Accuracy = 90.62% f1(macro) = 93.56%
Epoc 1, Batch 1200  loss= 0.2589 Accuracy = 90.62% f1(macro) = 82.80%
Epoc 1, Batch 1300  loss= 0.0705 Accuracy = 96.88% f1(macro) = 97.78%
Epoc 1, Batch 1400  loss= 0.0246 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 1, Batch 1500  loss= 0.0585 Accuracy = 96.88% f1(macro) = 96.14%
Epoc 1, Batch 1600  loss= 0.0710 Accuracy = 96.88% f1(macro) = 97.09%
Epoc 1, Batch 1700  loss= 0.1233 Accuracy = 93.75% f1(macro) = 93.46%
Epoc 1, Batch 1800  loss= 0.0112 Accuracy = 100.00% f1(macro) = 100.00%
Report of Validation Data
epoch  1
loss = 0.0984, accuracy =0.97%, f1_score(macro) = 0.97%


              precision    recall  f1-score   support

           0       0.96      0.99      0.97       526
           1       0.99      0.99      0.99       582
           2       0.97      0.97      0.97       519
           3       0.95      0.96      0.96       467
           4       0.97      0.97      0.97       476
           5       0.96      0.98      0.97       451
           6       0.98      0.98      0.98       490
           7       0.98      0.93      0.96       517
           8       0.97      0.94      0.95       466
           9       0.95      0.96      0.95       506

    accuracy                           0.97      5000
   macro avg       0.97      0.97      0.97      5000
weighted avg       0.97      0.97      0.97      5000
```

```
Epoc 2, Batch 100  loss= 0.0172 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 2, Batch 200  loss= 0.0885 Accuracy = 96.88% f1(macro) = 89.09%
Epoc 2, Batch 300  loss= 0.1394 Accuracy = 96.88% f1(macro) = 87.30%
Epoc 2, Batch 400  loss= 0.1125 Accuracy = 96.88% f1(macro) = 97.18%
Epoc 2, Batch 500  loss= 0.0798 Accuracy = 96.88% f1(macro) = 96.57%
Epoc 2, Batch 600  loss= 0.0383 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 2, Batch 700  loss= 0.0163 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 2, Batch 800  loss= 0.1063 Accuracy = 96.88% f1(macro) = 95.76%
Epoc 2, Batch 900  loss= 0.1665 Accuracy = 93.75% f1(macro) = 93.24%
Epoc 2, Batch 1000  loss= 0.0477 Accuracy = 96.88% f1(macro) = 96.57%
Epoc 2, Batch 1100  loss= 0.0480 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 2, Batch 1200  loss= 0.2215 Accuracy = 93.75% f1(macro) = 93.56%
Epoc 2, Batch 1300  loss= 0.0461 Accuracy = 96.88% f1(macro) = 97.78%
Epoc 2, Batch 1400  loss= 0.0139 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 2, Batch 1500  loss= 0.0589 Accuracy = 96.88% f1(macro) = 96.14%
Epoc 2, Batch 1600  loss= 0.0317 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 2, Batch 1700  loss= 0.0331 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 2, Batch 1800  loss= 0.0033 Accuracy = 100.00% f1(macro) = 100.00%
Report of Validation Data
epoch  2
loss = 0.0739, accuracy =0.98%, f1_score(macro) = 0.98%


              precision    recall  f1-score   support

           0       0.97      0.99      0.98       526
           1       0.98      1.00      0.99       582
           2       0.98      0.98      0.98       519
           3       0.96      0.99      0.97       467
           4       0.98      0.99      0.99       476
           5       0.94      0.99      0.97       451
           6       1.00      0.96      0.98       490
           7       0.98      0.95      0.97       517
           8       0.98      0.95      0.96       466
           9       0.98      0.96      0.97       506

    accuracy                           0.98      5000
   macro avg       0.98      0.98      0.98      5000
weighted avg       0.98      0.98      0.98      5000
```

```
Epoc 3, Batch 100  loss= 0.0095 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 3, Batch 200  loss= 0.0453 Accuracy = 96.88% f1(macro) = 89.09%
Epoc 3, Batch 300  loss= 0.1099 Accuracy = 96.88% f1(macro) = 87.30%
Epoc 3, Batch 400  loss= 0.1275 Accuracy = 96.88% f1(macro) = 97.18%
Epoc 3, Batch 500  loss= 0.0527 Accuracy = 96.88% f1(macro) = 96.57%
Epoc 3, Batch 600  loss= 0.0210 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 3, Batch 700  loss= 0.0075 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 3, Batch 800  loss= 0.0850 Accuracy = 96.88% f1(macro) = 95.76%
Epoc 3, Batch 900  loss= 0.0772 Accuracy = 96.88% f1(macro) = 96.57%
Epoc 3, Batch 1000  loss= 0.0421 Accuracy = 96.88% f1(macro) = 96.57%
Epoc 3, Batch 1100  loss= 0.0212 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 3, Batch 1200  loss= 0.2266 Accuracy = 93.75% f1(macro) = 93.56%
Epoc 3, Batch 1300  loss= 0.0297 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 3, Batch 1400  loss= 0.0083 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 3, Batch 1500  loss= 0.0336 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 3, Batch 1600  loss= 0.0106 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 3, Batch 1700  loss= 0.0144 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 3, Batch 1800  loss= 0.0022 Accuracy = 100.00% f1(macro) = 100.00%
Report of Validation Data
epoch  3
loss = 0.0594, accuracy =0.98%, f1_score(macro) = 0.98%



              precision    recall  f1-score   support

           0       0.98      0.99      0.99       526
           1       0.98      1.00      0.99       582
           2       0.98      0.98      0.98       519
           3       0.97      0.99      0.98       467
           4       0.98      0.99      0.99       476
           5       0.96      0.99      0.98       451
           6       1.00      0.97      0.98       490
           7       0.99      0.96      0.97       517
           8       0.98      0.95      0.97       466
           9       0.97      0.97      0.97       506

    accuracy                           0.98      5000
   macro avg       0.98      0.98      0.98      5000
weighted avg       0.98      0.98      0.98      5000
```

```
Epoc 4, Batch 100  loss= 0.0074 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 4, Batch 200  loss= 0.0480 Accuracy = 96.88% f1(macro) = 89.09%
Epoc 4, Batch 300  loss= 0.0899 Accuracy = 93.75% f1(macro) = 82.36%
Epoc 4, Batch 400  loss= 0.1011 Accuracy = 96.88% f1(macro) = 97.18%
Epoc 4, Batch 500  loss= 0.0474 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 4, Batch 600  loss= 0.0203 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 4, Batch 700  loss= 0.0038 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 4, Batch 800  loss= 0.0596 Accuracy = 96.88% f1(macro) = 95.76%
Epoc 4, Batch 900  loss= 0.0599 Accuracy = 96.88% f1(macro) = 96.57%
Epoc 4, Batch 1000  loss= 0.0415 Accuracy = 96.88% f1(macro) = 96.57%
Epoc 4, Batch 1100  loss= 0.0114 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 4, Batch 1200  loss= 0.2438 Accuracy = 90.62% f1(macro) = 91.40%
Epoc 4, Batch 1300  loss= 0.0190 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 4, Batch 1400  loss= 0.0055 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 4, Batch 1500  loss= 0.0272 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 4, Batch 1600  loss= 0.0056 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 4, Batch 1700  loss= 0.0112 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 4, Batch 1800  loss= 0.0019 Accuracy = 100.00% f1(macro) = 100.00%
Report of Validation Data
epoch  4
loss = 0.0508, accuracy =0.98%, f1_score(macro) = 0.98%



              precision    recall  f1-score   support

           0       0.98      0.99      0.99       526
           1       0.99      1.00      0.99       582
           2       0.99      0.98      0.99       519
           3       0.98      1.00      0.99       467
           4       0.98      1.00      0.99       476
           5       0.98      0.99      0.98       451
           6       0.99      0.98      0.98       490
           7       0.99      0.96      0.97       517
           8       0.98      0.97      0.98       466
           9       0.98      0.97      0.98       506

    accuracy                           0.98      5000
   macro avg       0.98      0.98      0.98      5000
weighted avg       0.98      0.98      0.98      5000
```

```
Epoc 5, Batch 100  loss= 0.0054 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 5, Batch 200  loss= 0.0536 Accuracy = 96.88% f1(macro) = 97.91%
Epoc 5, Batch 300  loss= 0.0877 Accuracy = 93.75% f1(macro) = 82.36%
Epoc 5, Batch 400  loss= 0.0736 Accuracy = 96.88% f1(macro) = 97.18%
Epoc 5, Batch 500  loss= 0.0370 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 5, Batch 600  loss= 0.0162 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 5, Batch 700  loss= 0.0028 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 5, Batch 800  loss= 0.0414 Accuracy = 96.88% f1(macro) = 95.76%
Epoc 5, Batch 900  loss= 0.0474 Accuracy = 96.88% f1(macro) = 96.57%
Epoc 5, Batch 1000  loss= 0.0395 Accuracy = 96.88% f1(macro) = 96.57%
Epoc 5, Batch 1100  loss= 0.0051 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 5, Batch 1200  loss= 0.2844 Accuracy = 87.50% f1(macro) = 89.45%
Epoc 5, Batch 1300  loss= 0.0116 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 5, Batch 1400  loss= 0.0046 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 5, Batch 1500  loss= 0.0186 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 5, Batch 1600  loss= 0.0032 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 5, Batch 1700  loss= 0.0102 Accuracy = 100.00% f1(macro) = 100.00%
Epoc 5, Batch 1800  loss= 0.0015 Accuracy = 100.00% f1(macro) = 100.00%
Report of Validation Data
epoch  5
loss = 0.0458, accuracy =0.98%, f1_score(macro) = 0.98%


              precision    recall  f1-score   support

           0       0.98      0.99      0.99       526
           1       0.99      1.00      1.00       582
           2       0.99      0.98      0.99       519
           3       0.98      1.00      0.99       467
           4       0.97      0.99      0.98       476
           5       0.99      0.99      0.99       451
           6       1.00      0.98      0.99       490
           7       0.99      0.96      0.97       517
           8       0.98      0.98      0.98       466
           9       0.98      0.97      0.97       506

    accuracy                           0.98      5000
   macro avg       0.98      0.98      0.98      5000
weighted avg       0.98      0.98      0.98      5000
```

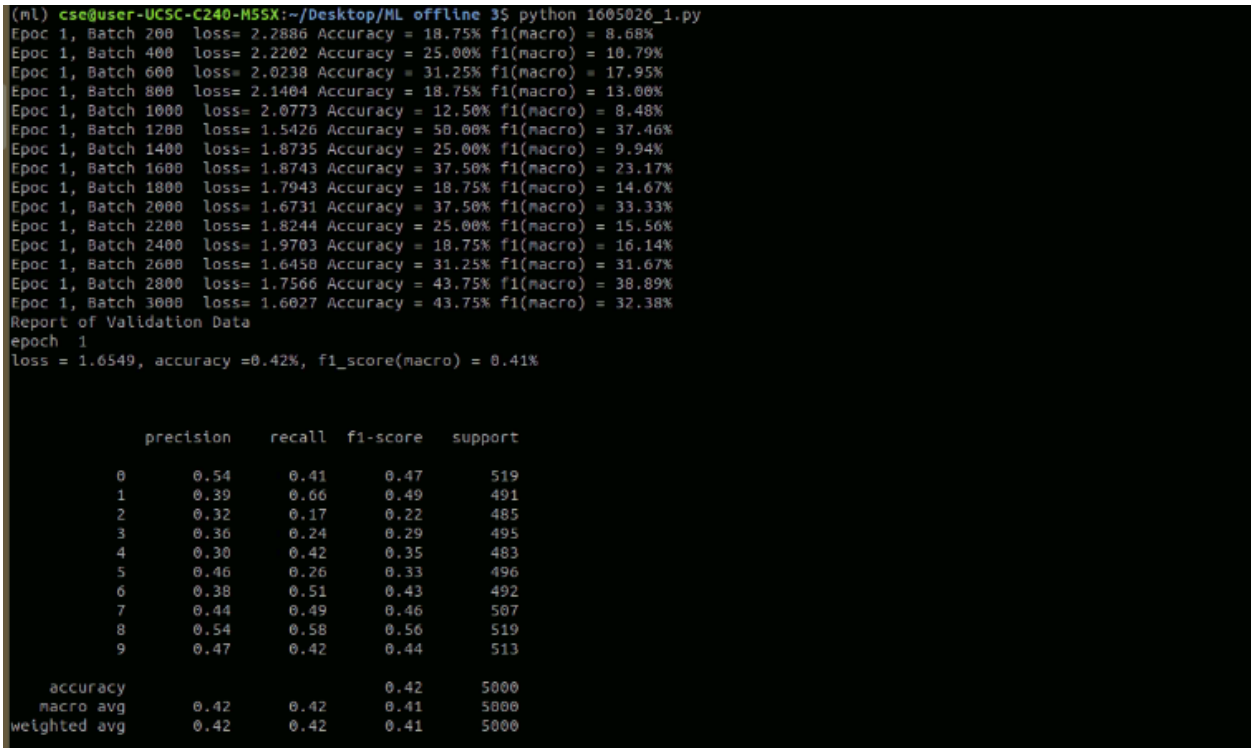
```
Report of Test Data
loss = 0.0589, accuracy =98.06%, f1_score(macro) = 98.04%


              precision    recall  f1-score   support

           0       0.97      0.99      0.98       454
           1       0.97      1.00      0.99       553
           2       0.99      0.98      0.98       513
           3       0.99      0.98      0.98       543
           4       0.98      1.00      0.99       506
           5       0.97      0.99      0.98       441
           6       1.00      0.95      0.97       468
           7       0.98      0.97      0.97       511
           8       0.98      0.97      0.98       508
           9       0.98      0.98      0.98       503

    accuracy                           0.98      5000
   macro avg       0.98      0.98      0.98      5000
weighted avg       0.98      0.98      0.98      5000
```

Dataset: CIFAR-10

Batch Size: 16
Learning rate: 0.001
Validation accuracy :

Epoch	Loss	Validation Accuracy	f1-score(macro)
1	1.6549	42%	41%
2	1.5200	47%	46%
3	1.4676	48%	47%

Test Loss: 1.4829
Test Accuracy: 47.24%
Test f1-score(macro): 46.71%



```
Epoc 2, Batch 200  loss= 1.7856 Accuracy = 12.50% f1(macro) = 9.26%
Epoc 2, Batch 400  loss= 1.7883 Accuracy = 50.00% f1(macro) = 35.00%
Epoc 2, Batch 600  loss= 1.5714 Accuracy = 31.25% f1(macro) = 27.00%
Epoc 2, Batch 800  loss= 1.9019 Accuracy = 31.25% f1(macro) = 24.44%
Epoc 2, Batch 1000  loss= 1.8376 Accuracy = 25.00% f1(macro) = 20.56%
Epoc 2, Batch 1200  loss= 1.1349 Accuracy = 62.50% f1(macro) = 46.90%
Epoc 2, Batch 1400  loss= 1.8735 Accuracy = 37.50% f1(macro) = 19.70%
Epoc 2, Batch 1600  loss= 1.6095 Accuracy = 37.50% f1(macro) = 31.33%
Epoc 2, Batch 1800  loss= 1.5942 Accuracy = 25.00% f1(macro) = 16.67%
Epoc 2, Batch 2000  loss= 1.6115 Accuracy = 43.75% f1(macro) = 39.00%
Epoc 2, Batch 2200  loss= 1.6371 Accuracy = 37.50% f1(macro) = 28.52%
Epoc 2, Batch 2400  loss= 2.1882 Accuracy = 18.75% f1(macro) = 15.83%
Epoc 2, Batch 2600  loss= 1.6584 Accuracy = 43.75% f1(macro) = 38.67%
Epoc 2, Batch 2800  loss= 1.6461 Accuracy = 50.00% f1(macro) = 47.78%
Epoc 2, Batch 3000  loss= 1.3526 Accuracy = 50.00% f1(macro) = 34.00%
Report of Validation Data
epoch  2
loss = 1.5200, accuracy =0.47%, f1_score(macro) = 0.46%



              precision    recall  f1-score   support

           0       0.55      0.50      0.52       519
           1       0.47      0.66      0.55       491
           2       0.41      0.32      0.36       485
           3       0.37      0.32      0.35       495
           4       0.37      0.46      0.41       483
           5       0.51      0.30      0.38       496
           6       0.47      0.55      0.51       492
           7       0.51      0.55      0.53       507
           8       0.56      0.63      0.59       519
           9       0.50      0.43      0.46       513

    accuracy                           0.47      5000
   macro avg       0.47      0.47      0.46      5000
weighted avg       0.47      0.47      0.47      5000
```

```
Epoc 3, Batch 200  loss= 1.9188 Accuracy = 18.75% f1(macro) = 12.96%
Epoc 3, Batch 400  loss= 1.4435 Accuracy = 50.00% f1(macro) = 33.60%
Epoc 3, Batch 600  loss= 1.4096 Accuracy = 43.75% f1(macro) = 40.33%
Epoc 3, Batch 800  loss= 1.6640 Accuracy = 43.75% f1(macro) = 35.33%
Epoc 3, Batch 1000  loss= 1.8389 Accuracy = 37.50% f1(macro) = 27.52%
Epoc 3, Batch 1200  loss= 1.0992 Accuracy = 62.50% f1(macro) = 50.00%
Epoc 3, Batch 1400  loss= 1.7139 Accuracy = 43.75% f1(macro) = 30.56%
Epoc 3, Batch 1600  loss= 1.4535 Accuracy = 31.25% f1(macro) = 25.33%
Epoc 3, Batch 1800  loss= 1.5011 Accuracy = 25.00% f1(macro) = 18.75%
Epoc 3, Batch 2000  loss= 1.3841 Accuracy = 62.50% f1(macro) = 60.00%
Epoc 3, Batch 2200  loss= 1.6625 Accuracy = 31.25% f1(macro) = 23.02%
Epoc 3, Batch 2400  loss= 2.0454 Accuracy = 37.50% f1(macro) = 38.33%
Epoc 3, Batch 2600  loss= 1.7797 Accuracy = 25.00% f1(macro) = 23.33%
Epoc 3, Batch 2800  loss= 1.6558 Accuracy = 50.00% f1(macro) = 43.60%
Epoc 3, Batch 3000  loss= 1.2215 Accuracy = 56.25% f1(macro) = 40.74%
Report of Validation Data
epoch  3
loss = 1.4676, accuracy =0.48%, f1_score(macro) = 0.47%



              precision    recall  f1-score   support

           0       0.58      0.50      0.54       519
           1       0.45      0.68      0.54       491
           2       0.44      0.29      0.35       485
           3       0.40      0.35      0.37       495
           4       0.41      0.43      0.42       483
           5       0.48      0.34      0.40       496
           6       0.54      0.49      0.51       492
           7       0.47      0.62      0.54       507
           8       0.56      0.66      0.60       519
           9       0.49      0.45      0.47       513

    accuracy                           0.48      5000
   macro avg       0.48      0.48      0.47      5000
weighted avg       0.48      0.48      0.48      5000
```

```
Report of Test Data
loss = 1.4829, accuracy =47.24%, f1_score(macro) = 46.71%

              precision    recall  f1-score   support

           0       0.58      0.55      0.57       481
           1       0.46      0.65      0.54       509
           2       0.46      0.29      0.36       515
           3       0.34      0.29      0.31       505
           4       0.42      0.44      0.43       517
           5       0.46      0.31      0.37       504
           6       0.55      0.50      0.52       508
           7       0.42      0.55      0.48       493
           8       0.53      0.62      0.57       481
           9       0.52      0.54      0.53       487

    accuracy                           0.47      5000
   macro avg       0.47      0.47      0.47      5000
weighted avg       0.47      0.47      0.47      5000
```

I also experiment this dataset with batch size = 64 and learning rate = .01 .
After 3 epochs, test accuracy was 33.34% and f1-score(macro) was 31.55%.

Changing Hyperparameters:

Total Epoch	Batch Size	Learning rate	Test Accuracy	f1-score(macro)
2	32	0.001	43.76%	42.08%
3	64	0.01	33.34%	31.55%
3	16	0.001	47.24%	46.71%