

Intro to Deep Learning

Assignment 4

The results obtained for training and testing the LeNet model on the CIFAR10 dataset is shown below:

```
Train Epoch: 50 [0/50000 (0%)] Loss: 1.125054
Train Epoch: 50 [1280/50000 (3%)] Loss: 1.330339
Train Epoch: 50 [2560/50000 (5%)] Loss: 1.349255
Train Epoch: 50 [3840/50000 (8%)] Loss: 1.007726
Train Epoch: 50 [5120/50000 (10%)] Loss: 1.402813
Train Epoch: 50 [6400/50000 (13%)] Loss: 1.158183
Train Epoch: 50 [7680/50000 (15%)] Loss: 1.392872
Train Epoch: 50 [8960/50000 (18%)] Loss: 1.130676
Train Epoch: 50 [10240/50000 (20%)] Loss: 1.298515
Train Epoch: 50 [11520/50000 (23%)] Loss: 1.293175
Train Epoch: 50 [12800/50000 (26%)] Loss: 1.207006
Train Epoch: 50 [14080/50000 (28%)] Loss: 1.199305
Train Epoch: 50 [15360/50000 (31%)] Loss: 1.293876
Train Epoch: 50 [16640/50000 (33%)] Loss: 1.333812
Train Epoch: 50 [17920/50000 (36%)] Loss: 1.272209
Train Epoch: 50 [19200/50000 (38%)] Loss: 1.382418
Train Epoch: 50 [20480/50000 (41%)] Loss: 1.187829
Train Epoch: 50 [21760/50000 (43%)] Loss: 1.310849
Train Epoch: 50 [23040/50000 (46%)] Loss: 1.416883
Train Epoch: 50 [24320/50000 (49%)] Loss: 1.344059
Train Epoch: 50 [25600/50000 (51%)] Loss: 1.134820
Train Epoch: 50 [26880/50000 (54%)] Loss: 1.100027
Train Epoch: 50 [28160/50000 (56%)] Loss: 1.117422
Train Epoch: 50 [29440/50000 (59%)] Loss: 1.124947
Train Epoch: 50 [30720/50000 (61%)] Loss: 1.222524
Train Epoch: 50 [32000/50000 (64%)] Loss: 1.220479
Train Epoch: 50 [33280/50000 (66%)] Loss: 1.285347
Train Epoch: 50 [34560/50000 (69%)] Loss: 1.232865
Train Epoch: 50 [35840/50000 (72%)] Loss: 1.061050
Train Epoch: 50 [37120/50000 (74%)] Loss: 1.218194
Train Epoch: 50 [38400/50000 (77%)] Loss: 1.081244
Train Epoch: 50 [39680/50000 (79%)] Loss: 1.378664
Train Epoch: 50 [40960/50000 (82%)] Loss: 1.102321
Train Epoch: 50 [42240/50000 (84%)] Loss: 1.129489
Train Epoch: 50 [43520/50000 (87%)] Loss: 1.091162
Train Epoch: 50 [44800/50000 (90%)] Loss: 1.303407
Train Epoch: 50 [46080/50000 (92%)] Loss: 1.072111
Train Epoch: 50 [47360/50000 (95%)] Loss: 1.193904
Train Epoch: 50 [48640/50000 (97%)] Loss: 1.130429
Train Epoch: 50 [31200/50000 (100%)] Loss: 1.277939

Test set: Average loss: 1.0860, Accuracy: 6258/10000 (63%)

Training and Testing total execution time is: 786.8885610103607 seconds
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On adding a dropout layer to the model, the results obtained on training and testing the model is shown below:

```
Train Epoch: 50 [0/50000 (0%)] Loss: 1.193789
Train Epoch: 50 [1280/50000 (3%)] Loss: 1.423355
Train Epoch: 50 [2560/50000 (5%)] Loss: 1.377645
Train Epoch: 50 [3840/50000 (8%)] Loss: 1.122970
Train Epoch: 50 [5120/50000 (10%)] Loss: 1.262598
Train Epoch: 50 [6400/50000 (13%)] Loss: 1.224379
Train Epoch: 50 [7680/50000 (15%)] Loss: 1.469418
Train Epoch: 50 [8960/50000 (18%)] Loss: 1.304289
Train Epoch: 50 [10240/50000 (20%)] Loss: 1.252479
Train Epoch: 50 [11520/50000 (23%)] Loss: 1.306089
Train Epoch: 50 [12800/50000 (26%)] Loss: 1.283241
Train Epoch: 50 [14080/50000 (28%)] Loss: 1.264683
Train Epoch: 50 [15360/50000 (31%)] Loss: 1.363750
Train Epoch: 50 [16640/50000 (33%)] Loss: 1.158437
Train Epoch: 50 [17920/50000 (36%)] Loss: 1.432135
Train Epoch: 50 [19200/50000 (38%)] Loss: 1.420183
Train Epoch: 50 [20480/50000 (41%)] Loss: 1.146276
Train Epoch: 50 [21760/50000 (43%)] Loss: 1.230886
Train Epoch: 50 [23040/50000 (46%)] Loss: 1.304023
Train Epoch: 50 [24320/50000 (49%)] Loss: 1.386340
Train Epoch: 50 [25600/50000 (51%)] Loss: 1.164740
Train Epoch: 50 [26880/50000 (54%)] Loss: 1.164183
Train Epoch: 50 [28160/50000 (56%)] Loss: 1.119666
Train Epoch: 50 [29440/50000 (59%)] Loss: 1.168429
Train Epoch: 50 [30720/50000 (61%)] Loss: 1.361451
Train Epoch: 50 [32000/50000 (64%)] Loss: 1.345731
Train Epoch: 50 [33280/50000 (66%)] Loss: 1.348541
Train Epoch: 50 [34560/50000 (69%)] Loss: 1.365960
Train Epoch: 50 [35840/50000 (72%)] Loss: 1.130035
Train Epoch: 50 [37120/50000 (74%)] Loss: 1.216237
Train Epoch: 50 [38400/50000 (77%)] Loss: 1.347380
Train Epoch: 50 [39680/50000 (79%)] Loss: 1.426750
Train Epoch: 50 [40960/50000 (82%)] Loss: 1.245992
Train Epoch: 50 [42240/50000 (84%)] Loss: 1.229347
Train Epoch: 50 [43520/50000 (87%)] Loss: 1.080333
Train Epoch: 50 [44800/50000 (90%)] Loss: 1.190190
Train Epoch: 50 [46080/50000 (92%)] Loss: 1.176709
Train Epoch: 50 [47360/50000 (95%)] Loss: 1.281274
Train Epoch: 50 [48640/50000 (97%)] Loss: 1.351262
Train Epoch: 50 [31200/50000 (100%)] Loss: 1.258105

Test set: Average loss: 1.1810, Accuracy: 5966/10000 (60%)

Training and Testing total execution time is: 787.677484035492 seconds
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Finally, on adding a batch normalization layer to the model, the results obtained on training and testing the model is shown below:


```
Train Epoch: 50 [0/50000 (0%)] Loss: 1.142463
Train Epoch: 50 [1280/50000 (3%)] Loss: 1.146262
Train Epoch: 50 [2560/50000 (5%)] Loss: 1.048293
Train Epoch: 50 [3840/50000 (8%)] Loss: 0.928892
Train Epoch: 50 [5120/50000 (10%)] Loss: 1.040171
Train Epoch: 50 [6400/50000 (13%)] Loss: 0.982272
Train Epoch: 50 [7680/50000 (15%)] Loss: 1.118113
Train Epoch: 50 [8960/50000 (18%)] Loss: 0.971418
Train Epoch: 50 [10240/50000 (20%)] Loss: 1.073143
Train Epoch: 50 [11520/50000 (23%)] Loss: 1.162706
Train Epoch: 50 [12800/50000 (26%)] Loss: 1.008039
Train Epoch: 50 [14080/50000 (28%)] Loss: 1.085289
Train Epoch: 50 [15360/50000 (31%)] Loss: 1.049511
Train Epoch: 50 [16640/50000 (33%)] Loss: 1.024291
Train Epoch: 50 [17920/50000 (36%)] Loss: 1.093595
Train Epoch: 50 [19200/50000 (38%)] Loss: 1.101349
Train Epoch: 50 [20480/50000 (41%)] Loss: 1.018378
Train Epoch: 50 [21760/50000 (43%)] Loss: 1.071448
Train Epoch: 50 [23040/50000 (46%)] Loss: 1.143653
Train Epoch: 50 [24320/50000 (49%)] Loss: 1.202225
Train Epoch: 50 [25600/50000 (51%)] Loss: 1.106310
Train Epoch: 50 [26880/50000 (54%)] Loss: 0.965923
Train Epoch: 50 [28160/50000 (56%)] Loss: 0.987512
Train Epoch: 50 [29440/50000 (59%)] Loss: 0.971635
Train Epoch: 50 [30720/50000 (61%)] Loss: 1.231806
Train Epoch: 50 [32000/50000 (64%)] Loss: 1.087970
Train Epoch: 50 [33280/50000 (66%)] Loss: 0.988973
Train Epoch: 50 [34560/50000 (69%)] Loss: 1.243155
Train Epoch: 50 [35840/50000 (72%)] Loss: 1.048290
Train Epoch: 50 [37120/50000 (74%)] Loss: 1.010018
Train Epoch: 50 [38400/50000 (77%)] Loss: 0.978833
Train Epoch: 50 [39680/50000 (79%)] Loss: 1.221609
Train Epoch: 50 [40960/50000 (82%)] Loss: 1.060551
Train Epoch: 50 [42240/50000 (84%)] Loss: 1.035741
Train Epoch: 50 [43520/50000 (87%)] Loss: 1.048177
Train Epoch: 50 [44800/50000 (90%)] Loss: 1.019008
Train Epoch: 50 [46080/50000 (92%)] Loss: 1.024051
Train Epoch: 50 [47360/50000 (95%)] Loss: 0.989189
Train Epoch: 50 [48640/50000 (97%)] Loss: 1.005365
Train Epoch: 50 [31200/50000 (100%)] Loss: 1.035578
```

Test set: Average loss: 0.9556, Accuracy: 6700/10000 (67%)

Training and Testing total execution time is: 909.3889510631561 seconds