

**PROJECT REPORT**

**A NOVEL METHOD FOR  
HANDWRITTEN DIGIT RECOGNITION**

submitted by  
**PNT2022TMID48440**

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## **Project Report**

<b>Team ID</b>	<b>PNT2022TMID48440</b>
<b>Project Name</b>	<b>A Novel Method for Handwritten Digit Recognition System</b>

### **1. INTRODUCTION**

#### **1.1 Project Overview:**

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 digitalized to reduce human effort. Hence, there comes a need for handwritten digit recognition in many real-time applications. 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

#### **1.2 Purpose:**

The total project lies with a great computation speed and by a online server where run and compilation done quickly. All the packages were imported that were needed for the software online. We need the tools to be imported also. This project at first is in need of the software of python. The total code is written in python so it needs Python3. Python2 was not chosen because python3 has some additional upgrade over python2. The packages have been imported and the algorithm created which is done by installing the new packages from online in python3. Apart from that the total project is online compiled or ran and done by the software provided by the Google Colab free version. Apart from choosing Anaconda Navigator, Spyder or Jupyter Notebook, Google Colab or Colabotory have been chosen because this provide more speed and accurate compilation as is known. Creation of the machine learning algorithms deals with data and bigger size programs.

## 2. LITERATURE SURVEY:

### 2.1 Existing problem:

The total world is working with the various problems of the machine learning. The goal of the machine learning is to factorize and to manipulate the real life data and the real life part of the human interaction or complex ideas or the problems in the real life. The most curious of those is Handwritten Character Recognition because it is the building block of the human certified and the classification interaction between other humans. So, the goal was to create an appropriate algorithm that can give the output of the handwritten character by taking just a picture of that character. If one asks about Image processing then this problem can't be solved because there can be a lot of noises in that taken image which can't be controlled by human. The main thing is when human write a handwritten character or for our case digit he has no single idea whether he has to draw it in the circulated pixels or just same as a standard image given. A machine can do that but not the human. So by matching only the pixels one can't recognize that. The idea of machine learning lies on supervised data. Machine learning algorithm fully dependent on modelled data. If someone models the Image directly, the model will get a lot of flatten values because that picture can be drawn with various RGB format or with various pixels which can't be modelled accurately due to noise. So, for this project one has to create a model by image processing and the machine learning. Both the techniques will be needed because these two techniques will enhance the technique of the machine learning and that can shape this project.

### 2.2 References:

#### PAPER 1:

**TITLE:** Fast Efficient Artificial Neural Network for Handwritten Digit Recognition

**AUTHOR NAME:** Viragkumar N. Jagtap, Shailendra K. Mishra

**PUBLICATION YEAR:** 2014

#### DESCRIPTION:

This paper is referred for fast efficient artificial neural network for handwritten digit recognition on GPU to reduce training time.

#### PAPER 2:

**TITLE:** A NOVEL METHOD FOR HAND WRITTEN DIGIT RECOGNITION USING DEEP LEARNING

**AUTHOR NAME:** Rohini.M, Dr.D.Surendran

**PUBLICATION YEAR:** 2019

#### DESCRIPTION:

MNIST is a dataset which is widely used for handwritten digit recognition. The dataset consist of 60,000 training images and 10,000 test images. The artificial neural networks can all most mimic the human brain and are a key ingredient in image processing field.

**PAPER 3:**

**TITLE:** Arduino A Novel Method on Handwritten Character Recognition

**AUTHOR NAME:** Anish S, Preeja V

**PUBLICATION YEAR:** 2015

**DESCRIPTION:**

This paper deals with texture extraction model for character recognition process. In this model co-occurrence matrix and Euclidean distance are used to recognize the characters in an image.

**PAPER 4:**

**TITLE:** A Review of Various Handwriting Recognition Methods

**AUTHOR NAME:** Salma Shofia Rosyda, Tito Waluyo Purboyo

**PUBLICATION YEAR:** 2018

**DESCRIPTION:**

Several methods to be discussed in this paper, in this paper to be discussed is a method that can be used for handwriting recognition.

**PAPER 5:**

**TITLE:** Waste Management Initiatives in India For Human Wellbeing

**AUTHOR NAME:** Dr. Raveesh Agarwal, Mona Chaudhary and Jayveer Singh

**PUBLICATION YEAR:** 2015

**DESCRIPTION:**

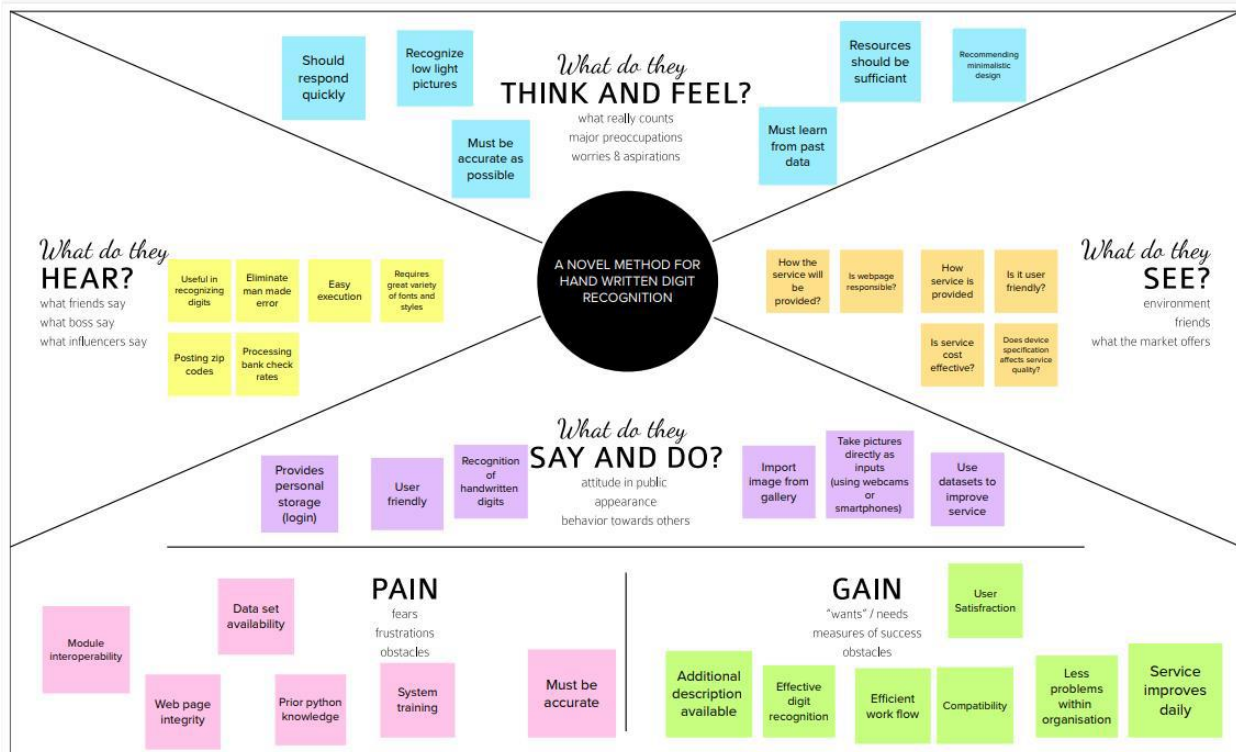
The objective of this paper is to examine the present methods used in India for the welfare of its people in different waste management efforts. The other goal is to offer advice on how to make Indian municipalities' trash disposal procedures better. On secondary research, this essay is founded. The system is improved by looking at the reports that have already been written about waste management and the suggestions made for improvement by planners, NGOs, consultants, government accountability organisations, and important business leaders. It provides in-depth understanding of the various waste management programmes in India and identifies areas where waste management might be improved for societal benefit. The essay makes an effort to comprehend the crucial part that our nation's official waste management sector plays in the waste management process.

**2.3 Problem Statement Definition:**

<b>Problem Statement (PS)</b>	<b>I am (Customer)</b>	<b>I'm trying to</b>	<b>But</b>	<b>Because</b>	<b>Which makes me feel</b>
PS-1	Client	Recognize digits	No clarity	Unable to understand digits	Frustrated
PS-2	Admin	Display output after recognition	False output	Not enough data sets	Worried

### 3. IDEATION & PROPOSED SOLUTION

#### 3.1 Empathy Map Canvas



#### 3.2 Ideation & Brainstorming

**Brainstorm & idea prioritization**

Use this template in your own brainstorming sessions so your team can unleash their imagination and start shaping concepts even if you're not sitting in the same room.

10 minutes to prepare  
1 hour to collaborate  
2-8 people recommended

Share template feedback

**Before you collaborate**

A little bit of preparation goes a long way with this session. Here's what you need to do to get going.

10 minutes

- Team gathering: Gather who should participate in the session and send an invite. Share relevant information or pre-work ahead.
- Set the goal: Think about the problem you'll be focusing on solving in the brainstorming session.
- Learn how to use the facilitation tools: Give the Facilitation Superpowers to have a happy and productive session.

Open article

**1 Define your problem statement**

What problem are you trying to solve? Frame your problem as a "How Might We..." statement. This will be the focus of your brainstorm.

5 minutes

How might we [your problem statement]?

**Key rules of brainstorming**  
To run a smooth and productive session

- Stay in topic
- Deferring judgment
- Go for volume
- Encourage wild ideas
- Listen to others
- If possible, be visual

**2 Brainstorm**

We'll come up with ideas that come to mind that address your problem statement.

10 minutes

**Arvind J**

- Recognize text
- Identification of style
- Acquisition of input from user
- Create GUI to predict digits
- Identification of stroke classification
- Training of models

**Maheswaran G**

- Identification of digits
- color identification
- space detection
- Indentation
- Line spacing
- number of lines to be counted

**Mohan Kumar V S**

- Pixel detection
- Pixel size
- digit classification
- Time interval
- Symbol classification
- Classification of digit

**Vigneshwaran G**

- Grabbing characters into grid
- Image sensing
- Resampling
- Acquisition
- Pixel detection
- Learning modules

**Need some inspiration?**  
Search ideas across 200+ sessions in our idea bank.

Open resource

### 3.3 Proposed Solution

S. No	Parameter	Description
1.	Problem Statement (Problem to be solved)	To identify handwritten digits
2.	Idea / Solution description	Create a web application as which gets photo of the handwritten digits as input, recognize digits using IBM datasets and displays the recognized digits as output.
3.	Novelty / Uniqueness	Handwritten digits of various handwriting can be recognized.
4.	Social Impact / Customer Satisfaction	Elimination of recognition of digits in sectors such as banks and transports.
5.	Business Model (Revenue Model)	1)Google adds – Adds can be displayed in the web application. 2)Subscription- Subscriptions can be provided to access specific features.

### 3.4 Problem Solution fit

<b>1. CUSTOMER SEGMENT(S)</b> <span>CS</span>  The Customers who deal with handwritten digits like Banking sectors, schools, colleges railways , firms , etc.		<b>6. CUSTOMER CONSTRAINTS</b> <span>CC</span>  They believe that the alternatives will result in errors and faults and will be inconvenient.	<b>5. AVAILABLE SOLUTIONS</b> <span>AS</span>  There are no widely used software's to detect handwriting; instead, they check with other people to affirm what number it is.
<b>2. JOBS-TO-BE-DONE / PROBLEMS</b> <span>J&amp;P</span>  Handwritten digits can be difficult to understand and interpret at times. It may cause errors when dealing with rough handwriting.		<b>9. PROBLEM ROOT CAUSE</b> <span>RC</span>  We face numerous challenges in handwritten number recognition. because of different people's jotting styles and the lack of Optical character recognition This investigation offers an in-depth comparison of various machine literacy and deep literacy	<b>7. BEHAVIOUR</b> <span>BE</span>  Finding the best software for detecting accurate digits in a more efficient manner
<b>3. TRIGGERS</b> <span>TR</span> To obtain the numbers accurately and quickly.	<b>4. EMOTIONS: BEFORE / AFTER</b> <span>EM</span> Feels frustrated and sad when numbers are not entered.	<b>10. YOUR SOLUTION</b> <span>SL</span>  A solution to this problem is the Handwritten digit recognition system, which uses a picture of a digit and recognises the digit present in the image. Convolutional Neural Network model built with PyTorch and applied to the MNIST dataset to recognise handwritten digits.	<b>8. CHANNELS OF BEHAVIOR</b> <span>CH</span>  Using software that is available on the internet. Obtaining assistance from those nearby in order to recognise the digits written by their customers.

## 4. REQUIREMENT ANALYSIS

### 4.1 Functional requirement

**Following are the functional requirements of the proposed solution.**

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Real time bin monitoring.	Image Data: Handwritten digit recognition alludes to a PC's ability to recognize human transcribed digits from different sources, for example, photos, reports, contact screens, and so on, and classify them into ten laid out orders (0-9). In the realm of deep learning, this has been the subject of endless examinations.
FR-2	Eliminate inefficient picks.	Website: Web facilitating makes the code, illustrations, and different things that make up a site open on the web. A server has each site you've at any point visited. The kind of facilitating decides how much space is designated to a site on a server. Shared, devoted, VPS, and affiliate facilitating are the four fundamental assortments.
FR-3	Plan waste collection routes.	Digit Classifier Model: To prepare a convolutional network to foresee the digit from a picture, utilize the MNIST information base of manually written digits. get the preparation and approval information first.
FR-4	Adjust bin distribution.	Cloud: The cloud offers a scope of IT administrations, including virtual capacity, organizing, servers, information bases, and applications. In plain English, cloud computing is portrayed as a virtual stage that empowers limitless capacity and admittance to your information over the web.
FR-5	Expensive bins.	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.**

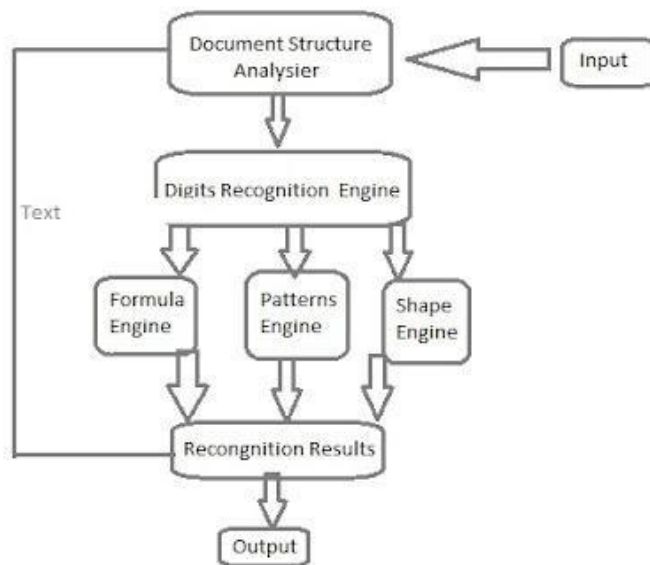
FR No.	Non-Functional Requirement	Description
NFR-1	<b>Usability</b>	One of the extremely critical issues in design acknowledgment applications is the acknowledgment of written by hand characters. Applications for digit acknowledgment incorporate finishing up structures, handling bank checks, and arranging mail.
NFR-2	<b>Security</b>	The framework creates an exhaustive portrayal of the launch boundaries.
NFR-3	<b>Reliability</b>	The web application is created to provide a smooth user experience and make clients satisfied with the digit recognition service.
NFR-4	<b>Performance</b>	The web application is created to provide a smooth user experience and make clients satisfied with the digit recognition service.
NFR-5	<b>Availability</b>	The web application will be available for everyone who owns a smart device with internet connection 24/7
NFR-6	<b>Scalability</b>	Scalability of the web application depends on the server size and datasets provided to the web application.

## 5.PROJECT DESIGN

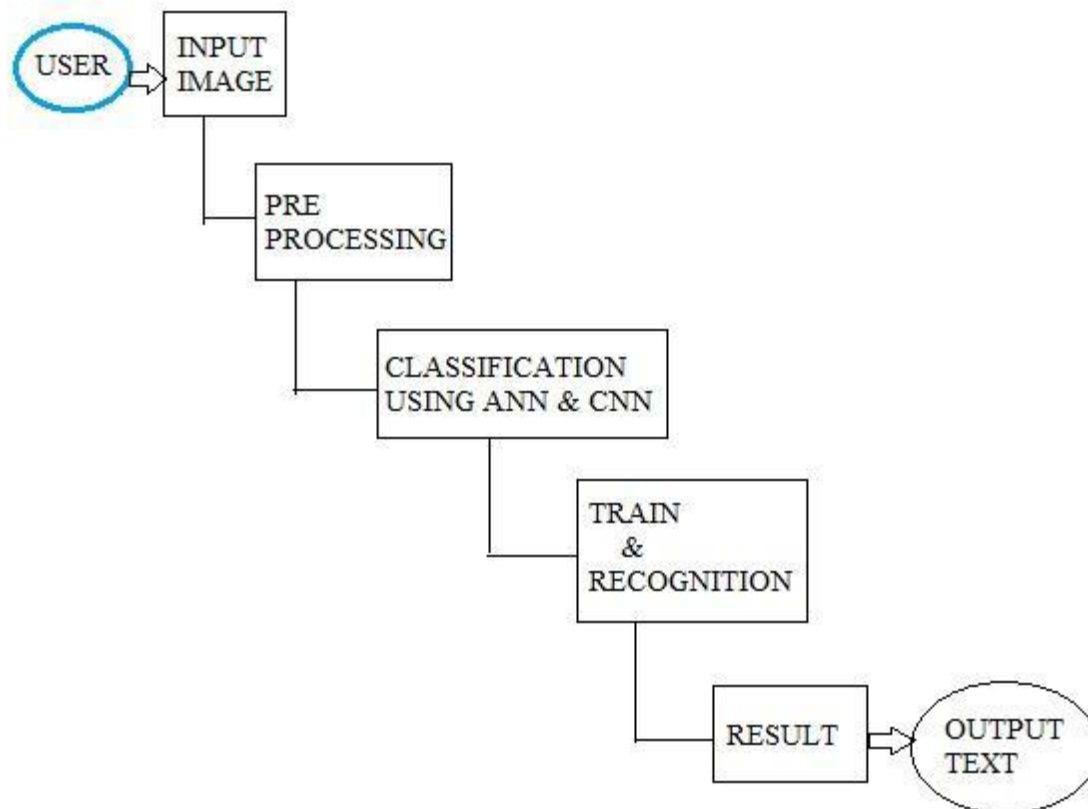
### 5.1Data Flow Diagrams

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.

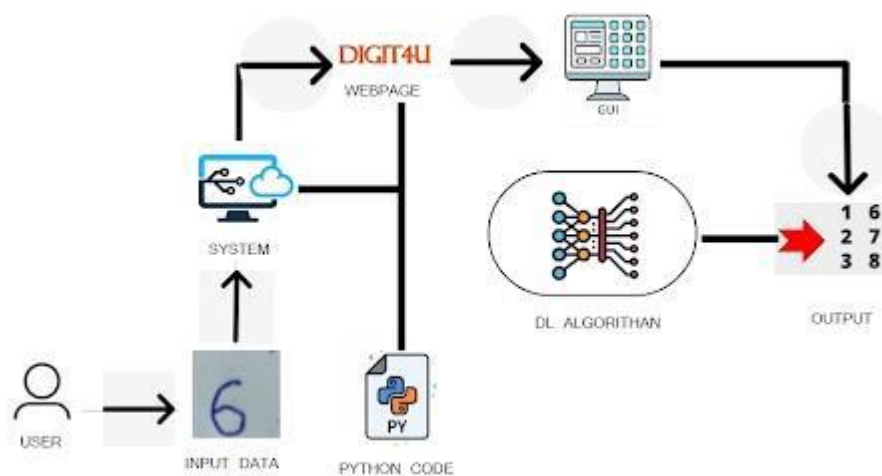
Level 0 (Industry Standard):

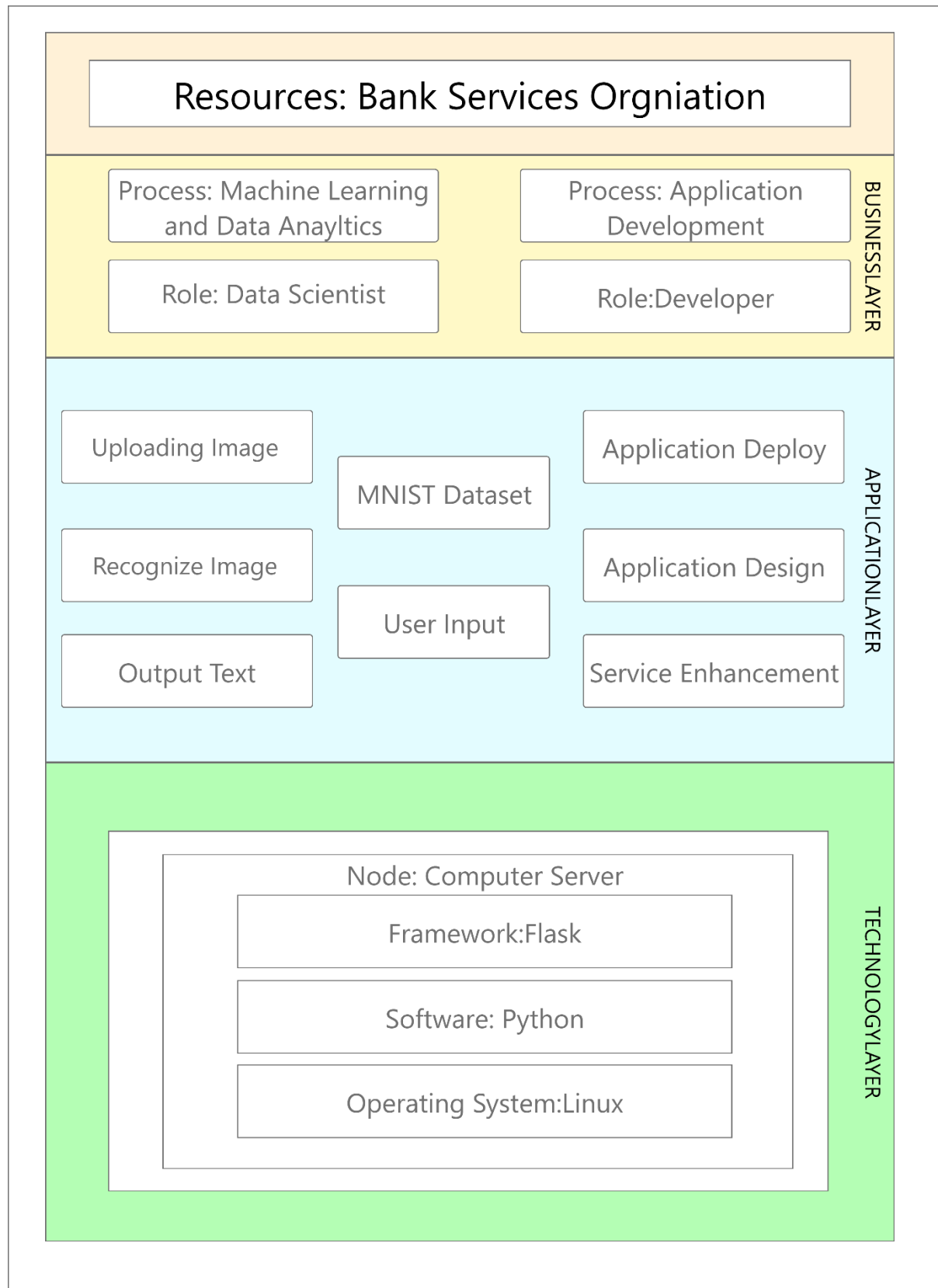


Simplified diagram:



## 5.2 Solution & Technical Architecture:





## 5.3 User Stories

User Type	Functional Requirements	User Story Number	User Story / Task	Acceptance Criteria	Priority	Release
Customer	Accessing the Application	USN-1	As a user, I should be able to access the application from anywhere and use on any devices	User can access the application using the browser on any device	High	Sprint-4
	Uploading Image	USN-2	As a user, I should be able to upload images to predict the digits	User can upload images	High	Sprint-3
	Viewing the Results	USN-3	As a user, I should be able to view the results	The result of the prediction is displayed	High	Sprint-3
	Viewing Other Prediction	USN-4	As a user, I should be able to see other close predictions	The accuracy of other values must be displayed	Medium	Sprint-4
	Usage Instruction	USN-5	As a user, I should have a usage instruction to know how to use the application	The usage instruction is displayed on the home page	Medium	Sprint-4

## 6. PROJECT PLANNING & SCHEDULING

### 6.1 Sprint Planning & Estimation

TITLE	DESCRIPTION	DATE
Literature Survey & Information Gathering	Literature survey on the selected project & gathering information by referring the, technical papers, research publications etc.	28 SEPTEMBER 2022
Prepare Empathy Map	Prepare Empathy Map Canvas to capture the user Pains & Gains, Prepare list of problem statements	24 SEPTEMBER 2022
Ideation	List the by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance.	25 SEPTEMBER 2022
Proposed Solution	Prepare the proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalability of solution, etc.	23 SEPTEMBER 2022
Problem Solution Fit	Prepare problem - solution fit document.	30 SEPTEMBER 2022
Solution Architecture	Prepare solution architecture document.	28 SEPTEMBER 2022

Customer Journey	Prepare the customer journey maps to understand the user interactions & experiences with the application (entry to exit).	05 OCTOBER 2022
Functional Requirement	Prepare the functional requirement document.	11 OCTOBER 2022
Data Flow Diagrams	Draw the data flow diagrams and submit for review.	12 OCTOBER 2022
Technology Architecture	Prepare the technology architecture diagram.	13 OCTOBER 2022
Prepare Milestone & Activity List	Prepare the milestones & activity list of the project.	21 OCTOBER 2022
Project Development - Delivery of Sprint-1, 2, 3 & 4	Develop & submit the developed code by testing it.	IN PROGRESS

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Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Dashboard	USN-1	As a client, they can see the data in regards to the expectation of handwritten digitrecognition.	2	High	Arvind.J Maheswaran.G Mohankumar.V.S Vigneshwaran.M
Sprint-1	Launch	USN-2	On tapping the launch button, it will divert the client to a page where the pictures to be anticipated can be transferred.	2	High	Arvind.J Maheswaran.G Mohankumar.V.S Vigneshwaran.M
Sprint-2	Upload	USN-3	Clients can choose the picture from the nearby capacity.	2	High	Arvind.J Maheswaran.G
Sprint-3	Predict	USN-4	When the picture is transferred, it will anticipate the particular picture.	2	High	Mohankumar.V.S Vigneshwaran.M
Sprint-4	Display	USN-5	The anticipated picture will be shown with the precision graph.	2	High	Arvind.J Maheswaran.G Mohankumar.V.S Vigneshwaran.M

## 6.2. Sprint Delivery Schedule

### Project Tracker, Velocity & Burndown Chart: (4 Marks)

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	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

### Velocity:

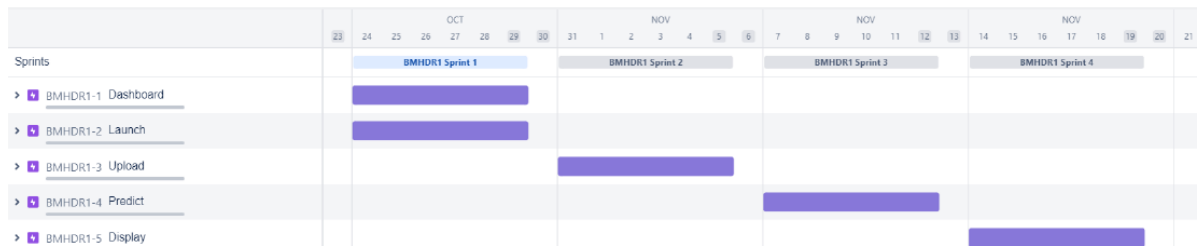
Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) per iteration unit (story points per day)

$$AV = \frac{\text{Sprint Duration}}{\text{Velocity}} = \frac{20}{6} = 3.33$$

## 6.3 Reports from JIRA

### Burndown Chart:

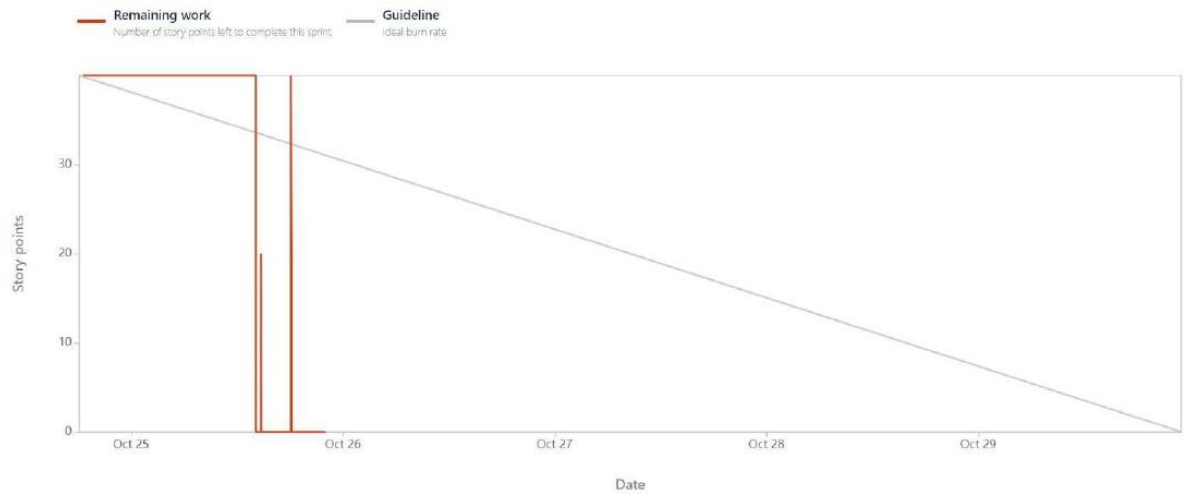
A burndown chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies such as Scrum. However, burn down charts can be applied to any project containing measurable progress over time.



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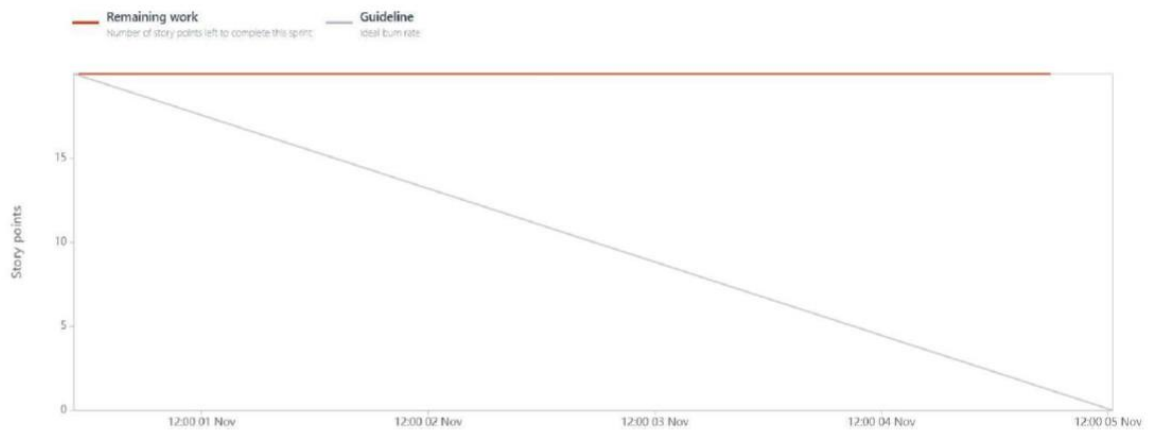
### Sprint 1:

Date - October 24th, 2022 - October 29th, 2022



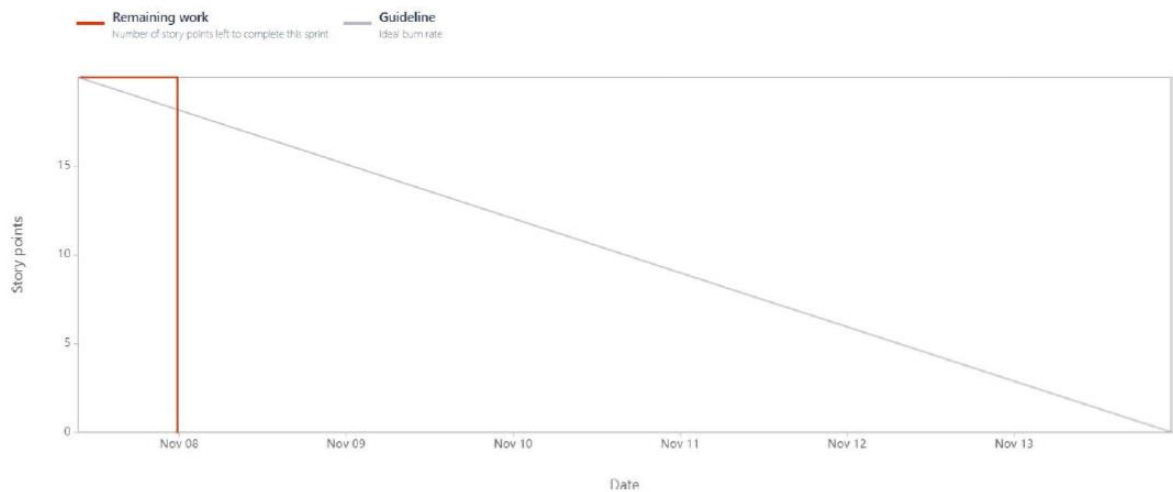
### Sprint 2:

Date - October 31st, 2022 - November 5th, 2022



### Sprint 3:

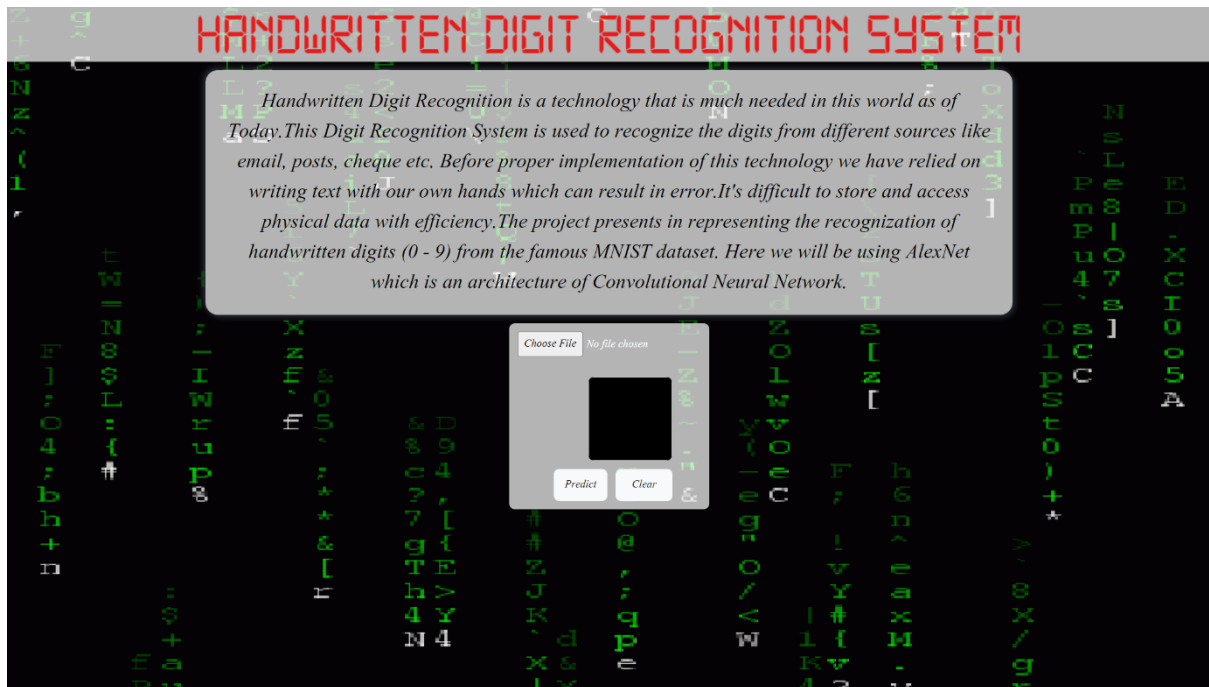
Date - November 7th, 2022 - November 13th, 2022



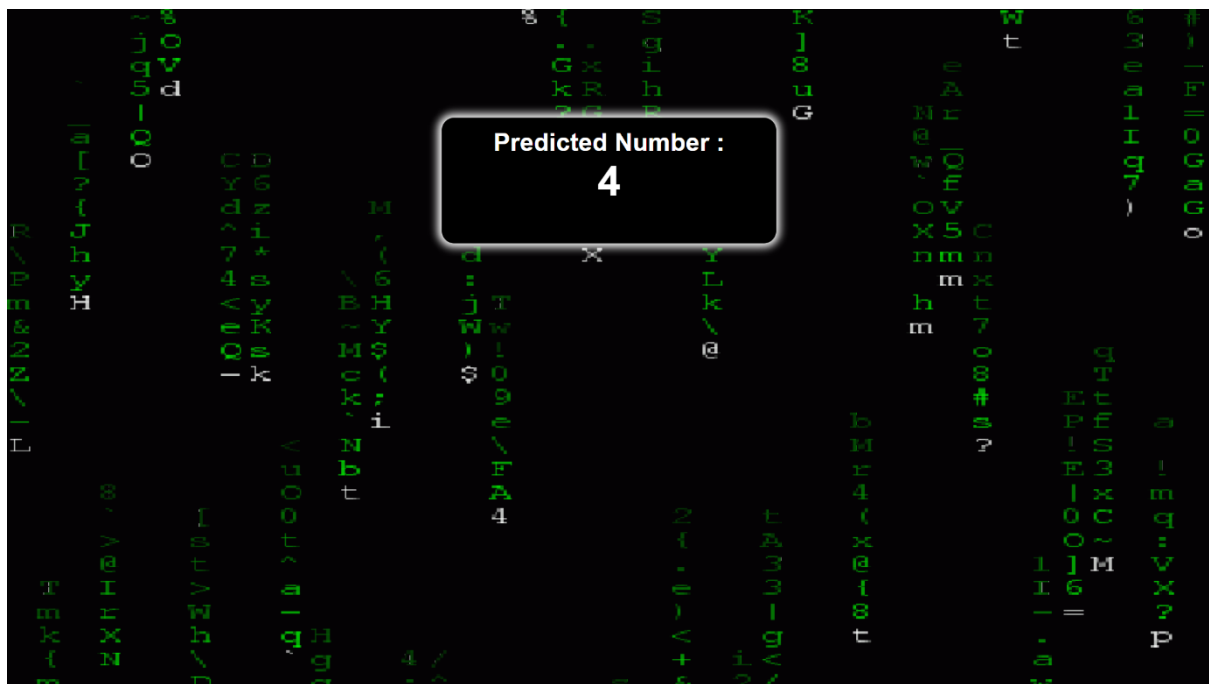


## 7.CODING & SOLUTIONING (Explain the features added in the project along with code)

### 7.1Feature 1- Input data upload

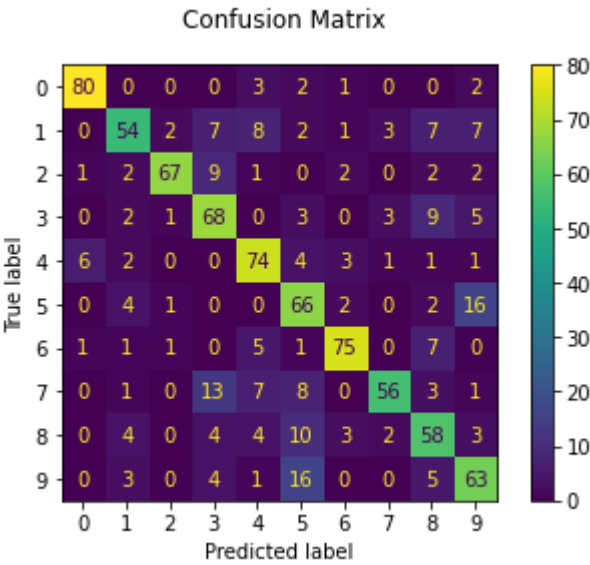
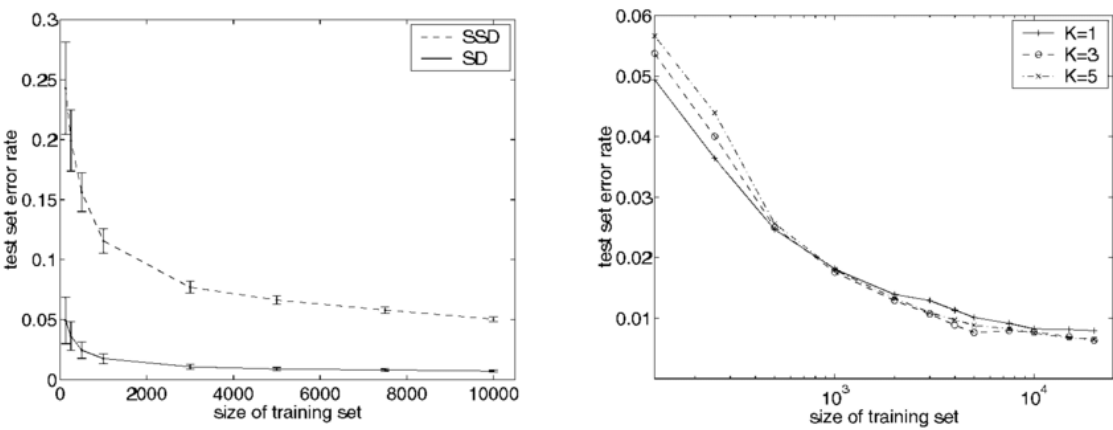


## 7.2 Feature 2- Output



8.RESULTS

8.1 Performance Metrics



## **9. ADVANTAGES & DISADVANTAGES**

### **ADVANTAGES:**

- 1) The system not only produces a classification of the digit but also a rich description of the instantiation parameters which can yield information such as the writing style.
- 2) The generative models can perform recognition driven segmentation.

### **DISADVANTAGES:**

- 1) It requires much more computation than more standard OCR techniques.
- 2) It is not appropriate for immediate text input.

## **10. CONCLUSION**

Machine learning is an approach to get the real life data into the action over human analysis. This project has an aim to achieve that much goal because all machine learning algorithms intends to go to the better way than a human. This project is a very much preliminary project based on those. This world entitles the work of Google everyday who himself hasn't achieved that much data also. This project entitles some different new ideas on

- 1) Image Processing
- 2) Machine learning
- 3) Activation Functions
- 4) Statistical predictive modelling
- 5) Optimiser into the programming
- 6) Text analysis
- 7) Digit extraction Features.

## **11.FUTURE SCOPE**

This project can be enhanced with a great field of machine learning and artificial intelligence. The world can think of a software which can recognise the text from a picture and can show it to the others, for example a the shop name detector. Or this project can be extended to a greater concept of all the character sets in the world. This project has not gone for the total English alphabet because there will be more and many more training sets and testing values that the neural network model will not be enough to detect. Think of an AI modelled car sensor going with a direction modelling in the roadside, user shall give only the destination. All of these enhancements is an application of the texture analysis where advanced image processing, Neural network model for training and advanced AI concepts will come. These applications can be modelled further. As this project is fully done by free and available resources and packages this can be also a limitation of the project.

## 12) APPENDIX

### Source Code

```
# Project : A Novel Method for Handwritten Digit Recognition System
# Team ID : PNT2022TMID48440
```

APP.py

```
import numpy as np
import os
from PIL import Image
from flask import Flask, request, render_template, url_for
from werkzeug.utils import secure_filename, redirect
# from gevent.pywsgi import WSGIServer
from keras.models import load_model
from keras.preprocessing import image
from flask import send_from_directory

UPLOAD_FOLDER = 'D:/ibm/data'

app = Flask(__name__)
app.config['UPLOAD_FOLDER'] = UPLOAD_FOLDER

model = load_model("./models/mnistCNN.h5")

@app.route('/')
def index():
    return render_template('index.html')

@app.route('/predict', methods=['GET', 'POST'])
def upload():
    if request.method == "POST":
        f = request.files["image"]
        filepath = secure_filename(f.filename)
        f.save(os.path.join(app.config['UPLOAD_FOLDER'], filepath))

        upload_img = os.path.join(UPLOAD_FOLDER, filepath)
        img = Image.open(upload_img).convert("L") # convert image to monochrome
        img = img.resize((28, 28)) # resizing of input image

        im2arr = np.array(img) # converting to image
        im2arr = im2arr.reshape(1, 28, 28, 1) # reshaping according to our requirement

        pred = model.predict(im2arr)

        num = np.argmax(pred, axis=1) # printing our Labels

        return render_template('predict.html', num=str(num[0]))

if __name__ == '__main__':
    app.run(debug=True, threaded=False)
```

```

<html>

<head>
  <title>HandWritten Digit Recognition</title>

  <meta name="viewport" content="width=device-width">
  <script src="https://cdnjs.cloudflare.com/ajax/libs/bootstrap/5.2.2/js/bootstrap.min.js"
  integrity="sha512-
  5BqtYqLWfJemW5+v+TZUs22uigI8tXeVah5S/1Z6qBLV07gakA0tk0zUtgq6dsIo5c0NJdmGPs0H9I+20HUHVQ=="
  crossorigin="anonymous" referrerpolicy="no-referrer"></script>
  <link rel="stylesheet"
  href="https://cdnjs.cloudflare.com/ajax/libs/bootstrap/5.2.2/css/bootstrap.min.css" integrity="sha512-
  CpIKUSyh90X2+zSdfGP+eWLx23C8Dj9/XmHjZY2uDtfkdLGo0uY12jgcnkX9vX0gYajEKb/jlw67EYm+kBf+6g=="
  crossorigin="anonymous" referrerpolicy="no-referrer" />
  <link rel="stylesheet" type= "text/css" href= "{{ url_for('static',filename='css/style.css') }}">

</head>
<body>
  <nav>
    
  </nav>
  <div class="caption_box">
    <h4>Handwritten Digit Recognition is a technology that is much needed in this world as of
    Today.This Digit Recognition System is used to recognize the digits from different sources
    like email, posts, cheque etc. Before proper implementation of this technology we have
    relied on writing text with our own hands which can result in error.It's difficult to store
    and access physical data with efficiency.The project presents in representing the
    recognition of handwritten digits (0 - 9) from the famous MNIST dataset. Here we will be
    using AlexNet which is an architecture of Convolutional Neural Network.
  </h4>
</div>
  <section id="content">
    <div class="leftside">
      <form action="/predict" method="POST" enctype="multipart/form-data" >
        <div class="d1"><input id="image" type="file" name="image" accept="image/png, image/jpeg"
        onchange="preview()">
        </div>
        <div class="d2"><img id="frame" width="100px" height="100px"/></div>
        <div class="buttons_div d3">
          <button type="submit" class="btn btn-light">Predict</button>
          <button type="button" class="btn btn-light">&nbsp;Clear &nbsp;</button>
        </div>
      </form>
    </div>
  </section>
</body>
</html>

```

GitHub Link:

<https://github.com/IBM-EPBL/IBM-Project-16903-1659624728>

Video Demo Link:

<https://drive.google.com/drive/folders/1k2f1wy1MAtLDXK79vXrY9Inj9FON51BO?usp=sharing>

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