SPRINT 2

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TEAM ID	PNT2022TMID25508
PROJECT NAME	A NOVEL METHOD FOR HAND WRITTEN DIGIT RECOGNITION

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]
```

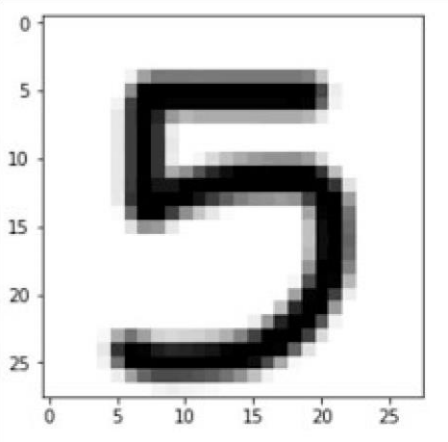
```
array([[ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
        0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,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

```
y_train[0]
```

```
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.]]
```