

Homework 1

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0.1 Code

```
import tensorflow as tf

#Start interactive session
sess = tf.InteractiveSession()
sess.close()
sess = tf.InteractiveSession()
from tensorflow.examples.tutorials.mnist import input_data
mnist = input_data.read_data_sets('MNIST_data', one_hot=True)

width = 28 # width of the image in pixels
height = 28 # height of the image in pixels
flat = width * height # number of pixels in one image
class_output = 10 # number of possible classifications for the problem

x = tf.placeholder(tf.float32, shape=[None, flat])
y_ = tf.placeholder(tf.float32, shape=[None, class_output])

# 1 channel image
# 28x28
# -1 interpreted as pending/default - will be batch # later

x_image = tf.reshape(x, [-1,28,28,1])
x_image

W_conv1 = tf.Variable(tf.truncated_normal([5, 5, 1, 32], stddev=0.1))
b_conv1 = tf.Variable(tf.constant(0.1, shape=[32])) # need 32 biases for 32
outputs
# 32 different ways/filters of reading every number for one image

convolve1 = tf.nn.conv2d(x_image, W_conv1, strides=[1, 1, 1, 1], padding='SAME')
+ b_conv1

h_conv1 = tf.nn.relu(convolve1)
# REctify Linear Unit
# "relu" if results less than 0, makes it 0,
# makes it easier for computation

# max pooling specifies a size of which to get max of that region
# image 28x28
# max pool 2x2
# output = 14x14
conv1 = tf.nn.max_pool(h_conv1, ksize=[1, 2, 2, 1], strides=[1, 2, 2, 1],
padding='SAME') #max_pool_2x2
conv1

W_conv2 = tf.Variable(tf.truncated_normal([5, 5, 32, 64], stddev=0.1))
b_conv2 = tf.Variable(tf.constant(0.1, shape=[64])) #need 64 biases for 64
outputs

convolve2 = tf.nn.conv2d(conv1, W_conv2, strides=[1, 1, 1, 1], padding='SAME')+
b_conv2
```

```

h_conv2 = tf.nn.relu(convolve2)

conv2 = tf.nn.max_pool(h_conv2, ksize=[1, 2, 2, 1], strides=[1, 2, 2, 1],
    padding='SAME') #max_pool_2x2
conv2

# flatten second layer into 1024 x 1
layer2_matrix = tf.reshape(conv2, [-1, 7*7*64])

# Fully Connected Layer

W_fc1 = tf.Variable(tf.truncated_normal([7 * 7 * 64, 1024], stddev=0.1))
b_fc1 = tf.Variable(tf.constant(0.1, shape=[1024])) # need 1024 biases for
    1024 outputs

fcl=tf.matmul(layer2_matrix, W_fc1) + b_fc1

h_fc1 = tf.nn.relu(fcl)
h_fc1

# Dropout layer
# tried to inflict "amnesia" make some values 0 to ignore
# makes it more robust to noise or variations
keep_prob = tf.placeholder(tf.float32)
layer_drop = tf.nn.dropout(h_fc1, keep_prob)
layer_drop

# 1024 because that's the prev layer
# 10 for outputs, num of classes
W_fc2 = tf.Variable(tf.truncated_normal([1024, 10], stddev=0.1)) #1024 neurons
b_fc2 = tf.Variable(tf.constant(0.1, shape=[10])) # 10 possibilities for
    digits [0,1,2,3,4,5,6,7,8,9]

fc=tf.matmul(layer_drop, W_fc2) + b_fc2

y_CNN= tf.nn.softmax(fc)
y_CNN

#### Design End ####

# Training

cross_entropy = tf.reduce_mean(-tf.reduce_sum(y_ * tf.log(y_CNN),
    reduction_indices=[1]))

# Another good optimizer, faster than grad desc
train_step = tf.train.AdamOptimizer(1e-4).minimize(cross_entropy)

# compare output to actual (highest 1)
correct_prediction = tf.equal(tf.argmax(y_CNN,1), tf.argmax(y_,1))

accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))

```

```

sess.run(tf.global_variables_initializer())

#
#####

#Baseline:

#for i in range(1000):
#    batch = mnist.train.next_batch(50)
#    if i%100 == 0:
#        train_accuracy = accuracy.eval(feed_dict={x:batch[0], y_: batch[1],
#        keep_prob: 1.0})
#        print("step %d, training accuracy %g"%(i, float(train_accuracy)))
#    train_step.run(feed_dict={x: batch[0], y_: batch[1], keep_prob: 0.5})

#baseline accuracy = 0.9651
#Time:
#real    0m9.208s
#user    0m9.724s
#sys     0m1.524s

#
#####

## Hw 1
# Run full dataset

#for i in range(20000):
#    batch = mnist.train.next_batch(50)
#    if i%100 == 0:
#        train_accuracy = accuracy.eval(feed_dict={
#        x:batch[0], y_: batch[1], keep_prob: 1.0})
#        print("step %d, training accuracy %g"%(i, train_accuracy))
#    train_step.run(feed_dict={x: batch[0], y_: batch[1], keep_prob: 0.5})

# full dataset accuracy = 0.9929
# Time:
#real    1m36.763s
#user    1m51.808s
#sys     0m15.312s

#
#####

# Custom 1:

#for i in range(20000):
#    batch = mnist.train.next_batch(10)
#    if i%100 == 0:
#        train_accuracy = accuracy.eval(feed_dict={

```

```

#         x:batch[0], y_: batch[1], keep_prob: 1.0})
#         print("step %d, training accuracy %g"%(i, train_accuracy))
#         train_step.run(feed_dict={x: batch[0], y_: batch[1], keep_prob: 0.5})

# Custom 1 accuracy = 0.9894
#Time:
#real    1m7.127s
#user    1m25.648s
#sys     0m10.256s

#
#####

# Custon 2:

#for i in range(20000):
#    batch = mnist.train.next_batch(100)
#    if i%100 == 0:
#        train_accuracy = accuracy.eval(feed_dict={
#            x:batch[0], y_: batch[1], keep_prob: 1.0})
#        print("step %d, training accuracy %g"%(i, train_accuracy))
#        train_step.run(feed_dict={x: batch[0], y_: batch[1], keep_prob: 0.5})

# Custom 2 accuracy = 0.9917
# Time:
#real    2m31.050s
#user    2m47.836s
#sys     0m23.852s

print("test_accuracy %g"%accuracy.eval(feed_dict={x: mnist.test.images, y_:
    mnist.test.labels, keep_prob: 1.0}))
sess.close()

```

0.2 Results

0.2.1 Baseline:

```
Extracting MNIST_data/train-images-idx3-ubyte.gz
Extracting MNIST_data/train-labels-idx1-ubyte.gz
Extracting MNIST_data/t10k-images-idx3-ubyte.gz
Extracting MNIST_data/t10k-labels-idx1-ubyte.gz
step 0, training accuracy 0.1
step 100, training accuracy 0.88
step 200, training accuracy 0.96
step 300, training accuracy 0.92
step 400, training accuracy 0.98
step 500, training accuracy 0.9
step 600, training accuracy 0.96
step 700, training accuracy 0.92
step 800, training accuracy 0.94
step 900, training accuracy 0.98
test accuracy 0.9651
```

0.2.2 Full Data Set:

```
Extracting MNIST_data/train-images-idx3-ubyte.gz
Extracting MNIST_data/train-labels-idx1-ubyte.gz
Extracting MNIST_data/t10k-images-idx3-ubyte.gz
Extracting MNIST_data/t10k-labels-idx1-ubyte.gz
step 0, training accuracy 0.08
step 100, training accuracy 0.9
step 200, training accuracy 0.9
step 300, training accuracy 0.98
step 400, training accuracy 0.88
step 500, training accuracy 0.92
step 600, training accuracy 0.88
step 700, training accuracy 0.96
step 800, training accuracy 0.96
step 900, training accuracy 1
step 1000, training accuracy 1
step 1100, training accuracy 0.98
step 1200, training accuracy 0.94
step 1300, training accuracy 0.98
step 1400, training accuracy 0.96
step 1500, training accuracy 0.92
step 1600, training accuracy 0.96
step 1700, training accuracy 0.94
step 1800, training accuracy 0.94
step 1900, training accuracy 0.94
step 2000, training accuracy 0.98
step 2100, training accuracy 0.94
step 2200, training accuracy 1
step 2300, training accuracy 1
step 2400, training accuracy 0.98
step 2500, training accuracy 0.98
step 2600, training accuracy 0.94
step 2700, training accuracy 0.98
step 2800, training accuracy 0.94
step 2900, training accuracy 0.94
step 3000, training accuracy 0.96
step 3100, training accuracy 1
step 3200, training accuracy 0.98
step 3300, training accuracy 0.98
step 3400, training accuracy 1
step 3500, training accuracy 0.98
step 3600, training accuracy 0.98
step 3700, training accuracy 0.98
step 3800, training accuracy 1
step 3900, training accuracy 0.98
step 4000, training accuracy 1
step 4100, training accuracy 1
step 4200, training accuracy 1
step 4300, training accuracy 0.96
step 4400, training accuracy 1
step 4500, training accuracy 1
step 4600, training accuracy 0.98
step 4700, training accuracy 0.96
```

step	4800,	training	accuracy	1
step	4900,	training	accuracy	0.98
step	5000,	training	accuracy	1
step	5100,	training	accuracy	1
step	5200,	training	accuracy	0.96
step	5300,	training	accuracy	1
step	5400,	training	accuracy	1
step	5500,	training	accuracy	1
step	5600,	training	accuracy	1
step	5700,	training	accuracy	1
step	5800,	training	accuracy	1
step	5900,	training	accuracy	0.98
step	6000,	training	accuracy	0.96
step	6100,	training	accuracy	0.98
step	6200,	training	accuracy	0.98
step	6300,	training	accuracy	0.98
step	6400,	training	accuracy	0.98
step	6500,	training	accuracy	1
step	6600,	training	accuracy	0.98
step	6700,	training	accuracy	1
step	6800,	training	accuracy	1
step	6900,	training	accuracy	1
step	7000,	training	accuracy	1
step	7100,	training	accuracy	1
step	7200,	training	accuracy	1
step	7300,	training	accuracy	0.98
step	7400,	training	accuracy	1
step	7500,	training	accuracy	0.96
step	7600,	training	accuracy	1
step	7700,	training	accuracy	1
step	7800,	training	accuracy	1
step	7900,	training	accuracy	1
step	8000,	training	accuracy	1
step	8100,	training	accuracy	0.98
step	8200,	training	accuracy	1
step	8300,	training	accuracy	1
step	8400,	training	accuracy	1
step	8500,	training	accuracy	1
step	8600,	training	accuracy	1
step	8700,	training	accuracy	1
step	8800,	training	accuracy	1
step	8900,	training	accuracy	0.96
step	9000,	training	accuracy	1
step	9100,	training	accuracy	1
step	9200,	training	accuracy	1
step	9300,	training	accuracy	0.98
step	9400,	training	accuracy	0.98
step	9500,	training	accuracy	1
step	9600,	training	accuracy	1
step	9700,	training	accuracy	0.98
step	9800,	training	accuracy	1
step	9900,	training	accuracy	0.98
step	10000,	training	accuracy	1
step	10100,	training	accuracy	1

step	10200,	training	accuracy	1
step	10300,	training	accuracy	1
step	10400,	training	accuracy	1
step	10500,	training	accuracy	0.98
step	10600,	training	accuracy	1
step	10700,	training	accuracy	1
step	10800,	training	accuracy	0.98
step	10900,	training	accuracy	1
step	11000,	training	accuracy	1
step	11100,	training	accuracy	0.98
step	11200,	training	accuracy	1
step	11300,	training	accuracy	1
step	11400,	training	accuracy	1
step	11500,	training	accuracy	1
step	11600,	training	accuracy	1
step	11700,	training	accuracy	0.98
step	11800,	training	accuracy	1
step	11900,	training	accuracy	1
step	12000,	training	accuracy	0.96
step	12100,	training	accuracy	1
step	12200,	training	accuracy	1
step	12300,	training	accuracy	0.98
step	12400,	training	accuracy	1
step	12500,	training	accuracy	1
step	12600,	training	accuracy	1
step	12700,	training	accuracy	1
step	12800,	training	accuracy	1
step	12900,	training	accuracy	1
step	13000,	training	accuracy	1
step	13100,	training	accuracy	1
step	13200,	training	accuracy	1
step	13300,	training	accuracy	1
step	13400,	training	accuracy	1
step	13500,	training	accuracy	1
step	13600,	training	accuracy	1
step	13700,	training	accuracy	1
step	13800,	training	accuracy	0.98
step	13900,	training	accuracy	1
step	14000,	training	accuracy	1
step	14100,	training	accuracy	1
step	14200,	training	accuracy	1
step	14300,	training	accuracy	1
step	14400,	training	accuracy	1
step	14500,	training	accuracy	1
step	14600,	training	accuracy	1
step	14700,	training	accuracy	1
step	14800,	training	accuracy	1
step	14900,	training	accuracy	1
step	15000,	training	accuracy	1
step	15100,	training	accuracy	1
step	15200,	training	accuracy	1
step	15300,	training	accuracy	1
step	15400,	training	accuracy	1
step	15500,	training	accuracy	1

```
step 15600, training accuracy 1
step 15700, training accuracy 1
step 15800, training accuracy 1
step 15900, training accuracy 1
step 16000, training accuracy 0.98
step 16100, training accuracy 1
step 16200, training accuracy 1
step 16300, training accuracy 1
step 16400, training accuracy 1
step 16500, training accuracy 1
step 16600, training accuracy 1
step 16700, training accuracy 1
step 16800, training accuracy 1
step 16900, training accuracy 1
step 17000, training accuracy 1
step 17100, training accuracy 1
step 17200, training accuracy 1
step 17300, training accuracy 1
step 17400, training accuracy 1
step 17500, training accuracy 1
step 17600, training accuracy 1
step 17700, training accuracy 1
step 17800, training accuracy 1
step 17900, training accuracy 1
step 18000, training accuracy 0.98
step 18100, training accuracy 1
step 18200, training accuracy 1
step 18300, training accuracy 1
step 18400, training accuracy 1
step 18500, training accuracy 1
step 18600, training accuracy 0.98
step 18700, training accuracy 1
step 18800, training accuracy 0.98
step 18900, training accuracy 1
step 19000, training accuracy 1
step 19100, training accuracy 1
step 19200, training accuracy 1
step 19300, training accuracy 1
step 19400, training accuracy 1
step 19500, training accuracy 1
step 19600, training accuracy 0.98
step 19700, training accuracy 1
step 19800, training accuracy 1
step 19900, training accuracy 1
test accuracy 0.9929
```

0.2.3 Smaller Batch Size:

```
Successfully downloaded train-images-idx3-ubyte.gz 9912422 bytes.  
Extracting MNIST_data/train-images-idx3-ubyte.gz  
Successfully downloaded train-labels-idx1-ubyte.gz 28881 bytes.  
Extracting MNIST_data/train-labels-idx1-ubyte.gz  
Successfully downloaded t10k-images-idx3-ubyte.gz 1648877 bytes.  
Extracting MNIST_data/t10k-images-idx3-ubyte.gz  
Successfully downloaded t10k-labels-idx1-ubyte.gz 4542 bytes.  
Extracting MNIST_data/t10k-labels-idx1-ubyte.gz  
step 0, training accuracy 0  
step 100, training accuracy 0.6  
step 200, training accuracy 0.9  
step 300, training accuracy 0.8  
step 400, training accuracy 1  
step 500, training accuracy 0.8  
step 600, training accuracy 1  
step 700, training accuracy 0.9  
step 800, training accuracy 0.9  
step 900, training accuracy 0.8  
step 1000, training accuracy 1  
step 1100, training accuracy 0.9  
step 1200, training accuracy 0.9  
step 1300, training accuracy 1  
step 1400, training accuracy 0.9  
step 1500, training accuracy 0.7  
step 1600, training accuracy 0.9  
step 1700, training accuracy 0.9  
step 1800, training accuracy 0.9  
step 1900, training accuracy 0.9  
step 2000, training accuracy 0.9  
step 2100, training accuracy 1  
step 2200, training accuracy 1  
step 2300, training accuracy 0.9  
step 2400, training accuracy 1  
step 2500, training accuracy 0.9  
step 2600, training accuracy 0.9  
step 2700, training accuracy 1  
step 2800, training accuracy 1  
step 2900, training accuracy 1  
step 3000, training accuracy 1  
step 3100, training accuracy 1  
step 3200, training accuracy 1  
step 3300, training accuracy 1  
step 3400, training accuracy 1  
step 3500, training accuracy 0.8  
step 3600, training accuracy 1  
step 3700, training accuracy 1  
step 3800, training accuracy 0.9  
step 3900, training accuracy 0.9  
step 4000, training accuracy 0.9  
step 4100, training accuracy 1  
step 4200, training accuracy 0.9  
step 4300, training accuracy 1
```

step	4400,	training	accuracy	1
step	4500,	training	accuracy	1
step	4600,	training	accuracy	1
step	4700,	training	accuracy	1
step	4800,	training	accuracy	0.9
step	4900,	training	accuracy	1
step	5000,	training	accuracy	1
step	5100,	training	accuracy	1
step	5200,	training	accuracy	1
step	5300,	training	accuracy	1
step	5400,	training	accuracy	1
step	5500,	training	accuracy	1
step	5600,	training	accuracy	1
step	5700,	training	accuracy	1
step	5800,	training	accuracy	1
step	5900,	training	accuracy	1
step	6000,	training	accuracy	1
step	6100,	training	accuracy	1
step	6200,	training	accuracy	1
step	6300,	training	accuracy	1
step	6400,	training	accuracy	0.9
step	6500,	training	accuracy	1
step	6600,	training	accuracy	0.9
step	6700,	training	accuracy	0.9
step	6800,	training	accuracy	1
step	6900,	training	accuracy	1
step	7000,	training	accuracy	1
step	7100,	training	accuracy	1
step	7200,	training	accuracy	1
step	7300,	training	accuracy	1
step	7400,	training	accuracy	0.9
step	7500,	training	accuracy	1
step	7600,	training	accuracy	0.9
step	7700,	training	accuracy	1
step	7800,	training	accuracy	1
step	7900,	training	accuracy	1
step	8000,	training	accuracy	1
step	8100,	training	accuracy	1
step	8200,	training	accuracy	1
step	8300,	training	accuracy	1
step	8400,	training	accuracy	1
step	8500,	training	accuracy	1
step	8600,	training	accuracy	1
step	8700,	training	accuracy	1
step	8800,	training	accuracy	1
step	8900,	training	accuracy	0.9
step	9000,	training	accuracy	0.9
step	9100,	training	accuracy	1
step	9200,	training	accuracy	0.9
step	9300,	training	accuracy	1
step	9400,	training	accuracy	1
step	9500,	training	accuracy	1
step	9600,	training	accuracy	1
step	9700,	training	accuracy	1

step 9800,	training accuracy	1
step 9900,	training accuracy	1
step 10000,	training accuracy	1
step 10100,	training accuracy	1
step 10200,	training accuracy	1
step 10300,	training accuracy	0.9
step 10400,	training accuracy	1
step 10500,	training accuracy	1
step 10600,	training accuracy	1
step 10700,	training accuracy	1
step 10800,	training accuracy	1
step 10900,	training accuracy	1
step 11000,	training accuracy	1
step 11100,	training accuracy	1
step 11200,	training accuracy	1
step 11300,	training accuracy	1
step 11400,	training accuracy	1
step 11500,	training accuracy	1
step 11600,	training accuracy	1
step 11700,	training accuracy	0.9
step 11800,	training accuracy	1
step 11900,	training accuracy	1
step 12000,	training accuracy	1
step 12100,	training accuracy	1
step 12200,	training accuracy	1
step 12300,	training accuracy	1
step 12400,	training accuracy	1
step 12500,	training accuracy	1
step 12600,	training accuracy	1
step 12700,	training accuracy	1
step 12800,	training accuracy	1
step 12900,	training accuracy	0.8
step 13000,	training accuracy	1
step 13100,	training accuracy	1
step 13200,	training accuracy	1
step 13300,	training accuracy	1
step 13400,	training accuracy	1
step 13500,	training accuracy	1
step 13600,	training accuracy	1
step 13700,	training accuracy	1
step 13800,	training accuracy	1
step 13900,	training accuracy	1
step 14000,	training accuracy	1
step 14100,	training accuracy	1
step 14200,	training accuracy	1
step 14300,	training accuracy	1
step 14400,	training accuracy	1
step 14500,	training accuracy	1
step 14600,	training accuracy	1
step 14700,	training accuracy	1
step 14800,	training accuracy	1
step 14900,	training accuracy	1
step 15000,	training accuracy	1
step 15100,	training accuracy	1

step	15200,	training	accuracy	1
step	15300,	training	accuracy	1
step	15400,	training	accuracy	1
step	15500,	training	accuracy	1
step	15600,	training	accuracy	1
step	15700,	training	accuracy	1
step	15800,	training	accuracy	1
step	15900,	training	accuracy	0.9
step	16000,	training	accuracy	1
step	16100,	training	accuracy	1
step	16200,	training	accuracy	1
step	16300,	training	accuracy	0.9
step	16400,	training	accuracy	1
step	16500,	training	accuracy	1
step	16600,	training	accuracy	1
step	16700,	training	accuracy	1
step	16800,	training	accuracy	0.9
step	16900,	training	accuracy	1
step	17000,	training	accuracy	1
step	17100,	training	accuracy	1
step	17200,	training	accuracy	1
step	17300,	training	accuracy	1
step	17400,	training	accuracy	1
step	17500,	training	accuracy	1
step	17600,	training	accuracy	1
step	17700,	training	accuracy	1
step	17800,	training	accuracy	1
step	17900,	training	accuracy	1
step	18000,	training	accuracy	1
step	18100,	training	accuracy	1
step	18200,	training	accuracy	1
step	18300,	training	accuracy	1
step	18400,	training	accuracy	0.9
step	18500,	training	accuracy	1
step	18600,	training	accuracy	1
step	18700,	training	accuracy	1
step	18800,	training	accuracy	1
step	18900,	training	accuracy	1
step	19000,	training	accuracy	1
step	19100,	training	accuracy	1
step	19200,	training	accuracy	1
step	19300,	training	accuracy	1
step	19400,	training	accuracy	1
step	19500,	training	accuracy	1
step	19600,	training	accuracy	1
step	19700,	training	accuracy	1
step	19800,	training	accuracy	1
step	19900,	training	accuracy	1
test	accuracy			0.9894

0.2.4 Larger Batch Size:

```
Extracting MNIST_data/train-images-idx3-ubyte.gz
Extracting MNIST_data/train-labels-idx1-ubyte.gz
Extracting MNIST_data/t10k-images-idx3-ubyte.gz
Extracting MNIST_data/t10k-labels-idx1-ubyte.gz
step 0, training accuracy 0.13
step 100, training accuracy 0.87
step 200, training accuracy 0.95
step 300, training accuracy 0.97
step 400, training accuracy 0.97
step 500, training accuracy 0.96
step 600, training accuracy 0.97
step 700, training accuracy 0.95
step 800, training accuracy 0.94
step 900, training accuracy 0.96
step 1000, training accuracy 0.96
step 1100, training accuracy 0.95
step 1200, training accuracy 0.97
step 1300, training accuracy 0.99
step 1400, training accuracy 0.96
step 1500, training accuracy 0.96
step 1600, training accuracy 1
step 1700, training accuracy 0.98
step 1800, training accuracy 0.99
step 1900, training accuracy 0.97
step 2000, training accuracy 0.99
step 2100, training accuracy 0.98
step 2200, training accuracy 1
step 2300, training accuracy 1
step 2400, training accuracy 1
step 2500, training accuracy 0.99
step 2600, training accuracy 0.98
step 2700, training accuracy 0.96
step 2800, training accuracy 1
step 2900, training accuracy 0.99
step 3000, training accuracy 0.98
step 3100, training accuracy 1
step 3200, training accuracy 0.98
step 3300, training accuracy 1
step 3400, training accuracy 0.99
step 3500, training accuracy 1
step 3600, training accuracy 1
step 3700, training accuracy 1
step 3800, training accuracy 0.99
step 3900, training accuracy 0.99
step 4000, training accuracy 1
step 4100, training accuracy 1
step 4200, training accuracy 1
step 4300, training accuracy 0.97
step 4400, training accuracy 1
step 4500, training accuracy 1
step 4600, training accuracy 0.98
step 4700, training accuracy 0.99
```

step	4800,	training	accuracy	0.99
step	4900,	training	accuracy	0.99
step	5000,	training	accuracy	1
step	5100,	training	accuracy	1
step	5200,	training	accuracy	0.99
step	5300,	training	accuracy	0.99
step	5400,	training	accuracy	1
step	5500,	training	accuracy	1
step	5600,	training	accuracy	0.99
step	5700,	training	accuracy	1
step	5800,	training	accuracy	0.98
step	5900,	training	accuracy	0.99
step	6000,	training	accuracy	0.99
step	6100,	training	accuracy	1
step	6200,	training	accuracy	1
step	6300,	training	accuracy	1
step	6400,	training	accuracy	0.99
step	6500,	training	accuracy	1
step	6600,	training	accuracy	1
step	6700,	training	accuracy	0.99
step	6800,	training	accuracy	1
step	6900,	training	accuracy	0.99
step	7000,	training	accuracy	0.98
step	7100,	training	accuracy	0.99
step	7200,	training	accuracy	1
step	7300,	training	accuracy	1
step	7400,	training	accuracy	0.99
step	7500,	training	accuracy	1
step	7600,	training	accuracy	1
step	7700,	training	accuracy	0.99
step	7800,	training	accuracy	1
step	7900,	training	accuracy	1
step	8000,	training	accuracy	1
step	8100,	training	accuracy	1
step	8200,	training	accuracy	1
step	8300,	training	accuracy	1
step	8400,	training	accuracy	1
step	8500,	training	accuracy	1
step	8600,	training	accuracy	1
step	8700,	training	accuracy	0.99
step	8800,	training	accuracy	1
step	8900,	training	accuracy	0.99
step	9000,	training	accuracy	1
step	9100,	training	accuracy	1
step	9200,	training	accuracy	1
step	9300,	training	accuracy	1
step	9400,	training	accuracy	1
step	9500,	training	accuracy	1
step	9600,	training	accuracy	1
step	9700,	training	accuracy	1
step	9800,	training	accuracy	1
step	9900,	training	accuracy	1
step	10000,	training	accuracy	1
step	10100,	training	accuracy	1

step	10200,	training	accuracy	1
step	10300,	training	accuracy	0.99
step	10400,	training	accuracy	1
step	10500,	training	accuracy	1
step	10600,	training	accuracy	1
step	10700,	training	accuracy	1
step	10800,	training	accuracy	1
step	10900,	training	accuracy	0.99
step	11000,	training	accuracy	1
step	11100,	training	accuracy	1
step	11200,	training	accuracy	1
step	11300,	training	accuracy	1
step	11400,	training	accuracy	1
step	11500,	training	accuracy	1
step	11600,	training	accuracy	1
step	11700,	training	accuracy	1
step	11800,	training	accuracy	1
step	11900,	training	accuracy	1
step	12000,	training	accuracy	1
step	12100,	training	accuracy	1
step	12200,	training	accuracy	1
step	12300,	training	accuracy	1
step	12400,	training	accuracy	1
step	12500,	training	accuracy	1
step	12600,	training	accuracy	1
step	12700,	training	accuracy	1
step	12800,	training	accuracy	1
step	12900,	training	accuracy	1
step	13000,	training	accuracy	1
step	13100,	training	accuracy	1
step	13200,	training	accuracy	1
step	13300,	training	accuracy	1
step	13400,	training	accuracy	1
step	13500,	training	accuracy	1
step	13600,	training	accuracy	1
step	13700,	training	accuracy	1
step	13800,	training	accuracy	1
step	13900,	training	accuracy	1
step	14000,	training	accuracy	1
step	14100,	training	accuracy	1
step	14200,	training	accuracy	1
step	14300,	training	accuracy	1
step	14400,	training	accuracy	1
step	14500,	training	accuracy	1
step	14600,	training	accuracy	1
step	14700,	training	accuracy	1
step	14800,	training	accuracy	1
step	14900,	training	accuracy	1
step	15000,	training	accuracy	1
step	15100,	training	accuracy	1
step	15200,	training	accuracy	1
step	15300,	training	accuracy	1
step	15400,	training	accuracy	0.99
step	15500,	training	accuracy	1

```
step 15600, training accuracy 1
step 15700, training accuracy 1
step 15800, training accuracy 1
step 15900, training accuracy 1
step 16000, training accuracy 1
step 16100, training accuracy 1
step 16200, training accuracy 1
step 16300, training accuracy 1
step 16400, training accuracy 1
step 16500, training accuracy 1
step 16600, training accuracy 1
step 16700, training accuracy 1
step 16800, training accuracy 1
step 16900, training accuracy 1
step 17000, training accuracy 1
step 17100, training accuracy 1
step 17200, training accuracy 1
step 17300, training accuracy 1
step 17400, training accuracy 1
step 17500, training accuracy 1
step 17600, training accuracy 1
step 17700, training accuracy 1
step 17800, training accuracy 1
step 17900, training accuracy 1
step 18000, training accuracy 1
step 18100, training accuracy 1
step 18200, training accuracy 1
step 18300, training accuracy 1
step 18400, training accuracy 1
step 18500, training accuracy 1
step 18600, training accuracy 1
step 18700, training accuracy 1
step 18800, training accuracy 1
step 18900, training accuracy 1
step 19000, training accuracy 1
step 19100, training accuracy 1
step 19200, training accuracy 1
step 19300, training accuracy 1
step 19400, training accuracy 1
step 19500, training accuracy 1
step 19600, training accuracy 1
step 19700, training accuracy 1
step 19800, training accuracy 1
step 19900, training accuracy 1
test accuracy 0.9917
```