

PCA with sklearn - Intro tensorflow

for python 2.7

```
In [213]: import sklearn
          from sklearn import decomposition,datasets
          from sklearn.decomposition import PCA

          import numpy as np

          import seaborn
          import matplotlib.pyplot as plt
          import cv2
```

```
In [214]: print("sklearn v: {0}\nseaborn v: {1} \nnumpy v: {2}".format(sklearn.__version__,seaborn.__version__,np.__version__))

sklearn v: 0.18.1
seaborn v: 0.7.1
numpy v: 1.13.0
```

Part 1: sklearn

1) data exploration (quick)

```
In [215]: #### MNIST dataset
          #### each row contains 64 values corresponding to 64 pixels "unrolled"
          #### the image shape is 8*8
```

```
In [216]: from sklearn.datasets import load_digits
          digits = load_digits()
          print(digits.data.shape)

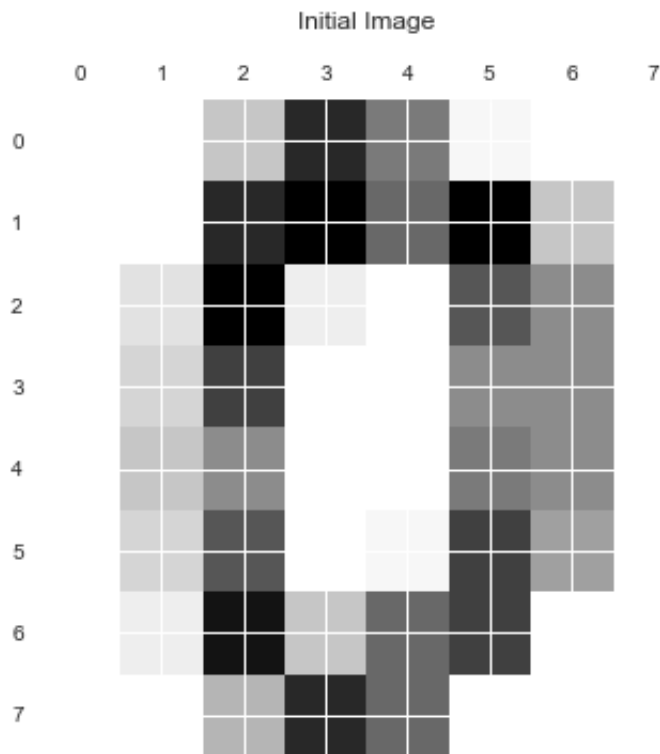
(1797, 64)
```

```
In [217]: sample_image=digits.images[0]
```

Plot the first element of the dataset

```
In [218]: plt.matshow(sample_image)
plt.title("Initial Image\n")

plt.show()
```



```
In [219]: ##Let's check the size of the image
```

```
In [220]: print(sample_image.shape)

(8, 8)
```

```
In [221]: X_mnist= digits.data
```

2) PCA

a) the digits (MNIST) dataset

Let's reduce the dimensionality to 5:

```
In [222]: n_components = 5
```

```
In [223]: pca = PCA(n_components)
X_mnist_reduced = pca.fit_transform(X_mnist)
```

```
In [224]: print(X_mnist_reduced.shape)

(1797, 5)
```

Let's reconstruct the image_dataset:

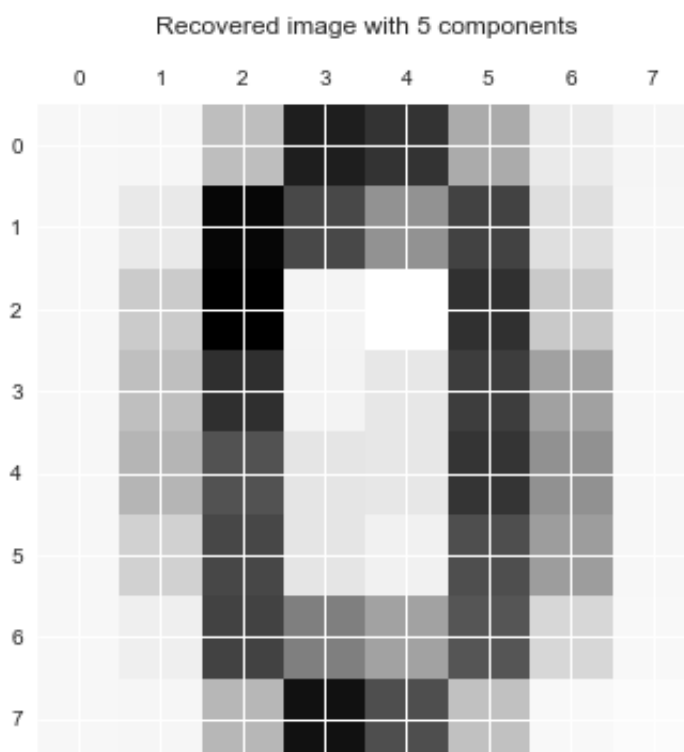
```
In [225]: X_mnist_recovered = pca.inverse_transform(X_mnist_reduced)
```

```
In [226]: X_mnist_recovered.shape
```

```
Out[226]: (1797, 64)
```

Let's draw the recovered image corresponding to the sample image:

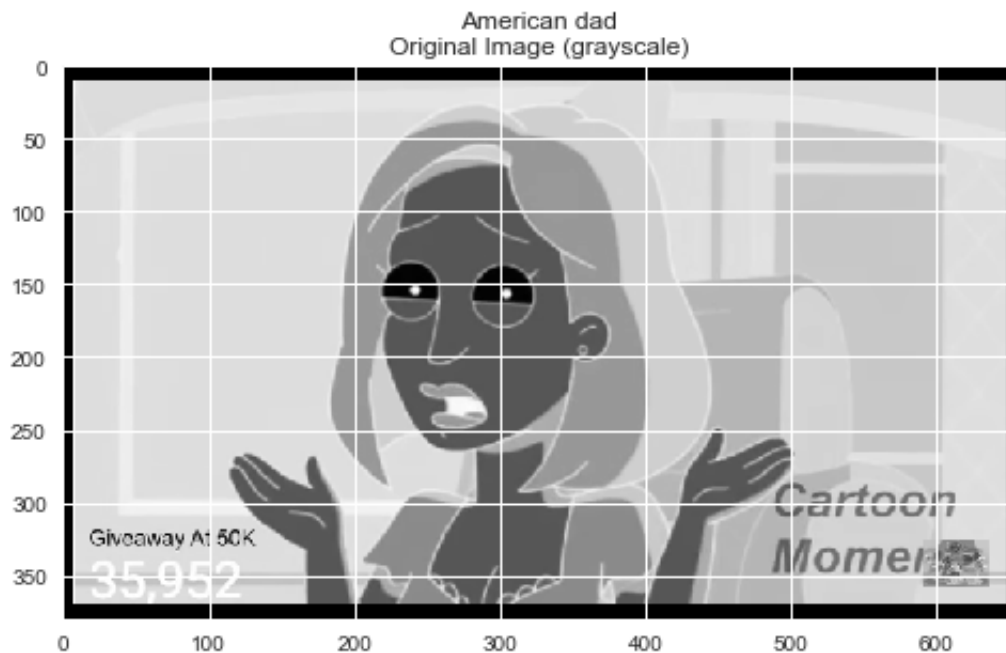
```
In [227]: recovered_im=np.array(X_mnist_recovered[0]).reshape(sample_image.sh
ape)
plt.matshow(recovered_im)
plt.title("Recovered image with {0} components\n".format(n_componen
ts))
plt.show()
```



b) Image from Youtube (American Dad)

Let's load the image as grayscale

```
In [228]: im=cv2.imread("/Users/assansanogo/Downloads/try_img.png",0)
plt.imshow(im)
plt.title("American dad\nOriginal Image (grayscale)")
plt.show()
```



```
In [229]: print(im.shape)
(380, 655)
```

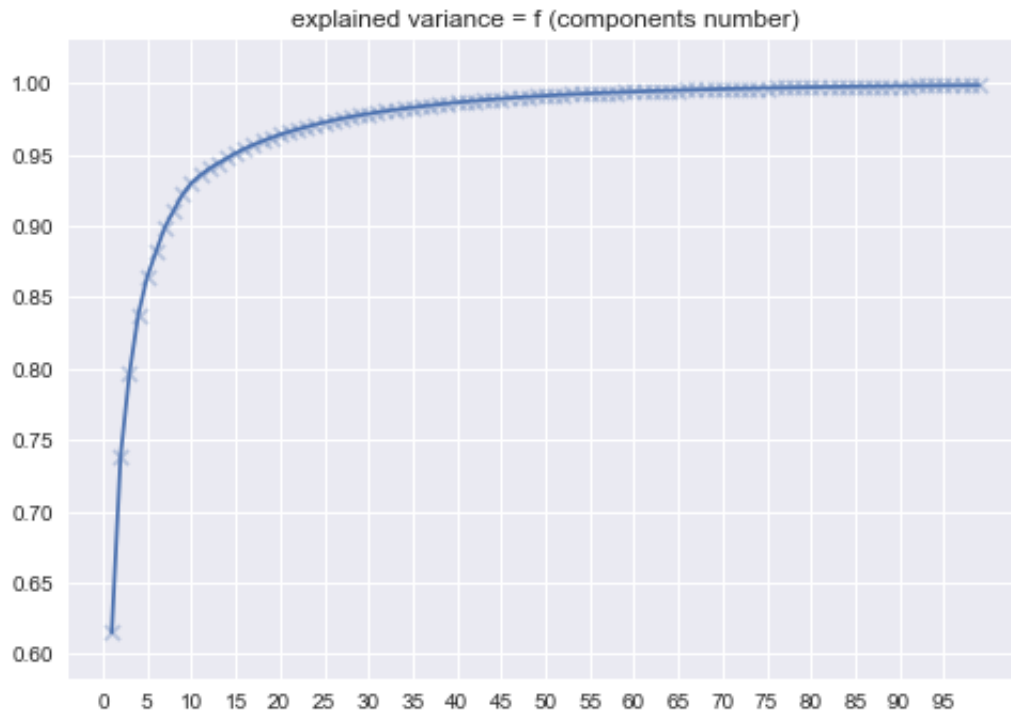
We will run PCA with various number of components (0 to 100)

```
In [230]: X=[]
Y=[]
for i in range(1,100,1):
    n_components = i
    X.append(n_components)

    pca = PCA(n_components)
    im_reduced = pca.fit_transform(im)
    Y.append(sum(pca.explained_variance_ratio_))
```

Let's plot variance and components number

```
In [231]: plt.scatter(X,Y, marker = 'x',alpha=0.3)
plt.plot(X,Y)
plt.title("explained variance = f (components number)")
plt.xticks(np.arange(0,100,5))
plt.show()
```

***Let's even put some interactivity with Plotly API :)***

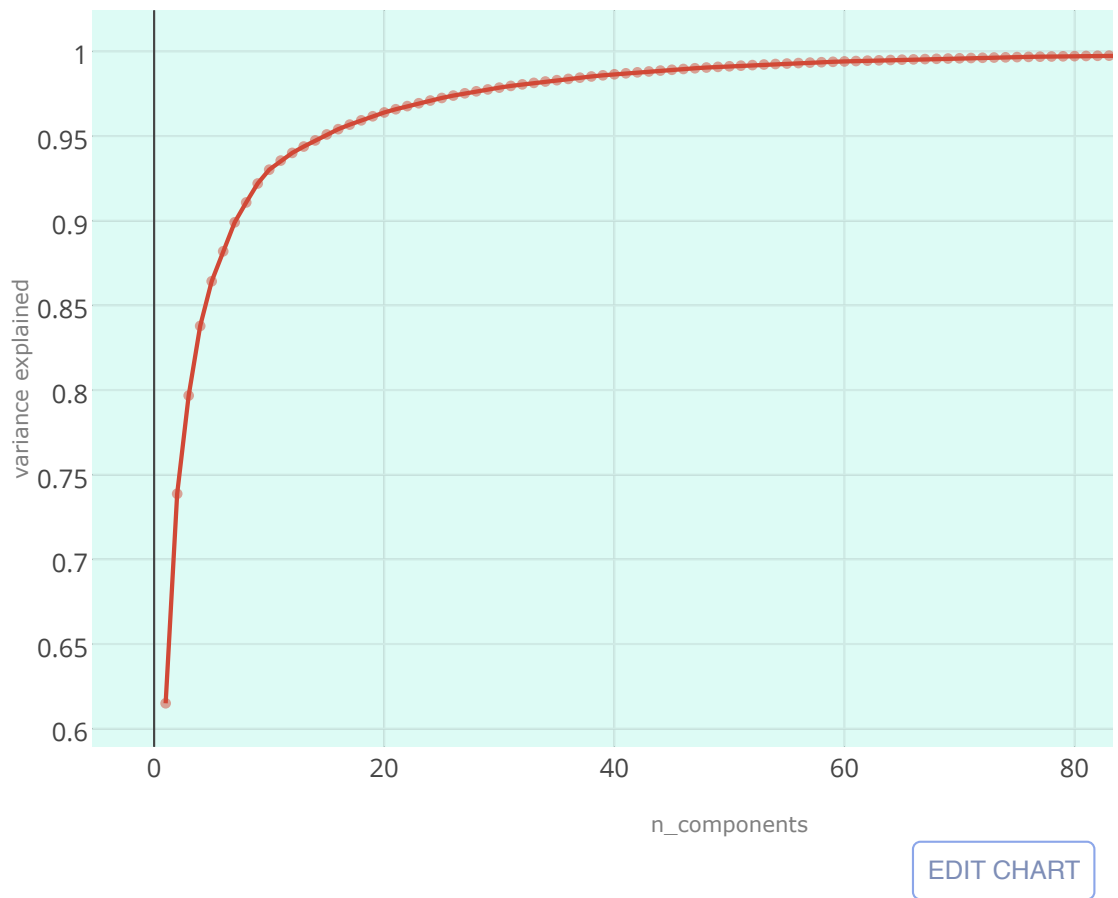
```
In [232]: import plotly
import plotly.plotly as py
import plotly.graph_objs as go

plotly.tools.set_credentials_file(username='AssanSanogo', api_key='
vCYO3IAT0bz37AAvE0Ca')
```

```
In [233]: trace1 = go.Scatter(  
    x=X,  
    y=Y,  
    mode='markers',  
    marker=dict(  
        color='rgba(209, 72, 54, 0.5)',  
        size=5,  
    )  
)  
  
trace2 = go.Scatter(  
    x=X,  
    y=Y,  
    mode='lines',  
    marker=dict(  
        color='rgba(209, 72, 54, 1)',  
        size=5,  
    )  
)  
data=[trace1,trace2]  
  
layout = go.Layout(  
    plot_bgcolor= "rgba(87, 237, 207, 0.2)",  
    title='variance explained = f(n_components)',  
    xaxis=dict(  
        title='n_components',  
        titlefont=dict(  
            family='Verdana',  
            size=10,  
            color='#7f7f7f'  
        )  
    ),  
    yaxis=dict(  
        title='variance explained',  
        titlefont=dict(  
            family='Verdana',  
            size=10,  
            color='#7f7f7f'  
        )  
    )  
)  
  
fig = go.Figure(data=data, layout=layout)  
py.iplot(fig, filename='styling-names')
```

Out[233]:

variance explained = f(n_components)

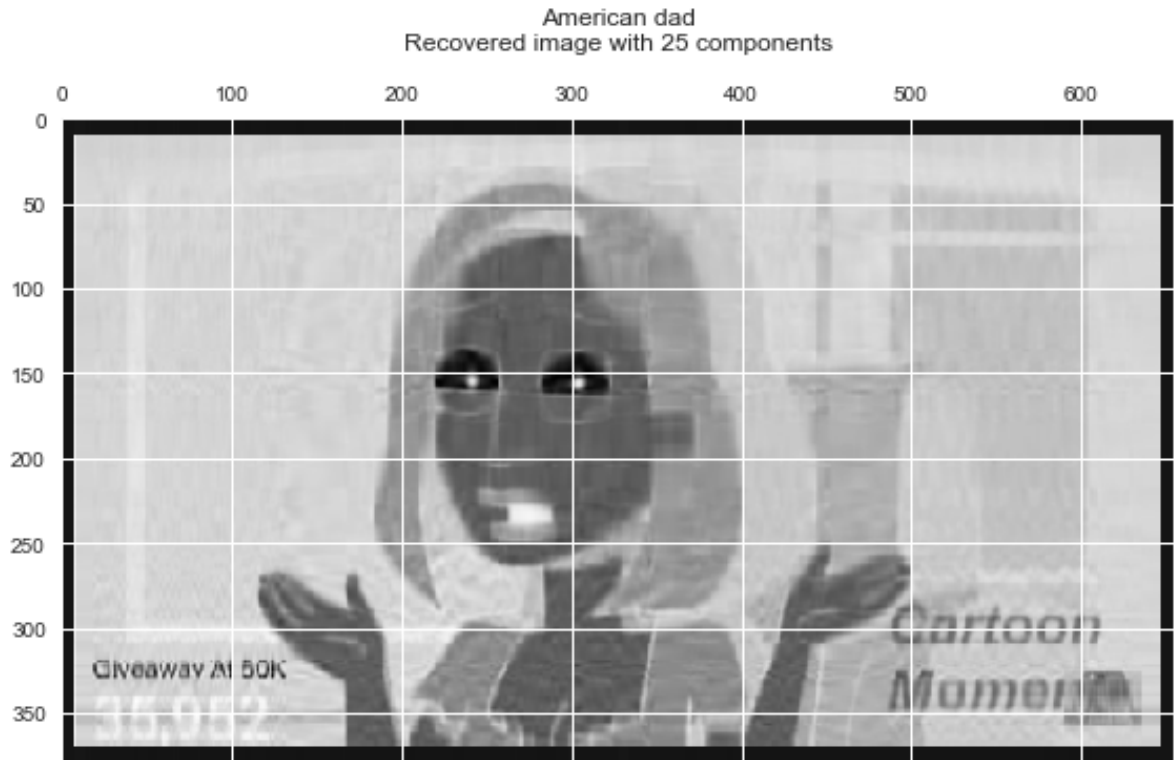


Let's make a pca with 15 elements: since it retains >90% of variance

```
In [234]: n_components = 25  
pca = PCA(n_components)  
im_reduced = pca.fit_transform(im)
```

Let 's recover the image : does the reduced information still captures picture details?

```
In [235]: recovered_im = pca.inverse_transform(im_reduced)
recovered_im=np.array(recovered_im).reshape(im.shape)
plt.matshow(recovered_im)
plt.title("American dad\nRecovered image with {0} components\n".format(n_components))
plt.show()
```



Part 2: Tensorflow

1) Introduction

imports

```
In [236]: import tensorflow as tf
```

Generalities

addition:(dirty version)


```
In [237]: node1 = tf.constant(3.0, dtype=tf.float32)
node2 = tf.constant(4.0, dtype=tf.float32)
print(node1, node2)

(<tf.Tensor 'Const_31:0' shape=() dtype=float32>, <tf.Tensor 'Const_32:0' shape=() dtype=float32>)
```

```
In [239]: sess = tf.Session()
```

```
In [240]: print(sess.run([node1, node2]))

[3.0, 4.0]
```

```
In [241]: node3 = tf.add(node1, -node2)
```

```
In [242]: print(sess.run(node3))

-1.0
```

addition:(clean version)

```
In [243]: #the usage of with allows to write cleaner code
with tf.Session() as sess:
    node1 = tf.constant(3.0, dtype=tf.float32)
    node2 = tf.constant(4.0, dtype=tf.float32)
    node1.eval()
    node3 = tf.add(node1, -node2)
    res = node3.eval()
    print(res)

-1.0
```

Create x1 and x2 variables

```
In [244]: x1 = tf.Variable(4.0,name="x")
x2 = tf.Variable(3.0,name="z")
```

```
In [245]: y=x1*x2- x1/x2
```

```
In [246]: sess=tf.Session()
```

```
# Initialize the 2 variables all at once
```

```
In [247]: init = tf.global_variables_initializer()
sess.run(init)
```

Initialize the 2 variables after each other

```
In [248]: sess.run(x1.initializer)
sess.run(x2.initializer)
```

```
In [249]: # Run the calculation
```

```
In [250]: result=sess.run(y)
```

```
In [251]: # Print the result
```

```
In [252]: print(result)
```

10.6667

Calculations with x1 and x2 variables

Simple addition

```
In [253]: a = tf.placeholder(tf.float32)
b = tf.placeholder(tf.float32)
```

```
In [254]: adder_node=a+b
```

```
In [255]: print(sess.run(adder_node, {a: 1, b: [20, 5]}))
[ 21.   6.]
```

```
In [256]: print(sess.run(adder_node, {a: [1,2], b: [20, 5]}))
[ 21.   7.]
```

Addition+Multiplication

```
In [257]: add_triple=adder_node*3
```

```
In [258]: print(sess.run(add_triple, {a: 1, b: [20, 5]}))  
[ 63.  18.]
```

2) Linear Regression

a) Generalities

Variables

```
In [259]: W = tf.Variable([.3], dtype=tf.float32)  
b = tf.Variable([-0.3], dtype=tf.float32)
```

Place_holder (input data that must be modelled)

```
In [260]: x = tf.placeholder(tf.float32)  
linear_model = W * x + b
```

Initialize variables

```
In [261]: init = tf.global_variables_initializer()  
sess.run(init)
```

*Calculate: $W * x + b$*

```
In [262]: print(sess.run(linear_model, {x:[1,2,3,4]}))  
[ 0.          0.30000001  0.60000002  0.90000004]
```

*Calculate: $(y - W * x + b)^2$*

```
In [263]: y = tf.placeholder(tf.float32)  
squared_deltas = tf.square(linear_model - y)
```

Calculate: $1/\text{len}(x) \text{ Sum}(y - Wx + b)^2$

```
In [264]: loss = tf.reduce_sum(squared_deltas)
          print(sess.run(loss, {x:[1,2,3,4], y:[0,-1,-2,-3]}))

          23.66
```

b) Linear regression - optimize the weights and bias

Model parameters

```
In [265]: import numpy as np
          import tensorflow as tf

          # Model parameters
          W = tf.Variable([.3], dtype=tf.float32)
          b = tf.Variable([-0.3], dtype=tf.float32)
```

Model input and output

```
In [266]: # Model input and output
          x = tf.placeholder(tf.float32)
          linear_model = W * x + b
          y = tf.placeholder(tf.float32)
```

Loss

```
In [267]: # loss
          loss = tf.reduce_sum(tf.square(linear_model - y)) # sum of the squares
```

Optimizer

```
In [268]: # optimizer
          optimizer = tf.train.GradientDescentOptimizer(0.01)
          train = optimizer.minimize(loss)
```

Training data

```
In [269]: # training data
x_train = [1,2,3,4]
y_train = [0,-1,-2,-3]
```

Training loop

```
In [270]: # training loop
# initialize the variables W,b

init = tf.global_variables_initializer()
# start the session
sess = tf.Session()

# reset values to pre-initialized values
sess.run(init)

#will calculate the optimization of the loss function 1000 times
for i in range(1000):
    sess.run(train, {x:x_train, y:y_train})
```

Evaluate accuracy

```
In [271]: # evaluate training accuracy:
# it will calculate W,b : variables
# and evaluate the loss function
# based on the place_holders x and y

curr_W, curr_b, curr_loss = sess.run([W, b, loss], {x:x_train, y:y_train})
print("W: %s b: %s loss: %s"%(curr_W, curr_b, curr_loss))

W: [-0.9999969] b: [ 0.99999082] loss: 5.69997e-11
```

3) Deep Convoluted Neural Network:

a) Introduction

```
In [272]: from tensorflow.examples.tutorials.mnist import input_data
```

```
In [273]: mnist = input_data.read_data_sets("MNIST_data/", one_hot=True)
```

```
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
```

```
In [274]: sample_image=mnist.train.images[0]
```

```
In [275]: ### The image has been unrolled into a vector of length 784
```

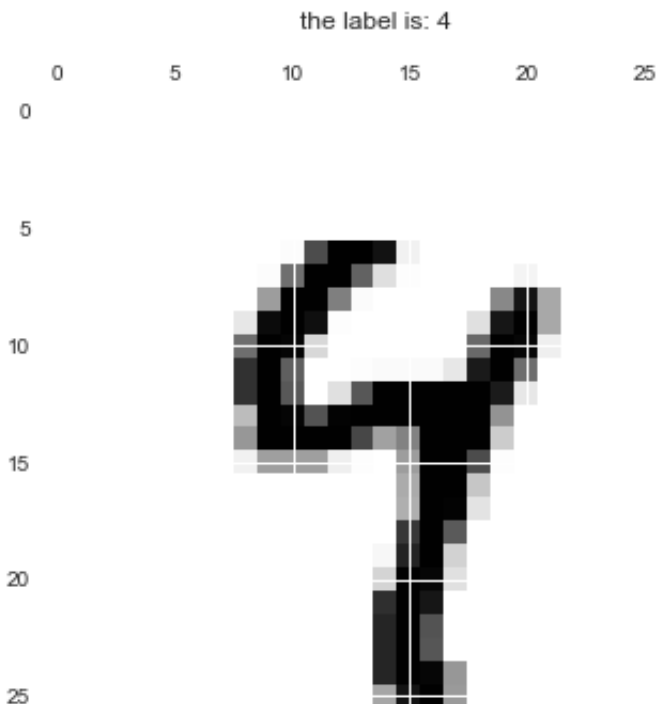
```
In [276]: sample_image.shape
```

```
Out[276]: (784,)
```

```
In [277]: ### The original image as a shape of 28*28,  
### we reshape then the "unrolled" image back to what it was
```

```
In [278]: def plot_mnist(i=0):  
    sample_image=mnist.train.images[i]  
    im_resaped=np.array(sample_image).reshape(28,28)  
    plt.matshow(im_resaped)  
    plt.title( "the label is: {0}\n".format((mnist.train.labels[i])  
    .tolist().index(1.)))  
    plt.show()
```

```
In [279]: plot_mnist(2)
```



```
In [280]: # the MNIST dataset is a tensor of shape 55000*784
```

```
In [281]: mnist.train.images.shape
```

```
Out[281]: (55000, 784)
```

b) Regression with tensorflow applied to MNIST

calculated : $y = x \cdot W + b$ labels: $y_{\text{}}$

```
In [282]: x = tf.placeholder(tf.float32, [None, 784])
```

```
In [283]: W= tf.Variable(tf.zeros([784,10]))
```

```
In [284]: b= tf.Variable(tf.zeros([10]))
```

```
In [285]: y = tf.matmul(x,W)+b
```

```
In [286]: y_ = tf.placeholder(tf.float32, [None, 10])
```

In layman terms : cross_entropy is calculated to measure how good is the prediction

```
In [287]: cross_entropy = tf.reduce_mean(tf.nn.softmax_cross_entropy_with_log  
its(labels=y_, logits=y))
```

```
In [288]: train_step = tf.train.GradientDescentOptimizer(0.5).minimize(cross_  
entropy)
```

```
In [289]: with tf.Session() as sess:
            tf.global_variables_initializer().run()
            for _ in range(10):
                batch_xs, batch_ys = mnist.train.next_batch(100)
                sess.run(train_step, feed_dict={x: batch_xs, y_: batch_ys})

            correct_prediction = tf.equal(tf.argmax(y,1), tf.argmax(y_,1))
            accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))

            accuracy_train=sess.run(accuracy, feed_dict={x: mnist.train.images,y_: mnist.train.labels})
            accuracy_test=sess.run(accuracy, feed_dict={x: mnist.test.images,y_: mnist.test.labels})

            print("the accuracy on training data is: {0}".format(accuracy_train))
            print("the accuracy on test data is: {0}".format(accuracy_test))
            )
```

the accuracy on training data is: 0.772018194199
the accuracy on test data is: 0.783800005913

c) DNN

let's define functions:

```
In [290]: def weight_variable(input_shape):
            initial = tf.truncated_normal(input_shape, stddev=0.1)
            return tf.Variable(initial)
```

```
In [291]: def bias_variable(input_shape):
            initial = tf.constant(0.1, shape=input_shape)
            return tf.Variable(initial)
```

```
In [292]: def conv2d(x, W):
            return tf.nn.conv2d(x, W, strides=[1, 1, 1, 1], padding='SAME')
```

```
In [293]: def max_pool_2x2(x):
            return tf.nn.max_pool(x, ksize=[1, 2, 2, 1],
                                   strides=[1, 2, 2, 1], padding='SAME')
```



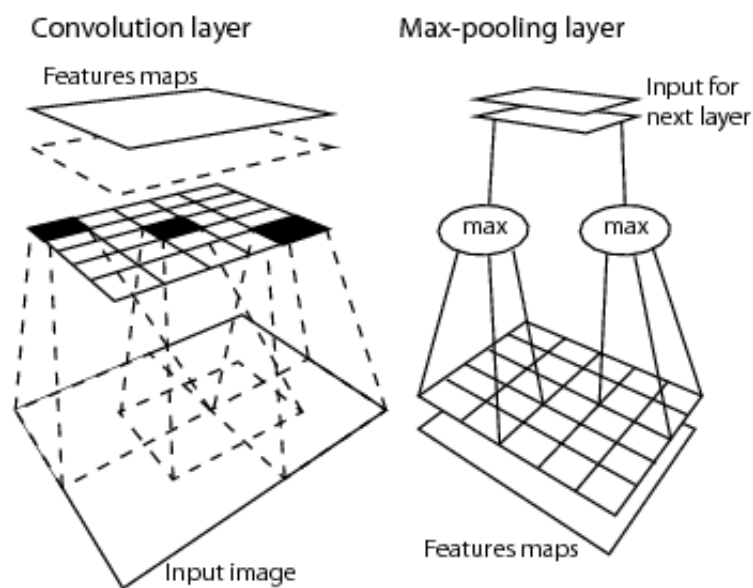
```
In [294]: def max_pool_nxn(x,n):
          return tf.nn.max_pool(x, ksize=[1, n, n, 1],
                                strides=[1, n, n, 1], padding='SAME')
```

let's build our NN:

```
In [295]: #input layer
```

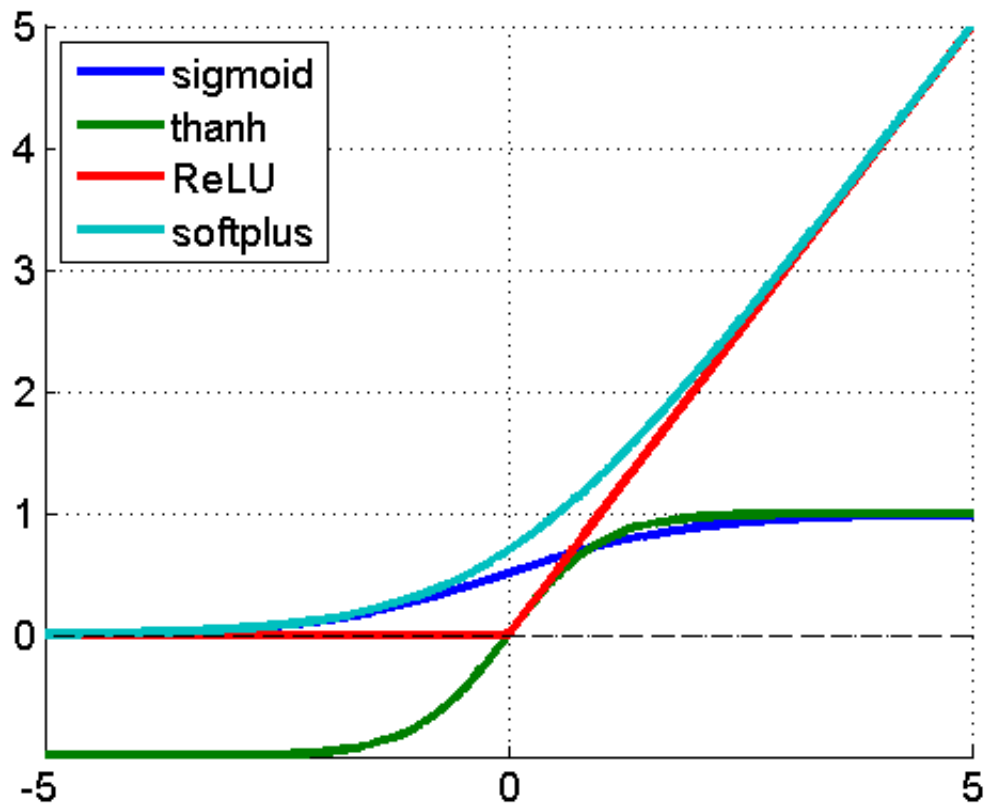
```
In [296]: x_image = tf.reshape(x, [-1, 28, 28, 1])
```

```
In [297]: ## Layer 1: first layer of convolution + reLu + max pool
```



```
In [298]: W_conv1 = weight_variable([5, 5, 1, 16])
          b_conv1 = bias_variable([16])
```

```
In [299]: ##reLu output
```



```
In [300]: h_conv1 = tf.nn.relu(conv2d(x_image, W_conv1) + b_conv1)
```

```
In [301]: h_conv1
```

```
Out[301]: <tf.Tensor 'Relu_6:0' shape=(?, 28, 28, 16) dtype=float32>
```

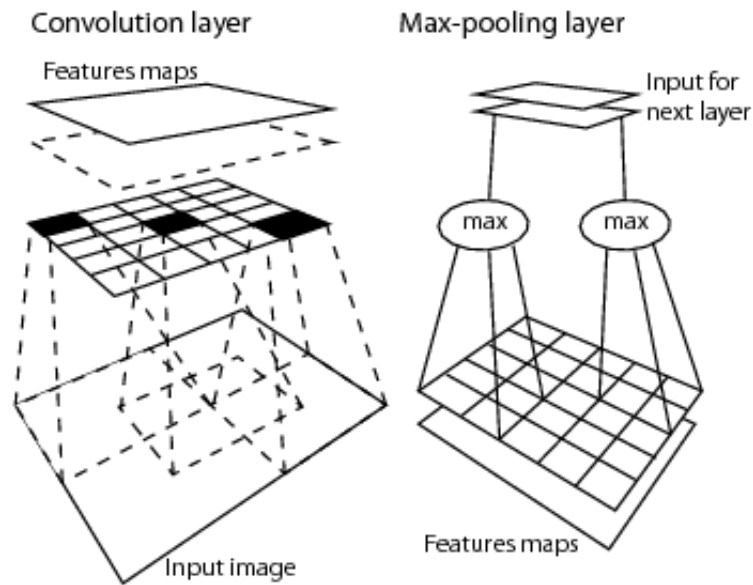
```
In [302]: ## max pooling
```

```
In [303]: h_pool1 = max_pool_2x2(h_conv1)
```

```
In [304]: h_pool1
```

```
Out[304]: <tf.Tensor 'MaxPool_4:0' shape=(?, 14, 14, 16) dtype=float32>
```

```
In [305]: #Layer 2: A second layer of convolution + reLu + max pool
```



```
In [307]: W_conv2 = weight_variable([5, 5, 16, 32])
          b_conv2 = bias_variable([32])
```

```
In [308]: h_conv2 = tf.nn.relu(conv2d(h_pool1, W_conv2) + b_conv2)
```

```
In [309]: h_conv2
```

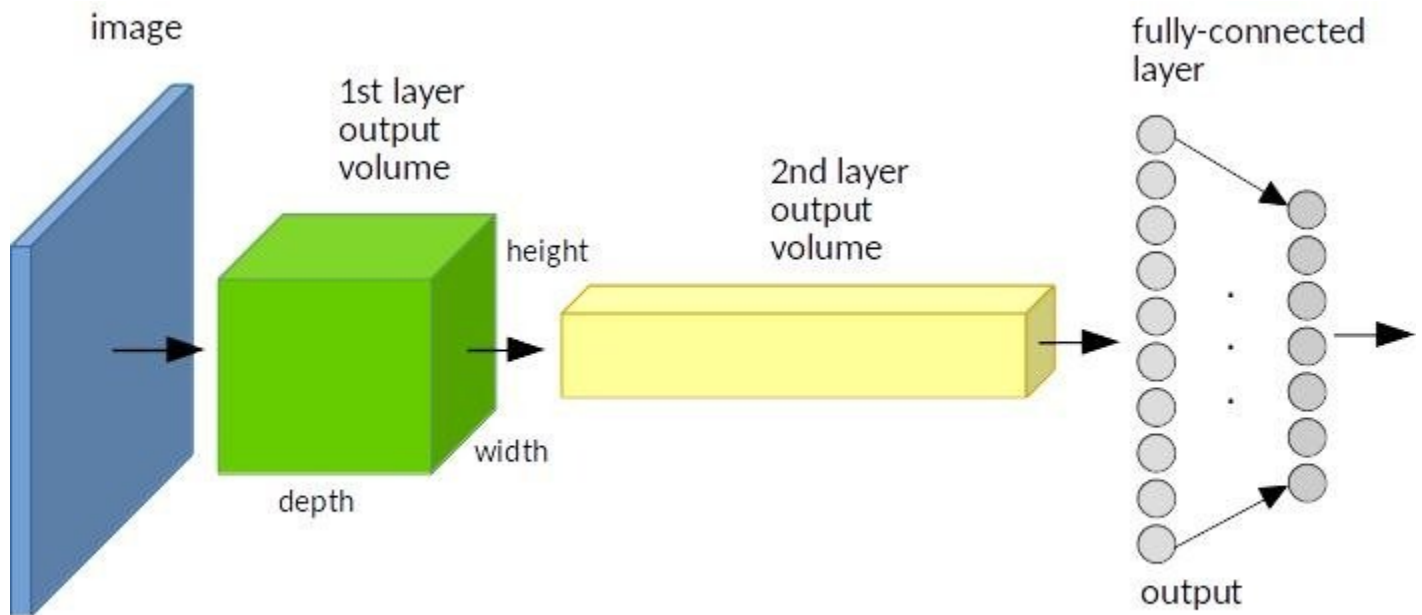
```
Out[309]: <tf.Tensor 'Relu_7:0' shape=(?, 14, 14, 32) dtype=float32>
```

```
In [310]: h_pool2 = max_pool_2x2(h_conv2)
```

```
In [311]: h_pool2
```

```
Out[311]: <tf.Tensor 'MaxPool_5:0' shape=(?, 7, 7, 32) dtype=float32>
```

```
In [312]: #Layer 3:  third layer = fully connected layer
```



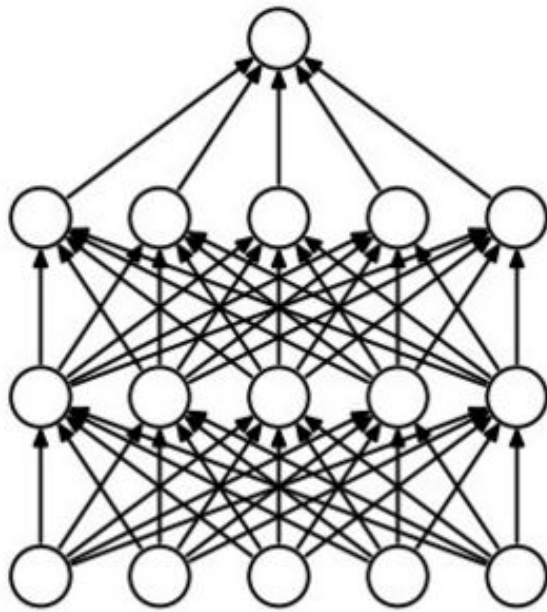
```
In [313]: h_pool2_flat = tf.reshape(h_pool2, [-1, 7*7*32])
```

```
In [314]: W_fc1 = weight_variable([7 * 7 * 32, 512])
```

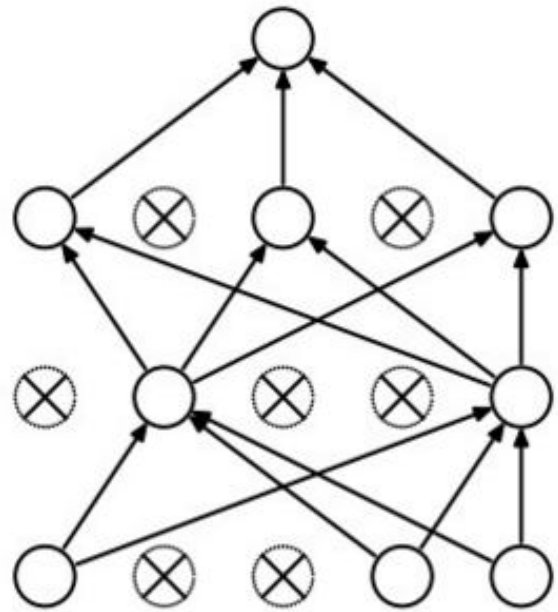
```
In [315]: b_fc1 = bias_variable([512])
```

```
In [316]: h_fc1 = tf.nn.relu(tf.matmul(h_pool2_flat, W_fc1) + b_fc1)
```

```
In [317]: #Layer 4: dropouts
```



(a) Standard Neural Net



(b) After applying dropout.

```
In [318]: keep_prob = tf.placeholder(tf.float32)
          h_fc1_drop = tf.nn.dropout(h_fc1, keep_prob)
```

```
In [319]: #Output Layer
```

```
In [320]: W_fc2 = weight_variable([512, 10])
          b_fc2 = bias_variable([10])

          y_conv = tf.matmul(h_fc1_drop, W_fc2) + b_fc2
```

```
***
```

```
In [321]: #Training
```

```
In [322]: # after 9800 steps : accuracy ~0.988
```

```
In [210]: cross_entropy = tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits(labels=y_, logits=y_conv))
train_step = tf.train.AdamOptimizer(1e-4).minimize(cross_entropy)
correct_prediction = tf.equal(tf.argmax(y_conv, 1), tf.argmax(y_, 1))
accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))

with tf.Session() as sess:
    sess.run(tf.global_variables_initializer())
    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})

        print('test accuracy %g' % accuracy.eval(feed_dict={
            x: mnist.test.images, y_: mnist.test.labels, keep_prob: 1.0})))
```

```
step 0, training accuracy 0.04
test accuracy 0.1373
test accuracy 0.1471
test accuracy 0.1507
test accuracy 0.153
test accuracy 0.15
test accuracy 0.1466
test accuracy 0.1482
test accuracy 0.1525
test accuracy 0.1603
test accuracy 0.1693
test accuracy 0.175
test accuracy 0.1847
test accuracy 0.2047
test accuracy 0.2166
test accuracy 0.2207
test accuracy 0.2187
test accuracy 0.2231
test accuracy 0.2285
test accuracy 0.2425
test accuracy 0.2712
test accuracy 0.3013
test accuracy 0.3328
test accuracy 0.3703
test accuracy 0.3975
test accuracy 0.4193
test accuracy 0.4247
test accuracy 0.4182
test accuracy 0.4109
test accuracy 0.4051
```

```
test accuracy 0.4071
test accuracy 0.4098
test accuracy 0.4201
test accuracy 0.4342
test accuracy 0.4446
test accuracy 0.4586
test accuracy 0.4724
test accuracy 0.485
test accuracy 0.4923
test accuracy 0.5043
test accuracy 0.5161
test accuracy 0.5245
test accuracy 0.5295
test accuracy 0.5344
test accuracy 0.54
test accuracy 0.5414
test accuracy 0.5463
test accuracy 0.5485
test accuracy 0.5577
test accuracy 0.5627
test accuracy 0.5691
test accuracy 0.5777
test accuracy 0.5889
test accuracy 0.6009
test accuracy 0.6103
test accuracy 0.621
test accuracy 0.6306
test accuracy 0.6404
test accuracy 0.6455
test accuracy 0.6552
test accuracy 0.6613
test accuracy 0.6669
test accuracy 0.6705
test accuracy 0.6731
test accuracy 0.6767
test accuracy 0.681
test accuracy 0.6817
test accuracy 0.6836
test accuracy 0.6836
test accuracy 0.6837
test accuracy 0.686
test accuracy 0.6894
test accuracy 0.6914
test accuracy 0.696
test accuracy 0.7002
test accuracy 0.7055
test accuracy 0.7058
test accuracy 0.7072
test accuracy 0.706
test accuracy 0.7026
test accuracy 0.6981
test accuracy 0.6927
test accuracy 0.6891
test accuracy 0.6845
```

```
test accuracy 0.6848
test accuracy 0.6861
test accuracy 0.6921
test accuracy 0.6978
test accuracy 0.7027
test accuracy 0.7067
test accuracy 0.7147
test accuracy 0.72
test accuracy 0.7231
test accuracy 0.7278
test accuracy 0.7332
test accuracy 0.74
test accuracy 0.7447
test accuracy 0.7481
test accuracy 0.7483
test accuracy 0.7493
test accuracy 0.7509
step 100, training accuracy 0.72
test accuracy 0.7519
test accuracy 0.7507
test accuracy 0.749
test accuracy 0.7489
test accuracy 0.7481
test accuracy 0.7451
test accuracy 0.7436
test accuracy 0.7426
test accuracy 0.7474
test accuracy 0.7537
test accuracy 0.7594
test accuracy 0.766
test accuracy 0.774
test accuracy 0.7792
test accuracy 0.7828
test accuracy 0.7856
test accuracy 0.7877
test accuracy 0.7879
test accuracy 0.7868
test accuracy 0.784
test accuracy 0.7819
test accuracy 0.7782
test accuracy 0.7739
test accuracy 0.7716
test accuracy 0.77
test accuracy 0.7687
test accuracy 0.7714
test accuracy 0.7741
test accuracy 0.7769
test accuracy 0.7766
test accuracy 0.777
test accuracy 0.7787
test accuracy 0.7819
test accuracy 0.7866
test accuracy 0.7914
test accuracy 0.7955
```



```
test accuracy 0.7971
test accuracy 0.8012
test accuracy 0.8041
test accuracy 0.8075
test accuracy 0.8112
test accuracy 0.8127
test accuracy 0.8146
test accuracy 0.8165
test accuracy 0.8167
test accuracy 0.8168
test accuracy 0.8173
test accuracy 0.8173
test accuracy 0.8204
test accuracy 0.8201
test accuracy 0.82
test accuracy 0.8195
test accuracy 0.8191
test accuracy 0.8209
test accuracy 0.823
test accuracy 0.8254
test accuracy 0.8288
test accuracy 0.8324
test accuracy 0.8358
test accuracy 0.8384
test accuracy 0.8397
test accuracy 0.838
test accuracy 0.8377
test accuracy 0.8361
test accuracy 0.8372
test accuracy 0.837
test accuracy 0.8393
test accuracy 0.8397
test accuracy 0.8413
test accuracy 0.841
test accuracy 0.8407
test accuracy 0.8381
test accuracy 0.8371
test accuracy 0.837
test accuracy 0.8379
test accuracy 0.8408
test accuracy 0.8435
test accuracy 0.8453
test accuracy 0.8467
test accuracy 0.8474
test accuracy 0.849
test accuracy 0.8513
test accuracy 0.8518
test accuracy 0.8535
test accuracy 0.8557
test accuracy 0.8573
test accuracy 0.8576
test accuracy 0.8587
test accuracy 0.8592
test accuracy 0.8595
```

```
test accuracy 0.86
test accuracy 0.8608
test accuracy 0.8607
test accuracy 0.861
test accuracy 0.861
test accuracy 0.8602
test accuracy 0.861
test accuracy 0.8618
test accuracy 0.8627
test accuracy 0.8625
step 200, training accuracy 0.98
test accuracy 0.8634
test accuracy 0.8633
test accuracy 0.8615
test accuracy 0.8592
test accuracy 0.8581
test accuracy 0.8588
test accuracy 0.8583
test accuracy 0.8583
test accuracy 0.8569
test accuracy 0.8558
test accuracy 0.8552
test accuracy 0.8565
test accuracy 0.859
test accuracy 0.8606
test accuracy 0.8616
test accuracy 0.8609
test accuracy 0.861
test accuracy 0.8626
test accuracy 0.8629
test accuracy 0.8628
test accuracy 0.863
test accuracy 0.8653
test accuracy 0.8662
test accuracy 0.8677
test accuracy 0.8676
test accuracy 0.8696
test accuracy 0.87
test accuracy 0.871
test accuracy 0.8714
test accuracy 0.8713
test accuracy 0.8723
test accuracy 0.8734
test accuracy 0.8733
test accuracy 0.8728
test accuracy 0.8718
test accuracy 0.8722
test accuracy 0.8726
test accuracy 0.8729
test accuracy 0.8739
test accuracy 0.8749
test accuracy 0.8756
test accuracy 0.8768
test accuracy 0.8775
```

```
test accuracy 0.8781
test accuracy 0.8791
test accuracy 0.877
test accuracy 0.877
test accuracy 0.8777
test accuracy 0.8779
test accuracy 0.88
test accuracy 0.8819
test accuracy 0.8837
test accuracy 0.8853
test accuracy 0.8852
test accuracy 0.8851
test accuracy 0.8842
test accuracy 0.8827
test accuracy 0.8822
test accuracy 0.8817
test accuracy 0.8799
test accuracy 0.8778
test accuracy 0.8759
test accuracy 0.8741
test accuracy 0.8735
test accuracy 0.8714
test accuracy 0.8713
test accuracy 0.872
test accuracy 0.8729
test accuracy 0.8747
test accuracy 0.8767
test accuracy 0.8799
test accuracy 0.8817
test accuracy 0.8828
test accuracy 0.8845
test accuracy 0.8864
test accuracy 0.8861
test accuracy 0.8891
test accuracy 0.89
test accuracy 0.8896
test accuracy 0.8902
test accuracy 0.8913
test accuracy 0.8909
test accuracy 0.8912
test accuracy 0.8918
test accuracy 0.8911
test accuracy 0.8921
test accuracy 0.8925
test accuracy 0.8926
test accuracy 0.8919
test accuracy 0.8915
test accuracy 0.8922
test accuracy 0.8944
test accuracy 0.8954
test accuracy 0.8963
test accuracy 0.8967
test accuracy 0.8959
test accuracy 0.8936
```

```
test accuracy 0.8931
test accuracy 0.8904
test accuracy 0.8888
step 300, training accuracy 0.94
test accuracy 0.8875
test accuracy 0.887
test accuracy 0.8856
test accuracy 0.8857
test accuracy 0.8853
test accuracy 0.8876
test accuracy 0.8899
test accuracy 0.8916
test accuracy 0.8928
test accuracy 0.8933
test accuracy 0.8924
test accuracy 0.8925
test accuracy 0.8928
test accuracy 0.8935
test accuracy 0.8947
test accuracy 0.8963
test accuracy 0.8998
test accuracy 0.9014
test accuracy 0.9028
test accuracy 0.905
test accuracy 0.9046
test accuracy 0.9049
test accuracy 0.9042
test accuracy 0.9043
test accuracy 0.9048
test accuracy 0.9038
test accuracy 0.9032
test accuracy 0.9023
test accuracy 0.9017
test accuracy 0.9021
test accuracy 0.9036
test accuracy 0.9038
test accuracy 0.9055
test accuracy 0.9062
test accuracy 0.9069
test accuracy 0.9079
test accuracy 0.909
test accuracy 0.9091
test accuracy 0.9095
test accuracy 0.9093
test accuracy 0.9089
test accuracy 0.9088
test accuracy 0.9068
test accuracy 0.9067
test accuracy 0.9042
test accuracy 0.9015
test accuracy 0.9008
test accuracy 0.9
test accuracy 0.8997
test accuracy 0.8989
```

```
test accuracy 0.9002
test accuracy 0.9012
test accuracy 0.9014
test accuracy 0.9013
test accuracy 0.902
test accuracy 0.9011
test accuracy 0.9011
test accuracy 0.9006
test accuracy 0.9015
test accuracy 0.9024
test accuracy 0.9023
test accuracy 0.903
test accuracy 0.9047
test accuracy 0.9064
test accuracy 0.9074
test accuracy 0.9089
test accuracy 0.9115
test accuracy 0.9137
test accuracy 0.9134
test accuracy 0.9133
test accuracy 0.9124
test accuracy 0.9114
test accuracy 0.9096
test accuracy 0.9095
test accuracy 0.9097
test accuracy 0.9091
test accuracy 0.9092
test accuracy 0.9098
test accuracy 0.9105
test accuracy 0.9105
test accuracy 0.9111
test accuracy 0.9123
test accuracy 0.9125
test accuracy 0.9115
test accuracy 0.9111
test accuracy 0.911
test accuracy 0.911
test accuracy 0.9113
test accuracy 0.9107
test accuracy 0.9105
test accuracy 0.91
test accuracy 0.9094
test accuracy 0.9099
test accuracy 0.91
test accuracy 0.9107
test accuracy 0.911
test accuracy 0.9109
test accuracy 0.9106
test accuracy 0.9122
test accuracy 0.9138
step 400, training accuracy 0.84
test accuracy 0.915
test accuracy 0.9162
test accuracy 0.9172
```

```
test accuracy 0.917
test accuracy 0.9174
test accuracy 0.9183
test accuracy 0.9173
test accuracy 0.917
test accuracy 0.9164
test accuracy 0.9162
test accuracy 0.9163
test accuracy 0.916
test accuracy 0.9164
test accuracy 0.9158
test accuracy 0.916
test accuracy 0.9159
test accuracy 0.9158
test accuracy 0.9159
test accuracy 0.9156
test accuracy 0.915
test accuracy 0.9146
test accuracy 0.914
test accuracy 0.9139
test accuracy 0.9146
test accuracy 0.9142
test accuracy 0.9137
test accuracy 0.9142
test accuracy 0.9132
test accuracy 0.9125
test accuracy 0.9129
test accuracy 0.9141
test accuracy 0.9134
test accuracy 0.9129
test accuracy 0.9129
test accuracy 0.9143
test accuracy 0.9142
test accuracy 0.9146
test accuracy 0.9166
test accuracy 0.9168
test accuracy 0.9181
test accuracy 0.9184
test accuracy 0.9189
test accuracy 0.9209
test accuracy 0.9215
test accuracy 0.9215
test accuracy 0.9208
test accuracy 0.9205
test accuracy 0.9206
test accuracy 0.9215
test accuracy 0.9216
test accuracy 0.9218
test accuracy 0.9227
test accuracy 0.9223
test accuracy 0.9216
test accuracy 0.9216
test accuracy 0.9224
test accuracy 0.9212
```

```
test accuracy 0.9207
test accuracy 0.9198
test accuracy 0.9188
test accuracy 0.9188
test accuracy 0.9187
test accuracy 0.9183
test accuracy 0.9192
test accuracy 0.9198
test accuracy 0.9198
test accuracy 0.9203
test accuracy 0.921
test accuracy 0.9214
test accuracy 0.922
test accuracy 0.9213
test accuracy 0.9214
test accuracy 0.9222
test accuracy 0.9218
test accuracy 0.9226
test accuracy 0.9233
test accuracy 0.9223
test accuracy 0.9226
test accuracy 0.9237
test accuracy 0.924
test accuracy 0.9242
test accuracy 0.9236
test accuracy 0.9232
test accuracy 0.9234
test accuracy 0.9228
test accuracy 0.9234
test accuracy 0.9235
test accuracy 0.9249
test accuracy 0.926
test accuracy 0.9257
test accuracy 0.9262
test accuracy 0.9255
test accuracy 0.9253
test accuracy 0.9255
test accuracy 0.9251
test accuracy 0.925
test accuracy 0.9247
test accuracy 0.9257
test accuracy 0.9261
test accuracy 0.9263
step 500, training accuracy 0.86
test accuracy 0.9256
test accuracy 0.9259
test accuracy 0.9255
test accuracy 0.9268
test accuracy 0.9273
test accuracy 0.9268
test accuracy 0.9262
test accuracy 0.9255
test accuracy 0.925
test accuracy 0.9257
```

```
test accuracy 0.9257
test accuracy 0.9256
test accuracy 0.9255
test accuracy 0.9256
test accuracy 0.9251
test accuracy 0.9252
test accuracy 0.9252
test accuracy 0.9255
test accuracy 0.9264
test accuracy 0.9275
test accuracy 0.9274
test accuracy 0.926
test accuracy 0.9269
test accuracy 0.9266
test accuracy 0.926
test accuracy 0.9239
test accuracy 0.9233
test accuracy 0.9223
test accuracy 0.9214
test accuracy 0.9219
test accuracy 0.9225
test accuracy 0.9231
test accuracy 0.9246
test accuracy 0.9244
test accuracy 0.9254
test accuracy 0.926
test accuracy 0.9264
test accuracy 0.9266
test accuracy 0.9275
test accuracy 0.927
test accuracy 0.927
test accuracy 0.9267
test accuracy 0.927
test accuracy 0.9278
test accuracy 0.9289
test accuracy 0.9301
test accuracy 0.9313
test accuracy 0.9315
test accuracy 0.9317
test accuracy 0.9322
test accuracy 0.9326
test accuracy 0.9324
test accuracy 0.9327
test accuracy 0.9328
test accuracy 0.9333
test accuracy 0.9327
test accuracy 0.9333
test accuracy 0.9335
test accuracy 0.9341
test accuracy 0.9346
test accuracy 0.9353
test accuracy 0.9358
test accuracy 0.9351
test accuracy 0.935
```



```
test accuracy 0.9353
test accuracy 0.9346
test accuracy 0.9338
test accuracy 0.9333
test accuracy 0.9327
test accuracy 0.9323
test accuracy 0.9316
test accuracy 0.9311
test accuracy 0.9309
test accuracy 0.9307
test accuracy 0.9307
test accuracy 0.9312
test accuracy 0.9321
test accuracy 0.932
test accuracy 0.9326
test accuracy 0.9323
test accuracy 0.9337
test accuracy 0.9341
test accuracy 0.9333
test accuracy 0.9325
test accuracy 0.9326
test accuracy 0.932
test accuracy 0.9338
test accuracy 0.9343
test accuracy 0.9348
test accuracy 0.9349
test accuracy 0.9356
test accuracy 0.936
test accuracy 0.9359
test accuracy 0.9358
test accuracy 0.936
test accuracy 0.9369
test accuracy 0.9368
test accuracy 0.9375
test accuracy 0.9365
test accuracy 0.9354
step 600, training accuracy 0.92
test accuracy 0.9345
test accuracy 0.934
test accuracy 0.9336
test accuracy 0.9319
test accuracy 0.931
test accuracy 0.9302
test accuracy 0.9303
test accuracy 0.9305
test accuracy 0.9314
test accuracy 0.9319
test accuracy 0.9323
test accuracy 0.9339
test accuracy 0.9367
test accuracy 0.9375
test accuracy 0.9385
test accuracy 0.9387
test accuracy 0.9387
```

```
test accuracy 0.9382
test accuracy 0.9385
test accuracy 0.9388
test accuracy 0.9387
test accuracy 0.9384
test accuracy 0.9381
test accuracy 0.9389
test accuracy 0.9394
test accuracy 0.9395
test accuracy 0.9395
test accuracy 0.939
test accuracy 0.9382
test accuracy 0.9386
test accuracy 0.9384
test accuracy 0.9378
test accuracy 0.9382
test accuracy 0.9383
test accuracy 0.9391
test accuracy 0.9388
test accuracy 0.9386
test accuracy 0.9382
test accuracy 0.9375
test accuracy 0.9365
test accuracy 0.9366
test accuracy 0.9352
test accuracy 0.9354
test accuracy 0.9347
test accuracy 0.9346
test accuracy 0.9349
test accuracy 0.9346
test accuracy 0.9361
test accuracy 0.9367
test accuracy 0.937
test accuracy 0.938
test accuracy 0.9383
test accuracy 0.9375
test accuracy 0.9381
test accuracy 0.939
test accuracy 0.9392
test accuracy 0.939
test accuracy 0.94
test accuracy 0.9384
test accuracy 0.9391
test accuracy 0.9383
test accuracy 0.9365
test accuracy 0.9362
test accuracy 0.9361
test accuracy 0.9369
test accuracy 0.9369
test accuracy 0.9375
test accuracy 0.9387
test accuracy 0.9402
test accuracy 0.94
test accuracy 0.9403
```

```
test accuracy 0.9401
test accuracy 0.9405
test accuracy 0.9405
test accuracy 0.9403
test accuracy 0.9408
test accuracy 0.9405
test accuracy 0.9406
test accuracy 0.9408
test accuracy 0.9408
test accuracy 0.9402
test accuracy 0.9399
test accuracy 0.9399
test accuracy 0.9396
test accuracy 0.9394
test accuracy 0.9393
test accuracy 0.9402
test accuracy 0.9408
test accuracy 0.9416
test accuracy 0.9416
test accuracy 0.9417
test accuracy 0.9422
test accuracy 0.9424
test accuracy 0.9427
test accuracy 0.9431
test accuracy 0.9437
test accuracy 0.9435
test accuracy 0.9433
test accuracy 0.9429
test accuracy 0.9421
step 700, training accuracy 1
test accuracy 0.9423
test accuracy 0.9423
test accuracy 0.9419
test accuracy 0.9414
test accuracy 0.9407
test accuracy 0.9406
test accuracy 0.9393
test accuracy 0.9389
test accuracy 0.9387
test accuracy 0.9383
test accuracy 0.9388
test accuracy 0.9401
test accuracy 0.9407
test accuracy 0.9415
test accuracy 0.9415
test accuracy 0.9423
test accuracy 0.9432
test accuracy 0.9435
test accuracy 0.9435
test accuracy 0.9435
test accuracy 0.9434
test accuracy 0.9435
test accuracy 0.9444
test accuracy 0.9448
```

```
test accuracy 0.9451
test accuracy 0.9456
test accuracy 0.9451
test accuracy 0.9445
test accuracy 0.9451
test accuracy 0.9445
test accuracy 0.9434
test accuracy 0.943
test accuracy 0.9436
test accuracy 0.943
test accuracy 0.9424
test accuracy 0.9422
test accuracy 0.9425
test accuracy 0.9426
test accuracy 0.9431
test accuracy 0.9436
test accuracy 0.9435
test accuracy 0.9435
test accuracy 0.9433
test accuracy 0.9436
test accuracy 0.9437
test accuracy 0.9432
test accuracy 0.9432
test accuracy 0.9433
test accuracy 0.9432
test accuracy 0.9434
test accuracy 0.943
test accuracy 0.9437
test accuracy 0.9441
test accuracy 0.9453
test accuracy 0.9461
test accuracy 0.9464
test accuracy 0.9471
test accuracy 0.9469
test accuracy 0.9466
test accuracy 0.9467
test accuracy 0.9459
test accuracy 0.9446
test accuracy 0.9424
test accuracy 0.942
test accuracy 0.9419
test accuracy 0.9418
test accuracy 0.942
test accuracy 0.942
test accuracy 0.9433
test accuracy 0.944
test accuracy 0.9435
test accuracy 0.9444
test accuracy 0.9449
test accuracy 0.945
test accuracy 0.9462
test accuracy 0.9457
test accuracy 0.947
test accuracy 0.9469
```

```
test accuracy 0.9468
test accuracy 0.9471
test accuracy 0.9464
test accuracy 0.9457
test accuracy 0.9451
test accuracy 0.9451
test accuracy 0.9451
test accuracy 0.9453
test accuracy 0.9448
test accuracy 0.9458
test accuracy 0.9457
test accuracy 0.9462
test accuracy 0.9468
test accuracy 0.9466
test accuracy 0.9471
test accuracy 0.9476
test accuracy 0.9478
test accuracy 0.9474
test accuracy 0.9486
test accuracy 0.9481
test accuracy 0.9489
test accuracy 0.9489
step 800, training accuracy 0.92
test accuracy 0.9494
test accuracy 0.9487
test accuracy 0.9481
test accuracy 0.9475
test accuracy 0.9472
test accuracy 0.9459
test accuracy 0.9461
test accuracy 0.9444
test accuracy 0.9437
test accuracy 0.9435
test accuracy 0.9438
test accuracy 0.9443
test accuracy 0.9432
test accuracy 0.944
test accuracy 0.9444
test accuracy 0.945
test accuracy 0.9456
test accuracy 0.9458
test accuracy 0.9457
test accuracy 0.9456
test accuracy 0.9468
test accuracy 0.9476
test accuracy 0.9478
test accuracy 0.9483
test accuracy 0.9496
test accuracy 0.9493
test accuracy 0.9487
test accuracy 0.9484
test accuracy 0.9481
test accuracy 0.9477
test accuracy 0.9476
```

```
test accuracy 0.9471
test accuracy 0.9475
test accuracy 0.9483
test accuracy 0.9486
test accuracy 0.9495
test accuracy 0.9494
test accuracy 0.9493
test accuracy 0.9495
test accuracy 0.9506
test accuracy 0.9501
test accuracy 0.9498
test accuracy 0.9499
test accuracy 0.9502
test accuracy 0.9503
test accuracy 0.9513
test accuracy 0.9511
test accuracy 0.951
test accuracy 0.9503
test accuracy 0.9502
test accuracy 0.9503
test accuracy 0.9502
test accuracy 0.95
test accuracy 0.9502
test accuracy 0.9501
test accuracy 0.9503
test accuracy 0.9509
test accuracy 0.9502
test accuracy 0.95
test accuracy 0.9502
test accuracy 0.9502
test accuracy 0.9507
test accuracy 0.9504
test accuracy 0.9507
test accuracy 0.95
test accuracy 0.95
test accuracy 0.9497
test accuracy 0.9502
test accuracy 0.95
test accuracy 0.95
test accuracy 0.9504
test accuracy 0.9506
test accuracy 0.9511
test accuracy 0.9509
test accuracy 0.951
test accuracy 0.951
test accuracy 0.9514
test accuracy 0.9512
test accuracy 0.9511
test accuracy 0.9509
test accuracy 0.951
test accuracy 0.9513
test accuracy 0.9512
test accuracy 0.9518
test accuracy 0.9521
```

```
test accuracy 0.9519
test accuracy 0.952
test accuracy 0.951
test accuracy 0.9513
test accuracy 0.9515
test accuracy 0.9507
test accuracy 0.9504
test accuracy 0.9503
test accuracy 0.9501
test accuracy 0.95
test accuracy 0.9498
test accuracy 0.9491
test accuracy 0.9487
test accuracy 0.9491
test accuracy 0.9487
step 900, training accuracy 0.94
test accuracy 0.9486
test accuracy 0.9482
test accuracy 0.9478
test accuracy 0.9479
test accuracy 0.9475
test accuracy 0.9473
test accuracy 0.9471
test accuracy 0.9471
test accuracy 0.9474
test accuracy 0.947
test accuracy 0.9477
test accuracy 0.9479
test accuracy 0.9483
test accuracy 0.9488
test accuracy 0.9492
test accuracy 0.9493
test accuracy 0.9492
test accuracy 0.9494
test accuracy 0.9491
test accuracy 0.9488
test accuracy 0.948
test accuracy 0.948
test accuracy 0.9486
test accuracy 0.9488
test accuracy 0.9491
test accuracy 0.9499
test accuracy 0.9503
test accuracy 0.9502
test accuracy 0.9496
test accuracy 0.9506
test accuracy 0.951
test accuracy 0.9504
test accuracy 0.9495
test accuracy 0.9487
test accuracy 0.9483
test accuracy 0.9485
test accuracy 0.9482
test accuracy 0.948
```

```
test accuracy 0.948
test accuracy 0.9478
test accuracy 0.9475
test accuracy 0.9479
test accuracy 0.9484
test accuracy 0.9506
test accuracy 0.952
test accuracy 0.9531
test accuracy 0.9531
test accuracy 0.9531
test accuracy 0.9533
test accuracy 0.954
test accuracy 0.9538
test accuracy 0.953
test accuracy 0.9525
test accuracy 0.9528
test accuracy 0.9531
test accuracy 0.9543
test accuracy 0.9545
test accuracy 0.9542
test accuracy 0.9538
test accuracy 0.9544
test accuracy 0.9542
test accuracy 0.9538
test accuracy 0.9535
test accuracy 0.9526
test accuracy 0.9525
test accuracy 0.9517
test accuracy 0.9511
test accuracy 0.9511
test accuracy 0.9509
test accuracy 0.9506
test accuracy 0.9496
test accuracy 0.9487
test accuracy 0.9491
test accuracy 0.9499
test accuracy 0.9502
test accuracy 0.951
test accuracy 0.952
test accuracy 0.9526
test accuracy 0.9529
test accuracy 0.9527
test accuracy 0.9532
test accuracy 0.9534
test accuracy 0.9532
test accuracy 0.9535
test accuracy 0.9535
test accuracy 0.9536
test accuracy 0.9533
test accuracy 0.9535
test accuracy 0.9528
test accuracy 0.9525
test accuracy 0.952
test accuracy 0.9516
```



```
test accuracy 0.9523
test accuracy 0.952
test accuracy 0.9515
test accuracy 0.9512
test accuracy 0.9507
test accuracy 0.9502
test accuracy 0.9501
test accuracy 0.9498
step 1000, training accuracy 0.96
test accuracy 0.9498
test accuracy 0.9496
test accuracy 0.9501
test accuracy 0.9506
test accuracy 0.9507
test accuracy 0.9513
test accuracy 0.9516
test accuracy 0.9525
test accuracy 0.9529
test accuracy 0.9539
test accuracy 0.9535
test accuracy 0.953
test accuracy 0.9526
test accuracy 0.9523
test accuracy 0.9521
test accuracy 0.9518
test accuracy 0.9508
test accuracy 0.9498
test accuracy 0.9497
test accuracy 0.9495
test accuracy 0.9503
test accuracy 0.9515
test accuracy 0.9524
test accuracy 0.9534
test accuracy 0.9539
test accuracy 0.9541
test accuracy 0.9544
test accuracy 0.9547
test accuracy 0.9547
test accuracy 0.9543
test accuracy 0.9543
test accuracy 0.954
test accuracy 0.9539
test accuracy 0.9538
test accuracy 0.9539
test accuracy 0.9539
test accuracy 0.9543
test accuracy 0.9543
test accuracy 0.955
test accuracy 0.9552
test accuracy 0.9551
test accuracy 0.9552
test accuracy 0.955
test accuracy 0.9547
test accuracy 0.9545
```

```
test accuracy 0.9543
test accuracy 0.9541
test accuracy 0.9539
test accuracy 0.954
test accuracy 0.9541
test accuracy 0.954
test accuracy 0.9542
test accuracy 0.954
test accuracy 0.9542
test accuracy 0.9547
test accuracy 0.9544
test accuracy 0.954
test accuracy 0.9546
test accuracy 0.9543
test accuracy 0.9544
test accuracy 0.9542
test accuracy 0.9544
test accuracy 0.9549
test accuracy 0.9552
test accuracy 0.9553
test accuracy 0.9547
test accuracy 0.955
test accuracy 0.9551
test accuracy 0.9545
test accuracy 0.9542
test accuracy 0.9539
test accuracy 0.9538
test accuracy 0.9542
test accuracy 0.9544
test accuracy 0.9551
test accuracy 0.9551
test accuracy 0.9557
test accuracy 0.9559
test accuracy 0.956
test accuracy 0.9559
test accuracy 0.9561
test accuracy 0.9562
test accuracy 0.9564
test accuracy 0.9563
test accuracy 0.9562
test accuracy 0.9559
test accuracy 0.9557
test accuracy 0.9556
test accuracy 0.9553
test accuracy 0.9551
test accuracy 0.956
test accuracy 0.9561
test accuracy 0.9562
test accuracy 0.9561
test accuracy 0.9558
test accuracy 0.9551
test accuracy 0.9548
test accuracy 0.9552
test accuracy 0.9553
```

```
test accuracy 0.9558
step 1100, training accuracy 0.96
test accuracy 0.9553
test accuracy 0.9551
test accuracy 0.9554
test accuracy 0.9555
test accuracy 0.9559
test accuracy 0.9568
test accuracy 0.9569
test accuracy 0.9563
test accuracy 0.9564
test accuracy 0.9565
test accuracy 0.9565
test accuracy 0.9563
test accuracy 0.9567
test accuracy 0.9563
test accuracy 0.9564
test accuracy 0.9563
test accuracy 0.9557
test accuracy 0.955
test accuracy 0.9547
test accuracy 0.954
test accuracy 0.9543
test accuracy 0.9536
test accuracy 0.9532
test accuracy 0.9526
test accuracy 0.9521
test accuracy 0.9511
test accuracy 0.9514
test accuracy 0.9518
test accuracy 0.952
test accuracy 0.9517
test accuracy 0.9518
test accuracy 0.9525
test accuracy 0.9533
test accuracy 0.9536
test accuracy 0.954
test accuracy 0.9541
test accuracy 0.9546
test accuracy 0.9551
test accuracy 0.9546
test accuracy 0.9548
test accuracy 0.9547
test accuracy 0.9549
test accuracy 0.9553
test accuracy 0.9556
test accuracy 0.956
test accuracy 0.9564
test accuracy 0.9565
test accuracy 0.9564
test accuracy 0.9567
test accuracy 0.9567
test accuracy 0.9565
test accuracy 0.9565
```

```
test accuracy 0.9569
test accuracy 0.9569
test accuracy 0.957
test accuracy 0.9569
test accuracy 0.9572
test accuracy 0.9577
test accuracy 0.9573
test accuracy 0.9563
test accuracy 0.9554
test accuracy 0.9541
test accuracy 0.9536
test accuracy 0.9528
test accuracy 0.9526
test accuracy 0.9521
test accuracy 0.9521
test accuracy 0.9525
test accuracy 0.9536
test accuracy 0.9542
test accuracy 0.9549
test accuracy 0.956
test accuracy 0.9565
test accuracy 0.9571
test accuracy 0.9569
test accuracy 0.9567
test accuracy 0.9568
test accuracy 0.957
test accuracy 0.9565
test accuracy 0.9559
test accuracy 0.956
test accuracy 0.9563
test accuracy 0.9566
test accuracy 0.9571
test accuracy 0.9574
test accuracy 0.9576
test accuracy 0.9583
test accuracy 0.9581
test accuracy 0.9583
test accuracy 0.9582
test accuracy 0.9583
test accuracy 0.9578
test accuracy 0.9579
test accuracy 0.958
test accuracy 0.9582
test accuracy 0.9583
test accuracy 0.9582
test accuracy 0.9587
test accuracy 0.9587
test accuracy 0.9586
step 1200, training accuracy 0.98
test accuracy 0.9584
test accuracy 0.958
test accuracy 0.9581
test accuracy 0.9577
test accuracy 0.9583
```

```
test accuracy 0.9583
test accuracy 0.9579
test accuracy 0.9575
test accuracy 0.9571
test accuracy 0.9568
test accuracy 0.9576
test accuracy 0.9587
test accuracy 0.9587
test accuracy 0.9589
test accuracy 0.9586
test accuracy 0.9587
test accuracy 0.9583
test accuracy 0.9582
test accuracy 0.9587
test accuracy 0.9587
test accuracy 0.9586
test accuracy 0.9581
test accuracy 0.9583
test accuracy 0.958
test accuracy 0.9577
test accuracy 0.9575
test accuracy 0.9577
test accuracy 0.9581
test accuracy 0.9578
test accuracy 0.9576
test accuracy 0.9573
test accuracy 0.9564
test accuracy 0.9564
test accuracy 0.9549
test accuracy 0.9542
test accuracy 0.9538
test accuracy 0.9535
test accuracy 0.9536
test accuracy 0.9532
test accuracy 0.9535
test accuracy 0.9538
test accuracy 0.9543
test accuracy 0.9547
test accuracy 0.9561
test accuracy 0.9563
test accuracy 0.9569
test accuracy 0.9565
test accuracy 0.9578
test accuracy 0.9576
test accuracy 0.9576
test accuracy 0.9585
test accuracy 0.9584
test accuracy 0.9586
test accuracy 0.9584
test accuracy 0.9584
test accuracy 0.9591
test accuracy 0.9596
test accuracy 0.9601
test accuracy 0.9599
```

```
test accuracy 0.9604
test accuracy 0.9604
test accuracy 0.9599
test accuracy 0.9591
test accuracy 0.9587
test accuracy 0.9587
test accuracy 0.959
test accuracy 0.9588
test accuracy 0.9589
test accuracy 0.9593
test accuracy 0.9593
test accuracy 0.9597
test accuracy 0.9597
test accuracy 0.9596
test accuracy 0.959
test accuracy 0.9593
test accuracy 0.9588
test accuracy 0.9586
test accuracy 0.9581
test accuracy 0.9583
test accuracy 0.9583
test accuracy 0.9581
test accuracy 0.9579
test accuracy 0.9583
test accuracy 0.9581
test accuracy 0.9582
test accuracy 0.9583
test accuracy 0.9581
test accuracy 0.958
test accuracy 0.9582
test accuracy 0.9582
test accuracy 0.958
test accuracy 0.9579
test accuracy 0.9579
test accuracy 0.9582
test accuracy 0.9579
test accuracy 0.9575
test accuracy 0.9572
test accuracy 0.9571
test accuracy 0.9574
test accuracy 0.9571
step 1300, training accuracy 0.98
test accuracy 0.9564
test accuracy 0.9566
test accuracy 0.9565
test accuracy 0.9566
test accuracy 0.9569
test accuracy 0.9575
test accuracy 0.9577
test accuracy 0.9579
test accuracy 0.9582
test accuracy 0.9581
test accuracy 0.958
test accuracy 0.9581
```

```
test accuracy 0.9579
test accuracy 0.9581
test accuracy 0.9584
test accuracy 0.9587
test accuracy 0.9591
test accuracy 0.9592
test accuracy 0.9589
test accuracy 0.9589
test accuracy 0.9591
test accuracy 0.9589
test accuracy 0.9586
test accuracy 0.9589
test accuracy 0.9596
test accuracy 0.9602
test accuracy 0.9603
test accuracy 0.9602
test accuracy 0.9599
test accuracy 0.9597
test accuracy 0.9594
test accuracy 0.9594
test accuracy 0.9594
test accuracy 0.9592
test accuracy 0.9595
test accuracy 0.9596
test accuracy 0.9594
test accuracy 0.9596
test accuracy 0.9595
test accuracy 0.9597
test accuracy 0.9599
test accuracy 0.9603
test accuracy 0.9599
test accuracy 0.9607
test accuracy 0.9607
test accuracy 0.9613
test accuracy 0.9616
test accuracy 0.9616
test accuracy 0.9614
test accuracy 0.9611
test accuracy 0.9609
test accuracy 0.9608
test accuracy 0.9603
test accuracy 0.9594
test accuracy 0.9595
test accuracy 0.9592
test accuracy 0.9593
test accuracy 0.9599
test accuracy 0.9601
test accuracy 0.9611
test accuracy 0.9615
test accuracy 0.9612
test accuracy 0.9612
test accuracy 0.961
test accuracy 0.9609
test accuracy 0.9612
```

```
test accuracy 0.9615
test accuracy 0.9609
test accuracy 0.9608
test accuracy 0.961
test accuracy 0.9601
test accuracy 0.9603
test accuracy 0.9605
test accuracy 0.9606
test accuracy 0.9601
test accuracy 0.9597
test accuracy 0.9599
test accuracy 0.9599
test accuracy 0.9597
test accuracy 0.96
test accuracy 0.9599
test accuracy 0.9598
test accuracy 0.9595
test accuracy 0.9606
test accuracy 0.9608
test accuracy 0.9608
test accuracy 0.9614
test accuracy 0.9623
test accuracy 0.9622
test accuracy 0.9622
test accuracy 0.9623
test accuracy 0.9622
test accuracy 0.9621
test accuracy 0.9624
test accuracy 0.9625
test accuracy 0.9622
test accuracy 0.9619
test accuracy 0.9616
test accuracy 0.9616
test accuracy 0.9612
step 1400, training accuracy 1
test accuracy 0.9608
test accuracy 0.9598
test accuracy 0.9599
test accuracy 0.9594
test accuracy 0.959
test accuracy 0.9586
test accuracy 0.9591
test accuracy 0.9584
test accuracy 0.958
test accuracy 0.9586
test accuracy 0.9592
test accuracy 0.959
test accuracy 0.9597
test accuracy 0.9603
test accuracy 0.96
test accuracy 0.9603
test accuracy 0.9607
test accuracy 0.9611
test accuracy 0.9622
```



```
test accuracy 0.9624
test accuracy 0.9622
test accuracy 0.9622
test accuracy 0.9616
test accuracy 0.9615
test accuracy 0.9621
test accuracy 0.9619
test accuracy 0.9616
test accuracy 0.9615
test accuracy 0.9611
test accuracy 0.9617
test accuracy 0.9621
test accuracy 0.9617
test accuracy 0.9623
test accuracy 0.9625
test accuracy 0.9624
test accuracy 0.9622
test accuracy 0.9625
test accuracy 0.9626
test accuracy 0.9629
test accuracy 0.9625
test accuracy 0.9625
test accuracy 0.9626
test accuracy 0.9632
test accuracy 0.963
test accuracy 0.963
test accuracy 0.9632
test accuracy 0.963
test accuracy 0.9625
test accuracy 0.9626
test accuracy 0.9623
test accuracy 0.9622
test accuracy 0.9624
test accuracy 0.9624
test accuracy 0.962
test accuracy 0.962
test accuracy 0.9626
test accuracy 0.9628
test accuracy 0.9624
test accuracy 0.9624
test accuracy 0.9619
test accuracy 0.9618
test accuracy 0.9615
test accuracy 0.9615
test accuracy 0.9621
test accuracy 0.9622
test accuracy 0.9615
test accuracy 0.9614
test accuracy 0.9614
test accuracy 0.961
test accuracy 0.9609
test accuracy 0.9611
test accuracy 0.9612
test accuracy 0.9616
```

```
test accuracy 0.9619
test accuracy 0.9628
test accuracy 0.9628
test accuracy 0.9632
test accuracy 0.9635
test accuracy 0.9627
test accuracy 0.9627
test accuracy 0.9625
test accuracy 0.9627
test accuracy 0.9624
test accuracy 0.9624
test accuracy 0.9626
test accuracy 0.9623
test accuracy 0.9623
test accuracy 0.9627
test accuracy 0.9623
test accuracy 0.9627
test accuracy 0.9628
test accuracy 0.9632
test accuracy 0.9628
test accuracy 0.9628
test accuracy 0.9626
test accuracy 0.9624
test accuracy 0.9627
test accuracy 0.9628
test accuracy 0.963
test accuracy 0.9628
step 1500, training accuracy 0.96
test accuracy 0.9624
test accuracy 0.9632
test accuracy 0.9636
test accuracy 0.9639
test accuracy 0.9635
test accuracy 0.9635
test accuracy 0.9637
test accuracy 0.964
test accuracy 0.9641
test accuracy 0.9637
test accuracy 0.9642
test accuracy 0.9637
test accuracy 0.9634
test accuracy 0.9633
test accuracy 0.9626
test accuracy 0.9619
test accuracy 0.9616
test accuracy 0.9614
test accuracy 0.9617
test accuracy 0.9621
test accuracy 0.9619
test accuracy 0.962
test accuracy 0.9616
test accuracy 0.9617
test accuracy 0.9621
test accuracy 0.9622
```

```
test accuracy 0.9619
test accuracy 0.9627
test accuracy 0.9626
test accuracy 0.9627
test accuracy 0.9627
test accuracy 0.9633
test accuracy 0.9632
test accuracy 0.9639
test accuracy 0.9639
test accuracy 0.9643
test accuracy 0.9641
test accuracy 0.9641
test accuracy 0.9644
test accuracy 0.9641
test accuracy 0.9638
test accuracy 0.9637
test accuracy 0.9632
test accuracy 0.9636
test accuracy 0.9636
test accuracy 0.9641
test accuracy 0.9641
test accuracy 0.9638
test accuracy 0.9637
test accuracy 0.9638
test accuracy 0.9636
test accuracy 0.9638
test accuracy 0.964
test accuracy 0.9639
test accuracy 0.9638
test accuracy 0.9638
test accuracy 0.9639
test accuracy 0.9636
test accuracy 0.9638
test accuracy 0.9639
test accuracy 0.9632
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test accuracy 0.9625
test accuracy 0.9629
test accuracy 0.9626
test accuracy 0.9629
test accuracy 0.9632
test accuracy 0.9633
test accuracy 0.9632
test accuracy 0.9639
test accuracy 0.9646
test accuracy 0.9648
test accuracy 0.9645
test accuracy 0.9632
test accuracy 0.9632
test accuracy 0.9633
test accuracy 0.9634
test accuracy 0.9633
```

```
test accuracy 0.9631
test accuracy 0.9634
test accuracy 0.9634
test accuracy 0.9636
test accuracy 0.9634
test accuracy 0.9635
test accuracy 0.9634
test accuracy 0.9633
test accuracy 0.9641
test accuracy 0.9639
test accuracy 0.9637
test accuracy 0.9639
test accuracy 0.9635
test accuracy 0.9635
test accuracy 0.9638
test accuracy 0.9633
test accuracy 0.9629
test accuracy 0.9628
test accuracy 0.9635
test accuracy 0.9633
step 1600, training accuracy 0.98
test accuracy 0.9637
test accuracy 0.9636
test accuracy 0.9634
test accuracy 0.9636
test accuracy 0.9642
test accuracy 0.9639
test accuracy 0.9644
test accuracy 0.9648
test accuracy 0.9648
test accuracy 0.9644
test accuracy 0.9647
test accuracy 0.9652
test accuracy 0.9655
test accuracy 0.9656
test accuracy 0.9656
test accuracy 0.9658
test accuracy 0.966
test accuracy 0.9658
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test accuracy 0.9654
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test accuracy 0.9658
test accuracy 0.9658
test accuracy 0.9659
test accuracy 0.9662
test accuracy 0.9661
test accuracy 0.9661
test accuracy 0.9664
test accuracy 0.9667
test accuracy 0.9666
test accuracy 0.9663
test accuracy 0.9664
test accuracy 0.9666
```

```
test accuracy 0.9666
test accuracy 0.9663
test accuracy 0.9661
test accuracy 0.9661
test accuracy 0.966
test accuracy 0.9659
test accuracy 0.9662
test accuracy 0.9661
test accuracy 0.966
test accuracy 0.9664
test accuracy 0.9665
test accuracy 0.9664
test accuracy 0.9668
test accuracy 0.9666
test accuracy 0.9661
test accuracy 0.966
test accuracy 0.9657
test accuracy 0.965
test accuracy 0.9643
test accuracy 0.9641
test accuracy 0.9643
test accuracy 0.9642
test accuracy 0.964
test accuracy 0.9633
test accuracy 0.9633
test accuracy 0.9633
test accuracy 0.9633
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test accuracy 0.9633
test accuracy 0.9634
test accuracy 0.9632
test accuracy 0.9635
test accuracy 0.9637
test accuracy 0.9639
test accuracy 0.9639
test accuracy 0.9638
test accuracy 0.9641
test accuracy 0.964
test accuracy 0.9645
test accuracy 0.9643
test accuracy 0.9646
test accuracy 0.9651
test accuracy 0.9652
test accuracy 0.966
test accuracy 0.9662
test accuracy 0.9659
test accuracy 0.966
test accuracy 0.9665
test accuracy 0.9663
test accuracy 0.9663
test accuracy 0.9657
test accuracy 0.9656
test accuracy 0.9657
test accuracy 0.9657
```

```
test accuracy 0.9658
test accuracy 0.9659
test accuracy 0.9654
test accuracy 0.9651
test accuracy 0.9649
test accuracy 0.9651
test accuracy 0.9646
test accuracy 0.9643
test accuracy 0.9643
test accuracy 0.9646
test accuracy 0.9646
test accuracy 0.9645
test accuracy 0.9644
step 1700, training accuracy 0.98
test accuracy 0.9647
test accuracy 0.9649
test accuracy 0.9657
test accuracy 0.9656
test accuracy 0.9648
test accuracy 0.9654
test accuracy 0.9656
test accuracy 0.9655
test accuracy 0.9656
test accuracy 0.9657
test accuracy 0.966
test accuracy 0.9662
test accuracy 0.9659
test accuracy 0.9662
test accuracy 0.966
test accuracy 0.966
test accuracy 0.9664
test accuracy 0.9665
test accuracy 0.9669
test accuracy 0.9669
test accuracy 0.9663
test accuracy 0.9657
test accuracy 0.9657
test accuracy 0.966
test accuracy 0.9659
test accuracy 0.9656
test accuracy 0.966
test accuracy 0.9665
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test accuracy 0.9662
test accuracy 0.9663
test accuracy 0.9662
test accuracy 0.966
test accuracy 0.9664
test accuracy 0.9661
test accuracy 0.9661
test accuracy 0.9659
test accuracy 0.9655
test accuracy 0.9653
test accuracy 0.9652
```

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test accuracy 0.9651
test accuracy 0.9647
test accuracy 0.9647
test accuracy 0.9648
test accuracy 0.9645
test accuracy 0.9643
test accuracy 0.9647
test accuracy 0.9647
test accuracy 0.9653
test accuracy 0.9658
test accuracy 0.966
test accuracy 0.9665
test accuracy 0.9666
test accuracy 0.9664
test accuracy 0.966
test accuracy 0.9661
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test accuracy 0.966
test accuracy 0.9657
test accuracy 0.9654
test accuracy 0.9656
test accuracy 0.9661
test accuracy 0.966
test accuracy 0.9663
test accuracy 0.9662
test accuracy 0.9663
test accuracy 0.9666
test accuracy 0.9665
test accuracy 0.9661
test accuracy 0.9662
test accuracy 0.966
test accuracy 0.9656
test accuracy 0.9659
test accuracy 0.9656
test accuracy 0.965
test accuracy 0.9652
test accuracy 0.9651
test accuracy 0.9662
test accuracy 0.966
test accuracy 0.966
test accuracy 0.9664
test accuracy 0.9664
test accuracy 0.9664
test accuracy 0.9664
test accuracy 0.9665
test accuracy 0.9664
test accuracy 0.9661
test accuracy 0.9658
test accuracy 0.9654
test accuracy 0.9652
test accuracy 0.9646
test accuracy 0.9649
test accuracy 0.9646
```

```
test accuracy 0.9646
test accuracy 0.9648
test accuracy 0.9653
test accuracy 0.9655
test accuracy 0.9659
test accuracy 0.9658
step 1800, training accuracy 0.96
test accuracy 0.9663
test accuracy 0.9668
test accuracy 0.9672
test accuracy 0.9673
test accuracy 0.9674
test accuracy 0.9676
test accuracy 0.9672
test accuracy 0.9672
test accuracy 0.9671
test accuracy 0.9668
test accuracy 0.966
test accuracy 0.9659
test accuracy 0.9654
test accuracy 0.9654
test accuracy 0.9655
test accuracy 0.9657
test accuracy 0.9661
test accuracy 0.9661
test accuracy 0.9657
test accuracy 0.9656
test accuracy 0.9658
test accuracy 0.966
test accuracy 0.966
test accuracy 0.9655
test accuracy 0.9653
test accuracy 0.9652
test accuracy 0.9655
test accuracy 0.9656
test accuracy 0.9662
test accuracy 0.9662
test accuracy 0.9664
test accuracy 0.9663
test accuracy 0.9662
test accuracy 0.9662
test accuracy 0.9662
test accuracy 0.9662
test accuracy 0.9666
test accuracy 0.9668
test accuracy 0.9669
test accuracy 0.9668
test accuracy 0.967
test accuracy 0.9673
test accuracy 0.9673
test accuracy 0.9676
test accuracy 0.9678
test accuracy 0.9681
test accuracy 0.968
test accuracy 0.9678
```



```
test accuracy 0.9679
test accuracy 0.9681
test accuracy 0.9681
test accuracy 0.9684
test accuracy 0.9686
test accuracy 0.9685
test accuracy 0.9681
test accuracy 0.9675
test accuracy 0.9671
test accuracy 0.9665
test accuracy 0.9661
test accuracy 0.9662
test accuracy 0.9667
test accuracy 0.9668
test accuracy 0.9665
test accuracy 0.9668
test accuracy 0.9671
test accuracy 0.967
test accuracy 0.9672
test accuracy 0.9677
test accuracy 0.9684
test accuracy 0.9682
test accuracy 0.9681
test accuracy 0.9683
test accuracy 0.9682
test accuracy 0.9678
test accuracy 0.9677
test accuracy 0.9674
test accuracy 0.9672
test accuracy 0.9672
test accuracy 0.967
test accuracy 0.9672
test accuracy 0.9671
test accuracy 0.9673
test accuracy 0.9677
test accuracy 0.9679
test accuracy 0.9681
test accuracy 0.9685
test accuracy 0.9683
test accuracy 0.9683
test accuracy 0.9679
test accuracy 0.9674
test accuracy 0.9674
test accuracy 0.9673
test accuracy 0.9669
test accuracy 0.9665
test accuracy 0.9667
test accuracy 0.9664
test accuracy 0.966
test accuracy 0.9659
test accuracy 0.9657
test accuracy 0.9663
test accuracy 0.9667
step 1900, training accuracy 0.98
```

```
test accuracy 0.9668
test accuracy 0.9671
test accuracy 0.9669
test accuracy 0.9668
test accuracy 0.9667
test accuracy 0.9665
test accuracy 0.9664
test accuracy 0.9673
test accuracy 0.9674
test accuracy 0.9669
test accuracy 0.9672
test accuracy 0.9677
test accuracy 0.9672
test accuracy 0.967
test accuracy 0.9668
test accuracy 0.9666
test accuracy 0.9663
test accuracy 0.9666
test accuracy 0.9664
test accuracy 0.9669
test accuracy 0.9666
test accuracy 0.9667
test accuracy 0.9669
test accuracy 0.9666
test accuracy 0.9666
test accuracy 0.9672
test accuracy 0.967
test accuracy 0.9671
test accuracy 0.9671
test accuracy 0.9672
test accuracy 0.9677
test accuracy 0.9675
test accuracy 0.9674
test accuracy 0.9674
test accuracy 0.9672
test accuracy 0.9673
test accuracy 0.9668
test accuracy 0.9671
test accuracy 0.9671
test accuracy 0.9676
test accuracy 0.9675
test accuracy 0.9678
test accuracy 0.968
test accuracy 0.968
test accuracy 0.9682
test accuracy 0.9685
test accuracy 0.9685
test accuracy 0.9683
test accuracy 0.9683
test accuracy 0.968
test accuracy 0.9675
test accuracy 0.9673
test accuracy 0.9676
test accuracy 0.9674
```

```
test accuracy 0.967
test accuracy 0.9673
test accuracy 0.9677
test accuracy 0.9684
test accuracy 0.9682
test accuracy 0.968
test accuracy 0.9684
test accuracy 0.9682
test accuracy 0.9687
test accuracy 0.9685
test accuracy 0.9688
test accuracy 0.969
test accuracy 0.969
test accuracy 0.9691
test accuracy 0.9694
test accuracy 0.9692
test accuracy 0.969
test accuracy 0.9689
test accuracy 0.9688
test accuracy 0.969
test accuracy 0.9688
test accuracy 0.9686
test accuracy 0.9683
test accuracy 0.9682
test accuracy 0.9681
test accuracy 0.9686
test accuracy 0.9688
test accuracy 0.9687
test accuracy 0.9681
test accuracy 0.9682
test accuracy 0.9673
test accuracy 0.9673
test accuracy 0.967
test accuracy 0.9669
test accuracy 0.9674
test accuracy 0.9676
test accuracy 0.9679
test accuracy 0.9681
test accuracy 0.9684
test accuracy 0.9682
test accuracy 0.9682
test accuracy 0.9683
test accuracy 0.9683
test accuracy 0.9686
test accuracy 0.9693
test accuracy 0.97
step 2000, training accuracy 0.98
test accuracy 0.9699
test accuracy 0.9695
test accuracy 0.9697
test accuracy 0.9698
test accuracy 0.9698
test accuracy 0.9696
test accuracy 0.9696
```

```
test accuracy 0.97
test accuracy 0.9703
test accuracy 0.9702
test accuracy 0.9701
test accuracy 0.9698
test accuracy 0.9697
test accuracy 0.9698
test accuracy 0.9698
test accuracy 0.9698
test accuracy 0.9695
test accuracy 0.9698
test accuracy 0.9694
test accuracy 0.9693
test accuracy 0.9694
test accuracy 0.9691
test accuracy 0.9693
test accuracy 0.9695
test accuracy 0.9696
test accuracy 0.9693
test accuracy 0.9693
test accuracy 0.9694
test accuracy 0.9694
test accuracy 0.9696
test accuracy 0.9693
test accuracy 0.9695
test accuracy 0.969
test accuracy 0.9687
test accuracy 0.9682
test accuracy 0.9687
test accuracy 0.9683
test accuracy 0.9684
test accuracy 0.9686
test accuracy 0.9686
test accuracy 0.9686
test accuracy 0.9685
test accuracy 0.9678
test accuracy 0.9682
test accuracy 0.9685
test accuracy 0.9688
test accuracy 0.9685
test accuracy 0.9683
test accuracy 0.9681
test accuracy 0.9685
test accuracy 0.9689
test accuracy 0.9688
test accuracy 0.969
test accuracy 0.9693
test accuracy 0.9693
test accuracy 0.9693
test accuracy 0.9696
test accuracy 0.9689
test accuracy 0.9689
test accuracy 0.9687
test accuracy 0.9691
```

```
test accuracy 0.9689
test accuracy 0.9689
test accuracy 0.9689
test accuracy 0.969
test accuracy 0.9691
test accuracy 0.9692
test accuracy 0.9689
test accuracy 0.9688
test accuracy 0.9686
test accuracy 0.9682
test accuracy 0.968
test accuracy 0.9678
test accuracy 0.968
test accuracy 0.9681
test accuracy 0.9684
test accuracy 0.9684
test accuracy 0.9685
test accuracy 0.969
test accuracy 0.9694
test accuracy 0.9693
test accuracy 0.969
test accuracy 0.9681
test accuracy 0.9682
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test accuracy 0.9684
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test accuracy 0.9687
test accuracy 0.9687
test accuracy 0.9682
test accuracy 0.9687
step 2100, training accuracy 0.98
test accuracy 0.9691
test accuracy 0.9693
test accuracy 0.97
test accuracy 0.9706
test accuracy 0.9704
test accuracy 0.9704
test accuracy 0.9705
test accuracy 0.9702
test accuracy 0.9706
test accuracy 0.9707
test accuracy 0.9704
test accuracy 0.9697
test accuracy 0.9697
test accuracy 0.9696
```

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test accuracy 0.9694
test accuracy 0.9693
test accuracy 0.9694
test accuracy 0.9687
test accuracy 0.9691
test accuracy 0.969
test accuracy 0.9684
test accuracy 0.9684
test accuracy 0.968
test accuracy 0.9681
test accuracy 0.968
test accuracy 0.9682
test accuracy 0.968
test accuracy 0.9684
test accuracy 0.9684
test accuracy 0.9687
test accuracy 0.9687
test accuracy 0.9691
test accuracy 0.9699
test accuracy 0.9697
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test accuracy 0.9698
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test accuracy 0.9698
test accuracy 0.97
test accuracy 0.9696
test accuracy 0.97
test accuracy 0.9701
test accuracy 0.9695
test accuracy 0.9698
test accuracy 0.9697
test accuracy 0.9697
test accuracy 0.9696
test accuracy 0.9697
test accuracy 0.9701
test accuracy 0.97
test accuracy 0.9703
test accuracy 0.9705
test accuracy 0.9703
test accuracy 0.9702
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test accuracy 0.9703
test accuracy 0.9705
test accuracy 0.9705
test accuracy 0.9703
test accuracy 0.9698
test accuracy 0.9693
test accuracy 0.9696
test accuracy 0.9692
test accuracy 0.9691
test accuracy 0.9689
test accuracy 0.969
```

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test accuracy 0.9693
test accuracy 0.9697
test accuracy 0.9696
test accuracy 0.9699
test accuracy 0.9702
test accuracy 0.9697
test accuracy 0.9697
test accuracy 0.97
test accuracy 0.9694
test accuracy 0.9696
test accuracy 0.9694
test accuracy 0.9698
test accuracy 0.9704
test accuracy 0.9704
test accuracy 0.9708
test accuracy 0.9707
test accuracy 0.9703
test accuracy 0.97
test accuracy 0.9701
test accuracy 0.9699
test accuracy 0.9697
test accuracy 0.9696
test accuracy 0.9694
test accuracy 0.9689
test accuracy 0.9693
test accuracy 0.97
test accuracy 0.9703
test accuracy 0.97
test accuracy 0.9695
test accuracy 0.9701
test accuracy 0.9696
test accuracy 0.9699
step 2200, training accuracy 0.98
test accuracy 0.9695
test accuracy 0.9697
test accuracy 0.9694
test accuracy 0.9694
test accuracy 0.9693
test accuracy 0.9691
test accuracy 0.9689
test accuracy 0.9688
test accuracy 0.9692
test accuracy 0.9692
test accuracy 0.9689
test accuracy 0.9688
test accuracy 0.9689
test accuracy 0.9683
test accuracy 0.968
test accuracy 0.9683
test accuracy 0.9689
test accuracy 0.9688
test accuracy 0.969
test accuracy 0.9693
test accuracy 0.9698
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test accuracy 0.9704
test accuracy 0.9705
test accuracy 0.9709
test accuracy 0.971
test accuracy 0.971
test accuracy 0.9713
test accuracy 0.9711
test accuracy 0.9711
test accuracy 0.9712
test accuracy 0.9711
test accuracy 0.9709
test accuracy 0.9711
test accuracy 0.9707
test accuracy 0.9702
test accuracy 0.9708
test accuracy 0.9706
test accuracy 0.9704
test accuracy 0.9704
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test accuracy 0.9705
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test accuracy 0.9709
test accuracy 0.9708
test accuracy 0.9708
test accuracy 0.9706
test accuracy 0.9709
test accuracy 0.9707
test accuracy 0.971
test accuracy 0.9716
test accuracy 0.9717
test accuracy 0.9715
test accuracy 0.9712
test accuracy 0.9717
test accuracy 0.9717
test accuracy 0.9718
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test accuracy 0.9699
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test accuracy 0.9697
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test accuracy 0.9687
test accuracy 0.9689
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test accuracy 0.9693
test accuracy 0.9691
test accuracy 0.9695
test accuracy 0.9696
test accuracy 0.9696
test accuracy 0.9697
test accuracy 0.9698
test accuracy 0.9694
test accuracy 0.9696
step 2300, training accuracy 0.94
test accuracy 0.97
test accuracy 0.9703
test accuracy 0.9705
test accuracy 0.9706
test accuracy 0.9705
test accuracy 0.9705
test accuracy 0.9707
test accuracy 0.9708
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test accuracy 0.9717
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test accuracy 0.9713
test accuracy 0.972
test accuracy 0.9721
test accuracy 0.9727
test accuracy 0.9728
test accuracy 0.9726
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test accuracy 0.9721
test accuracy 0.972
test accuracy 0.9719
test accuracy 0.9716
test accuracy 0.9713
test accuracy 0.9708
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test accuracy 0.9718
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test accuracy 0.9722
test accuracy 0.9724
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test accuracy 0.9724
test accuracy 0.9722
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test accuracy 0.9725
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test accuracy 0.9729
test accuracy 0.9721
test accuracy 0.9717
test accuracy 0.9717
test accuracy 0.9716
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test accuracy 0.972
test accuracy 0.9722
step 2400, training accuracy 0.96
test accuracy 0.9724
test accuracy 0.9722
test accuracy 0.9721
test accuracy 0.9722
test accuracy 0.9724
test accuracy 0.9724
test accuracy 0.9726
test accuracy 0.9726
test accuracy 0.973
test accuracy 0.9729
test accuracy 0.9736
test accuracy 0.9739
test accuracy 0.9731
test accuracy 0.973
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test accuracy 0.9731
test accuracy 0.972
test accuracy 0.9717
test accuracy 0.9716
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test accuracy 0.9718
test accuracy 0.9724
test accuracy 0.9727
test accuracy 0.9731
test accuracy 0.9736
test accuracy 0.9734
test accuracy 0.974
test accuracy 0.9739
test accuracy 0.9742
test accuracy 0.9737
test accuracy 0.9738
test accuracy 0.9736
test accuracy 0.9738
test accuracy 0.9734
test accuracy 0.9735
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test accuracy 0.9736
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test accuracy 0.9739
test accuracy 0.9736
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test accuracy 0.9732
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test accuracy 0.9718
test accuracy 0.972
step 2500, training accuracy 0.94
test accuracy 0.972
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test accuracy 0.974
test accuracy 0.9738
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test accuracy 0.974
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test accuracy 0.9741
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test accuracy 0.9748
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test accuracy 0.9739
test accuracy 0.9741
test accuracy 0.974
test accuracy 0.9745
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test accuracy 0.9742
test accuracy 0.9747
test accuracy 0.9747
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test accuracy 0.9749
test accuracy 0.975
test accuracy 0.9753
test accuracy 0.9753
step 2600, training accuracy 1
test accuracy 0.9754
test accuracy 0.9754
test accuracy 0.9757
test accuracy 0.9756
test accuracy 0.9753
test accuracy 0.9754
test accuracy 0.9754
test accuracy 0.9754
test accuracy 0.9754
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test accuracy 0.9753
test accuracy 0.9751
test accuracy 0.9752
test accuracy 0.9746
test accuracy 0.9748
test accuracy 0.9747
test accuracy 0.9746
test accuracy 0.9745
test accuracy 0.9746
test accuracy 0.9748
test accuracy 0.9748
test accuracy 0.9749
test accuracy 0.975
test accuracy 0.9749
test accuracy 0.975
test accuracy 0.9751
test accuracy 0.9748
test accuracy 0.9747
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test accuracy 0.9749
test accuracy 0.975
test accuracy 0.9749
test accuracy 0.9751
test accuracy 0.9752
test accuracy 0.9752
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test accuracy 0.9741
test accuracy 0.9741
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test accuracy 0.9741
test accuracy 0.9743
test accuracy 0.9742
step 2700, training accuracy 0.98
test accuracy 0.9742
test accuracy 0.974
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test accuracy 0.974
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test accuracy 0.974
test accuracy 0.9742
test accuracy 0.9741
test accuracy 0.9748
step 2800, training accuracy 0.96
test accuracy 0.9749
test accuracy 0.975
test accuracy 0.9753
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test accuracy 0.9758
test accuracy 0.9756
test accuracy 0.9753
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test accuracy 0.9759
test accuracy 0.9763
test accuracy 0.9765
test accuracy 0.9764
test accuracy 0.9764
test accuracy 0.9767
test accuracy 0.9761
test accuracy 0.9762
test accuracy 0.9762
test accuracy 0.976
test accuracy 0.9759
step 2900, training accuracy 1
test accuracy 0.9761
test accuracy 0.9764
test accuracy 0.9761
test accuracy 0.9763
test accuracy 0.9762
test accuracy 0.976
test accuracy 0.9761
test accuracy 0.9767
test accuracy 0.9766
test accuracy 0.9763
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test accuracy 0.9758
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test accuracy 0.9767
test accuracy 0.9768
test accuracy 0.9771
test accuracy 0.977
test accuracy 0.9779
test accuracy 0.9783
test accuracy 0.9783
test accuracy 0.9783
test accuracy 0.9778
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test accuracy 0.9777
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test accuracy 0.9784
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test accuracy 0.9779
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test accuracy 0.9768
step 3000, training accuracy 0.96
test accuracy 0.9767
test accuracy 0.9762
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test accuracy 0.9762
test accuracy 0.976
test accuracy 0.9757
test accuracy 0.9762
test accuracy 0.9765
test accuracy 0.9764
step 3100, training accuracy 0.96
test accuracy 0.9771
test accuracy 0.9775
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step 3200, training accuracy 1
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step 3300, training accuracy 0.98
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test accuracy 0.9774
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step 3400, training accuracy 1
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test accuracy 0.9782
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test accuracy 0.9787
step 3500, training accuracy 0.98
test accuracy 0.9785
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test accuracy 0.9785
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test accuracy 0.9784
test accuracy 0.9784
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test accuracy 0.9785
test accuracy 0.9784
test accuracy 0.9786
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test accuracy 0.9784
test accuracy 0.9786
test accuracy 0.9783
test accuracy 0.9784
test accuracy 0.9782
test accuracy 0.9782
test accuracy 0.9783
test accuracy 0.978
test accuracy 0.9782
test accuracy 0.9782
test accuracy 0.9781
test accuracy 0.9781
test accuracy 0.9783
test accuracy 0.9786
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test accuracy 0.9791
test accuracy 0.9793
test accuracy 0.9793
test accuracy 0.9795
test accuracy 0.9799
test accuracy 0.9793
step 3600, training accuracy 0.98
test accuracy 0.9792
test accuracy 0.9786
test accuracy 0.9783
test accuracy 0.9785
test accuracy 0.9786
test accuracy 0.9788
test accuracy 0.9793
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test accuracy 0.9787
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test accuracy 0.9797
test accuracy 0.9801
test accuracy 0.9801
test accuracy 0.9804
test accuracy 0.9804
test accuracy 0.9804
test accuracy 0.9798
test accuracy 0.98
test accuracy 0.98
test accuracy 0.9801
test accuracy 0.9801
test accuracy 0.9802
test accuracy 0.9799
test accuracy 0.9797
test accuracy 0.9792
test accuracy 0.9792
test accuracy 0.9797
test accuracy 0.9801
test accuracy 0.9801
test accuracy 0.9802
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test accuracy 0.9799
test accuracy 0.9797
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test accuracy 0.9785
test accuracy 0.9782
test accuracy 0.9782
test accuracy 0.9782
test accuracy 0.9781
test accuracy 0.9778
test accuracy 0.9774
test accuracy 0.9775
test accuracy 0.9776
test accuracy 0.9775
step 3700, training accuracy 0.94
test accuracy 0.9778
test accuracy 0.9778
test accuracy 0.9779
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test accuracy 0.9789
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test accuracy 0.9802
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test accuracy 0.9793
test accuracy 0.9795
test accuracy 0.9797
test accuracy 0.9798
test accuracy 0.98
test accuracy 0.9802
test accuracy 0.9799
step 3800, training accuracy 0.92
test accuracy 0.9796
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test accuracy 0.9797
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test accuracy 0.98
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test accuracy 0.9802
test accuracy 0.9801
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test accuracy 0.9803
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test accuracy 0.9798
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test accuracy 0.9803
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test accuracy 0.9801
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test accuracy 0.9803
test accuracy 0.9801
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test accuracy 0.9801
step 3900, training accuracy 0.98
test accuracy 0.9801
test accuracy 0.9801
test accuracy 0.9802
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test accuracy 0.9803
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test accuracy 0.9799
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test accuracy 0.9806
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test accuracy 0.9785
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test accuracy 0.9764
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test accuracy 0.9788
test accuracy 0.9795
test accuracy 0.9797
test accuracy 0.9799
test accuracy 0.98
test accuracy 0.9797
step 4000, training accuracy 1
test accuracy 0.9797
test accuracy 0.9799
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test accuracy 0.9796
test accuracy 0.9795
test accuracy 0.9797
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step 4100, training accuracy 0.98
test accuracy 0.9795
test accuracy 0.9798
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test accuracy 0.98
test accuracy 0.9803
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test accuracy 0.9799
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test accuracy 0.9801
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test accuracy 0.981
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test accuracy 0.9824
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step 4200, training accuracy 0.94
test accuracy 0.9826
test accuracy 0.9827
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test accuracy 0.9815
step 4300, training accuracy 1
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step 4400, training accuracy 0.98
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step 4500, training accuracy 0.98
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step 4600, training accuracy 0.98
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test accuracy 0.9809
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step 4700, training accuracy 0.98
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step 4800, training accuracy 0.9
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test accuracy 0.9822
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step 4900, training accuracy 0.98
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step 5000, training accuracy 1
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test accuracy 0.9823
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KeyboardInterrupt                                Traceback (most recent c
all last)
<ipython-input-210-2dbd1c329a04> in <module>()
    16
    17         print('test accuracy %g' % accuracy.eval(feed_dict
={
--> 18             x: mnist.test.images, y_: mnist.test.labels, kee
p_prob: 1.0}))

/Users/assansanogo/Downloads/anaconda2/envs/Assan/lib/python2.7/si
te-packages/tensorflow/python/framework/ops.py in eval(self, feed
_dict, session)
    604
    605         """
--> 606         return _eval_using_default_session(self, feed_dict,
self.graph, session)
    607
    608

/Users/assansanogo/Downloads/anaconda2/envs/Assan/lib/python2.7/si
te-packages/tensorflow/python/framework/ops.py in _eval_using_def
ault_session(tensors, feed_dict, graph, session)
    3926                                     "the tensor's graph is different fr
om the session's "
    3927                                     "graph.")
-> 3928         return session.run(tensors, feed_dict)
    3929
    3930

/Users/assansanogo/Downloads/anaconda2/envs/Assan/lib/python2.7/si
te-packages/tensorflow/python/client/session.py in run(self, fetc
hes, feed_dict, options, run_metadata)
    787         try:
    788             result = self._run(None, fetches, feed_dict, options
_ptr,
--> 789                                     run_metadata_ptr)
    790         if run_metadata:
    791             proto_data = tf_session.TF_GetBuffer(run_metadata_
ptr)

/Users/assansanogo/Downloads/anaconda2/envs/Assan/lib/python2.7/si
te-packages/tensorflow/python/client/session.py in _run(self, han
dle, fetches, feed_dict, options, run_metadata)
    995         if final_fetches or final_targets:
    996             results = self._do_run(handle, final_targets, final_
fetches,
--> 997                                     feed_dict_string, options, ru
n_metadata)
    998         else:
    999             results = []

/Users/assansanogo/Downloads/anaconda2/envs/Assan/lib/python2.7/si
te-packages/tensorflow/python/client/session.py in _do_run(self,

```

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handle, target_list, fetch_list, feed_dict, options, run_metadata)
    1130     if handle is None:
    1131         return self._do_call(_run_fn, self._session, feed_dict,
-> 1132         fetch_list,
                                target_list, options, run_metadata)
    1133     else:
    1134         return self._do_call(_prun_fn, self._session, handle,
, feed_dict,

/Users/assansanogo/Downloads/anaconda2/envs/Assan/lib/python2.7/site-packages/tensorflow/python/client/session.pyc in _do_call(self,
fn, *args)
    1137     def _do_call(self, fn, *args):
    1138         try:
-> 1139             return fn(*args)
    1140     except errors.OpError as e:
    1141         message = compat.as_text(e.message)

/Users/assansanogo/Downloads/anaconda2/envs/Assan/lib/python2.7/site-packages/tensorflow/python/client/session.pyc in _run_fn(session,
feed_dict, fetch_list, target_list, options, run_metadata)
    1119         return tf_session.TF_Run(session, options,
    1120         feed_dict, fetch_list,
target_list,
-> 1121         status, run_metadata)
    1122
    1123     def _prun_fn(session, handle, feed_dict, fetch_list):

KeyboardInterrupt:

```

In []: