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Import the necessary packages

```
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()
```

Data Analysis

```
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,  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]
```

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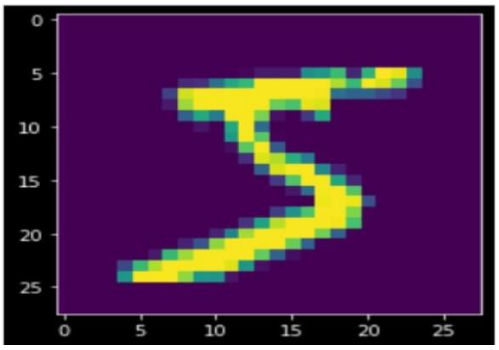
```
plt.imshow(X_train[0])
```



Data Pre-Processing

```
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"])
```

Train the model

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

Epoch 1/5

1875/1875 [==============================] - 13s 5ms/step - loss: 0.2126 - accuracy: 0.9506 - val_loss: 0.1034 - val_accuracy: 0.9682

Epoch 2/5

1875/1875 [==============================] - 9s 5ms/step - loss: 0.0670 - accuracy: 0.9797 - val_loss: 0.0881 - val_accuracy: 0.9750

Epoch 3/5

1875/1875 [==============================] - 9s 5ms/step - loss: 0.0442 - accuracy: 0.9855 - val_loss: 0.1156 - val_accuracy: 0.9713

Epoch 4/5

1875/1875 [==============================] - 9s 5ms/step - loss: 0.0341 - accuracy: 0.9894 - val_loss: 0.0914 - val_accuracy: 0.9767

Epoch 5/5

1875/1875 [==============================] - 9s 5ms/step - loss: 0.0267 - accuracy: 0.9920 - val_loss: 0.0862 - val_accuracy: 0.9802

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):

[0.08617018163204193, 0.9801999926567078]

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

print(prediction)
```

1/1 [==============================] - 0s 264ms/step

```
[[8.46943826e-13 1.57253368e-19 1.96990776e-14 3.01160138e-12
  1.78030464e-18 4.28635279e-16 1.02099006e-19 1.00000000e+00
  2.31007786e-13 1.16059251e-09]
 [3.43382928e-13 7.29512642e-13 1.00000000e+00 2.59724435e-18
```

```
  7.18828121e-19 4.43095160e-20 1.57180150e-12 2.10340672e-20
  9.12680796e-15 2.57497593e-20]
 [7.42934214e-10 9.99712765e-01 3.03818706e-06 6.55358634e-13
  1.32370133e-05 4.26156277e-10 6.16142026e-10 1.36882345e-05
  2.57250038e-04 1.04902729e-12]
 [9.99999762e-01 2.01685658e-18 1.22698598e-08 2.35469518e-14
  3.93878913e-13 1.61292490e-09 1.53220476e-08 1.24054740e-08
  5.34298192e-13 2.85961761e-07]]
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.]]
```