

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

Double-click (or enter) to edit

```
print(X_train.shape)

(60000, 28, 28)

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

(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)

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()
```

```
-----
NameError                                Traceback (most recent call last)
<ipython-input-1-dac25d50f557> in <cell line: 7>()
      5     plt.xticks([])
      6     plt.yticks([])
----> 7 plt.figure(figsize=(16, 10))
      8 for i in range(20):
      9     plot_digit(X_train[i], y_train[i], plt, i)

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

SEARCH STACK OVERFLOW

```
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")
])
```

The commonly used arguments of `tk.keras.layers.Conv2D()` filters, kernel_size, strides, padding, activation.

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

Model: "sequential"

Layer (type)	Output Shape	Param #
=====		
conv2d (Conv2D)	(None, 26, 26, 32)	320
max_pooling2d (MaxPooling2D)	(None, 13, 13, 32)	0
flatten (Flatten)	(None, 5408)	0
dense (Dense)	(None, 100)	540900
dense_1 (Dense)	(None, 10)	1010
=====		
Total params: 542230 (2.07 MB)		
Trainable params: 542230 (2.07 MB)		
Non-trainable params: 0 (0.00 Byte)		

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

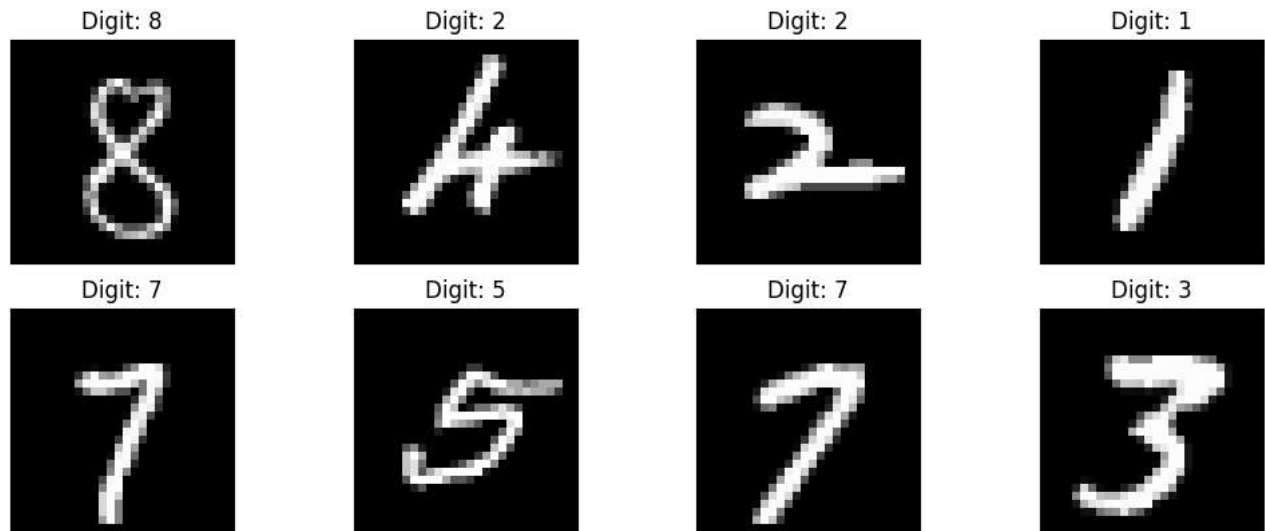
```
Epoch 1/10
1875/1875 [=====] - 32s 17ms/step - loss: 0.2322 - accuracy: 0.9299
Epoch 2/10
1875/1875 [=====] - 30s 16ms/step - loss: 0.0773 - accuracy: 0.9769
Epoch 3/10
1875/1875 [=====] - 30s 16ms/step - loss: 0.0516 - accuracy: 0.9838
Epoch 4/10
1875/1875 [=====] - 31s 16ms/step - loss: 0.0373 - accuracy: 0.9883
Epoch 5/10
1875/1875 [=====] - 30s 16ms/step - loss: 0.0277 - accuracy: 0.9915
Epoch 6/10
1875/1875 [=====] - 30s 16ms/step - loss: 0.0202 - accuracy: 0.9941
Epoch 7/10
1875/1875 [=====] - 30s 16ms/step - loss: 0.0164 - accuracy: 0.9952
Epoch 8/10
1875/1875 [=====] - 31s 17ms/step - loss: 0.0123 - accuracy: 0.9961
Epoch 9/10
1875/1875 [=====] - 30s 16ms/step - loss: 0.0091 - accuracy: 0.9975
Epoch 10/10
1875/1875 [=====] - 30s 16ms/step - loss: 0.0066 - accuracy: 0.9983
<keras.src.callbacks.History at 0x7f733bfe2bc0>
```

```
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 95ms/step
1/1 [=====] - 0s 21ms/step
1/1 [=====] - 0s 22ms/step
1/1 [=====] - 0s 22ms/step
1/1 [=====] - 0s 26ms/step
1/1 [=====] - 0s 22ms/step
1/1 [=====] - 0s 24ms/step
1/1 [=====] - 0s 20ms/step
1/1 [=====] - 0s 26ms/step
1/1 [=====] - 0s 21ms/step
1/1 [=====] - 0s 21ms/step
1/1 [=====] - 0s 21ms/step
1/1 [=====] - 0s 27ms/step
1/1 [=====] - 0s 22ms/step
1/1 [=====] - 0s 22ms/step
1/1 [=====] - 0s 22ms/step
1/1 [=====] - 0s 21ms/step
1/1 [=====] - 0s 23ms/step
1/1 [=====] - 0s 23ms/step
1/1 [=====] - 0s 23ms/step

```



```

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

```

```

313/313 [=====] - 2s 5ms/step
0.9859

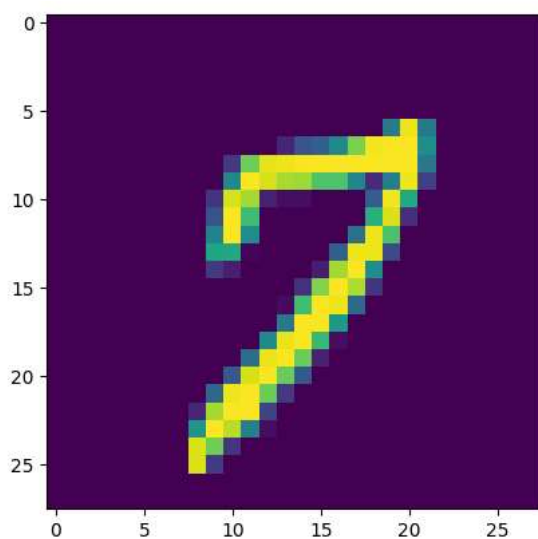
```



```

n=random.randint(0,9999)
plt.imshow(X_test[n])
plt.show()

```



```

predicted_value=model.predict(X_test)
print("Handwritten number in the image is= %d" %np.argmax(predicted_value[n]))

```

```

313/313 [=====] - 2s 5ms/step
Handwritten number in the image is= 7

```

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

Test loss: 0.04999436065554619
Test accuracy: 0.9858999848365784

#The implemented CNN model is giving Loss=0.04624301567673683 and
#accuracy: 0.9872000217437744 for test mnist dataset
```