```
%tensorflow_version 1.x
```

```
TensorFlow 1.x selected.
```

```
!git clone https://github.com/krzysztofspalinski/deep-learning-methods-project-2.git
!mv deep-learning-methods-project-2 src
```

```
Cloning into 'deep-learning-methods-project-2'...
remote: Enumerating objects: 119, done.
remote: Counting objects: 100% (119/119), done.
remote: Compressing objects: 100% (90/90), done.
remote: Total 119 (delta 39), reused 98 (delta 24), pack-reused 0
Receiving objects: 100% (119/119), 3.17 MiB | 11.66 MiB/s, done.
Resolving deltas: 100% (39/39), done.
```

```
import tensorflow as tf

class ResnetIdentityBlock(tf.keras.Model):
  def __init__(self, kernel_size, filters, batch_normalization=True, conv_first=False):
    super(ResnetIdentityBlock, self).__init__(name='')

    self.residual_layers = []

    for i in range(len(filters)):

        if conv_first:
            setattr(self, 'conv' + str(i+1), tf.keras.layers.Conv2D(filters[i], kernel_siz
            self.residual_layers.append('conv' + str(i+1))

            if batch_normalization:
                setattr(self, 'bn' + str(i+1), tf.keras.layers.BatchNormalization())
                self.residual_layers.append('bn' + str(i+1))

        else:
            if batch_normalization:
                setattr(self, 'bn' + str(i+1), tf.keras.layers.BatchNormalization())
                self.residual_layers.append('bn' + str(i+1))

            setattr(self, 'conv' + str(i+1), tf.keras.layers.Conv2D(filters[i], kernel_siz
            self.residual_layers.append('conv' + str(i+1))



  def call(self, input_tensor, training=False):

    x = input_tensor

    for layer in self.residual_layers:

        if isinstance(layer, tf.keras.layers.Conv2D):
            x = getattr(self, layer)(x)
        else:
            x = getattr(self, layer)(x, training=False)
        x = tf.nn.relu(x)
```

```
    x += input_tensor
    return tf.nn.relu(x)


# Loading the data (MNIST)
import numpy as np

mnist = tf.contrib.learn.datasets.load_dataset("mnist")
x_train = mnist.train.images.reshape(mnist.train.images.shape[0], 28, 28, 1)
y_train = np.asarray(mnist.train.labels, dtype=np.int32)
x_test = mnist.test.images.reshape(mnist.test.images.shape[0], 28, 28, 1)
y_test = np.asarray(mnist.test.labels, dtype=np.int32)
```

```
WARNING:tensorflow:
The TensorFlow contrib module will not be included in TensorFlow 2.0.
For more information, please see:
  * https://github.com/tensorflow/community/blob/master/rfcs/20180907-contrib-sunset.
  * https://github.com/tensorflow/addons
  * https://github.com/tensorflow/io (for I/O related ops)
If you depend on functionality not listed there, please file an issue.

WARNING:tensorflow:From <ipython-input-4-47d359e84b5a>:3: load_dataset (from tensorfl
Instructions for updating:
Please use tf.data.
WARNING:tensorflow:From /tensorflow-1.15.2/python3.6/tensorflow_core/contrib/learn/py
Instructions for updating:
Please use alternatives such as official/mnist/dataset.py from tensorflow/models.
WARNING:tensorflow:From /tensorflow-1.15.2/python3.6/tensorflow_core/contrib/learn/py
Instructions for updating:
Please use alternatives such as official/mnist/dataset.py from tensorflow/models.
WARNING:tensorflow:From /tensorflow-1.15.2/python3.6/tensorflow_core/contrib/learn/py
Instructions for updating:
Please write your own downloading logic.
WARNING:tensorflow:From /tensorflow-1.15.2/python3.6/tensorflow_core/contrib/learn/py
Instructions for updating:
Please use urllib or similar directly.
Successfully downloaded train-images-idx3-ubyte.gz 9912422 bytes.
WARNING:tensorflow:From /tensorflow-1.15.2/python3.6/tensorflow_core/contrib/learn/py
Instructions for updating:
Please use tf.data to implement this functionality.
Extracting MNIST-data/train-images-idx3-ubyte.gz
Successfully downloaded train-labels-idx1-ubyte.gz 28881 bytes.
WARNING:tensorflow:From /tensorflow-1.15.2/python3.6/tensorflow_core/contrib/learn/py
Instructions for updating:
Please use tf.data to implement this functionality.
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
WARNING:tensorflow:From /tensorflow-1.15.2/python3.6/tensorflow_core/contrib/learn/py
Instructions for updating:
Please use alternatives such as official/mnist/dataset.py from tensorflow/models.
```

```
x_train = x_train/255
x_test = x_test/255
```

```
print(x_train.shape)
print(x_test.shape)
```

```
(55000, 28, 28, 1)
(10000, 28, 28, 1)
```

```
from keras.utils.np_utils import to_categorical

y_train = to_categorical(y_train, num_classes=10)
y_test = to_categorical(y_test, num_classes=10)
```

```
Using TensorFlow backend.
```

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

import tensorflow as tf
from tensorflow.keras.preprocessing.image import ImageDataGenerator


datagen = ImageDataGenerator(
        # set input mean to 0 over the dataset
        featurewise_center=False,
        # set each sample mean to 0
        samplewise_center=False,
        # divide inputs by std of dataset
        featurewise_std_normalization=False,
        # divide each input by its std
        samplewise_std_normalization=False,
        # apply ZCA whitening
        zca_whitening=False,
        # epsilon for ZCA whitening
        zca_epsilon=1e-06,
        # randomly rotate images in the range (deg 0 to 180)
        rotation_range=5,
        # randomly shift images horizontally
        width_shift_range=0.1,
        # randomly shift images vertically
        height_shift_range=0.1,
        # set range for random shear
        shear_range=0.,
        # set range for random zoom
        zoom_range=0.,
        # set range for random channel shifts
        channel_shift_range=0.,
        # set mode for filling points outside the input boundaries
        fill_mode='nearest',
        # value used for fill_mode = "constant"
        cval=0.,
        # randomly flip images
        horizontal_flip=True,
        # randomly flip images
        vertical_flip=False,
        # set rescaling factor (applied before any other transformation)
```

```
        rescale=None,
        # set function that will be applied on each input
        preprocessing_function=None,
        # image data format, either "channels_first" or "channels_last"
        data_format=None,
        # fraction of images reserved for validation (strictly between 0 and 1)
        validation_split=0.05)


NUM_CLASSES = 10
INPUT_SHAPE = (28, 28, 1)

NUM_EPOCHS = 80
learning_rate = 1e-4
BATCH_SIZE=128


model = tf.keras.Sequential()
model.add(tf.keras.layers.Conv2D(128, (3, 3), activation='relu', input_shape=INPUT_SHAPE))

model.add(ResnetIdentityBlock((3,3), filters=(128, 128)))
model.add(ResnetIdentityBlock((3,3), filters=(128, 128)))
model.add(ResnetIdentityBlock((3,3), filters=(128, 128)))
model.add(tf.keras.layers.Conv2D(64, (3, 3), padding='same'))

model.add(ResnetIdentityBlock((3,3), filters=(64, 64)))
model.add(ResnetIdentityBlock((3,3), filters=(64, 64)))
model.add(ResnetIdentityBlock((3,3), filters=(64, 64)))

model.add(tf.keras.layers.BatchNormalization())
model.add(tf.keras.layers.Activation('relu'))
model.add(tf.keras.layers.AveragePooling2D(pool_size=8))
model.add(tf.keras.layers.Flatten())

model.add(tf.keras.layers.Dense(NUM_CLASSES, activation='softmax'))
```

```
WARNING:tensorflow:From /tensorflow-1.15.2/python3.6/tensorflow_core/python/ops/resou
Instructions for updating:
If using Keras pass *_constraint arguments to layers.
WARNING:tensorflow:Entity <bound method ResnetIdentityBlock.call of <__main__.ResnetI
WARNING: Entity <bound method ResnetIdentityBlock.call of <__main__.ResnetIdentityBlo
WARNING:tensorflow:Entity <bound method ResnetIdentityBlock.call of <__main__.ResnetI
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WARNING: Entity <bound method ResnetIdentityBlock.call of <__main__.ResnetIdentityBlo
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WARNING: Entity <bound method ResnetIdentityBlock.call of <__main__.ResnetIdentityBlo
WARNING:tensorflow:Entity <bound method ResnetIdentityBlock.call of <__main__.ResnetI
WARNING: Entity <bound method ResnetIdentityBlock.call of <__main__.ResnetIdentityBlo
```

```
model.summary()

datagen.fit(x_train)
```

```
sgd = tf.keras.optimizers.Adam(learning_rate)

model.compile(optimizer=sgd,
              loss='categorical_crossentropy',
              metrics=['accuracy'])

model.fit_generator(datagen.flow(x_train, y_train, batch_size=BATCH_SIZE),
                    validation_data=(x_test, y_test),
                    epochs=NUM_EPOCHS)
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 26, 26, 128)       1280
_________________________________________________________________
resnet_identity_block (Resne (None, 26, 26, 128)       296192
_________________________________________________________________
resnet_identity_block_1 (Res (None, 26, 26, 128)       296192
_________________________________________________________________
resnet_identity_block_2 (Res (None, 26, 26, 128)       296192
_________________________________________________________________
conv2d_7 (Conv2D)            (None, 26, 26, 64)        73792
_________________________________________________________________
resnet_identity_block_3 (Res (None, 26, 26, 64)        74368
_________________________________________________________________
resnet_identity_block_4 (Res (None, 26, 26, 64)        74368
_________________________________________________________________
resnet_identity_block_5 (Res (None, 26, 26, 64)        74368
_________________________________________________________________
batch_normalization_12 (Batc (None, 26, 26, 64)        256
_________________________________________________________________
activation (Activation)      (None, 26, 26, 64)        0
_________________________________________________________________
average_pooling2d (AveragePo (None, 3, 3, 64)          0
_________________________________________________________________
flatten (Flatten)            (None, 576)               0
_________________________________________________________________
dense (Dense)                (None, 10)                5770
=================================================================
Total params: 1,192,778
Trainable params: 1,190,346
Non-trainable params: 2,432
_________________________________________________________________
Epoch 1/80
429/430 [============================>.] - ETA: 0s - loss: 1.2564 - acc: 0.6293Epoch
10000/430 [==============================================================================
430/430 [==============================] - 51s 119ms/step - loss: 1.2550 - acc: 0.629
Epoch 2/80
429/430 [============================>.] - ETA: 0s - loss: 0.4780 - acc: 0.8678Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.4778 - acc: 0.867
Epoch 3/80
429/430 [============================>.] - ETA: 0s - loss: 0.3036 - acc: 0.9160Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.3035 - acc: 0.916
Epoch 4/80
429/430 [============================>.] - ETA: 0s - loss: 0.2280 - acc: 0.9379Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.2278 - acc: 0.937
Epoch 5/80
429/430 [============================>.] - ETA: 0s - loss: 0.1828 - acc: 0.9499Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.1827 - acc: 0.949
Epoch 6/80
429/430 [============================>.] - ETA: 0s - loss: 0.1562 - acc: 0.9553Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.1562 - acc: 0.955
Epoch 7/80
429/430 [============================>.] - ETA: 0s - loss: 0.1391 - acc: 0.9597Epoch
10000/430 [==============================================================================
```

```
430/430 [==============================] - 43s 100ms/step - loss: 0.1390 - acc: 0.959
Epoch 8/80
429/430 [============================>.] - ETA: 0s - loss: 0.1201 - acc: 0.9654Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.1202 - acc: 0.965
Epoch 9/80
429/430 [============================>.] - ETA: 0s - loss: 0.1179 - acc: 0.9658Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.1179 - acc: 0.965
Epoch 10/80
429/430 [============================>.] - ETA: 0s - loss: 0.1008 - acc: 0.9700Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.1007 - acc: 0.970
Epoch 11/80
429/430 [============================>.] - ETA: 0s - loss: 0.0942 - acc: 0.9728Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0942 - acc: 0.972
Epoch 12/80
429/430 [============================>.] - ETA: 0s - loss: 0.0901 - acc: 0.9733Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0902 - acc: 0.973
Epoch 13/80
429/430 [============================>.] - ETA: 0s - loss: 0.0841 - acc: 0.9749Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0841 - acc: 0.974
Epoch 14/80
429/430 [============================>.] - ETA: 0s - loss: 0.0806 - acc: 0.9755Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0807 - acc: 0.975
Epoch 15/80
429/430 [============================>.] - ETA: 0s - loss: 0.0732 - acc: 0.9786Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0732 - acc: 0.978
Epoch 16/80
429/430 [============================>.] - ETA: 0s - loss: 0.0692 - acc: 0.9797Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0692 - acc: 0.979
Epoch 17/80
429/430 [============================>.] - ETA: 0s - loss: 0.0703 - acc: 0.9793Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0708 - acc: 0.979
Epoch 18/80
429/430 [============================>.] - ETA: 0s - loss: 0.0639 - acc: 0.9806Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0639 - acc: 0.980
Epoch 19/80
429/430 [============================>.] - ETA: 0s - loss: 0.0621 - acc: 0.9815Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0621 - acc: 0.981
Epoch 20/80
429/430 [============================>.] - ETA: 0s - loss: 0.0594 - acc: 0.9825Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0594 - acc: 0.982
Epoch 21/80
429/430 [============================>.] - ETA: 0s - loss: 0.0559 - acc: 0.9826Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0558 - acc: 0.982
Epoch 22/80
429/430 [============================>.] - ETA: 0s - loss: 0.0540 - acc: 0.9834Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0540 - acc: 0.983
Epoch 23/80
```

```
Epoch 23/80
429/430 [============================>.] - ETA: 0s - loss: 0.0541 - acc: 0.9835Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0541 - acc: 0.983
Epoch 24/80
429/430 [============================>.] - ETA: 0s - loss: 0.0557 - acc: 0.9826Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0557 - acc: 0.982
Epoch 25/80
429/430 [============================>.] - ETA: 0s - loss: 0.0496 - acc: 0.9849Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 99ms/step - loss: 0.0497 - acc: 0.9849
Epoch 26/80
429/430 [============================>.] - ETA: 0s - loss: 0.0477 - acc: 0.9850Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0477 - acc: 0.985
Epoch 27/80
429/430 [============================>.] - ETA: 0s - loss: 0.0484 - acc: 0.9852Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0483 - acc: 0.985
Epoch 28/80
429/430 [============================>.] - ETA: 0s - loss: 0.0462 - acc: 0.9859Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 101ms/step - loss: 0.0462 - acc: 0.985
Epoch 29/80
429/430 [============================>.] - ETA: 0s - loss: 0.0450 - acc: 0.9864Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 101ms/step - loss: 0.0449 - acc: 0.986
Epoch 30/80
429/430 [============================>.] - ETA: 0s - loss: 0.0446 - acc: 0.9862Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0446 - acc: 0.986
Epoch 31/80
429/430 [============================>.] - ETA: 0s - loss: 0.0444 - acc: 0.9859Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0446 - acc: 0.985
Epoch 32/80
429/430 [============================>.] - ETA: 0s - loss: 0.0417 - acc: 0.9868Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0419 - acc: 0.986
Epoch 33/80
429/430 [============================>.] - ETA: 0s - loss: 0.0419 - acc: 0.9872Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0420 - acc: 0.987
Epoch 34/80
429/430 [============================>.] - ETA: 0s - loss: 0.0400 - acc: 0.9880Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0400 - acc: 0.988
Epoch 35/80
429/430 [============================>.] - ETA: 0s - loss: 0.0387 - acc: 0.9882Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0387 - acc: 0.988
Epoch 36/80
429/430 [============================>.] - ETA: 0s - loss: 0.0391 - acc: 0.9873Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0391 - acc: 0.987
Epoch 37/80
429/430 [============================>.] - ETA: 0s - loss: 0.0380 - acc: 0.9882Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0380 - acc: 0.988
Epoch 38/80
429/430 [============================>.] - ETA: 0s - loss: 0.0371 - acc: 0.9884Epoch
```

```
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0371 - acc: 0.988
Epoch 39/80
429/430 [============================>.] - ETA: 0s - loss: 0.0374 - acc: 0.9881Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0374 - acc: 0.988
Epoch 40/80
429/430 [============================>.] - ETA: 0s - loss: 0.0370 - acc: 0.9884Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 99ms/step - loss: 0.0370 - acc: 0.9884
Epoch 41/80
429/430 [============================>.] - ETA: 0s - loss: 0.0350 - acc: 0.9891Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0350 - acc: 0.989
Epoch 42/80
429/430 [============================>.] - ETA: 0s - loss: 0.0347 - acc: 0.9892Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0347 - acc: 0.989
Epoch 43/80
429/430 [============================>.] - ETA: 0s - loss: 0.0348 - acc: 0.9891Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0349 - acc: 0.989
Epoch 44/80
429/430 [============================>.] - ETA: 0s - loss: 0.0334 - acc: 0.9892Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0333 - acc: 0.989
Epoch 45/80
429/430 [============================>.] - ETA: 0s - loss: 0.0315 - acc: 0.9899Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0315 - acc: 0.989
Epoch 46/80
429/430 [============================>.] - ETA: 0s - loss: 0.0392 - acc: 0.9876Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0392 - acc: 0.987
Epoch 47/80
429/430 [============================>.] - ETA: 0s - loss: 0.0309 - acc: 0.9903Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0309 - acc: 0.990
Epoch 48/80
429/430 [============================>.] - ETA: 0s - loss: 0.0302 - acc: 0.9904Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0302 - acc: 0.990
Epoch 49/80
429/430 [============================>.] - ETA: 0s - loss: 0.0296 - acc: 0.9907Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0296 - acc: 0.990
Epoch 50/80
429/430 [============================>.] - ETA: 0s - loss: 0.0296 - acc: 0.9909Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 99ms/step - loss: 0.0296 - acc: 0.9909
Epoch 51/80
429/430 [============================>.] - ETA: 0s - loss: 0.0288 - acc: 0.9909Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0288 - acc: 0.990
Epoch 52/80
429/430 [============================>.] - ETA: 0s - loss: 0.0289 - acc: 0.9908Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0290 - acc: 0.990
Epoch 53/80
429/430 [============================>.] - ETA: 0s - loss: 0.0283 - acc: 0.9905Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0283 - acc: 0.990
```

```
Epoch 54/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0282 - acc: 0.9909Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 99ms/step - loss: 0.0282 - acc: 0.9910
Epoch 55/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0270 - acc: 0.9914Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 99ms/step - loss: 0.0270 - acc: 0.9914
Epoch 56/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0258 - acc: 0.9917Epoch
10000/430 [==============================================================================
430/430 [==============================] - 44s 101ms/step - loss: 0.0258 - acc: 0.991
Epoch 57/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0265 - acc: 0.9917Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0265 - acc: 0.991
Epoch 58/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0259 - acc: 0.9918Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0259 - acc: 0.991
Epoch 59/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0273 - acc: 0.9911Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0273 - acc: 0.991
Epoch 60/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0253 - acc: 0.9920Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0253 - acc: 0.992
Epoch 61/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0252 - acc: 0.9917Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0252 - acc: 0.991
Epoch 62/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0249 - acc: 0.9917Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0249 - acc: 0.991
Epoch 63/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0237 - acc: 0.9924Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0237 - acc: 0.992
Epoch 64/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0254 - acc: 0.9917Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0254 - acc: 0.991
Epoch 65/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0230 - acc: 0.9927Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0230 - acc: 0.992
Epoch 66/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0229 - acc: 0.9923Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0229 - acc: 0.992
Epoch 67/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0226 - acc: 0.9928Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0227 - acc: 0.992
Epoch 68/80
429/430 [===========================>.] - ETA: 0s - loss: 0.0226 - acc: 0.9927Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0226 - acc: 0.992
Epoch 69/80
```

```
429/430 [============================>.] - ETA: 0s - loss: 0.0223 - acc: 0.9926Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0224 - acc: 0.992
Epoch 70/80
429/430 [============================>.] - ETA: 0s - loss: 0.0220 - acc: 0.9929Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0220 - acc: 0.993
Epoch 71/80
429/430 [============================>.] - ETA: 0s - loss: 0.0240 - acc: 0.9921Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0241 - acc: 0.992
Epoch 72/80
429/430 [============================>.] - ETA: 0s - loss: 0.0213 - acc: 0.9927Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0213 - acc: 0.992
Epoch 73/80
429/430 [============================>.] - ETA: 0s - loss: 0.0201 - acc: 0.9935Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0201 - acc: 0.993
Epoch 74/80
429/430 [============================>.] - ETA: 0s - loss: 0.0209 - acc: 0.9934Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 100ms/step - loss: 0.0209 - acc: 0.993
Epoch 75/80
429/430 [============================>.] - ETA: 0s - loss: 0.0200 - acc: 0.9939Epoch
10000/430 [==============================================================================
430/430 [==============================] - 43s 101ms/step - loss: 0.0201 - acc: 0.993
Epoch 76/80
429/430 [============================>.] - ETA: 0s - loss: 0.0196 - acc: 0.9937Epoch
10000/430 [==============================================================================
430/430 [==============================] - 44s 102ms/step - loss: 0.0196 - acc: 0.993
Epoch 77/80
429/430 [============================>.] - ETA: 0s - loss: 0.0205 - acc: 0.9929Epoch
10000/430 [==============================================================================
430/430 [==============================] - 44s 101ms/step - loss: 0.0205 - acc: 0.992
Epoch 78/80
429/430 [============================>.] - ETA: 0s - loss: 0.0182 - acc: 0.9942Epoch
10000/430 [==============================================================================
430/430 [==============================] - 44s 101ms/step - loss: 0.0182 - acc: 0.994
Epoch 79/80
429/430 [============================>.] - ETA: 0s - loss: 0.0194 - acc: 0.9939Epoch
10000/430 [==============================================================================
430/430 [==============================] - 44s 101ms/step - loss: 0.0194 - acc: 0.993
Epoch 80/80
429/430 [============================>.] - ETA: 0s - loss: 0.0182 - acc: 0.9942Epoch
10000/430 [==============================================================================
430/430 [==============================] - 44s 101ms/step - loss: 0.0183 - acc: 0.994
<tensorflow.python.keras.callbacks.History at 0x7f81bebb6780>
```

```
history1 = model.history.history

# summarize history for accuracy
plt.plot(history1['acc'])
plt.plot(history1['val_acc'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
```

```
plt.show()

# summarize history for loss
plt.plot(history1['loss'])
plt.plot(history1['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```