

```
import numpy as np
import pandas as pd
import random
import tensorflow as tf
import matplotlib.pyplot as plt

from sklearn.metrics import accuracy_score
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Flatten, Conv2D, Dense, MaxPooling2D
from tensorflow.keras.optimizers import SGD
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.datasets import mnist

(X_train, y_train), (X_test, y_test) = mnist.load_data()

Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz
11490434/11490434 [=====] - 1s 0us/step

print(X_train.shape)
(60000, 28, 28)

(60000, 28, 28)
(60000, 28, 28)

X_train[0].min(), X_train[0].max()
(0, 255)

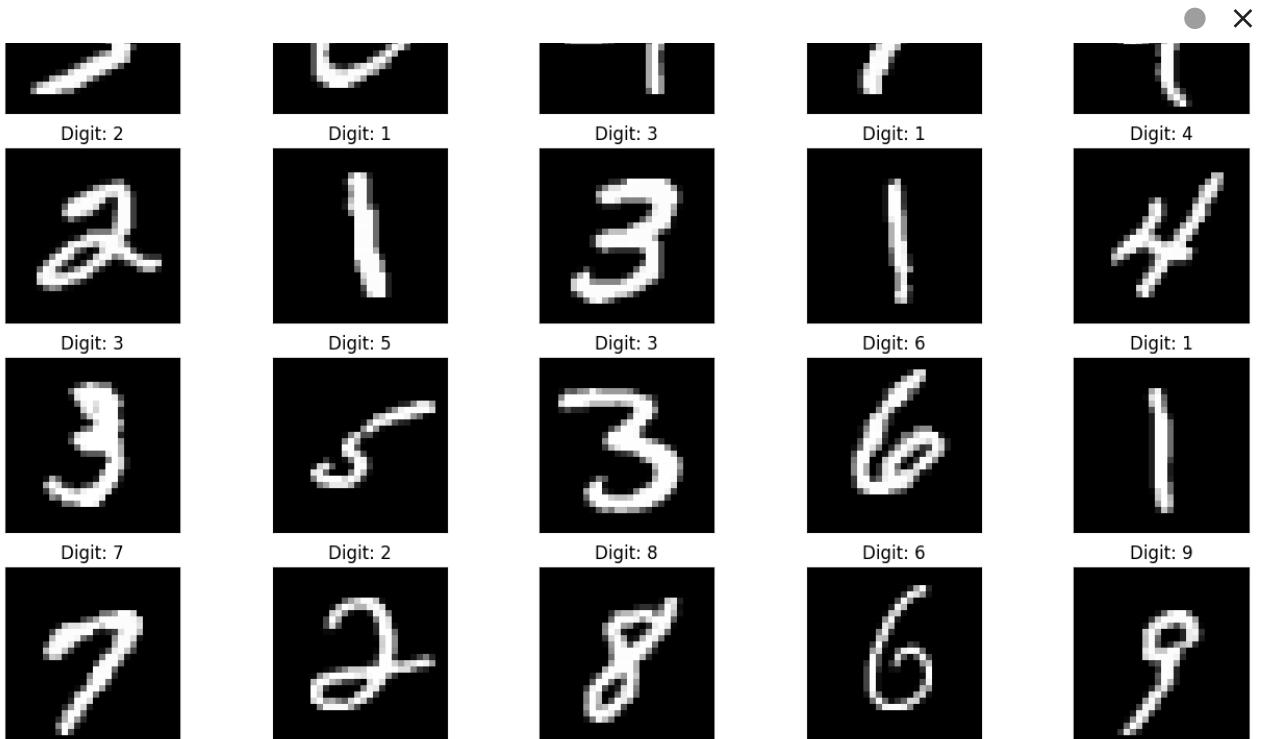
(0, 255)

X_train = (X_train - 0.0) / (255.0 - 0.0)
X_test = (X_test - 0.0) / (255.0 - 0.0)
X_train[0].min(), X_train[0].max()
(0.0, 1.0)

(0.0, 1.0)

def plot_digit(image, digit, plt, i):
    plt.subplot(4,5,i+1)
    plt.imshow(image, cmap=plt.get_cmap('gray'))
    plt.title(f"Digit: {digit}")
    plt.xticks([])
    plt.yticks([])
plt.figure(figsize=(16, 10))
for i in range(20):
    plot_digit(X_train[i], y_train[i], plt, i)
plt.show()
```





```
X_train = X_train.reshape((X_train.shape + (1,)))
X_test = X_test.reshape((X_test.shape + (1,)))
```

```
y_train[0:20]
```

```
array([5, 0, 4, 1, 9, 2, 1, 3, 1, 4, 3, 5, 3, 6, 1, 7, 2, 8, 6, 9],
      dtype=uint8)
```

```
model = Sequential([
    Conv2D(32, (3, 3), activation="relu", input_shape=(28, 28, 1)),
```

```
MaxPooling2D((2, 2)),  
Flatten(),  
Dense(100, activation="relu"),  
Dense(10, activation="softmax")  
])
```

```
optimizer = SGD(lr=0.01, momentum=0.9)  
model.compile(  
    optimizer=optimizer,  
    loss="sparse_categorical_crossentropy",  
    metrics=["accuracy"]  
)  
model.summary()
```

```
WARNING:absl:`lr` is deprecated in Keras optimizer, please use `learning_rate`  
Model: "sequential_1"
```

Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 26, 26, 32)	320
max_pooling2d_1 (MaxPooling2D)	(None, 13, 13, 32)	0
flatten_1 (Flatten)	(None, 5408)	0
dense_2 (Dense)	(None, 100)	540900
dense_3 (Dense)	(None, 10)	1010
<hr/>		
Total params: 542,230		
Trainable params: 542,230		
Non-trainable params: 0		

---

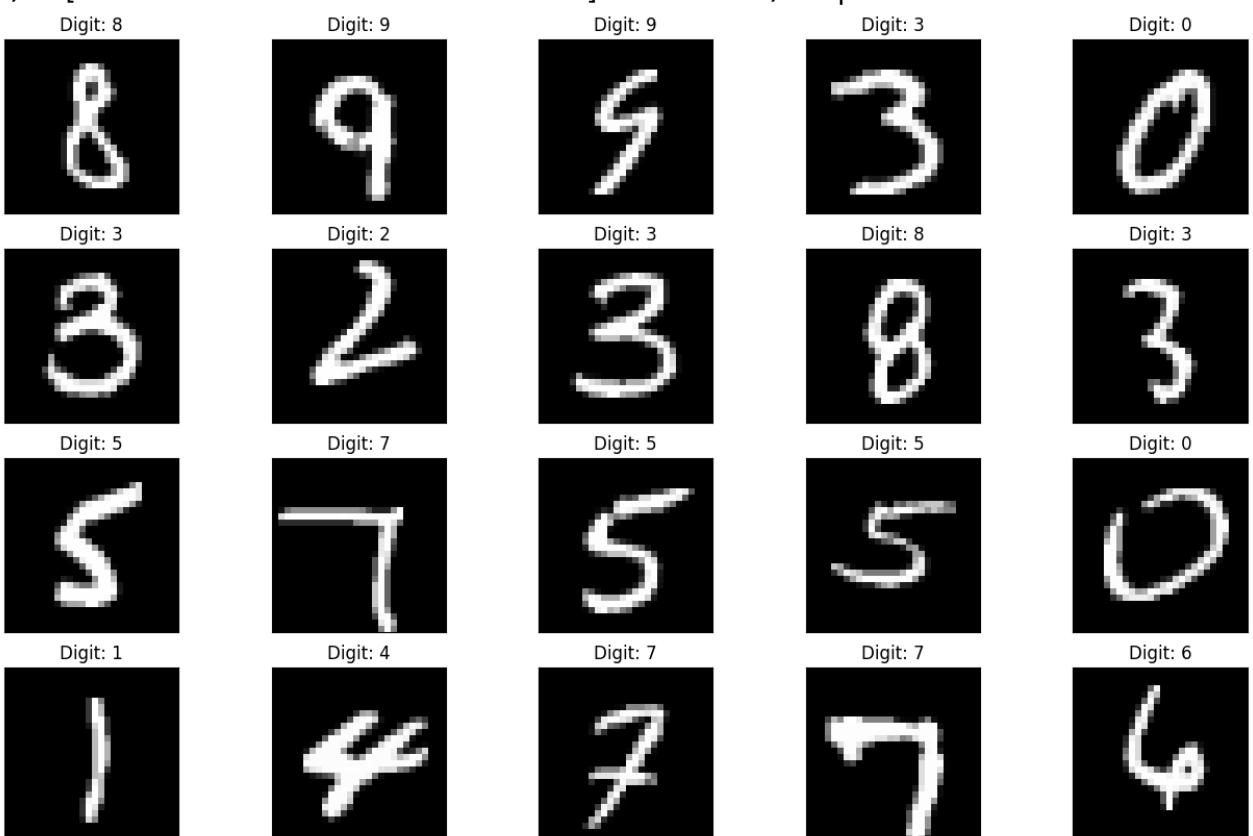
```
model.fit(X_train, y_train, epochs=10, batch_size=32)
```

```
Epoch 1/10  
1875/1875 [=====] - 41s 22ms/step - loss: 0.2394 -  
Epoch 2/10  
1875/1875 [=====] - 46s 25ms/step - loss: 0.0794 -  
Epoch 3/10  
1875/1875 [=====] - 40s 21ms/step - loss: 0.0503 -  
Epoch 4/10  
1875/1875 [=====] - 40s 21ms/step - loss: 0.0364 -  
Epoch 5/10  
1875/1875 [=====] - 39s 21ms/step - loss: 0.0268 -  
Epoch 6/10  
1875/1875 [=====] - 40s 21ms/step - loss: 0.0201 -  
Epoch 7/10  
1875/1875 [=====] - 39s 21ms/step - loss: 0.0150 -  
Epoch 8/10  
1875/1875 [=====] - 39s 21ms/step - loss: 0.0107 -  
Epoch 9/10
```

```
1875/1875 [=====] - 42s 22ms/step - loss: 0.0077 -  
Epoch 10/10  
1875/1875 [=====] - 39s 21ms/step - loss: 0.0059 -  
<keras.callbacks.History at 0x7c68a71fe200>
```

```
plt.figure(figsize=(16, 10))  
for i in range(20):  
    image = random.choice(X_test).squeeze()  
    digit = np.argmax(model.predict(image.reshape((1, 28, 28, 1)))[0],  
                      axis=-1)  
    plot_digit(image, digit, plt, i)  
plt.show()
```

```
1/1 [=====] - 0s 101ms/step  
1/1 [=====] - 0s 25ms/step  
1/1 [=====] - 0s 22ms/step  
1/1 [=====] - 0s 22ms/step  
1/1 [=====] - 0s 23ms/step  
1/1 [=====] - 0s 22ms/step  
1/1 [=====] - 0s 24ms/step  
1/1 [=====] - 0s 37ms/step  
1/1 [=====] - 0s 36ms/step  
1/1 [=====] - 0s 34ms/step  
1/1 [=====] - 0s 36ms/step  
1/1 [=====] - 0s 40ms/step  
1/1 [=====] - 0s 33ms/step  
1/1 [=====] - 0s 32ms/step  
1/1 [=====] - 0s 33ms/step  
1/1 [=====] - 0s 39ms/step  
1/1 [=====] - 0s 38ms/step  
1/1 [=====] - 0s 37ms/step  
1/1 [=====] - 0s 33ms/step  
1/1 [=====] - 0s 46ms/step
```



```
predictions = np.argmax(model.predict(X_test), axis=-1)
accuracy_score(y_test, predictions)
```

```
313/313 [=====] - 4s 14ms/step
0.9862
```

```
score = model.evaluate(X_test, y_test, verbose=0)
print('Test loss:', score[0]) #Test loss: 0.0296396646054
print('Test accuracy:', score[1]) #Test accuracy: 0.9904
```

```
Test loss: 0.045736633241176605
Test accuracy: 0.9861999750137329
```

```
import os
# plotting the metrics
fig = plt.figure()
plt.subplot(2,1,1)
plt.plot(model_log.history['acc'])
plt.plot(model_log.history['val_acc'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='lower right')
plt.subplot(2,1,2)
plt.plot(model_log.history['loss'])
plt.plot(model_log.history['val_loss'])
```

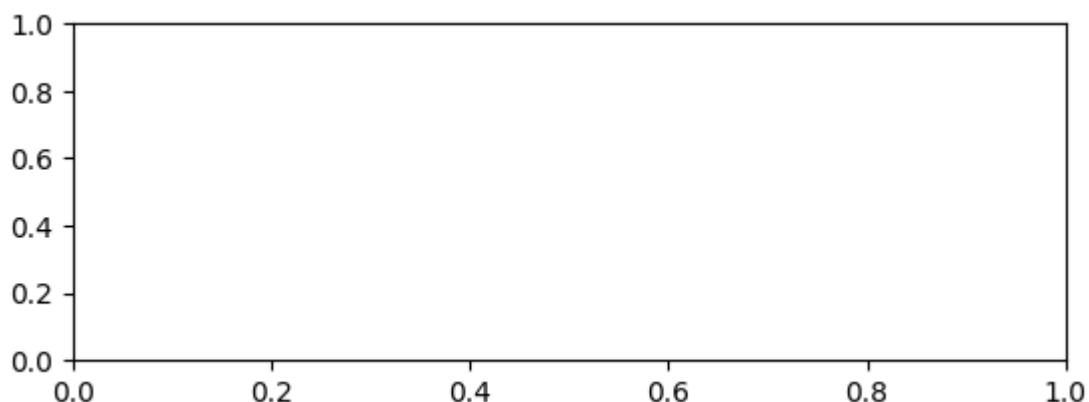
NameError

Traceback (most recent call

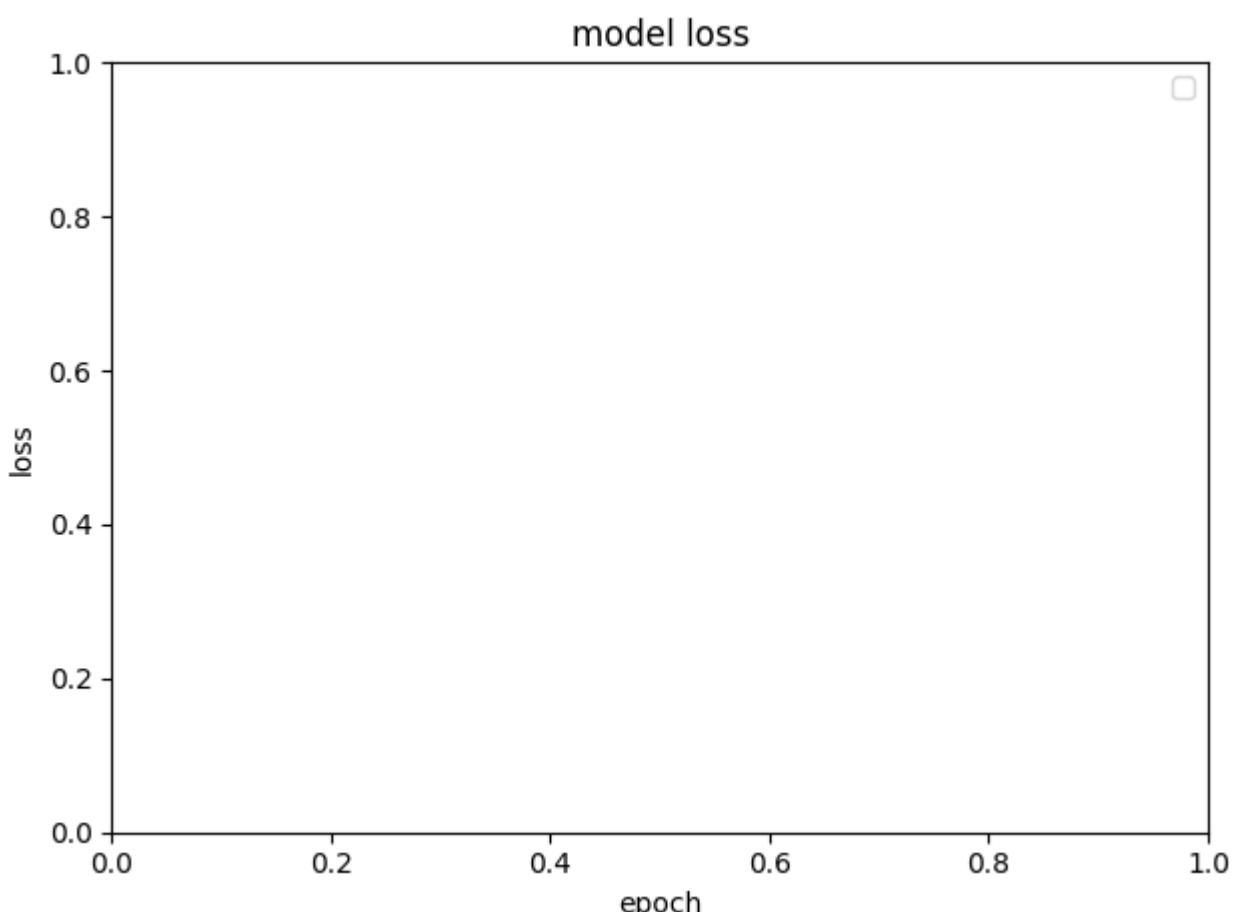
```
last)
<ipython-input-47-2bf36b0ac16a> in <cell line: 5>()
      3 fig = plt.figure()
      4 plt.subplot(2,1,1)
----> 5 plt.plot(model_log.history['acc'])
      6 plt.plot(model_log.history['val_acc'])
      7 plt.title('model accuracy')

NameError: name 'model_log' is not defined
```

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```
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper right')
plt.tight_layout()
```



```
#Save the model
# serialize model to JSON
model_digit_json = model.to_json()
with open("model_digit.json", "w") as json_file:
    json_file.write(model_digit_json)
# serialize weights to HDF5
model.save_weights("model_digit.h5")
print("Saved model to disk")
```

Saved model to disk

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