

```
Train loss:0.257335, acc:0.910606
Valid loss:0.326309, acc:0.883157
----Epoch 62 ---
Train loss:0.256185, acc:0.910627
Valid loss:0.325410, acc:0.884074
----Epoch 63 ---
Train loss:0.254832, acc:0.911564
Valid loss:0.326157, acc:0.882740
----Epoch 64 ---
Train loss:0.253487, acc:0.911939
Valid loss:0.326470, acc:0.882407
----Epoch 65 ---
Train loss:0.252247, acc:0.912356
Valid loss:0.325385, acc:0.882990
----Epoch 66 ---
Train loss:0.250305, acc:0.913981
Valid loss:0.323843, acc:0.883740
----Epoch 67 ---
Train loss:0.249719, acc:0.913502
Valid loss:0.323223, acc:0.884407
----Epoch 68 ---
Train loss:0.248072, acc:0.914189
Valid loss:0.326325, acc:0.881157
----Epoch 69 ---
Train loss:0.246640, acc:0.914377
Valid loss:0.324797, acc:0.883407
----Epoch 70 ---
Train loss:0.245818, acc:0.914939
Valid loss:0.321983, acc:0.884324
----Epoch 71 ---
Train loss:0.243906, acc:0.916002
Valid loss:0.325461, acc:0.882240
----Epoch 72 ---
Train loss:0.242990, acc:0.916481
Valid loss:0.325729, acc:0.883490
----Epoch 73 ---
Train loss:0.242056, acc:0.915731
Valid loss:0.322647, acc:0.885157
----Epoch 74 ---
Train loss:0.240532, acc:0.917231
Valid loss:0.321986, acc:0.884157
----Epoch 75 ---
Train loss:0.239489, acc:0.916981
Valid loss:0.321728, acc:0.884407
----Epoch 76 ---
Train loss:0.238399, acc:0.917627
Valid loss:0.322100, acc:0.885074
----Epoch 77 ---
```

```

Train loss:0.237221, acc:0.918106
Valid loss:0.321794, acc:0.886407
----Epoch 78 ---
Train loss:0.235938, acc:0.918648
Valid loss:0.319888, acc:0.886324
----Epoch 79 ---
Train loss:0.234753, acc:0.919043
Valid loss:0.320292, acc:0.886574
----Epoch 80 ---
Train loss:0.233564, acc:0.919773
Valid loss:0.323041, acc:0.883740
----Epoch 81 ---
Train loss:0.232434, acc:0.920064
Valid loss:0.323008, acc:0.884824
----Epoch 82 ---
Train loss:0.231703, acc:0.919918
Valid loss:0.321310, acc:0.885074
----Epoch 83 ---
Train loss:0.230237, acc:0.920231
Valid loss:0.320228, acc:0.885324
----Epoch 84 ---
Train loss:0.228928, acc:0.921189
Valid loss:0.321172, acc:0.883990
----Epoch 85 ---
Train loss:0.228216, acc:0.921481
Valid loss:0.321299, acc:0.885490
----Epoch 86 ---
Train loss:0.227288, acc:0.921731
Valid loss:0.324955, acc:0.883740
Early Stopping
Test set: x:(10000, 784), y:(10000, 10)
Loss:    0.349194
Acc:     0.876100

```

---

Figures now render in the Plots pane by default. To make them also appear inline in the Console, uncheck "Mute Inline Plotting" under the Plots pane options menu.

---

```

In [2]:      '/Users/xuchaoqi/Documents/GitHub/CSE253_PA2/
neuralnet.py'      = '/Users/xuchaoqi/Documents/GitHub/CSE253_PA2'
--- Config settings ---
layer_specs: [784, 50, 10]
activation: tanh

```

```

learning_rate: 1e-05
batch_size: 128
epochs: 95
early_stop: False
early_stop_epoch: 4
L2_penalty: 0.001
momentum: True
momentum_gamma: 0.9
--- Model summary ---
Layer 0: 784 inputs, 50 outputs
Layer 2: 50 inputs, 10 outputs
--- Training set: x: (48001, 784) y: (48001, 10) ---
--- Validation set: x: (11999, 784) y: (11999, 10) ---
----Epoch 0 ---
      Train loss:0.939902, acc:0.726172
      Valid loss:0.727108, acc:0.790899
----Epoch 1 ---
      Train loss:0.702658, acc:0.796963
      Valid loss:0.676789, acc:0.803150
----Epoch 2 ---
      Train loss:0.673081, acc:0.807004
      Valid loss:0.663113, acc:0.810151
----Epoch 3 ---
      Train loss:0.661488, acc:0.810316
      Valid loss:0.653333, acc:0.811651
----Epoch 4 ---
      Train loss:0.654690, acc:0.812754
      Valid loss:0.647025, acc:0.811234
----Epoch 5 ---
      Train loss:0.650428, acc:0.811754
      Valid loss:0.643598, acc:0.814818
----Epoch 6 ---
      Train loss:0.647542, acc:0.813629
      Valid loss:0.642082, acc:0.815068
----Epoch 7 ---
      Train loss:0.646080, acc:0.813379
      Valid loss:0.640622, acc:0.814651
----Epoch 8 ---
      Train loss:0.644202, acc:0.814921
      Valid loss:0.639922, acc:0.815651
----Epoch 9 ---
      Train loss:0.643565, acc:0.814608
      Valid loss:0.637686, acc:0.815818
----Epoch 10 ---
      Train loss:0.642264, acc:0.814650
      Valid loss:0.637518, acc:0.817735
----Epoch 11 ---
      Train loss:0.642160, acc:0.814941

```

```

Valid loss:0.636210, acc:0.815818
----Epoch 12 ---
Train loss:0.640845, acc:0.815296
Valid loss:0.639987, acc:0.815068
----Epoch 13 ---
Train loss:0.641061, acc:0.814296
Valid loss:0.637141, acc:0.815985
----Epoch 14 ---
Train loss:0.640082, acc:0.815129
Valid loss:0.636365, acc:0.816151
----Epoch 15 ---
Train loss:0.640403, acc:0.815587
Valid loss:0.635079, acc:0.813734
----Epoch 16 ---
Train loss:0.640052, acc:0.815566
Valid loss:0.635705, acc:0.815401
----Epoch 17 ---
Train loss:0.639703, acc:0.815421
Valid loss:0.634978, acc:0.814985
----Epoch 18 ---
Train loss:0.639407, acc:0.815379
Valid loss:0.636115, acc:0.816318
----Epoch 19 ---
Train loss:0.639612, acc:0.815858
Valid loss:0.634934, acc:0.815735
----Epoch 20 ---
Train loss:0.639100, acc:0.815087
Valid loss:0.634795, acc:0.815318
----Epoch 21 ---
Train loss:0.638534, acc:0.815587
Valid loss:0.634514, acc:0.813984
----Epoch 22 ---
Train loss:0.639194, acc:0.814900
Valid loss:0.634192, acc:0.814318
----Epoch 23 ---
Train loss:0.638308, acc:0.815379
Valid loss:0.633960, acc:0.817151
----Epoch 24 ---
Train loss:0.638197, acc:0.815525
Valid loss:0.633363, acc:0.814151
----Epoch 25 ---
Train loss:0.638373, acc:0.814587
Valid loss:0.633809, acc:0.813984
----Epoch 26 ---
Train loss:0.637841, acc:0.815129
Valid loss:0.634362, acc:0.814735
----Epoch 27 ---
Train loss:0.638196, acc:0.816316

```

```
Valid loss:0.634492, acc:0.813901
Early Stopping
Test set: x:(10000, 784), y:(10000, 10)
Loss:    0.654763
Acc:     0.803500
```

```
In [3]:      '/Users/xuchaoqi/Documents/GitHub/CSE253_PA2/
neuralnet.py'      = '/Users/xuchaoqi/Documents/GitHub/CSE253_PA2'
```

```
--- Config settings ---
```

```
layer_specs: [784, 50, 10]
```

```
activation: tanh
```

```
learning_rate: 1e-05
```

```
batch_size: 128
```

```
epochs: 95
```

```
early_stop: False
```

```
early_stop_epoch: 4
```

```
L2_penalty: 0.001
```

```
momentum: True
```

```
momentum_gamma: 0.9
```

```
--- Model summary ---
```

```
Layer 0: 784 inputs, 50 outputs
```

```
Layer 2: 50 inputs, 10 outputs
```

```
--- Training set: x: (48001, 784) y: (48001, 10) ---
```

```
--- Validation set: x: (11999, 784) y: (11999, 10) ---
```

```
----Epoch 0 ---
```

```
Train loss:0.939902, acc:0.726172
```

```
Valid loss:0.727108, acc:0.790899
```

```
----Epoch 1 ---
```

```
Train loss:0.702658, acc:0.796963
```

```
Valid loss:0.676789, acc:0.803150
```

```
----Epoch 2 ---
```

```
Train loss:0.673081, acc:0.807004
```

```
Valid loss:0.663113, acc:0.810151
```

```
----Epoch 3 ---
```

```
Train loss:0.661488, acc:0.810316
```

```
Valid loss:0.653333, acc:0.811651
```

```
----Epoch 4 ---
```

```
Train loss:0.654690, acc:0.812754
```

```
Valid loss:0.647025, acc:0.811234
```

```
----Epoch 5 ---
```

```
Train loss:0.650428, acc:0.811754
```

```
Valid loss:0.643598, acc:0.814818
```

```
----Epoch 6 ---
```

```
Train loss:0.647542, acc:0.813629
```

```
Valid loss:0.642082, acc:0.815068
```

```
----Epoch 7 ---
```

```
Train loss:0.646080, acc:0.813379
```

```
Valid loss:0.640622, acc:0.814651
```

```

-----Epoch 8 ---
      Train loss:0.644202, acc:0.814921
      Valid loss:0.639922, acc:0.815651
-----Epoch 9 ---
      Train loss:0.643565, acc:0.814608
      Valid loss:0.637686, acc:0.815818
-----Epoch 10 ---
      Train loss:0.642264, acc:0.814650
      Valid loss:0.637518, acc:0.817735
-----Epoch 11 ---
      Train loss:0.642160, acc:0.814941
      Valid loss:0.636210, acc:0.815818
-----Epoch 12 ---
      Train loss:0.640845, acc:0.815296
      Valid loss:0.639987, acc:0.815068
-----Epoch 13 ---
      Train loss:0.641061, acc:0.814296
      Valid loss:0.637141, acc:0.815985
-----Epoch 14 ---
      Train loss:0.640082, acc:0.815129
      Valid loss:0.636365, acc:0.816151
-----Epoch 15 ---
      Train loss:0.640403, acc:0.815587
      Valid loss:0.635079, acc:0.813734
-----Epoch 16 ---
      Train loss:0.640052, acc:0.815566
      Valid loss:0.635705, acc:0.815401
-----Epoch 17 ---
      Train loss:0.639703, acc:0.815421
      Valid loss:0.634978, acc:0.814985
-----Epoch 18 ---
      Train loss:0.639407, acc:0.815379
      Valid loss:0.636115, acc:0.816318
-----Epoch 19 ---
      Train loss:0.639612, acc:0.815858
      Valid loss:0.634934, acc:0.815735
-----Epoch 20 ---
      Train loss:0.639100, acc:0.815087
      Valid loss:0.634795, acc:0.815318
-----Epoch 21 ---
      Train loss:0.638534, acc:0.815587
      Valid loss:0.634514, acc:0.813984
-----Epoch 22 ---
      Train loss:0.639194, acc:0.814900
      Valid loss:0.634192, acc:0.814318
-----Epoch 23 ---
      Train loss:0.638308, acc:0.815379
      Valid loss:0.633960, acc:0.817151

```

```
-----Epoch 24 ----
      Train loss:0.638197, acc:0.815525
      Valid loss:0.633363, acc:0.814151
-----Epoch 25 ----
      Train loss:0.638373, acc:0.814587
      Valid loss:0.633809, acc:0.813984
-----Epoch 26 ----
      Train loss:0.637841, acc:0.815129
      Valid loss:0.634362, acc:0.814735
-----Epoch 27 ----
      Train loss:0.638196, acc:0.816316
      Valid loss:0.634492, acc:0.813901
-----Epoch 28 ----
      Train loss:0.637891, acc:0.814796
      Valid loss:0.634624, acc:0.814568
-----Epoch 29 ----
      Train loss:0.638317, acc:0.814816
      Valid loss:0.636447, acc:0.815568
-----Epoch 30 ----
      Train loss:0.638308, acc:0.814566
      Valid loss:0.633741, acc:0.814818
-----Epoch 31 ----
      Train loss:0.637908, acc:0.815608
      Valid loss:0.634089, acc:0.815651
-----Epoch 32 ----
      Train loss:0.638496, acc:0.815212
      Valid loss:0.634334, acc:0.816485
-----Epoch 33 ----
      Train loss:0.638056, acc:0.814233
      Valid loss:0.634291, acc:0.815985
-----Epoch 34 ----
      Train loss:0.637339, acc:0.814837
      Valid loss:0.634180, acc:0.816485
-----Epoch 35 ----
      Train loss:0.638142, acc:0.814712
      Valid loss:0.634560, acc:0.816985
-----Epoch 36 ----
      Train loss:0.637756, acc:0.813921
      Valid loss:0.633332, acc:0.813818
-----Epoch 37 ----
      Train loss:0.637815, acc:0.815837
      Valid loss:0.633279, acc:0.813984
-----Epoch 38 ----
      Train loss:0.637380, acc:0.815046
      Valid loss:0.634718, acc:0.817068
-----Epoch 39 ----
      Train loss:0.637575, acc:0.815608
      Valid loss:0.634045, acc:0.814235
```

```
-----Epoch 40 ----
      Train loss:0.637601, acc:0.815066
      Valid loss:0.633435, acc:0.816818
-----Epoch 41 ----
      Train loss:0.637325, acc:0.816316
      Valid loss:0.633791, acc:0.815985
-----Epoch 42 ----
      Train loss:0.637917, acc:0.815212
      Valid loss:0.632968, acc:0.815318
-----Epoch 43 ----
      Train loss:0.637317, acc:0.815254
      Valid loss:0.632751, acc:0.814318
-----Epoch 44 ----
      Train loss:0.637505, acc:0.815754
      Valid loss:0.632148, acc:0.813901
-----Epoch 45 ----
      Train loss:0.637144, acc:0.814796
      Valid loss:0.633684, acc:0.815651
-----Epoch 46 ----
      Train loss:0.637569, acc:0.815316
      Valid loss:0.634301, acc:0.815735
-----Epoch 47 ----
      Train loss:0.636877, acc:0.815212
      Valid loss:0.633262, acc:0.814151
-----Epoch 48 ----
      Train loss:0.637659, acc:0.814921
      Valid loss:0.632406, acc:0.815818
-----Epoch 49 ----
      Train loss:0.637083, acc:0.815275
      Valid loss:0.633562, acc:0.813818
-----Epoch 50 ----
      Train loss:0.636947, acc:0.815046
      Valid loss:0.632873, acc:0.815401
-----Epoch 51 ----
      Train loss:0.637172, acc:0.815337
      Valid loss:0.632342, acc:0.814151
-----Epoch 52 ----
      Train loss:0.636892, acc:0.814983
      Valid loss:0.632553, acc:0.814651
-----Epoch 53 ----
      Train loss:0.637221, acc:0.815212
      Valid loss:0.632697, acc:0.815068
-----Epoch 54 ----
      Train loss:0.637185, acc:0.815650
      Valid loss:0.632807, acc:0.814985
-----Epoch 55 ----
      Train loss:0.637076, acc:0.814921
      Valid loss:0.632434, acc:0.817485
```



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-----Epoch 56 ----
      Train loss:0.637115, acc:0.815358
      Valid loss:0.633343, acc:0.816401
-----Epoch 57 ----
      Train loss:0.637104, acc:0.815004
      Valid loss:0.632876, acc:0.815068
-----Epoch 58 ----
      Train loss:0.637035, acc:0.814900
      Valid loss:0.633087, acc:0.815818
-----Epoch 59 ----
      Train loss:0.637142, acc:0.815608
      Valid loss:0.633156, acc:0.814318
-----Epoch 60 ----
      Train loss:0.637294, acc:0.814983
      Valid loss:0.632131, acc:0.815818
-----Epoch 61 ----
      Train loss:0.637051, acc:0.814921
      Valid loss:0.634728, acc:0.815318
-----Epoch 62 ----
      Train loss:0.636801, acc:0.815108
      Valid loss:0.633670, acc:0.813901
-----Epoch 63 ----
      Train loss:0.636924, acc:0.815379
      Valid loss:0.633476, acc:0.817318
-----Epoch 64 ----
      Train loss:0.637457, acc:0.815566
      Valid loss:0.631957, acc:0.813818
-----Epoch 65 ----
      Train loss:0.636913, acc:0.815691
      Valid loss:0.632069, acc:0.816068
-----Epoch 66 ----
      Train loss:0.637127, acc:0.815066
      Valid loss:0.632169, acc:0.816651
-----Epoch 67 ----
      Train loss:0.636401, acc:0.814879
      Valid loss:0.632849, acc:0.816401
-----Epoch 68 ----
      Train loss:0.637103, acc:0.815587
      Valid loss:0.633229, acc:0.815151
-----Epoch 69 ----
      Train loss:0.636945, acc:0.815671
      Valid loss:0.633838, acc:0.818152
-----Epoch 70 ----
      Train loss:0.636908, acc:0.815316
      Valid loss:0.633223, acc:0.816485
-----Epoch 71 ----
      Train loss:0.637491, acc:0.814962
      Valid loss:0.632533, acc:0.817318

```

```

----Epoch 72 ---
    Train loss:0.637055, acc:0.815525
    Valid loss:0.632730, acc:0.814568
----Epoch 73 ---
    Train loss:0.636621, acc:0.815191
    Valid loss:0.633984, acc:0.815568
----Epoch 74 ---
    Train loss:0.637094, acc:0.814733
    Valid loss:0.634195, acc:0.816151
----Epoch 75 ---
    Train loss:0.637162, acc:0.815025
    Valid loss:0.632888, acc:0.815568
----Epoch 76 ---
    Train loss:0.637135, acc:0.814921
    Valid loss:0.632642, acc:0.816901
----Epoch 77 ---
    Train loss:0.636684, acc:0.815379
    Valid loss:0.633369, acc:0.817151
----Epoch 78 ---
    Train loss:0.637142, acc:0.815129
    Valid loss:0.633788, acc:0.814985
----Epoch 79 ---
    Train loss:0.636740, acc:0.815421
    Valid loss:0.632666, acc:0.815235
----Epoch 80 ---
    Train loss:0.637245, acc:0.815504
    Valid loss:0.632112, acc:0.815485
----Epoch 81 ---
    Train loss:0.636455, acc:0.815087
    Valid loss:0.633359, acc:0.815735
----Epoch 82 ---
    Train loss:0.637340, acc:0.815441
    Valid loss:0.632965, acc:0.814151
----Epoch 83 ---
    Train loss:0.637192, acc:0.815441
    Valid loss:0.634088, acc:0.816318
----Epoch 84 ---
    Train loss:0.636724, acc:0.815504
    Valid loss:0.633134, acc:0.814735
----Epoch 85 ---
    Train loss:0.637077, acc:0.815171
    Valid loss:0.634645, acc:0.815651
----Epoch 86 ---
    Train loss:0.637214, acc:0.814587
    Valid loss:0.632975, acc:0.816151
----Epoch 87 ---
    Train loss:0.636845, acc:0.815296
    Valid loss:0.632601, acc:0.815985

```

```
----Epoch 88 ---
    Train loss:0.636879, acc:0.814671
    Valid loss:0.633826, acc:0.815818
----Epoch 89 ---
    Train loss:0.637515, acc:0.815504
    Valid loss:0.633465, acc:0.816068
----Epoch 90 ---
    Train loss:0.637061, acc:0.814087
    Valid loss:0.633159, acc:0.816068
----Epoch 91 ---
    Train loss:0.636902, acc:0.814941
    Valid loss:0.633277, acc:0.816985
----Epoch 92 ---
    Train loss:0.637228, acc:0.814504
    Valid loss:0.632685, acc:0.814985
----Epoch 93 ---
    Train loss:0.637073, acc:0.815462
    Valid loss:0.634286, acc:0.814068
----Epoch 94 ---
    Train loss:0.636950, acc:0.814837
    Valid loss:0.632613, acc:0.816735
Test set: x:(10000, 784), y:(10000, 10)
    Loss:    0.652838
    Acc:     0.803400
```

In [4]: