In [6]:
```
# load train and test dataset
#load dataset
import gzip
import sys
import pickle
import numpy as np

#load dataset
def load_dataset():
    f = gzip.open('mnist.pkl.gz', 'rb')
    if sys.version_info < (3,):
        data = pickle.load(f)
    else:
        data = pickle.load(f, encoding='bytes')
    f.close()
    (trainX,trainY ), (testX, testY) = data
    # reshape dataset to have a single channel
    trainX = trainX.reshape((trainX.shape[0], 28, 28, 1))
    testX = testX.reshape((testX.shape[0], 28, 28, 1))
    # one hot encode target values
    trainY = to_categorical(trainY)
    testY = to_categorical(testY)
    return trainX, trainY, testX, testY
```

In [7]:
```
from keras.utils import to_categorical
from keras.models import Sequential
from keras.layers import Conv2D
from keras.layers import MaxPooling2D
from keras.layers import Dense
from keras.layers import Flatten
from keras.optimizers import SGD

# scale pixels
def prep_pixels(train, test):
    # convert from integers to floats
    train_norm = train.astype('float32')
    test_norm = test.astype('float32')
    # normalize to range 0-1
    train_norm = train_norm / 255.0
    test_norm = test_norm / 255.0
    # return normalized images
    return train_norm, test_norm

# define cnn model
def define_model():
    model = Sequential()
    model.add(Conv2D(32, (3, 3), activation='relu', kernel_initializer='he_uni
form', input_shape=( 28, 28,1)))
    model.add(MaxPooling2D((2, 2)))
    model.add(Conv2D(64, (3, 3), activation='relu', kernel_initializer='he_uni
form'))
    model.add(Conv2D(64, (3, 3), activation='relu', kernel_initializer='he_uni
form'))
    model.add(MaxPooling2D((2, 2)))
    model.add(Flatten())
    model.add(Dense(100, activation='relu', kernel_initializer='he_uniform'))
    model.add(Dense(10, activation='softmax'))
    # compile model
    opt = SGD(lr=0.01, momentum=0.9)
    model.compile(optimizer=opt, loss='categorical_crossentropy', metrics=['ac
curacy'])
    return model

# run the test harness for evaluating a model
def run_test_harness():
    # load dataset
    trainX, trainY, testX, testY = load_dataset()
    # prepare pixel data
    trainX, testX = prep_pixels(trainX, testX)
    # define model
    model = define_model()
    # fit model
    #In general, batch size of 32 is a good starting point, and we can try wit
h 64, 128, and 256.
    model.fit(trainX, trainY, epochs=10, batch_size=32, verbose=0)
    print("model completed")
    # save model
    model.save('final_model.h5')
```

```
# entry point, run the test harness
run_test_harness()
```

```
model completed
```

In [ ]:

In [8]:
```
# evaluate the deep model on the test dataset
# make a prediction for a new image.
from keras.preprocessing.image import load_img
from keras.preprocessing.image import img_to_array
from keras.models import load_model
# run the test harness for evaluating a model
def run_test_harness2():
    # load dataset
    trainX, trainY, testX, testY = load_dataset()
    # prepare pixel data
    trainX, testX = prep_pixels(trainX, testX)
    # load model
    model = load_model('final_model.h5')
    # evaluate model on test dataset
    _, acc = model.evaluate(testX, testY, verbose=0)
    print("CNN Error: %.2f%%" % (100-acc*100))
    print('Accuracy of model is > %.3f' % (acc * 100.0))

# entry point, run the test harness
run_test_harness2()
```

```
CNN Error: 0.82%
Accuracy of model is > 99.180
```

In [14]:
```
# make a prediction for a new image.
from keras.preprocessing.image import load_img
from keras.preprocessing.image import img_to_array
from keras.models import load_model

# load and prepare the image
def load_image(filename):
    # load the image
    img = load_img(filename, grayscale=True, target_size=(28, 28))
    # convert to array
    img = img_to_array(img)
    # reshape into a single sample with 1 channel
    img = img.reshape(1,28, 28, 1)
    # prepare pixel data
    img = img.astype('float32')
    img = img / 255.0
    return img

# load an image and predict the class
def run_example():
    # load the image
    img = load_image('sample_image.png')
    # load model
    model = load_model('final_model.h5')
    # predict the class
    digit = model.predict_classes(img)
    print("Image digit is ",digit[0])

# entry point, run the example
run_example()
```

```
Image digit is  7
```