```
%tensorflow_version 1.x
```

```
!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 | 1.24 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)
    return tf.nn.relu(x)


from keras.datasets import cifar10

(x_train,y_train),(x_test,y_test) = cifar10.load_data()

x_train = x_train /255
x_test = x_test / 255


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)


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,
        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 = (32, 32, 3)

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:Entity <bound method ResnetIdentityBlock.call of <__main__.ResnetI
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```

```
model.summary()

datagen.fit(x_train)

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

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

generator = datagen.flow(x_train, y_train, batch_size=BATCH_SIZE)

model.fit_generator(generator, validation_data=(x_test, y_test),
                    epochs=NUM_EPOCHS)
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_14 (Conv2D)           (None, 30, 30, 128)       3584
_________________________________________________________________
resnet_identity_block_6 (Res (None, 30, 30, 128)       296192
_________________________________________________________________
resnet_identity_block_7 (Res (None, 30, 30, 128)       296192
_________________________________________________________________
resnet_identity_block_8 (Res (None, 30, 30, 128)       296192
_________________________________________________________________
conv2d_21 (Conv2D)           (None, 30, 30, 64)        73792
_________________________________________________________________
resnet_identity_block_9 (Res (None, 30, 30, 64)        74368
_________________________________________________________________
resnet_identity_block_10 (Re (None, 30, 30, 64)        74368
_________________________________________________________________
resnet_identity_block_11 (Re (None, 30, 30, 64)        74368
_________________________________________________________________
batch_normalization_25 (Batc (None, 30, 30, 64)        256
_________________________________________________________________
activation_1 (Activation)    (None, 30, 30, 64)        0
_________________________________________________________________
average_pooling2d_1 (Average (None, 3, 3, 64)          0
_________________________________________________________________
flatten_1 (Flatten)          (None, 576)               0
_________________________________________________________________
dense_1 (Dense)              (None, 10)                5770
=================================================================
Total params: 1,195,082
Trainable params: 1,192,650
Non-trainable params: 2,432
_________________________________________________________________
Epoch 1/80
390/391 [============================>.] - ETA: 0s - loss: 1.6970 - acc: 0.3847Epoch
10000/391 [==========================================================================
391/391 [==============================] - 128s 328ms/step - loss: 1.6961 - acc: 0.38
Epoch 2/80
390/391 [============================>.] - ETA: 0s - loss: 1.3815 - acc: 0.5014Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 1.3812 - acc: 0.50
Epoch 3/80
390/391 [============================>.] - ETA: 0s - loss: 1.2312 - acc: 0.5623Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 1.2316 - acc: 0.56
Epoch 4/80
390/391 [============================>.] - ETA: 0s - loss: 1.1167 - acc: 0.6065Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 1.1164 - acc: 0.60
Epoch 5/80
390/391 [============================>.] - ETA: 0s - loss: 1.0315 - acc: 0.6374Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 303ms/step - loss: 1.0314 - acc: 0.63
Epoch 6/80
390/391 [============================>.] - ETA: 0s - loss: 0.9639 - acc: 0.6611Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 303ms/step - loss: 0.9638 - acc: 0.66
Epoch 7/80
390/391 [============================>.] - ETA: 0s - loss: 0.9119 - acc: 0.6816Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 303ms/step - loss: 0.9116 - acc: 0.68
Epoch 8/80
390/391 [============================>.] - ETA: 0s - loss: 0.8671 - acc: 0.6972Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.8668 - acc: 0.69
Epoch 9/80
390/391 [============================>.] - ETA: 0s - loss: 0.8179 - acc: 0.7147Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.8176 - acc: 0.71
Epoch 10/80
390/391 [============================>.] - ETA: 0s - loss: 0.7848 - acc: 0.7269Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.7851 - acc: 0.72
Epoch 11/80
390/391 [============================>.] - ETA: 0s - loss: 0.7536 - acc: 0.7400Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.7539 - acc: 0.74
Epoch 12/80
390/391 [============================>.] - ETA: 0s - loss: 0.7218 - acc: 0.7473Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.7216 - acc: 0.74
Epoch 13/80
390/391 [============================>.] - ETA: 0s - loss: 0.7017 - acc: 0.7575Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.7017 - acc: 0.75
Epoch 14/80
390/391 [============================>.] - ETA: 0s - loss: 0.6712 - acc: 0.7666Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.6713 - acc: 0.76
Epoch 15/80
390/391 [============================>.] - ETA: 0s - loss: 0.6487 - acc: 0.7761Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.6486 - acc: 0.77
Epoch 16/80
390/391 [============================>.] - ETA: 0s - loss: 0.6290 - acc: 0.7836Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.6294 - acc: 0.78
Epoch 17/80
390/391 [============================>.] - ETA: 0s - loss: 0.6092 - acc: 0.7894Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.6093 - acc: 0.78
Epoch 18/80
390/391 [============================>.] - ETA: 0s - loss: 0.5877 - acc: 0.7972Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.5877 - acc: 0.79
Epoch 19/80
390/391 [============================>.] - ETA: 0s - loss: 0.5715 - acc: 0.8023Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.5714 - acc: 0.80
Epoch 20/80
390/391 [============================>.] - ETA: 0s - loss: 0.5529 - acc: 0.8107Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.5530 - acc: 0.81
Epoch 21/80
390/391 [============================>.] - ETA: 0s - loss: 0.5356 - acc: 0.8156Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 303ms/step - loss: 0.5361 - acc: 0.81
Epoch 22/80
390/391 [============================>.] - ETA: 0s - loss: 0.5239 - acc: 0.8204Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.5244 - acc: 0.82
Epoch 23/80
Epoch 23/80
390/391 [============================>.] - ETA: 0s - loss: 0.5116 - acc: 0.8246Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 303ms/step - loss: 0.5116 - acc: 0.82
Epoch 24/80
390/391 [============================>.] - ETA: 0s - loss: 0.5021 - acc: 0.8277Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.5020 - acc: 0.82
Epoch 25/80
390/391 [============================>.] - ETA: 0s - loss: 0.4831 - acc: 0.8343Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.4831 - acc: 0.83
Epoch 26/80
390/391 [============================>.] - ETA: 0s - loss: 0.4736 - acc: 0.8363Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.4735 - acc: 0.83
Epoch 27/80
390/391 [============================>.] - ETA: 0s - loss: 0.4619 - acc: 0.8417Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.4618 - acc: 0.84
Epoch 28/80
390/391 [============================>.] - ETA: 0s - loss: 0.4490 - acc: 0.8450Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.4490 - acc: 0.84
Epoch 29/80
390/391 [============================>.] - ETA: 0s - loss: 0.4376 - acc: 0.8485Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.4375 - acc: 0.84
Epoch 30/80
390/391 [============================>.] - ETA: 0s - loss: 0.4282 - acc: 0.8522Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.4281 - acc: 0.85
Epoch 31/80
390/391 [============================>.] - ETA: 0s - loss: 0.4176 - acc: 0.8575Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.4177 - acc: 0.85
Epoch 32/80
390/391 [============================>.] - ETA: 0s - loss: 0.4103 - acc: 0.8582Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.4102 - acc: 0.85
Epoch 33/80
390/391 [============================>.] - ETA: 0s - loss: 0.4015 - acc: 0.8626Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.4014 - acc: 0.86
Epoch 34/80
390/391 [============================>.] - ETA: 0s - loss: 0.3906 - acc: 0.8658Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.3909 - acc: 0.86
Epoch 35/80
390/391 [============================>.] - ETA: 0s - loss: 0.3765 - acc: 0.8709Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.3764 - acc: 0.87
Epoch 36/80
390/391 [============================>.] - ETA: 0s - loss: 0.3720 - acc: 0.8728Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.3720 - acc: 0.87
Epoch 37/80
390/391 [============================>.] - ETA: 0s - loss: 0.3613 - acc: 0.8771Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.3612 - acc: 0.87
Epoch 38/80
390/391 [============================>.] - ETA: 0s - loss: 0.3582 - acc: 0.8769Epoch
```

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10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.3585 - acc: 0.87
Epoch 39/80
390/391 [============================>.] - ETA: 0s - loss: 0.3461 - acc: 0.8818Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.3461 - acc: 0.88
Epoch 40/80
390/391 [============================>.] - ETA: 0s - loss: 0.3390 - acc: 0.8831Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.3390 - acc: 0.88
Epoch 41/80
390/391 [============================>.] - ETA: 0s - loss: 0.3305 - acc: 0.8874Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.3305 - acc: 0.88
Epoch 42/80
390/391 [============================>.] - ETA: 0s - loss: 0.3244 - acc: 0.8884Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.3241 - acc: 0.88
Epoch 43/80
390/391 [============================>.] - ETA: 0s - loss: 0.3250 - acc: 0.8876Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.3251 - acc: 0.88
Epoch 44/80
390/391 [============================>.] - ETA: 0s - loss: 0.3076 - acc: 0.8939Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.3075 - acc: 0.89
Epoch 45/80
390/391 [============================>.] - ETA: 0s - loss: 0.3021 - acc: 0.8955Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.3021 - acc: 0.89
Epoch 46/80
390/391 [============================>.] - ETA: 0s - loss: 0.3019 - acc: 0.8970Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.3019 - acc: 0.89
Epoch 47/80
390/391 [============================>.] - ETA: 0s - loss: 0.2953 - acc: 0.8973Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2953 - acc: 0.89
Epoch 48/80
390/391 [============================>.] - ETA: 0s - loss: 0.2858 - acc: 0.9013Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2858 - acc: 0.90
Epoch 49/80
390/391 [============================>.] - ETA: 0s - loss: 0.2819 - acc: 0.9030Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2820 - acc: 0.90
Epoch 50/80
390/391 [============================>.] - ETA: 0s - loss: 0.2777 - acc: 0.9039Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2775 - acc: 0.90
Epoch 51/80
390/391 [============================>.] - ETA: 0s - loss: 0.2715 - acc: 0.9064Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.2714 - acc: 0.90
Epoch 52/80
390/391 [============================>.] - ETA: 0s - loss: 0.2666 - acc: 0.9096Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.2665 - acc: 0.90
Epoch 53/80
390/391 [============================>.] - ETA: 0s - loss: 0.2591 - acc: 0.9112Epoch
10000/391 [==========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2591 - acc: 0.91
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391/391 [==============================] - 119s 305ms/step - loss: 0.2591 - acc: 0.91
Epoch 54/80
390/391 [============================>.] - ETA: 0s - loss: 0.2555 - acc: 0.9130Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2555 - acc: 0.91
Epoch 55/80
390/391 [============================>.] - ETA: 0s - loss: 0.2437 - acc: 0.9170Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2437 - acc: 0.91
Epoch 56/80
390/391 [============================>.] - ETA: 0s - loss: 0.2460 - acc: 0.9154Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2458 - acc: 0.91
Epoch 57/80
390/391 [============================>.] - ETA: 0s - loss: 0.2370 - acc: 0.9181Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.2371 - acc: 0.91
Epoch 58/80
390/391 [============================>.] - ETA: 0s - loss: 0.2313 - acc: 0.9204Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.2316 - acc: 0.92
Epoch 59/80
390/391 [============================>.] - ETA: 0s - loss: 0.2296 - acc: 0.9211Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2296 - acc: 0.92
Epoch 60/80
390/391 [============================>.] - ETA: 0s - loss: 0.2214 - acc: 0.9224Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2212 - acc: 0.92
Epoch 61/80
390/391 [============================>.] - ETA: 0s - loss: 0.2202 - acc: 0.9239Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2204 - acc: 0.92
Epoch 62/80
390/391 [============================>.] - ETA: 0s - loss: 0.2129 - acc: 0.9271Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2129 - acc: 0.92
Epoch 63/80
390/391 [============================>.] - ETA: 0s - loss: 0.2066 - acc: 0.9294Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 306ms/step - loss: 0.2066 - acc: 0.92
Epoch 64/80
390/391 [============================>.] - ETA: 0s - loss: 0.2063 - acc: 0.9292Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2063 - acc: 0.92
Epoch 65/80
390/391 [============================>.] - ETA: 0s - loss: 0.2011 - acc: 0.9302Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 306ms/step - loss: 0.2015 - acc: 0.93
Epoch 66/80
390/391 [============================>.] - ETA: 0s - loss: 0.2052 - acc: 0.9300Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.2052 - acc: 0.93
Epoch 67/80
390/391 [============================>.] - ETA: 0s - loss: 0.1971 - acc: 0.9320Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.1972 - acc: 0.93
Epoch 68/80
390/391 [============================>.] - ETA: 0s - loss: 0.1925 - acc: 0.9333Epoch
10000/391 [========================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.1925 - acc: 0.93
Epoch 69/80
```

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390/391 [============================>.] - ETA: 0s - loss: 0.1847 - acc: 0.9373Epoch
10000/391 [============================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.1847 - acc: 0.93
Epoch 70/80
390/391 [============================>.] - ETA: 0s - loss: 0.1834 - acc: 0.9369Epoch
10000/391 [============================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.1834 - acc: 0.93
Epoch 71/80
390/391 [============================>.] - ETA: 0s - loss: 0.1783 - acc: 0.9383Epoch
10000/391 [============================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.1783 - acc: 0.93
Epoch 72/80
390/391 [============================>.] - ETA: 0s - loss: 0.1781 - acc: 0.9373Epoch
10000/391 [============================================================================
391/391 [==============================] - 119s 305ms/step - loss: 0.1780 - acc: 0.93
Epoch 73/80
390/391 [============================>.] - ETA: 0s - loss: 0.1736 - acc: 0.9396Epoch
10000/391 [============================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.1735 - acc: 0.93
Epoch 74/80
390/391 [============================>.] - ETA: 0s - loss: 0.1707 - acc: 0.9408Epoch
10000/391 [============================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.1704 - acc: 0.94
Epoch 75/80
390/391 [============================>.] - ETA: 0s - loss: 0.1644 - acc: 0.9435Epoch
10000/391 [============================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.1644 - acc: 0.94
Epoch 76/80
390/391 [============================>.] - ETA: 0s - loss: 0.1641 - acc: 0.9429Epoch
10000/391 [============================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.1640 - acc: 0.94
Epoch 77/80
390/391 [============================>.] - ETA: 0s - loss: 0.1583 - acc: 0.9466Epoch
10000/391 [============================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.1582 - acc: 0.94
Epoch 78/80
390/391 [============================>.] - ETA: 0s - loss: 0.1574 - acc: 0.9467Epoch
10000/391 [============================================================================
391/391 [==============================] - 119s 303ms/step - loss: 0.1574 - acc: 0.94
Epoch 79/80
390/391 [============================>.] - ETA: 0s - loss: 0.1591 - acc: 0.9448Epoch
10000/391 [============================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.1593 - acc: 0.94
Epoch 80/80
390/391 [============================>.] - ETA: 0s - loss: 0.1486 - acc: 0.9494Epoch
10000/391 [============================================================================
391/391 [==============================] - 119s 304ms/step - loss: 0.1485 - acc: 0.94
<tensorflow.python.keras.callbacks.History at 0x7ff86e1a1198>
```
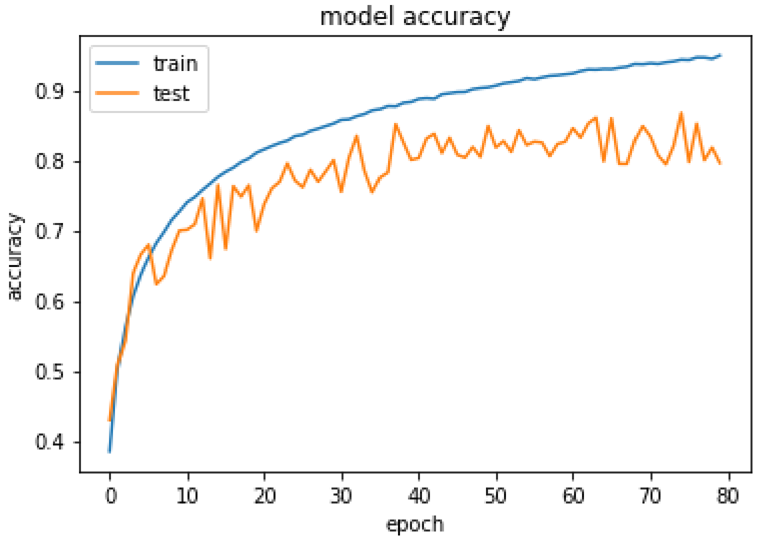
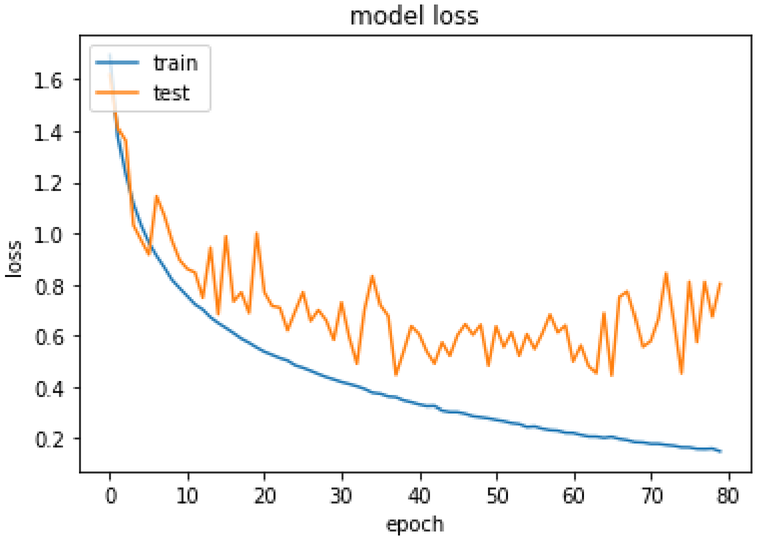

```
history1 = model.history.history

# 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()
```


model accuracy


model loss