```
#Importing packages
import tensorflow as tf
import numpy as np
from matplotlib import pyplot as plt
import seaborn as sns
```

Loading dataset

```
#loading dataset
(x_train,y_train),(x_test,y_test)=tf.keras.datasets.mnist.load_data()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mni
11493376/11490434 [==============================] - 11s 1us/step
11501568/11490434 [==============================] - 11s 1us/step
```

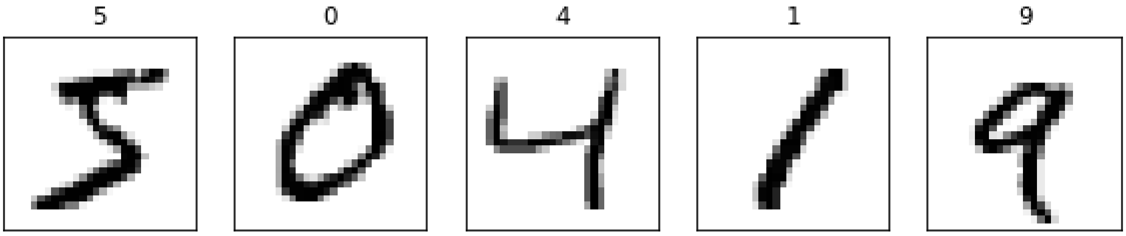
Plotting count plot

```
plt.figure(figsize = (10,8))
sns.countplot(y_train)
```

```
C:\Users\Nishant\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning
  warnings.warn(
```

Displaying some images

```
#Dataset properties
# Display some images
fig, axes = plt.subplots(ncols=5, sharex=False,
    sharey=True, figsize=(10, 4))
for i in range(5):
    axes[i].set_title(y_train[i])
    axes[i].imshow(x_train[i], cmap='gray_r')
    axes[i].get_xaxis().set_visible(False)
    axes[i].get_yaxis().set_visible(False)
plt.show()
```



Pre-processing the data

```
# Pre-processing the data
print('Training images shape : ',x_train.shape)
print('Testing images shape : ',x_test.shape)
```

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

```
x_train = x_train.reshape(x_train.shape[0], 28, 28, 1)
x_test = x_test.reshape(x_test.shape[0], 28, 28, 1)
input_shape = (28, 28, 1)
```

```
#applying normalization
x_train=x_train/255.0
x_testg=x_test/255.0
num_classes = 10
```

Creating the model

Model Architecture

We will have to first build the model architecture and define it based on our dataset. We are going to add the following layers:

1. Conv2D - for the convolution layers
2. Dropout - to prevent overfitting
3. Dense - a fully connected layer
4. Softmax activation - This is used to convert all predictions into probability The model architecture can be tuned to get optimal performance

so i am goimg to create a model with

CNN + Three layers + relu + (3,3) kernel_size + Dropout rate (0.3)

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout, Flatten,Activation
from tensorflow.keras.layers import Conv2D,MaxPooling2D
from tensorflow.keras.layers import BatchNormalization


model = Sequential()

model.add(Conv2D(128, kernel_size=(3, 3),
                 activation=tf.nn.relu,
                 input_shape=input_shape))
model.add(BatchNormalization())
model.add(Dropout(0.3))

model.add(Conv2D(64, (3, 3), activation=tf.nn.relu))
model.add(BatchNormalization())
model.add(Dropout(0.3))

model.add(Conv2D(32, (3, 3), activation=tf.nn.relu))
model.add(BatchNormalization())
model.add(Dropout(0.3))


model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.3))
model.add(Flatten())
model.add(Dense(128, activation=tf.nn.relu))
model.add(Dropout(0.3))
model.add(Dense(num_classes, activation=tf.nn.softmax))


model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 26, 26, 128)       1280
 batch_normalization (BatchN  (None, 26, 26, 128)      512
 ormalization)

 dropout (Dropout)           (None, 26, 26, 128)      0

 conv2d_1 (Conv2D)           (None, 24, 24, 64)       73792

 batch_normalization_1 (Batc  (None, 24, 24, 64)      256
 hNormalization)

 dropout_1 (Dropout)         (None, 24, 24, 64)       0

 conv2d_2 (Conv2D)           (None, 22, 22, 32)       18464

 batch_normalization_2 (Batc  (None, 22, 22, 32)      128
 hNormalization)

 dropout_2 (Dropout)         (None, 22, 22, 32)       0

 max_pooling2d (MaxPooling2D  (None, 11, 11, 32)      0
 )

 dropout_3 (Dropout)         (None, 11, 11, 32)       0

 flatten (Flatten)           (None, 3872)             0

 dense (Dense)               (None, 128)              495744

 dropout_4 (Dropout)         (None, 128)              0

 dense_1 (Dense)             (None, 10)               1290

=================================================================
Total params: 591,466
Trainable params: 591,018
Non-trainable params: 448
_________________________________________________________________
```

Training the model

```
# Train the model
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])
history=model.fit(x=x_train,
                  y=y_train,
                  validation_split=0.1,
                  epochs=10)
```

```
Epoch 1/10
1688/1688 [==============================] - 572s 321ms/step - loss: 0.2633 - accura
Epoch 2/10
1688/1688 [==============================] - 551s 326ms/step - loss: 0.1112 - accura
Epoch 3/10
1688/1688 [==============================] - 553s 328ms/step - loss: 0.0897 - accura
```

```
Epoch 4/10
1688/1688 [==============================] - 547s 324ms/step - loss: 0.0750 - accurac
Epoch 5/10
1688/1688 [==============================] - 546s 323ms/step - loss: 0.0644 - accurac
Epoch 6/10
1688/1688 [==============================] - 544s 322ms/step - loss: 0.0597 - accurac
Epoch 7/10
1688/1688 [==============================] - 587s 348ms/step - loss: 0.0534 - accurac
Epoch 8/10
1688/1688 [==============================] - 632s 374ms/step - loss: 0.0480 - accurac
Epoch 9/10
1688/1688 [==============================] - 632s 374ms/step - loss: 0.0441 - accurac
Epoch 10/10
1688/1688 [==============================] - 632s 374ms/step - loss: 0.0418 - accurac
```

Saving and loading the model

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

```
from tensorflow.keras.models import load_model
model = load_model('MNproject.h5')
```

Evaluating the model

```
# Evaluate the model
loss_and_acc=model.evaluate(x_test,y_test)
print("Test Loss", loss_and_acc[0])
print("Test Accuracy", loss_and_acc[1])
```

```
313/313 [==============================] - 20s 62ms/step - loss: 2.5056 - accuracy: 0
Test Loss 2.5055582523345947
Test Accuracy 0.9876999855041504
```

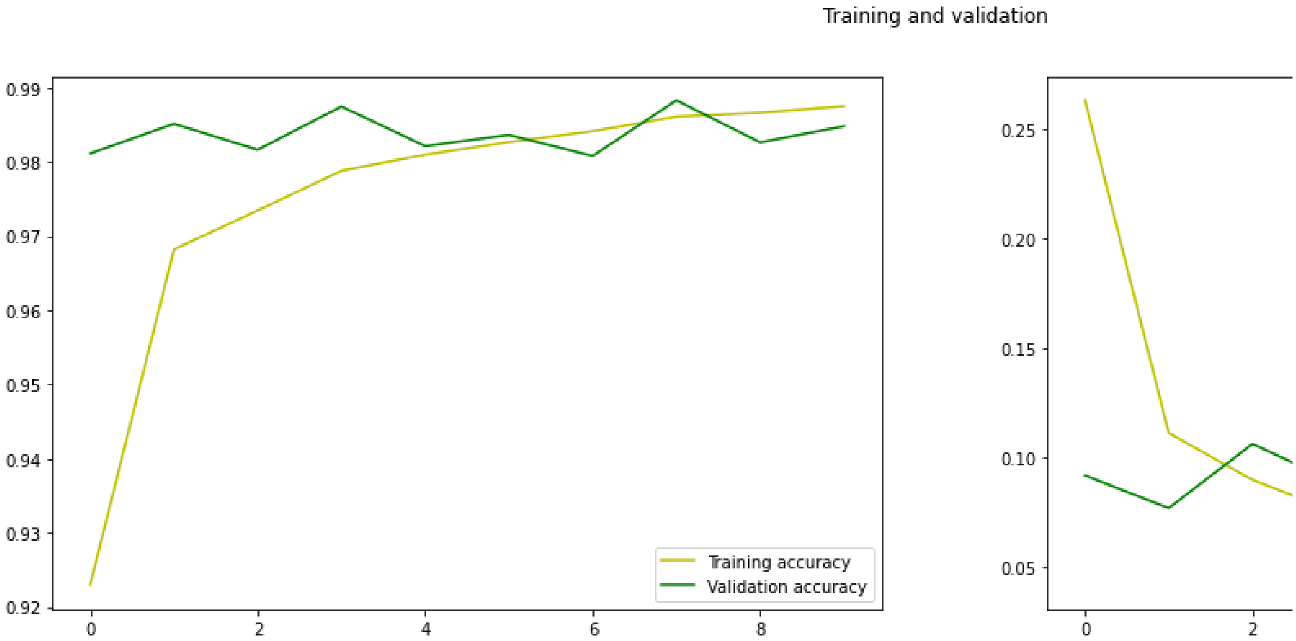
Plotting Training & Validation plots

```
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']
epochs = range(len(acc))

fig, ax = plt.subplots(nrows=1, ncols=2, figsize=(20, 6))
ax[0].plot(epochs, acc, 'y', label='Training accuracy')
ax[0].plot(epochs, val_acc, 'g', label='Validation accuracy')
ax[0].legend(loc=0)
ax[1].plot(epochs, loss, 'y', label='Training loss')
```

```
ax[1].plot(epochs, val_loss, 'g', label='Validation loss')
ax[1].legend(loc=0)

plt.suptitle('Training and validation')
plt.show()
```



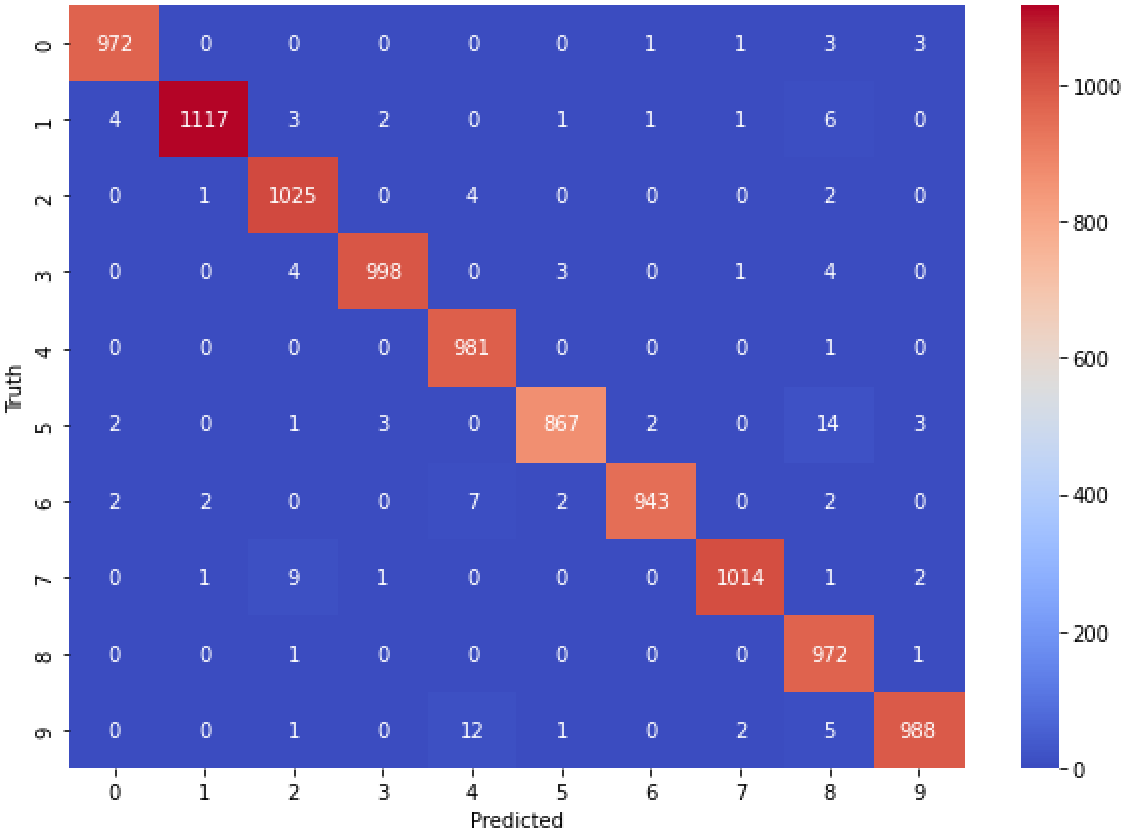
```
# Confusion Matrix
y_predicted = model.predict(x_test)
y_predicted_labels = [np.argmax(i) for i in y_predicted]
cm = tf.math.confusion_matrix(labels=y_test,predictions=y_predicted_labels)
cm
```

```
<tf.Tensor: shape=(10, 10), dtype=int32, numpy=
array([[ 972,    0,    0,    0,    0,    0,    1,    1,    3,    3],
       [   4, 1117,    3,    2,    0,    1,    1,    1,    6,    0],
       [   0,    1, 1025,    0,    4,    0,    0,    0,    2,    0],
       [   0,    0,    4,  998,    0,    3,    0,    1,    4,    0],
       [   0,    0,    0,    0,  981,    0,    0,    0,    1,    0],
       [   2,    0,    1,    3,    0,  867,    2,    0,   14,    3],
       [   2,    2,    0,    0,    7,    2,  943,    0,    2,    0],
       [   0,    1,    9,    1,    0,    0,    0, 1014,    1,    2],
       [   0,    0,    1,    0,    0,    0,    0,    0,  972,    1],
       [   0,    0,    1,    0,   12,    1,    0,    2,    5,  988]])>
```

Plotting heat map

```
plt.figure(figsize = (10,7))
sns.heatmap(cm, annot=True, fmt='d', cmap = 'coolwarm')
plt.xlabel('Predicted')
plt.ylabel('Truth')
```

```
Text(69.0, 0.5, 'Truth')
```



Truth \ Predicted	0	1	2	3	4	5	6	7	8	9
0	972	0	0	0	0	0	1	1	3	3
1	4	1117	3	2	0	1	1	1	6	0
2	0	1	1025	0	4	0	0	0	2	0
3	0	0	4	998	0	3	0	1	4	0
4	0	0	0	0	981	0	0	0	1	0
5	2	0	1	3	0	867	2	0	14	3
6	2	2	0	0	7	2	943	0	2	0
7	0	1	9	1	0	0	0	1014	1	2
8	0	0	1	0	0	0	0	0	972	1
9	0	0	1	0	12	1	0	2	5	988

Testing the Model

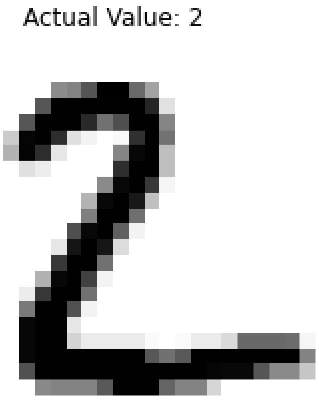
```
# Testing the Model
plt.imshow(x_test[7],cmap='gray_r')
plt.title('Actual Value: {}'.format(y_test[7]))
prediction=model.predict(x_test)

plt.axis('off')
print('Predicted Value: ',np.argmax(prediction[7]))
if(y_test[7]==(np.argmax(prediction[7]))):
  print('Successful prediction')
else:
  print('Unsuccessful prediction')
```

```
Predicted Value:  9
Successful prediction
```

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

```
Predicted Value:  2
Successful prediction
```


Actual Value: 2