IST_597 Deep Learning Assignment 00010 Report
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Github Link: https://github.com/thejasvi204/IST597_spring22
Inputs:

```
# Constants
size_input = 784
size_hidden = [128,128,128]
size_output = 10
number_of_train_examples = 60000 #60000
number_of_test_examples = 10000    #10000
```

Total number of epochs: 20

```
Inferences_seeds=[5097,1111,1234,5678,199991,99999,3421,6642,8754,3454444]
```

For one step inference number of epochs=10

Model X: With L2 Regularization(MLP)(GPU)
Model Y:With custom optimization(MLP_custopt)(GPU)

Findings:

After running the both models we observed that custom optimization is an adam algorithm which gives before result than the tensorflow adam implementation when applying hyper tune parameters with validation. Thus model X proved to be a more optimal model rather than model Y.

For MNIST with L2 regularization:

Number of Epoch = 1 - Average Cross Entropy:= 692.44344 - Validation Accuracy: 80.3500 - Train Accuracy: 79.7140

Number of Epoch = 2 - Average Cross Entropy:= 146.18757 - Validation Accuracy: 85.4000 - Train Accuracy: 85.3640

Number of Epoch = 3 - Average Cross Entropy:= 83.96339 - Validation Accuracy: 87.4100 - Train Accuracy: 87.8120

Number of Epoch = 4 - Average Cross Entropy:= 54.85464 - Validation Accuracy: 88.4500 - Train Accuracy: 89.0880

Number of Epoch = 5 - Average Cross Entropy:= 38.18434 - Validation Accuracy: 88.8000 - Train Accuracy: 89.5440

Number of Epoch = 6 - Average Cross Entropy:= 27.3571525 - Validation Accuracy: 89.6000 - Train Accuracy: 90.1680

Number of Epoch = 7 - Average Cross Entropy:= 20.40848875 - Validation Accuracy: 89.8300 - Train Accuracy: 90.6980

Number of Epoch = 8 - Average Cross Entropy:= 15.17595625 - Validation Accuracy: 90.3600 - Train Accuracy: 90.9620

Number of Epoch = 9 - Average Cross Entropy:= 11.45799125 - Validation Accuracy: 89.9300 - Train Accuracy: 90.8700

Number of Epoch = 10 - Average Cross Entropy:= 8.6464775 - Validation Accuracy: 90.5300 - Train Accuracy: 91.1760

Number of Epoch = 11 - Average Cross Entropy:= 6.584948125 - Validation Accuracy: 90.4200 - Train Accuracy: 91.3000

Number of Epoch = 12 - Average Cross Entropy:= 5.1266353125 - Validation Accuracy: 90.7400 - Train Accuracy: 91.2960

Number of Epoch = 13 - Average Cross Entropy:= 3.8462 - Validation Accuracy: 90.9300 - Train Accuracy: 91.3220

Number of Epoch = 14 - Average Cross Entropy:= 2.906023125 - Validation Accuracy: 90.5000 - Train Accuracy: 90.5540

Number of Epoch = 15 - Average Cross Entropy:= 2.15948921875 - Validation Accuracy: 90.8300 - Train Accuracy: 91.3340

Number of Epoch = 16 - Average Cross Entropy:= 1.54754375 - Validation Accuracy: 90.1200 - Train Accuracy: 90.5940

Number of Epoch = 17 - Average Cross Entropy:= 1.093516484375 - Validation Accuracy: 91.5900 - Train Accuracy: 92.5020

Number of Epoch = 18 - Average Cross Entropy:= 0.762530078125 - Validation Accuracy: 91.5700 - Train Accuracy: 92.3120

Number of Epoch = 19 - Average Cross Entropy:= 0.5527118359375 - Validation Accuracy: 92.1000 - Train Accuracy: 92.7360

Number of Epoch = 20 - Average Cross Entropy:= 0.39376734375 - Validation Accuracy: 92.7200 - Train Accuracy: 93.3440

Total time taken (in seconds): 384.44

For fashion MNIST with L2 regularization:

Number of Epoch = 1 - Average Cross Entropy:= 662.99 - Validation Accuracy: 72.8000 - Train Accuracy: 73.6920

Number of Epoch = 2 - Average Cross Entropy:= 169.87914 - Validation Accuracy: 74.5500 - Train Accuracy: 75.9520

Number of Epoch = 3 - Average Cross Entropy:= 110.83137 - Validation Accuracy: 76.2800 - Train Accuracy: 77.5600

Number of Epoch = 4 - Average Cross Entropy:= 80.26645 - Validation Accuracy: 75.9600 - Train Accuracy: 77.9640

Number of Epoch = 5 - Average Cross Entropy:= 61.159335 - Validation Accuracy: 75.8600 - Train Accuracy: 77.7680

Number of Epoch = 6 - Average Cross Entropy:= 48.858745 - Validation Accuracy: 77.0300 - Train Accuracy: 78.7180

Number of Epoch = 7 - Average Cross Entropy:= 40.47324 - Validation Accuracy: 76.8500 - Train Accuracy: 78.8680

Number of Epoch = 8 - Average Cross Entropy:= 33.7314225 - Validation Accuracy: 77.4400 - Train Accuracy: 79.3120

Number of Epoch = 9 - Average Cross Entropy:= 27.8493375 - Validation Accuracy: 77.3700 - Train Accuracy: 79.3260

Number of Epoch = 10 - Average Cross Entropy:= 23.5389425 - Validation Accuracy: 77.9700 - Train Accuracy: 79.6320

Number of Epoch = 11 - Average Cross Entropy:= 20.08859875 - Validation Accuracy: 76.1900 - Train Accuracy: 78.1620

Number of Epoch = 12 - Average Cross Entropy:= 17.33827 - Validation Accuracy: 78.6200 - Train Accuracy: 80.5020

Number of Epoch = 13 - Average Cross Entropy:= 15.0787125 - Validation Accuracy: 78.5900 - Train Accuracy: 80.1320

Number of Epoch = 14 - Average Cross Entropy:= 13.22634625 - Validation Accuracy: 78.0300 - Train Accuracy: 80.0220

Number of Epoch = 15 - Average Cross Entropy:= 11.39514125 - Validation Accuracy: 77.6200 - Train Accuracy: 79.0940

Number of Epoch = 16 - Average Cross Entropy:= 9.524544375 - Validation Accuracy: 78.0500 - Train Accuracy: 79.6900

Number of Epoch = 17 - Average Cross Entropy:= 6.266871875 - Validation Accuracy: 75.4500 - Train Accuracy: 77.1160

Number of Epoch = 18 - Average Cross Entropy:= 2.433026875 - Validation Accuracy: 76.3600 - Train Accuracy: 77.5240

Number of Epoch = 19 - Average Cross Entropy:= 1.299948125 - Validation Accuracy: 78.4300 - Train Accuracy: 79.7260

Number of Epoch = 20 - Average Cross Entropy:= 0.905051796875 - Validation Accuracy: 78.6900 - Train Accuracy: 80.7700

Total time taken (in seconds): 399.44

For custom optimization MNIST:

Number of Epoch = 1 - Average Cross Entropy:= 1.115157734375 - Validation Accuracy: 83.9000 - Train Accuracy: 83.5040
Number of Epoch = 2 - Average Cross Entropy:= 0.24750677734375 - Validation Accuracy: 86.0600 - Train Accuracy: 86.7680
Number of Epoch = 3 - Average Cross Entropy:= 0.17437345703125 - Validation Accuracy: 87.0200 - Train Accuracy: 88.6180
Number of Epoch = 4 - Average Cross Entropy:= 0.13611361328125 - Validation Accuracy: 88.0300 - Train Accuracy: 90.0100
Number of Epoch = 5 - Average Cross Entropy:= 0.112529921875 - Validation Accuracy: 88.3400 - Train Accuracy: 90.8020
Number of Epoch = 6 - Average Cross Entropy:= 0.09576990234375 - Validation Accuracy: 88.9000 - Train Accuracy: 91.3920
Number of Epoch = 7 - Average Cross Entropy:= 0.08328705078125 - Validation Accuracy: 89.1500 - Train Accuracy: 91.9940
Number of Epoch = 8 - Average Cross Entropy:= 0.0729369384765625 - Validation Accuracy: 89.3500 - Train Accuracy: 92.5020
Number of Epoch = 9 - Average Cross Entropy:= 0.0647045703125 - Validation Accuracy: 89.5400 - Train Accuracy: 92.9560
Number of Epoch = 10 - Average Cross Entropy:= 0.0579143505859375 - Validation Accuracy: 89.6100 - Train Accuracy: 93.1480
Number of Epoch = 11 - Average Cross Entropy:= 0.0517647314453125 - Validation Accuracy: 89.9100 - Train Accuracy: 93.6820
Number of Epoch = 12 - Average Cross Entropy:= 0.0464691943359375 - Validation Accuracy: 90.0700 - Train Accuracy: 94.0200
Number of Epoch = 13 - Average Cross Entropy:= 0.0417388427734375 - Validation Accuracy: 90.0100 - Train Accuracy: 94.3420
Number of Epoch = 14 - Average Cross Entropy:= 0.0377021337890625 - Validation Accuracy: 90.0600 - Train Accuracy: 94.4920
Number of Epoch = 15 - Average Cross Entropy:= 0.03404048828125 - Validation Accuracy: 90.2500 - Train Accuracy: 94.8300
Number of Epoch = 16 - Average Cross Entropy:= 0.03079493408203125 - Validation Accuracy: 90.3600 - Train Accuracy: 94.9960
Number of Epoch = 17 - Average Cross Entropy:= 0.02788538818359375 - Validation Accuracy: 90.3300 - Train Accuracy: 95.2680
Number of Epoch = 18 - Average Cross Entropy:= 0.02555072265625 - Validation Accuracy: 90.5100 - Train Accuracy: 95.6280
Number of Epoch = 19 - Average Cross Entropy:= 0.02302570068359375 - Validation Accuracy: 90.5100 - Train Accuracy: 95.8700
Number of Epoch = 20 - Average Cross Entropy:= 0.02083108154296875 - Validation Accuracy: 90.6300 - Train Accuracy: 95.8680
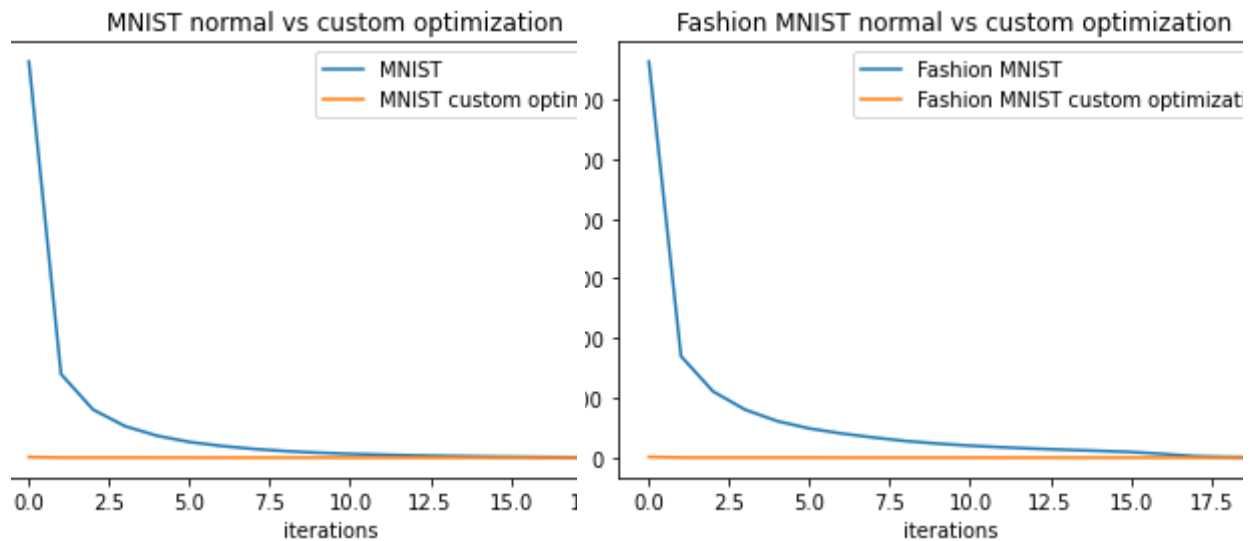
Total time taken (in seconds): 121.33

For Fashion MNIST cust opt GPU

Number of Epoch = 1 - Average Cross Entropy:= 1.302851328125 - Validation Accuracy: 72.9100 - Train Accuracy: 74.1880
Number of Epoch = 2 - Average Cross Entropy:= 0.3207939453125 - Validation Accuracy: 73.3400 - Train Accuracy: 75.3300
Number of Epoch = 3 - Average Cross Entropy:= 0.24268263671875 - Validation Accuracy: 75.2000 - Train Accuracy: 77.1920
Number of Epoch = 4 - Average Cross Entropy:= 0.19930689453125 - Validation Accuracy: 75.8900 - Train Accuracy: 77.9380
Number of Epoch = 5 - Average Cross Entropy:= 0.17002083984375 - Validation Accuracy: 76.3600 - Train Accuracy: 78.5360
Number of Epoch = 6 - Average Cross Entropy:= 0.148209150390625 - Validation Accuracy: 76.4600 - Train Accuracy: 78.9380
Number of Epoch = 7 - Average Cross Entropy:= 0.132809013671875 - Validation Accuracy: 76.6700 - Train Accuracy: 79.5720
Number of Epoch = 8 - Average Cross Entropy:= 0.119841591796875 - Validation Accuracy: 76.4000 - Train Accuracy: 79.1460
Number of Epoch = 9 - Average Cross Entropy:= 0.10898759765625 - Validation Accuracy: 76.4700 - Train Accuracy: 79.5240
Number of Epoch = 10 - Average Cross Entropy:= 0.100175771484375 - Validation Accuracy: 77.0500 - Train Accuracy: 80.0060
Number of Epoch = 11 - Average Cross Entropy:= 0.09218388671875 - Validation Accuracy: 76.9600 - Train Accuracy: 80.0700
Number of Epoch = 12 - Average Cross Entropy:= 0.0861180859375 - Validation Accuracy: 76.9000 - Train Accuracy: 80.1620
Number of Epoch = 13 - Average Cross Entropy:= 0.080760146484375 - Validation Accuracy: 77.1600 - Train Accuracy: 80.6460
Number of Epoch = 14 - Average Cross Entropy:= 0.075221796875 - Validation Accuracy: 77.9600 - Train Accuracy: 81.3580
Number of Epoch = 15 - Average Cross Entropy:= 0.0704721484375 - Validation Accuracy: 78.4400 - Train Accuracy: 81.9760
Number of Epoch = 16 - Average Cross Entropy:= 0.0665190673828125 - Validation Accuracy: 78.4700 - Train Accuracy: 81.8920
Number of Epoch = 17 - Average Cross Entropy:= 0.0623525927734375 - Validation Accuracy: 78.5200 - Train Accuracy: 81.9780
Number of Epoch = 18 - Average Cross Entropy:= 0.0588616064453125 - Validation Accuracy: 78.0700 - Train Accuracy: 81.6080
Number of Epoch = 19 - Average Cross Entropy:= 0.0558525146484375 - Validation Accuracy: 78.6900 - Train Accuracy: 82.1000
Number of Epoch = 20 - Average Cross Entropy:= 0.0530804541015625 - Validation Accuracy: 78.4100 - Train Accuracy: 82.0280

Total time taken (in seconds): 104.95

Graphs:

MNIST normal vs custom optimization — Fashion MNIST normal vs custom optimization

One Step Inference Values

For MNIST with L2 regularization:

For seed:5097

Test loss: 0.5459 - Test Accuracy:0.82
For seed:1111

Test loss: 0.5459 - Test Accuracy:0.82
For seed:1234

Test loss: 0.5459 - Test Accuracy:0.82
For seed:5678

Test loss: 0.5459 - Test Accuracy:0.82
For seed:199991

Test loss: 0.5459 - Test Accuracy:0.82
For seed:99999

Test loss: 0.5459 - Test Accuracy:0.82
For seed:3421

Test loss: 0.5459 - Test Accuracy:0.82
For seed:6642

Test loss: 0.5459 - Test Accuracy:0.82
For seed:8754

Test loss: 0.5459 - Test Accuracy:0.82
For seed:3454444

Test loss: 0.5459 - Test Accuracy:0.82

For MNIST with custom optimization:

For MNIST inference

For seed:5097

Test loss: 14.5440 - Test Accuracy:0.90
For seed:1111

Test loss: 14.5440 - Test Accuracy:0.90
For seed:1234

Test loss: 14.5440 - Test Accuracy:0.90
For seed:5678

Test loss: 14.5440 - Test Accuracy:0.90
For seed:199991

Test loss: 14.5440 - Test Accuracy:0.90
For seed:99999

Test loss: 14.5440 - Test Accuracy:0.90
For seed:3421

Test loss: 14.5440 - Test Accuracy:0.90
For seed:6642

Test loss: 14.5440 - Test Accuracy:0.90
For seed:8754

Test loss: 14.5440 - Test Accuracy:0.90
For seed:3454444

Test loss: 14.5440 - Test Accuracy:0.90

For Fashion MNIST with L2 regularization:

For Fashion MNIST inference

For seed:5097

Test loss: 32.5170 - Test Accuracy:0.77
For seed:1111

Test loss: 20.9601 - Test Accuracy:0.77
For seed:1234

Test loss: 26.2997 - Test Accuracy:0.78
For seed:5678

Test loss: 21.2807 - Test Accuracy:0.78
For seed:199991

Test loss: 40.4129 - Test Accuracy:0.77
For seed:99999

Test loss: 25.0911 - Test Accuracy:0.77
For seed:3421

Test loss: 29.6495 - Test Accuracy:0.78
For seed:6642

Test loss: 31.0274 - Test Accuracy:0.75
For seed:8754

Test loss: 34.5056 - Test Accuracy:0.78
For seed:3454444

Test loss: 26.0062 - Test Accuracy:0.78

For Fashion MNIST with custom optimization:

For Fashion MNIST custom inference

For seed:5097

For Fashion MNIST cust opt GPU

Test loss: 0.6798 - Test Accuracy:0.77
For seed:1111

For Fashion MNIST cust opt GPU

Test loss: 0.7838 - Test Accuracy:0.78
For seed:1234

For Fashion MNIST cust opt GPU

Test loss: 0.7275 - Test Accuracy:0.78
For seed:5678

For Fashion MNIST cust opt GPU

Test loss: 0.7891 - Test Accuracy:0.78
For seed:199991

For Fashion MNIST cust opt GPU

Test loss: 0.6510 - Test Accuracy:0.77
For seed:99999

For Fashion MNIST cust opt GPU

Test loss: 0.6267 - Test Accuracy:0.77
For seed:3421

For Fashion MNIST cust opt GPU

Test loss: 0.8094 - Test Accuracy:0.78
For seed:6642

For Fashion MNIST cust opt GPU

Test loss: 0.7029 - Test Accuracy:0.77
For seed:8754

For Fashion MNIST cust opt GPU

Test loss: 0.8078 - Test Accuracy:0.79
For seed:3454444

For Fashion MNIST cust opt GPU

Test loss: 0.8034 - Test Accuracy:0.77