TEAM ID: PNT2022TMID50703

TEAM NAME: A Novel Method for Handwritten Digit Recognition System

```
!pip install keras
!pip install tensorflow
Requirement already satisfied: keras in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (2.2.4)
Requirement already satisfied: numpy>=1.9.1 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from keras) (1.20.3)
Requirement already satisfied: keras-applications>=1.0.6 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from keras) (1.0.8)
Requirement already satisfied: pyyaml in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from keras) (5.4.1)
Requirement already satisfied: six>=1.9.0 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from keras) (1.15.0)
Requirement already satisfied: keras-preprocessing>=1.0.5 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from keras) (1.1.2)
Requirement already satisfied: h5py in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from keras) (3.2.1)
Requirement already satisfied: scipy>=0.14 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from keras) (1.7.3)
Requirement already satisfied: tensorflow in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (2.7.2)
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: astunparse>=1.6.0 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from tensorflow) (1.6.3)
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: wrapt>=1.11.0 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from tensorflow) (1.12.1)
Collecting keras<2.8,>=2.7.0
  Downloading keras-2.7.0-py2.py3-none-any.whl (1.3 MB)
     |████████████████████████████████| 1.3 MB 17.2 MB/s eta 0:00:01
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: 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: 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: 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: wheel<1.0,>=0.32.0 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from tensorflow) (0.37.0)
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: flatbuffers<3.0,>=1.12 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from tensorflow)
(2.0)
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: 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: six>=1.12.0 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from tensorflow) (1.15.0)
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: tensorboard~=2.7 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from tensorflow) (2.7.0)
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: 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: 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: 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: 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: 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: 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: 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: 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: 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: 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: 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: 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: 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: 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: 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: 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: 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)
Installing collected packages: keras
  Attempting uninstall: keras
    Found existing installation: Keras 2.2.4
    Uninstalling Keras-2.2.4:
      Successfully uninstalled Keras-2.2.4
Successfully installed keras-2.7.0
```

```python
pwd
```

```
'/home/wsuser/work'
```

```python
import tensorflow as tf
from matplotlib import pyplot as plt
import numpy as np
```

```python
from keras.datasets import mnist
objects=mnist
(train_img,train_lab),(test_img,test_lab)=objects.load_data()
```

```python
for i in range(20):
  plt.subplot(4,5,i+1)
  plt.imshow(train_img[i],cmap='gray_r')
  plt.title("Digit : {}".format(train_lab[i]))
  plt.subplots_adjust(hspace=0.5)
  plt.axis('off')
```

```python
print('Training images shape : ',train_img.shape)
print('Testing images shape : ',test_img.shape)
```

```
Training images shape :  (60000, 28, 28)
Testing images shape :  (10000, 28, 28)
```

```python
print('How image looks like : ')
print(train_img[0])
```

```
How image looks like :
[[  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   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]]
```

```python
plt.hist(train_img[0].reshape(784),facecolor='orange')
plt.title('Pixel vs its intensity',fontsize=16)
plt.ylabel('PIXEL')
plt.xlabel('Intensity')
```

Text(0.5, 0, 'Intensity')

```python
train_img=train_img/255.0
test_img=test_img/255.0
```

```
print('How image looks like after normalising: ')
print(train_img[0])
```

How image looks like after normalising:
```
[[0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.        ]
 [0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.        ]
 [0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.        ]
 [0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.        ]
 [0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.        ]
 [0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.         0.         0.
  0.01176471 0.07058824 0.07058824 0.07058824 0.49411765 0.53333333
  0.68627451 0.10196078 0.65098039 1.         0.96862745 0.49803922
  0.         0.         0.         0.        ]
 [0.         0.         0.         0.         0.         0.
  0.         0.         0.11764706 0.14117647 0.36862745 0.60392157
  0.66666667 0.99215686 0.99215686 0.99215686 0.99215686 0.99215686
  0.88235294 0.6745098  0.99215686 0.94901961 0.76470588 0.25098039
  0.         0.         0.         0.        ]
 [0.         0.         0.         0.         0.         0.
  0.         0.19215686 0.93333333 0.99215686 0.99215686 0.99215686
  0.99215686 0.99215686 0.99215686 0.99215686 0.99215686 0.98431373
  0.36470588 0.32156863 0.32156863 0.21960784 0.15294118 0.
  0.         0.         0.         0.        ]
 [0.         0.         0.         0.         0.         0.
  0.         0.07058824 0.85882353 0.99215686 0.99215686 0.99215686
  0.99215686 0.99215686 0.77647059 0.71372549 0.96862745 0.94509804
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.        ]
 [0.         0.         0.         0.         0.         0.
  0.         0.         0.31372549 0.61176471 0.41960784 0.99215686
  0.99215686 0.80392157 0.04313725 0.         0.16862745 0.60392157
  0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.        ]
 [0.         0.         0.         0.         0.         0.
  0.         0.         0.         0.05490196 0.00392157 0.60392157
```

```
   0.99215686 0.35294118 0.         0.         0.         0.
   0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         ]
 [0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         0.         0.54509804
   0.99215686 0.74509804 0.00784314 0.         0.         0.
   0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         ]
 [0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         0.         0.04313725
   0.74509804 0.99215686 0.2745098  0.         0.         0.
   0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         ]
 [0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         0.         0.
   0.1372549  0.94509804 0.88235294 0.62745098 0.42352941 0.00392157
   0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         ]
 [0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         0.         0.
   0.         0.31764706 0.94117647 0.99215686 0.99215686 0.46666667
   0.09803922 0.         0.         0.         0.         0.
   0.         0.         0.         0.         ]
 [0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         0.         0.
   0.         0.         0.17647059 0.72941176 0.99215686 0.99215686
   0.58823529 0.10588235 0.         0.         0.         0.
   0.         0.         0.         0.         ]
 [0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.0627451  0.36470588 0.98823529
   0.99215686 0.73333333 0.         0.         0.         0.
   0.         0.         0.         0.         ]
 [0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         0.         0.97647059
   0.99215686 0.97647059 0.25098039 0.         0.         0.
   0.         0.         0.         0.         ]
 [0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         0.         0.
   0.         0.         0.18039216 0.50980392 0.71764706 0.99215686
   0.99215686 0.81176471 0.00784314 0.         0.         0.
   0.         0.         0.         0.         ]
 [0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         0.         0.
   0.15294118 0.58039216 0.89803922 0.99215686 0.99215686 0.99215686
   0.98039216 0.71372549 0.         0.         0.         0.
   0.         0.         0.         0.         ]
 [0.         0.         0.         0.         0.         0.
   0.         0.         0.         0.         0.09411765 0.44705882
   0.86666667 0.99215686 0.99215686 0.99215686 0.99215686 0.78823529
   0.30588235 0.         0.         0.         0.         0.
   0.         0.         0.         0.         ]
 [0.         0.         0.         0.         0.         0.
   0.         0.         0.09019608 0.25882353 0.83529412 0.99215686
   0.99215686 0.99215686 0.99215686 0.77647059 0.31764706 0.00784314
   0.         0.         0.         0.         0.         0.
```

```
   0.         0.          0.          0.          ]
 [0.         0.          0.          0.          0.          0.
  0.07058824 0.67058824 0.85882353 0.99215686 0.99215686 0.99215686
  0.99215686 0.76470588 0.31372549 0.03529412 0.          0.
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          ]
 [0.         0.          0.          0.          0.21568627 0.6745098
  0.88627451 0.99215686 0.99215686 0.99215686 0.99215686 0.95686275
  0.52156863 0.04313725 0.          0.          0.          0.
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          ]
 [0.         0.          0.          0.          0.53333333 0.99215686
  0.99215686 0.99215686 0.83137255 0.52941176 0.51764706 0.0627451
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          ]
 [0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          ]
 [0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          ]
 [0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          0.          0.
  0.         0.          0.          0.          ]]
```

```python
plt.hist(train_img[0].reshape(784),facecolor='orange')
plt.title('Pixel vs its intensity',fontsize=16)
plt.ylabel('PIXEL')
plt.xlabel('Intensity')
```

```
Text(0.5, 0, 'Intensity')
```

```python
from keras.models import Sequential
from keras.layers import Flatten,Dense
model=Sequential()
input_layer= Flatten(input_shape=(28,28))
model.add(input_layer)
hidden_layer1=Dense(512,activation='relu')
model.add(hidden_layer1)
hidden_layer2=Dense(512,activation='relu')
model.add(hidden_layer2)
output_layer=Dense(10,activation='softmax')
model.add(output_layer)
```

```python
#compiling the sequential model
model.compile(optimizer = 'adam',
             loss = 'sparse_categorical_crossentropy',
             metrics=['accuracy'])
```

```
model.fit(train_img,train_lab,epochs=50)
```

Epoch 1/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.1829 -
accuracy: 0.9441
Epoch 2/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0801 -
accuracy: 0.9755
Epoch 3/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0555 -
accuracy: 0.9827
Epoch 4/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0441 -
accuracy: 0.9860
Epoch 5/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0345 -
accuracy: 0.9889
Epoch 6/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0293 -
accuracy: 0.9906
Epoch 7/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0234 -
accuracy: 0.9924
Epoch 8/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0218 -
accuracy: 0.9931
Epoch 9/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0218 -
accuracy: 0.9932
Epoch 10/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0193 -
accuracy: 0.9941
Epoch 11/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0166 -
accuracy: 0.9950
Epoch 12/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0147 -
accuracy: 0.9956
Epoch 13/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0158 -
accuracy: 0.9955
Epoch 14/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0164 -
accuracy: 0.9957
Epoch 15/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0150 -
accuracy: 0.9956
Epoch 16/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0117 -
accuracy: 0.9962
Epoch 17/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0127 -
accuracy: 0.9967
Epoch 18/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0143 -
accuracy: 0.9962

```
Epoch 19/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0117 -
accuracy: 0.9967
Epoch 20/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0132 -
accuracy: 0.9967
Epoch 21/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0145 -
accuracy: 0.9964
Epoch 22/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0120 -
accuracy: 0.9971
Epoch 23/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0076 -
accuracy: 0.9979
Epoch 24/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0143 -
accuracy: 0.9965
Epoch 25/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0138 -
accuracy: 0.9973
Epoch 26/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0116 -
accuracy: 0.9973
Epoch 27/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0122 -
accuracy: 0.9973
Epoch 28/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0108 -
accuracy: 0.9976
Epoch 29/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0106 -
accuracy: 0.9980
Epoch 30/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0121 -
accuracy: 0.9975
Epoch 31/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0065 -
accuracy: 0.9984
Epoch 32/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0112 -
accuracy: 0.9980
Epoch 33/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0148 -
accuracy: 0.9970
Epoch 34/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0083 -
accuracy: 0.9982
Epoch 35/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0117 -
accuracy: 0.9978
Epoch 36/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0103 -
accuracy: 0.9980
Epoch 37/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0091 -
accuracy: 0.9981
```

```
Epoch 38/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0103 -
accuracy: 0.9983
Epoch 39/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0114 -
accuracy: 0.9979
Epoch 40/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0124 -
accuracy: 0.9977
Epoch 41/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0116 -
accuracy: 0.9980
Epoch 42/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0083 -
accuracy: 0.9985
Epoch 43/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0099 -
accuracy: 0.9983
Epoch 44/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0094 -
accuracy: 0.9984
Epoch 45/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0079 -
accuracy: 0.9984
Epoch 46/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0110 -
accuracy: 0.9982
Epoch 47/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0096 -
accuracy: 0.9981
Epoch 48/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0102 -
accuracy: 0.9984
Epoch 49/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0128 -
accuracy: 0.9981
Epoch 50/50
1875/1875 [==============================] - 17s 9ms/step - loss: 0.0117 -
accuracy: 0.9985
```

```
model.save('project.h5')
```

```
!tar -zcvf project.tgz project.h5
```

```
project.h5
```

```
ls -1
```

```
project.h5
project.tgz
```

```
!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 9.1 MB/s eta 0:00:01
```

```
Requirement already satisfied: boto3 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from watson-machine-learning-client)
(1.18.21)
Requirement already satisfied: tqdm in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from watson-machine-learning-client)
(4.62.3)
Requirement already satisfied: requests in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from watson-machine-learning-client)
(2.26.0)
Requirement already satisfied: ibm-cos-sdk in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from watson-machine-learning-client)
(2.11.0)
Requirement already satisfied: certifi in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from watson-machine-learning-client)
(2022.9.24)
Requirement already satisfied: lomond in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from watson-machine-learning-client) (0.3.3)
Requirement already satisfied: tabulate in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from watson-machine-learning-client) (0.8.9)
Requirement already satisfied: urllib3 in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from watson-machine-learning-client)
(1.26.7)
Requirement already satisfied: pandas in /opt/conda/envs/Python-
3.9/lib/python3.9/site-packages (from watson-machine-learning-client) (1.3.4)
Requirement already satisfied: jmespath<1.0.0,>=0.7.1 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from boto3->watson-
machine-learning-client) (0.10.0)
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-learning-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: python-dateutil<3.0.0,>=2.1 in
/opt/conda/envs/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/python3.9/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-core==2.11.0 in
/opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm-cos-sdk-
>watson-machine-learning-client) (2.11.0)
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-machine-learning-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

from ibm_watson_machine_learning import APIClient

wml_credentials = {
    "url": "https://us-south.ml.cloud.ibm.com",
    "apikey":"lqekv1q2qiHXlgu7j73HBBVXgv7oHvULPT_rH5B29-Vr"
}

client = APIClient(wml_credentials)


client = APIClient(wml_credentials)


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


space_uid = guid_from_space_name(client, "handwritten-digit-recognition")
print("Space UID = " + space_uid)

Space UID = 05a5928a-31dc-470a-bb57-d62fe2280206

client.set.default_space(space_uid)


'SUCCESS'

client.software_specifications.list()
```

```
----------------------------  ----------------------------------  ----
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
autoai-kb_rt22.2-py3.10       125b6d9a-5b1f-5e8d-972a-b251688ccf40  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
autoai-ts_rt22.2-py3.10        396b2e83-0953-5b86-9a55-7ce1628a406f   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
pytorch-onnx_rt22.2-py3.10     40e73f55-783a-5535-b3fa-0c8b94291431   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-4240ba1ed5f7   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
---------------------------    ------------------------------------   ----
Note: Only first 50 records were displayed. To display more use 'limit'
parameter.
```

```
software_spec_uid = client.software_specifications.get_uid_by_name("runtime-
22.1-py3.9")
software_spec_uid
```

```
'12b83a17-24d8-5082-900f-0ab31fbfd3cb'
```

```
model_details =
client.repository.store_model(model='project.tgz',meta_props={
    client.repository.ModelMetaNames.NAME: "CNN",
    client.repository.ModelMetaNames.TYPE: "tensorflow_2.7",
    client.repository.ModelMetaNames.SOFTWARE_SPEC_UID: software_spec_uid}
                                       )
```

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

```
This method is deprecated, please use get_model_id()
/opt/conda/envs/Python-3.9/lib/python3.9/site-
packages/ibm_watson_machine_learning/repository.py:1453: UserWarning: This
method is deprecated, please use get_model_id()
  warn("This method is deprecated, please use get_model_id()")
```

```
model_id
```

```
'403cbf90-c760-40a3-8ea3-bd4d8e533357'
```

```python
loss_and_acc=model.evaluate(test_img,test_lab,verbose=2)
print("Test Loss", loss_and_acc[0])
print("Test Accuracy", loss_and_acc[1])

Test Loss 0.582893428286937
Test Accuracy 0.9835000038146973
```

```python
plt.imshow(test_img[0],cmap='gray_r')
plt.title('Actual Value: {}'.format(test_lab[0]))
prediction=model.predict(test_img)
plt.axis('off')
print('Predicted Value: ',np.argmax(prediction[0]))
if(test_lab[0]==(np.argmax(prediction[0]))):
  print('Successful prediction')
else:
  print('Unsuccessful prediction')

Predicted Value:  7
Successful prediction
```

```python
plt.imshow(test_img[1],cmap='gray_r')
plt.title('Actual Value: {}'.format(test_lab[1]))
prediction=model.predict(test_img)
plt.axis('off')
print('Predicted Value: ',np.argmax(prediction[1]))
if(test_lab[1]==(np.argmax(prediction[1]))):
  print('Successful prediction')
else:
  print('Unsuccessful prediction')

Predicted Value:  2
Successful prediction
```

```python
plt.imshow(test_img[2],cmap='gray_r')
plt.title('Actual Value: {}'.format(test_lab[2]))
prediction=model.predict(test_img)
plt.axis('off')
print('Predicted Value: ',np.argmax(prediction[2]))
if(test_lab[2]==(np.argmax(prediction[2]))):
  print('Successful prediction')
else:
  print('Unsuccessful prediction')

Predicted Value:  1
Successful prediction
```

```python
# make a prediction for a new image.
from keras.preprocessing.image import load_img
from keras.preprocessing.image import img_to_array
from keras.models import load_model

# load and prepare the image
def load_image(filename):
```

```python
    # load the image
    img = load_img(filename, grayscale=True, target_size=(28, 28))
    # convert to array
    img = img_to_array(img)
    # reshape into a single sample with 1 channel
    img = img.reshape(1, 28, 28)
    # prepare pixel data
    img = img.astype('float32')
    img = img / 255.0
    return img
```

```python
from google.colab import files
uploaded = files.upload()
```

Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.
Saving 5img.jpeg to 5img.jpeg

```python
from IPython.display import Image
Image('5img.jpeg',width=250,height=250)
```

```python
img = load_image('5img.jpeg')
digit=new_model.predict(img)
print('Predicted value : ',np.argmax(digit))
```

Predicted value : 5

/usr/local/lib/python3.6/dist-
packages/keras_preprocessing/image/utils.py:107: UserWarning: grayscale is
deprecated. Please use color_mode = "grayscale"
  warnings.warn('grayscale is deprecated. Please use '

```python
from google.colab import files
uploaded = files.upload()
```

Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.
Saving 4.jpg to 4.jpg

```python
from IPython.display import Image
Image('4.jpg')
```

```python
img = load_image('4.jpg')
digit=model.predict(img)
print(np.argmax(digit))
```

4
/usr/local/lib/python3.6/dist-
packages/keras_preprocessing/image/utils.py:107: UserWarning: grayscale is
deprecated. Please use color_mode = "grayscale"
  warnings.warn('grayscale is deprecated. Please use '

```python
from google.colab import files
uploaded = files.upload()
```

Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.
```
Saving project1.h5 to project1.h5
```

```
model=tf.keras.models.load_model('project1.h5')      # I have renamed the
file as project1 in my PC
```