```python
#@title Import Libraries

!pip install opencv-python
!pip install tensorflow
import numpy as np
import matplotlib.pyplot as plt
import tensorflow
from tensorflow.keras.datasets import mnist
from tensorflow.keras.layers import Dense,Flatten
from keras.layers.convolutional import Conv2D
from tensorflow.keras.models import Sequential
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.optimizers  import  Adam
from keras. utils import np_utils
```

Requirement already satisfied: opencv-python in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (4.6.0.66)
Requirement already satisfied: numpy>=1.17.3 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from opencv-
python) (1.20.3)
Requirement already satisfied: tensorflow in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (2.7.2)
Requirement already satisfied: tensorflow-estimator<2.8,~=2.7.0 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorflow) (2.7.0)
Requirement already satisfied: flatbuffers<3.0,>=1.12 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorflow) (2.0)
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: 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: gast<0.5.0,>=0.2.1 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorflow) (0.4.0)
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: wheel<1.0,>=0.32.0 in
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tensorflow) (0.37.0)
Requirement already satisfied: termcolor>=1.1.0 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
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Requirement already satisfied: tensorboard~=2.7 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorflow) (2.7.0)
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: 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: protobuf>=3.9.2 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorflow) (3.19.1)
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: tensorflow-io-gcs-filesystem>=0.21.0 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorflow) (0.23.1)
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: keras<2.8,>=2.7.0 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorflow) (2.7.0)
Requirement already satisfied: absl-py>=0.4.0 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorflow) (0.12.0)
Requirement already satisfied: numpy>=1.14.5 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorflow) (1.20.3)
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: wrapt>=1.11.0 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorflow) (1.12.1)
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~=2.7->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~=2.7->tensorflow) (2.26.0)
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~=2.7->tensorflow) (0.4.4)
Requirement already satisfied: google-auth<3,>=1.6.3 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorboard~=2.7->tensorflow) (1.23.0)
Requirement already satisfied: tensorboard-plugin-wit>=1.6.0 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorboard~=2.7->tensorflow) (1.6.0)
Requirement already satisfied: setuptools>=41.0.0 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorboard~=2.7->tensorflow) (58.0.4)
Requirement already satisfied: markdown>=2.6.8 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from

tensorboard~=2.7->tensorflow) (3.3.3)
Requirement already satisfied: werkzeug>=0.11.15 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from
tensorboard~=2.7->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~=2.7->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~=2.7->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~=2.7->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~=2.7->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~=2.7->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~=2.7->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~=2.7->tensorflow) (1.26.7)
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~=2.7->tensorflow) (3.3)
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~=2.7->tensorflow) (2.0.4)
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~=2.7-
>tensorflow) (3.2.1)

```python
#@title Loading Data


(X_train,y_train),(X_test,y_test)=mnist.load_data()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-
keras-datasets/mnist.npz
11493376/11490434 [==============================] - 0s 0us/step
11501568/11490434 [==============================] - 0s 0us/step
```

```python
#@title Shape of images in the dataset


X_train.shape,y_train.shape,X_test.shape,y_test.shape
```
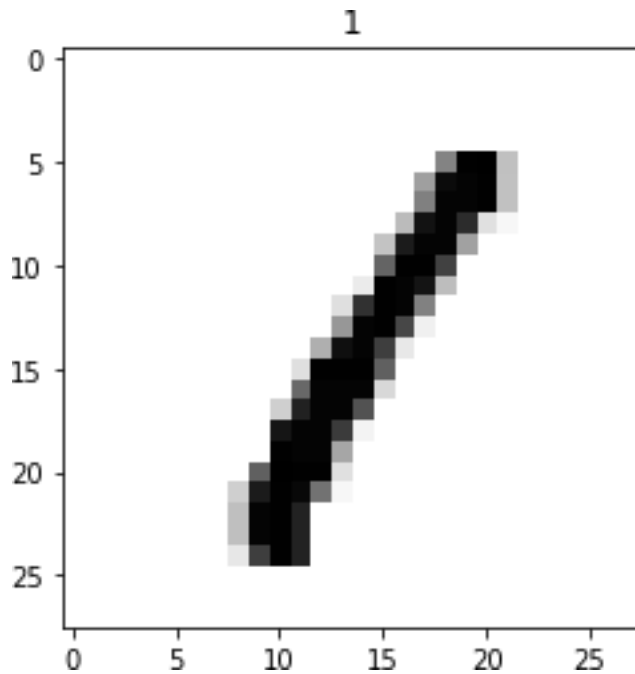
```
((60000, 28, 28), (60000,), (10000, 28, 28), (10000,))
```

```python
def plot_input_img(i):
  plt.imshow(X_train[i],cmap='binary')
  plt.title(y_train[i])
  plt.show
plot_input_img(3)
```

```python
X_train=X_train.reshape(60000,28,28,1).astype('float32')
X_test=X_test.reshape(10000,28,28,1).astype('float32')
X_train.shape,y_train.shape,X_test.shape,y_test.shape
```

```
((60000, 28, 28, 1), (60000,), (10000, 28, 28, 1), (10000,))
```

```python
classes_no=10
y_train=np_utils.to_categorical(y_train,classes_no)
y_test=np_utils.to_categorical(y_test,classes_no)
```

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

#adding modeL Layer
layer1=Conv2D(64,kernel_size=3,activation='relu',input_shape=(28,28,1)
)
layer2=Conv2D(32,kernel_size=3,activation='relu')

#flatten the dimension of the image
layer3=Flatten()

#output layer with 10 neurons
layer4=Dense(10,activation='softmax')

#@title Adding layers to the model.


model.add(layer1)
model.add(layer2)
model.add(layer3)
model.add(layer4)

#@title Compile the Model.


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

#@title Train Model


model.fit(X_train,y_train,validation_data=(X_test,y_test),epochs=10,ba
tch_size=32)

Epoch 1/10
1875/1875 [==============================] - 166s 88ms/step - loss:
0.2602 - accuracy: 0.9505 - val_loss: 0.1014 - val_accuracy: 0.9668
Epoch 2/10
1875/1875 [==============================] - 166s 88ms/step - loss:
0.0742 - accuracy: 0.9783 - val_loss: 0.0708 - val_accuracy: 0.9796
Epoch 3/10
1875/1875 [==============================] - 164s 87ms/step - loss:
0.0518 - accuracy: 0.9841 - val_loss: 0.0956 - val_accuracy: 0.9739
Epoch 4/10
1875/1875 [==============================] - 163s 87ms/step - loss:
0.0383 - accuracy: 0.9875 - val_loss: 0.1215 - val_accuracy: 0.9658
Epoch 5/10
1875/1875 [==============================] - 164s 88ms/step - loss:
0.0320 - accuracy: 0.9898 - val_loss: 0.1043 - val_accuracy: 0.9741
```

```
Epoch 6/10
1875/1875 [==============================] - 165s 88ms/step - loss:
0.0256 - accuracy: 0.9921 - val_loss: 0.1168 - val_accuracy: 0.9766
Epoch 7/10
1875/1875 [==============================] - 165s 88ms/step - loss:
0.0242 - accuracy: 0.9932 - val_loss: 0.1296 - val_accuracy: 0.9786
Epoch 8/10
1875/1875 [==============================] - 164s 87ms/step - loss:
0.0207 - accuracy: 0.9942 - val_loss: 0.1849 - val_accuracy: 0.9723
Epoch 9/10
1875/1875 [==============================] - 163s 87ms/step - loss:
0.0174 - accuracy: 0.9946 - val_loss: 0.1497 - val_accuracy: 0.9793
Epoch 10/10
1875/1875 [==============================] - 164s 87ms/step - loss:
0.0174 - accuracy: 0.9952 - val_loss: 0.2393 - val_accuracy: 0.9726

<keras.callbacks.History at 0x7fe9dd541dc0>
```

```python
#@title Evaluate the Model


metrics = model.evaluate(X_test, y_test, verbose=0)
print("Metrics (Test Loss & Test Accuracy): ")
print(metrics)
```

```
Metrics (Test Loss & Test Accuracy):
[0.2392578423023224, 0.972599983215332]
```

```python
#@title Test the model


test_img=X_test[15]
prediction=model.predict(test_img.reshape(1,28,28,1))
#first output
print("softmax{}".format(prediction))
hard_maxed_prediction=np.zeros(prediction.shape)
hard_maxed_prediction[0][np.argmax(prediction)]=1
#second output
print("hardmax{}".format(hard_maxed_prediction))
#third output
plt.imshow(test_img.reshape(28,28),cmap="gray")
plt.show()
print("final{}".format(np.argmax(prediction)))
```

```
softmax[[7.5888513e-37 0.0000000e+00 5.4936177e-29 1.3545132e-11
1.9612329e-36
  1.0000000e+00 8.3028593e-30 1.9509480e-31 1.3362523e-27 3.8361595e-
36]]
hardmax[[0. 0. 0. 0. 0. 1. 0. 0. 0. 0.]]
```

final5

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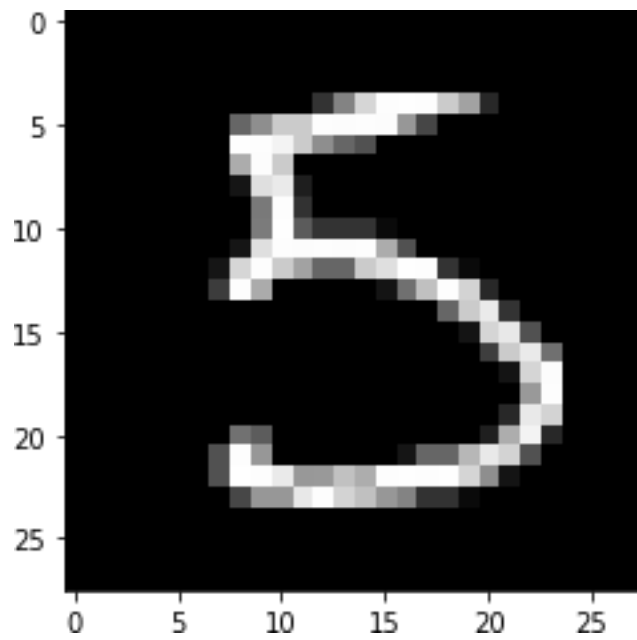
```python
model.save('models/mnistCNN.h5')
```

```python
cd models
```

/home/wsuser/work/models/models

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