

PROJECT REPORT

A NOVEL METHOD FOR HANDWRITTEN DIGIT RECONITION SYSTEM

SUBMITTED BY

TEAM ID: PNT2022TMID10802

TEAM LEAD: Gnanadesigan V

TEAM MEMBER1: Sanjay K

TEAM MEMBER2: Vimalraj S

TEAM MEMBER3: Praveen Raj B

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Project Overview

1.2 Purpose

2. LITERATURE SURVEY

2.1 Existing problem

2.2 References

2.3 Problem Statement Definition

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas

3.2 Ideation & Brainstorming

3.3 Proposed Solution

3.4 Problem Solution fit

4. REQUIREMENT ANALYSIS

4.1 Functional requirement

4.2 Non-Functional requirements

5. PROJECT DESIGN

5.1 Data Flow Diagrams

5.2 Solution & Technical Architecture

5.3 User Stories

6. PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

6.2 Sprint Delivery Schedule

6.3 Reports from JIRA

7. CODING & SOLUTIONING

8. TESTING

8.1 Test Cases

8.2 User Acceptance Testing

9. RESULTS

9.1 Performance Metrics

10.ADVANTAGES & DISADVANTAGES

11.CONCLUSION

12.FUTURE SCOPE

13.APPENDIX

Source Code

GitHub & Project Demo Link

CHAPTER 1

INTRODUCTION

1.1 PROJECT OVERVIEW

Artificial intelligence and computer technology both heavily rely on machine learning and deep learning. Human effort in identifying, learning, making predictions, and many other areas can be decreased with the application of deep learning and machine learning.

The ability of computer systems to recognize handwritten digits from various sources, such as photographs, papers, and so on, is known as handwritten digit recognition. The goal of this project is to enable users to utilize machine learning to eliminate manual digit recognition jobs.

1.2 PURPOSE

Digit recognition systems are able to identify numbers from a variety of sources, including emails, bank checks, papers, images, etc. They can also be used in a variety of real-world situations, such as online handwriting recognition on computer tablets or systems, identifying vehicle license plates, processing bank cheque amounts, and reading numbers from forms that have been filled out by hand (such as tax forms).

CHAPTER 2

LITERATURE SURVEY

2.1 EXISTING PROBLEM

The main issue with handwritten digit recognition is that because handwriting varies from person to person, handwritten digits do not always have the same size, width, orientation, and margins. In addition, it would be difficult to distinguish the numbers due to similarities between the numerals, such as 1 and 7, 5 and 6, 3 and 8, 2 and 5, and 2 and 7. Finally, the distinctiveness and variety of each person's handwriting have an impact on the digits' shape and appearance.

2.2 REFERENCES

Title: Handwritten English Character and Digit Recognition (2021)

Author: Al-Mahmud; Asnuva Tanvin; Sazia Rahman

one of the most sought-after technologies is a handwritten character recognition system. It has the potential to solve a wide range of issues and bring about radical change in our lives. We used Convolutional Neural Networks (CNNs) to recognize handwritten English capital letters and digits in this research. We improved a previously developed CNN architecture by adjusting hyperparameters and minimizing the model's overfitting. The MNIST digit dataset is used to evaluate the experiments, which are then compared to different methods. On the MNIST dataset, 99.47 percent test accuracy was attained, which is superior to other approaches. The research was then expanded upon by the addition of a new dataset for recognizing English capital letters. 98.94 percent accuracy was achieved on this extended dataset.

Title: Image Classification using Deep Learning: An Experimental Study on Handwritten Digit Recognition

Author: Mukesh Kumar Rohil; Raju Singh

This paper presents an experimental study of the use of Deep Learning using Convolution Neural Networks (CNNs) for Image Classification. Specially, the problem being addressed here is of recognition of handwritten digits. The objective is to report variations in testing errors and accuracies with varying kernel size and varying number of feature maps. We performed handwritten digit classification using neural network and deep learning for a subset from the MNIST dataset, which contains 60,000 training images and 10,000 test images in all. It is observed that the accuracy and loss are stabilizing with minor change in the kernel size and the number of feature maps.

Title: Real Time Handwritten Digits Recognition Using Convolutional Neural Network.

Author: Kaveti Upender; Venkata Siva Kumar Pasupuleti.

Reading handwritten information like examination answer sheets is still a difficult task for many of us, because each one of us is having a different interpretation style. As the world is moving towards digitization, converting the handwritten information to a readable digital format reduces the difficulty. This approach will be beneficial for the readers as it gives a better understanding of the information. With the help of machine learning and deep learning algorithms, the handwritten patterns can be recognized and classify them accordingly to a digital format with human level accuracy. This research paper deals with predicting the real time handwritten digits only. To classify the handwritten digits MNIST data set is used for training the model. OpenCV python

library is used for detecting the patterns in the real time handwritten digits. These detected patterns are predicted to human level accuracy with the help of a Convolutional Neural Network model.

Title: An Efficient and Improved Scheme for Handwritten Digit Recognition Based on Convolutional Neural Network (2019)

Author: Ali, Saqib and Shaukat, Zeeshan and Azeem, Muhammad and Sakhawat, Zareen and Mahmood, Tariq and others

This study uses rectified linear units (ReLU) activation and a convolutional neural network (CNN) that incorporates the Deeplearning4j (DL4J) architecture to recognize handwritten digits. The proposed CNN framework has all the necessary parameters for a high level of MNIST digit classification accuracy. The system's training takes into account the time factor as well. The system is also tested by altering the number of CNN layers for additional accuracy verification. It is important to note that the CNN architecture consists of two convolutional layers, the first with 32 filters and a 5x5 window size and the second with 64 filters and a 7x7 window size. In comparison to earlier proposed systems, the experimental findings show that the proposed CNN architecture for the MNIST dataset demonstrates great performance in terms of time and accuracy. As a result, handwritten numbers are detected with a recognition rate of 99.89% and high precision (99.21%) in a short amount of time.

Title: Improved Handwritten Digit Recognition Using Quantum K-Nearest Neighbor Algorithm (2019)

Author: Wang, Yuxiang and Wang, Ruijin and Li, Dongfen and Adu-Gyamfi, Daniel and Tian, Kaibin and Zhu, Yixin

The KNN classical machine learning technique is used in this research to enable quantum parallel computing and superposition. They used the KNN algorithm with quantum acceleration to enhance handwritten digit recognition. When dealing with more complicated and sizable handwritten digital data sets, their suggested method considerably lowered the computational time complexity of the traditional KNN algorithm. The paper offered a theoretical investigation of how quantum concepts can be applied to machine learning. Finally, they established a fundamental operational concept and procedure for machine learning with quantum acceleration.

Title: Handwritten Digit Recognition Using Machine and Deep Learning Algorithms (2021)

Author: Pashine, Samay and Dixit, Ritik and Kushwah, Rishika

In this study, they developed three deep and machine learning-based models for handwritten digit recognition using MNIST datasets. To determine which model was the most accurate, they compared them based on their individual properties. Support vector machines are among the simplest classifiers, making them faster than other algorithms and providing the highest training accuracy rate in this situation. However, due to their simplicity, SVMs cannot categorize complicated and ambiguous images as accurately as MLP and CNN algorithms can. In their research, they discovered that CNN produced the most precise outcomes for handwritten digit recognition. This led them to the conclusion that CNN is the most effective solution for all types of prediction issues, including those using picture data. Next, by comparing the execution times of the algorithms, they determined that increasing the number of epochs without changing the configuration of the algorithm is pointless due to the limitation of a certain model, and they

discovered that beyond a certain number of epochs, the model begins overfitting the dataset and provides bias

2.3 PROBLEM STATEMENT DEFINITION

The traffic department has been pursuing violators of traffic laws for years. These criminals put not only their own life at peril but also those of others. It is essential to punish these offenders in order to prevent others from following in their footsteps.

The inability of the average person to jot down a careless driver's license plate makes it nearly impossible to identify these offenders. The project's objective is to assist the traffic department in locating these offenders in order to decrease traffic violations as a result.

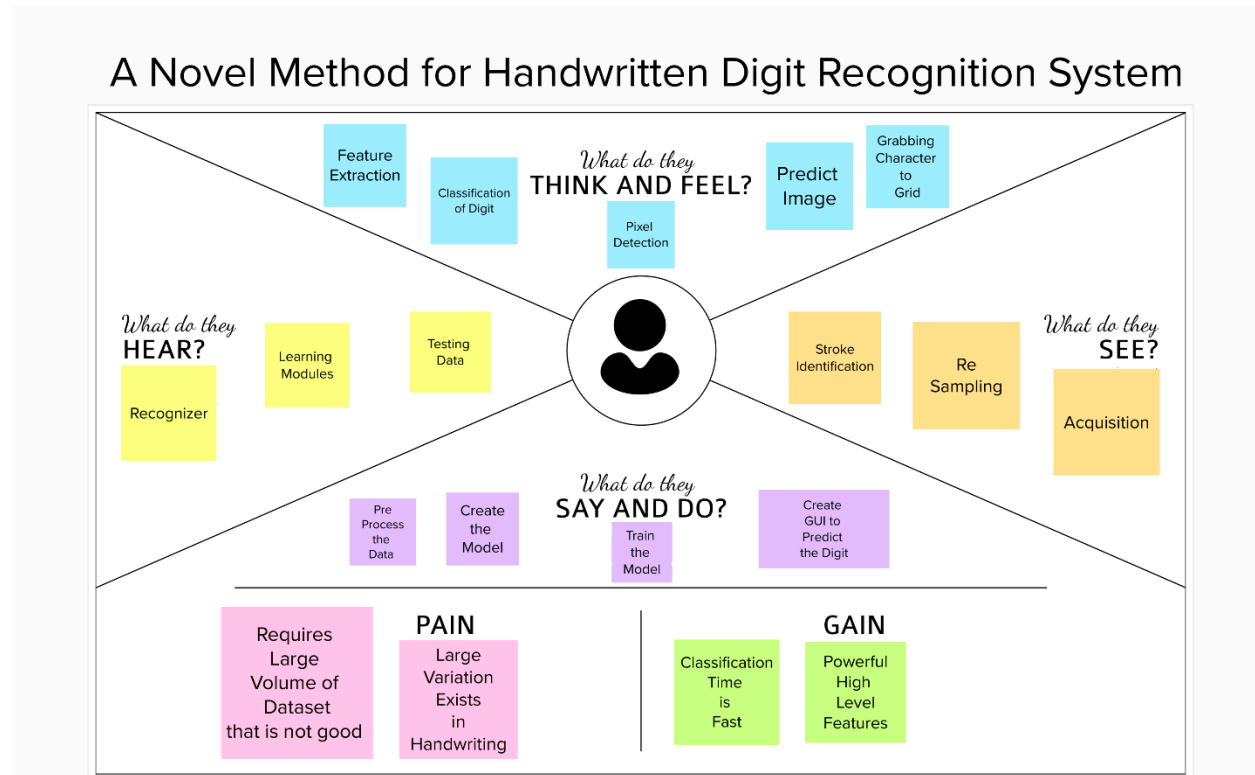
I am	Describe customer with 3-4 key characteristics - <i>who are they?</i>	Describe the customer and their attributes here
I'm trying to	List their outcome or "job" the care about - <i>what are they trying to achieve?</i>	List the thing they are trying to achieve here
but	Describe what problems or barriers stand in the way - <i>what bothers them most?</i>	Describe the problems or barriers that get in the way here
because	Enter the "root cause" of why the problem or barrier exists - <i>what needs to be solved?</i>	Describe the reason the problems or barriers exist
which makes me feel	Describe the emotions from the customer's point of view - <i>how does it impact them emotionally?</i>	Describe the emotions the result from experiencing the problems or barriers

Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	A girl	Recognize the last date for paying the exam fees which is written on the board	I can't find the correct date	The shape of the digits is little bit different	Sad that I can't recognize the date
PS-2	A client	Recognize the digits written on document	I can't recognize it	The digits are not written properly	confused

CHAPTER 3

IDEATION AND PROPOSED SOLUTION

3.1 EMPATHY MAP CANVAS



3.2 IDEATION & BRAINSTORMING

Template



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
2-6 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

Define 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

Use the Facilitation Superpowers to run 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

PROBLEM

To identify the letters of the sentence written by the user in their devices and to convert the handwritten text into digital format.

Key rules of brainstorming

To run a smooth and productive session

Stay in topic.

Encourage wild ideas.

Defer judgment.

Listen to others.

Go for volume.

If possible, be visual.

Recognition-driven segmentation is a capability of the generative models. Training for the procedure is relatively simple and quick because there are just a few parameters involved



Need some inspiration?

View a featured version of this template to kickstart your work.

[Open examples](#)

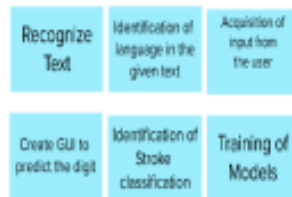
2

Brainstorm

Write down any ideas that come to mind that address your problem statement.

🕒 10 minutes

GNANADESIGAN V



VIMALRAJ S



SANJAY K



PRAVEEN RAJ B



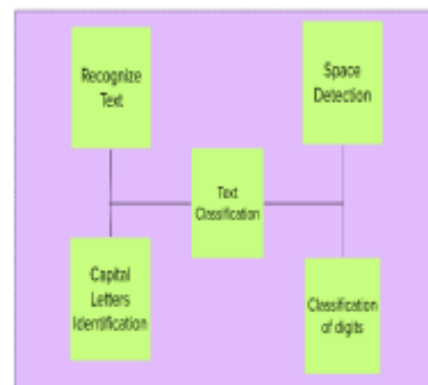
1

Group ideas

Take turns sharing your ideas while clustering similar or related notes as you go. Once all sticky notes have been grouped, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you can break it up into smaller sub-groups.

🕒 30 minutes

IDENTIFICATION



MODULES



4

Prioritize

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

🕒 20 minutes



After you collaborate

You can export the mural as an image or pdf to share with members of your company who might find it helpful.

Quick add-ons

- Share the mural**
Share a view link to the mural with stakeholders to keep them in the loop about the outcomes of the session.
- Export the mural**
Export a copy of the mural as a PNG or PDF to attach to emails, include in slides, or save in your drive.

Keep moving forward

- Strategy blueprint**
Define the components of a new idea or strategy.
[Open the template →](#)
- Customer experience journey map**
Understand customer needs, motivations, and obstacles for an experience.
[Open the template →](#)
- Strengths, weaknesses, opportunities & threats**
Identify strengths, weaknesses, opportunities, and threats (SWOT) to develop a plan.
[Open the template →](#)

[Share template feedback](#)

3.3 PROPOSED SOLUTION

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Computer programmes' ability to detect human-written numbers is known as handwritten digit recognition. Because handwritten figures are not always accurate and can take many various forms and sizes, it is a difficult work for the machine.
2.	Idea / Solution description	Using data from various sources, including images, documents, and touch defences, a computer is able to celebrate the mortal handwritten numbers. It permits users to convert all of their handwritten notes and signatures into text documents in electronic form, using much less physical space than would be needed to store the physical copies of those documents.
3.	Novelty / Uniqueness	Recognize the digits precisely rather than all the characters like OCR.
4.	Social Impact / Customer Satisfaction	The Handwritten Digit Recognizer software was made using artificial intelligence. It approximates the printed word digitally by identifying letters using sophisticated algorithms before producing a digital approximation.
5.	Business Model (Revenue Model)	For efficient traffic control, this technology can be connected with traffic surveillance cameras to read licence plates. Pin-code details can be easily identified and recognised by integrating with the postal system.
6.	Scalability of the Solution	The capacity to recognise numbers in more distracting circumstances. The maximum number of digits that can be recognised is unlimited.

3.4 PROBLEM SOLUTION FIT

Define CS, fit into CC	1. CUSTOMER SEGMENT(S) CS <ul style="list-style-type: none"> Clients are those who use handwritten numbers at work or in institutions like banks, colleges, trains, etc. 	6. CUSTOMER CONSTRAINTS CC <ul style="list-style-type: none"> Internet connections that are unreliable, the lack of laptops and mobile devices, and the inaccessibility of cameras that are suitable. Computers have a difficult time processing handwritten numbers since they are frequently inaccurate and can have a wide range of preferences. Through the use of handwritten digit recognition, this problem can be resolved by identifying the digit that is present in a picture of a digit. 	5. AVAILABLE SOLUTIONS AS <ul style="list-style-type: none"> Despite the fact that there are currently alternatives to this strategy, they are not very accurate, reliable, or rotation- and variation-invariant. A computer's capacity to respect the imperfect handwriting found in a variety of contexts, such as in documents, pictures, and touch input. 	Explore AS, differentiate
------------------------	---	---	---	---------------------------

Focus on J&P, tap into BE, understand RC	2. JOBS-TO-BE-DONE / PROBLEMS J&P <ul style="list-style-type: none"> Understanding and analyzing the scribbled numbers is really difficult. More training data are needed. Dim illumination, poor eyesight, difficult to distinguish the digits. 	9. PROBLEM ROOT CAUSE RC <ul style="list-style-type: none"> Due to several issues including deteriorating eyesight, a lack of time, etc., handwritten digits are more challenging to read because they are written in a variety of fonts and size. (Example) customers have to do it because of the change in regulations. 	7. BEHAVIOUR BE <ul style="list-style-type: none"> Finding the software that recognizes numbers most fast and accurately. The client requests dependable internet and top-notch cameras. 	Focus on J&P, tap into BE, understand RC
--	---	---	---	--

Identify strong TR & EM	3. TRIGGERS TR <ul style="list-style-type: none"> One of the easiest methods to communicate with a computer and learn the language is through information exchange, which is made simple. Accurately and efficiently gathering the data. 	10. YOUR SOLUTION SL <ul style="list-style-type: none"> The Convolutional Neural Network (CNN) method is used in the solution to accurately recognize handwritten digits, enhancing worker productivity and decreasing costs for the business. 	8. CHANNELS of BEHAVIOUR CH <p>OFFLINE Invest in modern electronics and make sure they work.</p> <p>ONLINE A reliable internet connection is needed for both photo processing and uploading.</p>	Identify strong TR & EM
	4. EMOTIONS: BEFORE / AFTER EM Before: Unsure, Protected, and Confused. AFTER: Confident, upright, and reasonable			

CHAPTER 4

REQUIREMENT ANALYSIS

4.1 FUNCTIONAL REQUIREMENTS

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	GUI	Allows the user to insert the handwritten image and get the digitized form of the digits. Created for easy virtualization.
FR-2	Uploading image	User can upload the handwritten image
FR-3	Writing in Canvas	User can directly draw/write in the canvas
FR-4	Evaluation	<ul style="list-style-type: none">• The MNIST dataset should be trained using CNN to create a trained the model• The trained model has to be tested by using a test data• Predict the output for the input data and display it in a GUI

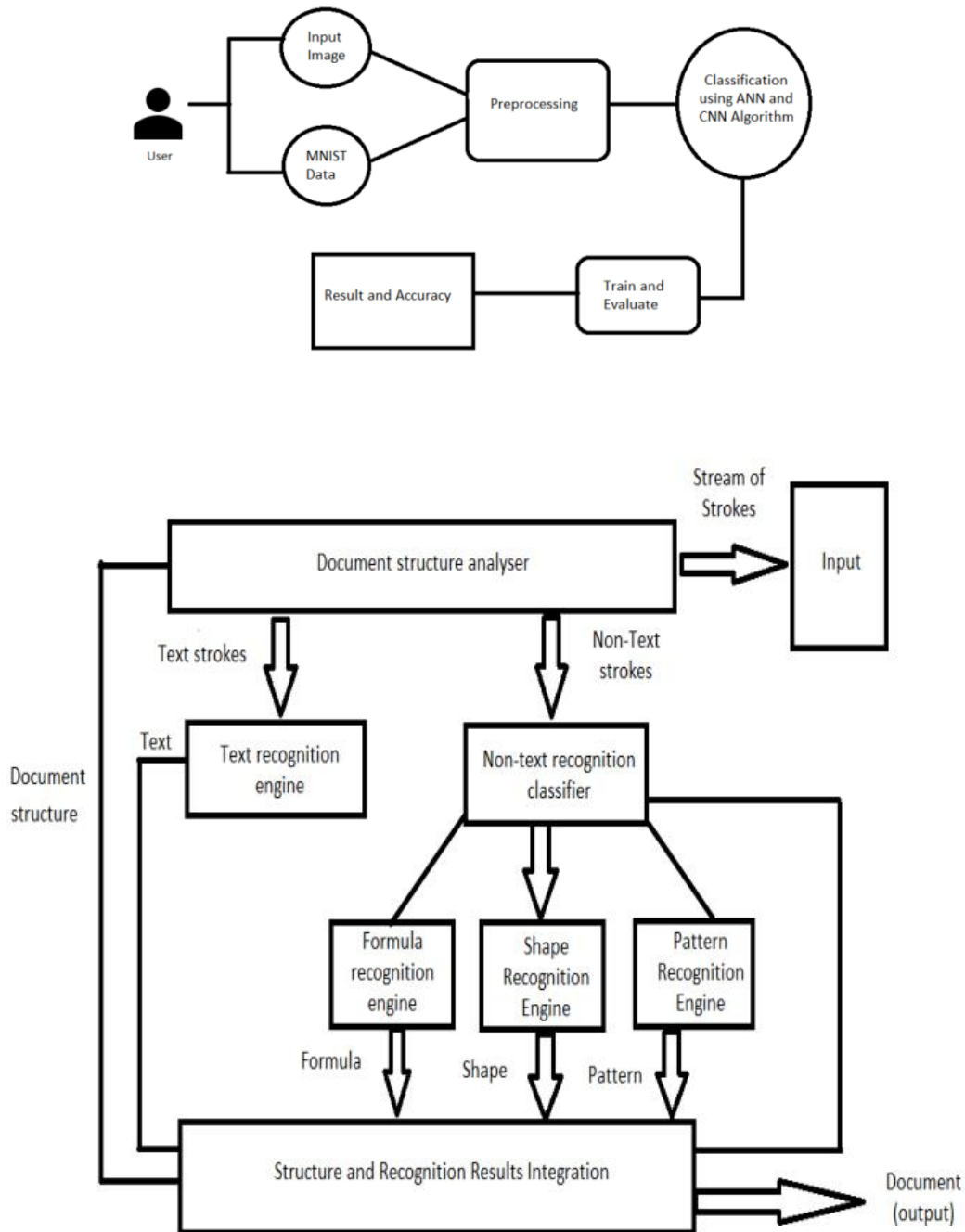
4.2 NON-FUNCTIONAL REQUIREMENTS

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	The recognition of handwritten characters is one of the major issues with pattern recognition applications. Filling out forms, processing bank checks, and sorting mail are examples of applications using digit recognition.
NFR-2	Security	<ul style="list-style-type: none">• The segmentation capabilities of the generative models are powered by recognition.• The method makes use of a relatively.
NFR-3	Reliability	<ul style="list-style-type: none">• The neural network uses the data to automatically determine rules for reading handwritten numerals. By increasing the number of training instances, the network may also learn more about handwriting and hence improve its accuracy.• To recognize handwritten numbers, a wide range of approaches and algorithms can be employed, including Deep Learning/CNN, SVM, Gaussian
NFR-4	Performance	Optical character recognition (OCR) technology gives more accuracy rates for typed text in high-quality pictures.
NFR-5	Availability	Available for the user who wants to convert handwritten image to digital format
NFR-6	Scalability	The task of handwritten digit recognition using a classifier is of great importance and use in a variety of applications, including online handwriting recognition on computer tablets, the processing of bank check amounts, numeric entries in forms filled out by hand and more.

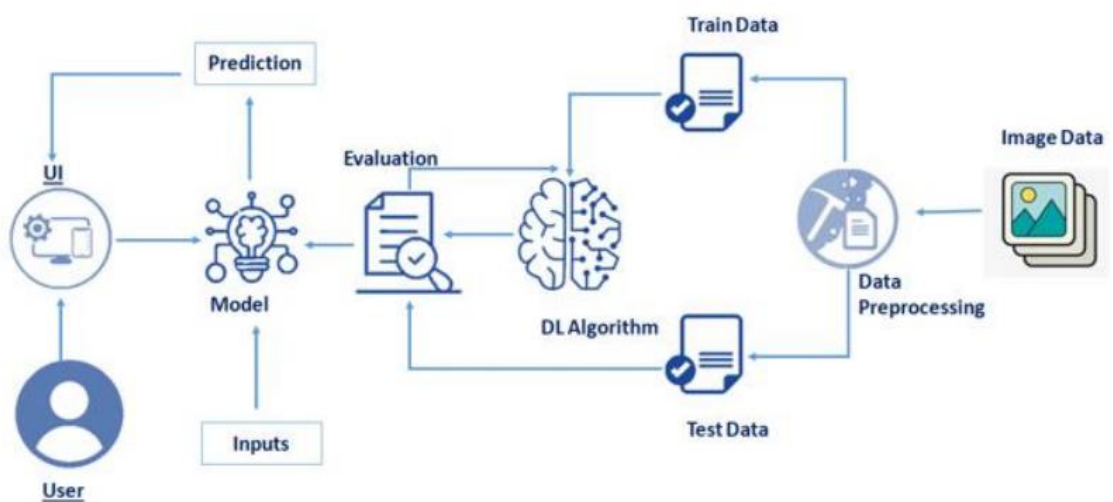
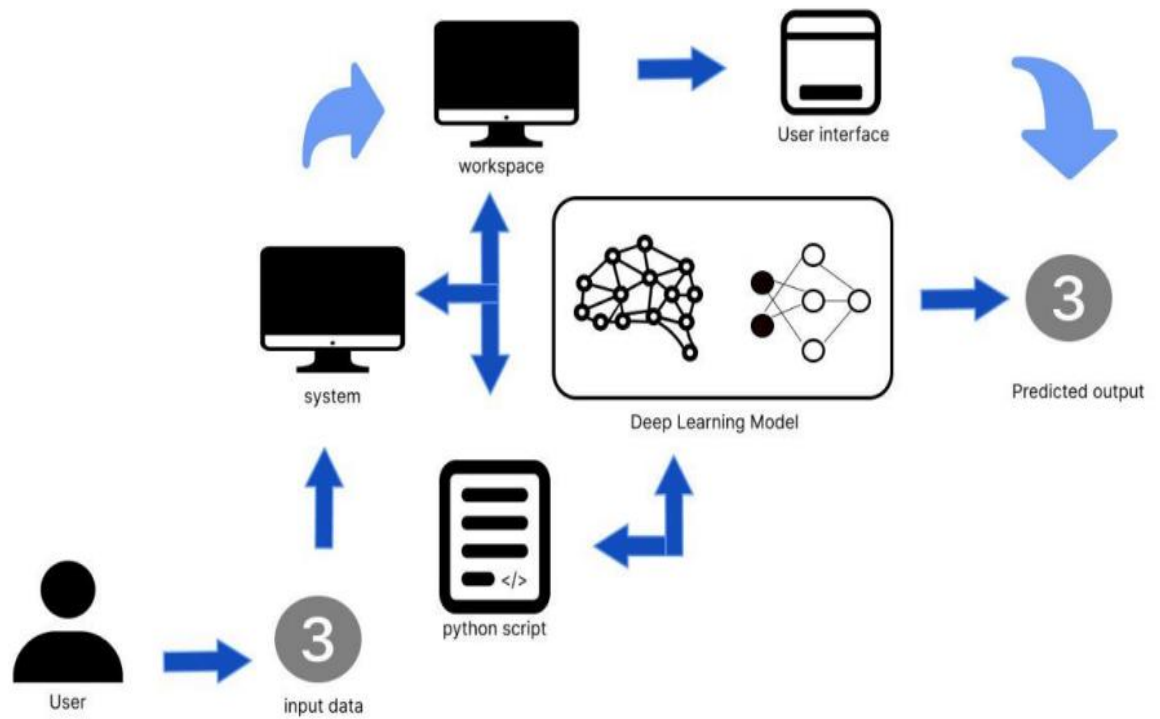
CHAPTER 5

PROJECT DESIGN

5.1 DATA FLOW DIAGRAM



5.2 SOLUTION & TECHNICAL ARCHITECTURE



5.3 USER STORIES

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Home	USN-1	I can view the user manual and am aware of how to use this application.	I can see the limitations of this software and the awareness of how to use it.	Low	Sprint-1
		USN-2	I'm authorized to watch the instructional film to learn how to utilize this application's interface as a user.	I can learn how to use this application through a hands-on approach.	Low	Sprint-1
		USN-3	I am able to understand the directions for using this application as a user.	I am able to read the directions and utilize it according to them.	Low	Sprint-2
	Recognize	USN-4	I get to select the image on this prediction page as a user.	I am able to select an image from our local system and forecast the results.	High	Sprint-2
	Predict	USN-6	I am permitted to upload and pick the image that will be submitted as a user.	From the system storage as well as any virtual storage, I may upload and select an image.	Medium	Sprint-3
		USN-7	I will train and evaluate the input as a user to ensure the output	I am able to test and train the application till the results	High	Sprint-4

			is as accurate as possible.	are as accurate as possible.		
		USN-8	I have access to the MNIST data collection as a user.	To produce the precise output, I may access the MNIST data set.	Medium	Sprint-3
Customer (Web user)	Home	USN-9	I may see the web app's user manual as a user.	I can see that you are aware of this application's restrictions.	Low	Sprint-1

CHAPTER 6

PROJECT PLANNING AND SCHEDULING

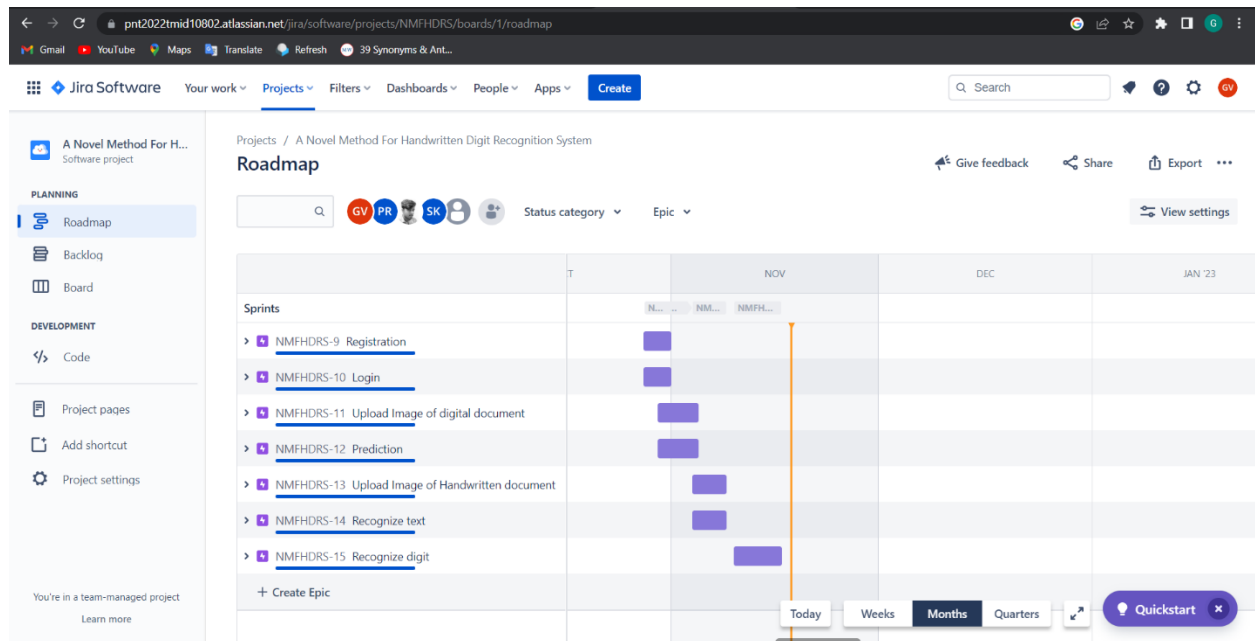
6.1 SPRINT PLANNING AND ESTIMATION

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	13	High	Gnanadesigan V
Sprint-1	Login	USN-2	As a user, I can log into the application by entering email & password	7	High	Vimalraj S
Sprint-2	Upload Image of digital document	USN-3	As a user, I can able to input the images of digital documents to the application	9	Medium	Praveen Raj B
Sprint-2	Prediction	USN-4	As a user, I can predict the word	11	Medium	Sanjay K
Sprint-3	Upload Image of Handwritten document	USN-5	As a user, I can able to input the images of the handwritten documents or images to the application	12	High	Gnanadesigan V
Sprint-3	Recognize text	USN-6	As a user, I can able to choose the font of the text to be displayed	8	Medium	Vimalraj S
Sprint-4	Recognize digit	USN-7	As a user I can able to get the recognized digit as output from the images of digital documents or images	10	Medium	Praveen Raj B

6.2 SPRINT DELIVERY SCHEDULE

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	7 Days	28 Oct 2022	31 Oct 2022	20	31 Oct 2022
Sprint-2	20	7 Days	31 Oct 2022	07 Nov 2022	20	07 Nov 2022
Sprint-3	20	7 Days	07 Nov 2022	14 Nov 2022	20	14 Nov 2022
Sprint-4	20	7 Days	12 Nov 2022	19 Nov 2022	20	19 Nov 2022

6.3 REPORTS FROM JIRA



CHAPTER 7

CODING & SOLUTIONING

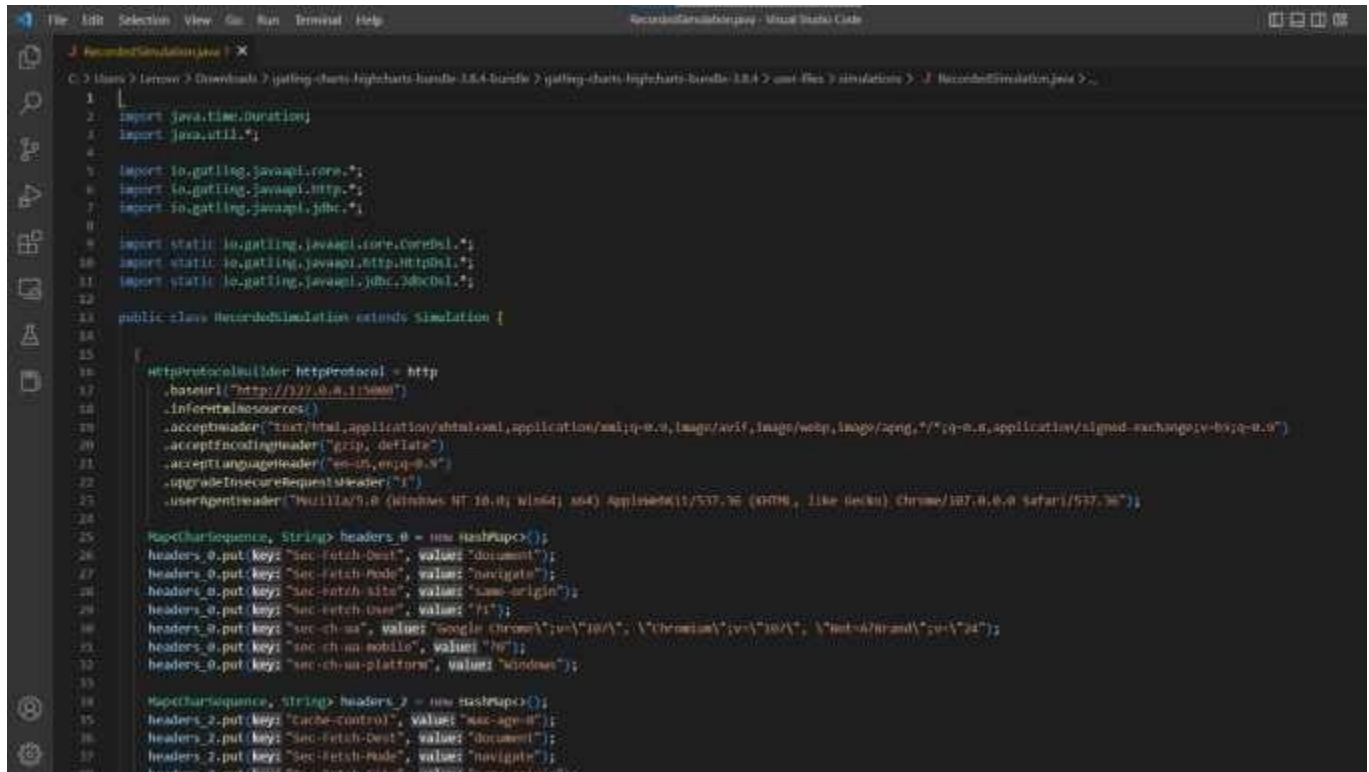
```
1 import os
2 import random
3 import string
4 from pathlib import Path
5 import numpy as np
6 from tensorflow.keras.models import load_model
7 from PIL import Image, ImageOps
8 import cv2
9
```

```
10
11 def recognize(image: bytes) -> Int:
12     """
13     Predicts the digit in the image.
14
15     Args:
16         image (bytes): The image data.
17
18     Returns:
19         Tuple: The best prediction, other predictions and file name
20     """
21
22     model=load_model(Path("./model/digit.h5"))
23     image = cv2.imread(image)
24     gray = cv2.cvtColor(image.copy(), cv2.COLOR_BGR2GRAY)
25     ret, thresh = cv2.threshold(gray.copy(), 75, 255, cv2.THRESH_BINARY_INV)
26     contours, _ = cv2.findContours(thresh.copy(), cv2.RETR_EXTERNAL, cv2.CHAIN_APPROX_SIMPLE)
27     preprocessed_digits = []
28     for x in contours:
29         x,y,w,h = cv2.boundingRect(x)
30         cv2.rectangle(image, (x,y), (x+w, y+h), color=(0, 255, 0), thickness=2)
31         digit = thresh[y:y+h, x:x+w]
32         resized_digit = cv2.resize(digit, (18,18))
33         padded_digit = np.pad(resized_digit, ((5,5),(5,5)), "constant", constant_values=0)
34         preprocessed_digits.append(padded_digit)
35     for digit in preprocessed_digits:
36         prediction = model.predict(digit.reshape(1, 18, 18, 1))
37         best= np.argmax(prediction)
38
39
40
41     return best, "1.jpg"
```

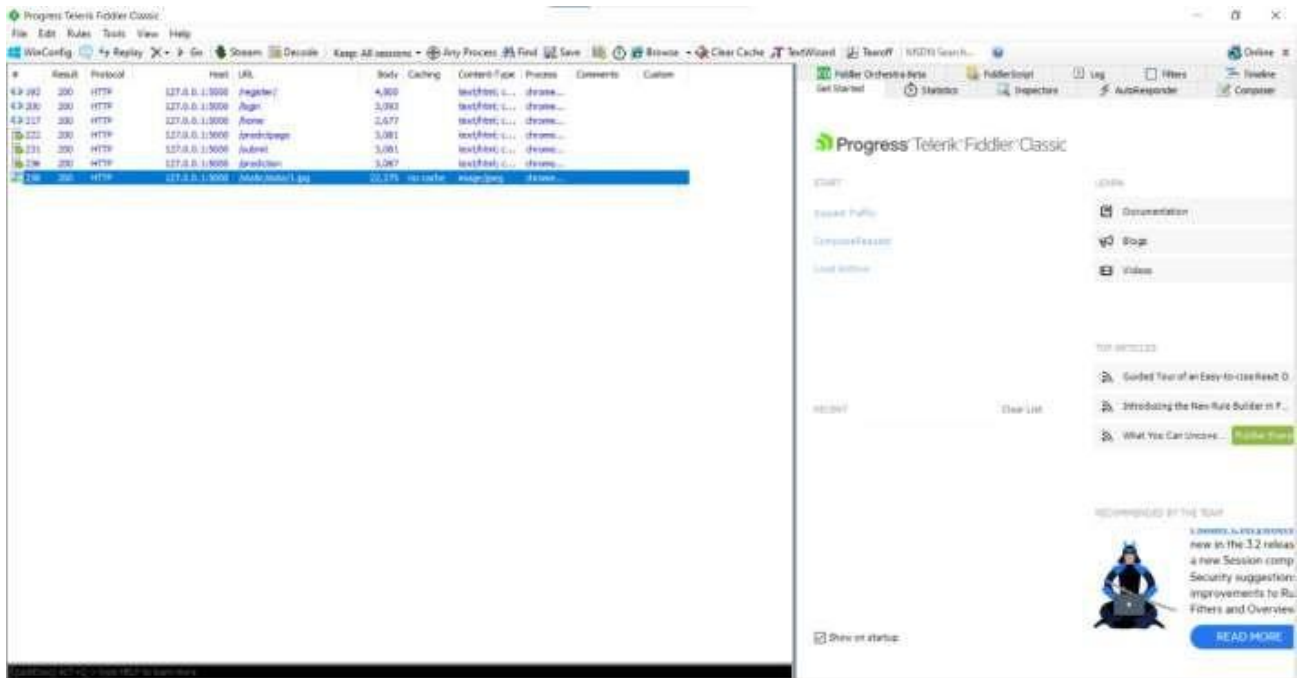
CHAPTER 8

TESTING

8.2 TEST CASES



```
1  |
2  | import java.time.Duration;
3  | import java.util.*;
4  |
5  | import io.gatling.javaapi.core.*;
6  | import io.gatling.javaapi.http.*;
7  | import io.gatling.javaapi.jdbc.*;
8  |
9  | import static io.gatling.javaapi.core.CoreDel.*;
10 | import static io.gatling.javaapi.http.HttpDel.*;
11 | import static io.gatling.javaapi.jdbc.JdbcDel.*;
12 |
13 | public class RecordedSimulation extends Simulation {
14 |
15 |     {
16 |         HttpProtocolBuilder httpProtocol = http
17 |             .baseUrl("http://127.0.0.1:5000")
18 |             .infernalHttpSources();
19 |         .acceptHeader("text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,image/apng,*/*;q=0.8,application/signed-exchange;v=b3;q=0.9")
20 |         .acceptEncodingHeader("gzip, deflate")
21 |         .acceptLanguageHeader("en-US,en;q=0.9")
22 |         .upgradeInsecureRequestsHeader("1")
23 |         .userAgentHeader("Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/107.0.0.0 Safari/537.36");
24 |
25 |         Map<CharSequence, String> headers_0 = new HashMap<>();
26 |         headers_0.put(key: "sec-fetch-dest", value: "document");
27 |         headers_0.put(key: "sec-fetch-mode", value: "navigate");
28 |         headers_0.put(key: "sec-fetch-site", value: "same-origin");
29 |         headers_0.put(key: "sec-fetch-user", value: "?1");
30 |         headers_0.put(key: "sec-ch-ua", value: "Google Chrome/v=\\\"10\\\", \\\"Chromium\\\"/v=\\\"10\\\", \\\"Not-A.Brand\\\"/v=\\\"24\\\"");
31 |         headers_0.put(key: "sec-ch-ua-mobile", value: "?0");
32 |         headers_0.put(key: "sec-ch-ua-platform", value: "Windows");
33 |
34 |         Map<CharSequence, String> headers_2 = new HashMap<>();
35 |         headers_2.put(key: "cache-control", value: "max-age=0");
36 |         headers_2.put(key: "sec-fetch-dest", value: "document");
37 |         headers_2.put(key: "sec-fetch-mode", value: "navigate");
38 |         headers_2.put(key: "sec-fetch-site", value: "same-origin");
```



8.2 USER ACCEPTANCE TESTING

Test Case ID	Feature Type	Component	Test Scenario	Steps To Execute	Test Data	Expected Result	Actual Result	Status
HomePage_TC_001	Functional	Home Page	Verify user is able to see the Login/Signup popup when user clicked on My account button	1.Enter URL and click go 2.Click on My Account icon 3.Verify login/Signup popup displayed or not	-	Login/Signup popup should display	Working as expected	Pass
RegisterPage_TC_001	UI	Registration Page	Verify the UI elements in Register/Signup page	1.Enter URL and click go 2.Click on My Account dropdown button 3.Verify Register/Signup popup with below UI elements: a.name text box b. email text box c. phone number text box d. password text box e. gender text box f. Already have an account? Click login	-	Application should show below UI elements: a.name text box b. email text box c. phone number text box d. password text box e. gender text box f. Already have an account? Click login	Working as expected	Pass
RegisterPage_TC_002	Functional	Registration Page	Verify the users entering the unique email	1.Enter URL and click go 2.Click on My Account dropdown button 3.Verify Register/Signup page accepts only unique email	-	Application should allow only unique email address	Working as expected	Pass
RegisterPage_TC_002	Functional	Registration Page	Verify that the user can able to register with valid credentials	1.Enter URL and click go 2.Click on My Account dropdown button 3.Click Register/Signup popup A. Enter name b. Enter email c. Enter phone number d. Enter password e. Enter gender f. Click Register button	-	User should navigate to sign in page	Working as expected	Pass

LoginPage_TC_001	UI	Login page	Verify the UI elements in Login/Sign in page	1.Enter URL and click go 2.Click on My Account dropdown button 3.Verify login/Signup popup with below UI elements: a. email text box b. password text box c. Login button d. <u>New</u> customer? Create account link	-	Application should show below UI elements: <u>a.email</u> text box <u>b.password</u> text box <u>c.Login</u> button with orange colour <u>d.New</u> customer? Create account link	Working as expected	Pass
LoginPage_TC_002	Functional	Login page	Verify user is able to log into application with Valid credentials	1.Enter URL and click go 2.Click on My Account dropdown button and click on sign in/login pop up 3.Enter Valid email in Email text box 4.Enter valid password in password text box 5.Click on login button	Email: chalam@gmail.com password: Testing123	User should navigate to Description page	Working as expected	Pass
LoginPage_TC_003	Functional	Login page	Verify user is not able to log into application with Invalid credentials	1.Enter URL and click go 2.Click on My Account dropdown button and click on sign in/login pop up 3.Enter Invalid email in <u>Email</u> text box 4.Enter valid password	Username: <u>chalam@gmail</u> password: Testing123	Application should show 'Email not available' validation message.	Working as expected	Pass
				in password text box 5.Click on login button				
LoginPage_TC_004	Functional	Login page	Verify user is not able to log into application with Invalid credentials	1.Enter URL and click go 2.Click on My Account dropdown button and click on sign in/login pop up 3.Enter Valid username/email in Email text box 4.Enter Invalid password in password text box 5.Click on login button	Username: chalam@gmail.com password: Testing123678686786876876	Application should show 'Incorrect password' validation message.	Working as expected	Pass
DescriptionPage_TC_002	UI	Description page	Verify user is able to see the description and predict button	1.Enter URL and click go 2.Click on My Account dropdown button 3.Enter Valid email in Email text box 4.Enter valid password in password text box 5.Click on login button		Application should navigate to Description page and user can able to view the description and predict button	Working as expected	Pass

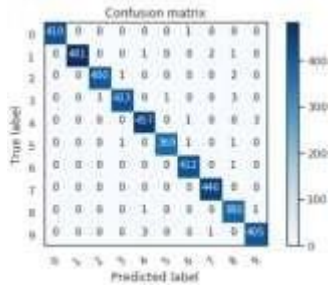
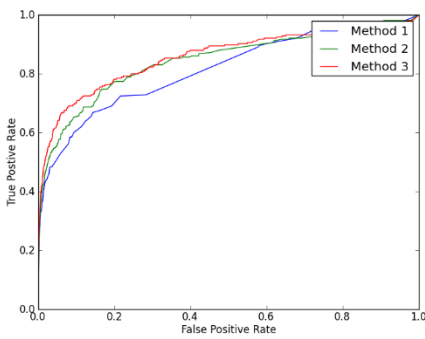
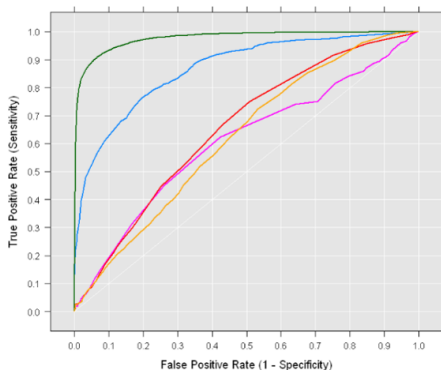
DescriptionPage_TC_002	Functional	Description page	Verify user is able to click the predict button	1.Enter URL and click go 2.Click on My Account dropdown button 3.Enter Valid email in Email text box 4.Enter valid password in password text box 5.Click on login button 6.Click on predict button		User Should navigate to Prediction page	Working as expected	Pass
DescriptionPage_TC_003	Functional	Description page	Verify user is able to click the logout button			User should navigate to Home page after clicking on Logout button	Working as expected	Pass
PredictionPage_TC_001	UI	Prediction Page	Verify user is able to Choose and submit the file and predict the output	1.Enter URL and click go 2.Click on My Account dropdown button 3.Enter Valid email in Email text box 4.Enter valid password in password text box 5.Click on login button 6.Click on predict button 7.Click on Choose		User can able to upload the file and predict the output	Working as expected	Pass
				button to select the file				
PredictionPage_TC_002	Functional	Prediction Page	Verify user is able to choose only the accepted file format		A.pdf	User can able to upload <u>only</u> .png, .jpg, .jpeg files		Fail

CHAPTER 9

RESULTS

9.1 PERFORMANCE METRICS

S.No.	Parameter	Values	Screenshot
1.	Model Summary	Model: "sequential" Layer (type) Output Shape Param # conv2d (Conv2D) (None, 26, 26, 64) 640 conv2d_1 (Conv2D) (None, 24, 24, 32) 18464 flatten (Flatten) (None, 18432) 0 dense (Dense) (None, 10) 184330 Total params: 203,434 Trainable params: 203,434 Non-trainable params: 0	<pre>from tensorflow.keras.models import load_model model=load_model("digit.h5") model.summary() Model: "sequential" Layer (type) Output shape Param # ----- conv2d (Conv2D) (None, 26, 26, 64) 640 conv2d_1 (Conv2D) (None, 24, 24, 32) 18464 flatten (Flatten) (None, 18432) 0 dense (Dense) (None, 10) 184330 Total params: 203,434 Trainable params: 203,434 Non-trainable params: 0</pre>
2.	Accuracy	Training Accuracy -0.9979166388511658 Validation Accuracy -0.98089998960495	<pre>metrics = model.evaluate(X_testi, y_testi, verbose=0) print("Metrics (Test loss & Test Accuracy): ") print(metrics) Metrics (Test loss & Test Accuracy): [0.14363985787467957, 0.98089998960495] metrics = model.evaluate(X_traini, y_traini, verbose=0) print("Metrics (Train loss & Train Accuracy): ") print(metrics) Metrics (Train loss & Train Accuracy): [0.007249436806887388, 0.9979166388511658]</pre>
3.	Metrics	Classification Model: precision, recall, f1-score, support	<pre> precision recall f1-score support benign 0.53 0.70 0.60 9711 dos 0.89 0.41 0.56 7636 probe 0.92 0.10 0.18 2423 r2l 0.19 0.36 0.25 2574 u2r 0.06 0.32 0.10 200 micro avg 0.49 0.49 0.49 22544 macro avg 0.52 0.38 0.34 22544 weighted avg 0.65 0.49 0.50 22544 0.49463271823988647 Precision Score : 0.49463271823988647 Recall Score : 0.49463271823988647 F1 score: 0.49463271823988647</pre>

4.	Metrics	Confusion Matrix	
5.	Metrics	Precision-Recall or PR curve	
6.	Metrics	ROC (Receiver Operating Characteristics) curve	

CHAPTER 10

ADVANTAGES & DISADVANTAGES

ADVANTAGES:

- Useful anywhere and on any device
- Able to manage a lot of data
- More precise than the average human
- Cuts down on manual labor

DISADVANTAGES:

- Unable to deal with complex data
- All information must be stored digitally.
- Needs a powerful server to make predictions more quickly.
- Occasionally prone to errors

CHAPTER 11

CONCLUSION

In this project, a web application that recognizes handwritten digits using machine learning was demonstrated. This project was made using a variety of technologies, including JavaScript, HTML, CSS, and Flask. The model uses a CNN network to predict the handwritten digit. The model scored a 98% recognition rate in testing. The suggested idea is easily scalable and capable of supporting a large number of users. It is compatible with any device that can run a browser because it is a web application. This project is very helpful in real-world settings like reading license plates of moving automobiles, processing the amounts on bank checks, entering numbers manually filled out forms (like tax forms), and so on. There is so much potential for development that can be included in later iterations.

CHAPTER 12

FUTURE SCOPE

There is still much work to be done on this project, and it may use a lot of improvement.

The following are a few ways this project could be improved:

- The capability to recognize numbers in hand writing
- Include a feature to recognize multiple digits.
- Enhance the model to recognize numbers in complicated images
- Include support for more languages to assist users from around the world

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

APPENDIX

SOURCE CODE

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 event.pywsgi import WSGIServer
from keras.models import load_model
from keras.preprocessing import image
from flask import send_from_directory
app = Flask(__name__)
UPLOAD_FOLDER = 'C:\\Users\\vimal\\Downloads\\ibm\\Models'
app.config['UPLOAD_FOLDER'] = UPLOAD_FOLDER
model = load_model("C:\\Users\\vimal\\Downloads\\ibm\\Models\\mnistCNN.h5")
@app.route("/")
def index():
    return render_template("index.html")
@app.route("/web", methods = ['GET', 'POST'])
def web():
    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('web.html',num=str(num[0]))
return render_template('web.html')
if __name__ == "__main__":
    app.run(debug = True)
```

index.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>Document</title>
</head>
<style>
  .background{
    height:100vh;
  }
  .background img{
    width:100%;
    height:100%;
  }
  .Header{
    position:absolute;
    transform:translate(-60,-30);
    color:black;
    font-size: xx-large;
    right: 0px;
    left: 450px;
```

```

    top:30px;
    bottom:0px;
    font-style: italic;
}
.navbar{
    position:absolute;
    transform:translate(-60,-50);
    top:12px;
    left:1200px;
    right:600px;
}
.text{
    position:absolute;
    transform:translate(_60,-49);
    top:140px;
    bottom:0px;
    left:10px;
    right:0px;
}
.text h1{
    text-decoration: underline;
}
</style>
<body>
<div class="background">
    
</div>
<div class="Header">
    <p> A Novel Method For Handwritten Recognition System</p>
</div>
<div class="navbar">

```

```

<ul>
  <li><a href="{{ url_for('index') }}">Home</a></li>
  <br>
  <li><a href="{{ url_for('web') }}">Recognize</a></li>
  <!-- <li><a href="/templates/index.html">Home</a></li>
  <li><a href="/templates/web.html">Recognize</a></li> -->
</ul>
</div>
<div class="text">
  <h1 class="title">Handwritten Recognition System:</h1>
  <p class="details">Handwritten Text Recognition is a technology that is much in this world
as of today.

  This digit Recognition system is used to recognize the digits from the different
sources like emails,

  bank cheque, papers ,images, etc. Before proper implementation of this technology we
have relied on writing texts

  with our hands which can result in errors. It's difficult to store and access physical data
with efficiency . The project

  presents recognizing the handwritten digits (0to9) from the famous MNIST dataset.
Here we will

  be using artificial neural networks/ convolution neural network.</p>
</div>
</div>
</body>
</html>

```

Web.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">
<link rel="stylesheet" href="/static/style.css">
<title> Hand Written Digit Recongizer</title>
</head>
<style>
    * {
        border: 0;
        margin: 0;
    }
    .parent-container {
        width: 100%;
        float: left;
    }
    .header {
        width: 100%;
        height: 80px;
        float: left;
        background-color: lightslategray;
        border-bottom: 5px solid rgb(100, 93, 93) ;
    }
    .heading {
        padding: 30px;
        float: left;
        color: white ;
        font-size: 18px;
    }
    ul {
        list-style-type: none;
        margin: 0;
        padding: 0;
```



```
}  
.navbar {  
  padding: 30px;  
  float: right;  
}  
li  
{  
  display: inline;  
  padding: 20px;  
  margin: 0px 10px;  
  color: white;  
}  
li a {  
  display: inline;  
  text-align: center;  
  font-size: 18px;  
  padding: 14px 16px;  
  text-decoration: none;  
  color: white;  
}  
li a:hover {  
  color: lightblue;  
}  
.body-container {  
  width: 100%;  
  float: left;  
}  
.background-image  
{  
  width: 100%;  
  float: left;
```

```
}  
.image  
{  
    width: 100%;  
    height: 650px;  
    float: left;  
}  
.text{  
    position: absolute;  
    padding: 20px;  
    width: 50%;  
    height: 50px;  
    text-align: center;  
}  
.title  
{  
    text-align: center;  
    padding: 10px;  
}  
.submit-btn  
{  
text-align: center;  
}  
.button  
{  
    margin: 20px;  
}  
.btn  
{  
    padding: 15px;  
    margin: 20px;
```

```

border: 1px solid black;
border-radius: 3px;
background-color: lightblue;
cursor: pointer;
}
.img::after
{
width: 200px;
height: 200px;
}
.image-border
{
border : 3px solid black;
width: 200px;
height: 200px;
margin: auto;
}
.file
{
margin:30px;
}
</style>
<body>
<div class="Parent-container">
<div class="header">
<h3 class="heading">Hand Written Recognition</h3>
<div class="navbar">
<ul>
<li><a href="jira-1.html">Home</a></li>
<li><a href="jira-2.html">Recognize</a></li>
<!-- <li><a href="/templates/index.html">Home</a></li>

```

```

        <li><a href="/templates/web.html">Recognize</a></li> -->
    </ul>
</div>
</div>
<div class="background-image">
    
    <div class="text">
        <form action="/web" method="POST" enctype="multipart/form-data">
            <div class="file">
                <label>Select a image:</label>
                <input id="image" type="file" name="image" accept="image/png, image/jpeg"
onchange="preview()">
            </div>
            <div class="image-border">
                <img id="frame" class="img" src="" />
            </div>
            <div class="button">
                <button type="submit" class="btn">Predict</button>
                <button type="button" class="btn" onclick="cleardata()">&nbsp; Clear
&nbsp;</button>
            </div>
            <div>
                <h3>The Number is: { { num } }</h3>
            </div>
        </form>
    </div>
</div>
</div>
</body>
<script>
    function preview() {

```

```
        document.getElementById("frame").src = URL.createObjectURL(event.target.files[0]);
    }
    function cleardata(){
        document.getElementById("frame").src = "";
        document.getElementById("image").value = "";
    }
</script>
</html>eb.html
```



GITHUB

<https://github.com/IBM-EPBL/IBM-Project-22014-1659801107>



PROJECT DEMO

https://drive.google.com/file/d/1gg_sWyxhM0DeOuYNA8vbrikToXZHlrrp/view?usp=share_link