Computer Vision Assignment-2

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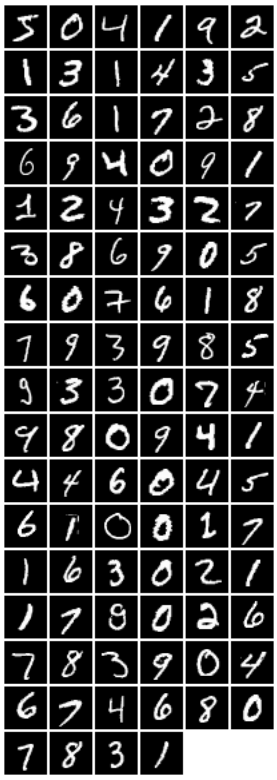
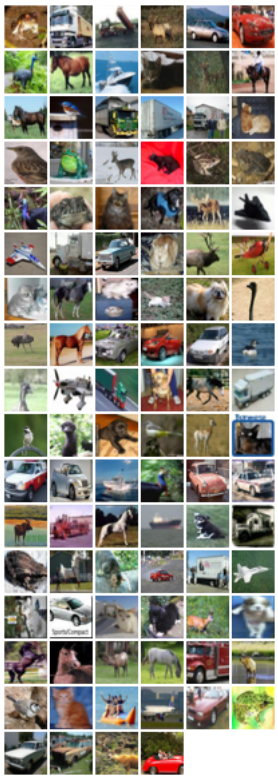
2. The images for the MNIST and CIFAR training data are as follows:



(a) MNIST-100



(b) CIFAR-100

3.(a) The output after training, validating and testing on 1000 examples.

```
train | epoch = 1 | lr = 0.1000 | loss: 29293.0637 | error: 668.0000 - valid | validloss: 10181.8040 | validerror: 419.0000 | s/iter: 0.2010
train | epoch = 2 | lr = 0.1000 | loss: 3712.8518 | error: 244.0000 - valid | validloss: 2766.7456 | validerror: 228.0000 | s/iter: 0.1829
train | epoch = 3 | lr = 0.1000 | loss: 1273.6265 | error: 133.0000 - valid | validloss: 2527.4130 | validerror: 226.0000 | s/iter: 0.1890
train | epoch = 4 | lr = 0.1000 | loss: 1601.3950 | error: 156.0000 - valid | validloss: 2233.3753 | validerror: 201.0000 | s/iter: 0.1794
train | epoch = 5 | lr = 0.1000 | loss: 713.4778 | error: 88.0000 - valid | validloss: 1746.5079 | validerror: 171.0000 | s/iter: 0.1855
train | epoch = 6 | lr = 0.1000 | loss: 527.5201 | error: 86.0000 - valid | validloss: 1993.9952 | validerror: 211.0000 | s/iter: 0.1890
train | epoch = 7 | lr = 0.1000 | loss: 464.6825 | error: 92.0000 - valid | validloss: 1802.6563 | validerror: 193.0000 | s/iter: 0.1854
train | epoch = 8 | lr = 0.1000 | loss: 238.6802 | error: 54.0000 - valid | validloss: 1765.2389 | validerror: 198.0000 | s/iter: 0.1821
train | epoch = 9 | lr = 0.1000 | loss: 746.3244 | error: 100.0000 - valid | validloss: 3751.9471 | validerror: 274.0000 | s/iter: 0.1822
train | epoch = 10 | lr = 0.1000 | loss: 354.2497 | error: 62.0000 - valid | validloss: 1854.9411 | validerror: 195.0000 | s/iter: 0.1804
| test | error: 191.0000
```

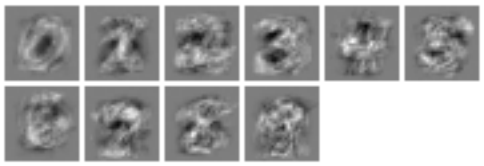
Figure 2

(b) The output after training on 50 examples and using the full validation and test set.

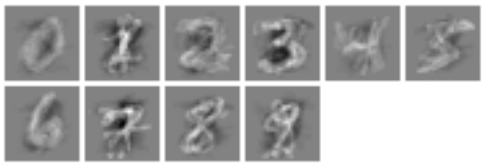
```
train | epoch = 1 | lr = 0.1000 | loss: 64.8796 | error: 43.0000 - valid | validloss: 20685.1468 | validerror: 6954.0000 | s/iter: 0.9792
train | epoch = 2 | lr = 0.1000 | loss: 14671.3541 | error: 26.0000 - valid | validloss: 22151.6520 | validerror: 6878.0000 | s/iter: 0.9875
train | epoch = 3 | lr = 0.1000 | loss: 19053.0497 | error: 28.0000 - valid | validloss: 20575.2377 | validerror: 5673.0000 | s/iter: 0.9006
train | epoch = 4 | lr = 0.1000 | loss: 12373.6498 | error: 18.0000 - valid | validloss: 16194.0607 | validerror: 5246.0000 | s/iter: 0.9659
train | epoch = 5 | lr = 0.1000 | loss: 9386.8868 | error: 12.0000 - valid | validloss: 15390.5190 | validerror: 6269.0000 | s/iter: 0.9032
train | epoch = 6 | lr = 0.1000 | loss: 7582.5734 | error: 22.0000 - valid | validloss: 25863.8462 | validerror: 7828.0000 | s/iter: 0.8917
train | epoch = 7 | lr = 0.1000 | loss: 14390.5032 | error: 24.0000 - valid | validloss: 18583.1501 | validerror: 6385.0000 | s/iter: 0.8922
train | epoch = 8 | lr = 0.1000 | loss: 14692.9140 | error: 20.0000 - valid | validloss: 4741.7797 | validerror: 4068.0000 | s/iter: 0.8963
train | epoch = 9 | lr = 0.1000 | loss: 188.3231 | error: 1.0000 - valid | validloss: 4642.1204 | validerror: 3873.0000 | s/iter: 0.8996
train | epoch = 10 | lr = 0.1000 | loss: 0.0000 | error: 0.0000 - valid | validloss: 4642.1204 | validerror: 3873.0000 | s/iter: 0.8960
| test | error: 4095.0000
```

Figure 3

Visualization of the network weights for both models:



(a) Weights for 1000 examples



(b) Weights for 50 examples

4.(a)

```
train | epoch = 1 | lr = 0.1000 | loss: 5.5752 | error: 698.0000 - valid | validloss: 7.7601 | validerror: 548.0000 | s/iter: 0.4165
train | epoch = 2 | lr = 0.1000 | loss: 9.9345 | error: 709.0000 - valid | validloss: 13.7427 | validerror: 660.0000 | s/iter: 0.3681
train | epoch = 3 | lr = 0.1000 | loss: 12.0517 | error: 695.0000 - valid | validloss: 13.0474 | validerror: 813.0000 | s/iter: 0.4952
train | epoch = 4 | lr = 0.1000 | loss: 12.0060 | error: 694.0000 - valid | validloss: 9.1808 | validerror: 849.0000 | s/iter: 0.4278
train | epoch = 5 | lr = 0.1000 | loss: 11.2823 | error: 653.0000 - valid | validloss: 5.7648 | validerror: 575.0000 | s/iter: 0.4284
train | epoch = 6 | lr = 0.1000 | loss: 8.3635 | error: 613.0000 - valid | validloss: 9.6513 | validerror: 685.0000 | s/iter: 0.3523
train | epoch = 7 | lr = 0.1000 | loss: 8.6425 | error: 635.0000 - valid | validloss: 10.3998 | validerror: 557.0000 | s/iter: 0.3504
train | epoch = 8 | lr = 0.1000 | loss: 6.7254 | error: 552.0000 - valid | validloss: 8.9408 | validerror: 760.0000 | s/iter: 0.3328
train | epoch = 9 | lr = 0.1000 | loss: 9.8200 | error: 623.0000 - valid | validloss: 12.0858 | validerror: 618.0000 | s/iter: 0.3492
train | epoch = 10 | lr = 0.1000 | loss: 9.8584 | error: 621.0000 - valid | validloss: 7.9613 | validerror: 561.0000 | s/iter: 0.3476
| test | error: 517.0000
```

Figure 5

(b)

```
train | epoch = 1 | lr = 10.0000 | loss: 3139.2579 | error: 909.0000 - valid | validloss: 6168.4628 | validerror: 893.0000 | s/iter: 0.3713
train | epoch = 2 | lr = 10.0000 | loss: 3969.0109 | error: 888.0000 - valid | validloss: 5060.6471 | validerror: 893.0000 | s/iter: 0.3302
train | epoch = 3 | lr = 10.0000 | loss: 3671.6374 | error: 883.0000 - valid | validloss: 3582.3952 | validerror: 860.0000 | s/iter: 0.3334
train | epoch = 4 | lr = 10.0000 | loss: 3246.8756 | error: 846.0000 - valid | validloss: 4519.9848 | validerror: 896.0000 | s/iter: 0.3614
train | epoch = 5 | lr = 10.0000 | loss: 3840.3475 | error: 883.0000 - valid | validloss: 3816.6018 | validerror: 861.0000 | s/iter: 0.3451
train | epoch = 6 | lr = 10.0000 | loss: 3966.5387 | error: 885.0000 - valid | validloss: 4403.5726 | validerror: 893.0000 | s/iter: 0.4450
train | epoch = 7 | lr = 10.0000 | loss: 3445.2636 | error: 850.0000 - valid | validloss: 3715.3545 | validerror: 818.0000 | s/iter: 0.3811
train | epoch = 8 | lr = 10.0000 | loss: 3907.3177 | error: 887.0000 - valid | validloss: 3977.0998 | validerror: 895.0000 | s/iter: 0.3700
train | epoch = 9 | lr = 10.0000 | loss: 3435.8520 | error: 885.0000 - valid | validloss: 2674.8150 | validerror: 837.0000 | s/iter: 0.3752
train | epoch = 10 | lr = 10.0000 | loss: 2420.2164 | error: 783.0000 - valid | validloss: 2469.2453 | validerror: 746.0000 | s/iter: 0.3648
| test | error: 745.0000
```

Figure 6

Due to high learning rate, the model keeps on jumping back and forth in the curve. The 5.(a)

```
train | epoch = 1 | lr = 0.1000 | loss: 2.2430 | error: 10325.0000 - valid | validloss: 2.1465 | validerror: 2508.0000 | s/iter: 34.2126
train | epoch = 2 | lr = 0.1000 | loss: 2.0810 | error: 9281.0000 - valid | validloss: 2.0863 | validerror: 2357.0000 | s/iter: 54.2699
train | epoch = 3 | lr = 0.1000 | loss: 2.0070 | error: 8858.0000 - valid | validloss: 1.9537 | validerror: 2160.0000 | s/iter: 35.4339
train | epoch = 4 | lr = 0.1000 | loss: 1.9532 | error: 8623.0000 - valid | validloss: 2.0911 | validerror: 2274.0000 | s/iter: 32.3099
train | epoch = 5 | lr = 0.1000 | loss: 1.8134 | error: 8008.0000 - valid | validloss: 1.7031 | validerror: 1923.0000 | s/iter: 32.1239
train | epoch = 6 | lr = 0.1000 | loss: 1.7367 | error: 7644.0000 - valid | validloss: 1.7757 | validerror: 1943.0000 | s/iter: 30.8007
train | epoch = 7 | lr = 0.1000 | loss: 1.7080 | error: 7477.0000 - valid | validloss: 1.7801 | validerror: 1938.0000 | s/iter: 28.5090
train | epoch = 8 | lr = 0.1000 | loss: 1.6800 | error: 7274.0000 - valid | validloss: 1.6605 | validerror: 1807.0000 | s/iter: 28.5091
train | epoch = 9 | lr = 0.1000 | loss: 1.6190 | error: 7053.0000 - valid | validloss: 1.6619 | validerror: 1833.0000 | s/iter: 29.2602
train | epoch = 10 | lr = 0.1000 | loss: 1.6189 | error: 7066.0000 - valid | validloss: 1.6768 | validerror: 1790.0000 | s/iter: 28.1234
| test | error: 1788.0000
```

Figure 7

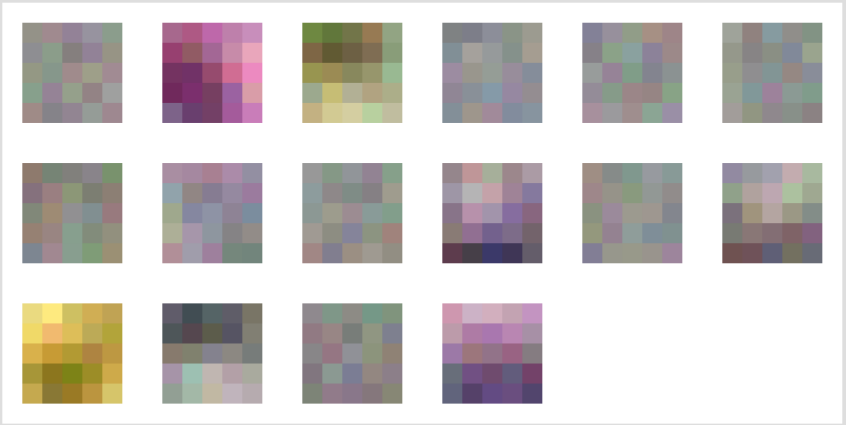


Figure 8: Image of first layer filters

(b) The parameters of the model are as follows:

1. Convolutional Layer (16((5x5x3)+1)) for 16 filters of 5x5x3 and 1 bias for each = 1216
2. NonLinearity Layer-Tanh (No parameters) = 0
3. MaxPooling Layer (No parameters) = 0
4. Convolutional Layer (128((5x5x16)+1)) for 128 filters of 5x5x16 and 1 bias for each = 51328
5. NonLinearity Layer-Tanh (No parameters) = 0
6. MaxPooling Layer (No parameters) = 0
7. Linear Layer (64((128x5x5)+1)) for 3200 units connected to 64 units each output having 1 bias = 204864
8. Linear Layer (10(64+1)) for 64 units connected to 10 units each output having 1 bias = 650

So, total number of parameters = 258058