

```
In [ ]: from tensorflow import keras
```

```
In [ ]: (x_train, y_train), (x_test, y_test) = keras.datasets.mnist.load_data()
```

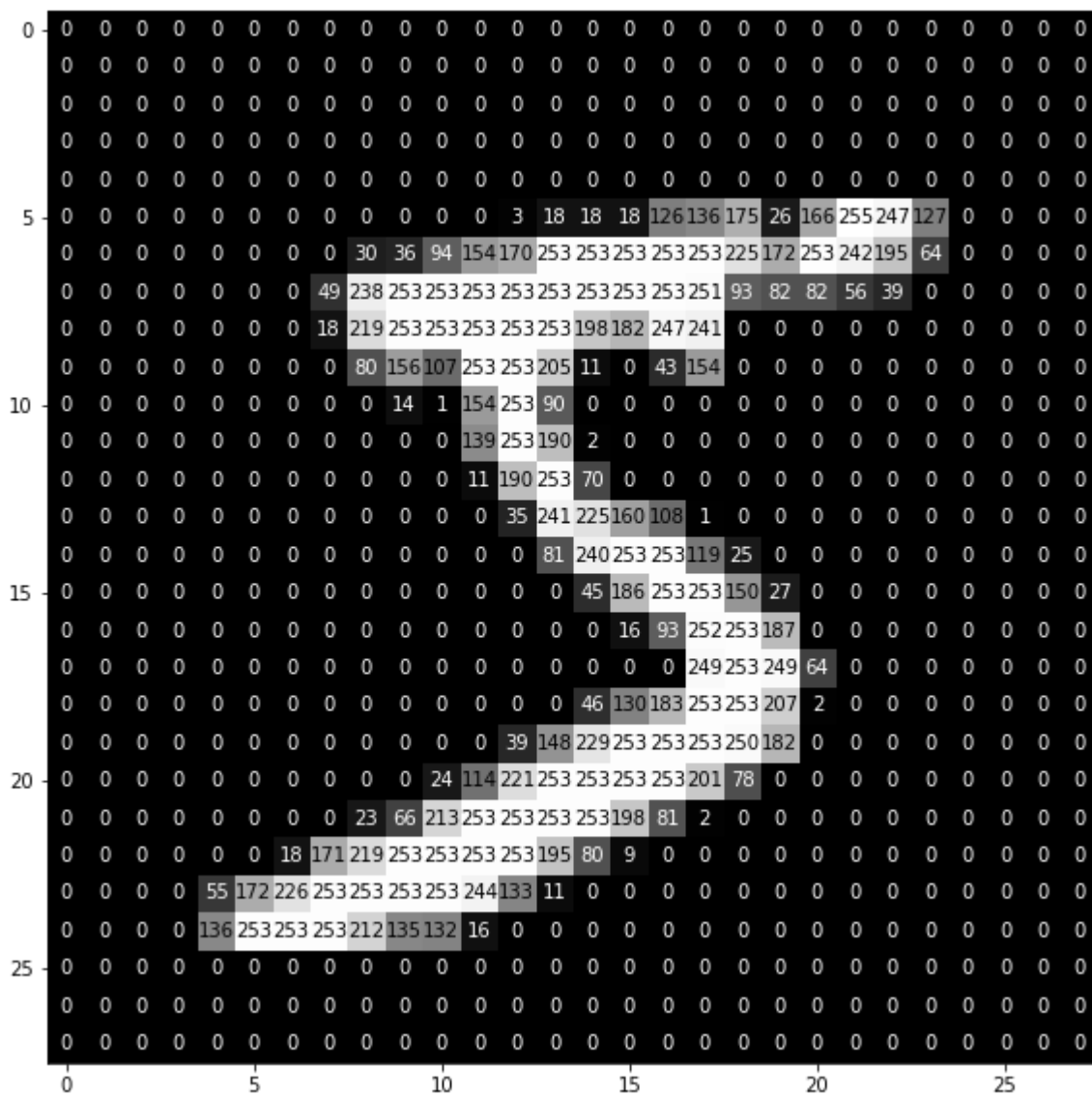
```
In [ ]: print(x_train.shape)
        print(x_test.shape)
```

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

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

```
In [ ]: def visualize_input(img, ax):
        ax.imshow(img, cmap='gray')
        width, height = img.shape
        thresh = img.max()/2.5
        for x in range(width):
            for y in range(height):
                ax.annotate(str(round(img[x][y],2)), xy=(y,x),
                            horizontalalignment='center',
                            verticalalignment='center',
                            color='white' if img[x][y]<thresh else 'black')
```

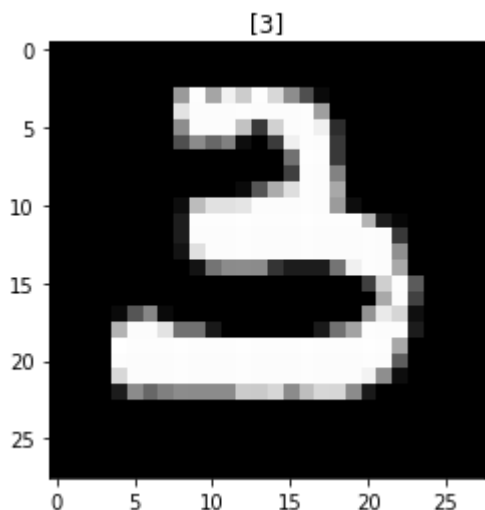
```
In [ ]: import matplotlib.pyplot as plt
fig = plt.figure(figsize = (10,10))
ax = fig.add_subplot(111)
visualize_input(x_train[0], ax)
plt.show()
```



```
In [ ]: print(y_train)
print(y_test)
```

```
[5 0 4 ... 5 6 8]
[7 2 1 ... 4 5 6]
```

```
In [ ]: # Lets see some random images and its Labels
import random
import matplotlib.pyplot as plt
i = random.randint(0,60000)
plt.imshow(x_train[i],cmap='gray') # Color map
plt.title([y_train[i]])
plt.show()
```



```
In [ ]: # How many images are there in every digit?
import numpy as np
np.unique(y_train,return_counts=True)
```

```
Out[8]: (array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9], dtype=uint8),
         array([5923, 6742, 5958, 6131, 5842, 5421, 5918, 6265, 5851, 5949]))
```

```
In [ ]: np.unique(y_test,return_counts=True)
```

```
Out[9]: (array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9], dtype=uint8),
         array([ 980, 1135, 1032, 1010,  982,  892,  958, 1028,  974, 1009]))
```

```
In [ ]: # Normalization : Scaling down the value to a specific range(0-1)
x_train=x_train/255
x_test = x_test/255
```

```
In [ ]: # After Normalization
print(x_train.max())
print(x_train.min())
```

```
1.0
0.0
```

```
In [ ]: from keras.layers import Dense
from keras.layers import Flatten
model = keras.models.Sequential()
model.add(Flatten(input_shape=(28,28))) # 784
model.add(Dense(392,activation='relu'))
model.add(Dense(10,activation='softmax'))
```

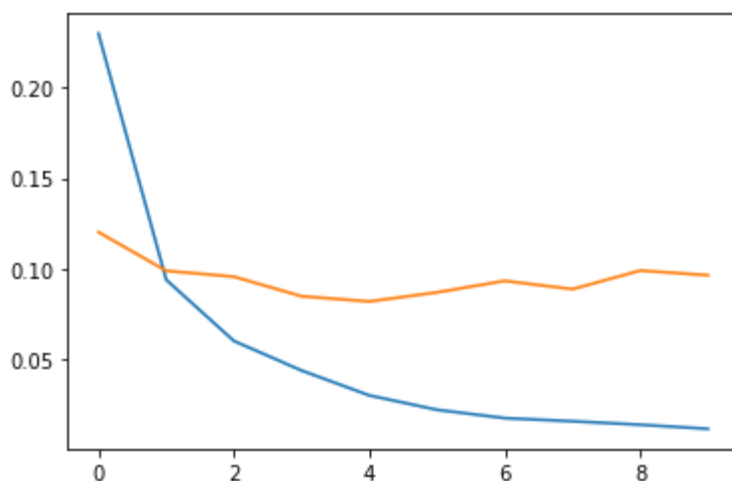
```
In [ ]: model.compile(optimizer='adam',loss='sparse_categorical_crossentropy',metrics=
```

```
In [ ]: history = model.fit(x_train,y_train,epochs=10,validation_split=0.2)
```

```
Epoch 1/10
1500/1500 [=====] - 5s 3ms/step - loss: 0.2301 - acc
uracy: 0.9332 - val_loss: 0.1202 - val_accuracy: 0.9643
Epoch 2/10
1500/1500 [=====] - 4s 3ms/step - loss: 0.0938 - acc
uracy: 0.9714 - val_loss: 0.0988 - val_accuracy: 0.9725
Epoch 3/10
1500/1500 [=====] - 4s 3ms/step - loss: 0.0600 - acc
uracy: 0.9818 - val_loss: 0.0956 - val_accuracy: 0.9697
Epoch 4/10
1500/1500 [=====] - 4s 3ms/step - loss: 0.0436 - acc
uracy: 0.9862 - val_loss: 0.0847 - val_accuracy: 0.9748
Epoch 5/10
1500/1500 [=====] - 4s 3ms/step - loss: 0.0299 - acc
uracy: 0.9904 - val_loss: 0.0818 - val_accuracy: 0.9783
Epoch 6/10
1500/1500 [=====] - 4s 3ms/step - loss: 0.0219 - acc
uracy: 0.9932 - val_loss: 0.0869 - val_accuracy: 0.9780
Epoch 7/10
1500/1500 [=====] - 4s 3ms/step - loss: 0.0173 - acc
uracy: 0.9946 - val_loss: 0.0932 - val_accuracy: 0.9753
Epoch 8/10
1500/1500 [=====] - 4s 3ms/step - loss: 0.0156 - acc
uracy: 0.9950 - val_loss: 0.0887 - val_accuracy: 0.9783
Epoch 9/10
1500/1500 [=====] - 4s 3ms/step - loss: 0.0137 - acc
uracy: 0.9959 - val_loss: 0.0989 - val_accuracy: 0.9762
Epoch 10/10
1500/1500 [=====] - 4s 3ms/step - loss: 0.0114 - acc
uracy: 0.9964 - val_loss: 0.0964 - val_accuracy: 0.9805
```

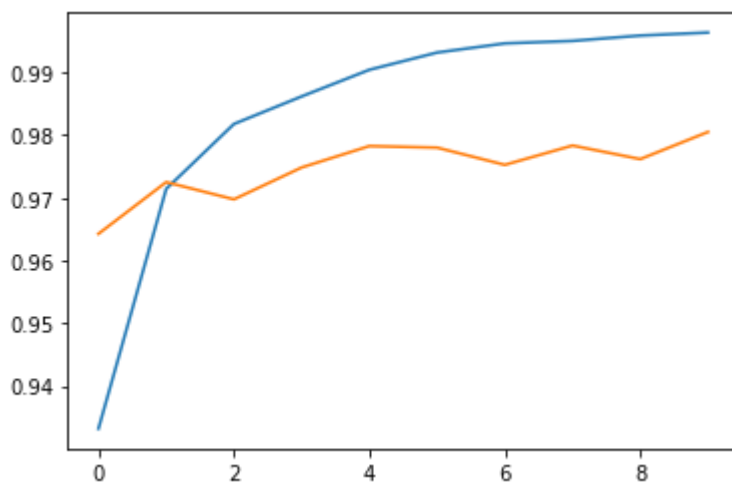
```
In [ ]: import matplotlib.pyplot as plt
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
```

Out[15]: [<matplotlib.lines.Line2D at 0x7efbc028fb90>]



```
In [ ]: plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
```

Out[16]: [<matplotlib.lines.Line2D at 0x7efbc01e51d0>]



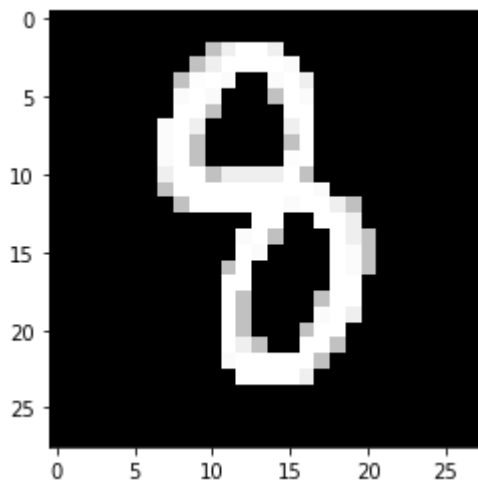
```
In [ ]: # Evaluate on test data

y_pred = model.predict(x_test)
y_pred = np.argmax(y_pred,axis=1)
y_pred
```

Out[17]: array([7, 2, 1, ..., 4, 5, 6])

```
In [ ]: from keras.preprocessing import image
```

```
In [ ]: img = image.load_img(path="/content/drive/MyDrive/Minor Project <Pankaj Kumar>
img = image.img_to_array(img)
plt.imshow(image.array_to_img(img), cmap="gray")
img = img.astype('float')/255
test_img = img.reshape((1, 28, 28, 1))
#img_class = model.predict_classes(test_img)
img_class = np.argmax(model.predict(test_img), axis = 1)
prediction = img_class[0]
```



```
In [ ]: prediction
```

Out[20]: 8

```
In [ ]:
```

```
In [ ]: from sklearn.metrics import accuracy_score, confusion_matrix, classification_rep
```

```
In [ ]: accuracy_score(y_pred, y_test)
```

Out[22]: 0.981

```
In [ ]: confusion_matrix(y_pred, y_test)
```

```
Out[23]: array([[ 972,    0,    6,    1,    3,    2,    2,    1,    1,    3],
 [   1, 1129,    1,    0,    1,    0,    3,    3,    0,    3],
 [   1,    2, 1002,    2,    1,    0,    2,    7,    1,    0],
 [   1,    0,    8,  989,    0,    6,    1,    2,    4,    5],
 [   0,    0,    2,    0,  960,    1,    1,    1,    0,    8],
 [   2,    0,    1,    5,    0,  873,    5,    0,    5,    3],
 [   0,    1,    3,    0,    4,    4,  942,    0,    1,    0],
 [   1,    0,    3,    4,    2,    0,    0, 1006,    1,    6],
 [   2,    3,    5,    3,    0,    5,    2,    2,  958,    2],
 [   0,    0,    1,    6,   11,    1,    0,    6,    3,  979]])
```

```
In [ ]: print(classification_report(y_pred,y_test))
```

	precision	recall	f1-score	support
0	0.99	0.98	0.99	991
1	0.99	0.99	0.99	1141
2	0.97	0.98	0.98	1018
3	0.98	0.97	0.98	1016
4	0.98	0.99	0.98	973
5	0.98	0.98	0.98	894
6	0.98	0.99	0.98	955
7	0.98	0.98	0.98	1023
8	0.98	0.98	0.98	982
9	0.97	0.97	0.97	1007
accuracy			0.98	10000
macro avg	0.98	0.98	0.98	10000
weighted avg	0.98	0.98	0.98	10000

```
In [ ]: model.save("mnist.hdf5")
```

WARNING:absl:Found untraced functions such as flatten\_layer\_call\_and\_return\_conditional\_losses, flatten\_layer\_call\_fn, dense\_layer\_call\_and\_return\_conditional\_losses, dense\_layer\_call\_fn, dense\_1\_layer\_call\_and\_return\_conditional\_losses while saving (showing 5 of 15). These functions will not be directly callable after loading.

INFO:tensorflow:Assets written to: mnist./assets

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```
In [ ]:
```