

# week\_1\_solution\_1\_9

March 15, 2018

```
In [1]: import os
import urllib2
# import urllib
import io
import gzip

def download_file(remote, local):
    url = remote

    u = urllib2.urlopen(url)
    f = open(local, 'wb')
    meta = u.info()

    file_size = int(meta.getheaders("Content-Length")[0])
    print "Downloading: %s Bytes: %s" % (local, file_size)

    file_size_dl = 0
    block_sz = 8192
    while True:
        buffer = u.read(block_sz)
        if not buffer:
            break

        file_size_dl += len(buffer)
        f.write(buffer)
        status = r"%10d  [%3.2f%%]" % (file_size_dl, file_size_dl * 100. / file_size)
        status = status + chr(8)*(len(status)+1)
        #     print status,

    f.close()

data_dir = "../data"
data_file_url = "https://github.com/mnielsen/neural-networks-and-deep-learning/raw/master"
if os.path.exists(data_dir) == False:
    os.makedirs(data_dir)
    print("Directory created: " + data_dir)
```

```
data_filename = "mnist.pkl.gz"
data_filepath = data_dir + "/" + data_filename

download_file(remote = data_file_url, local = data_filepath)
```

```
# with urllib2.urlopen(data_file_url) as d:
#     data = d.read()
#     d.close()
```

```
# with open(data_filepath, 'wb') as f:
#     f.write(data)
```

```
print("# Completed downloading file: " + data_filename)
```

```
Downloading: ../data/mnist.pkl.gz Bytes: 17051982
# Completed downloading file: mnist.pkl.gz
```

```
In [3]: 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 [31]: print("3. ")
```

```
image_train_list = []
class_train_list = []
```

```
for i in training_data:
    image_train_list.append(i[0])
    class_train_list.append(i[1])
```

```
no_of_image_train, image_size_train, m = np.array(image_train_list).shape
```

```
print("# Size of each image: " + str(image_size_train))
```

```
max_image_data = np.max(image_train_list)
min_image_data = np.min(image_train_list)
```

```
print("# Range of data: max = " + str(max_image_data) + ", min: " + str(min_image_data))
```

```

no_of_image_class, no_of_classes, class_dimension = np.array(class_train_list).shape

print("# Number of classes: " + str(no_of_classes))

3.
# Size of each image: 784
# Range of data: max = 0.99609375, min: 0.0
# Number of classes: 10

In [32]: image_test_list = []
        class_test_list = []

        image_validation_list = []
        class_validation_list = []

        for i in test_data:
            image_test_list.append(i[0])
            class_test_list.append(i[1])

        for i in validation_data:
            image_validation_list.append(i[0])
            class_validation_list.append(i[1])

no_of_image_test, image_size_test, m_test = np.array(image_test_list).shape
no_of_image_validation, image_size_validation, m_validation = np.array(image_validation_list).shape

print("# No of images in train: " + str(no_of_image_train))
print("# No of images in test: " + str(no_of_image_test))
print("# No of images in validation: " + str(no_of_image_validation))

# No of images in train: 50000
# No of images in test: 10000
# No of images in validation: 10000

In [34]: import network

        net = network.Network([784, 30, 10])

Out[34]: <network.Network at 0x659ef98>

In [37]: net.SGD(epochs=30, mini_batch_size=10, training_data=training_data, test_data=test_data)

Epoch 0: 9121 / 10000
Epoch 1: 9225 / 10000
Epoch 2: 9312 / 10000
Epoch 3: 9369 / 10000

```

```
Epoch 4: 9351 / 10000
Epoch 5: 9380 / 10000
Epoch 6: 9420 / 10000
Epoch 7: 9425 / 10000
Epoch 8: 9423 / 10000
Epoch 9: 9471 / 10000
Epoch 10: 9445 / 10000
Epoch 11: 9446 / 10000
Epoch 12: 9454 / 10000
Epoch 13: 9492 / 10000
Epoch 14: 9472 / 10000
Epoch 15: 9484 / 10000
Epoch 16: 9472 / 10000
Epoch 17: 9444 / 10000
Epoch 18: 9474 / 10000
Epoch 19: 9482 / 10000
Epoch 20: 9475 / 10000
Epoch 21: 9477 / 10000
Epoch 22: 9457 / 10000
Epoch 23: 9473 / 10000
Epoch 24: 9488 / 10000
Epoch 25: 9482 / 10000
Epoch 26: 9490 / 10000
Epoch 27: 9472 / 10000
Epoch 28: 9476 / 10000
Epoch 29: 9478 / 10000
```

```
In [39]: print("6. Repeat training step 4,5 but for 100 hidden neurons")
        no_hidden_neuron = 100
        net_100 = network.Network([784, no_hidden_neuron, 10])
        net_100.SGD(epochs=30, mini_batch_size=10, training_data=training_data, test_data=test_data)
```

6. Repeat training step 4,5 but for 100 hidden neurons

```
Epoch 0: 5490 / 10000
Epoch 1: 5638 / 10000
Epoch 2: 5712 / 10000
Epoch 3: 5658 / 10000
Epoch 4: 5687 / 10000
Epoch 5: 5731 / 10000
Epoch 6: 5760 / 10000
Epoch 7: 5731 / 10000
Epoch 8: 5825 / 10000
Epoch 9: 5893 / 10000
Epoch 10: 6028 / 10000
Epoch 11: 7498 / 10000
Epoch 12: 7507 / 10000
Epoch 13: 7503 / 10000
```

```
Epoch 14: 7560 / 10000
Epoch 15: 7534 / 10000
Epoch 16: 7554 / 10000
Epoch 17: 7580 / 10000
Epoch 18: 7594 / 10000
Epoch 19: 7590 / 10000
Epoch 20: 7583 / 10000
Epoch 21: 7572 / 10000
Epoch 22: 7593 / 10000
Epoch 23: 7601 / 10000
Epoch 24: 7606 / 10000
Epoch 25: 7601 / 10000
Epoch 26: 7585 / 10000
Epoch 27: 7588 / 10000
Epoch 28: 7608 / 10000
Epoch 29: 7599 / 10000
```

```
In [41]: print("7. Repeat training step 4,5 but for a learning rate of 0.001 and another time :")
        no_hidden_neuron = 30
        net_eta_001 = network.Network([784, no_hidden_neuron, 10])
        net_eta_001.SGD(epochs=30, mini_batch_size=10, training_data=training_data, test_data=test_data)
```

7. Repeat training step 4,5 but for a learning rate of 0.001 and another time for 100.0

```
Epoch 0: 962 / 10000
Epoch 1: 1012 / 10000
Epoch 2: 984 / 10000
Epoch 3: 982 / 10000
Epoch 4: 982 / 10000
Epoch 5: 982 / 10000
Epoch 6: 982 / 10000
Epoch 7: 983 / 10000
Epoch 8: 994 / 10000
Epoch 9: 1120 / 10000
Epoch 10: 1263 / 10000
Epoch 11: 1322 / 10000
Epoch 12: 1344 / 10000
Epoch 13: 1357 / 10000
Epoch 14: 1396 / 10000
Epoch 15: 1434 / 10000
Epoch 16: 1481 / 10000
Epoch 17: 1546 / 10000
Epoch 18: 1605 / 10000
Epoch 19: 1653 / 10000
Epoch 20: 1698 / 10000
Epoch 21: 1752 / 10000
Epoch 22: 1813 / 10000
Epoch 23: 1887 / 10000
```

```
Epoch 24: 1925 / 10000
Epoch 25: 1967 / 10000
Epoch 26: 2011 / 10000
Epoch 27: 2073 / 10000
Epoch 28: 2109 / 10000
Epoch 29: 2137 / 10000
```

```
In [43]: no_hidden_neuron = 30
        net_eta_100 = network.Network([784, no_hidden_neuron, 10])
        net_eta_100.SGD(epochs=30, mini_batch_size=10, training_data=training_data, test_data=test_data)
```

```
Epoch 0: 977 / 10000
Epoch 1: 1004 / 10000
Epoch 2: 1001 / 10000
Epoch 3: 998 / 10000
Epoch 4: 994 / 10000
Epoch 5: 989 / 10000
Epoch 6: 980 / 10000
Epoch 7: 1217 / 10000
Epoch 8: 1200 / 10000
Epoch 9: 1144 / 10000
Epoch 10: 1425 / 10000
Epoch 11: 1426 / 10000
Epoch 12: 1432 / 10000
Epoch 13: 1426 / 10000
Epoch 14: 1431 / 10000
Epoch 15: 1436 / 10000
Epoch 16: 1438 / 10000
Epoch 17: 1444 / 10000
Epoch 18: 1453 / 10000
Epoch 19: 1457 / 10000
Epoch 20: 1455 / 10000
Epoch 21: 1462 / 10000
Epoch 22: 1465 / 10000
Epoch 23: 1471 / 10000
Epoch 24: 1472 / 10000
Epoch 25: 1478 / 10000
Epoch 26: 1484 / 10000
Epoch 27: 1490 / 10000
Epoch 28: 1500 / 10000
Epoch 29: 1506 / 10000
```

```
In [24]: message = ""
        8. Use the network2.py and repeat 4,5 using cross-entropy cost function,
        learning rate of 0.5, using 10000 training data samples:
        net = network2.Network([784, 30, 10], cost=network2.CrossEntropyCost)
```

```

net.large_weight_initializer()
net.SGD(training_data[:1000], 400, 10, 0.5, evaluation_data=test_data,
... monitor_evaluation_accuracy=True, monitor_training_cost=True
"""
print(message)

import network2

net2 = network2.Network([784, 30, 10], cost=network2.CrossEntropyCost)
net2.large_weight_initializer()

epochs = 400
evaluation_cost, evaluation_accuracy, training_cost, training_accuracy = net2.SGD(
    training_data[:10000],
    epochs,
    10,
    0.5,
    evaluation_data=test_data,
    monitor_evaluation_cost=True,
    monitor_evaluation_accuracy=True,
    monitor_training_cost=True,
    monitor_training_accuracy=True
)

```

8. Use the network2.py and repeat 4,5 using cross-entropy cost function, learning rate of 0.5, using 10000 training data samples:

```

net = network2.Network([784, 30, 10], cost=network2.CrossEntropyCost)
net.large_weight_initializer()
net.SGD(training_data[:1000], 400, 10, 0.5, evaluation_data=test_data,
... monitor_evaluation_accuracy=True, monitor_training_cost=True

```

```

Epoch 0 training complete
Cost on training data: 0.844191821887
Accuracy on training data: 8697 / 10000
Cost on evaluation data: 0.950547988163
Accuracy on evaluation data: 8476 / 10000

```

```

Epoch 1 training complete
Cost on training data: 0.624359301467
Accuracy on training data: 9056 / 10000
Cost on evaluation data: 0.751689316204
Accuracy on evaluation data: 8795 / 10000

```

```

Epoch 2 training complete
Cost on training data: 0.521011780705
Accuracy on training data: 9259 / 10000
Cost on evaluation data: 0.689445793691

```

Accuracy on evaluation data: 8952 / 10000

Epoch 3 training complete

Cost on training data: 0.447727983907

Accuracy on training data: 9366 / 10000

Cost on evaluation data: 0.629181591087

Accuracy on evaluation data: 9064 / 10000

Epoch 4 training complete

Cost on training data: 0.396761678095

Accuracy on training data: 9439 / 10000

Cost on evaluation data: 0.604907362507

Accuracy on evaluation data: 9086 / 10000

Epoch 5 training complete

Cost on training data: 0.356241063934

Accuracy on training data: 9500 / 10000

Cost on evaluation data: 0.592809989241

Accuracy on evaluation data: 9118 / 10000

Epoch 6 training complete

Cost on training data: 0.358962796

Accuracy on training data: 9505 / 10000

Cost on evaluation data: 0.603162304581

Accuracy on evaluation data: 9103 / 10000

Epoch 7 training complete

Cost on training data: 0.339486223667

Accuracy on training data: 9517 / 10000

Cost on evaluation data: 0.60850396271

Accuracy on evaluation data: 9103 / 10000

Epoch 8 training complete

Cost on training data: 0.285860360373

Accuracy on training data: 9613 / 10000

Cost on evaluation data: 0.576646816484

Accuracy on evaluation data: 9169 / 10000

Epoch 9 training complete

Cost on training data: 0.272217656227

Accuracy on training data: 9638 / 10000

Cost on evaluation data: 0.571473720854

Accuracy on evaluation data: 9181 / 10000

Epoch 10 training complete

Cost on training data: 0.259208062952

Accuracy on training data: 9657 / 10000

Cost on evaluation data: 0.576816740297



Accuracy on evaluation data: 9168 / 10000

Epoch 11 training complete

Cost on training data: 0.239963036038

Accuracy on training data: 9689 / 10000

Cost on evaluation data: 0.570968886449

Accuracy on evaluation data: 9176 / 10000

Epoch 12 training complete

Cost on training data: 0.23889980342

Accuracy on training data: 9697 / 10000

Cost on evaluation data: 0.58143036904

Accuracy on evaluation data: 9161 / 10000

Epoch 13 training complete

Cost on training data: 0.209506072597

Accuracy on training data: 9752 / 10000

Cost on evaluation data: 0.574058011921

Accuracy on evaluation data: 9192 / 10000

Epoch 14 training complete

Cost on training data: 0.211233598

Accuracy on training data: 9751 / 10000

Cost on evaluation data: 0.594322307566

Accuracy on evaluation data: 9178 / 10000

Epoch 15 training complete

Cost on training data: 0.194570033817

Accuracy on training data: 9766 / 10000

Cost on evaluation data: 0.58674110229

Accuracy on evaluation data: 9206 / 10000

Epoch 16 training complete

Cost on training data: 0.185202283425

Accuracy on training data: 9779 / 10000

Cost on evaluation data: 0.585566044302

Accuracy on evaluation data: 9215 / 10000

Epoch 17 training complete

Cost on training data: 0.175175650317

Accuracy on training data: 9798 / 10000

Cost on evaluation data: 0.585715828758

Accuracy on evaluation data: 9205 / 10000

Epoch 18 training complete

Cost on training data: 0.172606846171

Accuracy on training data: 9801 / 10000

Cost on evaluation data: 0.603820204376

Accuracy on evaluation data: 9198 / 10000

Epoch 19 training complete

Cost on training data: 0.173402541659

Accuracy on training data: 9799 / 10000

Cost on evaluation data: 0.598955533679

Accuracy on evaluation data: 9174 / 10000

Epoch 20 training complete

Cost on training data: 0.154435006077

Accuracy on training data: 9830 / 10000

Cost on evaluation data: 0.601445410888

Accuracy on evaluation data: 9214 / 10000

Epoch 21 training complete

Cost on training data: 0.159912608052

Accuracy on training data: 9820 / 10000

Cost on evaluation data: 0.607559268023

Accuracy on evaluation data: 9195 / 10000

Epoch 22 training complete

Cost on training data: 0.14536232606

Accuracy on training data: 9823 / 10000

Cost on evaluation data: 0.603255755241

Accuracy on evaluation data: 9220 / 10000

Epoch 23 training complete

Cost on training data: 0.135960410076

Accuracy on training data: 9847 / 10000

Cost on evaluation data: 0.607616600438

Accuracy on evaluation data: 9219 / 10000

Epoch 24 training complete

Cost on training data: 0.137671172277

Accuracy on training data: 9859 / 10000

Cost on evaluation data: 0.630132321677

Accuracy on evaluation data: 9208 / 10000

Epoch 25 training complete

Cost on training data: 0.123891001162

Accuracy on training data: 9865 / 10000

Cost on evaluation data: 0.615772307776

Accuracy on evaluation data: 9217 / 10000

Epoch 26 training complete

Cost on training data: 0.126080389232

Accuracy on training data: 9863 / 10000

Cost on evaluation data: 0.626201557181

Accuracy on evaluation data: 9191 / 10000

Epoch 27 training complete

Cost on training data: 0.118177439126

Accuracy on training data: 9878 / 10000

Cost on evaluation data: 0.622774876214

Accuracy on evaluation data: 9216 / 10000

Epoch 28 training complete

Cost on training data: 0.121010866745

Accuracy on training data: 9876 / 10000

Cost on evaluation data: 0.631114027542

Accuracy on evaluation data: 9203 / 10000

Epoch 29 training complete

Cost on training data: 0.115319901278

Accuracy on training data: 9880 / 10000

Cost on evaluation data: 0.637464151551

Accuracy on evaluation data: 9202 / 10000

Epoch 30 training complete

Cost on training data: 0.108289328151

Accuracy on training data: 9884 / 10000

Cost on evaluation data: 0.637273073066

Accuracy on evaluation data: 9201 / 10000

Epoch 31 training complete

Cost on training data: 0.103264993696

Accuracy on training data: 9888 / 10000

Cost on evaluation data: 0.629101139246

Accuracy on evaluation data: 9225 / 10000

Epoch 32 training complete

Cost on training data: 0.10102542723

Accuracy on training data: 9892 / 10000

Cost on evaluation data: 0.637100861272

Accuracy on evaluation data: 9224 / 10000

Epoch 33 training complete

Cost on training data: 0.100782971259

Accuracy on training data: 9884 / 10000

Cost on evaluation data: 0.651794556456

Accuracy on evaluation data: 9208 / 10000

Epoch 34 training complete

Cost on training data: 0.1030261118

Accuracy on training data: 9893 / 10000

Cost on evaluation data: 0.654701136881

Accuracy on evaluation data: 9215 / 10000

Epoch 35 training complete

Cost on training data: 0.0961988721599

Accuracy on training data: 9900 / 10000

Cost on evaluation data: 0.66042835802

Accuracy on evaluation data: 9212 / 10000

Epoch 36 training complete

Cost on training data: 0.0899961796476

Accuracy on training data: 9903 / 10000

Cost on evaluation data: 0.658125728371

Accuracy on evaluation data: 9216 / 10000

Epoch 37 training complete

Cost on training data: 0.0929722763086

Accuracy on training data: 9901 / 10000

Cost on evaluation data: 0.670190576244

Accuracy on evaluation data: 9227 / 10000

Epoch 38 training complete

Cost on training data: 0.0883294209311

Accuracy on training data: 9906 / 10000

Cost on evaluation data: 0.670251707754

Accuracy on evaluation data: 9214 / 10000

Epoch 39 training complete

Cost on training data: 0.0877400679377

Accuracy on training data: 9905 / 10000

Cost on evaluation data: 0.671898444509

Accuracy on evaluation data: 9200 / 10000

Epoch 40 training complete

Cost on training data: 0.0844602078738

Accuracy on training data: 9917 / 10000

Cost on evaluation data: 0.670173279738

Accuracy on evaluation data: 9220 / 10000

Epoch 41 training complete

Cost on training data: 0.0800120886147

Accuracy on training data: 9912 / 10000

Cost on evaluation data: 0.683410002236

Accuracy on evaluation data: 9221 / 10000

Epoch 42 training complete

Cost on training data: 0.0798667297742

Accuracy on training data: 9916 / 10000

Cost on evaluation data: 0.686733312218

Accuracy on evaluation data: 9215 / 10000

Epoch 43 training complete

Cost on training data: 0.0752045439535

Accuracy on training data: 9922 / 10000

Cost on evaluation data: 0.678717693054

Accuracy on evaluation data: 9221 / 10000

Epoch 44 training complete

Cost on training data: 0.0820601574075

Accuracy on training data: 9910 / 10000

Cost on evaluation data: 0.679504166889

Accuracy on evaluation data: 9223 / 10000

Epoch 45 training complete

Cost on training data: 0.0724729920623

Accuracy on training data: 9927 / 10000

Cost on evaluation data: 0.687236710232

Accuracy on evaluation data: 9220 / 10000

Epoch 46 training complete

Cost on training data: 0.0739379432806

Accuracy on training data: 9924 / 10000

Cost on evaluation data: 0.693760475216

Accuracy on evaluation data: 9226 / 10000

Epoch 47 training complete

Cost on training data: 0.069371794003

Accuracy on training data: 9933 / 10000

Cost on evaluation data: 0.699177140667

Accuracy on evaluation data: 9208 / 10000

Epoch 48 training complete

Cost on training data: 0.0682355949293

Accuracy on training data: 9933 / 10000

Cost on evaluation data: 0.694851644949

Accuracy on evaluation data: 9224 / 10000

Epoch 49 training complete

Cost on training data: 0.067142173303

Accuracy on training data: 9936 / 10000

Cost on evaluation data: 0.709605949544

Accuracy on evaluation data: 9210 / 10000

Epoch 50 training complete

Cost on training data: 0.0629261989453

Accuracy on training data: 9939 / 10000

Cost on evaluation data: 0.705334768165

Accuracy on evaluation data: 9226 / 10000

Epoch 51 training complete

Cost on training data: 0.0705893867354

Accuracy on training data: 9931 / 10000

Cost on evaluation data: 0.71590241962

Accuracy on evaluation data: 9205 / 10000

Epoch 52 training complete

Cost on training data: 0.0617827772251

Accuracy on training data: 9934 / 10000

Cost on evaluation data: 0.71628822428

Accuracy on evaluation data: 9218 / 10000

Epoch 53 training complete

Cost on training data: 0.0618966523128

Accuracy on training data: 9935 / 10000

Cost on evaluation data: 0.717570457745

Accuracy on evaluation data: 9210 / 10000

Epoch 54 training complete

Cost on training data: 0.0589439379849

Accuracy on training data: 9939 / 10000

Cost on evaluation data: 0.720593595856

Accuracy on evaluation data: 9218 / 10000

Epoch 55 training complete

Cost on training data: 0.0598039097136

Accuracy on training data: 9938 / 10000

Cost on evaluation data: 0.719670555319

Accuracy on evaluation data: 9227 / 10000

Epoch 56 training complete

Cost on training data: 0.0564957022452

Accuracy on training data: 9947 / 10000

Cost on evaluation data: 0.719879357527

Accuracy on evaluation data: 9234 / 10000

Epoch 57 training complete

Cost on training data: 0.0550868819881

Accuracy on training data: 9947 / 10000

Cost on evaluation data: 0.726325539536

Accuracy on evaluation data: 9215 / 10000

Epoch 58 training complete

Cost on training data: 0.0551069437481

Accuracy on training data: 9946 / 10000

Cost on evaluation data: 0.7323236825

Accuracy on evaluation data: 9218 / 10000

Epoch 59 training complete

Cost on training data: 0.0535795604239

Accuracy on training data: 9950 / 10000

Cost on evaluation data: 0.738280068495

Accuracy on evaluation data: 9207 / 10000

Epoch 60 training complete

Cost on training data: 0.0522625025627

Accuracy on training data: 9946 / 10000

Cost on evaluation data: 0.731135567418

Accuracy on evaluation data: 9225 / 10000

Epoch 61 training complete

Cost on training data: 0.0508329338718

Accuracy on training data: 9951 / 10000

Cost on evaluation data: 0.735992317005

Accuracy on evaluation data: 9222 / 10000

Epoch 62 training complete

Cost on training data: 0.0494307719278

Accuracy on training data: 9948 / 10000

Cost on evaluation data: 0.741823931899

Accuracy on evaluation data: 9214 / 10000

Epoch 63 training complete

Cost on training data: 0.0500190348356

Accuracy on training data: 9949 / 10000

Cost on evaluation data: 0.747144701449

Accuracy on evaluation data: 9227 / 10000

Epoch 64 training complete

Cost on training data: 0.0512773936024

Accuracy on training data: 9953 / 10000

Cost on evaluation data: 0.758375455519

Accuracy on evaluation data: 9203 / 10000

Epoch 65 training complete

Cost on training data: 0.0478481812449

Accuracy on training data: 9955 / 10000

Cost on evaluation data: 0.750431568204

Accuracy on evaluation data: 9215 / 10000

Epoch 66 training complete

Cost on training data: 0.0472351425897

Accuracy on training data: 9954 / 10000

Cost on evaluation data: 0.756472596803

Accuracy on evaluation data: 9222 / 10000

Epoch 67 training complete

Cost on training data: 0.0458150426858

Accuracy on training data: 9954 / 10000

Cost on evaluation data: 0.759076777627

Accuracy on evaluation data: 9229 / 10000

Epoch 68 training complete

Cost on training data: 0.0465945324133

Accuracy on training data: 9962 / 10000

Cost on evaluation data: 0.761569551807

Accuracy on evaluation data: 9214 / 10000

Epoch 69 training complete

Cost on training data: 0.0452786139707

Accuracy on training data: 9962 / 10000

Cost on evaluation data: 0.763118146501

Accuracy on evaluation data: 9229 / 10000

Epoch 70 training complete

Cost on training data: 0.0453565153354

Accuracy on training data: 9956 / 10000

Cost on evaluation data: 0.76455341196

Accuracy on evaluation data: 9222 / 10000

Epoch 71 training complete

Cost on training data: 0.0440940471383

Accuracy on training data: 9960 / 10000

Cost on evaluation data: 0.768032283291

Accuracy on evaluation data: 9223 / 10000

Epoch 72 training complete

Cost on training data: 0.0424675502399

Accuracy on training data: 9961 / 10000

Cost on evaluation data: 0.771091822279

Accuracy on evaluation data: 9218 / 10000

Epoch 73 training complete

Cost on training data: 0.0432263267849

Accuracy on training data: 9963 / 10000

Cost on evaluation data: 0.776997372638

Accuracy on evaluation data: 9216 / 10000

Epoch 74 training complete

Cost on training data: 0.0421495749586

Accuracy on training data: 9963 / 10000

Cost on evaluation data: 0.785709136479



Accuracy on evaluation data: 9214 / 10000

Epoch 75 training complete

Cost on training data: 0.0424961572265

Accuracy on training data: 9966 / 10000

Cost on evaluation data: 0.779651912762

Accuracy on evaluation data: 9225 / 10000

Epoch 76 training complete

Cost on training data: 0.0415578310773

Accuracy on training data: 9964 / 10000

Cost on evaluation data: 0.788678444405

Accuracy on evaluation data: 9216 / 10000

Epoch 77 training complete

Cost on training data: 0.0401915117259

Accuracy on training data: 9965 / 10000

Cost on evaluation data: 0.789199503711

Accuracy on evaluation data: 9212 / 10000

Epoch 78 training complete

Cost on training data: 0.0398159364864

Accuracy on training data: 9969 / 10000

Cost on evaluation data: 0.785721528715

Accuracy on evaluation data: 9220 / 10000

Epoch 79 training complete

Cost on training data: 0.0390977286877

Accuracy on training data: 9967 / 10000

Cost on evaluation data: 0.798728037688

Accuracy on evaluation data: 9219 / 10000

Epoch 80 training complete

Cost on training data: 0.0381776513607

Accuracy on training data: 9970 / 10000

Cost on evaluation data: 0.794909821049

Accuracy on evaluation data: 9215 / 10000

Epoch 81 training complete

Cost on training data: 0.0381239141145

Accuracy on training data: 9968 / 10000

Cost on evaluation data: 0.791086003577

Accuracy on evaluation data: 9228 / 10000

Epoch 82 training complete

Cost on training data: 0.0380364869116

Accuracy on training data: 9970 / 10000

Cost on evaluation data: 0.801322934014

Accuracy on evaluation data: 9211 / 10000

Epoch 83 training complete

Cost on training data: 0.0377648328592

Accuracy on training data: 9971 / 10000

Cost on evaluation data: 0.805100009625

Accuracy on evaluation data: 9208 / 10000

Epoch 84 training complete

Cost on training data: 0.0362817626302

Accuracy on training data: 9970 / 10000

Cost on evaluation data: 0.80125678258

Accuracy on evaluation data: 9229 / 10000

Epoch 85 training complete

Cost on training data: 0.0371063250593

Accuracy on training data: 9967 / 10000

Cost on evaluation data: 0.81299944027

Accuracy on evaluation data: 9218 / 10000

Epoch 86 training complete

Cost on training data: 0.0367245610337

Accuracy on training data: 9969 / 10000

Cost on evaluation data: 0.806565680532

Accuracy on evaluation data: 9229 / 10000

Epoch 87 training complete

Cost on training data: 0.0364030020996

Accuracy on training data: 9971 / 10000

Cost on evaluation data: 0.811208129296

Accuracy on evaluation data: 9215 / 10000

Epoch 88 training complete

Cost on training data: 0.0350531136311

Accuracy on training data: 9971 / 10000

Cost on evaluation data: 0.817108494823

Accuracy on evaluation data: 9210 / 10000

Epoch 89 training complete

Cost on training data: 0.0349581466247

Accuracy on training data: 9972 / 10000

Cost on evaluation data: 0.818709704365

Accuracy on evaluation data: 9219 / 10000

Epoch 90 training complete

Cost on training data: 0.0350406603007

Accuracy on training data: 9975 / 10000

Cost on evaluation data: 0.829276567747

Accuracy on evaluation data: 9193 / 10000

Epoch 91 training complete

Cost on training data: 0.0333867954393

Accuracy on training data: 9973 / 10000

Cost on evaluation data: 0.824268462497

Accuracy on evaluation data: 9202 / 10000

Epoch 92 training complete

Cost on training data: 0.033135004466

Accuracy on training data: 9973 / 10000

Cost on evaluation data: 0.823740266887

Accuracy on evaluation data: 9209 / 10000

Epoch 93 training complete

Cost on training data: 0.0324232624279

Accuracy on training data: 9974 / 10000

Cost on evaluation data: 0.830128098453

Accuracy on evaluation data: 9210 / 10000

Epoch 94 training complete

Cost on training data: 0.0319661007346

Accuracy on training data: 9978 / 10000

Cost on evaluation data: 0.82888193501

Accuracy on evaluation data: 9210 / 10000

Epoch 95 training complete

Cost on training data: 0.0322813234134

Accuracy on training data: 9974 / 10000

Cost on evaluation data: 0.834771384601

Accuracy on evaluation data: 9205 / 10000

Epoch 96 training complete

Cost on training data: 0.0316140014586

Accuracy on training data: 9975 / 10000

Cost on evaluation data: 0.83419918211

Accuracy on evaluation data: 9212 / 10000

Epoch 97 training complete

Cost on training data: 0.0320255531909

Accuracy on training data: 9978 / 10000

Cost on evaluation data: 0.845850294968

Accuracy on evaluation data: 9206 / 10000

Epoch 98 training complete

Cost on training data: 0.0313710593554

Accuracy on training data: 9977 / 10000

Cost on evaluation data: 0.842512410362

Accuracy on evaluation data: 9200 / 10000

Epoch 99 training complete

Cost on training data: 0.0307296347838

Accuracy on training data: 9979 / 10000

Cost on evaluation data: 0.850544169164

Accuracy on evaluation data: 9201 / 10000

Epoch 100 training complete

Cost on training data: 0.0300213588033

Accuracy on training data: 9977 / 10000

Cost on evaluation data: 0.844566899719

Accuracy on evaluation data: 9206 / 10000

Epoch 101 training complete

Cost on training data: 0.0294891893282

Accuracy on training data: 9979 / 10000

Cost on evaluation data: 0.855557464035

Accuracy on evaluation data: 9195 / 10000

Epoch 102 training complete

Cost on training data: 0.0298215729426

Accuracy on training data: 9978 / 10000

Cost on evaluation data: 0.846420836782

Accuracy on evaluation data: 9203 / 10000

Epoch 103 training complete

Cost on training data: 0.028987710848

Accuracy on training data: 9981 / 10000

Cost on evaluation data: 0.850625247274

Accuracy on evaluation data: 9213 / 10000

Epoch 104 training complete

Cost on training data: 0.028810308359

Accuracy on training data: 9981 / 10000

Cost on evaluation data: 0.850631029419

Accuracy on evaluation data: 9199 / 10000

Epoch 105 training complete

Cost on training data: 0.0287547136238

Accuracy on training data: 9980 / 10000

Cost on evaluation data: 0.859509457452

Accuracy on evaluation data: 9199 / 10000

Epoch 106 training complete

Cost on training data: 0.0282063967202

Accuracy on training data: 9980 / 10000

Cost on evaluation data: 0.856714421086

Accuracy on evaluation data: 9202 / 10000

Epoch 107 training complete

Cost on training data: 0.0278047738511

Accuracy on training data: 9980 / 10000

Cost on evaluation data: 0.861633432968

Accuracy on evaluation data: 9201 / 10000

Epoch 108 training complete

Cost on training data: 0.0275895665411

Accuracy on training data: 9982 / 10000

Cost on evaluation data: 0.861005319221

Accuracy on evaluation data: 9204 / 10000

Epoch 109 training complete

Cost on training data: 0.0278110616505

Accuracy on training data: 9982 / 10000

Cost on evaluation data: 0.860680071668

Accuracy on evaluation data: 9215 / 10000

Epoch 110 training complete

Cost on training data: 0.0272229531342

Accuracy on training data: 9982 / 10000

Cost on evaluation data: 0.868495675875

Accuracy on evaluation data: 9195 / 10000

Epoch 111 training complete

Cost on training data: 0.0265306427906

Accuracy on training data: 9982 / 10000

Cost on evaluation data: 0.868057124344

Accuracy on evaluation data: 9203 / 10000

Epoch 112 training complete

Cost on training data: 0.0271731143477

Accuracy on training data: 9983 / 10000

Cost on evaluation data: 0.86413030061

Accuracy on evaluation data: 9207 / 10000

Epoch 113 training complete

Cost on training data: 0.0267057792013

Accuracy on training data: 9983 / 10000

Cost on evaluation data: 0.875396279655

Accuracy on evaluation data: 9196 / 10000

Epoch 114 training complete

Cost on training data: 0.0258102429159

Accuracy on training data: 9983 / 10000

Cost on evaluation data: 0.877082557858

Accuracy on evaluation data: 9204 / 10000

Epoch 115 training complete

Cost on training data: 0.0257282239443

Accuracy on training data: 9981 / 10000

Cost on evaluation data: 0.870728459158

Accuracy on evaluation data: 9203 / 10000

Epoch 116 training complete

Cost on training data: 0.0262162729495

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.879541342508

Accuracy on evaluation data: 9204 / 10000

Epoch 117 training complete

Cost on training data: 0.026416287837

Accuracy on training data: 9981 / 10000

Cost on evaluation data: 0.870357391611

Accuracy on evaluation data: 9207 / 10000

Epoch 118 training complete

Cost on training data: 0.025059260628

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.878541686819

Accuracy on evaluation data: 9209 / 10000

Epoch 119 training complete

Cost on training data: 0.0247581306878

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.882578439492

Accuracy on evaluation data: 9201 / 10000

Epoch 120 training complete

Cost on training data: 0.0246202775022

Accuracy on training data: 9983 / 10000

Cost on evaluation data: 0.887619208069

Accuracy on evaluation data: 9204 / 10000

Epoch 121 training complete

Cost on training data: 0.0244209966857

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.886878930915

Accuracy on evaluation data: 9206 / 10000

Epoch 122 training complete

Cost on training data: 0.0244573368334

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.88698755182

Accuracy on evaluation data: 9212 / 10000

Epoch 123 training complete

Cost on training data: 0.0243157317388

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.887627774807

Accuracy on evaluation data: 9205 / 10000

Epoch 124 training complete

Cost on training data: 0.0240911780951

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.893466123061

Accuracy on evaluation data: 9196 / 10000

Epoch 125 training complete

Cost on training data: 0.0242735576604

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.898320654688

Accuracy on evaluation data: 9190 / 10000

Epoch 126 training complete

Cost on training data: 0.0230517390069

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.894404379391

Accuracy on evaluation data: 9204 / 10000

Epoch 127 training complete

Cost on training data: 0.0239460750991

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.898825407437

Accuracy on evaluation data: 9212 / 10000

Epoch 128 training complete

Cost on training data: 0.0231843944566

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.895035903458

Accuracy on evaluation data: 9210 / 10000

Epoch 129 training complete

Cost on training data: 0.0229826249803

Accuracy on training data: 9983 / 10000

Cost on evaluation data: 0.898974390812

Accuracy on evaluation data: 9209 / 10000

Epoch 130 training complete

Cost on training data: 0.022546745256

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.902932502197

Accuracy on evaluation data: 9212 / 10000

Epoch 131 training complete

Cost on training data: 0.0227460087956

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.899187992857

Accuracy on evaluation data: 9212 / 10000

Epoch 132 training complete

Cost on training data: 0.0224056998591

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.90599799206

Accuracy on evaluation data: 9212 / 10000

Epoch 133 training complete

Cost on training data: 0.0222769981919

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.902205304401

Accuracy on evaluation data: 9212 / 10000

Epoch 134 training complete

Cost on training data: 0.0219584980714

Accuracy on training data: 9986 / 10000

Cost on evaluation data: 0.904575038954

Accuracy on evaluation data: 9211 / 10000

Epoch 135 training complete

Cost on training data: 0.0220374499851

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.906759251746

Accuracy on evaluation data: 9215 / 10000

Epoch 136 training complete

Cost on training data: 0.0219292575207

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.911852859146

Accuracy on evaluation data: 9212 / 10000

Epoch 137 training complete

Cost on training data: 0.0220419834058

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.912666690924

Accuracy on evaluation data: 9210 / 10000

Epoch 138 training complete

Cost on training data: 0.0213382900038

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.909397577254



Accuracy on evaluation data: 9216 / 10000

Epoch 139 training complete

Cost on training data: 0.0220058629191

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.918421578938

Accuracy on evaluation data: 9209 / 10000

Epoch 140 training complete

Cost on training data: 0.0211823607998

Accuracy on training data: 9987 / 10000

Cost on evaluation data: 0.913205669848

Accuracy on evaluation data: 9216 / 10000

Epoch 141 training complete

Cost on training data: 0.0210342069175

Accuracy on training data: 9983 / 10000

Cost on evaluation data: 0.913789357904

Accuracy on evaluation data: 9210 / 10000

Epoch 142 training complete

Cost on training data: 0.020882727867

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.916945287468

Accuracy on evaluation data: 9226 / 10000

Epoch 143 training complete

Cost on training data: 0.0213331019401

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.922612654457

Accuracy on evaluation data: 9208 / 10000

Epoch 144 training complete

Cost on training data: 0.0204883669831

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.919799093182

Accuracy on evaluation data: 9214 / 10000

Epoch 145 training complete

Cost on training data: 0.0203048404013

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.920861307497

Accuracy on evaluation data: 9222 / 10000

Epoch 146 training complete

Cost on training data: 0.0203175059171

Accuracy on training data: 9984 / 10000

Cost on evaluation data: 0.920983505105

Accuracy on evaluation data: 9211 / 10000

Epoch 147 training complete

Cost on training data: 0.0203477664773

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.926968294442

Accuracy on evaluation data: 9211 / 10000

Epoch 148 training complete

Cost on training data: 0.0206214591824

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.921005991433

Accuracy on evaluation data: 9220 / 10000

Epoch 149 training complete

Cost on training data: 0.0198472036676

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.92708910322

Accuracy on evaluation data: 9212 / 10000

Epoch 150 training complete

Cost on training data: 0.0198745031653

Accuracy on training data: 9985 / 10000

Cost on evaluation data: 0.92364728654

Accuracy on evaluation data: 9216 / 10000

Epoch 151 training complete

Cost on training data: 0.0204751749361

Accuracy on training data: 9986 / 10000

Cost on evaluation data: 0.933471007147

Accuracy on evaluation data: 9215 / 10000

Epoch 152 training complete

Cost on training data: 0.0193847821856

Accuracy on training data: 9987 / 10000

Cost on evaluation data: 0.92914453681

Accuracy on evaluation data: 9218 / 10000

Epoch 153 training complete

Cost on training data: 0.0192524160011

Accuracy on training data: 9988 / 10000

Cost on evaluation data: 0.933037407199

Accuracy on evaluation data: 9213 / 10000

Epoch 154 training complete

Cost on training data: 0.0192066295983

Accuracy on training data: 9987 / 10000

Cost on evaluation data: 0.930086794214

Accuracy on evaluation data: 9214 / 10000

Epoch 155 training complete

Cost on training data: 0.0191430230913

Accuracy on training data: 9987 / 10000

Cost on evaluation data: 0.933753810336

Accuracy on evaluation data: 9218 / 10000

Epoch 156 training complete

Cost on training data: 0.0188247223292

Accuracy on training data: 9986 / 10000

Cost on evaluation data: 0.933565759364

Accuracy on evaluation data: 9211 / 10000

Epoch 157 training complete

Cost on training data: 0.0187963001535

Accuracy on training data: 9987 / 10000

Cost on evaluation data: 0.93594236599

Accuracy on evaluation data: 9217 / 10000

Epoch 158 training complete

Cost on training data: 0.0187073199313

Accuracy on training data: 9987 / 10000

Cost on evaluation data: 0.936182949798

Accuracy on evaluation data: 9215 / 10000

Epoch 159 training complete

Cost on training data: 0.0185493878147

Accuracy on training data: 9988 / 10000

Cost on evaluation data: 0.942755630178

Accuracy on evaluation data: 9206 / 10000

Epoch 160 training complete

Cost on training data: 0.0187498633084

Accuracy on training data: 9987 / 10000

Cost on evaluation data: 0.938568967904

Accuracy on evaluation data: 9212 / 10000

Epoch 161 training complete

Cost on training data: 0.0187348545883

Accuracy on training data: 9986 / 10000

```
network2.py:54: RuntimeWarning: divide by zero encountered in log
  return np.sum(np.nan_to_num(-y*np.log(a)-(1-y)*np.log(1-a)))
network2.py:54: RuntimeWarning: invalid value encountered in multiply
  return np.sum(np.nan_to_num(-y*np.log(a)-(1-y)*np.log(1-a)))
```

Cost on evaluation data: 0.944693927311  
Accuracy on evaluation data: 9225 / 10000

Epoch 162 training complete  
Cost on training data: 0.0182534525961  
Accuracy on training data: 9988 / 10000  
Cost on evaluation data: 0.942168660857  
Accuracy on evaluation data: 9210 / 10000

Epoch 163 training complete  
Cost on training data: 0.0181933175353  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.940060432767  
Accuracy on evaluation data: 9205 / 10000

Epoch 164 training complete  
Cost on training data: 0.0178871336571  
Accuracy on training data: 9987 / 10000  
Cost on evaluation data: 0.948063707707  
Accuracy on evaluation data: 9211 / 10000

Epoch 165 training complete  
Cost on training data: 0.018034866842  
Accuracy on training data: 9987 / 10000  
Cost on evaluation data: 0.950971874073  
Accuracy on evaluation data: 9210 / 10000

Epoch 166 training complete  
Cost on training data: 0.0174949802018  
Accuracy on training data: 9987 / 10000  
Cost on evaluation data: 0.947178472766  
Accuracy on evaluation data: 9213 / 10000

Epoch 167 training complete  
Cost on training data: 0.0175280570698  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.945038248078  
Accuracy on evaluation data: 9202 / 10000

Epoch 168 training complete  
Cost on training data: 0.017367982305  
Accuracy on training data: 9988 / 10000  
Cost on evaluation data: 0.950512616234  
Accuracy on evaluation data: 9214 / 10000

Epoch 169 training complete  
Cost on training data: 0.017371131102  
Accuracy on training data: 9987 / 10000

Cost on evaluation data: 0.94991506412  
Accuracy on evaluation data: 9208 / 10000

Epoch 170 training complete  
Cost on training data: 0.0173513016462  
Accuracy on training data: 9987 / 10000  
Cost on evaluation data: 0.952959790374  
Accuracy on evaluation data: 9208 / 10000

Epoch 171 training complete  
Cost on training data: 0.017203127617  
Accuracy on training data: 9987 / 10000  
Cost on evaluation data: 0.959032255237  
Accuracy on evaluation data: 9211 / 10000

Epoch 172 training complete  
Cost on training data: 0.0168589356353  
Accuracy on training data: 9988 / 10000  
Cost on evaluation data: 0.954493809482  
Accuracy on evaluation data: 9215 / 10000

Epoch 173 training complete  
Cost on training data: 0.0168992794268  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.953384134447  
Accuracy on evaluation data: 9210 / 10000

Epoch 174 training complete  
Cost on training data: 0.016734297081  
Accuracy on training data: 9988 / 10000  
Cost on evaluation data: 0.959550216931  
Accuracy on evaluation data: 9215 / 10000

Epoch 175 training complete  
Cost on training data: 0.0168030859252  
Accuracy on training data: 9987 / 10000  
Cost on evaluation data: 0.955880512653  
Accuracy on evaluation data: 9209 / 10000

Epoch 176 training complete  
Cost on training data: 0.0166411775398  
Accuracy on training data: 9987 / 10000  
Cost on evaluation data: 0.959259525258  
Accuracy on evaluation data: 9218 / 10000

Epoch 177 training complete  
Cost on training data: 0.0164866488541  
Accuracy on training data: 9988 / 10000

Cost on evaluation data: 0.960520589347  
Accuracy on evaluation data: 9210 / 10000

Epoch 178 training complete  
Cost on training data: 0.0163277595494  
Accuracy on training data: 9988 / 10000  
Cost on evaluation data: 0.960604132142  
Accuracy on evaluation data: 9215 / 10000

Epoch 179 training complete  
Cost on training data: 0.0163266674675  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 0.96011843255  
Accuracy on evaluation data: 9210 / 10000

Epoch 180 training complete  
Cost on training data: 0.0161073258655  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.962585891139  
Accuracy on evaluation data: 9208 / 10000

Epoch 181 training complete  
Cost on training data: 0.0160191523685  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.961747139303  
Accuracy on evaluation data: 9210 / 10000

Epoch 182 training complete  
Cost on training data: 0.0159390604282  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 0.964420632506  
Accuracy on evaluation data: 9214 / 10000

Epoch 183 training complete  
Cost on training data: 0.0160551389122  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.967787246088  
Accuracy on evaluation data: 9217 / 10000

Epoch 184 training complete  
Cost on training data: 0.0158649846474  
Accuracy on training data: 9988 / 10000  
Cost on evaluation data: 0.967327127284  
Accuracy on evaluation data: 9208 / 10000

Epoch 185 training complete  
Cost on training data: 0.0158419086014  
Accuracy on training data: 9988 / 10000

Cost on evaluation data: 0.972435728371  
Accuracy on evaluation data: 9204 / 10000

Epoch 186 training complete  
Cost on training data: 0.0157341457213  
Accuracy on training data: 9988 / 10000  
Cost on evaluation data: 0.972571552146  
Accuracy on evaluation data: 9217 / 10000

Epoch 187 training complete  
Cost on training data: 0.0157130517912  
Accuracy on training data: 9987 / 10000  
Cost on evaluation data: 0.97616595108  
Accuracy on evaluation data: 9220 / 10000

Epoch 188 training complete  
Cost on training data: 0.0154929427579  
Accuracy on training data: 9988 / 10000  
Cost on evaluation data: 0.976830494215  
Accuracy on evaluation data: 9223 / 10000

Epoch 189 training complete  
Cost on training data: 0.0153454331813  
Accuracy on training data: 9988 / 10000  
Cost on evaluation data: 0.974517450801  
Accuracy on evaluation data: 9217 / 10000

Epoch 190 training complete  
Cost on training data: 0.0780347858698  
Accuracy on training data: 9938 / 10000  
Cost on evaluation data: 1.06845361224  
Accuracy on evaluation data: 9157 / 10000

Epoch 191 training complete  
Cost on training data: 0.0549398185207  
Accuracy on training data: 9958 / 10000  
Cost on evaluation data: 1.04335388794  
Accuracy on evaluation data: 9140 / 10000

Epoch 192 training complete  
Cost on training data: 0.0509774888683  
Accuracy on training data: 9960 / 10000  
Cost on evaluation data: 1.01575948048  
Accuracy on evaluation data: 9153 / 10000

Epoch 193 training complete  
Cost on training data: 0.0170547076303  
Accuracy on training data: 9989 / 10000

Cost on evaluation data: 0.9748280385  
Accuracy on evaluation data: 9202 / 10000

Epoch 194 training complete  
Cost on training data: 0.0161114139201  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.971845184714  
Accuracy on evaluation data: 9215 / 10000

Epoch 195 training complete  
Cost on training data: 0.0157486855767  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.975816320127  
Accuracy on evaluation data: 9200 / 10000

Epoch 196 training complete  
Cost on training data: 0.0159535155787  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 0.976055767664  
Accuracy on evaluation data: 9207 / 10000

Epoch 197 training complete  
Cost on training data: 0.0155520456721  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 0.977768874667  
Accuracy on evaluation data: 9204 / 10000

Epoch 198 training complete  
Cost on training data: 0.0151738534078  
Accuracy on training data: 9991 / 10000  
Cost on evaluation data: 0.97688267416  
Accuracy on evaluation data: 9201 / 10000

Epoch 199 training complete  
Cost on training data: 0.0149942255923  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 0.982232795606  
Accuracy on evaluation data: 9209 / 10000

Epoch 200 training complete  
Cost on training data: 0.0148145571019  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 0.977902332951  
Accuracy on evaluation data: 9208 / 10000

Epoch 201 training complete  
Cost on training data: 0.0147049107998  
Accuracy on training data: 9990 / 10000



Cost on evaluation data: 0.980155198616  
Accuracy on evaluation data: 9205 / 10000

Epoch 202 training complete  
Cost on training data: 0.0145874083695  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.979883496124  
Accuracy on evaluation data: 9205 / 10000

Epoch 203 training complete  
Cost on training data: 0.0146640831557  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.988065467915  
Accuracy on evaluation data: 9206 / 10000

Epoch 204 training complete  
Cost on training data: 0.0144243531496  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.986998804689  
Accuracy on evaluation data: 9207 / 10000

Epoch 205 training complete  
Cost on training data: 0.0146783432012  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.982956376221  
Accuracy on evaluation data: 9207 / 10000

Epoch 206 training complete  
Cost on training data: 0.0143938552515  
Accuracy on training data: 9988 / 10000  
Cost on evaluation data: 0.98093718487  
Accuracy on evaluation data: 9210 / 10000

Epoch 207 training complete  
Cost on training data: 0.0144323804511  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 0.992827287808  
Accuracy on evaluation data: 9214 / 10000

Epoch 208 training complete  
Cost on training data: 0.0140503893538  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.986790586514  
Accuracy on evaluation data: 9215 / 10000

Epoch 209 training complete  
Cost on training data: 0.0138991028148  
Accuracy on training data: 9991 / 10000

Cost on evaluation data: 0.990999971885  
Accuracy on evaluation data: 9207 / 10000

Epoch 210 training complete  
Cost on training data: 0.0140372075396  
Accuracy on training data: 9989 / 10000  
Cost on evaluation data: 0.991087235487  
Accuracy on evaluation data: 9201 / 10000

Epoch 211 training complete  
Cost on training data: 0.0139186753128  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 0.994909552588  
Accuracy on evaluation data: 9208 / 10000

Epoch 212 training complete  
Cost on training data: 0.0138054583103  
Accuracy on training data: 9992 / 10000  
Cost on evaluation data: 0.989995374395  
Accuracy on evaluation data: 9201 / 10000

Epoch 213 training complete  
Cost on training data: 0.0136261679532  
Accuracy on training data: 9992 / 10000  
Cost on evaluation data: 0.9966314721  
Accuracy on evaluation data: 9208 / 10000

Epoch 214 training complete  
Cost on training data: 0.0135126416738  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 0.995480527898  
Accuracy on evaluation data: 9209 / 10000

Epoch 215 training complete  
Cost on training data: 0.0136267793216  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 0.996496307322  
Accuracy on evaluation data: 9211 / 10000

Epoch 216 training complete  
Cost on training data: 0.0135594307524  
Accuracy on training data: 9991 / 10000  
Cost on evaluation data: 0.993295501294  
Accuracy on evaluation data: 9212 / 10000

Epoch 217 training complete  
Cost on training data: 0.0134665620623  
Accuracy on training data: 9990 / 10000

Cost on evaluation data: 0.998428149203  
Accuracy on evaluation data: 9211 / 10000

Epoch 218 training complete  
Cost on training data: 0.0134832712637  
Accuracy on training data: 9991 / 10000  
Cost on evaluation data: 1.00112840224  
Accuracy on evaluation data: 9205 / 10000

Epoch 219 training complete  
Cost on training data: 0.0134495729786  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 1.00013213703  
Accuracy on evaluation data: 9209 / 10000

Epoch 220 training complete  
Cost on training data: 0.0141105424518  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 1.00792357864  
Accuracy on evaluation data: 9193 / 10000

Epoch 221 training complete  
Cost on training data: 0.013159947885  
Accuracy on training data: 9991 / 10000  
Cost on evaluation data: 0.998304252875  
Accuracy on evaluation data: 9206 / 10000

Epoch 222 training complete  
Cost on training data: 0.0130439791078  
Accuracy on training data: 9992 / 10000  
Cost on evaluation data: 1.00566910874  
Accuracy on evaluation data: 9211 / 10000

Epoch 223 training complete  
Cost on training data: 0.0130475296334  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 1.0037356352  
Accuracy on evaluation data: 9203 / 10000

Epoch 224 training complete  
Cost on training data: 0.013317980371  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 1.00392944147  
Accuracy on evaluation data: 9215 / 10000

Epoch 225 training complete  
Cost on training data: 0.0130462824593  
Accuracy on training data: 9991 / 10000

Cost on evaluation data: 1.00592089809  
Accuracy on evaluation data: 9204 / 10000

Epoch 226 training complete  
Cost on training data: 0.0128023902191  
Accuracy on training data: 9991 / 10000  
Cost on evaluation data: 1.00700323998  
Accuracy on evaluation data: 9203 / 10000

Epoch 227 training complete  
Cost on training data: 0.0128498506486  
Accuracy on training data: 9991 / 10000  
Cost on evaluation data: 1.00847448979  
Accuracy on evaluation data: 9208 / 10000

Epoch 228 training complete  
Cost on training data: 0.0130611384218  
Accuracy on training data: 9992 / 10000  
Cost on evaluation data: 1.00932387872  
Accuracy on evaluation data: 9206 / 10000

Epoch 229 training complete  
Cost on training data: 0.0131241381322  
Accuracy on training data: 9990 / 10000  
Cost on evaluation data: 1.00822924649  
Accuracy on evaluation data: 9210 / 10000

Epoch 230 training complete  
Cost on training data: 0.0130070074801  
Accuracy on training data: 9993 / 10000  
Cost on evaluation data: 1.01241121303  
Accuracy on evaluation data: 9202 / 10000

Epoch 231 training complete  
Cost on training data: 0.0127621725689  
Accuracy on training data: 9992 / 10000  
Cost on evaluation data: 1.01141031378  
Accuracy on evaluation data: 9209 / 10000

Epoch 232 training complete  
Cost on training data: 0.0130840470534  
Accuracy on training data: 9992 / 10000  
Cost on evaluation data: 1.01938250262  
Accuracy on evaluation data: 9204 / 10000

Epoch 233 training complete  
Cost on training data: 0.0125336213993  
Accuracy on training data: 9992 / 10000

Cost on evaluation data: 1.0119041829  
Accuracy on evaluation data: 9202 / 10000

Epoch 234 training complete  
Cost on training data: 0.0124874808725  
Accuracy on training data: 9991 / 10000  
Cost on evaluation data: 1.01637024214  
Accuracy on evaluation data: 9201 / 10000

Epoch 235 training complete  
Cost on training data: 0.0126297365285  
Accuracy on training data: 9991 / 10000  
Cost on evaluation data: 1.02021966105  
Accuracy on evaluation data: 9200 / 10000

Epoch 236 training complete  
Cost on training data: 0.0123981538213  
Accuracy on training data: 9993 / 10000  
Cost on evaluation data: 1.017393978  
Accuracy on evaluation data: 9200 / 10000

Epoch 237 training complete  
Cost on training data: 0.0125107232137  
Accuracy on training data: 9992 / 10000  
Cost on evaluation data: 1.02040444562  
Accuracy on evaluation data: 9204 / 10000

Epoch 238 training complete  
Cost on training data: 0.0123419023352  
Accuracy on training data: 9992 / 10000  
Cost on evaluation data: 1.01992335857  
Accuracy on evaluation data: 9204 / 10000

Epoch 239 training complete  
Cost on training data: 0.012162673107  
Accuracy on training data: 9992 / 10000  
Cost on evaluation data: 1.02003966597  
Accuracy on evaluation data: 9198 / 10000

Epoch 240 training complete  
Cost on training data: 0.0120707732884  
Accuracy on training data: 9993 / 10000  
Cost on evaluation data: 1.02388267078  
Accuracy on evaluation data: 9199 / 10000

Epoch 241 training complete  
Cost on training data: 0.0124021121348  
Accuracy on training data: 9993 / 10000

Cost on evaluation data: 1.02218144947  
Accuracy on evaluation data: 9190 / 10000

Epoch 242 training complete  
Cost on training data: 0.0131312769037  
Accuracy on training data: 9991 / 10000  
Cost on evaluation data: 1.03105907317  
Accuracy on evaluation data: 9187 / 10000

Epoch 243 training complete  
Cost on training data: 0.0121634662424  
Accuracy on training data: 9993 / 10000  
Cost on evaluation data: 1.02587555559  
Accuracy on evaluation data: 9199 / 10000

Epoch 244 training complete  
Cost on training data: 0.0118854741826  
Accuracy on training data: 9992 / 10000  
Cost on evaluation data: 1.02373115287  
Accuracy on evaluation data: 9196 / 10000

Epoch 245 training complete  
Cost on training data: 0.0116780362259  
Accuracy on training data: 9993 / 10000  
Cost on evaluation data: 1.03039863196  
Accuracy on evaluation data: 9196 / 10000

Epoch 246 training complete  
Cost on training data: 0.0116421306245  
Accuracy on training data: 9992 / 10000  
Cost on evaluation data: 1.02644300283  
Accuracy on evaluation data: 9194 / 10000

Epoch 247 training complete  
Cost on training data: 0.0115327977677  
Accuracy on training data: 9992 / 10000  
Cost on evaluation data: 1.03000126212  
Accuracy on evaluation data: 9196 / 10000

Epoch 248 training complete  
Cost on training data: 0.0116444804773  
Accuracy on training data: 9991 / 10000  
Cost on evaluation data: 1.02844688565  
Accuracy on evaluation data: 9196 / 10000

Epoch 249 training complete  
Cost on training data: 0.0114170600266  
Accuracy on training data: 9991 / 10000

Cost on evaluation data: 1.0280386844  
Accuracy on evaluation data: 9194 / 10000

Epoch 250 training complete  
Cost on training data: 0.0111736797274  
Accuracy on training data: 9994 / 10000  
Cost on evaluation data: 1.03010058541  
Accuracy on evaluation data: 9189 / 10000

Epoch 251 training complete  
Cost on training data: 0.0109857990008  
Accuracy on training data: 9994 / 10000  
Cost on evaluation data: 1.0332407613  
Accuracy on evaluation data: 9189 / 10000

Epoch 252 training complete  
Cost on training data: 0.0112919235428  
Accuracy on training data: 9994 / 10000  
Cost on evaluation data: 1.04476721841  
Accuracy on evaluation data: 9193 / 10000

Epoch 253 training complete  
Cost on training data: 0.0107638679344  
Accuracy on training data: 9994 / 10000  
Cost on evaluation data: 1.03785869916  
Accuracy on evaluation data: 9184 / 10000

Epoch 254 training complete  
Cost on training data: 0.010613016416  
Accuracy on training data: 9994 / 10000  
Cost on evaluation data: 1.03552872556  
Accuracy on evaluation data: 9183 / 10000

Epoch 255 training complete  
Cost on training data: 0.010462110529  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.03979895249  
Accuracy on evaluation data: 9182 / 10000

Epoch 256 training complete  
Cost on training data: 0.0104354651088  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.03905369845  
Accuracy on evaluation data: 9193 / 10000

Epoch 257 training complete  
Cost on training data: 0.0104268919118  
Accuracy on training data: 9996 / 10000

Cost on evaluation data: 1.04290533997  
Accuracy on evaluation data: 9188 / 10000

Epoch 258 training complete  
Cost on training data: 0.0105161820324  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.03977630505  
Accuracy on evaluation data: 9187 / 10000

Epoch 259 training complete  
Cost on training data: 0.0103092025876  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.0417877186  
Accuracy on evaluation data: 9185 / 10000

Epoch 260 training complete  
Cost on training data: 0.010136506615  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.04614268251  
Accuracy on evaluation data: 9177 / 10000

Epoch 261 training complete  
Cost on training data: 0.0100776634025  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.04771688745  
Accuracy on evaluation data: 9184 / 10000

Epoch 262 training complete  
Cost on training data: 0.0102424662886  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.04999717636  
Accuracy on evaluation data: 9180 / 10000

Epoch 263 training complete  
Cost on training data: 0.0100356155294  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.04782414553  
Accuracy on evaluation data: 9187 / 10000

Epoch 264 training complete  
Cost on training data: 0.00996008969079  
Accuracy on training data: 9994 / 10000  
Cost on evaluation data: 1.04622438908  
Accuracy on evaluation data: 9189 / 10000

Epoch 265 training complete  
Cost on training data: 0.0100323561392  
Accuracy on training data: 9996 / 10000



Cost on evaluation data: 1.05633208143  
Accuracy on evaluation data: 9179 / 10000

Epoch 266 training complete  
Cost on training data: 0.00983123809272  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.05334332352  
Accuracy on evaluation data: 9183 / 10000

Epoch 267 training complete  
Cost on training data: 0.00973877307779  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.04937853433  
Accuracy on evaluation data: 9184 / 10000

Epoch 268 training complete  
Cost on training data: 0.00965960164709  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.05153687527  
Accuracy on evaluation data: 9179 / 10000

Epoch 269 training complete  
Cost on training data: 0.00974107114271  
Accuracy on training data: 9994 / 10000  
Cost on evaluation data: 1.05493264313  
Accuracy on evaluation data: 9179 / 10000

Epoch 270 training complete  
Cost on training data: 0.00966333322455  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.05445192454  
Accuracy on evaluation data: 9185 / 10000

Epoch 271 training complete  
Cost on training data: 0.00952353781551  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.05666436499  
Accuracy on evaluation data: 9177 / 10000

Epoch 272 training complete  
Cost on training data: 0.00975608393133  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.06066743839  
Accuracy on evaluation data: 9176 / 10000

Epoch 273 training complete  
Cost on training data: 0.00975932991426  
Accuracy on training data: 9996 / 10000

Cost on evaluation data: 1.0644078394  
Accuracy on evaluation data: 9184 / 10000

Epoch 274 training complete  
Cost on training data: 0.00954463054916  
Accuracy on training data: 9994 / 10000  
Cost on evaluation data: 1.0616294759  
Accuracy on evaluation data: 9177 / 10000

Epoch 275 training complete  
Cost on training data: 0.00949477062087  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.05771116739  
Accuracy on evaluation data: 9183 / 10000

Epoch 276 training complete  
Cost on training data: 0.00936787007525  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.06142487257  
Accuracy on evaluation data: 9175 / 10000

Epoch 277 training complete  
Cost on training data: 0.0093309731193  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.06225617354  
Accuracy on evaluation data: 9180 / 10000

Epoch 278 training complete  
Cost on training data: 0.00958486773053  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.06280008384  
Accuracy on evaluation data: 9171 / 10000

Epoch 279 training complete  
Cost on training data: 0.00926887558198  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.06587782841  
Accuracy on evaluation data: 9180 / 10000

Epoch 280 training complete  
Cost on training data: 0.00922957077443  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.06467793581  
Accuracy on evaluation data: 9175 / 10000

Epoch 281 training complete  
Cost on training data: 0.00918833704749  
Accuracy on training data: 9996 / 10000

Cost on evaluation data: 1.06780225854  
Accuracy on evaluation data: 9179 / 10000

Epoch 282 training complete  
Cost on training data: 0.00925056681787  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.06529884617  
Accuracy on evaluation data: 9176 / 10000

Epoch 283 training complete  
Cost on training data: 0.00921852950571  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.06792972712  
Accuracy on evaluation data: 9183 / 10000

Epoch 284 training complete  
Cost on training data: 0.00913553520738  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.06844242448  
Accuracy on evaluation data: 9183 / 10000

Epoch 285 training complete  
Cost on training data: 0.00898336077119  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.06909117959  
Accuracy on evaluation data: 9179 / 10000

Epoch 286 training complete  
Cost on training data: 0.00899479012713  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.07096743138  
Accuracy on evaluation data: 9176 / 10000

Epoch 287 training complete  
Cost on training data: 0.00898721032491  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.07024135181  
Accuracy on evaluation data: 9177 / 10000

Epoch 288 training complete  
Cost on training data: 0.00915227544629  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.07273471865  
Accuracy on evaluation data: 9177 / 10000

Epoch 289 training complete  
Cost on training data: 0.00886303126984  
Accuracy on training data: 9996 / 10000

Cost on evaluation data: 1.07063890776  
Accuracy on evaluation data: 9181 / 10000

Epoch 290 training complete  
Cost on training data: 0.00877527557263  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.07470209753  
Accuracy on evaluation data: 9175 / 10000

Epoch 291 training complete  
Cost on training data: 0.00884373530636  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.07663479034  
Accuracy on evaluation data: 9171 / 10000

Epoch 292 training complete  
Cost on training data: 0.00880463850212  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.076971949  
Accuracy on evaluation data: 9177 / 10000

Epoch 293 training complete  
Cost on training data: 0.00908968312809  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.0757001828  
Accuracy on evaluation data: 9179 / 10000

Epoch 294 training complete  
Cost on training data: 0.00875647180551  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.07716053341  
Accuracy on evaluation data: 9185 / 10000

Epoch 295 training complete  
Cost on training data: 0.00869728586352  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.07908744998  
Accuracy on evaluation data: 9173 / 10000

Epoch 296 training complete  
Cost on training data: 0.00853859645558  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.07885208038  
Accuracy on evaluation data: 9183 / 10000

Epoch 297 training complete  
Cost on training data: 0.00869591943913  
Accuracy on training data: 9995 / 10000

Cost on evaluation data: 1.08173097841  
Accuracy on evaluation data: 9183 / 10000

Epoch 298 training complete  
Cost on training data: 0.00885069489307  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.08089715522  
Accuracy on evaluation data: 9173 / 10000

Epoch 299 training complete  
Cost on training data: 0.00874996311675  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.08364877821  
Accuracy on evaluation data: 9179 / 10000

Epoch 300 training complete  
Cost on training data: 0.00867521506776  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.08540767021  
Accuracy on evaluation data: 9181 / 10000

Epoch 301 training complete  
Cost on training data: 0.00859361597226  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.08316770578  
Accuracy on evaluation data: 9175 / 10000

Epoch 302 training complete  
Cost on training data: 0.00856386234362  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.08407899073  
Accuracy on evaluation data: 9180 / 10000

Epoch 303 training complete  
Cost on training data: 0.00839364440749  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.0851707754  
Accuracy on evaluation data: 9179 / 10000

Epoch 304 training complete  
Cost on training data: 0.00843742608443  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.08598358444  
Accuracy on evaluation data: 9174 / 10000

Epoch 305 training complete  
Cost on training data: 0.00839266736138  
Accuracy on training data: 9997 / 10000

Cost on evaluation data: 1.089336366  
Accuracy on evaluation data: 9177 / 10000

Epoch 306 training complete  
Cost on training data: 0.00829212266527  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.08785104408  
Accuracy on evaluation data: 9175 / 10000

Epoch 307 training complete  
Cost on training data: 0.00830708766179  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.08965316071  
Accuracy on evaluation data: 9172 / 10000

Epoch 308 training complete  
Cost on training data: 0.00848903347461  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.09261391425  
Accuracy on evaluation data: 9174 / 10000

Epoch 309 training complete  
Cost on training data: 0.00827894023081  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.08714435166  
Accuracy on evaluation data: 9178 / 10000

Epoch 310 training complete  
Cost on training data: 0.00836126231935  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.08870877453  
Accuracy on evaluation data: 9180 / 10000

Epoch 311 training complete  
Cost on training data: 0.00822791722347  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.09567183034  
Accuracy on evaluation data: 9179 / 10000

Epoch 312 training complete  
Cost on training data: 0.00809897563909  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.09343291854  
Accuracy on evaluation data: 9175 / 10000

Epoch 313 training complete  
Cost on training data: 0.00806356878232  
Accuracy on training data: 9997 / 10000

Cost on evaluation data: 1.089158385  
Accuracy on evaluation data: 9177 / 10000

Epoch 314 training complete  
Cost on training data: 0.00802863227618  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.09366491476  
Accuracy on evaluation data: 9171 / 10000

Epoch 315 training complete  
Cost on training data: 0.00800415660683  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.09657440531  
Accuracy on evaluation data: 9176 / 10000

Epoch 316 training complete  
Cost on training data: 0.00798713662595  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.09552058523  
Accuracy on evaluation data: 9178 / 10000

Epoch 317 training complete  
Cost on training data: 0.00795650053002  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.09792265671  
Accuracy on evaluation data: 9170 / 10000

Epoch 318 training complete  
Cost on training data: 0.00795417371359  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.10185316922  
Accuracy on evaluation data: 9177 / 10000

Epoch 319 training complete  
Cost on training data: 0.00791946774114  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.09520749613  
Accuracy on evaluation data: 9175 / 10000

Epoch 320 training complete  
Cost on training data: 0.00795323324726  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.09984935725  
Accuracy on evaluation data: 9183 / 10000

Epoch 321 training complete  
Cost on training data: 0.0078251255011  
Accuracy on training data: 9997 / 10000

Cost on evaluation data: 1.09915776317  
Accuracy on evaluation data: 9180 / 10000

Epoch 322 training complete  
Cost on training data: 0.00779155092916  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.09979035373  
Accuracy on evaluation data: 9182 / 10000

Epoch 323 training complete  
Cost on training data: 0.00777410582736  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.1025844314  
Accuracy on evaluation data: 9173 / 10000

Epoch 324 training complete  
Cost on training data: 0.00781872456101  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.10131741234  
Accuracy on evaluation data: 9181 / 10000

Epoch 325 training complete  
Cost on training data: 0.00797855689845  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.10415458751  
Accuracy on evaluation data: 9178 / 10000

Epoch 326 training complete  
Cost on training data: 0.00788080799589  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.10434345456  
Accuracy on evaluation data: 9175 / 10000

Epoch 327 training complete  
Cost on training data: 0.00770729251782  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.10703180433  
Accuracy on evaluation data: 9171 / 10000

Epoch 328 training complete  
Cost on training data: 0.00764236602433  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.10581600098  
Accuracy on evaluation data: 9171 / 10000

Epoch 329 training complete  
Cost on training data: 0.00770736728707  
Accuracy on training data: 9997 / 10000



Cost on evaluation data: 1.10502733348  
Accuracy on evaluation data: 9176 / 10000

Epoch 330 training complete  
Cost on training data: 0.00762317329695  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.10842221145  
Accuracy on evaluation data: 9174 / 10000

Epoch 331 training complete  
Cost on training data: 0.00758296946215  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.11257988507  
Accuracy on evaluation data: 9170 / 10000

Epoch 332 training complete  
Cost on training data: 0.00761043807907  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.11099520939  
Accuracy on evaluation data: 9179 / 10000

Epoch 333 training complete  
Cost on training data: 0.00752364651199  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.11313072773  
Accuracy on evaluation data: 9174 / 10000

Epoch 334 training complete  
Cost on training data: 0.00750640862425  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.11303618746  
Accuracy on evaluation data: 9177 / 10000

Epoch 335 training complete  
Cost on training data: 0.00745263336981  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.11036039364  
Accuracy on evaluation data: 9174 / 10000

Epoch 336 training complete  
Cost on training data: 0.00823609488501  
Accuracy on training data: 9995 / 10000  
Cost on evaluation data: 1.11378972282  
Accuracy on evaluation data: 9171 / 10000

Epoch 337 training complete  
Cost on training data: 0.00764344506634  
Accuracy on training data: 9997 / 10000

Cost on evaluation data: 1.11385664239  
Accuracy on evaluation data: 9175 / 10000

Epoch 338 training complete  
Cost on training data: 0.0074821456588  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.11775262284  
Accuracy on evaluation data: 9170 / 10000

Epoch 339 training complete  
Cost on training data: 0.00734035226131  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.11731660068  
Accuracy on evaluation data: 9172 / 10000

Epoch 340 training complete  
Cost on training data: 0.00737996688349  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.11365834452  
Accuracy on evaluation data: 9178 / 10000

Epoch 341 training complete  
Cost on training data: 0.00725258613755  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.11685060147  
Accuracy on evaluation data: 9175 / 10000

Epoch 342 training complete  
Cost on training data: 0.00723587865347  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.11838755576  
Accuracy on evaluation data: 9173 / 10000

Epoch 343 training complete  
Cost on training data: 0.00773924313842  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.11938582116  
Accuracy on evaluation data: 9163 / 10000

Epoch 344 training complete  
Cost on training data: 0.00734571867508  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.1200016843  
Accuracy on evaluation data: 9172 / 10000

Epoch 345 training complete  
Cost on training data: 0.00726564632746  
Accuracy on training data: 9997 / 10000

Cost on evaluation data: 1.11962975041  
Accuracy on evaluation data: 9168 / 10000

Epoch 346 training complete  
Cost on training data: 0.00713678695943  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.12183020541  
Accuracy on evaluation data: 9178 / 10000

Epoch 347 training complete  
Cost on training data: 0.00719705829279  
Accuracy on training data: 9996 / 10000  
Cost on evaluation data: 1.1241260075  
Accuracy on evaluation data: 9176 / 10000

Epoch 348 training complete  
Cost on training data: 0.00696963994433  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.12160416924  
Accuracy on evaluation data: 9176 / 10000

Epoch 349 training complete  
Cost on training data: 0.00702845245887  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.12277326608  
Accuracy on evaluation data: 9178 / 10000

Epoch 350 training complete  
Cost on training data: 0.00694035082604  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.12685358559  
Accuracy on evaluation data: 9173 / 10000

Epoch 351 training complete  
Cost on training data: 0.00678953072099  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.12407658363  
Accuracy on evaluation data: 9175 / 10000

Epoch 352 training complete  
Cost on training data: 0.00675484226026  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.1244551219  
Accuracy on evaluation data: 9177 / 10000

Epoch 353 training complete  
Cost on training data: 0.00679158105479  
Accuracy on training data: 9997 / 10000

Cost on evaluation data: 1.12699595551  
Accuracy on evaluation data: 9176 / 10000

Epoch 354 training complete  
Cost on training data: 0.00698573269787  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.13060057748  
Accuracy on evaluation data: 9172 / 10000

Epoch 355 training complete  
Cost on training data: 0.00671559734224  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.12851078565  
Accuracy on evaluation data: 9174 / 10000

Epoch 356 training complete  
Cost on training data: 0.00665556908807  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.12805230903  
Accuracy on evaluation data: 9173 / 10000

Epoch 357 training complete  
Cost on training data: 0.00677367219445  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.12518735576  
Accuracy on evaluation data: 9173 / 10000

Epoch 358 training complete  
Cost on training data: 0.00669678577547  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.12404507042  
Accuracy on evaluation data: 9173 / 10000

Epoch 359 training complete  
Cost on training data: 0.0067418860769  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.12630594088  
Accuracy on evaluation data: 9171 / 10000

Epoch 360 training complete  
Cost on training data: 0.00692792670072  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.13369567727  
Accuracy on evaluation data: 9167 / 10000

Epoch 361 training complete  
Cost on training data: 0.00674954128371  
Accuracy on training data: 9997 / 10000

Cost on evaluation data: 1.13193748725  
Accuracy on evaluation data: 9177 / 10000

Epoch 362 training complete  
Cost on training data: 0.00652054821787  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.13300799291  
Accuracy on evaluation data: 9170 / 10000

Epoch 363 training complete  
Cost on training data: 0.00665602539049  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.13440948163  
Accuracy on evaluation data: 9177 / 10000

Epoch 364 training complete  
Cost on training data: 0.00653397306475  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.13549114272  
Accuracy on evaluation data: 9170 / 10000

Epoch 365 training complete  
Cost on training data: 0.00651980387297  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.13393926032  
Accuracy on evaluation data: 9171 / 10000

Epoch 366 training complete  
Cost on training data: 0.00641112626994  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.13425551642  
Accuracy on evaluation data: 9173 / 10000

Epoch 367 training complete  
Cost on training data: 0.00639530002089  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.13398740149  
Accuracy on evaluation data: 9170 / 10000

Epoch 368 training complete  
Cost on training data: 0.00657829747882  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.13440204747  
Accuracy on evaluation data: 9171 / 10000

Epoch 369 training complete  
Cost on training data: 0.00644444619221  
Accuracy on training data: 9997 / 10000

Cost on evaluation data: 1.13224300717  
Accuracy on evaluation data: 9174 / 10000

Epoch 370 training complete  
Cost on training data: 0.00633404118718  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.13358040168  
Accuracy on evaluation data: 9173 / 10000

Epoch 371 training complete  
Cost on training data: 0.00635276387595  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.13477298606  
Accuracy on evaluation data: 9176 / 10000

Epoch 372 training complete  
Cost on training data: 0.00635207484972  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.13694948223  
Accuracy on evaluation data: 9170 / 10000

Epoch 373 training complete  
Cost on training data: 0.00634689868077  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.13823911471  
Accuracy on evaluation data: 9175 / 10000

Epoch 374 training complete  
Cost on training data: 0.00623051503615  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.13886573432  
Accuracy on evaluation data: 9175 / 10000

Epoch 375 training complete  
Cost on training data: 0.0062368726803  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.14086424702  
Accuracy on evaluation data: 9175 / 10000

Epoch 376 training complete  
Cost on training data: 0.00632173549356  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.14247898107  
Accuracy on evaluation data: 9175 / 10000

Epoch 377 training complete  
Cost on training data: 0.00616678036842  
Accuracy on training data: 9998 / 10000

Cost on evaluation data: 1.14506231833  
Accuracy on evaluation data: 9174 / 10000

Epoch 378 training complete  
Cost on training data: 0.00635988612807  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.14544557535  
Accuracy on evaluation data: 9172 / 10000

Epoch 379 training complete  
Cost on training data: 0.00653734205558  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.14432904556  
Accuracy on evaluation data: 9173 / 10000

Epoch 380 training complete  
Cost on training data: 0.00633371049105  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.14648210222  
Accuracy on evaluation data: 9180 / 10000

Epoch 381 training complete  
Cost on training data: 0.00619072924093  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.14590993305  
Accuracy on evaluation data: 9176 / 10000

Epoch 382 training complete  
Cost on training data: 0.00602023402858  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.14657350429  
Accuracy on evaluation data: 9175 / 10000

Epoch 383 training complete  
Cost on training data: 0.00632251849396  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.15097764337  
Accuracy on evaluation data: 9171 / 10000

Epoch 384 training complete  
Cost on training data: 0.00593973232947  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.14765441903  
Accuracy on evaluation data: 9174 / 10000

Epoch 385 training complete  
Cost on training data: 0.00591815674476  
Accuracy on training data: 9997 / 10000

Cost on evaluation data: 1.14807665641  
Accuracy on evaluation data: 9176 / 10000

Epoch 386 training complete  
Cost on training data: 0.00583504600182  
Accuracy on training data: 9997 / 10000  
Cost on evaluation data: 1.14769409807  
Accuracy on evaluation data: 9174 / 10000

Epoch 387 training complete  
Cost on training data: 0.00597212043643  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.14947271183  
Accuracy on evaluation data: 9177 / 10000

Epoch 388 training complete  
Cost on training data: 0.0058825675126  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.15381315412  
Accuracy on evaluation data: 9171 / 10000

Epoch 389 training complete  
Cost on training data: 0.00582751347431  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.15378273052  
Accuracy on evaluation data: 9176 / 10000

Epoch 390 training complete  
Cost on training data: 0.00578185611463  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.15286660818  
Accuracy on evaluation data: 9174 / 10000

Epoch 391 training complete  
Cost on training data: 0.00577965201358  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.15028595826  
Accuracy on evaluation data: 9181 / 10000

Epoch 392 training complete  
Cost on training data: 0.00568699610503  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.15434470549  
Accuracy on evaluation data: 9180 / 10000

Epoch 393 training complete  
Cost on training data: 0.00573123115896  
Accuracy on training data: 9998 / 10000



Cost on evaluation data: 1.15830909461  
Accuracy on evaluation data: 9170 / 10000

Epoch 394 training complete  
Cost on training data: 0.00573629303429  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.15482025057  
Accuracy on evaluation data: 9178 / 10000

Epoch 395 training complete  
Cost on training data: 0.00603901956273  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.15327888063  
Accuracy on evaluation data: 9179 / 10000

Epoch 396 training complete  
Cost on training data: 0.0057092164893  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.15713081816  
Accuracy on evaluation data: 9180 / 10000

Epoch 397 training complete  
Cost on training data: 0.00568197289267  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.15546131499  
Accuracy on evaluation data: 9178 / 10000

Epoch 398 training complete  
Cost on training data: 0.00569588532724  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.16060686202  
Accuracy on evaluation data: 9178 / 10000

Epoch 399 training complete  
Cost on training data: 0.00627017289375  
Accuracy on training data: 9998 / 10000  
Cost on evaluation data: 1.17114101475  
Accuracy on evaluation data: 9176 / 10000

```
In [25]: import plot_helper
```

```
In [26]: plot_helper.plot_training_cost(num_epochs=epochs, training_cost=training_cost, training_accuracy=training_accuracy, test_cost=evaluation_cost, test_accuracy=evaluation_accuracy, test_cost_xm=evaluation_cost_xm, test_accuracy_xm=evaluation_accuracy_xm)
```



