Assignment #4 Report – Nari Shin

Default MLP:

```
----------Sample values for debugging:----------

z_s[1][0:4]=
[10.08685914  0.40671609  8.98672967 -6.87494907]

a_s[-1][0:4]=
[0.3495267]

d_w[-1][0][0:4]=
[0.14788401 0.0887785  0.14787168 0.00015266]

d_b[0][0:4]=
[ 3.19604823e-06  3.26817897e-04  1.98406730e-05 -1.78973802e-04]

W[0][0][0:4]
[ 0.47143516 -1.19097569  1.43270697 -0.3126519 ]

B[0][0:4]
[ 0.13423762 -0.475063    0.11270962  0.03957573]
-------------------------------------------------
Epoch #   1/40  Train Loss: 0.2345    Valid Loss: 0.2397    Train Acc: 0.8433    Valid Acc: 0.8410
Epoch #   2/40  Train Loss: 0.1981    Valid Loss: 0.2059    Train Acc: 0.8729    Valid Acc: 0.8605
Epoch #   3/40  Train Loss: 0.1760    Valid Loss: 0.1826    Train Acc: 0.8922    Valid Acc: 0.8850
Epoch #   4/40  Train Loss: 0.1542    Valid Loss: 0.1639    Train Acc: 0.9107    Valid Acc: 0.8930
Epoch #   5/40  Train Loss: 0.1379    Valid Loss: 0.1503    Train Acc: 0.9201    Valid Acc: 0.8945
Epoch #   6/40  Train Loss: 0.1256    Valid Loss: 0.1389    Train Acc: 0.9273    Valid Acc: 0.9025
Epoch #   7/40  Train Loss: 0.1178    Valid Loss: 0.1303    Train Acc: 0.9312    Valid Acc: 0.9105
Epoch #   8/40  Train Loss: 0.1104    Valid Loss: 0.1239    Train Acc: 0.9356    Valid Acc: 0.9155
Epoch #   9/40  Train Loss: 0.1042    Valid Loss: 0.1176    Train Acc: 0.9386    Valid Acc: 0.9220
Epoch #  10/40  Train Loss: 0.0986    Valid Loss: 0.1127    Train Acc: 0.9420    Valid Acc: 0.9270
Epoch #  11/40  Train Loss: 0.0927    Valid Loss: 0.1081    Train Acc: 0.9473    Valid Acc: 0.9280
Epoch #  12/40  Train Loss: 0.0879    Valid Loss: 0.1043    Train Acc: 0.9496    Valid Acc: 0.9290
Epoch #  13/40  Train Loss: 0.0836    Valid Loss: 0.1010    Train Acc: 0.9533    Valid Acc: 0.9325
Epoch #  14/40  Train Loss: 0.0796    Valid Loss: 0.0981    Train Acc: 0.9558    Valid Acc: 0.9345
Epoch #  15/40  Train Loss: 0.0759    Valid Loss: 0.0954    Train Acc: 0.9584    Valid Acc: 0.9345
Epoch #  16/40  Train Loss: 0.0729    Valid Loss: 0.0935    Train Acc: 0.9596    Valid Acc: 0.9340
Epoch #  17/40  Train Loss: 0.0705    Valid Loss: 0.0917    Train Acc: 0.9602    Valid Acc: 0.9355
Epoch #  18/40  Train Loss: 0.0684    Valid Loss: 0.0899    Train Acc: 0.9611    Valid Acc: 0.9350
Epoch #  19/40  Train Loss: 0.0664    Valid Loss: 0.0886    Train Acc: 0.9624    Valid Acc: 0.9345
Epoch #  20/40  Train Loss: 0.0649    Valid Loss: 0.0882    Train Acc: 0.9626    Valid Acc: 0.9325
Epoch #  21/40  Train Loss: 0.0637    Valid Loss: 0.0878    Train Acc: 0.9626    Valid Acc: 0.9325
Epoch #  22/40  Train Loss: 0.0622    Valid Loss: 0.0870    Train Acc: 0.9639    Valid Acc: 0.9325
Epoch #  23/40  Train Loss: 0.0603    Valid Loss: 0.0859    Train Acc: 0.9652    Valid Acc: 0.9335
Epoch #  24/40  Train Loss: 0.0583    Valid Loss: 0.0847    Train Acc: 0.9668    Valid Acc: 0.9330
Epoch #  25/40  Train Loss: 0.0566    Valid Loss: 0.0837    Train Acc: 0.9682    Valid Acc: 0.9335
Epoch #  26/40  Train Loss: 0.0548    Valid Loss: 0.0825    Train Acc: 0.9695    Valid Acc: 0.9340
Epoch #  27/40  Train Loss: 0.0532    Valid Loss: 0.0816    Train Acc: 0.9716    Valid Acc: 0.9360
Epoch #  28/40  Train Loss: 0.0517    Valid Loss: 0.0809    Train Acc: 0.9722    Valid Acc: 0.9375
Epoch #  29/40  Train Loss: 0.0505    Valid Loss: 0.0803    Train Acc: 0.9724    Valid Acc: 0.9375
Epoch #  30/40  Train Loss: 0.0492    Valid Loss: 0.0795    Train Acc: 0.9740    Valid Acc: 0.9380
Epoch #  31/40  Train Loss: 0.0479    Valid Loss: 0.0785    Train Acc: 0.9742    Valid Acc: 0.9400
Epoch #  32/40  Train Loss: 0.0467    Valid Loss: 0.0775    Train Acc: 0.9752    Valid Acc: 0.9405
Epoch #  33/40  Train Loss: 0.0454    Valid Loss: 0.0766    Train Acc: 0.9758    Valid Acc: 0.9405
Epoch #  34/40  Train Loss: 0.0443    Valid Loss: 0.0758    Train Acc: 0.9762    Valid Acc: 0.9400
Epoch #  35/40  Train Loss: 0.0432    Valid Loss: 0.0751    Train Acc: 0.9768    Valid Acc: 0.9385
Epoch #  36/40  Train Loss: 0.0423    Valid Loss: 0.0744    Train Acc: 0.9771    Valid Acc: 0.9385
Epoch #  37/40  Train Loss: 0.0412    Valid Loss: 0.0737    Train Acc: 0.9777    Valid Acc: 0.9390
Epoch #  38/40  Train Loss: 0.0403    Valid Loss: 0.0731    Train Acc: 0.9782    Valid Acc: 0.9395
Epoch #  39/40  Train Loss: 0.0394    Valid Loss: 0.0724    Train Acc: 0.9788    Valid Acc: 0.9375
Epoch #  40/40  Train Loss: 0.0386    Valid Loss: 0.0719    Train Acc: 0.9794    Valid Acc: 0.9385
Naris-MacBook-Pro:a4 narishin$ 
```

Simple Perceptron:

```
----------Sample values for debugging:----------

z_s[1][0:4]=
[7.88349796]

a_s[-1][0:4]=
[0.99962323]

d_w[-1][0][0:4]=
[0. 0. 0. 0.]

d_b[0][0:4]=
[-2.51955987e-11]

W[0][0][0:4]
[ 0.47143516 -1.19097569  1.43270697 -0.3126519 ]

B[0][0:4]
[2.33759848]
--------------------------------------------------
Epoch #   1/40  Train Loss: 0.2517    Valid Loss: 0.2558    Train Acc: 0.7577    Valid Acc: 0.7595
Epoch #   2/40  Train Loss: 0.2213    Valid Loss: 0.2267    Train Acc: 0.7882    Valid Acc: 0.7840
Epoch #   3/40  Train Loss: 0.2048    Valid Loss: 0.2107    Train Acc: 0.8052    Valid Acc: 0.8000
Epoch #   4/40  Train Loss: 0.1940    Valid Loss: 0.2005    Train Acc: 0.8157    Valid Acc: 0.8110
Epoch #   5/40  Train Loss: 0.1857    Valid Loss: 0.1927    Train Acc: 0.8233    Valid Acc: 0.8165
Epoch #   6/40  Train Loss: 0.1789    Valid Loss: 0.1867    Train Acc: 0.8322    Valid Acc: 0.8250
Epoch #   7/40  Train Loss: 0.1737    Valid Loss: 0.1820    Train Acc: 0.8371    Valid Acc: 0.8305
Epoch #   8/40  Train Loss: 0.1694    Valid Loss: 0.1783    Train Acc: 0.8421    Valid Acc: 0.8335
Epoch #   9/40  Train Loss: 0.1658    Valid Loss: 0.1750    Train Acc: 0.8459    Valid Acc: 0.8365
Epoch #  10/40  Train Loss: 0.1626    Valid Loss: 0.1721    Train Acc: 0.8488    Valid Acc: 0.8385
Epoch #  11/40  Train Loss: 0.1597    Valid Loss: 0.1695    Train Acc: 0.8521    Valid Acc: 0.8410
Epoch #  12/40  Train Loss: 0.1572    Valid Loss: 0.1673    Train Acc: 0.8550    Valid Acc: 0.8410
Epoch #  13/40  Train Loss: 0.1550    Valid Loss: 0.1653    Train Acc: 0.8571    Valid Acc: 0.8430
Epoch #  14/40  Train Loss: 0.1530    Valid Loss: 0.1635    Train Acc: 0.8584    Valid Acc: 0.8455
Epoch #  15/40  Train Loss: 0.1512    Valid Loss: 0.1618    Train Acc: 0.8610    Valid Acc: 0.8465
Epoch #  16/40  Train Loss: 0.1495    Valid Loss: 0.1603    Train Acc: 0.8630    Valid Acc: 0.8495
Epoch #  17/40  Train Loss: 0.1480    Valid Loss: 0.1589    Train Acc: 0.8646    Valid Acc: 0.8515
Epoch #  18/40  Train Loss: 0.1465    Valid Loss: 0.1576    Train Acc: 0.8666    Valid Acc: 0.8515
Epoch #  19/40  Train Loss: 0.1452    Valid Loss: 0.1564    Train Acc: 0.8676    Valid Acc: 0.8545
Epoch #  20/40  Train Loss: 0.1440    Valid Loss: 0.1553    Train Acc: 0.8693    Valid Acc: 0.8565
Epoch #  21/40  Train Loss: 0.1428    Valid Loss: 0.1543    Train Acc: 0.8705    Valid Acc: 0.8565
Epoch #  22/40  Train Loss: 0.1418    Valid Loss: 0.1534    Train Acc: 0.8717    Valid Acc: 0.8575
Epoch #  23/40  Train Loss: 0.1408    Valid Loss: 0.1525    Train Acc: 0.8728    Valid Acc: 0.8570
Epoch #  24/40  Train Loss: 0.1398    Valid Loss: 0.1517    Train Acc: 0.8738    Valid Acc: 0.8565
Epoch #  25/40  Train Loss: 0.1390    Valid Loss: 0.1509    Train Acc: 0.8744    Valid Acc: 0.8570
Epoch #  26/40  Train Loss: 0.1381    Valid Loss: 0.1502    Train Acc: 0.8752    Valid Acc: 0.8590
Epoch #  27/40  Train Loss: 0.1373    Valid Loss: 0.1495    Train Acc: 0.8756    Valid Acc: 0.8595
Epoch #  28/40  Train Loss: 0.1365    Valid Loss: 0.1488    Train Acc: 0.8766    Valid Acc: 0.8605
Epoch #  29/40  Train Loss: 0.1358    Valid Loss: 0.1482    Train Acc: 0.8770    Valid Acc: 0.8625
Epoch #  30/40  Train Loss: 0.1351    Valid Loss: 0.1477    Train Acc: 0.8779    Valid Acc: 0.8635
Epoch #  31/40  Train Loss: 0.1345    Valid Loss: 0.1471    Train Acc: 0.8787    Valid Acc: 0.8625
Epoch #  32/40  Train Loss: 0.1338    Valid Loss: 0.1466    Train Acc: 0.8799    Valid Acc: 0.8630
Epoch #  33/40  Train Loss: 0.1332    Valid Loss: 0.1461    Train Acc: 0.8809    Valid Acc: 0.8645
Epoch #  34/40  Train Loss: 0.1326    Valid Loss: 0.1457    Train Acc: 0.8809    Valid Acc: 0.8640
Epoch #  35/40  Train Loss: 0.1321    Valid Loss: 0.1453    Train Acc: 0.8809    Valid Acc: 0.8650
Epoch #  36/40  Train Loss: 0.1316    Valid Loss: 0.1448    Train Acc: 0.8809    Valid Acc: 0.8655
Epoch #  37/40  Train Loss: 0.1311    Valid Loss: 0.1444    Train Acc: 0.8817    Valid Acc: 0.8650
Epoch #  38/40  Train Loss: 0.1306    Valid Loss: 0.1440    Train Acc: 0.8824    Valid Acc: 0.8650
Epoch #  39/40  Train Loss: 0.1301    Valid Loss: 0.1436    Train Acc: 0.8826    Valid Acc: 0.8645
Epoch #  40/40  Train Loss: 0.1296    Valid Loss: 0.1433    Train Acc: 0.8836    Valid Acc: 0.8645
Naris-MacBook-Pro:a4 narishin$
```

Evaluation:

For MLP we have 97.9% train accuracy and 93.8% validation accuracy.

For Simple Perceptron we have 88.4% train accuracy and 86.4% validation accuracy.

As we can see MLP obtained a higher accuracy than simple perceptron.

Feedback:

The most interesting part of the course that I found was the problem-solving areas and how we used algorithms to solve puzzles (like pacman). I thought the sat problem and neural networks was hard to understand and grasp at first, but it was interesting information to learn and I found some overlap with my other courses that had similar topics. Changes that I would suggest is to change the assignment scheduling somewhat because having an assignment due in the middle of finals is quite difficult. Other than that, it was an interesting course and I feel like I learned a lot from it. I spent around 30 hours on this assignment.