```
#SPRINT 2 TEAM ID:PNT2022TMID35216
```

#Importing required Libraries

In [1]:

```
import numpy#for numerical analysis
import tensorflow#open source ml tool by google
```

In [2]:

```
from tensorflow.keras.datasets import mnist #mnist dataset
from tensorflow.keras.models import Sequential
from tensorflow.keras import layers
```

In [3]:

```
from tensorflow.keras.layers import Dense,Flatten
from tensorflow.keras.layers import Conv2D
from tensorflow import keras
```

In [4]:

```
from tensorflow.keras.optimizers import Adam
from keras.utils import np_utils
```

#Loading dataset

Dataset is available in tensorflow dataset repository

In [34]:

```
(x_train,y_train),(x_test,y_test)=mnist.load_data()
```

In [6]:

```
print(x_train.shape)
print(y_train.shape)
```

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

Training Dataset has 60000 images & testing has 10000 images

In [7]:

```
print(x_test.shape)
print(y_test.shape)
```

```
(10000, 28, 28)
(10000,)
```

Analyze the data

In [8]:

```
x_train[3]
```

Out[8]:

```
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,   0, 124, 253, 255,  63,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0,   0,   0,  96, 244, 251, 253,  62,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0,   0,   0, 127, 251, 251, 253,  62,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0,   0,  68, 236, 251, 211,  31,   8,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0,  60, 228, 251, 251,  94,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0, 155, 253, 253, 189,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,  20, 253, 251, 235,  66,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
         32, 205, 253, 251, 126,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
        104, 251, 253, 184,  15,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,  80,
        240, 251, 193,  23,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,  32, 253,
        253, 253, 159,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0, 151, 251,
        251, 251,  39,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,  48, 221, 251,
        251, 172,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0, 234, 251, 251,
        196,  12,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0, 253, 251, 251,
         89,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0, 159, 255, 253, 253,
         31,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,  48, 228, 253, 247, 140,
          8,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,  64, 251, 253, 220,   0,
          0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,  64, 251, 253, 220,   0,
          0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,  24, 193, 253, 220,   0,
          0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   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)
```

In [9]:

```
y_train[3]
```

Out[9]:

```
1
```

In [10]:

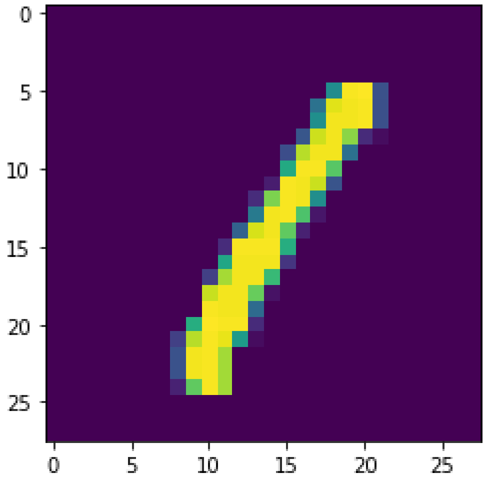
```
import matplotlib.pyplot as plt
```

In [11]:

```
plt.imshow(x_train[3])
```

Out[11]:

```
<matplotlib.image.AxesImage at 0x7efc3a0d9f50>
```



#Reshaping the data

,As we are using Deep learning neural network, the input for this network to get trained on should be of higher dimensional. Our dataset is having three-dimensional images so we have to reshape them too higher dimensions

In [41]:

```
#(batch,height,width,channel)
x_train=x_train.reshape(60000,28,28,1).astype('float32')
x_test=x_test.reshape(10000,28,28,1).astype('float32')
```

#Applying one hot encoding

One hot encoding to convert numerical values to classes where 0 to 9 are 10 seperate classes if value is 5 class 5 is 1 else 0

In [42]:

```
no_of_classes=10
y_train=np_utils.to_categorical(y_train,no_of_classes)
y_test=np_utils.to_categorical(y_test,no_of_classes)
```

In [43]:

```
y_test[3]
```

Out[43]:

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

#Creating the model

In [15]:

```
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(no_of_classes,activation='softmax'))
```

#Compile the model

In [16]:

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

#Train the model

In [27]:

```
model.fit(x_train,y_train,validation_data=(x_test,y_test),epochs=5,batch_size=32)
```

```
Epoch 1/5
1875/1875 [==============================] - 237s 126ms/step - loss: 0.0667
- accuracy: 0.9801 - val_loss: 0.0696 - val_accuracy: 0.9788
Epoch 2/5
1875/1875 [==============================] - 241s 128ms/step - loss: 0.0492
- accuracy: 0.9844 - val_loss: 0.0686 - val_accuracy: 0.9785
Epoch 3/5
1875/1875 [==============================] - 214s 114ms/step - loss: 0.0356
- accuracy: 0.9896 - val_loss: 0.0872 - val_accuracy: 0.9791
Epoch 4/5
1875/1875 [==============================] - 204s 109ms/step - loss: 0.0260
- accuracy: 0.9921 - val_loss: 0.1150 - val_accuracy: 0.9766
Epoch 5/5
1875/1875 [==============================] - 202s 108ms/step - loss: 0.0229
- accuracy: 0.9930 - val_loss: 0.1600 - val_accuracy: 0.9703
```

Out[27]:

```
<keras.callbacks.History at 0x7efc310ad850>
```

#metrics are noticed

In [44]:

```
metrics=model.evaluate(x_test,y_test,verbose=0)
print("metrics-score=>test loss & accuracy")
print(metrics)
```

```
metrics-score=>test loss & accuracy
[0.10003039240837097, 0.968999981880188]
```

#Test the model

In [45]:

```
prediction=model.predict(x_test[:5])
print(prediction)
```

```
1/1 [==============================] - 0s 65ms/step
[[1.3260176e-08 7.7986006e-13 3.6455315e-08 2.9610092e-07 1.5646798e-11
  1.3778896e-10 4.1263667e-13 9.9999964e-01 1.1379490e-07 2.1045294e-09]
 [2.1006859e-07 1.2594641e-07 9.9999034e-01 3.5162945e-08 4.3353143e-09
  9.1123662e-12 9.1517586e-06 3.2703376e-10 1.4321186e-07 3.1940206e-13]
 [2.4802778e-06 9.9979466e-01 1.4921059e-05 3.7803684e-07 8.7335298e-05
  2.8903003e-05 2.7718106e-05 1.2867370e-05 3.0750452e-05 2.2935906e-08]
 [9.9995744e-01 4.6908321e-11 3.4130477e-05 4.1088759e-09 8.1136318e-07
  5.7254068e-09 7.3323104e-06 9.4911625e-09 2.1464933e-07 4.6556575e-08]
 [3.2597340e-09 1.9132728e-11 2.1055206e-10 9.5630396e-12 1.0000000e+00
  4.2450727e-11 8.9529953e-11 1.0034685e-10 7.5573428e-12 1.3646383e-09]]
```

In [46]:

```
import numpy as np
```

In [47]:

```
print(np.argmax(prediction,axis=1))
```

```
[7 2 1 0 4]
```

In [48]:

```
print(y_test[:5])
```

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

#model saving

In [49]:

```
model.save('models/mnistcnn.h5')
```

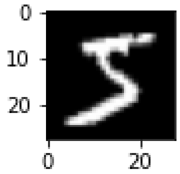
#Test the saved model

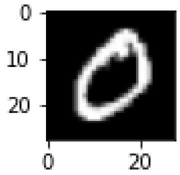
inputs loaded from mnist

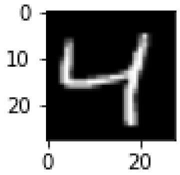
In [50]:

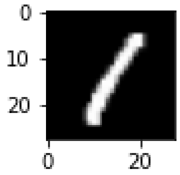
```
print('X_train:' +str(X_train.shape))
print('y_train:' +str(y_train.shape))
print('X_test:' +str(X_test.shape))
print('y_test:' +str(y_test.shape))
from matplotlib import pyplot
for i in range(9):
  pyplot.subplot(330+1+i)
  pyplot.imshow(X_train[i],cmap=pyplot.get_cmap('gray'))
  pyplot.show()
```

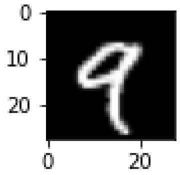
```
X_train:(60000, 28, 28)
y_train:(60000, 10)
X_test:(10000, 28, 28)
y_test:(10000, 10)
```

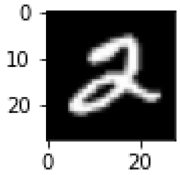


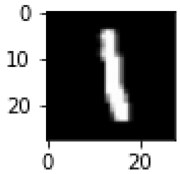


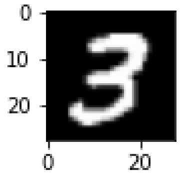


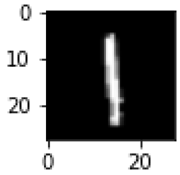












ouput predicted from saved model

inputs as hown are 5,0,4,1,9,2,1,3,1

In [54]:

```
from tensorflow.keras.models import load_model
model=load_model('models/mnistcnn.h5')
from PIL import Image
for index in range(9):
  img=X_train[index].reshape((28,28))
  imgarray=np.array(img)
  imgarray=imgarray.reshape(1,28,28,1)
  y_pred=model.predict(imgarray)
  print(np.argmax(y_pred))
```

```
1/1 [==============================] - 0s 67ms/step
5
1/1 [==============================] - 0s 21ms/step
0
1/1 [==============================] - 0s 21ms/step
4
1/1 [==============================] - 0s 23ms/step
1
1/1 [==============================] - 0s 19ms/step
9
1/1 [==============================] - 0s 19ms/step
2
1/1 [==============================] - 0s 19ms/step
1
1/1 [==============================] - 0s 22ms/step
3
1/1 [==============================] - 0s 18ms/step
1
```