Importing the required libraries

!pip install tensorflow --upgrade

Requirement already satisfied: tensorflow in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (2.10.0)

Requirement already satisfied: setuptools in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (58.0.4)

Requirement already satisfied: gast<=0.4.0,>=0.2.1 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (0.4.0)

Requirement already satisfied: h5py>=2.9.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (3.2.1)

Requirement already satisfied: absl-py>=1.0.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (1.3.0)

Requirement already satisfied: opt-einsum>=2.3.2 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (3.3.0)

Requirement already satisfied: astunparse>=1.6.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (1.6.3)

Requirement already satisfied: packaging in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (21.3)

Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (0.23.1)

Requirement already satisfied: typing-extensions>=3.6.6 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (4.1.1)

Requirement already satisfied: protobuf<3.20,>=3.9.2 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (3.19.1)

Requirement already satisfied: libclang>=13.0.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (14.0.6)

Requirement already satisfied: numpy>=1.20 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (1.20.3)

Requirement already satisfied: grpcio<2.0,>=1.24.3 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (1.42.0)

Requirement already satisfied: tensorflow-estimator<2.11,>=2.10.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (2.10.0)

Requirement already satisfied: wrapt>=1.11.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (1.12.1)

Requirement already satisfied: six>=1.12.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (1.15.0)

Requirement already satisfied: keras-preprocessing>=1.1.1 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (1.1.2)

Requirement already satisfied: termcolor>=1.1.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (1.1.0)

Requirement already satisfied: flatbuffers>=2.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (2.0)

Requirement already satisfied: keras<2.11,>=2.10.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (2.10.0)

Requirement already satisfied: tensorboard<2.11,>=2.10 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (2.10.1)

Requirement already satisfied: google-pasta>=0.1.1 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (0.2.0)

Requirement already satisfied: wheel<1.0,>=0.23.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from astunparse>=1.6.0->tensorflow) (0.37.0)

Requirement already satisfied: google-auth-oauthlib<0.5,>=0.4.1 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorboard<2.11,>=2.10->tensorflow) (0.4.4)

Requirement already satisfied: requests<3,>=2.21.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorboard<2.11,>=2.10->tensorflow) (2.26.0)

Requirement already satisfied: tensorboard-plugin-wit>=1.6.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorboard<2.11,>=2.10->tensorflow) (1.6.0)

Requirement already satisfied: google-auth<3,>=1.6.3 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorboard<2.11,>=2.10->tensorflow) (1.23.0)

Requirement already satisfied: werkzeug>=1.0.1 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorboard<2.11,>=2.10->tensorflow) (2.0.2)

Requirement already satisfied: tensorboard-data-server<0.7.0,>=0.6.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorboard<2.11,>=2.10->tensorflow) (0.6.1)

Requirement already satisfied: markdown>=2.6.8 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorboard<2.11,>=2.10->tensorflow) (3.3.3)

Requirement already satisfied: cachetools<5.0,>=2.0.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from google-auth<3,>=1.6.3->tensorboard<2.11,>=2.10->tensorflow) (4.2.2)

Requirement already satisfied: pyasn1-modules>=0.2.1 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from google-auth<3,>=1.6.3->tensorboard<2.11,>=2.10->tensorflow) (0.2.8)

Requirement already satisfied: rsa<5,>=3.1.4 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from google-auth<3,>=1.6.3->tensorboard<2.11,>=2.10->tensorflow) (4.7.2)

Requirement already satisfied: requests-oauthlib>=0.7.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from google-auth-oauthlib<0.5,>=0.4.1->tensorboard<2.11,>=2.10->tensorflow) (1.3.0)

Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from pyasn1-modules>=0.2.1->google-auth<3,>=1.6.3->tensorboard<2.11,>=2.10->tensorflow) (0.4.8)

Requirement already satisfied: charset-normalizer~=2.0.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from requests<3,>=2.21.0->tensorboard<2.11,>=2.10->tensorflow) (2.0.4)

Requirement already satisfied: idna<4,>=2.5 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from requests<3,>=2.21.0->tensorboard<2.11,>=2.10->tensorflow) (3.3)

Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from requests<3,>=2.21.0->tensorboard<2.11,>=2.10->tensorflow) (2022.9.24)

Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from requests<3,>=2.21.0->tensorboard<2.11,>=2.10->tensorflow) (1.26.7)

Requirement already satisfied: oauthlib>=3.0.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from requests-oauthlib>=0.7.0->google-auth-oauthlib<0.5,>=0.4.1->tensorboard<2.11,>=2.10->tensorflow) (3.2.1)

Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from packaging->tensorflow) (3.0.4)

import numpy as np

import tensorflow #open source used for both ML and DL for computation

from tensorflow.keras.datasets import mnist #mnist dataset

from tensorflow.keras.models import Sequential #it is a plain stack of layers

from tensorflow.keras import layers #A Layer consists of a tensor- in tensor-out computat ion funct ion

from tensorflow.keras.layers import Dense, Flatten #Dense-Dense Layer is the regular deeply connected r

#faltten -used fot flattening the input or change the dimension

from tensorflow.keras.layers import Conv2D #onvoLutiona l Layer

from keras.optimizers import Adam #opt imizer

from keras. utils import np_utils #used for one-hot encoding

import matplotlib.pyplot as plt #used for data visualization

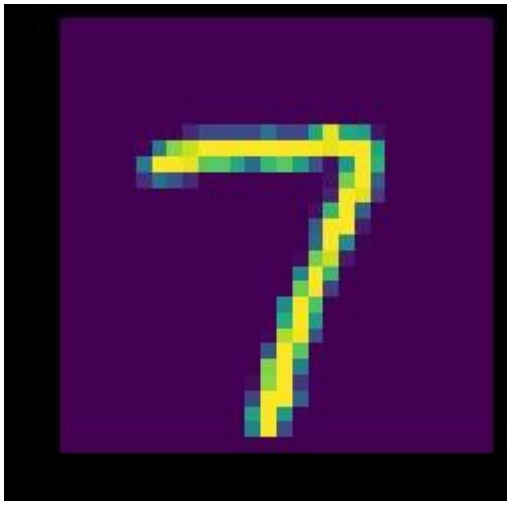
Load data

(x_train, y_train), (x_test, y_test)=mnist.load_data () #splitting the mnist data into train and test

```
print (x_train.shape)  #shape is used for give the dimens ion values #60000-rows 28x28-pixels
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)
plt.imshow(x_train[5100])
```



np.argmax(y_train[5100])

0

Reshaping Dataset

#Reshaping to format which CNN expects (batch, height, width, channels)

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

number_of_classes = 10 #storing the no of classes in a variable

y_train = np_utils.to_categorical (y_train, number_of_classes) #converts the output in binary format

y_test = np_utils.to_categorical (y_test, number_of_classes)

Add CNN Layers

#create model

model=Sequential ()

#adding modeL Layer

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

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

#flatten the dimension of the image

model.add(Flatten())

#output layer with 10 neurons

model.add(Dense(number_of_classes,activation = 'softmax'))

Compiling the model

#Compile model

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

x_train = np.asarray(x_train)

y_train = np.asarray(y_train)

Train the model

#fit the model

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

Epoch 1/5

1875/1875 [==============================] - 216s 115ms/step - loss: 0.2739 - accuracy: 0.9499 - val_loss: 0.1067 - val_accuracy: 0.9690

Epoch 2/5

1875/1875 [==============================] - 205s 109ms/step - loss: 0.0724 - accuracy: 0.9779 - val_loss: 0.0930 - val_accuracy: 0.9718

Epoch 3/5

1875/1875 [==============================] - 206s 110ms/step - loss: 0.0509 - accuracy: 0.9841 - val_loss: 0.0899 - val_accuracy: 0.9749

Epoch 4/5

1875/1875 [==============================] - 201s 107ms/step - loss: 0.0403 - accuracy: 0.9875 - val_loss: 0.0905 - val_accuracy: 0.9763

Epoch 5/5

1875/1875 [==============================] - 199s 106ms/step - loss: 0.0289 - accuracy: 0.9906 - val_loss: 0.0885 - val_accuracy: 0.9773