



```
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: setuptools in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (58.0.4)
Requirement already satisfied: packaging in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (21.3)
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: 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: 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: h5py>=2.9.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow) (3.2.1)
Collecting tensorflow-estimator<2.11,>=2.10.0
  Downloading tensorflow_estimator-2.10.0-py2.py3-none-any.whl (438 kB)
    |████████████████████████████████████████| 438 kB 83.2 MB/s eta 0:00:01
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: 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<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: 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: 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: 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: 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: 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: 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: 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: 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: 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: 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: 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: 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: 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)
Installing collected packages: absl-py, tensorflow-estimator, tensorboard, libclang, keras, tensorflow
  Attempting uninstall: absl-py
    Found existing installation: absl-py 0.12.0
    Uninstalling absl-py-0.12.0:
      Successfully uninstalled absl-py-0.12.0
  Attempting uninstall: tensorflow-estimator
    Found existing installation: tensorflow-estimator 2.7.0
    Uninstalling tensorflow-estimator-2.7.0:
      Successfully uninstalled tensorflow-estimator-2.7.0
  Attempting uninstall: tensorboard
    Found existing installation: tensorboard 2.7.0
    Uninstalling tensorboard-2.7.0:
      Successfully uninstalled tensorboard-2.7.0
  Attempting uninstall: keras
    Found existing installation: Keras 2.2.4
    Uninstalling Keras-2.2.4:
      Successfully uninstalled Keras-2.2.4
  Attempting uninstall: tensorflow
    Found existing installation: tensorflow 2.7.2
    Uninstalling tensorflow-2.7.2:
      Successfully uninstalled tensorflow-2.7.2
ERROR: pip's dependency resolver does not currently take into account all the packages that are installed. This behaviour is the source of the following dependency conflicts.
tensorflow-text 2.7.3 requires tensorflow<2.8,>=2.7.0, but you have tensorflow 2.10.0 which is incompatible.
tensorflow-metadata 1.5.0 requires absl-py<0.13,>=0.9, but you have absl-py 1.3.0 which is incompatible.
autoai-ts-libs 1.1.9 requires tensorflow<2.8,>=2.7.0; python_version >= "3.9", but you have tensorflow 2.10.0 which is incompatible.
Successfully installed absl-py-1.3.0 keras-2.10.0 libclang-14.0.6 tensorboard-2.10.1 tensorflow-2.10.0 tensorflow-estimator-2.10.0

```

In [31]:

```

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 #convolutional Layer
from keras.utils import np_utils #used for one-hot encoding
import matplotlib.pyplot as plt #used for data visualization
```

## Load data

In [32]:

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

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz
```

```
11493376/11490434 [=====] - 0s 0us/step
```

```
11501568/11490434 [=====] - 0s 0us/step
```

In [33]:

```
print (x_train.shape)  #shape is used for give the dimension values
```

```
#60000-rows 28x28-pixels
```

```
print (x test.shape)
```

(60000, 28, 28)

$$(10000, 28, 28)$$

In [34]:

```
x_train[0]
```

Out[34]:

```
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,  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]
```

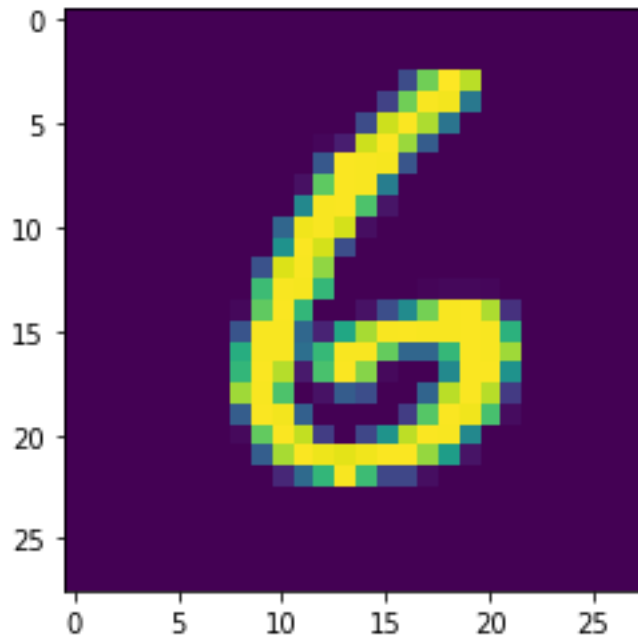
[ 0, 0, 0, 0, 0, 0, 0, 18, 219, 253, 253, 253, 253,  
253, 198, 182, 247, 241, 0, 0, 0, 0, 0, 0, 0, 0,  
0, 0],  
[ 0, 0, 0, 0, 0, 0, 0, 0, 80, 156, 107, 253, 253,  
205, 11, 0, 43, 154, 0, 0, 0, 0, 0, 0, 0, 0,  
0, 0],  
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 14, 1, 154, 253,  
90, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,  
0, 0],  
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 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, 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,  
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, 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, 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, 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, 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, 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,  0]], dtype=uint8)
```

In [35]:

```
plt.imshow(x_train[6000])      #ploting the index=image
```

Out[35]:



In [36]:

```
np.argmax(y_train[6000])
```

Out[36]:

0

## Reshaping Dataset

In [37]:

```
#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

In [38]:

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

In [39]:

```
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

In [40]:

```
#create model
model=Sequential ()
```

In [41]:

```
#adding model Layer
model.add(Conv2D(64, (3, 3), input_shape=(28, 28, 1), activation='relu'))
model.add(Conv2D(32, (3, 3), activation = 'relu'))
```

In [42]:

```
#flatten the dimension of the image
model.add(Flatten())
```

In [43]:

```
#output layer with 10 neurons
model.add(Dense(number_of_classes,activation = 'softmax'))
```

## Compiling the model

In [44]:

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

In [45]:

```
x_train = np.asarray(x_train)
y_train = np.asarray(y_train)
```

## Train the model

In [46]:

```
#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 [=====] - 126s 67ms/step - loss: 0.2690
- accuracy: 0.9514 - val_loss: 0.0884 - val_accuracy: 0.9728
Epoch 2/5
1875/1875 [=====] - 125s 66ms/step - loss: 0.0676
- accuracy: 0.9789 - val_loss: 0.0803 - val_accuracy: 0.9788
Epoch 3/5
1875/1875 [=====] - 125s 67ms/step - loss: 0.0458
- accuracy: 0.9852 - val_loss: 0.0791 - val_accuracy: 0.9788
Epoch 4/5
1875/1875 [=====] - 125s 67ms/step - loss: 0.0387
- accuracy: 0.9883 - val_loss: 0.1079 - val_accuracy: 0.9759
Epoch 5/5
1875/1875 [=====] - 125s 67ms/step - loss: 0.0280
- accuracy: 0.9909 - val_loss: 0.0991 - val_accuracy: 0.9774
```

Out[46]:

## Observing the metrics

In [47]:

```
# Final evaluation of the model
metrics = model.evaluate(x_test, y_test, verbose=0)
print("Metrics (Test loss &Test Accuracy) : ")
print(metrics)

Metrics (Test loss &Test Accuracy) :
[0.09910603612661362, 0.977400004863739]
```

## Test The Model

In [48]:

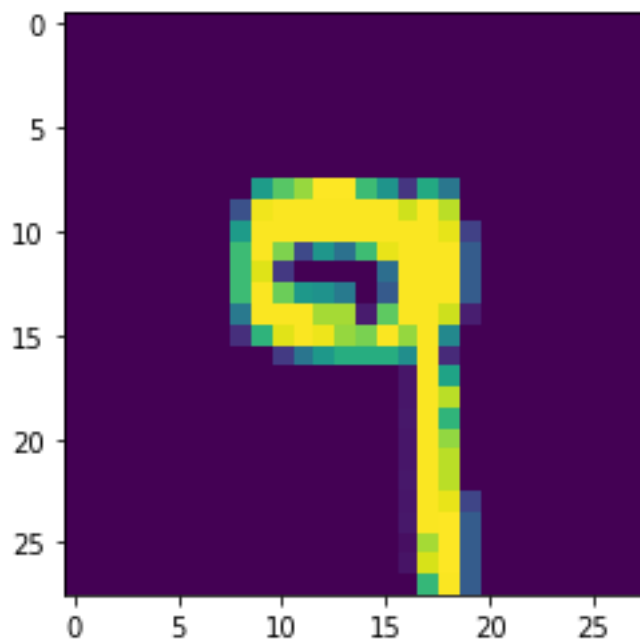
```
prediction=model.predict(x_test[6000:6001])
print(prediction)

[[9.1516389e-13  8.1778777e-19  2.4542002e-14  1.7823329e-07  5.2257418e-04
  5.8763407e-09  6.2800168e-17  3.1880148e-07  6.3142506e-03  9.9316275e-01]]
```

In [49]:

```
plt.imshow(x_test[6000])
```

Out[49]:



In [50]:

```
import numpy as np
print(np.argmax(prediction, axis=1)) #printing our Labels from first 4
images

[9]
```

In [51]:

```
np.argmax(y_test[6000:6001]) #printing the actual labels
```

Out[51]:

9

## Save The model



```
# Save the model
model.save('models/mnistCNN.h5')
```

```
cd models
/home/wsuser/work/models
```

```
!tar -zcvf handwritten-digit-recognition-model_new.tgz mnistCNN.h5
mnistCNN.h5
```

```
!pip install watson-machine-learning-client --upgrade
Collecting watson-machine-learning-client
  Downloading watson_machine_learning_client-1.0.391-py3-none-any.whl (538
kB)
    |████████████████████████████████████████████████████████████████████████████████| 538 kB 21.5 MB/s eta 0:00:01
Requirement already satisfied: lomond in /opt/conda/envs/Python-3.9/lib/pyth
on3.9/site-packages (from watson-machine-learning-client) (0.3.3)
Requirement already satisfied: boto3 in /opt/conda/envs/Python-3.9/lib/pyth
on3.9/site-packages (from watson-machine-learning-client) (1.18.21)
Requirement already satisfied: tqdm in /opt/conda/envs/Python-3.9/lib/pytho
n3.9/site-packages (from watson-machine-learning-client) (4.62.3)
Requirement already satisfied: pandas in /opt/conda/envs/Python-3.9/lib/pyt
hon3.9/site-packages (from watson-machine-learning-client) (1.3.4)
Requirement already satisfied: tabulate in /opt/conda/envs/Python-3.9/lib/p
ython3.9/site-packages (from watson-machine-learning-client) (0.8.9)
Requirement already satisfied: certifi in /opt/conda/envs/Python-3.9/lib/py
thon3.9/site-packages (from watson-machine-learning-client) (2022.9.24)
Requirement already satisfied: urllib3 in /opt/conda/envs/Python-3.9/lib/py
thon3.9/site-packages (from watson-machine-learning-client) (1.26.7)
Requirement already satisfied: ibm-cos-sdk in /opt/conda/envs/Python-3.9/li
b/python3.9/site-packages (from watson-machine-learning-client) (2.11.0)
Requirement already satisfied: requests in /opt/conda/envs/Python-3.9/lib/p
ython3.9/site-packages (from watson-machine-learning-client) (2.26.0)
Requirement already satisfied: botocore<1.22.0,>=1.21.21 in /opt/conda/envs
/Python-3.9/lib/python3.9/site-packages (from boto3->watson-machine-learnin
g-client) (1.21.41)
Requirement already satisfied: s3transfer<0.6.0,>=0.5.0 in /opt/conda/envs/
Python-3.9/lib/python3.9/site-packages (from boto3->watson-machine-learning
-client) (0.5.0)
Requirement already satisfied: jmespath<1.0.0,>=0.7.1 in /opt/conda/envs/P
ython-3.9/lib/python3.9/site-packages (from boto3->watson-machine-learning-c
lient) (0.10.0)
Requirement already satisfied: python-dateutil<3.0.0,>=2.1 in /opt/conda/en
vs/Python-3.9/lib/python3.9/site-packages (from botocore<1.22.0,>=1.21.21->
boto3->watson-machine-learning-client) (2.8.2)
Requirement already satisfied: six>=1.5 in /opt/conda/envs/Python-3.9/lib/p
ython3.9/site-packages (from python-dateutil<3.0.0,>=2.1->botocore<1.22.0,>
=1.21.21->boto3->watson-machine-learning-client) (1.15.0)
Requirement already satisfied: ibm-cos-sdk-s3transfer==2.11.0 in /opt/conda
/envs/Python-3.9/lib/python3.9/site-packages (from ibm-cos-sdk->watson-mach
ine-learning-client) (2.11.0)
Requirement already satisfied: ibm-cos-sdk-core==2.11.0 in /opt/conda/envs/
Python-3.9/lib/python3.9/site-packages (from ibm-cos-sdk->watson-machine-le
arning-client) (2.11.0)
```

Requirement already satisfied: charset-normalizer~=2.0.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from requests->watson-machine-learning-client) (2.0.4)

Requirement already satisfied: idna<4,>=2.5 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from requests->watson-machine-learning-client) (3.3)

Requirement already satisfied: pytz>=2017.3 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from pandas->watson-machine-learning-client) (2021.3)

Requirement already satisfied: numpy>=1.17.3 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from pandas->watson-machine-learning-client) (1.20.3)

Installing collected packages: watson-machine-learning-client

Successfully installed watson-machine-learning-client-1.0.391

## Cloud deploy

In [56]:

```
from ibm_watson_machine_learning import APIClient
credentials = {
    "url": "https://jp-tok.ml.cloud.ibm.com",
    "apikey": "BHyalu2c7JN6n9cnvAVULvSKRYFVLMQ_m51toZ9Yk0nS"
}
client = APIClient(credentials)
client
```

Out[56]:

In [57]:

```
client.spaces.get_details()
```

Out[57]:

```
{'resources': [{'entity': {'compute': [{'crn': 'crn:v1:bluemix:public:pm-20:jp-tok:a/53f9f6400d0d44889534e8abcd2dfe39:0f4376b6-c944-4b27-b23e-48b54d8f4bbd::',
    'guid': '0f4376b6-c944-4b27-b23e-48b54d8f4bbd',
    'name': 'Watson Machine Learning-sp',
    'type': 'machine_learning'}],
    'description': '',
    'name': 'digitrecognition',
    'scope': {'bss_account_id': '53f9f6400d0d44889534e8abcd2dfe39'},
    'stage': {'production': False},
    'status': {'state': 'active'},
    'storage': {'properties': {'bucket_name': '63888f6f-d1ef-475c-a8d8-a2e4957bb673',
    'bucket_region': 'jp-tok-standard',
    'credentials': {'admin': {'access_key_id': '834b3358ebb945fb9ebbb4020cd2bf0e',
    'api_key': '2JONUuPfYzZzPGzTp1J7dwjNTpkOsyxdW5gx_vml3m',
    'secret_access_key': '1ed5b29fdd6c65b48ca72963b6177133ce51a7b23acdc
aa5',
    'service_id': 'ServiceId-a2495f73-f36b-4fa1-9991-976f110c1a4f'}},
    'editor': {'access_key_id': 'b56d445c54794369b2a4e0115e166605',
    'api_key': 'wcwCBLp8z4xpgnsEDeUCOZquAovrWhXu2wcF9Kz5Vhpe',
    'resource_key_crn': 'crn:v1:bluemix:public:cloud-object-storage:global:a/53f9f6400d0d44889534e8abcd2dfe39:d8fa8aee-cd61-4757-9543-a61f55971074::',
```

```

        'secret_access_key': '84b0b128f52e57c025e6517604a06212b8d19f0b349ee
ea3',
        'service_id': 'ServiceId-4elf87ab-27bc-4654-b6ea-667a8640c7e0'},
        'viewer': {'access_key_id': '558109e942fb4bleb020c881f04d8588',
        'api_key': 'zWS-VZ_d9GfkDt1XnCmWoOA6liYXNnGtrPwJt2fIOUI5',
        'resource_key_crn': 'crn:v1:bluemix:public:cloud-object-storage:glob
bal:a/53f9f6400d0d44889534e8abcd2dfe39:d8fa8aee-cd61-4757-9543-a61f55971074
::',
        'secret_access_key': '3e2d27ab9d4041707cfa721daa638d1ad57f42ab8df94
c09',
        'service_id': 'ServiceId-93177c88-86e2-470d-b5bf-3aed99d093a8'}},
        'endpoint_url': 'https://s3.jp-tok.cloud-object-storage.appdomain.clo
ud',
        'guid': 'd8fa8aee-cd61-4757-9543-a61f55971074',
        'resource_crn': 'crn:v1:bluemix:public:cloud-object-storage:global:a/
53f9f6400d0d44889534e8abcd2dfe39:d8fa8aee-cd61-4757-9543-a61f55971074::',
        'type': 'bmcos_object_storage'}},
        'metadata': {'created_at': '2022-10-31T10:33:07.575Z',
        'creator_id': 'IBMid-667000CZ2Y',
        'id': 'aa24227a-9f01-493f-90e6-1b6132057fc6',
        'updated_at': '2022-10-31T10:33:25.148Z',
        'url': '/v2/spaces/aa24227a-9f01-493f-90e6-1b6132057fc6'}}}]

```

In [58]:

```

def guid_from_space_name(client,deploy):
    space = client.spaces.get_details()
    return (next(item for item in space['resources'] if
item['entity']['name']==deploy)['metadata']['id'])

```

In [59]:

```

space_uid = guid_from_space_name(client,'digitrecognition')
print("Space UID = " + space_uid)

Space UID = aa24227a-9f01-493f-90e6-1b6132057fc6

```

In [60]:

```
client.set.default_space(space_uid)
```

Out[60]:

```
'SUCCESS'
```

In [61]:

```
client.software_specifications.list(limit=100)
```

NAME	ASSET_ID	TYPE
default_py3.6	0062b8c9-8b7d-44a0-a9b9-46c416adcbd9	base
kernel-spark3.2-scala2.12	020d69ce-7ac1-5e68-ac1a-31189867356a	base
pytorch-onnx_1.3-py3.7-edt	069ea134-3346-5748-b513-49120e15d288	base
scikit-learn_0.20-py3.6	09c5a1d0-9c1e-4473-a344-eb7b665ff687	base
spark-mllib_3.0-scala_2.12	09f4cff0-90a7-5899-b9ed-1ef348aebdee	base
pytorch-onnx_rt22.1-py3.9	0b848dd4-e681-5599-be41-b5f6fccc6471	base
ai-function_0.1-py3.6	0cdb0f1e-5376-4f4d-92dd-da3b69aa9bda	base
shiny-r3.6	0e6e79df-875e-4f24-8ae9-62dcc2148306	base
tensorflow_2.4-py3.7-horovod	1092590a-307d-563d-9b62-4eb7d64b3f22	base
pytorch_1.1-py3.6	10ac12d6-6b30-4ccd-8392-3e922c096a92	base
tensorflow_1.15-py3.6-ddl	111e41b3-de2d-5422-a4d6-bf776828c4b7	base
runtime-22.1-py3.9	12b83a17-24d8-5082-900f-0ab31fbfd3cb	base
scikit-learn_0.22-py3.6	154010fa-5b3b-4ac1-82af-4d5ee5abbc85	base
default_r3.6	1b70aec3-ab34-4b87-8aa0-a4a3c8296a36	base
pytorch-onnx_1.3-py3.6	1bc6029a-cc97-56da-b8e0-39c3880dbbe7	base

kernel-spark3.3-r3.6	1c9e5454-f216-59dd-a20e-474a5cdf5988	base
pytorch-onnx_rt22.1-py3.9-edt	1d362186-7ad5-5b59-8b6c-9d0880bde37f	base
tensorflow_2.1-py3.6	1eb25b84-d6ed-5dde-b6a5-3fbdf1665666	base
spark-mllib_3.2	20047f72-0a98-58c7-9ff5-a77b012eb8f5	base
tensorflow_2.4-py3.8-horovod	217c16f6-178f-56bf-824a-b19f20564c49	base
runtime-22.1-py3.9-cuda	26215f05-08c3-5a41-a1b0-da66306ce658	base
do_py3.8	295addb5-9ef9-547e-9bf4-92ae3563e720	base
autoai-ts_3.8-py3.8	2aa0c932-798f-5ae9-abd6-15e0c2402fb5	base
tensorflow_1.15-py3.6	2b73a275-7cbf-420b-a912-eae7f436e0bc	base
kernel-spark3.3-py3.9	2b7961e2-e3b1-5a8c-a491-482c8368839a	base
pytorch_1.2-py3.6	2c8ef57d-2687-4b7d-acce-01f94976dac1	base
spark-mllib_2.3	2e51f700-bca0-4b0d-88dc-5c6791338875	base
pytorch-onnx_1.1-py3.6-edt	32983cea-3f32-4400-8965-dde874a8d67e	base
spark-mllib_3.0-py37	36507ebe-8770-55ba-ab2a-eafe787600e9	base
spark-mllib_2.4	390d21f8-e58b-4fac-9c55-d7ceda621326	base
xgboost_0.82-py3.6	39e31acd-5f30-41dc-ae44-60233c80306e	base
pytorch-onnx_1.2-py3.6-edt	40589d0e-7019-4e28-8daa-fb03b6f4fe12	base
default_r36py38	41c247d3-45f8-5a71-b065-8580229facf0	base
autoai-ts_rt22.1-py3.9	4269d26e-07ba-5d40-8f66-2d495b0c71f7	base
autoai-obm_3.0	42b92e18-d9ab-567f-988a-4240baled5f7	base
pmml-3.0_4.3	493bcb95-16f1-5bc5-bee8-81b8af80e9c7	base
spark-mllib_2.4-r_3.6	49403dff-92e9-4c87-a3d7-a42d0021c095	base
xgboost_0.90-py3.6	4ff8d6c2-1343-4c18-85e1-689c965304d3	base
pytorch-onnx_1.1-py3.6	50f95b2a-bc16-43bb-bc94-b0bed208c60b	base
autoai-ts_3.9-py3.8	52c57136-80fa-572e-8728-a5e7cbb42cde	base
spark-mllib_2.4-scala_2.11	55a70f99-7320-4be5-9fb9-9edb5a443af5	base
spark-mllib_3.0	5c1b0ca2-4977-5c2e-9439-ffd44ea8ffe9	base
autoai-obm_2.0	5c2e37fa-80b8-5e77-840f-d912469614ee	base
spss-modeler_18.1	5c3cad7e-507f-4b2a-a9a3-ab53a21dee8b	base
cuda-py3.8	5d3232bf-c86b-5df4-a2cd-7bb870a1cd4e	base
autoai-kb_3.1-py3.7	632d4b22-10aa-5180-88f0-f52dfb6444d7	base
pytorch-onnx_1.7-py3.8	634d3cdc-b562-5bf9-a2d4-ea90a478456b	base
spark-mllib_2.3-r_3.6	6586b9e3-ccd6-4f92-900f-0f8cb2bd6f0c	base
tensorflow_2.4-py3.7	65e171d7-72d1-55d9-8ebb-f813d620c9bb	base
spss-modeler_18.2	687eddc9-028a-4117-b9dd-e57b36f1efa5	base
pytorch-onnx_1.2-py3.6	692a6a4d-2c4d-45ff-a1ed-b167ee55469a	base
spark-mllib_2.3-scala_2.11	7963efe5-bbec-417e-92cf-0574e21b4e8d	base
spark-mllib_2.4-py37	7abc992b-b685-532b-a122-a396a3cdbaab	base
caffe_1.0-py3.6	7bb3dbe2-da6e-4145-918d-b6d84aa93b6b	base
pytorch-onnx_1.7-py3.7	812c6631-42b7-5613-982b-02098e6c909c	base
cuda-py3.6	82c79ece-4d12-40e6-8787-a7b9e0f62770	base
tensorflow_1.15-py3.6-horovod	8964680e-d5e4-5bb8-919b-8342c6c0dfd8	base
hybrid_0.1	8c1a58c6-62b5-4dc4-987a-df751c2756b6	base
pytorch-onnx_1.3-py3.7	8d5d8a87-a912-54cf-81ec-3914adaa988d	base
caffe-ibm_1.0-py3.6	8d863266-7927-4d1e-97d7-56a7f4c0a19b	base
spss-modeler_17.1	902d0051-84bd-4af6-ab6b-8f6aa6fdeabb	base
do_12.10	9100fd72-8159-4eb9-8a0b-a87e12eefa36	base
do_py3.7	9447fa8b-2051-4d24-9eef-5acb0e3c59f8	base
spark-mllib_3.0-r_3.6	94bb6052-c837-589d-83f1-f4142f219e32	base
cuda-py3.7-opence	94e9652b-7f2d-59d5-ba5a-23a414ea488f	base
nlp-py3.8	96e60351-99d4-5a1c-9cc0-473ac1b5a864	base
cuda-py3.7	9a44990c-1aa1-4c7d-baf8-c4099011741c	base
hybrid_0.2	9b3f9040-9cee-4ead-8d7a-780600f542f7	base
spark-mllib_3.0-py38	9f7a8fc1-4d3c-5e65-ab90-41fa8de2d418	base
autoai-kb_3.3-py3.7	a545cca3-02df-5c61-9e88-998b09dc79af	base
spark-mllib_3.0-py39	a6082a27-5acc-5163-b02c-6b96916eb5e0	base
runtime-22.1-py3.9-do	a7e7dbf1-1d03-5544-994d-e5ec845ce99a	base

default_py3.8	ab9e1b80-f2ce-592c-a7d2-4f2344f77194	base
tensorflow_rt22.1-py3.9	acd9c798-6974-5d2f-a657-ce06e986df4d	base
kernel-spark3.2-py3.9	ad7033ee-794e-58cf-812e-a95f4b64b207	base
autoai-obm_2.0 with Spark 3.0	af10f35f-69fa-5d66-9bf5-acb58434263a	base
default_py3.7_opence	c2057dd4-f42c-5f77-a02f-72bdbd3282c9	base
tensorflow_2.1-py3.7	c4032338-2a40-500a-beef-b01ab2667e27	base
do_py3.7_opence	cc8f8976-b74a-551a-bb66-6377f8d865b4	base
spark-mllib_3.3	d11f2434-4fc7-58b7-8a62-755da64fdaf8	base
autoai-kb_3.0-py3.6	d139f196-e04b-5d8b-9140-9a10ca1fa91a	base
spark-mllib_3.0-py36	d82546d5-dd78-5fbb-9131-2ec309bc56ed	base
autoai-kb_3.4-py3.8	da9b39c3-758c-5a4f-9cfd-457dd4d8c395	base
kernel-spark3.2-r3.6	db2fe4d6-d641-5d05-9972-73c654c60e0a	base
autoai-kb_rt22.1-py3.9	db6afe93-665f-5910-b117-d879897404d9	base
tensorflow_rt22.1-py3.9-horovod	dda170cc-ca67-5da7-9b7a-cf84c6987fae	base
autoai-ts_1.0-py3.7	deef04f0-0c42-5147-9711-89f9904299db	base
tensorflow_2.1-py3.7-horovod	e384fce5-fdd1-53f8-bc71-11326c9c635f	base
default_py3.7	e4429883-c883-42b6-87a8-f419d64088cd	base
do_22.1	e51999ba-6452-5f1f-8287-17228b88b652	base
autoai-obm_3.2	eae86aab-da30-5229-a6a6-1d0d4e368983	base
do_20.1	f686cdd9-7904-5f9d-a732-01b0d6b10dc5	base
scikit-learn_0.19-py3.6	f963fa9d-4bb7-5652-9c5d-8d9289ef6ad9	base
tensorflow_2.4-py3.8	fe185c44-9a99-5425-986b-59bd1d2eda46	base

In [62]:

```
software_space_uid =
client.software_specifications.get_uid_by_name('tensorflow_rt22.1-py3.9')
software_space_uid
```

Out[62]:

```
'acd9c798-6974-5d2f-a657-ce06e986df4d'
```

In [63]:

```
model_details = client.repository.store_model(model='handwritten-digit-
recognition-model_new.tgz',meta_props={
    client.repository.ModelMetaNames.NAME:"CNN Digit recognition model",
    client.repository.ModelMetaNames.TYPE:"tensorflow_2.7",
    client.repository.ModelMetaNames.SOFTWARE_SPEC_UID:software_space_uid
})
```

In [64]:

```
model_details
```

Out[64]:

```
{'entity': {'hybrid_pipeline_software_specs': [],
  'software_spec': {'id': 'acd9c798-6974-5d2f-a657-ce06e986df4d',
    'name': 'tensorflow_rt22.1-py3.9'},
  'type': 'tensorflow_2.7'},
  'metadata': {'created_at': '2022-11-01T10:15:40.847Z',
    'id': '97d463b1-45ee-47f7-b8af-aed338794ce1',
    'modified_at': '2022-11-01T10:15:44.197Z',
    'name': 'CNN Digit recognition model',
    'owner': 'IBMid-667000CZ2Y',
    'resource_key': '84636ddb-9fa8-47e4-8fa4-3c36731e2fe6',
    'space_id': 'aa24227a-9f01-493f-90e6-1b6132057fc6'},
  'system': {'warnings': []}}
```

In [65]:

```
model_id = client.repository.get_model_id(model_details)
model_id
```

```
'97d463b1-45ee-47f7-b8af-aed338794ce1'
```

Out[65]:

```
client.repository.download(model_id, 'DigitRecog_IBM_model.tar.gz')  
Successfully saved model content to file: 'DigitRecog_IBM_model.tar.gz'
```

Out[66]:

```
 '/home/wsuser/work/models/DigitRecog_IBM_model.tar.gz'
```

In [67]:

```
ls
```

```
DigitRecog_IBM_model.tar.gz          mnistCNN.h5  
handwritten-digit-recognition-model_new.tgz
```

## TEST MODEL

```
from tensorflow.keras.models import load_model  
from keras.preprocessing import image  
from PIL import Image  
import numpy as np
```

In [286]:

```
model = load_model("mnistCNN.h5")
```

In [287]:

```
import os, types  
import pandas as pd  
from botocore.client import Config  
import ibm_boto3
```

In [288]:

```
def __iter__(self): return 0
```

```
# @hidden_cell  
# The following code accesses a file in your IBM Cloud Object Storage. It  
# includes your credentials.  
# You might want to remove those credentials before you share the notebook.  
cos_client = ibm_boto3.client(service_name='s3',  
                               ibm_api_key_id='is_QZGPYU8oxZr3W-td-LCHXS3QPMaWArILi18FdSyGT',  
                               ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",  
                               config=Config(signature_version='oauth'),  
                               endpoint_url='https://s3.private.ap.cloud-object-  
storage.appdomain.cloud')
```

```
bucket = 'handwrittenimagerecognition-donotdelete-pr-8tlrnykut46vpi'  
object_key = 'mnist-dataset-1024x424 (2).png'
```

```
streaming_body_1 = cos_client.get_object(Bucket=bucket,  
Key=object_key)['Body']
```

```
# Your data file was loaded into a botocore.response.StreamingBody object.  
# Please read the documentation of ibm_boto3 and pandas to learn more about  
# the possibilities to load the data.  
# ibm_boto3 documentation: https://ibm.github.io/ibm-cos-sdk-python/  
# pandas documentation: http://pandas.pydata.org/
```

In [289]:

```
img = Image.open(streaming_body_1).convert("L") # convert image to monochrome
```

```
img = img.resize( (28,28) ) # resizing of input image
```

In [290]:

```
img
```

Out[290]:



In [291]:

```
im2arr = np.array(img) #converting to image
```

```
im2arr = im2arr.reshape(1, 28, 28, 1) #reshaping according to our requirement
```

In [292]:

```
pred = model.predict(im2arr)
```

```
print(pred)
```

```
[[1.0000000e+00 5.3912803e-17 3.9648812e-11 2.0051219e-16 5.1053910e-18  
 2.9315760e-12 7.0849349e-13 2.0999634e-16 2.9204243e-09 7.4729778e-11]]
```

In [293]:

```
print(np.argmax(pred, axis=1)) #printing our Labels
```

```
[0]
```