

week_1_solution_18_19_1

March 15, 2018

```
In [14]: import mnist_loader
import numpy as np
import pandas as pd

training_data, validation_data, test_data = mnist_loader.load_data_wrapper()
print("Training data, validation data and test data loaded.")
```

Training data, validation data and test data loaded.

```
In [18]: import network2
network2 = reload(network2)

net2_all_train = network2.Network([784,100, 10], cost=network2.CrossEntropyCost, activation=network2.ReLU,
net2_all_train.large_weight_initializer()

evaluation_cost_all_train, evaluation_accuracy_all_train, training_cost_all_train, training_accuracy_all_train = network2.evaluate_network(
    training_data=training_data,
    epochs=30,
    mini_batch_size=10,
    eta=0.0001,
    evaluation_data=test_data,
    lambda=5.0,
    monitor_evaluation_cost=True,
    monitor_evaluation_accuracy=True,
    monitor_training_cost=True,
    monitor_training_accuracy=True
)
```

Epoch 0 training complete

Cost on training data: 4.40284341451

Accuracy on training data: 7260 / 50000

Cost on evaluation data: 20.1677906477

Accuracy on evaluation data: 1414 / 10000

Epoch 1 training complete

Cost on training data: 4.51385082674

Accuracy on training data: 8282 / 50000
Cost on evaluation data: 20.2553782192
Accuracy on evaluation data: 1662 / 10000

Epoch 2 training complete
Cost on training data: 4.63656893423
Accuracy on training data: 8638 / 50000
Cost on evaluation data: 20.3394556165
Accuracy on evaluation data: 1722 / 10000

Epoch 3 training complete
Cost on training data: 4.76735701798
Accuracy on training data: 8792 / 50000
Cost on evaluation data: 20.4671514245
Accuracy on evaluation data: 1728 / 10000

Epoch 4 training complete
Cost on training data: 4.90147774232
Accuracy on training data: 8803 / 50000
Cost on evaluation data: 20.6110467273
Accuracy on evaluation data: 1753 / 10000

Epoch 5 training complete
Cost on training data: 5.08205568213
Accuracy on training data: 8890 / 50000
Cost on evaluation data: 20.760133332
Accuracy on evaluation data: 1798 / 10000

Epoch 6 training complete
Cost on training data: 5.27244473911
Accuracy on training data: 8905 / 50000
Cost on evaluation data: 20.9592348797
Accuracy on evaluation data: 1824 / 10000

Epoch 7 training complete
Cost on training data: 5.49538732246
Accuracy on training data: 9014 / 50000
Cost on evaluation data: 21.1849161746
Accuracy on evaluation data: 1837 / 10000

Epoch 8 training complete
Cost on training data: 5.76613353233
Accuracy on training data: 9144 / 50000
Cost on evaluation data: 21.4347508861
Accuracy on evaluation data: 1850 / 10000

Epoch 9 training complete
Cost on training data: 6.05029746252

Accuracy on training data: 9479 / 50000
Cost on evaluation data: 21.7051325387
Accuracy on evaluation data: 1917 / 10000

Epoch 10 training complete
Cost on training data: 6.35851485146
Accuracy on training data: 9831 / 50000
Cost on evaluation data: 22.0357348786
Accuracy on evaluation data: 1989 / 10000

Epoch 11 training complete
Cost on training data: 6.65126868719
Accuracy on training data: 10248 / 50000
Cost on evaluation data: 22.3236636726
Accuracy on evaluation data: 2069 / 10000

Epoch 12 training complete
Cost on training data: 6.90026007017
Accuracy on training data: 10912 / 50000
Cost on evaluation data: 22.5754189357
Accuracy on evaluation data: 2229 / 10000

Epoch 13 training complete
Cost on training data: 7.08334820588
Accuracy on training data: 11636 / 50000
Cost on evaluation data: 22.789240336
Accuracy on evaluation data: 2366 / 10000

Epoch 14 training complete
Cost on training data: 7.15591229534
Accuracy on training data: 12525 / 50000
Cost on evaluation data: 22.8090629046
Accuracy on evaluation data: 2564 / 10000

Epoch 15 training complete
Cost on training data: 7.15160962082
Accuracy on training data: 13662 / 50000
Cost on evaluation data: 22.7828993943
Accuracy on evaluation data: 2839 / 10000

Epoch 16 training complete
Cost on training data: 7.05356373529
Accuracy on training data: 14729 / 50000
Cost on evaluation data: 22.6824963115
Accuracy on evaluation data: 3035 / 10000

Epoch 17 training complete
Cost on training data: 7.03253014965

Accuracy on training data: 16110 / 50000
Cost on evaluation data: 22.6428446717
Accuracy on evaluation data: 3310 / 10000

Epoch 18 training complete
Cost on training data: 6.8454381184
Accuracy on training data: 17343 / 50000
Cost on evaluation data: 22.4132540261
Accuracy on evaluation data: 3583 / 10000

Epoch 19 training complete
Cost on training data: 6.8235985582
Accuracy on training data: 18666 / 50000
Cost on evaluation data: 22.3772701083
Accuracy on evaluation data: 3818 / 10000

Epoch 20 training complete
Cost on training data: 6.73881870796
Accuracy on training data: 19999 / 50000
Cost on evaluation data: 22.3032946312
Accuracy on evaluation data: 4080 / 10000

Epoch 21 training complete
Cost on training data: 6.68199869134
Accuracy on training data: 21179 / 50000
Cost on evaluation data: 22.2218686471
Accuracy on evaluation data: 4347 / 10000

Epoch 22 training complete
Cost on training data: 6.6055394845
Accuracy on training data: 22090 / 50000
Cost on evaluation data: 22.1481124598
Accuracy on evaluation data: 4548 / 10000

Epoch 23 training complete
Cost on training data: 6.51261109742
Accuracy on training data: 23268 / 50000
Cost on evaluation data: 22.0425468177
Accuracy on evaluation data: 4805 / 10000

Epoch 24 training complete
Cost on training data: 6.45839883941
Accuracy on training data: 23726 / 50000
Cost on evaluation data: 21.9895405994
Accuracy on evaluation data: 4891 / 10000

Epoch 25 training complete
Cost on training data: 6.4033041359

Accuracy on training data: 24660 / 50000
Cost on evaluation data: 21.94254791
Accuracy on evaluation data: 5062 / 10000

Epoch 26 training complete
Cost on training data: 6.33721147395
Accuracy on training data: 25371 / 50000
Cost on evaluation data: 21.8621680366
Accuracy on evaluation data: 5199 / 10000

Epoch 27 training complete
Cost on training data: 6.3514314454
Accuracy on training data: 25990 / 50000
Cost on evaluation data: 21.8708532664
Accuracy on evaluation data: 5348 / 10000

Epoch 28 training complete
Cost on training data: 6.25234946929
Accuracy on training data: 26537 / 50000
Cost on evaluation data: 21.7675961533
Accuracy on evaluation data: 5436 / 10000

Epoch 29 training complete
Cost on training data: 6.23038307832
Accuracy on training data: 27095 / 50000
Cost on evaluation data: 21.741749438
Accuracy on evaluation data: 5529 / 10000

```
In [19]: evaluation_cost_all_train, evaluation_accuracy_all_train, training_cost_all_train, tra
        training_data=training_data,
        epochs=30,
        mini_batch_size=10,
        eta=0.0001,
        evaluation_data=test_data,
        lambda=5.0,
        monitor_evaluation_cost=True,
        monitor_evaluation_accuracy=True,
        monitor_training_cost=True,
        monitor_training_accuracy=True
    )
```

Epoch 0 training complete
Cost on training data: 6.2417828399
Accuracy on training data: 27514 / 50000
Cost on evaluation data: 21.7685391017
Accuracy on evaluation data: 5637 / 10000

Epoch 1 training complete
Cost on training data: 6.19719850212
Accuracy on training data: 28125 / 50000
Cost on evaluation data: 21.7211730106
Accuracy on evaluation data: 5743 / 10000

Epoch 2 training complete
Cost on training data: 6.15422727506
Accuracy on training data: 28583 / 50000
Cost on evaluation data: 21.6755053818
Accuracy on evaluation data: 5873 / 10000

Epoch 3 training complete
Cost on training data: 6.12850897522
Accuracy on training data: 28818 / 50000
Cost on evaluation data: 21.6407264116
Accuracy on evaluation data: 5870 / 10000

Epoch 4 training complete
Cost on training data: 6.11152084645
Accuracy on training data: 28998 / 50000
Cost on evaluation data: 21.6240318896
Accuracy on evaluation data: 5916 / 10000

Epoch 5 training complete
Cost on training data: 6.1046457249
Accuracy on training data: 29459 / 50000
Cost on evaluation data: 21.6109982744
Accuracy on evaluation data: 6009 / 10000

Epoch 6 training complete
Cost on training data: 6.07120694667
Accuracy on training data: 29827 / 50000
Cost on evaluation data: 21.577161613
Accuracy on evaluation data: 6089 / 10000

Epoch 7 training complete
Cost on training data: 6.07566603996
Accuracy on training data: 29836 / 50000
Cost on evaluation data: 21.5837528187
Accuracy on evaluation data: 6111 / 10000

Epoch 8 training complete
Cost on training data: 6.04601628133
Accuracy on training data: 30075 / 50000
Cost on evaluation data: 21.5580356624
Accuracy on evaluation data: 6160 / 10000

Epoch 9 training complete
Cost on training data: 6.04309410736
Accuracy on training data: 30215 / 50000
Cost on evaluation data: 21.5500607984
Accuracy on evaluation data: 6211 / 10000

Epoch 10 training complete
Cost on training data: 6.02958215772
Accuracy on training data: 30400 / 50000
Cost on evaluation data: 21.5363995077
Accuracy on evaluation data: 6220 / 10000

Epoch 11 training complete
Cost on training data: 6.03682804456
Accuracy on training data: 30661 / 50000
Cost on evaluation data: 21.536048423
Accuracy on evaluation data: 6289 / 10000

Epoch 12 training complete
Cost on training data: 5.98265390941
Accuracy on training data: 30715 / 50000
Cost on evaluation data: 21.4810276743
Accuracy on evaluation data: 6280 / 10000

Epoch 13 training complete
Cost on training data: 5.98993077176
Accuracy on training data: 30985 / 50000
Cost on evaluation data: 21.490536831
Accuracy on evaluation data: 6323 / 10000

Epoch 14 training complete
Cost on training data: 5.96893030731
Accuracy on training data: 31184 / 50000
Cost on evaluation data: 21.4720577073
Accuracy on evaluation data: 6378 / 10000

Epoch 15 training complete
Cost on training data: 5.97342725097
Accuracy on training data: 31277 / 50000
Cost on evaluation data: 21.4700027806
Accuracy on evaluation data: 6386 / 10000

Epoch 16 training complete
Cost on training data: 5.96888347755
Accuracy on training data: 31253 / 50000
Cost on evaluation data: 21.4660116227
Accuracy on evaluation data: 6422 / 10000

Epoch 17 training complete
Cost on training data: 5.95598167037
Accuracy on training data: 31555 / 50000
Cost on evaluation data: 21.4540323832
Accuracy on evaluation data: 6433 / 10000

Epoch 18 training complete
Cost on training data: 5.93870029972
Accuracy on training data: 31685 / 50000
Cost on evaluation data: 21.4324490984
Accuracy on evaluation data: 6480 / 10000

Epoch 19 training complete
Cost on training data: 5.95209354455
Accuracy on training data: 31783 / 50000
Cost on evaluation data: 21.4459333477
Accuracy on evaluation data: 6485 / 10000

Epoch 20 training complete
Cost on training data: 5.95509913456
Accuracy on training data: 31674 / 50000
Cost on evaluation data: 21.4484347032
Accuracy on evaluation data: 6479 / 10000

Epoch 21 training complete
Cost on training data: 5.93231986277
Accuracy on training data: 31706 / 50000
Cost on evaluation data: 21.430491987
Accuracy on evaluation data: 6497 / 10000

Epoch 22 training complete
Cost on training data: 5.92268446545
Accuracy on training data: 32069 / 50000
Cost on evaluation data: 21.4132298039
Accuracy on evaluation data: 6564 / 10000

Epoch 23 training complete
Cost on training data: 5.93311248627
Accuracy on training data: 32021 / 50000
Cost on evaluation data: 21.420344028
Accuracy on evaluation data: 6542 / 10000

Epoch 24 training complete
Cost on training data: 5.90541340386
Accuracy on training data: 32263 / 50000
Cost on evaluation data: 21.3982963101
Accuracy on evaluation data: 6591 / 10000

Epoch 25 training complete
Cost on training data: 5.92392655358
Accuracy on training data: 32249 / 50000
Cost on evaluation data: 21.4115830468
Accuracy on evaluation data: 6544 / 10000

Epoch 26 training complete
Cost on training data: 5.90041426277
Accuracy on training data: 32229 / 50000
Cost on evaluation data: 21.3907450007
Accuracy on evaluation data: 6552 / 10000

Epoch 27 training complete
Cost on training data: 5.89933218511
Accuracy on training data: 32352 / 50000
Cost on evaluation data: 21.3834931271
Accuracy on evaluation data: 6609 / 10000

Epoch 28 training complete
Cost on training data: 5.89655380292
Accuracy on training data: 32438 / 50000
Cost on evaluation data: 21.3802263269
Accuracy on evaluation data: 6617 / 10000

Epoch 29 training complete
Cost on training data: 5.91334907584
Accuracy on training data: 32428 / 50000
Cost on evaluation data: 21.3980874854
Accuracy on evaluation data: 6646 / 10000

```
In [21]: evaluation_cost_all_train, evaluation_accuracy_all_train, training_cost_all_train, tr
        training_data=training_data,
        epochs=50,
        mini_batch_size=10,
        eta=0.001,
        evaluation_data=test_data,
        lambda=5.0,
        monitor_evaluation_cost=True,
        monitor_evaluation_accuracy=True,
        monitor_training_cost=True,
        monitor_training_accuracy=True
    )
```

Epoch 0 training complete
Cost on training data: 5.86418380255

Accuracy on training data: 32067 / 50000
Cost on evaluation data: 21.3202098458
Accuracy on evaluation data: 6544 / 10000

Epoch 1 training complete
Cost on training data: 5.88446848528
Accuracy on training data: 32613 / 50000
Cost on evaluation data: 21.3231166057
Accuracy on evaluation data: 6658 / 10000

Epoch 2 training complete
Cost on training data: 5.825515199
Accuracy on training data: 33187 / 50000
Cost on evaluation data: 21.2543085198
Accuracy on evaluation data: 6715 / 10000

Epoch 3 training complete
Cost on training data: 5.80075238273
Accuracy on training data: 33543 / 50000
Cost on evaluation data: 21.2110359332
Accuracy on evaluation data: 6850 / 10000

Epoch 4 training complete
Cost on training data: 5.79282763853
Accuracy on training data: 33142 / 50000
Cost on evaluation data: 21.193069232
Accuracy on evaluation data: 6703 / 10000

Epoch 5 training complete
Cost on training data: 5.78461969103
Accuracy on training data: 33342 / 50000
Cost on evaluation data: 21.1727282255
Accuracy on evaluation data: 6774 / 10000

Epoch 6 training complete
Cost on training data: 5.79222516038
Accuracy on training data: 33021 / 50000
Cost on evaluation data: 21.1605646982
Accuracy on evaluation data: 6693 / 10000

Epoch 7 training complete
Cost on training data: 5.74662873078
Accuracy on training data: 33517 / 50000
Cost on evaluation data: 21.1037842338
Accuracy on evaluation data: 6791 / 10000

Epoch 8 training complete
Cost on training data: 5.7569717178

Accuracy on training data: 33846 / 50000
Cost on evaluation data: 21.0942095001
Accuracy on evaluation data: 6883 / 10000

Epoch 9 training complete
Cost on training data: 5.73924622545
Accuracy on training data: 34170 / 50000
Cost on evaluation data: 21.0621095219
Accuracy on evaluation data: 6937 / 10000

Epoch 10 training complete
Cost on training data: 5.74474496666
Accuracy on training data: 33410 / 50000
Cost on evaluation data: 21.0544553865
Accuracy on evaluation data: 6781 / 10000

Epoch 11 training complete
Cost on training data: 5.71234408108
Accuracy on training data: 34212 / 50000
Cost on evaluation data: 21.0022209187
Accuracy on evaluation data: 6961 / 10000

Epoch 12 training complete
Cost on training data: 5.73394413314
Accuracy on training data: 33654 / 50000
Cost on evaluation data: 21.0083478851
Accuracy on evaluation data: 6842 / 10000

Epoch 13 training complete
Cost on training data: 5.72100027425
Accuracy on training data: 34589 / 50000
Cost on evaluation data: 20.9812720893
Accuracy on evaluation data: 7046 / 10000

Epoch 14 training complete
Cost on training data: 5.67591449401
Accuracy on training data: 34898 / 50000
Cost on evaluation data: 20.9207298138
Accuracy on evaluation data: 7073 / 10000

Epoch 15 training complete
Cost on training data: 5.65634441202
Accuracy on training data: 34373 / 50000
Cost on evaluation data: 20.8837477015
Accuracy on evaluation data: 6991 / 10000

Epoch 16 training complete
Cost on training data: 5.68135610327

Accuracy on training data: 33999 / 50000
Cost on evaluation data: 20.9015290377
Accuracy on evaluation data: 6862 / 10000

Epoch 17 training complete
Cost on training data: 5.67835331664
Accuracy on training data: 34253 / 50000
Cost on evaluation data: 20.8819513512
Accuracy on evaluation data: 6915 / 10000

Epoch 18 training complete
Cost on training data: 5.65980533322
Accuracy on training data: 34265 / 50000
Cost on evaluation data: 20.8469664729
Accuracy on evaluation data: 6959 / 10000

Epoch 19 training complete
Cost on training data: 5.65800356321
Accuracy on training data: 34206 / 50000
Cost on evaluation data: 20.8270463387
Accuracy on evaluation data: 6960 / 10000

Epoch 20 training complete
Cost on training data: 5.66826225855
Accuracy on training data: 33720 / 50000
Cost on evaluation data: 20.8306020191
Accuracy on evaluation data: 6817 / 10000

Epoch 21 training complete
Cost on training data: 5.64848513553
Accuracy on training data: 34473 / 50000
Cost on evaluation data: 20.7870218128
Accuracy on evaluation data: 7000 / 10000

Epoch 22 training complete
Cost on training data: 5.63486633673
Accuracy on training data: 34691 / 50000
Cost on evaluation data: 20.7579130716
Accuracy on evaluation data: 7031 / 10000

Epoch 23 training complete
Cost on training data: 5.66724202367
Accuracy on training data: 33312 / 50000
Cost on evaluation data: 20.7727938583
Accuracy on evaluation data: 6770 / 10000

Epoch 24 training complete
Cost on training data: 5.62247450386

Accuracy on training data: 34262 / 50000
Cost on evaluation data: 20.7190038951
Accuracy on evaluation data: 6933 / 10000

Epoch 25 training complete
Cost on training data: 5.64059845796
Accuracy on training data: 34805 / 50000
Cost on evaluation data: 20.7186623009
Accuracy on evaluation data: 7052 / 10000

Epoch 26 training complete
Cost on training data: 5.60151354798
Accuracy on training data: 34834 / 50000
Cost on evaluation data: 20.6663041646
Accuracy on evaluation data: 7076 / 10000

Epoch 27 training complete
Cost on training data: 5.59112100084
Accuracy on training data: 34498 / 50000
Cost on evaluation data: 20.6426274684
Accuracy on evaluation data: 6990 / 10000

Epoch 28 training complete
Cost on training data: 5.59965756856
Accuracy on training data: 34896 / 50000
Cost on evaluation data: 20.636223855
Accuracy on evaluation data: 7100 / 10000

Epoch 29 training complete
Cost on training data: 5.59575571968
Accuracy on training data: 34628 / 50000
Cost on evaluation data: 20.6142172975
Accuracy on evaluation data: 7010 / 10000

Epoch 30 training complete
Cost on training data: 5.59024287194
Accuracy on training data: 34610 / 50000
Cost on evaluation data: 20.6006748217
Accuracy on evaluation data: 6998 / 10000

Epoch 31 training complete
Cost on training data: 5.57390484474
Accuracy on training data: 34578 / 50000
Cost on evaluation data: 20.5563348219
Accuracy on evaluation data: 7034 / 10000

Epoch 32 training complete
Cost on training data: 5.56915632847

Accuracy on training data: 34901 / 50000
Cost on evaluation data: 20.5408212718
Accuracy on evaluation data: 7094 / 10000

Epoch 33 training complete
Cost on training data: 5.56077952909
Accuracy on training data: 34915 / 50000
Cost on evaluation data: 20.5149721879
Accuracy on evaluation data: 7117 / 10000

Epoch 34 training complete
Cost on training data: 5.55521726558
Accuracy on training data: 34946 / 50000
Cost on evaluation data: 20.4984881153
Accuracy on evaluation data: 7080 / 10000

Epoch 35 training complete
Cost on training data: 5.55311862008
Accuracy on training data: 35010 / 50000
Cost on evaluation data: 20.4850601451
Accuracy on evaluation data: 7071 / 10000

Epoch 36 training complete
Cost on training data: 5.54093537601
Accuracy on training data: 35024 / 50000
Cost on evaluation data: 20.4567885951
Accuracy on evaluation data: 7049 / 10000

Epoch 37 training complete
Cost on training data: 5.53789789783
Accuracy on training data: 35042 / 50000
Cost on evaluation data: 20.4350544815
Accuracy on evaluation data: 7087 / 10000

Epoch 38 training complete
Cost on training data: 5.53273436305
Accuracy on training data: 35117 / 50000
Cost on evaluation data: 20.4197416981
Accuracy on evaluation data: 7109 / 10000

Epoch 39 training complete
Cost on training data: 5.53118050444
Accuracy on training data: 35160 / 50000
Cost on evaluation data: 20.400821426
Accuracy on evaluation data: 7113 / 10000

Epoch 40 training complete
Cost on training data: 5.52343686861

Accuracy on training data: 34940 / 50000
Cost on evaluation data: 20.3819736986
Accuracy on evaluation data: 7031 / 10000

Epoch 41 training complete
Cost on training data: 5.52439987367
Accuracy on training data: 35019 / 50000
Cost on evaluation data: 20.3620089821
Accuracy on evaluation data: 7079 / 10000

Epoch 42 training complete
Cost on training data: 5.52346963135
Accuracy on training data: 34856 / 50000
Cost on evaluation data: 20.3519049589
Accuracy on evaluation data: 7010 / 10000

Epoch 43 training complete
Cost on training data: 5.51385053325
Accuracy on training data: 35169 / 50000
Cost on evaluation data: 20.3210347583
Accuracy on evaluation data: 7102 / 10000

Epoch 44 training complete
Cost on training data: 5.50014220662
Accuracy on training data: 34957 / 50000
Cost on evaluation data: 20.2920572342
Accuracy on evaluation data: 7046 / 10000

Epoch 45 training complete
Cost on training data: 5.47835788652
Accuracy on training data: 35091 / 50000
Cost on evaluation data: 20.2555791775
Accuracy on evaluation data: 7025 / 10000

Epoch 46 training complete
Cost on training data: 5.47021725784
Accuracy on training data: 35269 / 50000
Cost on evaluation data: 20.2350585117
Accuracy on evaluation data: 7122 / 10000

Epoch 47 training complete
Cost on training data: 5.48487844639
Accuracy on training data: 35129 / 50000
Cost on evaluation data: 20.2352386425
Accuracy on evaluation data: 7080 / 10000

Epoch 48 training complete
Cost on training data: 5.47846441493

Accuracy on training data: 35133 / 50000
Cost on evaluation data: 20.2104821535
Accuracy on evaluation data: 7115 / 10000

Epoch 49 training complete
Cost on training data: 5.4761995872
Accuracy on training data: 35217 / 50000
Cost on evaluation data: 20.1894875531
Accuracy on evaluation data: 7097 / 10000

```
In [22]: evaluation_cost_all_train, evaluation_accuracy_all_train, training_cost_all_train, tr
        training_data=training_data,
        epochs=50,
        mini_batch_size=10,
        eta=0.001,
        evaluation_data=test_data,
        lambda=5.0,
        monitor_evaluation_cost=True,
        monitor_evaluation_accuracy=True,
        monitor_training_cost=True,
        monitor_training_accuracy=True
    )
```

Epoch 0 training complete
Cost on training data: 5.48317485007
Accuracy on training data: 34980 / 50000
Cost on evaluation data: 20.1887229329
Accuracy on evaluation data: 7093 / 10000

Epoch 1 training complete
Cost on training data: 5.45913287016
Accuracy on training data: 35457 / 50000
Cost on evaluation data: 20.1452007092
Accuracy on evaluation data: 7143 / 10000

Epoch 2 training complete
Cost on training data: 5.45781593938
Accuracy on training data: 35321 / 50000
Cost on evaluation data: 20.1319403693
Accuracy on evaluation data: 7143 / 10000

Epoch 3 training complete
Cost on training data: 5.42829921661
Accuracy on training data: 35200 / 50000
Cost on evaluation data: 20.0861229009
Accuracy on evaluation data: 7076 / 10000

Epoch 4 training complete
Cost on training data: 5.44272000476
Accuracy on training data: 35588 / 50000
Cost on evaluation data: 20.0899550119
Accuracy on evaluation data: 7195 / 10000

Epoch 5 training complete
Cost on training data: 5.43820851325
Accuracy on training data: 35319 / 50000
Cost on evaluation data: 20.0672279299
Accuracy on evaluation data: 7100 / 10000

Epoch 6 training complete
Cost on training data: 5.42588702969
Accuracy on training data: 35518 / 50000
Cost on evaluation data: 20.0399462801
Accuracy on evaluation data: 7150 / 10000

Epoch 7 training complete
Cost on training data: 5.4216747967
Accuracy on training data: 35004 / 50000
Cost on evaluation data: 20.0245178617
Accuracy on evaluation data: 7051 / 10000

Epoch 8 training complete
Cost on training data: 5.42548858882
Accuracy on training data: 35197 / 50000
Cost on evaluation data: 20.0108374566
Accuracy on evaluation data: 7092 / 10000

Epoch 9 training complete
Cost on training data: 5.42727121159
Accuracy on training data: 35140 / 50000
Cost on evaluation data: 19.9971965973
Accuracy on evaluation data: 7118 / 10000

Epoch 10 training complete
Cost on training data: 5.41147808091
Accuracy on training data: 35674 / 50000
Cost on evaluation data: 19.9636377917
Accuracy on evaluation data: 7161 / 10000

Epoch 11 training complete
Cost on training data: 5.41809841536
Accuracy on training data: 35335 / 50000
Cost on evaluation data: 19.959389149
Accuracy on evaluation data: 7162 / 10000

Epoch 12 training complete
Cost on training data: 5.41532576803
Accuracy on training data: 35812 / 50000
Cost on evaluation data: 19.943346232
Accuracy on evaluation data: 7228 / 10000

Epoch 13 training complete
Cost on training data: 5.39317598156
Accuracy on training data: 35619 / 50000
Cost on evaluation data: 19.9123620416
Accuracy on evaluation data: 7131 / 10000

Epoch 14 training complete
Cost on training data: 5.34876427625
Accuracy on training data: 35985 / 50000
Cost on evaluation data: 19.8458598706
Accuracy on evaluation data: 7272 / 10000

Epoch 15 training complete
Cost on training data: 5.39705576201
Accuracy on training data: 35429 / 50000
Cost on evaluation data: 19.8830296511
Accuracy on evaluation data: 7123 / 10000

Epoch 16 training complete
Cost on training data: 5.39118247517
Accuracy on training data: 35389 / 50000
Cost on evaluation data: 19.8545532003
Accuracy on evaluation data: 7161 / 10000

Epoch 17 training complete
Cost on training data: 5.36854310336
Accuracy on training data: 35723 / 50000
Cost on evaluation data: 19.8236891379
Accuracy on evaluation data: 7174 / 10000

Epoch 18 training complete
Cost on training data: 5.36072672917
Accuracy on training data: 35953 / 50000
Cost on evaluation data: 19.8049783052
Accuracy on evaluation data: 7237 / 10000

Epoch 19 training complete
Cost on training data: 5.3581768429
Accuracy on training data: 35956 / 50000
Cost on evaluation data: 19.7808611273
Accuracy on evaluation data: 7249 / 10000

Epoch 20 training complete
Cost on training data: 5.36479566082
Accuracy on training data: 35897 / 50000
Cost on evaluation data: 19.7761263189
Accuracy on evaluation data: 7252 / 10000

Epoch 21 training complete
Cost on training data: 5.36434576474
Accuracy on training data: 35477 / 50000
Cost on evaluation data: 19.7605149585
Accuracy on evaluation data: 7146 / 10000

Epoch 22 training complete
Cost on training data: 5.3565099676
Accuracy on training data: 35315 / 50000
Cost on evaluation data: 19.7435024513
Accuracy on evaluation data: 7090 / 10000

Epoch 23 training complete
Cost on training data: 5.34884897446
Accuracy on training data: 36031 / 50000
Cost on evaluation data: 19.71801597
Accuracy on evaluation data: 7244 / 10000

Epoch 24 training complete
Cost on training data: 5.33378239633
Accuracy on training data: 35425 / 50000
Cost on evaluation data: 19.6833500772
Accuracy on evaluation data: 7133 / 10000

Epoch 25 training complete
Cost on training data: 5.33385831625
Accuracy on training data: 35897 / 50000
Cost on evaluation data: 19.6718381384
Accuracy on evaluation data: 7237 / 10000

Epoch 26 training complete
Cost on training data: 5.3360746279
Accuracy on training data: 35769 / 50000
Cost on evaluation data: 19.657314605
Accuracy on evaluation data: 7187 / 10000

Epoch 27 training complete
Cost on training data: 5.31979586149
Accuracy on training data: 35858 / 50000
Cost on evaluation data: 19.6285776326
Accuracy on evaluation data: 7260 / 10000

Epoch 28 training complete
Cost on training data: 5.31627702805
Accuracy on training data: 35984 / 50000
Cost on evaluation data: 19.6096344314
Accuracy on evaluation data: 7256 / 10000

Epoch 29 training complete
Cost on training data: 5.32186484478
Accuracy on training data: 36189 / 50000
Cost on evaluation data: 19.6021564871
Accuracy on evaluation data: 7325 / 10000

Epoch 30 training complete
Cost on training data: 5.30142174374
Accuracy on training data: 35827 / 50000
Cost on evaluation data: 19.5644064046
Accuracy on evaluation data: 7224 / 10000

Epoch 31 training complete
Cost on training data: 5.30185592274
Accuracy on training data: 35958 / 50000
Cost on evaluation data: 19.5541898376
Accuracy on evaluation data: 7259 / 10000

Epoch 32 training complete
Cost on training data: 5.28615550398
Accuracy on training data: 36261 / 50000
Cost on evaluation data: 19.5225597692
Accuracy on evaluation data: 7347 / 10000

Epoch 33 training complete
Cost on training data: 5.28686172636
Accuracy on training data: 36035 / 50000
Cost on evaluation data: 19.5162800571
Accuracy on evaluation data: 7308 / 10000

Epoch 34 training complete
Cost on training data: 5.28842797891
Accuracy on training data: 35957 / 50000
Cost on evaluation data: 19.4996645851
Accuracy on evaluation data: 7253 / 10000

Epoch 35 training complete
Cost on training data: 5.29513284269
Accuracy on training data: 36068 / 50000
Cost on evaluation data: 19.4967758816
Accuracy on evaluation data: 7273 / 10000

Epoch 36 training complete
Cost on training data: 5.27524340161
Accuracy on training data: 35924 / 50000
Cost on evaluation data: 19.4548881844
Accuracy on evaluation data: 7226 / 10000

Epoch 37 training complete
Cost on training data: 5.26265769537
Accuracy on training data: 36261 / 50000
Cost on evaluation data: 19.4282962709
Accuracy on evaluation data: 7300 / 10000

Epoch 38 training complete
Cost on training data: 5.2659598038
Accuracy on training data: 36259 / 50000
Cost on evaluation data: 19.4239872573
Accuracy on evaluation data: 7287 / 10000

Epoch 39 training complete
Cost on training data: 5.2720251313
Accuracy on training data: 35985 / 50000
Cost on evaluation data: 19.4133057886
Accuracy on evaluation data: 7244 / 10000

Epoch 40 training complete
Cost on training data: 5.2605199427
Accuracy on training data: 35982 / 50000
Cost on evaluation data: 19.38639426
Accuracy on evaluation data: 7281 / 10000

Epoch 41 training complete
Cost on training data: 5.25597591931
Accuracy on training data: 36250 / 50000
Cost on evaluation data: 19.3678298511
Accuracy on evaluation data: 7353 / 10000

Epoch 42 training complete
Cost on training data: 5.23551422581
Accuracy on training data: 36166 / 50000
Cost on evaluation data: 19.3327572824
Accuracy on evaluation data: 7286 / 10000

Epoch 43 training complete
Cost on training data: 5.23438584541
Accuracy on training data: 36034 / 50000
Cost on evaluation data: 19.31358028
Accuracy on evaluation data: 7282 / 10000

Epoch 44 training complete
Cost on training data: 5.22719637715
Accuracy on training data: 36474 / 50000
Cost on evaluation data: 19.2953358965
Accuracy on evaluation data: 7342 / 10000

Epoch 45 training complete
Cost on training data: 5.2296736899
Accuracy on training data: 36262 / 50000
Cost on evaluation data: 19.2866871827
Accuracy on evaluation data: 7294 / 10000

Epoch 46 training complete
Cost on training data: 5.21921699538
Accuracy on training data: 36362 / 50000
Cost on evaluation data: 19.2549669128
Accuracy on evaluation data: 7361 / 10000

Epoch 47 training complete
Cost on training data: 5.22251553114
Accuracy on training data: 36294 / 50000
Cost on evaluation data: 19.2503389905
Accuracy on evaluation data: 7341 / 10000

Epoch 48 training complete
Cost on training data: 5.20783383003
Accuracy on training data: 36538 / 50000
Cost on evaluation data: 19.2219603652
Accuracy on evaluation data: 7372 / 10000

Epoch 49 training complete
Cost on training data: 5.19089013194
Accuracy on training data: 36485 / 50000
Cost on evaluation data: 19.1909993695
Accuracy on evaluation data: 7340 / 10000

```
In [23]: evaluation_cost_all_train, evaluation_accuracy_all_train, training_cost_all_train, tr
         training_data=training_data,
         epochs=30,
         mini_batch_size=10,
         eta=0.01,
         evaluation_data=test_data,
         lambda=5.0,
         monitor_evaluation_cost=True,
         monitor_evaluation_accuracy=True,
```

```
        monitor_training_cost=True,  
        monitor_training_accuracy=True  
    )
```

Epoch 0 training complete

Cost on training data: 6.89060993892

Accuracy on training data: 20580 / 50000

Cost on evaluation data: 20.7467119318

Accuracy on evaluation data: 4112 / 10000

Epoch 1 training complete

Cost on training data: 6.35556463523

Accuracy on training data: 19817 / 50000

Cost on evaluation data: 20.0999336164

Accuracy on evaluation data: 3969 / 10000

Epoch 2 training complete

Cost on training data: 5.99223215635

Accuracy on training data: 22426 / 50000

Cost on evaluation data: 19.5842546748

Accuracy on evaluation data: 4527 / 10000

Epoch 3 training complete

Cost on training data: 6.07466779728

Accuracy on training data: 23714 / 50000

Cost on evaluation data: 19.5386614427

Accuracy on evaluation data: 4781 / 10000

Epoch 4 training complete

Cost on training data: 5.3696611814

Accuracy on training data: 29875 / 50000

Cost on evaluation data: 18.6789488152

Accuracy on evaluation data: 6102 / 10000

Epoch 5 training complete

Cost on training data: 5.15534127188

Accuracy on training data: 32924 / 50000

Cost on evaluation data: 18.3545670805

Accuracy on evaluation data: 6668 / 10000

Epoch 6 training complete

Cost on training data: 5.53185933527

Accuracy on training data: 28946 / 50000

Cost on evaluation data: 18.5984492676

Accuracy on evaluation data: 5844 / 10000

Epoch 7 training complete

Cost on training data: 5.2123493616

Accuracy on training data: 33296 / 50000
Cost on evaluation data: 18.130258166
Accuracy on evaluation data: 6788 / 10000

Epoch 8 training complete
Cost on training data: 5.29976555089
Accuracy on training data: 29486 / 50000
Cost on evaluation data: 18.0916338136
Accuracy on evaluation data: 5962 / 10000

Epoch 9 training complete
Cost on training data: 5.27126869138
Accuracy on training data: 27120 / 50000
Cost on evaluation data: 17.9494998288
Accuracy on evaluation data: 5436 / 10000

Epoch 10 training complete
Cost on training data: 5.4124248881
Accuracy on training data: 26635 / 50000
Cost on evaluation data: 17.9364950668
Accuracy on evaluation data: 5428 / 10000

Epoch 11 training complete
Cost on training data: 5.13980346846
Accuracy on training data: 32057 / 50000
Cost on evaluation data: 17.5643582345
Accuracy on evaluation data: 6474 / 10000

Epoch 12 training complete
Cost on training data: 5.25237216096
Accuracy on training data: 28222 / 50000
Cost on evaluation data: 17.5771005818
Accuracy on evaluation data: 5696 / 10000

Epoch 13 training complete
Cost on training data: 5.27231115783
Accuracy on training data: 28221 / 50000
Cost on evaluation data: 17.4319165878
Accuracy on evaluation data: 5685 / 10000

Epoch 14 training complete
Cost on training data: 5.08312361205
Accuracy on training data: 30704 / 50000
Cost on evaluation data: 17.1311076418
Accuracy on evaluation data: 6258 / 10000

Epoch 15 training complete
Cost on training data: 4.95880364105

Accuracy on training data: 30575 / 50000
Cost on evaluation data: 16.8752058829
Accuracy on evaluation data: 6203 / 10000

Epoch 16 training complete
Cost on training data: 5.11130247381
Accuracy on training data: 32383 / 50000
Cost on evaluation data: 16.9187123085
Accuracy on evaluation data: 6504 / 10000

Epoch 17 training complete
Cost on training data: 4.73128727841
Accuracy on training data: 35444 / 50000
Cost on evaluation data: 16.4280924574
Accuracy on evaluation data: 7171 / 10000

Epoch 18 training complete
Cost on training data: 4.64317175776
Accuracy on training data: 35908 / 50000
Cost on evaluation data: 16.2116858799
Accuracy on evaluation data: 7214 / 10000

Epoch 19 training complete
Cost on training data: 4.6525590318
Accuracy on training data: 35961 / 50000
Cost on evaluation data: 16.100868139
Accuracy on evaluation data: 7260 / 10000

Epoch 20 training complete
Cost on training data: 4.75859591428
Accuracy on training data: 34602 / 50000
Cost on evaluation data: 16.1073030024
Accuracy on evaluation data: 7031 / 10000

Epoch 21 training complete
Cost on training data: 4.89431913311
Accuracy on training data: 28595 / 50000
Cost on evaluation data: 16.1177894131
Accuracy on evaluation data: 5825 / 10000

Epoch 22 training complete
Cost on training data: 5.17932216727
Accuracy on training data: 24494 / 50000
Cost on evaluation data: 16.3064777896
Accuracy on evaluation data: 4923 / 10000

Epoch 23 training complete
Cost on training data: 4.68145208978

Accuracy on training data: 34065 / 50000
Cost on evaluation data: 15.6827102626
Accuracy on evaluation data: 6905 / 10000

Epoch 24 training complete
Cost on training data: 4.44971494234
Accuracy on training data: 35061 / 50000
Cost on evaluation data: 15.3596684405
Accuracy on evaluation data: 7074 / 10000

Epoch 25 training complete
Cost on training data: 4.48750875503
Accuracy on training data: 36009 / 50000
Cost on evaluation data: 15.2759961788
Accuracy on evaluation data: 7340 / 10000

Epoch 26 training complete
Cost on training data: 4.44786840865
Accuracy on training data: 35161 / 50000
Cost on evaluation data: 15.1303569609
Accuracy on evaluation data: 7095 / 10000

Epoch 27 training complete
Cost on training data: 4.2856049154
Accuracy on training data: 37316 / 50000
Cost on evaluation data: 14.8597009189
Accuracy on evaluation data: 7525 / 10000

Epoch 28 training complete
Cost on training data: 4.51119299328
Accuracy on training data: 35102 / 50000
Cost on evaluation data: 14.9935707233
Accuracy on evaluation data: 7089 / 10000

Epoch 29 training complete
Cost on training data: 4.13808964518
Accuracy on training data: 39083 / 50000
Cost on evaluation data: 14.4947473584
Accuracy on evaluation data: 7873 / 10000

```
In [25]: evaluation_cost_all_train, evaluation_accuracy_all_train, training_cost_all_train, tra
         training_data=training_data,
         epochs=30,
         mini_batch_size=10,
         eta=0.001,
         evaluation_data=test_data,
```

```
        lambda=5.0,  
        monitor_evaluation_cost=True,  
        monitor_evaluation_accuracy=True,  
        monitor_training_cost=True,  
        monitor_training_accuracy=True  
    )
```

Epoch 0 training complete

Cost on training data: 3.66499125911

Accuracy on training data: 41592 / 50000

Cost on evaluation data: 12.3496310096

Accuracy on evaluation data: 8389 / 10000

Epoch 1 training complete

Cost on training data: 3.65343994635

Accuracy on training data: 41879 / 50000

Cost on evaluation data: 12.3341561497

Accuracy on evaluation data: 8459 / 10000

Epoch 2 training complete

Cost on training data: 3.64871734738

Accuracy on training data: 41860 / 50000

Cost on evaluation data: 12.3165654591

Accuracy on evaluation data: 8479 / 10000

Epoch 3 training complete

Cost on training data: 3.64196765297

Accuracy on training data: 41874 / 50000

Cost on evaluation data: 12.3017094901

Accuracy on evaluation data: 8466 / 10000

Epoch 4 training complete

Cost on training data: 3.6386352019

Accuracy on training data: 41922 / 50000

Cost on evaluation data: 12.287400793

Accuracy on evaluation data: 8452 / 10000

Epoch 5 training complete

Cost on training data: 3.63450285264

Accuracy on training data: 41694 / 50000

Cost on evaluation data: 12.2757665336

Accuracy on evaluation data: 8441 / 10000

Epoch 6 training complete

Cost on training data: 3.63588950588

Accuracy on training data: 41908 / 50000

Cost on evaluation data: 12.2684592045

Accuracy on evaluation data: 8457 / 10000

Epoch 7 training complete
Cost on training data: 3.63803413351
Accuracy on training data: 42047 / 50000
Cost on evaluation data: 12.2608982165
Accuracy on evaluation data: 8485 / 10000

Epoch 8 training complete
Cost on training data: 3.63684563053
Accuracy on training data: 41718 / 50000
Cost on evaluation data: 12.2527973873
Accuracy on evaluation data: 8452 / 10000

Epoch 9 training complete
Cost on training data: 3.62737828412
Accuracy on training data: 41999 / 50000
Cost on evaluation data: 12.2364288014
Accuracy on evaluation data: 8510 / 10000

Epoch 10 training complete
Cost on training data: 3.62267869365
Accuracy on training data: 41735 / 50000
Cost on evaluation data: 12.2199012043
Accuracy on evaluation data: 8450 / 10000

Epoch 11 training complete
Cost on training data: 3.62437708857
Accuracy on training data: 41839 / 50000
Cost on evaluation data: 12.2153037265
Accuracy on evaluation data: 8473 / 10000

Epoch 12 training complete
Cost on training data: 3.62320167618
Accuracy on training data: 41700 / 50000
Cost on evaluation data: 12.2023744928
Accuracy on evaluation data: 8420 / 10000

Epoch 13 training complete
Cost on training data: 3.61564400382
Accuracy on training data: 41897 / 50000
Cost on evaluation data: 12.1911288079
Accuracy on evaluation data: 8489 / 10000

Epoch 14 training complete
Cost on training data: 3.61491209637
Accuracy on training data: 42136 / 50000
Cost on evaluation data: 12.1773088381
Accuracy on evaluation data: 8534 / 10000

Epoch 15 training complete
Cost on training data: 3.6118231792
Accuracy on training data: 41923 / 50000
Cost on evaluation data: 12.1695497328
Accuracy on evaluation data: 8489 / 10000

Epoch 16 training complete
Cost on training data: 3.61018632051
Accuracy on training data: 41831 / 50000
Cost on evaluation data: 12.1611901773
Accuracy on evaluation data: 8437 / 10000

Epoch 17 training complete
Cost on training data: 3.61273386357
Accuracy on training data: 41722 / 50000
Cost on evaluation data: 12.1525356195
Accuracy on evaluation data: 8441 / 10000

Epoch 18 training complete
Cost on training data: 3.60951605664
Accuracy on training data: 41865 / 50000
Cost on evaluation data: 12.1424701443
Accuracy on evaluation data: 8473 / 10000

Epoch 19 training complete
Cost on training data: 3.59995072498
Accuracy on training data: 41870 / 50000
Cost on evaluation data: 12.1202289067
Accuracy on evaluation data: 8466 / 10000

Epoch 20 training complete
Cost on training data: 3.60093756016
Accuracy on training data: 41840 / 50000
Cost on evaluation data: 12.1154293615
Accuracy on evaluation data: 8445 / 10000

Epoch 21 training complete
Cost on training data: 3.59977931562
Accuracy on training data: 42103 / 50000
Cost on evaluation data: 12.1037900256
Accuracy on evaluation data: 8498 / 10000

Epoch 22 training complete
Cost on training data: 3.59862893339
Accuracy on training data: 41864 / 50000
Cost on evaluation data: 12.102388354
Accuracy on evaluation data: 8485 / 10000

Epoch 23 training complete
Cost on training data: 3.5901720042
Accuracy on training data: 41783 / 50000
Cost on evaluation data: 12.0764426796
Accuracy on evaluation data: 8449 / 10000

Epoch 24 training complete
Cost on training data: 3.59011396676
Accuracy on training data: 41929 / 50000
Cost on evaluation data: 12.0708150974
Accuracy on evaluation data: 8507 / 10000

Epoch 25 training complete
Cost on training data: 3.59645579025
Accuracy on training data: 42054 / 50000
Cost on evaluation data: 12.0716017906
Accuracy on evaluation data: 8503 / 10000

Epoch 26 training complete
Cost on training data: 3.59259392854
Accuracy on training data: 42019 / 50000
Cost on evaluation data: 12.0502595968
Accuracy on evaluation data: 8510 / 10000

Epoch 27 training complete
Cost on training data: 3.584267807
Accuracy on training data: 41719 / 50000
Cost on evaluation data: 12.0385443405
Accuracy on evaluation data: 8442 / 10000

Epoch 28 training complete
Cost on training data: 3.57861535824
Accuracy on training data: 41690 / 50000
Cost on evaluation data: 12.025302844
Accuracy on evaluation data: 8432 / 10000

Epoch 29 training complete
Cost on training data: 3.58001560708
Accuracy on training data: 41820 / 50000
Cost on evaluation data: 12.017989728
Accuracy on evaluation data: 8443 / 10000

In [26]: evaluation_cost_all_train, evaluation_accuracy_all_train, training_cost_all_train, tra
 training_data=training_data,
 epochs=30,

```
        mini_batch_size=10,  
        eta=0.001,  
        evaluation_data=test_data,  
        lambda=5.0,  
        monitor_evaluation_cost=True,  
        monitor_evaluation_accuracy=True,  
        monitor_training_cost=True,  
        monitor_training_accuracy=True  
    )
```

Epoch 0 training complete

Cost on training data: 3.57423249908

Accuracy on training data: 41732 / 50000

Cost on evaluation data: 12.0022392424

Accuracy on evaluation data: 8449 / 10000

Epoch 1 training complete

Cost on training data: 3.57773707119

Accuracy on training data: 42036 / 50000

Cost on evaluation data: 11.9997675144

Accuracy on evaluation data: 8515 / 10000

Epoch 2 training complete

Cost on training data: 3.57069042962

Accuracy on training data: 41896 / 50000

Cost on evaluation data: 11.9824642884

Accuracy on evaluation data: 8491 / 10000

Epoch 3 training complete

Cost on training data: 3.57068802939

Accuracy on training data: 42064 / 50000

Cost on evaluation data: 11.9771597902

Accuracy on evaluation data: 8493 / 10000

Epoch 4 training complete

Cost on training data: 3.57187489637

Accuracy on training data: 41844 / 50000

Cost on evaluation data: 11.9714282267

Accuracy on evaluation data: 8462 / 10000

Epoch 5 training complete

Cost on training data: 3.57148478914

Accuracy on training data: 41941 / 50000

Cost on evaluation data: 11.95521875

Accuracy on evaluation data: 8484 / 10000

Epoch 6 training complete

Cost on training data: 3.56496675771

Accuracy on training data: 42165 / 50000
Cost on evaluation data: 11.9428736683
Accuracy on evaluation data: 8508 / 10000

Epoch 7 training complete
Cost on training data: 3.56437675085
Accuracy on training data: 41833 / 50000
Cost on evaluation data: 11.939080157
Accuracy on evaluation data: 8423 / 10000

Epoch 8 training complete
Cost on training data: 3.55767762808
Accuracy on training data: 42087 / 50000
Cost on evaluation data: 11.9186962286
Accuracy on evaluation data: 8502 / 10000

Epoch 9 training complete
Cost on training data: 3.54981321792
Accuracy on training data: 42038 / 50000
Cost on evaluation data: 11.9040516004
Accuracy on evaluation data: 8493 / 10000

Epoch 10 training complete
Cost on training data: 3.55211615219
Accuracy on training data: 42099 / 50000
Cost on evaluation data: 11.8976092688
Accuracy on evaluation data: 8526 / 10000

Epoch 11 training complete
Cost on training data: 3.55213589291
Accuracy on training data: 41805 / 50000
Cost on evaluation data: 11.8894621972
Accuracy on evaluation data: 8423 / 10000

Epoch 12 training complete
Cost on training data: 3.54941712655
Accuracy on training data: 41731 / 50000
Cost on evaluation data: 11.8785834059
Accuracy on evaluation data: 8396 / 10000

Epoch 13 training complete
Cost on training data: 3.54233912039
Accuracy on training data: 41939 / 50000
Cost on evaluation data: 11.8623788381
Accuracy on evaluation data: 8488 / 10000

Epoch 14 training complete
Cost on training data: 3.544207473

Accuracy on training data: 42065 / 50000
Cost on evaluation data: 11.8511030934
Accuracy on evaluation data: 8514 / 10000

Epoch 15 training complete
Cost on training data: 3.53904472637
Accuracy on training data: 41901 / 50000
Cost on evaluation data: 11.844827671
Accuracy on evaluation data: 8456 / 10000

Epoch 16 training complete
Cost on training data: 3.53893138858
Accuracy on training data: 41888 / 50000
Cost on evaluation data: 11.8330477184
Accuracy on evaluation data: 8454 / 10000

Epoch 17 training complete
Cost on training data: 3.5327390885
Accuracy on training data: 41911 / 50000
Cost on evaluation data: 11.8163684461
Accuracy on evaluation data: 8475 / 10000

Epoch 18 training complete
Cost on training data: 3.53400313938
Accuracy on training data: 42004 / 50000
Cost on evaluation data: 11.812008337
Accuracy on evaluation data: 8487 / 10000

Epoch 19 training complete
Cost on training data: 3.54071051156
Accuracy on training data: 42070 / 50000
Cost on evaluation data: 11.8096965921
Accuracy on evaluation data: 8514 / 10000

Epoch 20 training complete
Cost on training data: 3.52459860405
Accuracy on training data: 41990 / 50000
Cost on evaluation data: 11.7864269192
Accuracy on evaluation data: 8491 / 10000

Epoch 21 training complete
Cost on training data: 3.525730358
Accuracy on training data: 42178 / 50000
Cost on evaluation data: 11.7810900319
Accuracy on evaluation data: 8526 / 10000

Epoch 22 training complete
Cost on training data: 3.51889471487

Accuracy on training data: 42016 / 50000
Cost on evaluation data: 11.7661896107
Accuracy on evaluation data: 8477 / 10000

Epoch 23 training complete
Cost on training data: 3.52738349344
Accuracy on training data: 42122 / 50000
Cost on evaluation data: 11.765968284
Accuracy on evaluation data: 8501 / 10000

Epoch 24 training complete
Cost on training data: 3.52187908052
Accuracy on training data: 42018 / 50000
Cost on evaluation data: 11.7514878809
Accuracy on evaluation data: 8479 / 10000

Epoch 25 training complete
Cost on training data: 3.50409850312
Accuracy on training data: 42068 / 50000
Cost on evaluation data: 11.7255074675
Accuracy on evaluation data: 8500 / 10000

Epoch 26 training complete
Cost on training data: 3.51734548355
Accuracy on training data: 42201 / 50000
Cost on evaluation data: 11.7310873338
Accuracy on evaluation data: 8526 / 10000

Epoch 27 training complete
Cost on training data: 3.51608264904
Accuracy on training data: 41718 / 50000
Cost on evaluation data: 11.7221344684
Accuracy on evaluation data: 8446 / 10000

Epoch 28 training complete
Cost on training data: 3.50280611707
Accuracy on training data: 42278 / 50000
Cost on evaluation data: 11.6973531023
Accuracy on evaluation data: 8548 / 10000

Epoch 29 training complete
Cost on training data: 3.51190832818
Accuracy on training data: 42124 / 50000
Cost on evaluation data: 11.7004131128
Accuracy on evaluation data: 8492 / 10000