# A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION

A PROJECT REPORT

*Submitted by*


| | |
|---|---|
| **AKASH K** | **[711719104008]** |
| **BALAJI M** | **[711719104016]** |
| **JOTHI PRASANNA B** | **[711719104038]** |
| **KIRUTHIKA A** | **[711719104046]** |
| **MOULIKA P** | **[711719104052]** |


*in partial fulfillment for the award of the degree of*

**BACHELOR OF ENGINEERING IN COMPUTER SCIENCE AND ENGINEERING**


KGISL INSTITUTE OF TECHNOLOGY, SARAVANAMPATTI

ANNA UNIVERSITY :: CHENNAI 600 025

# TABLE OF CONTENTS


**1.INTRODUCTION**

1.1 PROJECT OVERVIEW 5

1.2 PURPOSE 6

**2 LITERATURE SURVEY 7**

2.1 EXISTING PROBLEM 7

2.2 REFERENCES 8

2.3 PROBLEM STATEMENT DEFINITION 9

**3 IDEATION AND PROPOSED SOLUTION 10**

3.1 EMPATHY MAP CANVAS 10

3.2 IDEATION & BRAINSTORMING 11

3.3 PROPOSED SOLUTION 11

3.4 PROBLEM SOLUTION FIT 13

**4 REQUIREMENT ANALYSIS 15**

4.1 FUNCTIONAL REQUIREMENTS 15

4.2 NON FUNCTIONAL REQUIREMENTS 16

**5 PROJECT DESIGN 17**

4.3 DATA FLOW DIAGRAM 17

4.4 SOLUTION & TECHNICAL ARCHITECTURE 18

4.5 USER STORIES 1 9

**6. PROJECT PLANNING AND SCHEDULING 20**

SPRINT PLANNING AND ESTIMATION 20

SPRINT DELIVERY SCHEDULE 22

**7.SOLUTIONING** **24**

**7.1** FEATURE 1 24

**8.TESTING** **25**

8.1. TEST CASES 25

8.2. USER ACCEPTANCE TESTING 26

DEFECT ANALYSIS 26

TEST CASE ANALYSIS 27

**9.RESULTS** **28**

PERFORMANCE METRICS 29

**10. ADVANTAGES & DISADVANTAGES** **32**

ADVANTAGES 32

DISADVANTAGES 32

**11. CONCLUSION** **33**

**12. FUTURE SCOPE** **34**

**13. APPENDIX** **35**

MODEL BUILDING 35

FLASK APP 36

RECOGNITION 36

HTML FILES 38

GITHUB LINK 45

PROJECT DEMO VIDEO 45

# CHAPTER 1

# INTRODUCTION

HANDWRITTEN DIGIT RECOGNITION is the ability of a computer system to recognize the handwritten inputs like digits, characters etc. from a wide variety of sources like emails, papers, images, letters etc. Handwritten digit recognition is the capability of computer applications to recognize human handwritten digits. It is a hard task for the machine because handwritten digits are not perfect and can be made with many different shapes and sizes.This has been a topic of research for decades. Some of the research areas include signature verification, bank check processing, postal address interpretation from envelopes etc. Here comes the use of Deep Learning and Machine Learning. To make machines more intelligent, the developers are diving into machine learning and deep learning techniques. A human learns to perform a task by practicing and repeating it again and again so that it memorizes how to perform the tasks. Then the neurons in his brain automatically trigger and they can quickly perform the task they have learned. Deep learning is very similar to this. It uses different types of neural network architectures for different types of problems. **For example –** object recognition, image and sound classification, object detection, image segmentation, etc.A lot of machine learning tools have been developed like scikit-learn, scipy-image etc. and pybrains, Keras, Theano, Tensorflow by Google, TFLearn etc. for Deep Learning. These tools make the applications robust and therefore more accurate. The Artificial Neural Networks can almost mimic the human brain and

are a key ingredient in the image processing field. For example, Convolutional Neural Networks with Back Propagation for Image Processing, Deep Mind by Google for creating Art by learning from existing artist styles.

## 1.1 PROJECT OVERVIEW

Handwriting Recognition has an active community of academics studying it. The biggest conferences for handwriting recognition are the International Conference on Frontiers in Handwriting Recognition (ICFHR), held in even-numbered years, and the International Conference on Document Analysis and Recognition (ICDAR), held in odd-numbered years. Both of these conferences are endorsed by the IEEE. Active areas of research include: Online Recognition, OfflineRecognition, Signature Verification, Postal-Address Interpretation,Bank-Check Processing, Writer Recognition. Classification of images and patterns has been one of the major implementations of Machine Learning and Artificial Intelligence. People are continuously trying to make computers intelligent so that they can do almost all the work done by humans Handwriting recognition system is the most basic and an important step towards this huge and interesting area of Computer Vision.

.

## 1.2 PURPOSE

Handwriting recognition plays a big role in the technology world now. It also plays an important role in the storage and in the recovery of critical handwriting information. This handwriting recognition ensures accurate medical care and it also reduces storage costs. It ensures that an essential field of research remains available to students in the future. In this era of globalization, technologies continue to improve and improve more in no time.NestorWriter was the first handwriting recognition device found. The one who started the NestorWriter is Dr. Charles Elbaum and he is the one who also developed the NestorWriter. This all happen at the beginning, when many other companies tried to develop these devices and machines all through the years of 1990's. But most of the companies failed, but the devices didn't improve that much as they wanted.

# CHAPTER 2

# LITERATURE SURVEY

Handwriting recognition has gained a lot of attention in the field of pattern recognition and machine learning due to its application in various fields. Various techniques have been proposed for digit recognition in the handwriting recognition system. Even though sufficient studies and papers describe the techniques for converting textual or digit content from a paper document into machine readable form. In the coming days, the Digit recognition system might serve as a key factor to create a paperless environment by digitizing and processing existing paper documents.

## 2.1 EXISTING PROBLEM

In this way, since the handwritten digits are **not of same size, thickness, position**, various difficulties are faced in determining the problem of recognizing handwritten digits. Deep Learning has emerged as a central tool for self-perception problems like understanding images, voice from humans, robots exploring the world. The project aims to implement the concept of Convolution Neural Network which is one of the important architectures of deep learning. Understanding CNN and applying it to the handwritten recognition system, is the major target of the proposed system . There is a reason behind using CNN for handwritten digit recognition. Let us consider a multi-layer feedforward neural network to be applied on the MNIST dataset which contains images of size 28×28 pixels (roughly 784 pixels). So if a hidden layer has about 100 units, then the first layer weighs up to about 78k parameters, which is large but manageable. However, in the natural world the size of the image is much larger . If we consider the size of the typical image which is around 256×256 pixels (roughly about 56,000 pixels), then the first layer weights will have about 560k parameters! So that becomes too many parameters and hence make it unscalable for real images. Hence, it will be so large that it will become very difficult to generalize the new data fed into the network.

Convolution Neural Network extracts the feature maps from the 2D images by applying filters and hence making the task of feature extraction from the images easier. Basically, convolution neural networks consider the mapping of image pixels with the neighborhood space rather than having a fully connected layer of neurons. Convolution Neural Networks has been proved to be a very important and powerful tool in signal and image processing.

## 2.2 REFERENCES


[1] Dr. Alejandro Baldominos , Dr. Yago Achaerandio , Dr. Pedro Isas Published on 4

[2] Jaafar M. Alghazo , published online Dec. 14, 2018. [Multi-Language Handwritten]

[3] Reya Sharma , Baijnath Kaushik, published on Nov 2020,vol 38. [Offline recognition of handwritten Indic scripts: A state-of-the-art survey and future perspectives]

[4] Abdelhak Boukharouba , Faculté des Sciences et de la technologie, Département d'Electronique et de Télécommunications, Université 8 Mai 1945 Guelma, BP 401,Guelma 24000, Algeria. [Novel feature extraction technique for the recognition of handwritten digits]

[5] Monica Patel1 , Shital P. Thakkar2, International Journal of Advanced Research in Computer and Communication Engineering Vol. 4, Issue 2, February 2015. [Handwritten Character Recognition in English: A Survey]

[6] Dr. Ali Yahya, published 18th september in sensors. [A Novel Handwritten Digit Classification System Based on Convolutional Network Approach]

[7] Dr. Pradeepta K. Sarangi, Sarangi et. al, Apeejay - Journal of Management Sciences and Technology, 3 (1), October – 2015. [Handwritten Character Recognition: A Review]

[8] Sana saeed, Part of the Smart Innovation, Systems and Technologies book series (SIST,volume 136). published on 26th november 2019. [An Application of DeepLearning in Character Recognition: An Overview]

[9] Ahmed Remaida Engineering Science Laboratory, National School of Applied Sciences, Ibn Tofail University, Kenitra, MOROCCO. Article No.: 65. [Handwriting Recognition with Artificial Neural Networks a Decade Literature Review]

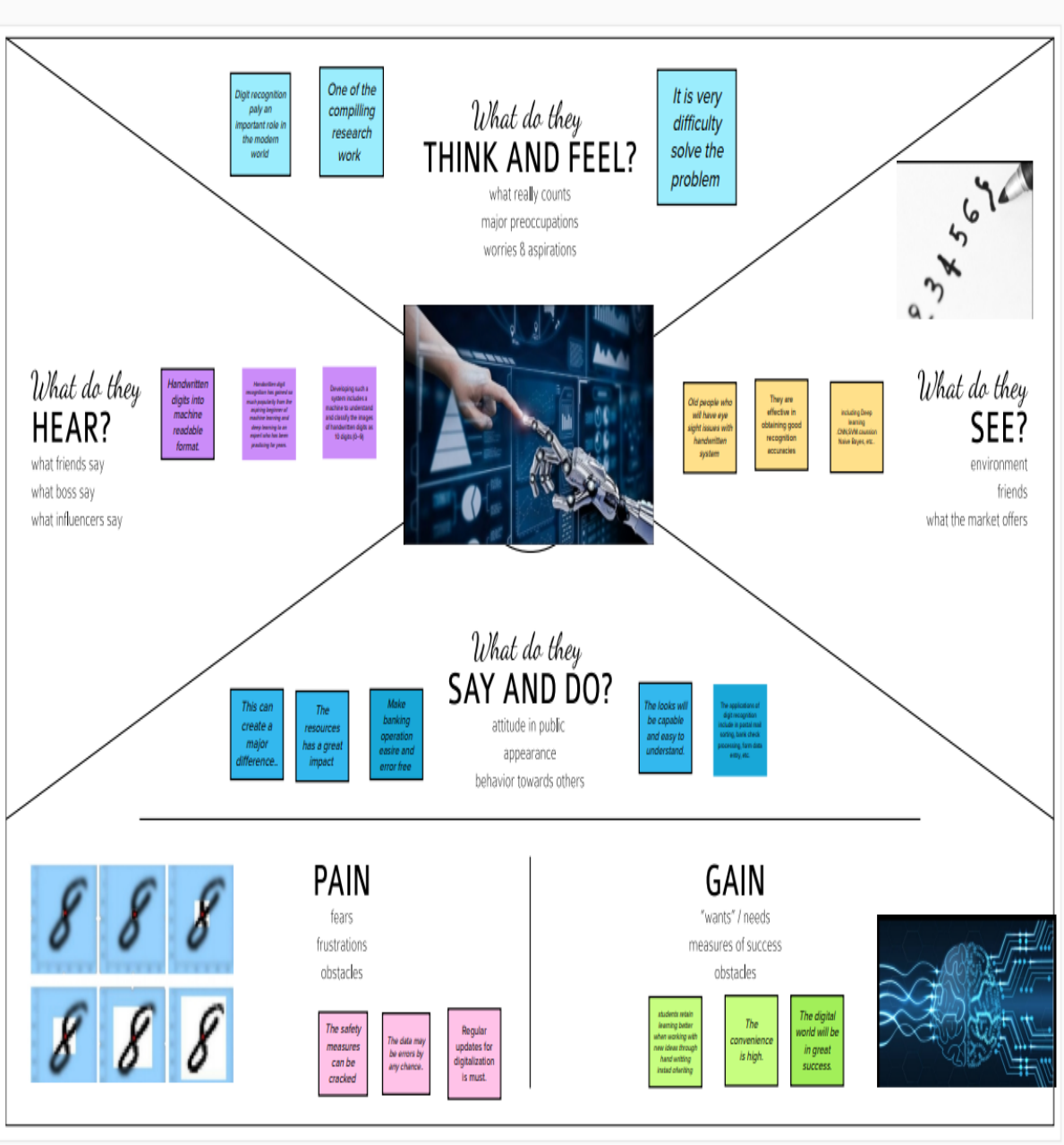
[10] Hubert Cecotti, Volume 73, 1 April 2016. [Active graph based semi-supervised learning using image matching: Application to handwritten digit recognition] network," in Neural networks for perception: Elsevier, 1992, pp.

## 2.3.PROBLEM STATEMENT DEFINITION

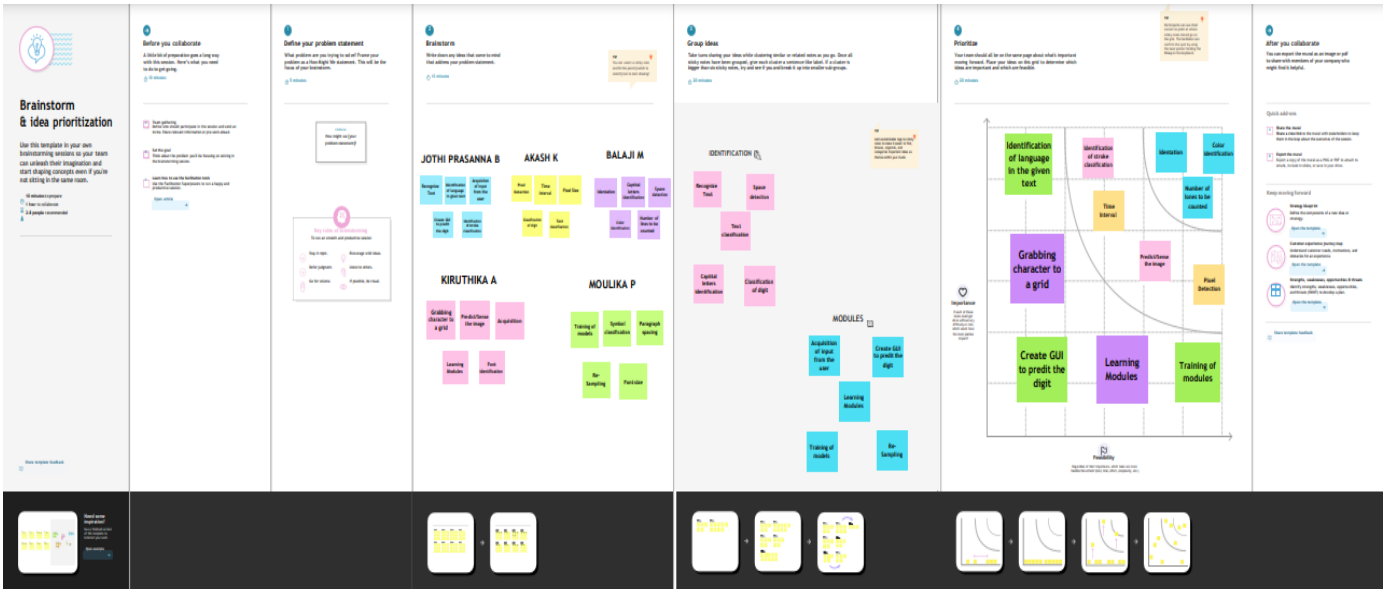
Handwritten Digit Recognition MNIST ("Modified National Institute of Standards and Technology") is considered an unofficial computer vision "hello-world" dataset. This is a collection of thousands of handwritten pictures used to train classification models using Machine Learning techniques. As a part of this problem statement, we will train a multi-layer perceptron using TensorFlow to recognize the handwritten digits.

## 3.IDEATIONS AND PROPOSED SOLUTION

### 3.1 EMPHATHY MAP CANVAS



## 3.2 IDEATION AND BRAINSTORMING




## 3.3 PROPOSED SOLUTION

| S.No. | Parameter | Description |
|---|---|---|
| 1. | Problem Statement (Problem to be solved) | **Statement:**Handwritten digit recognition is the capability of computer applications to recognize the human handwritten digits. **Description:** It is a hard task for the machine because handwritten digits are not perfect and can be made with many different shapes and sizes |
| 2. | Idea / Solution description | 1. It is the capability of a computer to fete the mortal handwritten integers from different sources like images, papers, touch defenses. 2. It allows user to translate all those signature and notes into electronic words in a text document format and this data only requires far less physical space than the storage of the physical copies |
| 3. | Novelty / Uniqueness | Accurately recognize the digits rather than recognizing all the characters like OCR. |

| | | |
|---|---|---|
| 4. | Social Impact / Customer Satisfaction | 1.Artificial Intelligence developed the app called Handwritten digit Recognizer.<br>2. It converts the written word into digital approximations and utilizes complex algorithms to identify characters before churning out a digital approximation |
| 5. | Business Model (Revenue Model) | • This system can be integrated with traffic surveillance cameras to recognize the vehicle's number plates for effective traffic management. PNT2022TMID31590<br>• Can be integrated with the Postal system to identify and recognize the pin-code details easily. |
| 6. | Scalability of the Solution | • Ability to recognise digits in more noisy environments. • There is no limit in the number of digits it can be recognized. |

3.4.Proposed Solution Fit:

| S.No. | Parameter | Description |
|---|---|---|
| 1. | Problem Statement (Problem to be solved) | A novel method for handwritten digit recognition system |
| 2. | Idea / Solution description | The proposed system uses CNN based model and trained using MNIST dataset |
| 3. | Novelty / Uniqueness | CNN model provide more accurate analysis alongwith image and voice recognition,which can be especially useful for blind,differently abled and elder people |
| 4. | Social Impact / Customer Satisfaction | Customers will no longer have to depend on any external system as this software can be easily installed in their mobile phones |
| 5. | Business Model (Revenue Model) | Input module, image processing and segmentation module, feature extraction, dataset training module etc |
| 6. | Scalability of the Solution | An accuracy of 99.98% can be obtained by training this model using MNIST dataset. The accuracy can be further increased by training with other types of dataset additionally |

3.4.Problem Solution Fit:

Handwriting recognition is one of the compelling research works going on because every individual in this world has their own style of writing. It is the capability of the computer to identify and understand handwritten digits or characters automatically. Because of the progress in the field of science and technology, everything is being

digitized to reduce human effort. Hence, there comes a need for handwritten digit recognition in many real-time applications. The MNIST data set is widely used for this recognition process and it has 70000 handwritten digits. We use Artificial neural networks to train these images and build a deep learning model. Web application is created where the user can upload an image of a handwritten digit. This image is analyzed by the model and the detected result is returned on to UI The MNIST Handwritten Digit Recognition Dataset contains 60,000 training and 10,000 testing labeled handwritten digit pictures. Each picture is 28 pixels in height and 28 pixels wide, for a total of 784 (28×28) pixels. Each pixel has a single pixel value associated with it. It indicates how bright or dark that pixel is (larger numbers indicate darker pixel). This pixel value is an integer ranging from 0 to 255.

# CHAPTER 4

# REQUIREMENT ANALYSIS

## 4.1 FUNCTIONAL REQUIREMENTS

Following are the functional requirements of the proposed solution.

| FR No. | Functional Requirement (Epic) | Sub Requirement (Story/ Sub-Task) |
|---|---|---|
| FR-1 | Image Data | Handwritten digit recognition refers to a computer's capacity to identify human handwritten digits from a variety of sources, such as photographs, documents, touch screens, etc., and categorize them into ten established classifications (0-9). In the realm of deep learning, this has been the subject of countless studies. |
| FR-2 | Website | Web hosting makes the code, graphics, and other items that make up a website accessible online. A server hosts every website you've ever visited. The type of hosting determines how much space is allotted to a website on a server. Shared, dedicated, VPS, and reseller hosting are the four basic varieties |
| FR-3 | Digit Classifier Model | To train a convolutional network to predict the digit from an image, use the MNIST database of handwritten digits. get the training and validation data first. |
| FR-4 | Modified National Institute of Standards and Technology dataset | The abbreviation MNIST stands for the MNIST dataset. It is a collection of 60,000 tiny square grayscale photographs, each measuring 28 by 28, comprising handwritten single digits between 0 and 9. |

## 4.2 NON FUNCTIONAL REQUIREMENTS

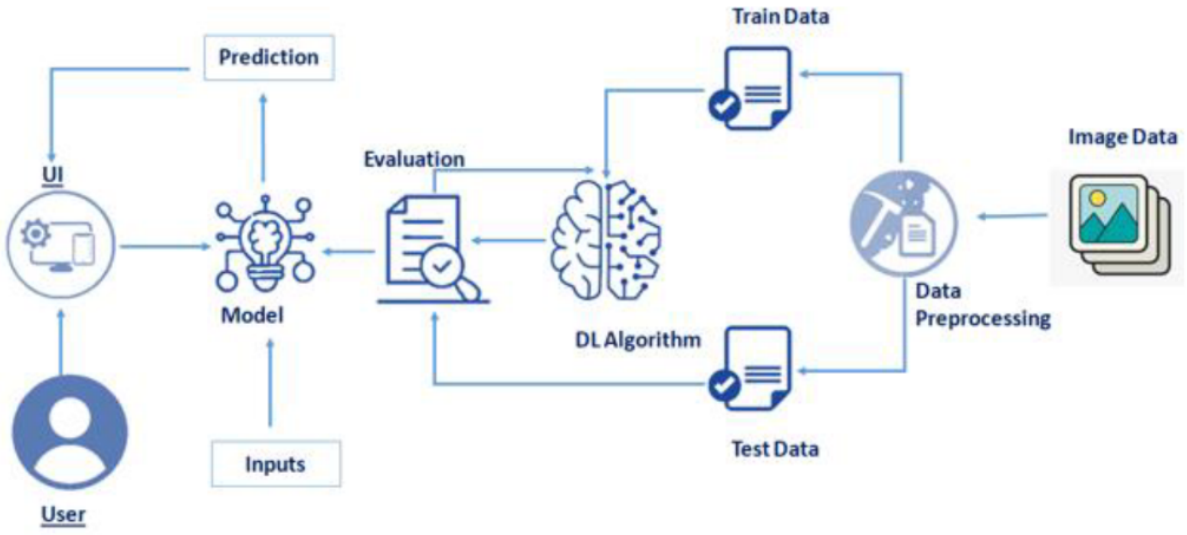
Following are the non-functional requirements of the proposed solution.

| FR No. | Non-Functional Requirement | Description |
|---|---|---|
| NFR-1 | **Usability** | One of the very significant problems in pattern recognition applications is the recognition of handwritten characters. Applications for digit recognition include filling out forms, processing bank checks, and sorting mail. |
| NFR-2 | **Security** | 1) The system generates a thorough description of the instantiation parameters, which might reveal information like the writing style, in addition to a categorization of the digit.<br>2) The generative models are capable of segmentation driven by recognition.<br>3) The procedure uses a relative. |
| NFR-3 | **Reliability** | The samples are used by the neural network to automatically deduce rules for reading handwritten digits. Furthermore, the network may learn more about handwriting and hence enhance its accuracy by increasing the quantity of training instances |
| NFR-4 | **Availability** | Numerous techniques and algorithms, such as Deep Learning/CNN, SVM, Gaussian Naive Bayes, KNN, Decision Trees, Random Forests, etc., can be used to recognise handwritten numbers. |
| NFR-5 | **Accuracy** | With typed text in high-quality photos, optical character recognition (OCR) technology offers accuracy rates of greater than 99%. However, variances in spacing, abnormalities in handwriting, and the variety of human writing styles result in less precise character identification. |

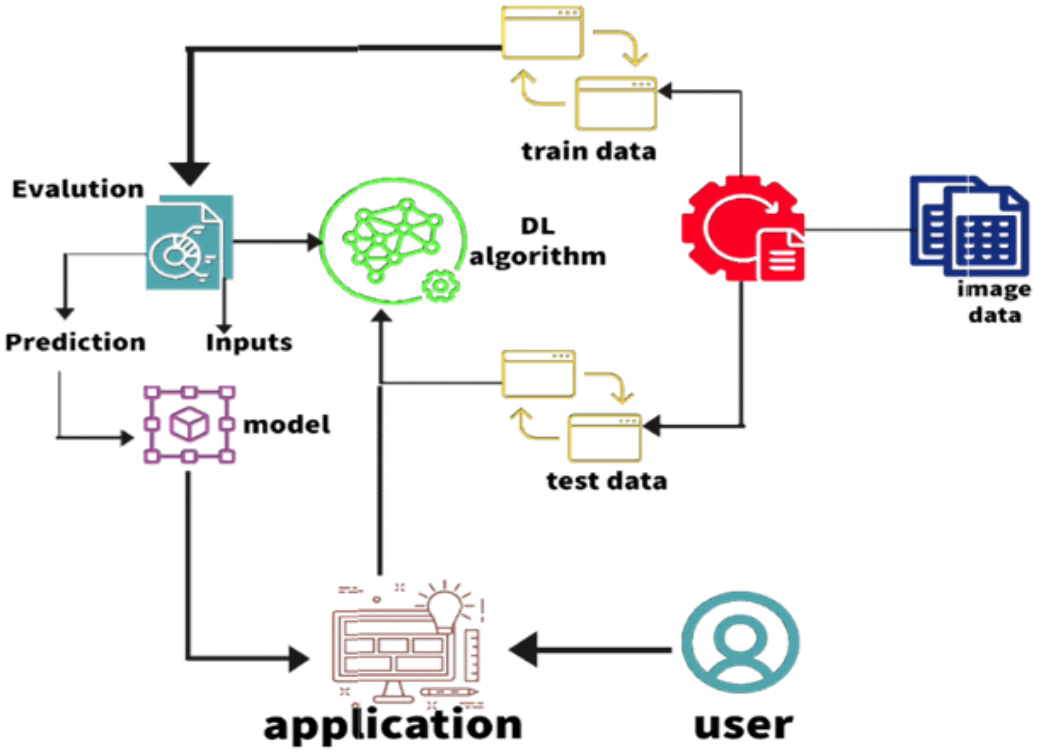
# CHAPTER 5

# PROJECT DESIGN

## 5.1 DATA FLOW DIAGRAM



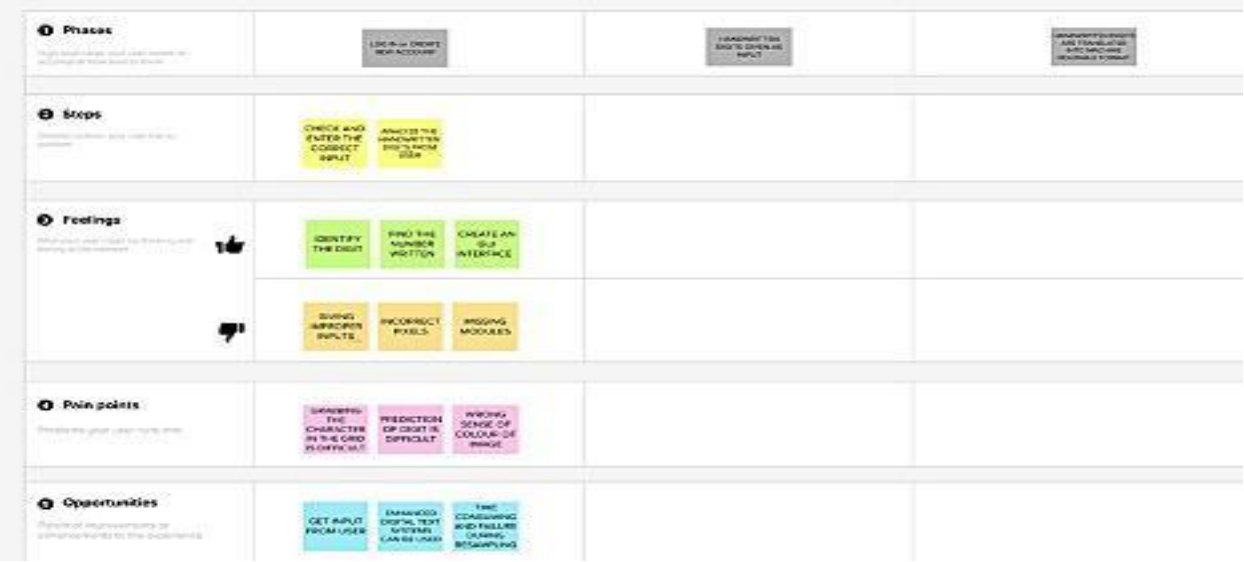
## 5.2. SOLUTION AND TECHNICAL ARCHITECTURE




`  *Architecture* -A Novel Method for Handwritten Digit Recognition System

## 5.3 USER STORIES

This is probably one of the most popular datasets among machine learning and deep learning enthusiasts. The MNIST dataset contains 60,000 training images of handwritten digits from zero to nine and 10,000 images for testing. So, the MNIST dataset has 10 different classes. The handwritten digits images are represented as a 28×28 matrix where each cell contains grayscale pixel value.Its simplicity and ease of use are what make this dataset so widely used and deeply understood.



# CHAPTER 6

# PROJECT PLANNING AND SCHEDULING

Currently, there are so many tasks running in every industries to convert the hand written digits into the digital form.The more time is being wasted, just to convert the hard copy into digital format.Due to this, there is less improvement in the productivity of a particular individual or an organization.With the use of hand written digit recognition system, the data entered by different people can be recognized and converted into digital format with minimal effort.The usage of this system will involves less effort during data entry process.MNIST data set is widely used for this recognition process and it has 70000 handwritten digits. We use Artificial neural networks to train these images and build a deep learning model. Web application is created where the user can upload an image of a handwritten digit. this image is analyzed by the model and the detected result is returned on to UI

## 6.1 SPRINT PLANNING AND ESTIMATION

| **Sprint** | **Total Story Points** | **Duration** | **Sprint start Date** | **Sprint End Date (Planned)** | **Story Points Completed (as on Planned End Date)** | **Sprint Release Date (Actual)** |
|---|---|---|---|---|---|---|
| Sprint-1 | 2 | 6 Days | 24 Oct 2022 | 29 Oct 2022 | 2 | 29 Oct 2022 |
| Sprint-2 | 2 | 6 Days | 31 Oct 2022 | 05 Nov 2022 | 2 | 05 Nov 2022 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sprint-3 | 2 | 6 Days | 07 Nov 2022 | 12 Nov 2022 | 2 | 12 Nov 2022 |
| Sprint-4 | 2 | 6 Days | 14 Nov 2022 | 19 Nov 2022 | 2 | 19 Nov 2022 |

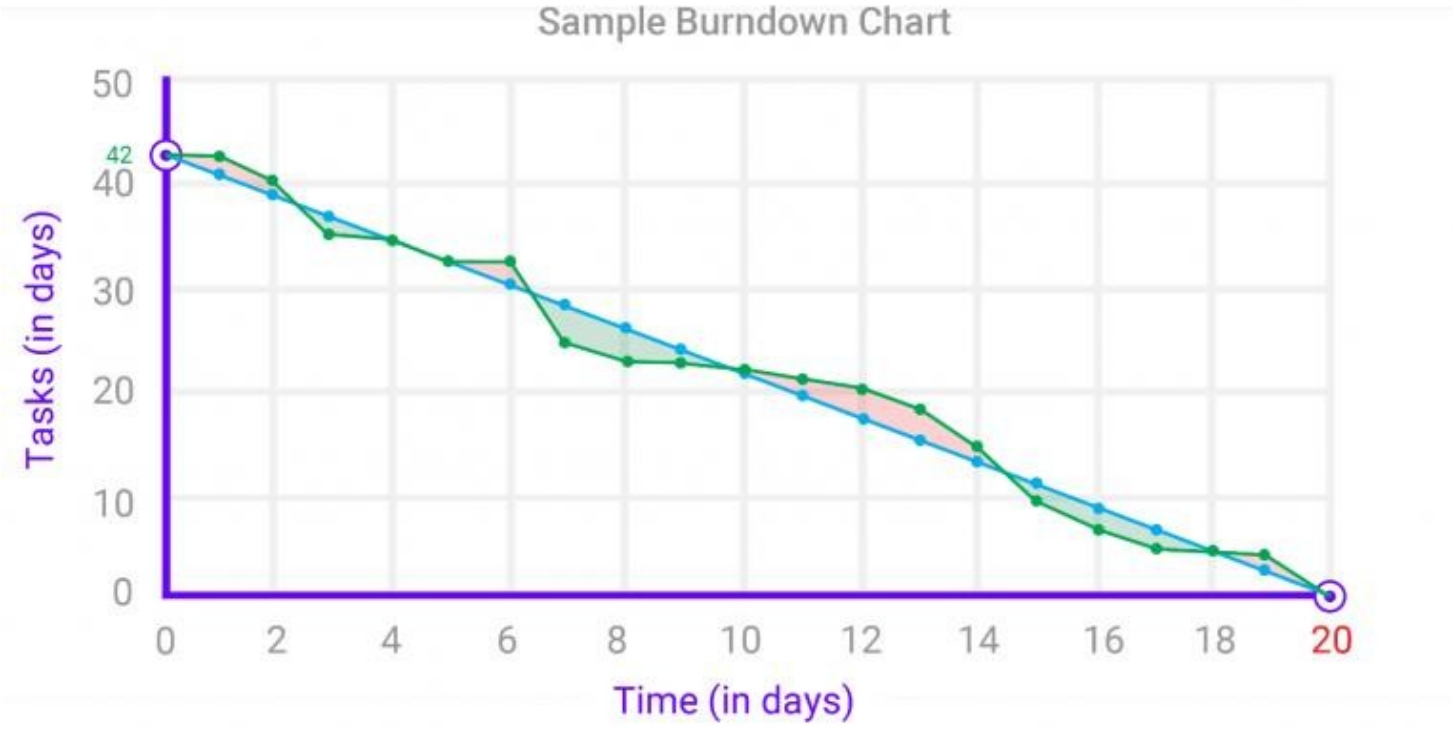
**Velocity:**

Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) per iteration unit (story points per day)

$$AV = \frac{sprint\ duration}{velocity} = \frac{20}{10} = 2$$

**Burndown Chart:**

A burn down chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies such as Scrum. However, burn down charts can be applied to any project containing measurable progress over time.




## 6.2.SPRINT DELIVERY SHEDULE

| Sprint | Functional Requirement | User Story Number | User Story / Task | Story Points | Priority | Team Members |
|---|---|---|---|---|---|---|
| Sprint-1 | Model Training | USN -1 | As a user, I can train the model by using the sequential model | 2 | High | Kiruthika A<br>Balaji M |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sprint-2 | Executing the model | USN-2 | As a user, I am able to upload the image and also be able to execute the model . | 2 | Medium | Akash K<br>Kiruthika A |
| Sprint-3 | Creating Homepage ,Recognize page to view the result of handwritten image or document. | USN-3 | As a user I can feel the user interface present in the web page. | 2 | High | Kiruthika A<br>Moulika P |
| Sprint-4 | Connecting our frontend page with the server using flask. | USN-4 | As a user, I am able to see the final result of the handwritten image by giving input through and getting the output in the webpage. | 1 | Medium | Jothi Prasanna B<br>Balaji M |

# CHAPTER 7

# SOLUTION

## 7.1 FEATURE 1

Reprocessing entails actions necessary to reshape the input picture into a format appropriate for segmentation. Red, green, and blue color intensities make up the triplet (R,G,B) that describes each color pixel. That may be reduced to a single integer that represents a grayscale value.In which the Color images are transformed into grayscale images, which are then transformed into binary images, or images that are black and white.We are adding several layers to reach the high accuracy.The layers which we added are layers that consist of activation function Rectified Linear Unit to extract the match from input image, flatten layer to convert the multi- dimensional array to the single dimensional array and the dense layer with softmax function to get the result as class number that has maximum level in the level of accuracy.

# CHAPTER 8

# TESTING

The testing part comes with some latest real time update in the machine learning part .The image processing work like webcam access and the other techniques has been discussed before that is why it has not been discussed here. So this part comes with some ransom upgrade of the technique which is very small to say but not that much easy to design.

## 8.1 TEST CASES

1. We use the training dataset of count 10,000 from the mnist data set.
2. Set the numpy array system to take input to the kernel along with the data.
3. Set the probabilistic statistical value into the biased dataset into unbiased. 22
4. Check the target and the output predicted value every time while training the dataset and set the number of epochs corresponding to the error.
5. Model check with checksum value removal and biased value removal after setting the weight value by the neural network on its set and set the dataset into the unbiased.
6. Upload the image that consists of a handwritten digit to test the accuracy of the model.

7. Measure the probability of the image after performing normalization and removing noise from the image

8. If the prediction value is high, then display the result in the .

## 8.2 USER ACCEPTANCE TESTING

This kind of software or system testing involves checking the availability of a system. Checking the business needs and determining if it will be approved for delivery are the goals of this test. we used the same platform and checked to see if this project had been approved by the delivery partner.
This kind of software or system testing involves checking the availability of a system. Checking the business needs and determining if it will be approved for delivery are the goals of this test.

**Defect Analysis**

This report shows the number of resolved or closed bugs at each severity level, and how they were resolved

| Resolution | Severity 1 | Severity 2 | Severity 3 | Severity 4 | Subtotal |
|---|---|---|---|---|---|
| By Design | 10 | 5 | 2 | 3 | 20 |
| Duplicate | 1 | 0 | 3 | 0 | 4 |
| External | 2 | 5 | 0 | 1 | 8 |
| Fixed | 10 | 3 | 2 | 18 | 33 |
| Not Reproduced | 0 | 0 | 1 | 0 | 1 |
| Skipped | 0 | 0 | 1 | 1 | 2 |
| Won't Fix | 0 | 5 | 2 | 1 | 8 |
| Totals | 23 | 18 | 11 | 24 | 76 |

## Test Case Analysis

This report shows the number of test cases that have passed, failed, and untested

| Section | Total Cases | Not Tested | Fail | Pass |
|---|---|---|---|---|
| Print Engine | 6 | 0 | 0 | 6 |
| Client Application | 62 | 0 | 0 | 58 |
| Security | 4 | 0 | 0 | 3 |
| Outsource Shipping | 2 | 0 | 0 | 2 |
| Exception Reporting | 7 | 0 | 0 | 7 |
| Final Report Output | 3 | 0 | 0 | 3 |
| Version Control | 6 | 0 | 0 | 5 |

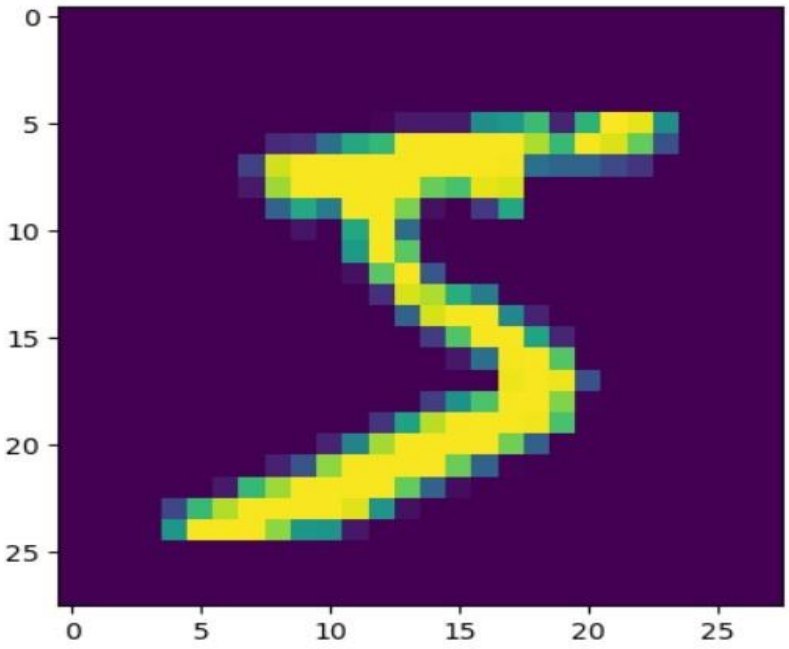
# CHAPTER 9

## RESULTS

As with any study or project done in the field of machine learning and image processing, we do not consider our results to be perfect.

Because machine learning is a field that is always evolving, there is always room for improvement in your approaches. Additionally, there will always be novel solutions to problems that have been solved before. The application was evaluated using three models: Multi-Layer Perceptron (MLP), Convolution Neural Network, and (CNN). With each model, we get a different classifier accuracy, showing which is better.

Out[19]:




So that the application won't have to redo the training process each time a user tries to recognise a digit, the network's training results are recorded in npz formats. For classification, we used a logistic classifier together with the SoftMax function, one hot encoding, cross entropy, loss minimization, and micro batch gradient descent. To process network output and display it to the user in an understandable way, it is necessary to comprehend some of the basic principles of neural network.

## 9.1 PERFORMANCE METRICES

### DATASET USED:

Mnist dataset is used for both training and testing purpose.This dataset consists of totally 70,00 data, where 60,00 for training and 10,000 for testing.Before training the model the images are reshaped into 28*28 pixels,converted into grayscale and normalized . For people who want to practice new abilities and pattern recognition algorithms on real data with the least amount of pre-processing and formatting work, this database is helpful. The databasecomes in from http://yann.lecun.com/exdb/mnist/

FIG 6: MNIST DATASET

## ANALYSIS OF THE RESULTS:

A business issue is analyzed with the intention of being improved through improved practises and processes. This process is known as system analysis and design.
System analysis and design are related to organizational design, improving performance, and achieving objectives for profitability and expansion. Systems in action, the relationships between subsystems, and their function in reaching a common goal are the main points of emphasis.

```
Epoch 23/70
938/938 [==============================] - 25s 26ms/step - loss: 2.3012 - accuracy: 0.1124 - val_loss: 2.3010
0.1135
Epoch 24/70
938/938 [==============================] - 25s 26ms/step - loss: 2.3012 - accuracy: 0.1124 - val_loss: 2.3010
0.1135
Epoch 25/70
938/938 [==============================] - 25s 27ms/step - loss: 2.3012 - accuracy: 0.1124 - val_loss: 2.3010
0.1135
Epoch 26/70
938/938 [==============================] - 26s 27ms/step - loss: 2.3012 - accuracy: 0.1124 - val_loss: 2.3010
0.1135
```

FIG.7.DATA TRAINING AND ACCURACY

System analysis involves looking at a system to see how well it works, what changes are required, and how well the results are produced. Organizations are complex systems made up of interdependent subsystems that are interrelated.

# CHAPTER 10

# ADVANTAGES AND DISADVANTAGES

## ADVANTAGES

- The system generates a rich description of the instantiation parameters, which can reveal information like the writing style, in addition to a classification of the digit.
- The generative models can perform recognition driven segmentation
- The method involves a relatively small number of parameters and hence training is relatively easy and fast;
- It can tolerate unrestricted scaling, translation, and a small amount of image rotation, unlike many other recognition techniques that rely on some kind of pre-normalization of input images.

## DISADVANTAGES

- IT REQUIRES MORE COMPUTATION THAN THE OCR TECHNIQUES

# CHAPTER 11

## CONCLUSION

Recognition system is used by most of the organizations to reduce the cumbersome task of data entry and analyses. The purpose of the system is to improve organizations performance and completing goals for profitability and expansion. The focus of a system is in operation, accuracy in the recognition and their role in achieving a shared objective. Our process is to examine a system to determine the effectiveness, the necessary adjustments, and the output's quality. Organizations are intricate systems made up of connected and interdependent components. Proposed Application Module:The handwritten digit recognition system accurately recognizes the handwritten digit data given in the form of an image. This system with the help of MNIST data set has been trained and tested successfully. The accuracy of the system has also been achieved by the Convolution Neural Network algorithm. The algorithm got trained with the different layers with various pre-processing techniques. With this system, users can identify the digit and recognize the digits written in different styles by different persons. This can reduce the cumbersome task done by the persons who are in the field of data entry and processing. This system can be used by the user with great comfort with the help of a great User Interface provided with the help of html, css and several bootstrap frameworks. At the interface provided, the user uploads the handwritten image data, then the data will be sent to the model with the help of a python framework called FLASK. The predicted result by the model will be displayed to the user in the web page.

# CHAPTER 12

## FUTURE SCOPE

The scope of this is to use the Handwritten Digital Awareness Framework and think of different categories and strategies by focusing on how to achieve closeness to personal performance.

This undertaking has limitless potential and may constantly be improved. By putting this idea into practice in the real world, numerous industries will gain, many workers' workloads will be reduced, and total work productivity will increase.

Future studies might consider using the architecture of the convolution network which gave the best result on the MNIST database and the proposed recognition system is implemented on handwritten digits.

# CHAPTER 13
# APPENDIX

## MODEL BUILDING

```
import numpy
from tensorflow.keras.models import load_model
import tensorflow
from tensorflow.keras.datasets import mnist
from tensorflow.keras.models import Sequential
from tensorflow.keras import layers
from tensorflow.keras.layers import  Dense,Flatten
from tensorflow.keras.layers import Conv2D
from keras.optimizers import  Adam
from keras.utils import np_utils
import matplotlib.pyplot as plt
import numpy as np
    (x_train,y_train),(x_test,y_test) = mnist.load_data()
        x_train = x_train.reshape(60000,28,28,1).astype("float32")
        x_test = x_test.reshape(10000,28,28,1).astype("float32")
            ClassCount = 10
            y_train = np_utils.to_categorical(y_train,ClassCount)
            y_test = np_utils.to_categorical(y_test,ClassCount)
print(y_train)
print(y_test)
    Model = Sequential()
        Model.add(Conv2D(64,(3,3), input_shape = (28,28,1),activation = 'relu'))
        Model.add(Conv2D(32,(3,3), activation= 'relu'     ))
        Model.add(Flatten())
Model.add(Dense(ClassCount,activation='softmax'))
Model.compile(loss='categorical_crossentropy',optimizer="Adam",metrics=['accuracy'])
Model.fit(x_train,y_train,validation_data = (x_test,y_test),epochs = 20,batch_size = 3233)
Metrics = Model.evaluate(x_test,y_test,verbose=1)
print("Test Losss and Test accuracy")
print(Metrics)
Prediction = Model.predict(x_test[:4])
print(Prediction)
print(np.argmax(Prediction,axis=1))
print(y_test[:4])
Model.save('models/mnistCNN.h5')

```

# FLASK APP

```
image.png
import Execution
from flask import Flask,render_template,redirect,url_for,request,redirect
from flask_wtf import FlaskForm
from wtforms import SubmitField,FileField
from werkzeug.utils import secure_filename
import os
App = Flask(__name__)
App.config["SECRET_KEY"] = "SSK"
@App.route("/")
@App.route("/Index1/Home")
def HomeMethod():
    return render_template("index.html")
    '''
@App.route("/Recognize/<File>")
def Recognize(File):
    return "5"
'''
@App.route("/Recognize/",methods=["GET","POST"])
def RecognizePage():
    if request.method == "POST":
        if request.files:

            File = request.files["image"]
            List = os.listdir("C:\\Users\\bjpra\\Desktop\\IBM_PROJECT\\data")

            File.save(os.path.join("C:\\Users\\bjpra\\Desktop\\IBM_PROJECT\\data\\",secure_filename(File.filename)))
            File = File.filename
            StringRes = ""
            Result = Execution.Execute(File)
            for i in Result:
                StringRes += str(i)
            if StringRes == "0":
                return render_template("Html_0.html")
            elif StringRes == "1":
                return render_template("Html_1.html")
            elif StringRes == "2":
                return render_template("Html_2.html")
            elif StringRes == "3":
                return render_template("Html_3.html")
            elif StringRes == "4":
                return render_template("Html_4.html")
            elif StringRes == "5":
                return render_template("Html_5.html")
            elif StringRes == "6":
                return render_template("Html_6.html")
            elif StringRes == "7":
                return render_template("Html_7.html")
            elif StringRes == "8":
                return render_template("Html_8.html")
            elif StringRes == "9":
                return render_template("Html_9.html")
            else:
                return  None
        return render_template("recognize.html")
        #@App.route('/rule/Admin')
#def GreetAdmin():
#    return "Hello Admin"
#@App.route('/rule2/<Guest>')
#def GreetGuest(Guest):
#    return "Hello  %s " % Guest
if __name__ == "__main__":
    App.run()
```

# RECOGNITION

```
from tensorflow.keras.models import load_model
from PIL import Image
import numpy as np

def Execute(File):
    Model = load_model(r"C:/Users/bjpra/Desktop/IBM_PROJECT/models/mnistCNN.h5")
    File = "C:\\Users\\bjpra\\Desktop\\IBM_PROJECT\\data\\"+File
    Img = Image.open(File).convert("L")
    Img = Img.resize((28,28) )
    Im2Arr = np.array(Img)
    Im2Arr = Im2Arr.reshape(1,28,28,1)
    Prediction = Model.predict(Im2Arr)
    print(Prediction)
    print(np.argmax(Prediction,axis=1))
    return np.argmax(Prediction,axis=1)
```

## HTML FILES

```html
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <title>Recognize</title>
</head>

<style>
    body{
    background-image:url('https://media.licdn.com/dms/image/C4D12AQE-6pABokfUkg/article-cover_image-shrink_600_2000/0/1588088594591?
    background-size:cover;
    background-repeat: no-repeat;
    background-attachment: fixed;
    display:grid ;
    height:100%;
    }

    #rectangle{
    width:400px;
    height:100px;
    background-color: #000000;
    border-radius: 15px;
    position:absolute;
    box-shadow: 0px 0px 10px 5px white;
    top:25%;
    left:50%;
    transform:translate(-50%,-50%);
    margin-top: 300px;


    }

    #head{
    text-align: center;
    font-size: 30px;
    margin: 0 auto;
    padding: 3% 5%;
    font-family: Arial, Helvetica, sans-serif;
    color: white;
```

```
}

#num{
    font-size: 50px;

}
.image{
    color: whitesmoke;
    font-size: xx-large;
    padding-bottom: 50px;


}
.buttons_div{
    border: none;
    color: white;
    padding: 15px 32px;
    text-align: center;
    text-decoration: none;
    display: inline-block;
    font-size: 50px;
    margin: 4px 2px;
    cursor: pointer;
    display: flex;
    justify-content: center;
    align-items: center;
    border-radius: 12px;

}
.button1 {background-color: whitesmoke;
font-size: xx-large;}
#image{
    font-size: xx-large;
    color: white;

```

```
    }
    #frame{
        color: whitesmoke;
        text-align: center;
        color: white;

    }
    .button1 {
        padding: 15px 25px;
        font-size: 24px;
        text-align: center;
        cursor: pointer;
        outline: none;
        color: #fff;
        background-color: #ee8c4b;
        border: none;
        border-radius: 15px;
        box-shadow: 0 9px #999;
}

.button:hover {background-color: #3e8e41}

.button:active {

  box-shadow: 0 5px #666;
  transform: translateY(4px);
}
.topnav {
  overflow: hidden;

}

.topnav a {
  float: left;
```

```
    color: #f2f2f2;
    text-align: center;
    padding: 14px 16px;
    text-decoration: none;
    font-size: 17px;
  }



  .topnav a.active {

    color: white;
  }

  .topnav-right {
    float: right;
  padding-right:250px;
  }

  </style>

  <body>

      <div class="topnav">

    </div>

      <div id="rectangle">
        <h1 id="head">Predicted Number : <br><center id="num">0</center></h1>
      </div>


      <section id="content">


    </section>

  </body>
  </html>
```

```
<!DOCTYPE html>
<html lang="en">

<head>
    <meta charset="UTF-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <title>PNT20
    <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.1.3/dist/css/bootstrap.min.css" rel="stylesheet"
        integrity="sha384-1BmE4kWBq78iYhFldvKuhfTAU6auU8tT94WrHftjDbrCEXSU1oBoqyl2QvZ6jIW3" crossorigin="anonymous">
    <link rel="stylesheet" href="/assets/style.css">
    <link href="https://fonts.googleapis.com/icon?family=Material+Icons" rel="stylesheet">
    <style>
    body{
        background-image:url('https://media.licdn.com/dms/image/C4D12AQE-6pABokfUkg/article-cover_image-shrink_600_2000/0/1588088594591?e=2147483647&v=beta&t=dy9JcUPN3mVNt4

        background-size:cover;
background-repeat: no-repeat;
background-attachment: fixed;
display:grid ;
height:100%;
position: sticky;
    }
    .h3{
      color: whitesmoke;

    }
    .p{
        color: azure;
        margin-left:20px;
    }
    .h1{
        color:black;
        margin-top: 1px;
        text-align:center ;
    }

```

Follow link (ctrl + click)

```
    .cards {
  box-shadow: 0 4px 8px 0 rgba(0, 0, 0, 0.2);
  max-width: 300px;
  padding: 20px;
  text-align: center;
  font-family: arial;
  margin-left: 1200px;
  background-color: rgb(99, 206, 206);
  box-shadow: 0 0 10px 5px #48abe0,
              0 0 20px 7px #ebecca,
              0 0 25px 20px #8a2be2,
              0 0 30px 25px #ff1493;
  }


.cards button {
  border: none;
  outline: 0;
  padding: 12px;
  color: white;
  background-color: #000;
  text-align: center;
  cursor: pointer;
  width: 100%;
  font-size: 18px;
}

.cards button:hover {
  opacity: 0.7;
}

.start {
  border-radius: 4px;
  background-color: #f41ef4;
  border: none;
```

```
  border: none;
  color: #FFFFFF;
  text-align: center;
  font-size: 28px;
  padding: 20px;
  width: 200px;
  transition: all 0.5s;
  cursor: pointer;
  margin: 5px;
}

.start span {
  cursor: pointer;
  display: inline-block;
  position: relative;
  transition: 0.5s;
}

.start span:after {
  content: '\00bb';
  position: absolute;
  opacity: 0;
  top: 0;
  right: -20px;
  transition: 0.5s;
}

.start:hover span {
  padding-right: 25px;
}

.start:hover span:after {
  opacity: 1;
  right: 0;}
    </style>
</head>

<body>
```

```
<div class="h1"><h1>HANDWRITTEN DIGIT RECOGNITION</h1><br></div>
<div class="p"><p class="lorem"><b>Handwritten Digit Recognition is a technology that is much needed in this world as<br> of Today.This Digit Recognition System is us
</p></div>

<section class="sec">
    <header>
        <div class="container">
            <div class="row">
                <nav class="navbar navbar-expand-lg navbar-light col-12">
                    <div class="nav  container-fluid col-12">

                        <button class="navbar-toggler" type="button" data-bs-toggle="collapse"
                            data-bs-target="#navbarSupportedContent" aria-controls="navbarSupportedContent"
                            aria-expanded="false" aria-label="Toggle navigation">
                            <span class="navbar-toggler-icon " style="color: white;"></span>
                        </button>
                        <div class="collapse navbar-collapse" id="navbarSupportedContent">


                            <ul class="navbar-nav ms-auto mb-2   mb-lg-0">




                                <li class="nav-item" style="margin-right: 5rem;">
                                </li>
                            </ul>

                        </div>
                    </div>
                </nav>
            </div>
        </div>
    </header>

    <section>
```

```
        <div class="cards">
            <h1>Make your zone comfort with our site</h1>


  <div class="start"><p><button><span><a class="nav-link text-white" aria-current="page" href="/Recognize/">start your Recognition</a></span></button></p></div>
        </div>









    </section>
</section>
<section class="mb-5">
    <div class="container">
        <div class="row mt-5">
            <div class="col-12">
                <div class="head text-center">
                    <div class="h3"><h3><b>EXECUTION FLOW</b></h3></div>
                    <div>
                        <p>Here are some examples </p>
                    </div>
                </div>
            </div>
        </div>
        <div class="row mt-5" style="margin-left:1rem;">
            <div class="" style="display: flex;justify-content: space-between;flex-wrap: inherit;">
                <div class="card" style="width: 18rem;">
                    <img src="{{url_for('static',filename = '33.png')}}" class="card-img-top" alt="..." height="283" width="50">
                    <div class="card-body">


                        <a href="#" class="btn2 btn btn-dark">User Input</a>
                    </div>
                </div>
```

```
                <div class="card" style="width: 18rem;">
                    <img src="{{url_for('static',filename = '22.png')}}" class="card-img-top" alt="...">
                    <div class="card-body">

                        <a href="#" class="btn2 btn btn-dark">Level 1</a>
                    </div>
                </div>
                <div class="card" style="width: 18rem;">
                    <img src="{{url_for('static',filename = '11.png')}}" class="card-img-top" alt="...">
                    <div class="card-body">
                        <a href="#" class="btn2 btn btn-dark">Level 2</a>
                    </div>
                </div>
                <div class="card" style="width: 18rem;">
                    <img src="{{url_for('static',filename = '44.png')}}" class="card-img-top" alt="..." height="283" width="50">
                    <div class="card-body">

                        <a href="#" class="btn2 btn btn-dark">Regonized Image</a>
                    </div>
                </div>
            </div>
        </div>

    </div>
</section>



<!-- bootstrap -->
<script src="https://cdn.jsdelivr.net/npm/bootstrap@5.1.3/dist/js/bootstrap.bundle.min.js"
    integrity="sha384-ka7Sk0Gln4gmtz2MlQnikT1wXgYsOg+OMhuP+IlRH9sENBO0LRn5q+8nbTov4+1p"
    crossorigin="anonymous"></script>
<script src="https://cdn.jsdelivr.net/npm/@popperjs/core@2.10.2/dist/umd/popper.min.js"
    integrity="sha384-7+zCNj/IqJ95wo16oMtfsKbZ9ccEh31eOz1HGyDuCQ6wgnyJNSYdrPa03rtR1zdB"
    crossorigin="anonymous"></script>
<script src="https://cdn.jsdelivr.net/npm/bootstrap@5.1.3/dist/js/bootstrap.min.js"
    integrity="sha384-OJHtvGhmr9XOIpI6YVutG+2QOK9T+ZnN4kzFN1RtK3zEFEIsxhlmWl5/YESvpZ13"
```

# GITHUB LINK

https://github.com/IBM-EPBL/IBM-Project-47315-1660798181.git

# PROJECT DEMO LINK

https://drive.google.com/file/d/1kbedeu_p9aucSmEPlDgCx8uTZHuOqndC/view?usp=sharing