Introduction

In this project, I will implement a neural network to classify handwritten digits using the MNIST dataset. The MNIST dataset comprises 28x28 grayscale images of handwritten digits ranging from 0 to 9. This project is a fundamental exercise in deep learning and image recognition, offering a solid understanding of how to handle image-based datasets. As a widely recognized benchmark problem, it serves as an ideal starting point for beginners in machine learning and neural networks.

Objective

The primary goal of this project is to build a neural network capable of classifying handwritten digits into their respective classes. The system will be trained on labeled image data, enabling it to learn patterns associated with each digit. Ultimately, I aim to develop a predictive system that can correctly identify the digit in any new handwritten image provided as input.

Approach

The project begins with data collection and preprocessing. Since the MNIST dataset is readily available in the Keras library, accessing it is straightforward. Preprocessing will include normalizing pixel values to a range of 0 to 1 and standardizing image dimensions. Labels for the images will be converted into one-hot encoded vectors.

Next, I will construct a neural network comprising fully connected layers. The architecture will include:

- 1. An input layer to accept the flattened image data.
- 2. Hidden layers with activation functions to capture non-linear patterns.
- 3. A final output layer with softmax activation for classifying digits.

The model will be trained using the training dataset, optimized with the Adam optimizer, and evaluated on a separate test dataset. Key metrics, such as accuracy, will assess the model's performance.

Finally, I will develop a predictive system. This system will take a new handwritten digit image as input and predict the corresponding digit. By completing this project, I aim to demonstrate the practical applications of neural networks in image recognition tasks and establish a robust foundation for tackling more complex deep learning challenges in the future.

step by Step Approch

1)importing the dataset

2)image processing

3)splitting the data into train_test spilt

4)building the neural network

5)training the neural network

6) giving new image to trained data

7)prediction is done on new image given to trained neural network.

IMPORTING THE NECESSARY LIBRARIES AND DEPENDENCIES

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In [109]:
```

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import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import cv2
from google.colab.patches import cv2_imshow
from PIL import Image
```

```
import tensorflow as tf

tf.random.set_seed(3)
from tensorflow import keras
from tensorflow.math import confusion_matrix
```

IMPORTING THE DATASET WHICH IS IN KERAS

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In [110]:
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from keras.datasets import mnist
```

so here in this dataset dta is already split into train test data so we just have to load it(for refrence you can visit keras mnist dataset on google)

Where

Training data have 60,000 Images

& Test data has 10,000 Images

Image dimension = 28 x 28

Grayscale Image = 1 channel

```
In [111]:
    (X_train, Y_train), (X_test, Y_test) = mnist.load_data()

In [112]:
    type(X_train)
Out[112]:
    numpy.ndarray

In [113]:
    print(X_train.shape, Y_train.shape, X_test.shape, Y_test.shape)
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In [115]:

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print(X_train[10].shape)
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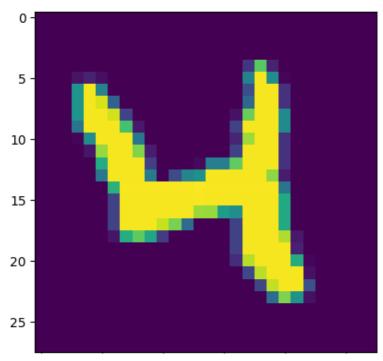
(28, 28)

In [116]:

```
#DISPLAYING THE IMAGE

plt.imshow(X_train[20])
plt.show()

print(Y_train[20])
```



```
print(Y_train.shape, Y_test.shape)
(60000,) (10000,)
In [118]:
#PRINTING UNIQUE VALUES INI Y train
print(np.unique(Y_train))
#PRINTING UNIQUE VALUES IN Y test
print(np.unique(Y_test))
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[0 1 2 3 4 5 6 7 8 9]
We can use these labels as such or we can also apply One Hot Encoding
All the images have the same dimensions in this dataset, If not, we have to resize all the images to a common
dimension
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#SCALING THE VALUES
X train = X train/255
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```

BUILDING NEURAL NETWORK

```
In [121]:
```

NOW COMPLILING THE NN

```
In [122]:
```

NOW TRAINING THE NN

```
In [123]:
```

```
Epoch 3/20
1875/1875
                              - 9s 2ms/step - accuracy: 0.9672 - loss: 0.1062
Epoch 4/20
1875/1875
                              • 5s 3ms/step - accuracy: 0.9754 - loss: 0.0824
Epoch 5/20
                              - 4s 2ms/step - accuracy: 0.9803 - loss: 0.0652
1875/1875
Epoch 6/20
1875/1875
                              • 6s 2ms/step - accuracy: 0.9829 - loss: 0.0560
Epoch 7/20
1875/1875
                              • 6s 3ms/step - accuracy: 0.9844 - loss: 0.0477
Epoch 8/20
                              - 4s 2ms/step - accuracy: 0.9869 - loss: 0.0415
1875/1875
Epoch 9/20
1875/1875
                              - 4s 2ms/step - accuracy: 0.9870 - loss: 0.0398
Epoch 10/20
                             - 6s 3ms/step - accuracy: 0.9876 - loss: 0.0360
1875/1875
Epoch 11/20
1875/1875
                             - 9s 2ms/step - accuracy: 0.9896 - loss: 0.0289
Epoch 12/20
1875/1875
                             - 6s 3ms/step - accuracy: 0.9893 - loss: 0.0322
Epoch 13/20
                             - 10s 2ms/step - accuracy: 0.9900 - loss: 0.0285
1875/1875
Epoch 14/20
                             - 5s 3ms/step - accuracy: 0.9907 - loss: 0.0265
1875/1875
Epoch 15/20
1875/1875 •
                             - 4s 2ms/step - accuracy: 0.9925 - loss: 0.0209
Epoch 16/20
1875/1875
                              - 4s 2ms/step - accuracy: 0.9921 - loss: 0.0248
Epoch 17/20
                              - 5s 3ms/step - accuracy: 0.9925 - loss: 0.0217
1875/1875
Epoch 18/20
1875/1875
                              - 4s 2ms/step - accuracy: 0.9925 - loss: 0.0218
Epoch 19/20
1875/1875
                              - 6s 2ms/step - accuracy: 0.9938 - loss: 0.0179
Epoch 20/20
1875/1875
                              - 5s 2ms/step - accuracy: 0.9940 - loss: 0.0175
Out[123]:
```

<keras.src.callbacks.history.History at 0x7af1d39b4f10>

accuracy: 99.40

NOR FOR ACCURACY ON TEST DATA

```
In [124]:
```

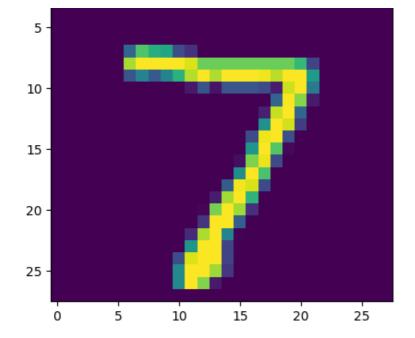
Accuracy:97.00

```
In [125]:
```

```
print(X_test.shape)
(10000, 28, 28)
```

In [126]:

```
#NOW FOR FIRST DATA POINT OF X_test
plt.imshow(X_test[0])
plt.show()
```



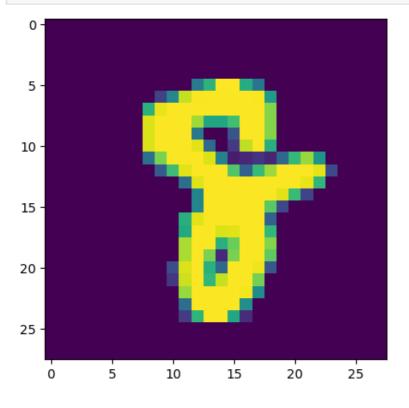
In [127]:

print(Y_test[0])

7

In [128]:

```
#NOW FOR ANY RANDOM NUMBER OF DATA POINT OF X_test
plt.imshow(X_test[277])
plt.show()
```



In [129]:

```
print(Y_test[277])
```

8

In [130]:

```
Y pred = model.predict(X test)
```

313/313 ______ 1s 2ms/step

```
In [131]:
print(Y pred.shape)
(10000, 10)
In [132]:
print(Y pred[0])
[3.8084084e-12 7.2866434e-01 8.3955041e-05 3.5990405e-01 2.9628985e-08
 2.1199497e-05 5.7384824e-25 1.0000000e+00 8.0411115e-07 8.5248584e-01]
In [133]:
#CONVERTING THE PREDICTION PROBABLITIES TO CLASS LABEL FOR FIRST DATA POINT.
label for first test image = np.argmax(Y pred[0])
print(label for first test image)
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In [134]:
#NOW FOR ALL DATA POINTS
Y pred labels = [np.argmax(i) for i in Y pred]
print(Y_pred_labels)
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```

WHERE

Y_test = True labels

Y_pred_labels = Predicted Labels

NOW CREATIN CONFUSION MATRIX

```
In [135]:
```

```
conf_mat = confusion_matrix(Y_test, Y_pred_labels)
```

In [136]:

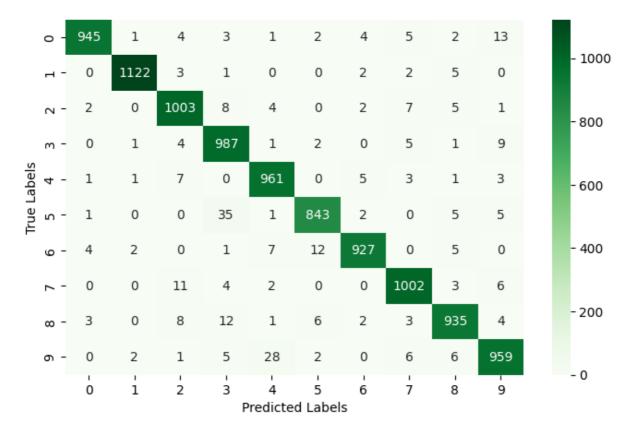
```
print(conf mat)
tf.Tensor(
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In [137]:

```
plt.figure(figsize=(8,5))
sns.heatmap(conf_mat, annot=True, fmt='d', cmap='Greens')
plt.ylabel('True Labels')
plt.xlabel('Predicted Labels')
```

Out[137]:

Text(0.5, 25.72222222222214, 'Predicted Labels')



NOW BUILDING A PREDICTIVE SYSTEM

```
In [138]:
input_image_path = '/content/MNIST_digit.png'
input image = cv2.imread(input image path)
In [139]:
type(input_image)
Out[139]:
numpy.ndarray
In [140]:
print(input_image)
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In [141]:
```

import cv2

```
import numpy as np
import requests
from google.colab.patches import cv2 imshow
# Load the image from the URL
url = 'https://upload.wikimedia.org/wikipedia/commons/2/27/MnistExamples.png'
response = requests.get(url, stream=True).raw
input image = np.asarray(bytearray(response.read()), dtype="uint8")
input image = cv2.imdecode(input image, cv2.IMREAD GRAYSCALE)
# Check image dimensions
print(f"Image dimensions: {input image.shape}")
# Crop a single digit (adjust coordinates based on the specific image layout)
# Example: Cropping the first digit (coordinates may vary)
single digit = input image[5:50, 5:50] # Replace with the coordinates of the desired di
git
# Display the single digit
cv2 imshow(single digit)
Image dimensions: (361, 594)
   0
In [142]:
input image.shape
Out[142]:
(361, 594)
In [143]:
grayscale = input image # The image is already in grayscale
In [144]:
grayscale.shape
Out[144]:
(361, 594)
In [145]:
input image resize = cv2.resize(grayscale, (28, 28))
In [146]:
input image resize.shape
Out[146]:
(28, 28)
In [147]:
cv2 imshow(input_image_resize)
In [148]:
input image resize = input image resize/255
In [149]:
type(input image resize)
```

Predictive System

In [154]:

```
input_image_path = input('Path of the image to be predicted: ')
input_image = cv2.imread(input_image_path)
cv2_imshow(input_image)
grayscale = cv2.cvtColor(input_image, cv2.COLOR_RGB2GRAY)
input_image_resize = cv2.resize(grayscale, (28, 28))
input_image_resize = input_image_resize/255
image_reshaped = np.reshape(input_image_resize, [1,28,28])
input_prediction = model.predict(image_reshaped)
input_pred_label = np.argmax(input_prediction)
print('The Handwritten Digit is recognised as ', input_pred_label)
```

Path of the image to be predicted: /content/digit_sample.png



1/1 ______ 0s 20ms/step The Handwritten Digit is recognised as 7