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Import Necessary Package

```
import numpy
import matplotlib.pyplot as plt
from keras.utils import np_utils
from tensorflow.keras.datasets import mnist
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, Dense, Flatten
from tensorflow.keras.optimizers import Adam
```

Load Data

```
(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 [==============================] - 0s 0us/step
print(X_train.shape)
print(X_test.shape)
```

(60000, 28, 28)

(10000, 28, 28)

```
X_train[0]
```

```
array([[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
```

0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 3,
18, 18, 18, 126, 136, 175, 26, 166, 255, 247, 127, 0, 0,
0, 0],
[0, 0, 0, 0, 0, 0, 0, 0, 30, 36, 94, 154, 170,
253, 253, 253, 253, 253, 225, 172, 253, 242, 195, 64, 0, 0,
0, 0],
[0, 0, 0, 0, 0, 0, 0, 49, 238, 253, 253, 253, 253,
253, 253, 253, 253, 251, 93, 82, 82, 56, 39, 0, 0, 0,
0, 0],
[0, 0, 0, 0, 0, 0, 0, 18, 219, 253, 253, 253, 253,
253, 198, 182, 247, 241, 0, 0, 0, 0, 0, 0, 0, 0,

```
      0,   0],
[   0,   0,   0,   0,   0,   0,   0,   0,  80, 156, 107, 253, 253,
  205,  11,   0,  43, 154,   0,   0,   0,   0,   0,   0,   0,   0,
      0,   0],
[   0,   0,   0,   0,   0,   0,   0,   0,   0,  14,   1, 154, 253,
   90,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
      0,   0],
[   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0, 139, 253,
  190,   2,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
      0,   0],
[   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,  11, 190,
  253,  70,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
      0,   0],
[   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,  35,
  241, 225, 160, 108,   1,   0,   0,   0,   0,   0,   0,   0,   0,
      0,   0],
[   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
   81, 240, 253, 253, 119,  25,   0,   0,   0,   0,   0,   0,   0,
      0,   0],
[   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
      0,  45, 186, 253, 253, 150,  27,   0,   0,   0,   0,   0,   0,
      0,   0],
[   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
      0,   0,  16,  93, 252, 253, 187,   0,   0,   0,   0,   0,   0,
      0,   0],
```

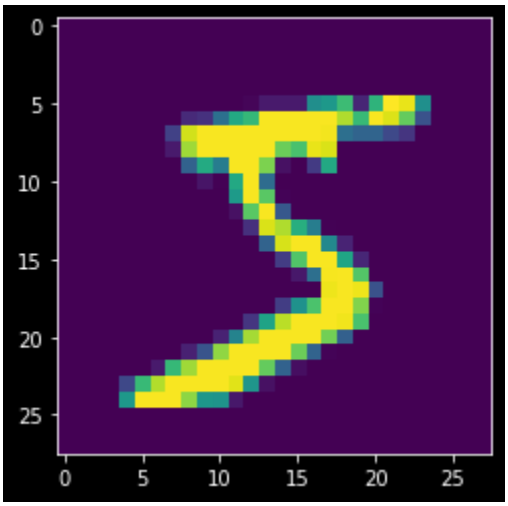
```
[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0,   0,   0, 249, 253, 249,  64,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
   0,  46, 130, 183, 253, 253, 207,   2,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,  39,
 148, 229, 253, 253, 253, 250, 182,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,  24, 114, 221,
 253, 253, 253, 253, 201,  78,   0,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0,  23,  66, 213, 253, 253,
 253, 253, 198,  81,   2,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,  18, 171, 219, 253, 253, 253, 253,
 195,  80,   9,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,  55, 172, 226, 253, 253, 253, 253, 244, 133,
  11,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0, 136, 253, 253, 253, 212, 135, 132,  16,   0,
   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
```

```
        0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
        0,   0],
       [ 0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
        0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
        0,   0],
       [ 0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
        0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
        0,   0]], dtype=uint8)
```

```
y_train[0]
```

```
5
```

```
plt.imshow(X_train[0])
```



Data Preprocessing

```
X_train = X_train.reshape(60000, 28, 28, 1).astype('float32')
```

```
X_test = X_test.reshape(10000, 28, 28, 1).astype('float32')
```

```
number_of_classes = 10
```

```
Y_train = np_utils.to_categorical(y_train, number_of_classes)
```

```
Y_test = np_utils.to_categorical(y_test, number_of_classes)
```

```
Y_train[0]
```

```
array([0., 0., 0., 0., 0., 1., 0., 0., 0., 0.], dtype=float32)
```

Create Model

```
model = Sequential()
```

```
model.add(Conv2D(64, (3, 3), input_shape=(28, 28, 1), activation="relu"))
```

```
model.add(Conv2D(32, (3, 3), activation="relu"))
```

```
model.add(Flatten())
```

```
model.add(Dense(number_of_classes, activation="softmax"))
```

```
model.compile(loss='categorical_crossentropy', optimizer="Adam", metrics=["accuracy"])
```

```
model.fit(X_train, Y_train, batch_size=32, epochs=5, validation_data=(X_test,Y_test))
```

```
Epoch 1/5
```

```
1875/1875 [==============================] - 196s 104ms/step - loss: 0.2287 - accuracy: 0.9545 - val_loss: 0.0985 - val_accuracy: 0.9733
```

```
Epoch 2/5
```

```
1875/1875 [==============================] - 195s 104ms/step - loss: 0.0621 - accuracy: 0.9812 - val_loss: 0.0776 - val_accuracy: 0.9790
```

```
Epoch 3/5
```

```
1875/1875 [==============================] - 194s 103ms/step - loss: 0.0461 - accuracy: 0.9851 - val_loss: 0.0847 - val_accuracy: 0.9763
```

Epoch 4/5

1875/1875 [==============================] - 193s 103ms/step - loss: 0.0323 - accuracy: 0.9897 - val_loss: 0.0955 - val_accuracy: 0.9778

Epoch 5/5

1875/1875 [==============================] - 194s 103ms/step - loss: 0.0283 - accuracy: 0.9914 - val_loss: 0.1242 - val_accuracy: 0.9743

Test the Model

```
metrics = model.evaluate(X_test, Y_test, verbose=0)
print("Metrics (Test Loss & Test Accuracy): ")
print(metrics)
```

Metrics (Test Loss & Test Accuracy):

[0.12420044839382172, 0.9743000268936157]

```
prediction = model.predict(X_test[:4])
print(prediction)
```

1/1 [==============================] - 0s 95ms/step

[[4.2476056e-08 5.0693601e-15 1.5794379e-08 1.4532749e-07 3.5170849e-16

1.2075290e-14 1.5686039e-18 9.9999988e-01 2.7307693e-11 6.1261085e-10]

[8.9022328e-10 6.4137801e-12 9.9999928e-01 9.6712305e-10 7.5354116e-17

2.2103276e-13 5.5830577e-07 2.1301915e-18 1.6853596e-07 3.5003905e-17]

[7.2572580e-11 9.9995959e-01 1.2934409e-07 3.3307094e-12 2.0014747e-06

6.9414054e-06 1.5949030e-09 7.7253696e-11 3.1403306e-05 3.6155386e-13]

[1.0000000e+00 1.4265362e-19 3.3638474e-11 1.2359819e-20 2.4845849e-17

5.4995043e-16 2.2762909e-16 5.6324746e-17 1.1860469e-11 1.6514998e-12]]

```
print(numpy.argmax(prediction, axis=1))
print(Y_test[:4])
```

[7 2 1 0]

[[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]

[0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]

[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]

[1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]]

```
model.save("models/mnistCNN.h5")
```