PROJECT REPORT

A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION SYSTEM

submitted by

TEAM ID - PNT2022TMID06896

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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 (Explain the features added in the project along with code)**
   - 7.1 Feature 1
   - 7.2 Feature 2

7.3 Database Schema (if Applicable)

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

In computer technology and artificial intelligence, machine learning and deep learning are crucial. Human effort can be decreased in many different areas with the help of deep learning and machine learning, including recognition, learning, predictions, and many more.

Handwritten Digit Recognition is the ability of computer systems to recogniseh and written digits from various sources, such as images, documents, and so on.This project aims to let users take advantage of machine learning to reduce manual tasks in recognizing digits.

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 licence plates, processing bank cheque amounts, and reading numbers from forms that have been filled out by hand (such as tax forms).

CHAPTER 2

2.LITERATURE SURVEY

2.1 EXISTING PROBLEM

Following are the constraints faced when computers approach to recognize handwritten digits:

- The Handwritten digits are not always of the same size, width, orientation and justified to margins as they differ from writing of person to person.
- The similarity between digits such as 1 and 7, 5 and 6, 3 and 8, 2 and 7 etc. So, classifying between these numbers is also a major problem for computers.
- The uniqueness and variety in the handwriting of different individuals also influence the formation and appearance of the digits..

2.2 REFERENCES

Hao Y., Shi Y., Zhang D., Zhu X. 2001, "An effective result-feedback neural algorithm for handwritten character recognition' International Journal of Neural Parallel & Science Computations, Vol. 9z No. 2, Pp.139~150

In this paper, a new algorithm of handwritten character recognition based on result-feedback is proposed. It is designed as an effective neural network by adding confidence back-propagation and input modification, thus both pre-processing and recognition operations are closely integrated together. The convergence of the algorithm is proved and many experiments show that the error rate in such a result-feedback neural network (RFNN) can be greatly reduced as well as the robust to environmental noise

Kimura, F. and Shiridhar, M. (1991). Handwritten numerical recognition based on multiple algorithms. Pattern Recognition, no. 10, vol. 24, pp. 969-983

In this paper, the authors developed two algorithms for application to recognition of unconstrained isolated handwritten numerals. While both algorithms yielded very low error rates, the authors combined the two algorithms in different ways to study the best polling strategy and realized significant improvement in performance.

M. Shridhar and A. Badreldin, Recognition of isolated and simply connected handwritten numerals, Pattern Recognition 19, 1-12 (1986).

In this paper the authors describe the results of their investigation into the development of a recognition algorithm for identifying numerals that may be

isolated or connected, broken or continuous. Using a structural classification scheme, the recognition algorithm is derived as a tree classifier. In an extensive test experiment, an accuracy of 99% was realized with isolated numerals. When connected numerals were also included a recognition accuracy of 93% was obtained.

Bora, Mayur Bhargab, DinthisrangDaimary, KhwairakpamAmitab, and DebdattaKandar. "Handwritten character recognition from images using CNN-ECOC." Procedia Computer Science 167 (2020): 2403-2409.

In this paper Mayur Bhargab Bora, DinthisrangDaimary, KhwairakpamAmitab, DebdattaKandar et. mentioned that The OCR is a process of classifying the optical patterns present in a digital image to the corresponding characters.he OCR is a process of classifying the optical patterns present in a digital image to the corresponding characters.The character recognition is achieved through important steps of feature extraction and classification. The OCR system simulates the human capability to recognize. And the advantages are he CNN is used for feature extraction and ECOC for recognition of characters. In order to find a suitable feature extractor, three popular CNN architectures have been explored, namely LeNet, AlexNet and ZfNet. AlexNet is the most suitable CNN for combining with ECOC, in order to recognize handwritten characters.

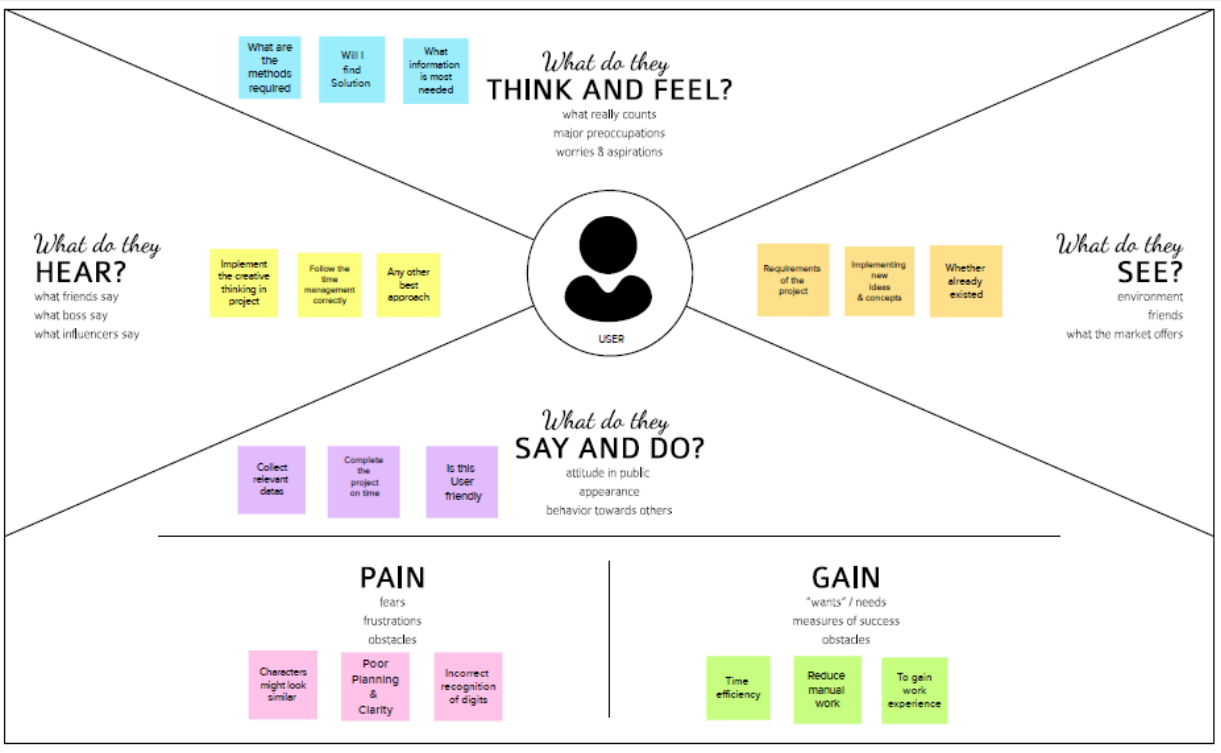
2.3 PROBLEM STATEMENT DEFINITION

Recognition of characters and digits is viral in today's digitized world,especially in organizations that deal with handwritten documents that they need to analyze using computer systems. Convolutional Neural Network gets trained from the real-time data and makes the model very simple by reducing the number of variables and gives relevant accuracy. It can be used to convert books, newspapers and handwritten notes into digital text format using machine learning models.

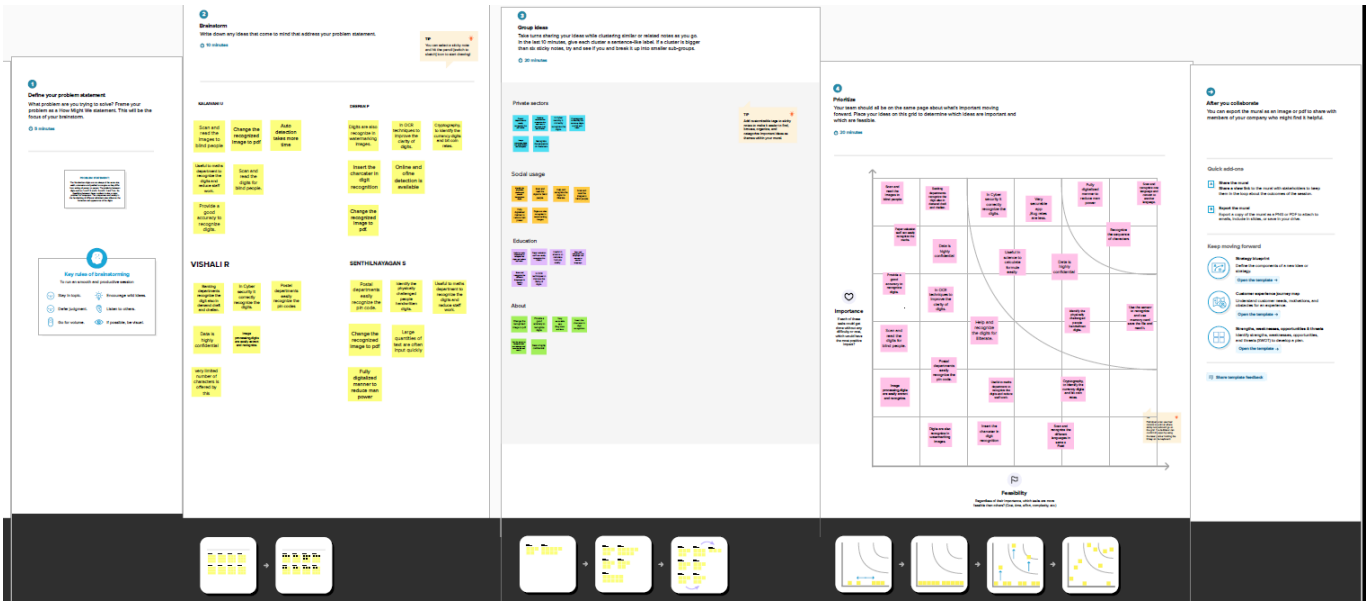
CHAPTER 3

3.IDEATION AND PROPOSED SOLUTION

3.1 EMPATHY MAP CANVAS



3.2 IDEATION & BRAINSTORMING

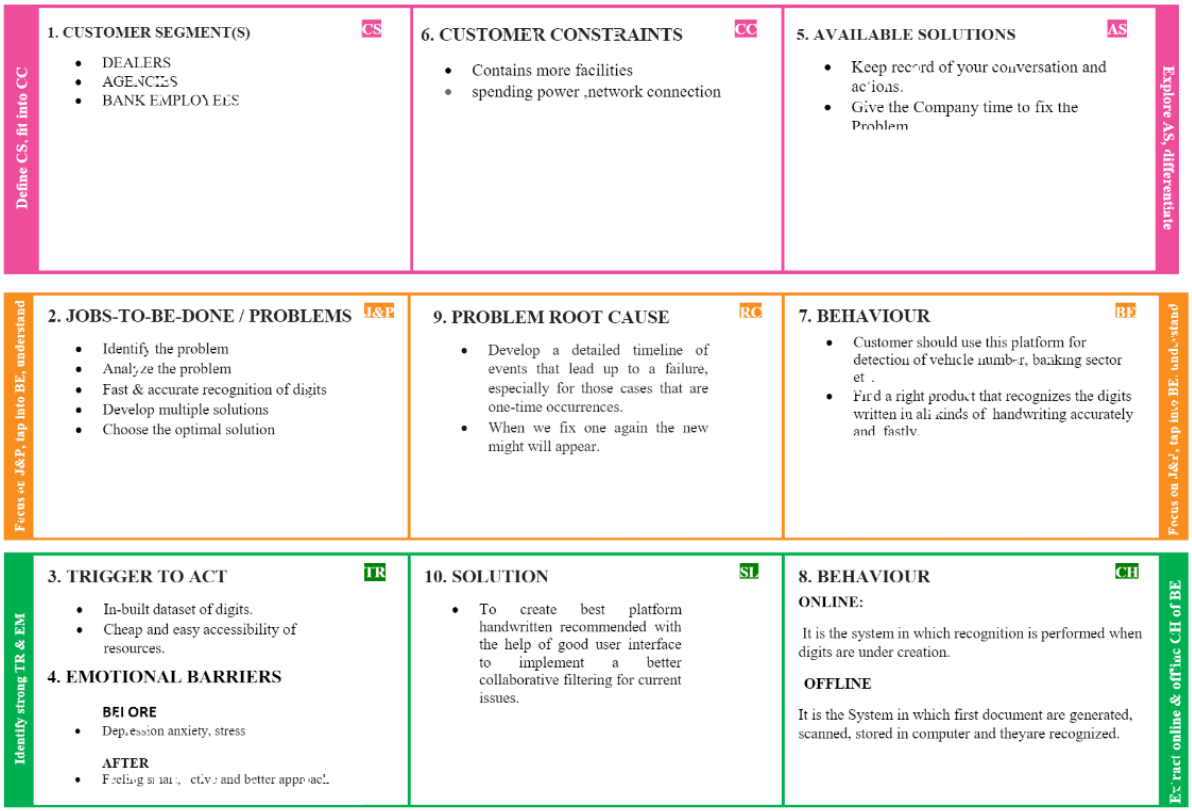


3.3 PROPOSED SOLUTION

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	• To create a system to recognize hand written digit using AI.
2.	Idea / Solution description	• Using AI the pattern in the handwritten notes are classified and recognized
3.	Novelty / Uniqueness	• Achieve maximum accuracy to recognise the digits.
4.	Social Impact / Customer Satisfaction	• User friendly • Easy to use and understand • Easy to calculate • Used to convert into digital form
5.	Business Model (Revenue Model)	• Data security • Future prediction • Useful in digitalizing the handwritten documents.
6.	Scalability of the Solution	• Can be extended to manage recognition • Ability to provide better solution • It is scalable from a dataset training perspective.

3.4 PROBLEM SOLUTION FIT

TITLE : A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGINITION - PROBLEM SOLUTION FIT- PNT2022TMID06896



CHAPTER 4

4.REQUIREMENT ANALYSIS

4.1 FUNCTIONAL REQUIREMENTS

FR.NO	FUNCTIONAL REQUIREMENTS	SUB REQUIREMENTS
FR-1	Model Creation	Get access the MNIST dataset
		Analyze the dataset
		Define a CNN model
		Train and Test the Model
FR-2	Application Development	Create a website to let the user recognize handwritten digits.
		Create a home page to upload images
		Create a result page to display the results
		Host the website to let the users use it from anywhere
FR-3	Input Image Upload	Let users upload images of various formats.
		Let users upload images of various size
		Prevent users from uploading unsupported image formats

		Pre-Process the image to use it on the model
		Create a database to store all the input images
FR-4	Display Results	Display the result from the model
		Display input image
		Display accuracy the result
		Display other possible predictions with their respective accuracy

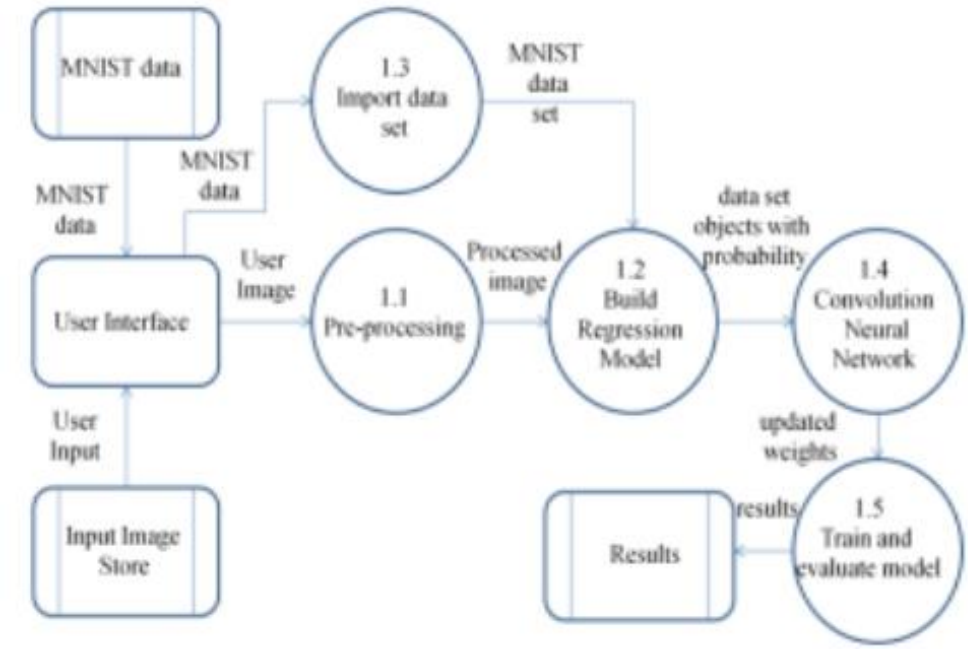
4.2 NON FUNCTIONAL REQUIREMENTS

NFR	NON-FUNCTIONAL REQUIREMENTS	DESCRIPTION
NFR-1	Usability	The application must be usable in all devices
NFR-2	Security	The application must protect user uploaded image
NFR-3	Reliability	The application must give an accurate result as much as possible
NFR-4	Performance	The application must be fast and quick to load up
NFR-5	Availability	The application must be available to use all the time
NFR-6	Scalability	The application must scale along with the user base

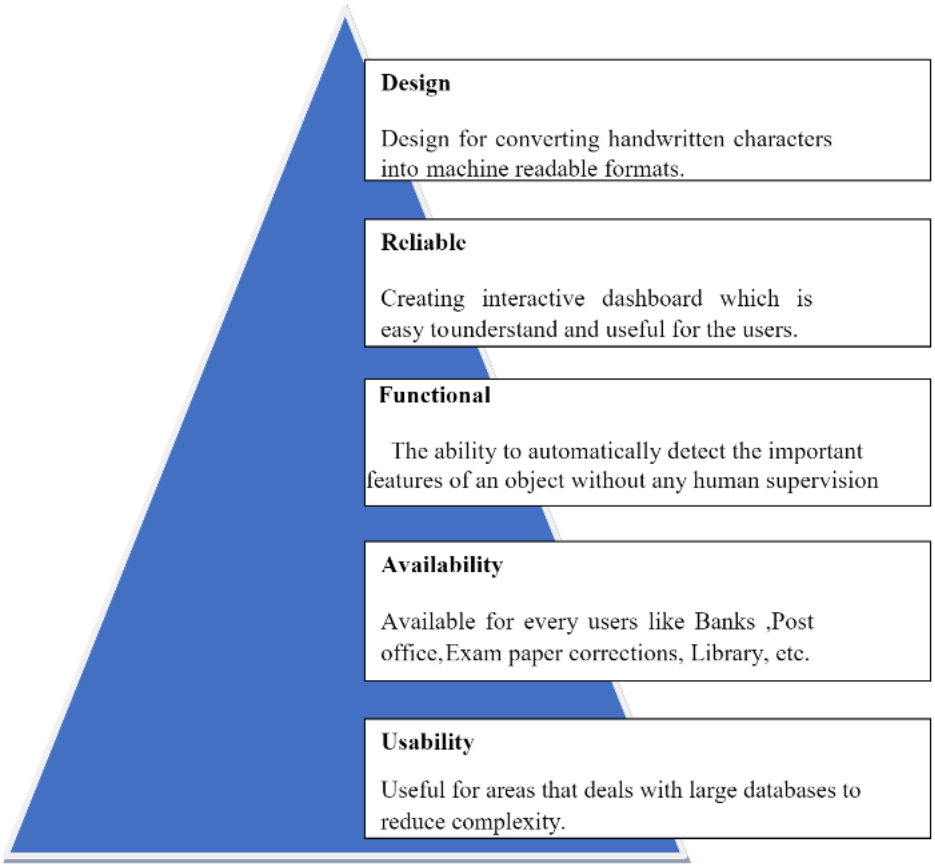
CHAPTER 5

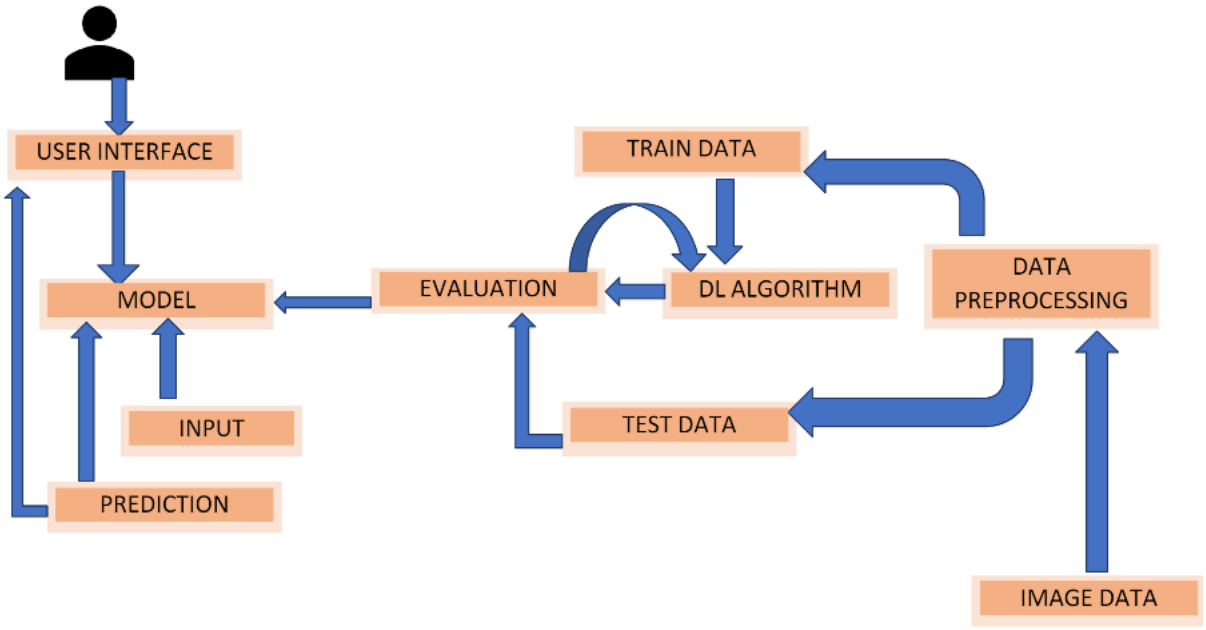
5 . PROJECT DESIGN

5.1 DATA FLOW DIAGRAM



5.2 SOLUTION & TECHNICAL ARCHITECTURE


Design
Design for converting handwritten characters into machine readable formats.
Reliable
Creating interactive dashboard which is easy tounderstand and useful for the users.
Functional
The ability to automatically detect the important features of an object without any human supervision
Availability
Available for every users like Banks ,Post office,Exam paper corrections, Library, etc.
Usability
Useful for areas that deals with large databases to reduce complexity.



5.3 USER STORIES

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
		USN-2	As a user, I will receive confirmation email once I have registered for the application.	I can receive confirmation email & click confirm	High	Sprint-1
		USN-3	As as user, I can view the guide and awareness to use this application.	I can view the awareness to use this application by a practical method.	Low	Sprint-2
		USN-4	As a user, I can read the instructions to use this application.	I can read instructions to use it in user-friendly method.	Medium	Sprint-1
	Login	USN-5	As a user, I can log into the application by entering email & password	I can enter the application	High	Sprint-1
	About	USN-6	I can click on the "About " to get the idea of a handwritten digit recognition tool for recognition of digits.	I can get an idea about the project	Low	Sprint-1
Customer (Web user)	Predict	USN-7	As a user I can upload my handwritten digits images to be recognised from the computer.	I can choose any image from my device	High	Sprint-2

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer Care Executive		USN-8	As a user I will train and test the input to get the maximum accuracy of output	I can able to train and test the application until it gets maximum accuracy of the result.	High	Sprint-4
Administrator	Launch	USN-9	As a user, I can upload my handwritten digit images to be recognised from the computer.	I can choose and upload the image from the system storage and also in any virtual storage.	Medium	Sprint-3
		USN-10	I can scan one page at once.	I can get the recognised digits from the input given.	High	Sprint-4
	Recognize	USN-11	As a user I can turn on the camera using the input button.	I can get the input to be digitized.	High	Sprint-3
		USN-12	As a user , I can use the web application virtually anywhere.	I can use the application portably anywhere.	High	Sprint-1
		USN-13	As it is open source,i can use it cost freely.	I can use it without any payment to be paid for it to access.	Medium	Sprint-2

CHAPTER 6

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.	2	High	Vishali.R Kalaivani.U Deepan.P Senthilnayagan. S
Sprint-1	Login	USN-2	As a user, I can log into the application by entering email & password	1	High	Vishali.R Kalaivani.U Deepan.P Senthilnayagan. S
Sprint-2	Upload image of digital document	USN-3	As a user, I can able to input the images of digital documents on the application	2	Low	Vishali.R Kalaivani.U Deepan.P Senthilnayagan. S
Sprint-2	Input correlation	USN-4	As a user, I can get a correlation	2	Medium	Vishali.R Kalaivani.U Deepan.P Senthilnayagan. S

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-3	Feature Extraction	USN-5	As a user, I can predict properly by good features	1	High	Vishali.R Kalaivani.U Deepan.P Senthilnayagan.S
Sprint-4	Recognizing digits	USN-6	As a user I can able to get the recognised digit as output from the images of hand written documents or images	2	High	Vishali.R Kalaivani.U Deepan.P Senthilnayagan.S

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	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

CHAPTER 7

CODING & SOLUTION

```python
from flask import Flask, flash, render_template, redirect, session, request, url_for
from flask_restful import Api


from flask_mysqldb import MySQL,MySQLdb
import bcrypt

app = Flask(__name__)
api = Api(app)

app.secret_key = "secret key"

app.config['MYSQL_HOST'] = 'localhost'
app.config['MYSQL_USER'] = 'root'
app.config['MYSQL_PASSWORD'] = ''
app.config['MYSQL_DB'] = 'flaskdb'
app.config['MYSQL_CURSORCLASS'] = 'DictCursor'
mysql = MySQL(app)


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

```python
@app.route('/register', methods=["GET", "POST"])
def register():
    if request.method == 'GET':
        return render_template("register.html")
    else:
        name = request.form['name']
        email = request.form['email']
        password = request.form['password'].encode('utf-8')
        hash_password = bcrypt.hashpw(password, bcrypt.gensalt())

        cur = mysql.connection.cursor()
        cur.execute("INSERT INTO users (name, email, password) VALUES (%s,%s,%s)",(name,email,hash_password,))
        mysql.connection.commit()
        session['name'] = request.form['name']
        session['email'] = request.form['email']
        session['loggedin'] = True
        return redirect(url_for('home'))

@app.route('/login',methods=["GET","POST"])
def login():
    if request.method == 'POST':
        email = request.form['email']
        password = request.form['password'].encode('utf-8')

        curl = mysql.connection.cursor(MySQLdb.cursors.DictCursor)
        curl.execute("SELECT * FROM users WHERE email=%s",(email,))
        user = curl.fetchone()
        curl.close()
```

```
        if len(user) > 0:
            if bcrypt.hashpw(password, user["password"].encode('utf-8')) == user["password"].encode('utf-8'):
                session['name'] = user['name']
                session['email'] = user['email']
                session['loggedin'] = True
                return render_template("index.html")
            else:
                return "Error password and email not match"
        else:
            return "Error user not found"
    else:
        return render_template("login.html")

@app.route('/logout')
def logout():
    session.pop('loggedin', None)
    session.clear()
    return render_template("index.html")



if __name__ == "__main__":
    app.debug = True
    app.run()
```

CHAPTER 8

TESTING

8.1 Test Cases:

Test caseID	Feature type	Component	Test Scenario	Excepted Result	Actual Result	Status	Executed By
Homepage_TC_001	Functional	Home Page	Verify user is able to see the Homepage when clicked on the link	Home page should be displayed	Working as expected	Pass	Kalaivani U Deepan P
Homepage_TC_002	UI	Home Page	Verify the UI elements in Homepage	The homepage must be displayed properly	Working as expected	Pass	Senthilnayagan S Vishali R
Homepage_TC_003	Functional	Home Page	Check if the UI elements are displayed properly in different screen sizes	The Home page must be displayed properly in all sizes	The UI displayed in correct size	Pass	Kalaivani U Vishali R
Homepage_TC_004	Functional	Home Page	Check if user can upload their file	The input image should be uploaded to the application successfully	Working as expected	**Pass**	Vishali R
Homepage_TC_005	Functional	Home Page	Check if user cannot upload unsupported files	The application Should not allow user to select a non image file	User is able to upload my file	**Pass**	Senthilnayagan S
Homepage_TC_006	Functional	Home Page	Check if the page redirects to result page once the input is given	The page should redirect to the result page	Working as expected	**Pass**	Kalaivani U Vishali R
BE_TC_001	Functional	Backend	Check if the connection is	The localhost	Working as expected	**Pass**	Senthilnayagan S Vishali R

			correctly established	connection must be correctly established			
M_TC_001	Functional	Model	Check if the model can handle various sizes	The model should rescale the image and predict the results	Working as expected	**PASS**	Deepan P Vishali R
M_TC_002	Functional	Model	Check if the model predict the digits	The model should predict the number	Working as expected	**PASS**	Senthilnayagan S Kalaivani U
M_TC_003	Functional	Model	Check if the model handle complex input image	The model should predict the number in the complex image	The model fails to identify the digit since the model is not built to handle such data	**PASS**	Deepan P Kalaivani U
Predict_TC_OO5	Functional	Predict page	Verify user is able to navigate to the predict to and view the predicted result	User must be navigated to the predict page and must view the predicted result	Working as expected	**PASS**	Deepan P Kalaivani U Vishali R
R_TC_001	UI	Result Page	Verify UI elements in the Result page	The result page must be displayed properly	The result displayed as expected	**PASS**	Deepan P Kalaivani U Vishali R Senthilnayagan S
R_TC_002	UI	Result Page	Check if the input image is displayed properly	The input page must be displayed properly	Working as expected	**PASS**	Deepan P Senthilnayagan S
R_TC_003	UI	Result Page	Check if the result image is displayed properly	The result should be displayed properly	Working as expected	**PASS**	Deepan P Vishali R
R_TC_004	UI	Result Page	Check if the other prediction page is	The other prediction page should be	Working as expected	**PASS**	Senthilnayagan S Kalaivani U

			displayed properly	displayed properly			

8.2 USER ACCEPTANCE TESTING

8.2.1 DEFECT ANALYSIS

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	**Total**
By Design	1	0	1	0	**2**
Duplicate	0	0	0	0	**0**
External	0	0	2	0	**2**
Fixed	3	1	0	1	**5**
Not Reproduced	0	0	0	1	**1**
Skipped	0	0	0	1	**1**
Won't Fix	1	0	1	0	**2**
Total	5	1	4	3	**13**

8.2.2TEST CASE ANALYSIS

Section	Total Cases	Not Tested	Fail	Pass
Client Application	10	0	1	9
Security	2	0	1	1
Performance	3	0	1	2
Exception Reporting	2	0	0	2

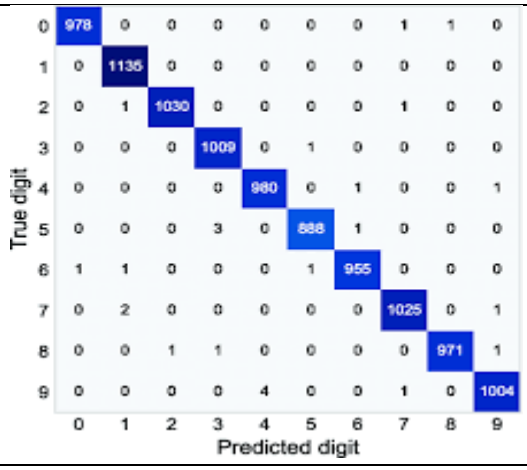
CHAPTER 9

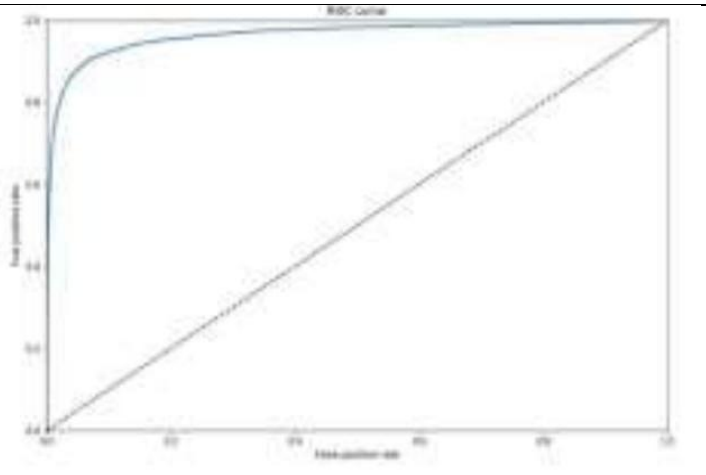
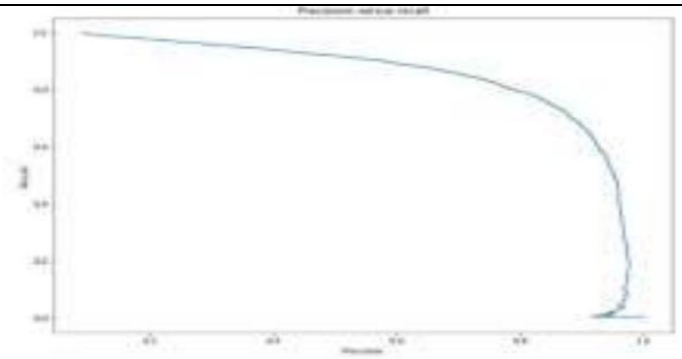
RESULTS

9.1.PERFORMANCE METRICS

.	Model Summary	The handwritten digit recognizer helps in predicting the number on the image. We use the libraries from tensor flow for building the model. This the model that was built using convolutional neutral network(CNN)	`[ ] from tensorflow.keras.models import Sequential`
			`from tensorflow.keras.layers import Convolution2D,MaxPooling2D,Flatten,Dense`
			`model = Sequential()`
			`model.add(Convolution2D(64, (3,3), input_shape=(28,28,1),activation='relu'))`
			`model.add(Convolution2D(32,(3,3),activation='relu'))`
			`model.add(Flatten())`
			`model.add(Dense(number_of_classes, activation='softmax'))`

2	Accuracy	Training Accuracy – 99%
		
		Validation Accuracy – 100%
			`[ ] metrics = model.evaluate(X_test, Y_test, verbose=0)`
			`print("Metrics(Test loss & Test Accuracy):")`
			`print(metrics)`
			
			`Metrics(Test loss & Test Accuracy):`
			`[0.03019659034907818, 0.9907000064849854]`

3	Metrics	Confusion matrix	

4.	Metrics	ROC(Receiver Operating System)	
5.	Metrics	Precision – Recall or PR curve	

CHAPTER 10

ADVANTAGES & DISADVANTAGES

ADVANTAGES :

- Reduces manual work
- More accurate than average human
- Capable of handling a lot of data
- Can be used anywhere from any device

DISADVANTAGES :

- Cannot handle complex data
- All the data must be in digital format
- Requires a high performance server for faster predictions
- Prone to occasional errors

CHAPTER 11

CONCLUSION

This project demonstrated a web application that uses machine learning to recognise handwritten numbers. Flask, HTML, CSS, JavaScript, and a few other technologies were used to create this project. The model predicts the handwritten digit using a CNN network. During testing, the model achieved a 99.61% recognition rate. The proposed project is scalable and can easily handle a huge number of users.

Since it is a web application, it is compatible with any device that can run a browser. This project is extremely useful in real-world scenarios such as recognizing number plates of vehicles, processing bank cheque amounts, numeric entries in forms filled up by hand (tax forms) and so on. There is so much room for improvement, which can be implemented in subsequent versions.

CHAPTER 12

FUTURE SCOPE:

This project is far from complete and there is a lot of room for improvement. Some of the improvements that can be made to this project are as follows:

- Add support to detect from digits multiple images and save the results
- Add support to detect multiple digits
- Improve model to detect digits from complex images
- Add support to different languages to help users from all over the world

This project has endless potential and can always be enhanced to become better. Implementing this concept in the real world will benefit several industries and reduce the workload on many workers, enhancing overall work efficiency.

APPENDIX

SOURCE CODE

1.INDEX.html

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

<head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">
    <meta name="keywords"
        content="extract text, extract text in image, extract text image python, extract text python, image to text python, extractor python text
    <meta name="description"
        content="TextExtractor it is software created to extract text from any type of image using python 3" />
    <title>Handwritten Digit Recognition System</title>
    <link rel="stylesheet" href="{{ url_for('static', filename='css/font-awesome.min.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/bootstrap.min.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/slick.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/style.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/responsive.css') }}">
    <link href="https://fonts.googleapis.com/css?family=Poppins&display=swap" rel="stylesheet">
    <link rel="icon" type="image/png" sizes="192x192" href="/android-icon-192x192.png">
    <link rel="icon" href="{{ url_for('static', filename='images/favicon.ico') }}" type="image/x-icon" />
</head>

<body id="dark-mode">
    <div class="preloader">
        <div class="frame">
            <div class="center">
                <div class="dot-1"></div>
                <div class="dot-2"></div>
                <div class="dot-3"></div>
            </div>
```

```
    <nav class="navbar navbar-expand-lg navbar-light bg-light sticky-top">
        <div class="container">
            <a style="text-decoration:none;" class="navbar-brand" href="/"><b>Handwritten Digit </b>Recognition
                System</a>
            <button class="navbar-toggler" type="button" data-toggle="collapse" data-target="#navbarSupportedContent"
                aria-controls="navbarSupportedContent" aria-expanded="false" aria-label="Toggle navigation">
                <i class="fa fa-bars" aria-hidden="true"></i>
            </button>
            <div class="collapse navbar-collapse menu-main" id="navbarSupportedContent">
                <ul class="navbar-nav ml-auto menu-item">

                    {% if session['name'] %}
                    <li class="nav-item">
                        <a style="text-decoration:none;" class="nav-link" href="{{url_for('logout')}}">Logout</a>
                    </li>

                    {% else %}
                    <li class="nav-item">
                        <a style="text-decoration:none;" class="nav-link" href="{{url_for('login')}}">Login</a>
                    </li>

                    <li class="nav-item">
                        <a style="text-decoration:none;" class="nav-link" href="{{url_for('register')}}">Register</a>
                    </li>
                    {% endif %}

                </ul>
            </div>
```

```
        </div>
    </nav>

    <section id="banner">
        <div class=".particles-js-canvas-el" id="particles-js"></div>
        <div class="container zindex">
            <div class="row align-items-center">
                <div class="col-lg-7 banner-txt">

                    <h5 style="color: aliceblue">Handwriting recognition is the capability of computer applications to recognise the human handw
                        It is the capability of the computer to identify and understand handwritten digits or characters automatically</h5>
                        <hr>


                </div>

                <div class="col-lg-5">
                    <div class="banner-img">
                        <img class="img-fluid" src="{{ url_for('static', filename='images/pencil.png') }}"
                            alt="banner-img">
                    </div>
                </div>
            </div>
        </div>



    </section>
```

```
    <!-- Optional JavaScript -->
    <script src="{{ url_for('static', filename='js/jquery-3.3.1.min.js') }}"></script>
    <script src="{{ url_for('static', filename='js/bootstrap.min.js') }}"></script>
    <script src="{{ url_for('static', filename='js/slick.min.js') }}"></script>
    <script src="{{ url_for('static', filename='js/particles.js') }}"></script>
    <script src="{{ url_for('static', filename='js/app.js') }}"></script>
    <script src="{{ url_for('static', filename='js/jquery.isotope.min.html') }}"></script>
    <script src="{{ url_for('static', filename='js/circular.js') }}"></script>
    <script src="{{ url_for('static', filename='js/custom.js') }}"></script>
</body>

</html>
```

2.REGISTER.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>Handwritten Digit Recognition System - Regsiter Page</title>
    <link rel="stylesheet" href="{{ url_for('static', filename='css/font-awesome.min.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/bootstrap.min.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/slick.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/style.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/responsive.css') }}">
    <link href="https://fonts.googleapis.com/css?family=Poppins&display=swap" rel="stylesheet">
    <link rel="icon" type="image/png" sizes="192x192" href="/android-icon-192x192.png">
    <link rel="icon" href="{{ url_for('static', filename='images/favicon.ico') }}" type="image/x-icon" />
</head>

<body id="dark-mode">
    <div class="preloader">
        <div class="frame">
            <div class="center">
                <div class="dot-1"></div>
                <div class="dot-2"></div>
                <div class="dot-3"></div>

            </div>
        </div>
    </div>
```

```
  <nav class="navbar navbar-expand-lg navbar-light bg-light sticky-top">
      <div class="container">
          <a style="text-decoration:none;" class="navbar-brand" href="/"><b>Handwritten Digit </b>Recognition
              System</a>
          <button class="navbar-toggler" type="button" data-toggle="collapse" data-target="#navbarSupportedContent"
              aria-controls="navbarSupportedContent" aria-expanded="false" aria-label="Toggle navigation">
              <i class="fa fa-bars" aria-hidden="true"></i>
          </button>
          <div class="collapse navbar-collapse menu-main" id="navbarSupportedContent">
              <ul class="navbar-nav ml-auto menu-item">


                  {% if session['name'] %}
                  <li class="nav-item">
                      <a style="text-decoration:none;" class="nav-link" href="{{url_for('logout')}}">Logout</a>
                  </li>

                  {% else %}
                  <li class="nav-item">
                      <a style="text-decoration:none;" class="nav-link" href="{{url_for('login')}}">Login</a>
                  </li>

                  <li class="nav-item">
                      <a style="text-decoration:none;" class="nav-link" href="{{url_for('register')}}">Register</a>
                  </li>
                  {% endif %}

              </ul>
```

```
        </div>


    </div>
</nav>

<section id="banner">
    <div class=".particles-js-canvas-el" id="particles-js"></div>


    <div class="container zindex">
        <div class="row">
            <div class="col-lg-7 banner-txt">



                <div class="row">
                    <center>
                        <h1 style="color: white ;"> Handwritten Digit Recognition System - Register </h1>
                    </center>
                </div>
                <hr>

                <form action="/register" method="POST">
                    <div class="form-group">
                        <label style="color: aliceblue">Name:</label>
                        <input type="text" class="form-control" name="name" required>
                    </div>
```

```
                    </div>
                    <div class="form-group">

                    </div>
                    <input
                        style="border-radius:10px;height:40px;width:100px;font-family: 'Poppins', sans-serif;background: rgb(255,85,0);
                    background: linear-gradient(90deg, rgba(255,85,0,1) 2%, rgba(237,109,20,1) 67%, rgba(246,128,0,1) 87%);border:0px;"
                        type="submit" name="submit" id="submit">

                </form>
            </div>




        </div>
    </div>
    </div>
    <!-- <div id="footer-btm">
    <div class="container">
        <div class="row">
            <div class="col-lg-12">
                <div class="fop-btm text-center">
                    <h2>Copyright &copy; 2020. All rights reserved by <a style="text-decoration:none;" href="https://amanzishan.me">amanzisha
                </div>
            </div>
        </div>
    </div>
</div> -->
</section>
```

```
    <!-- Optional JavaScript -->
    <script src="{{ url_for('static', filename='js/jquery-3.3.1.min.js') }}"></script>
    <script src="{{ url_for('static', filename='js/bootstrap.min.js') }}"></script>
    <script src="{{ url_for('static', filename='js/slick.min.js') }}"></script>
    <script src="{{ url_for('static', filename='js/particles.js') }}"></script>
    <script src="{{ url_for('static', filename='js/app.js') }}"></script>
    <script src="{{ url_for('static', filename='js/jquery.isotope.min.html') }}"></script>
    <script src="{{ url_for('static', filename='js/circular.js') }}"></script>
    <script src="{{ url_for('static', filename='js/custom.js') }}"></script>



</body>

</html>
```

3.LOGIN.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>Handwritten Digit Recognition System - Login Page</title>
    <link rel="stylesheet" href="{{ url_for('static', filename='css/font-awesome.min.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/bootstrap.min.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/slick.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/style.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/responsive.css') }}">
    <link href="https://fonts.googleapis.com/css?family=Poppins&display=swap" rel="stylesheet">
    <link rel="icon" type="image/png" sizes="192x192" href="/android-icon-192x192.png">
    <link rel="icon" href="{{ url_for('static', filename='images/favicon.ico') }}" type="image/x-icon" />
</head>

<body id="dark-mode">
    <div class="preloader">
        <div class="frame">
            <div class="center">
                <div class="dot-1"></div>
                <div class="dot-2"></div>
                <div class="dot-3"></div>

            </div>
        </div>
```

```
<nav class="navbar navbar-expand-lg navbar-light bg-light sticky-top">
    <div class="container">
        <a style="text-decoration:none;" class="navbar-brand" href="/">Handwritten Digit </b>Recognition System</a>
        <button class="navbar-toggler" type="button" data-toggle="collapse" data-target="#navbarSupportedContent"
            aria-controls="navbarSupportedContent" aria-expanded="false" aria-label="Toggle navigation">
            <i class="fa fa-bars" aria-hidden="true"></i>
        </button>
        <div class="collapse navbar-collapse menu-main" id="navbarSupportedContent">
            <ul class="navbar-nav ml-auto menu-item">


                {% if session['name'] %}
                <li class="nav-item">
                    <a style="text-decoration:none;" class="nav-link" href="{{url_for('logout')}}">Logout</a>
                </li>

                {% else %}
                <li class="nav-item">
                    <a style="text-decoration:none;" class="nav-link" href="{{url_for('login')}}">Login</a>
                </li>

                <li class="nav-item">
                    <a style="text-decoration:none;" class="nav-link" href="{{url_for('register')}}">Register</a>
                </li>
                {% endif %}

            </ul>
        </div>
```

```
    </div>
</nav>

<section id="banner">
    <div class=".particles-js-canvas-el" id="particles-js"></div>


    <div class="container zindex">
        <div class="row">
            <div class="col-lg-7 banner-txt">



                <div class="row">
                    <center>
                        <h1 style="color:■white ;"> Handwritten Digit Recognition System - Login </h1>
                    </center>
                </div>
                <hr>
                <form action="/login" method="POST">

                    <div class="form-group">
                        <label style="color:■aliceblue">Email:</label>
                        <input type="email" class="form-control" name="email">
                    </div>
                    <div class="form-group">
                        <label style="color:■aliceblue">Password:</label>
                        <input type="password" class="form-control" name="password">
                    </div>
```

```
                    </div>
                    <input
                        style="border-radius:10px;height:40px;width:100px;font-family: 'Poppins', sans-serif;background: rgb(255,85,0);
                    background: linear-gradient(90deg, rgba(255,85,0,1) 2%, rgba(237,109,20,1) 67%, rgba(246,128,0,1) 87%);border:0px;
                        type="submit" name="submit" id="submit">
                </form>
            </div>
        </div>

        </button>
        </form>
    </div>




    </div>
    </div>
    </div>
    <!-- <div id="footer-btm">
    <div class="container">
        <div class="row">
            <div class="col-lg-12">
                <div class="fop-btm text-center">
                    <h2>Copyright &copy; 2020. All rights reserved by <a style="text-decoration:none;" href="https://amanzishan.me">amanzisha
                </div>
            </div>
        </div>
    </div>
```

```
    </div> -->
    </section>


    <!-- Optional JavaScript -->
    <script src="{{ url_for('static', filename='js/jquery-3.3.1.min.js') }}"></script>
    <script src="{{ url_for('static', filename='js/bootstrap.min.js') }}"></script>
    <script src="{{ url_for('static', filename='js/slick.min.js') }}"></script>
    <script src="{{ url_for('static', filename='js/particles.js') }}"></script>
    <script src="{{ url_for('static', filename='js/app.js') }}"></script>
    <script src="{{ url_for('static', filename='js/jquery.isotope.min.html') }}"></script>
    <script src="{{ url_for('static', filename='js/circular.js') }}"></script>
    <script src="{{ url_for('static', filename='js/custom.js') }}"></script>



</body>

</html>
```

4.RECOGNIZE.html

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

<head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">
    <meta name="keywords"
        content="extract text, extract text in image, extract text image python, extract text python, image to text python, extractor python text
    <meta name="description"
        content="TextExtractor it is software created to extract text from any type of image using python 3" />
    <title>Handwritten Digit Recognition System</title>
    <link rel="stylesheet" href="{{ url_for('static', filename='css/font-awesome.min.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/bootstrap.min.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/slick.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/style.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/responsive.css') }}">
    <link href="https://fonts.googleapis.com/css?family=Poppins&display=swap" rel="stylesheet">
    <link rel="icon" type="image/png" sizes="192x192" href="/android-icon-192x192.png">
    <link rel="icon" href="{{ url_for('static', filename='images/favicon.ico') }}" type="image/x-icon" />

</head>

<body id="dark-mode">
    <div class="preloader">
        <div class="frame">
            <div class="center">
                <div class="dot-1"></div>
                <div class="dot-2"></div>
```

```
                <div class="dot-3"></div>
            </div>
        </div>
    </div>
    <nav class="navbar navbar-expand-lg navbar-light bg-light sticky-top">
        <div class="container">
            <a style="text-decoration:none;" class="navbar-brand" href="/"><b>Handwritten Digit </b>Recognition
                System</a>
            <button class="navbar-toggler" type="button" data-toggle="collapse" data-target="#navbarSupportedContent"
                aria-controls="navbarSupportedContent" aria-expanded="false" aria-label="Toggle navigation">
                <i class="fa fa-bars" aria-hidden="true"></i>
            </button>
            <div class="collapse navbar-collapse menu-main" id="navbarSupportedContent">
                <ul class="navbar-nav ml-auto menu-item">
                    <li class="nav-item">
                        <a style="text-decoration:none;" class="nav-link"
                            href="{{url_for('recognize_page')}}">Recognize</a>
                    </li>


                    {% if session['name'] %}
                    <li class="nav-item">
                        <a style="text-decoration:none;" class="nav-link" href="{{url_for('logout')}}">Logout</a>
                    </li>

                    {% else %}
                    <li class="nav-item">
```

5.PREDICT.html

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

<head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">
    <meta name="keywords"
        content="extract text, extract text in image, extract text image python, extract text python, image to text python, extractor python text
    <meta name="description"
        content="TextExtractor it is software created to extract text from any type of image using python 3" />
    <title>Handwritten Digit Recognition System</title>
    <link rel="stylesheet" href="{{ url_for('static', filename='css/font-awesome.min.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/bootstrap.min.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/slick.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/style.css') }}">
    <link rel="stylesheet" href="{{ url_for('static', filename='css/responsive.css') }}">
    <link href="https://fonts.googleapis.com/css?family=Poppins&display=swap" rel="stylesheet">
    <link rel="icon" type="image/png" sizes="192x192" href="/android-icon-192x192.png">
    <link rel="icon" href="{{ url_for('static', filename='images/favicon.ico') }}" type="image/x-icon" />



</head>

<body id="dark-mode">
    <div class="preloader">
        <div class="frame">
            <div class="center">
                <div class="dot-1"></div>
                <div class="dot-2"></div>
```

```
                <div class="dot-3"></div>
            </div>
        </div>
    </div>
<nav class="navbar navbar-expand-lg navbar-light bg-light sticky-top">
    <div class="container">
        <a style="text-decoration:none;" class="navbar-brand" href="/"><b>Handwritten Digit </b>Recognition
            System</a>
        <button class="navbar-toggler" type="button" data-toggle="collapse" data-target="#navbarSupportedContent"
            aria-controls="navbarSupportedContent" aria-expanded="false" aria-label="Toggle navigation">
            <i class="fa fa-bars" aria-hidden="true"></i>
        </button>
        <div class="collapse navbar-collapse menu-main" id="navbarSupportedContent">
            <ul class="navbar-nav ml-auto menu-item">
                <li class="nav-item">
                    <a style="text-decoration:none;" class="nav-link"
                        href="{{url_for('recognize_page')}}">Recognize</a>
                </li>


                {% if session['name'] %}
                <li class="nav-item">
                    <a style="text-decoration:none;" class="nav-link" href="{{url_for('logout')}}">Logout</a>
                </li>

                {% else %}
                <li class="nav-item">
                    <a style="text-decoration:none;" class="nav-link" href="{{url_for('login')}}">Login</a>
                </li>
```

```
                <li class="nav-item">
                    <a style="text-decoration:none;" class="nav-link" href="{{url_for('register')}}">Register</a>
                </li>
                {% endif %}

            </ul>
        </div>


    </div>
</nav>


<section id="banner">
    <div class=".particles-js-canvas-el" id="particles-js"></div>


    <div class="container zindex">



                <h1 id="ans">Predicted Number</h1>
                <p id="ans2">{{num}}</p>

        </div>
```

```
            </div>


        </div>

    </section>

    <section id="banner">
        <div class=".particles-js-canvas-el" id="particles-js"></div>
    </section>


    <!-- Optional JavaScript -->
    <script src="{{ url_for('static', filename='js/jquery-3.3.1.min.js') }}"></script>
    <script src="{{ url_for('static', filename='js/bootstrap.min.js') }}"></script>
    <script src="{{ url_for('static', filename='js/slick.min.js') }}"></script>
    <script src="{{ url_for('static', filename='js/particles.js') }}"></script>
    <script src="{{ url_for('static', filename='js/app.js') }}"></script>
    <script src="{{ url_for('static', filename='js/jquery.isotope.min.html') }}"></script>
    <script src="{{ url_for('static', filename='js/circular.js') }}"></script>
    <script src="{{ url_for('static', filename='js/custom.js') }}"></script>
</body>

</html>
```

```
                    <a style="text-decoration:none;" class="nav-link" href="{{url_for('login')}}">Login</a>
                </li>

                <li class="nav-item">
                    <a style="text-decoration:none;" class="nav-link" href="{{url_for('register')}}">Register</a>
                </li>
                {% endif %}

            </ul>
        </div>


    </div>
</nav>

<section id="banner">
    <div class=".particles-js-canvas-el" id="particles-js"></div>
    <div class="container zindex">
        <div class="row align-items-center">
            <div class="col-lg-7 banner-txt">

                <h5 style="color: aliceblue">Upload the handwritten Documents in the below link to detect the digits.</h5>
                    <hr>


                        <input style="border-radius:10px;height:40px;width:100px;font-family: 'Poppins', sans-serif;background: rgb(25
                    background: linear-gradient(90deg, rgba(255,85,0,1) 2%, rgba(237,109,20,1) 67%, rgba(246,128,0,1) 87%);border
```

```
            </div>

            <div class="col-lg-5">
                <div class="banner-img">
                    <img class="img-fluid" src="{{ url_for('static', filename='images/pencil.png') }}"
                        alt="banner-img">
                </div>
            </div>
        </div>
    </div>

</section>


<section id="banner">
    <div class=".particles-js-canvas-el" id="particles-js"></div>
</section>


<!-- Optional JavaScript -->
<script src="{{ url_for('static', filename='js/jquery-3.3.1.min.js') }}"></script>
<script src="{{ url_for('static', filename='js/bootstrap.min.js') }}"></script>
<script src="{{ url_for('static', filename='js/slick.min.js') }}"></script>
<script src="{{ url_for('static', filename='js/particles.js') }}"></script>
<script src="{{ url_for('static', filename='js/app.js') }}"></script>
<script src="{{ url_for('static', filename='js/jquery.isotope.min.html') }}"></script>
<script src="{{ url_for('static', filename='js/circular.js') }}"></script>
<script src="{{ url_for('static', filename='js/custom.js') }}"></script>
</body>
```

6.UPLOAD.html

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

<head>
  <meta charset="UTF-8">
  <meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">
  <meta name="keywords"
    content="extract text, extract text in image, extract text image python, extract text python, image to text python, extractor python text, ex
  <meta name="description"
    content="TextExtractor it is software created to extract text from any type of image using python 3" />
  <title>Handwritten Digit Recognition System</title>
  <link rel="stylesheet" href="{{ url_for('static', filename='css/font-awesome.min.css') }}">
  <link rel="stylesheet" href="{{ url_for('static', filename='css/bootstrap.min.css') }}">
  <link rel="stylesheet" href="{{ url_for('static', filename='css/slick.css') }}">
  <link rel="stylesheet" href="{{ url_for('static', filename='css/style.css') }}">
  <link rel="stylesheet" href="{{ url_for('static', filename='css/responsive.css') }}">
  <link href="https://fonts.googleapis.com/css?family=Poppins&display=swap" rel="stylesheet">
  <link rel="icon" type="image/png" sizes="192x192" href="/android-icon-192x192.png">
  <link rel="icon" href="{{ url_for('static', filename='images/favicon.ico') }}" type="image/x-icon" />
  <style>
    #clear_button {
      margin-left: 15px;
      font-weight: bold;
      color: blue;
    }

    #confidence {
      font-family: 'Josefin Sans', sans-serif;
    margin-top: 7.5%;
}

#content {
    margin: 0 auto;
    padding: 2% 15%;
    padding-bottom: 0;
}

.welcome {
    text-align: center;
    position: relative;
    color: black;
    background-color: rgba(0, 0, 0, 0.068);
    padding-top: 1%;
    padding-bottom: 1%;
    font-weight: bold;
    font-family: 'Prompt', sans-serif;
}

#team_id {
    text-align: right;
    font-size: 25px;
    padding-right: 3%;
}

#predict_button {
    margin-right: 15px;
```

```
  color: blue;
  font-weight: bold;
}

#prediction_heading {
  font-family: 'Josefin Sans', sans-serif;
  margin-top: 7.5%;
}

#result {
  font-size: 5rem;
}

#title {
  padding: 1.5% 15%;
  margin: 0 auto;
  text-align: center;
}

.btn {
  font-size: 15px;
  padding: 10px;

  background: #eee;
  border: 1px solid #888;
  margin-top: 20px;
  margin-bottom: 20px;
}
```

```
.buttons_div {
  margin-bottom: 30px;
  margin-right: 80px;
}

.heading {
  font-family: 'Varela Round', sans-serif;
  font-weight: 700;
  font-size: 2rem;
  display: inline;
}

.leftside {
  text-align: center;
  margin: 0 auto;
  margin-top: 2%;
  /* padding-left: 10%; */
}

#frame {
  margin-right: 10%;
}

.predicted_answer {
  text-align: center;
  margin: 0 auto;
  padding: 3% 5%;
  padding-top: 0;
```

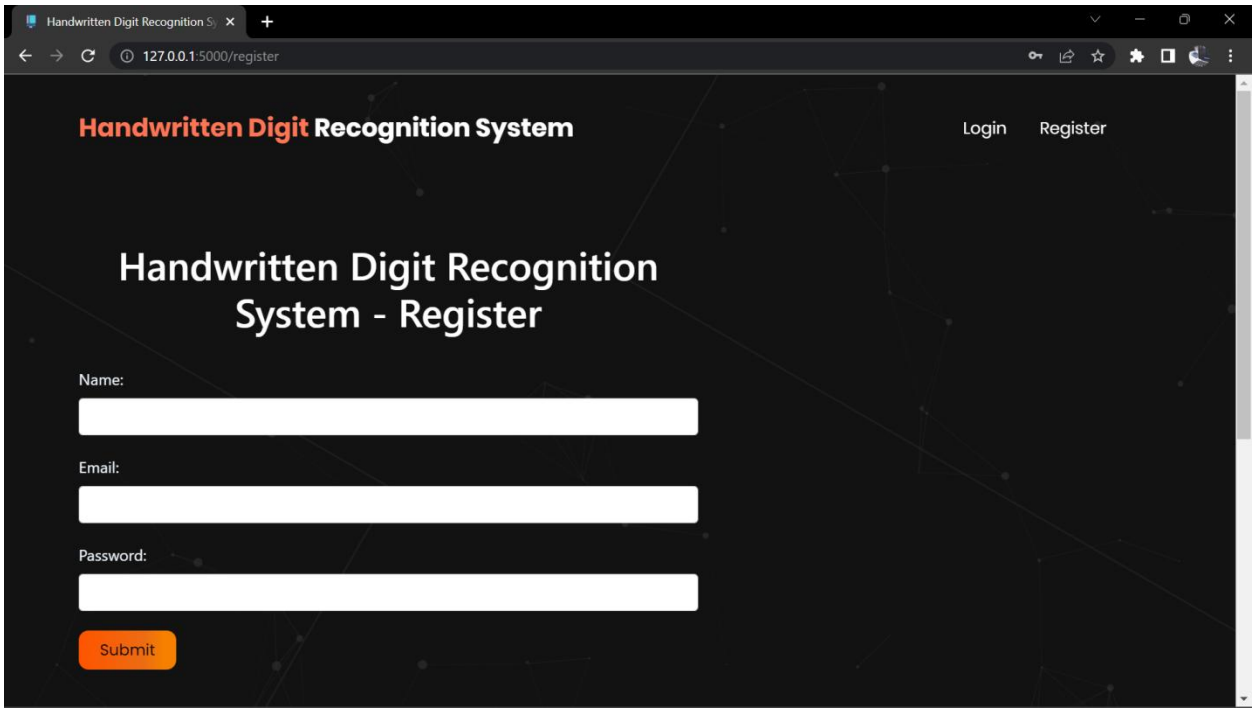
```
    p {
      font-family: 'Source Code Pro', monospace, sans-serif;
      margin-top: 1%;
    }

    @media (min-width: 720px) {
      .leftside {
        padding-left: 10%;
      }
    }
  </style>
</head>


<script>
  function preview() {
    frame.src = URL.createObjectURL(event.target.files[0]);
  }

  $(document).ready(function () {
    $('#clear_button').on('click', function () {
      $('#image').val('');
      $('#frame').attr('src', "");
    });
  });

</script>
```

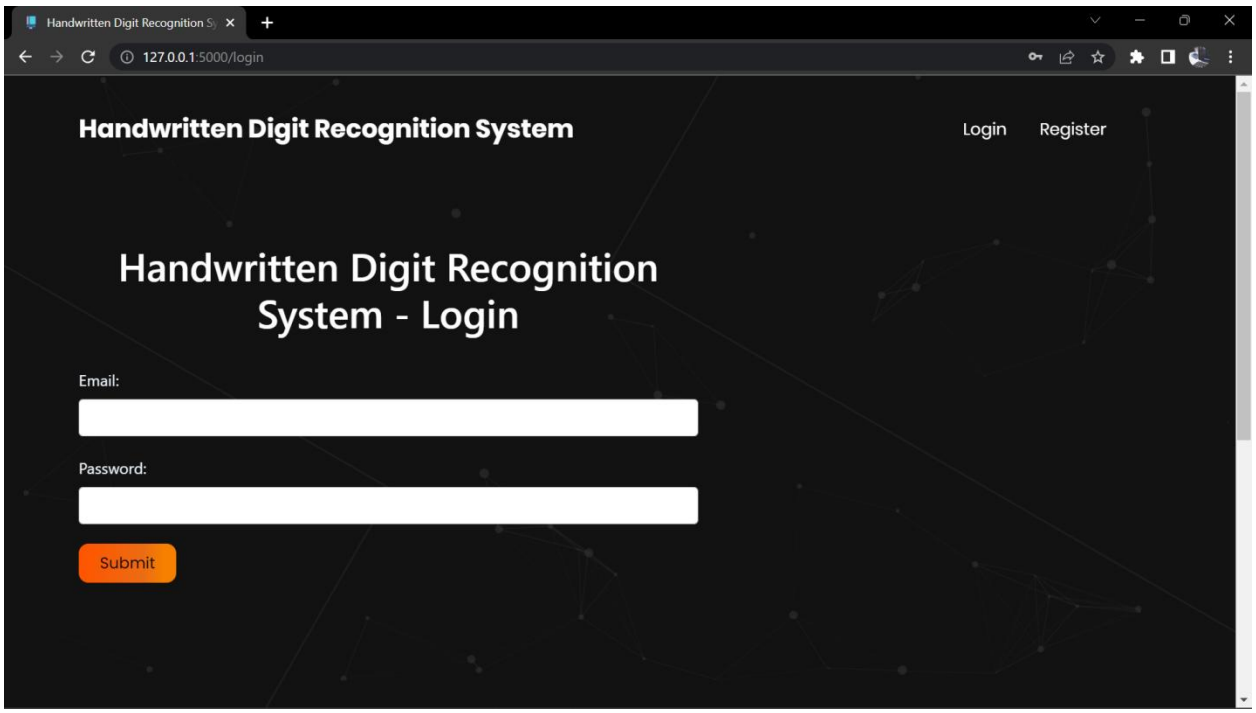
```
<body id="dark-mode">
  <div class="preloader">
    <div class="frame">
      <div class="center">
        <div class="dot-1"></div>
        <div class="dot-2"></div>
        <div class="dot-3"></div>
      </div>
    </div>
  </div>
  <nav class="navbar navbar-expand-lg navbar-light bg-light sticky-top">
    <div class="container">
      <a style="text-decoration:none;" class="navbar-brand" href="/"><b>Handwritten Digit </b>Recognition
        System</a>
      <button class="navbar-toggler" type="button" data-toggle="collapse" data-target="#navbarSupportedContent"
        aria-controls="navbarSupportedContent" aria-expanded="false" aria-label="Toggle navigation">
        <i class="fa fa-bars" aria-hidden="true"></i>
      </button>
      <div class="collapse navbar-collapse menu-main" id="navbarSupportedContent">
        <ul class="navbar-nav ml-auto menu-item">
          <li class="nav-item">
            <a style="text-decoration:none;" class="nav-link" href="{{url_for('recognize_page')}}">Recognize</a>
          </li>


          {% if session['name'] %}
          <li class="nav-item">
            <a style="text-decoration:none;" class="nav-link" href="{{url_for('logout')}}">Logout</a>
```

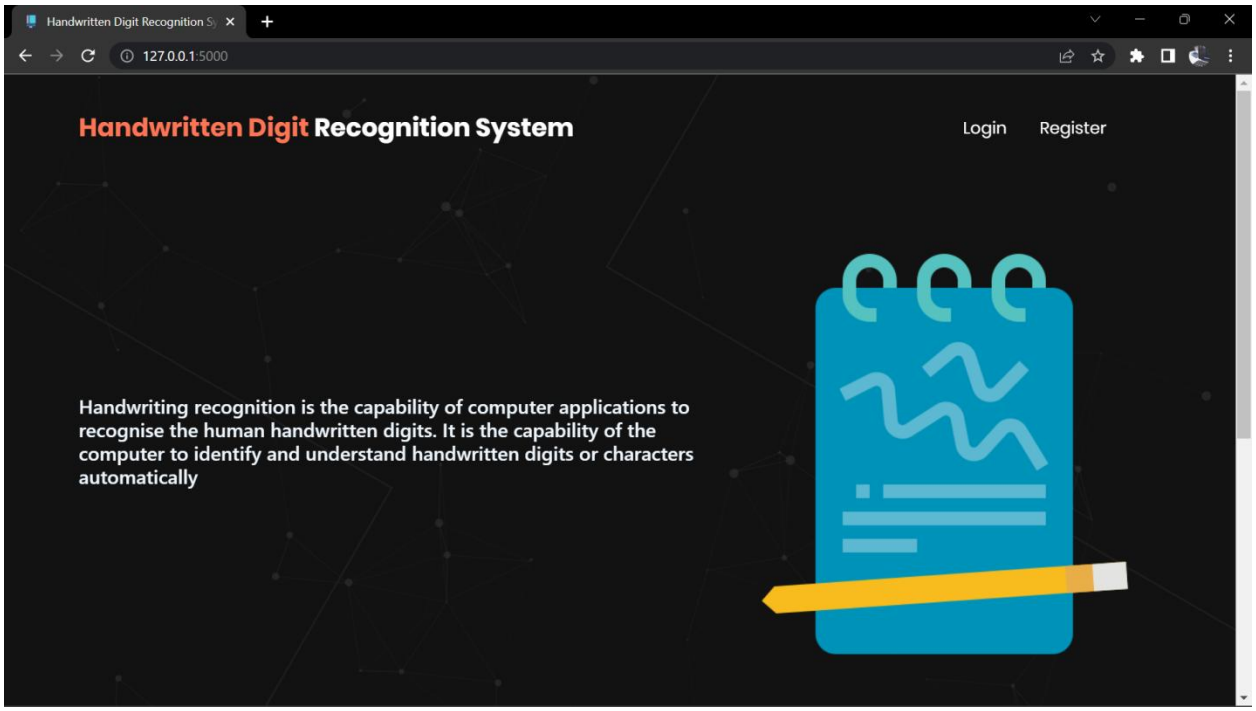
```
        <li class="nav-item">
          <a style="text-decoration:none;" class="nav-link" href="{{url_for('register')}}">Register</a>
        </li>
        {% endif %}
      </ul>
    </div>
  </div>
</nav>

<section id="banner">
  <div class=".particles-js-canvas-el" id="particles-js">
    <div class="container zindex">
      <div class="content-container">

        <section id="banner">
          <div class=".particles-js-canvas-el" id="particles-js">

          </div>


          <div class="container zindex">
            <div class="row align-items-center">
              <div class="col-lg-7 banner-txt">
                <h3>Upload Image</h3>
                <form action={{ url_for('upload') }} method="post" enctype="multipart/form-data">
                  <input style="border-radius:20px;font-family: 'Poppins', sans-serif;" type="file" name="imagefile"
                    value="{{request.form.imagefile}}" id="fileToUpload">
```

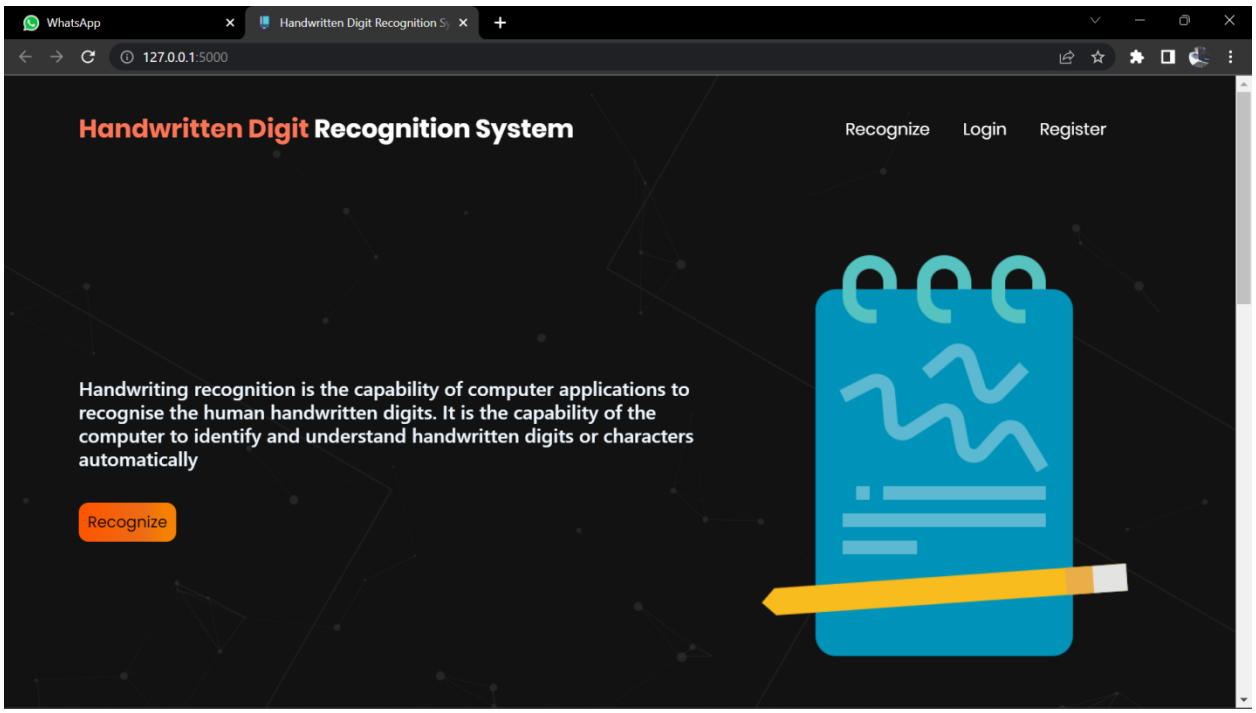
```
                </div>
                <div class="col-lg-5">
                  <div class="banner-img">
                    <img class="img-fluid" src="{{ url_for('static', filename='images/pencil.png') }}" alt="banner-img">
                  </div>
                </div>

              </div>
            </div>
          </section>
        </div>
      </div>
    </div>
  </section>

  <section id="banner">
    <div class=".particles-js-canvas-el" id="particles-js"></div>
  </section>


        <!-- Optional JavaScript -->
        <script src="{{ url_for('static', filename='js/jquery-3.3.1.min.js') }}"></script>
        <script src="{{ url_for('static', filename='js/bootstrap.min.js') }}"></script>
        <script src="{{ url_for('static', filename='js/slick.min.js') }}"></script>
        <script src="{{ url_for('static', filename='js/particles.js') }}"></script>
        <script src="{{ url_for('static', filename='js/app.js') }}"></script>
        <script src="{{ url_for('static', filename='js/jquery.isotope.min.html') }}"></script>
        <script src="{{ url_for('static', filename='js/circular.js') }}"></script>
        <script src="{{ url_for('static', filename='js/custom.js') }}"></script>
</body>
```

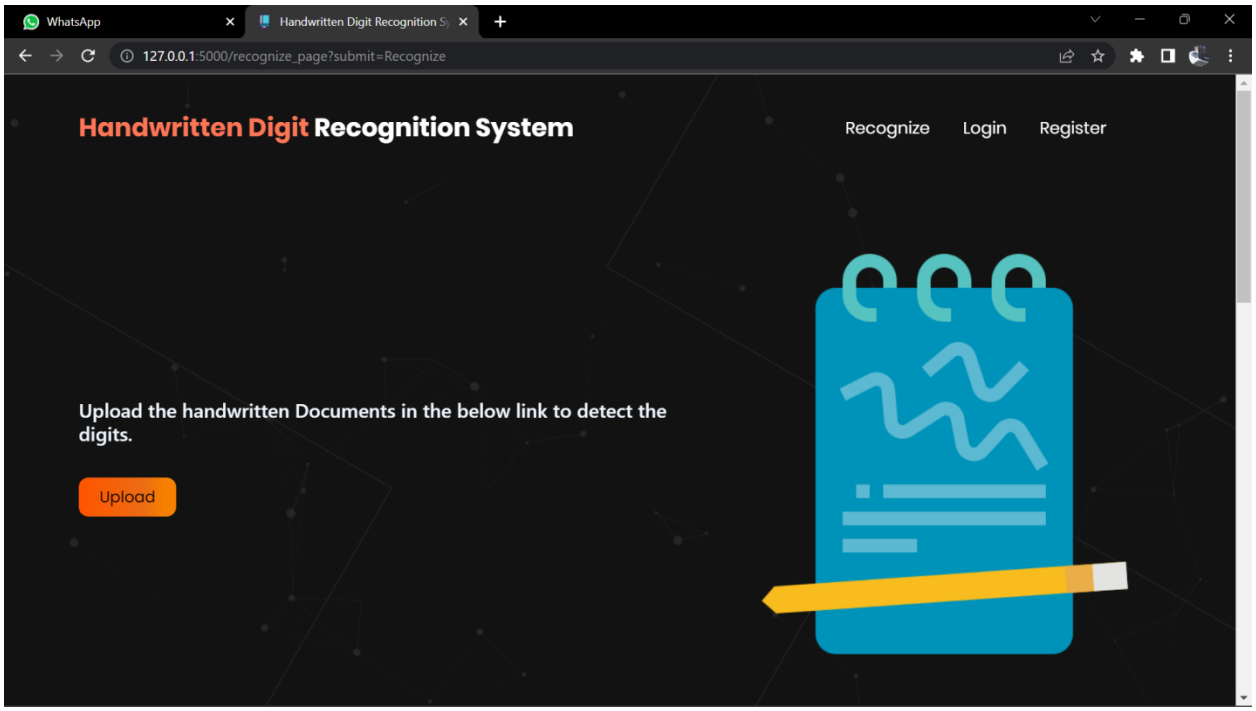
SCREENSHOTS:

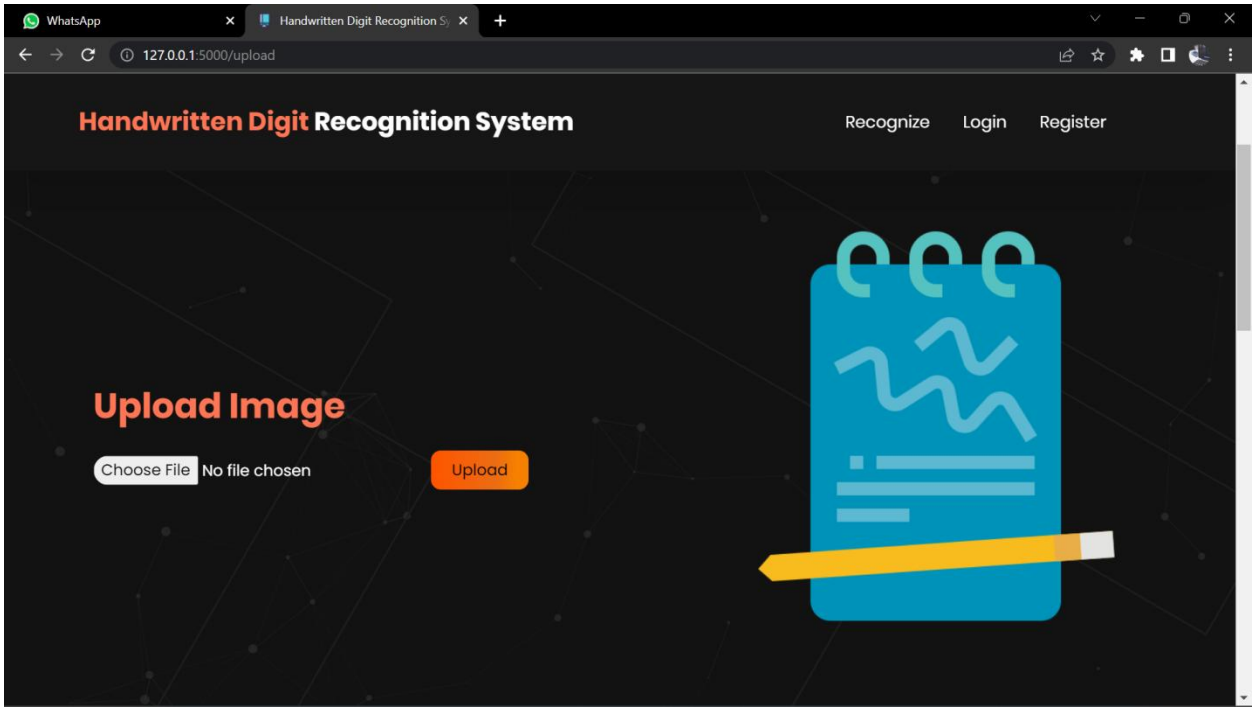


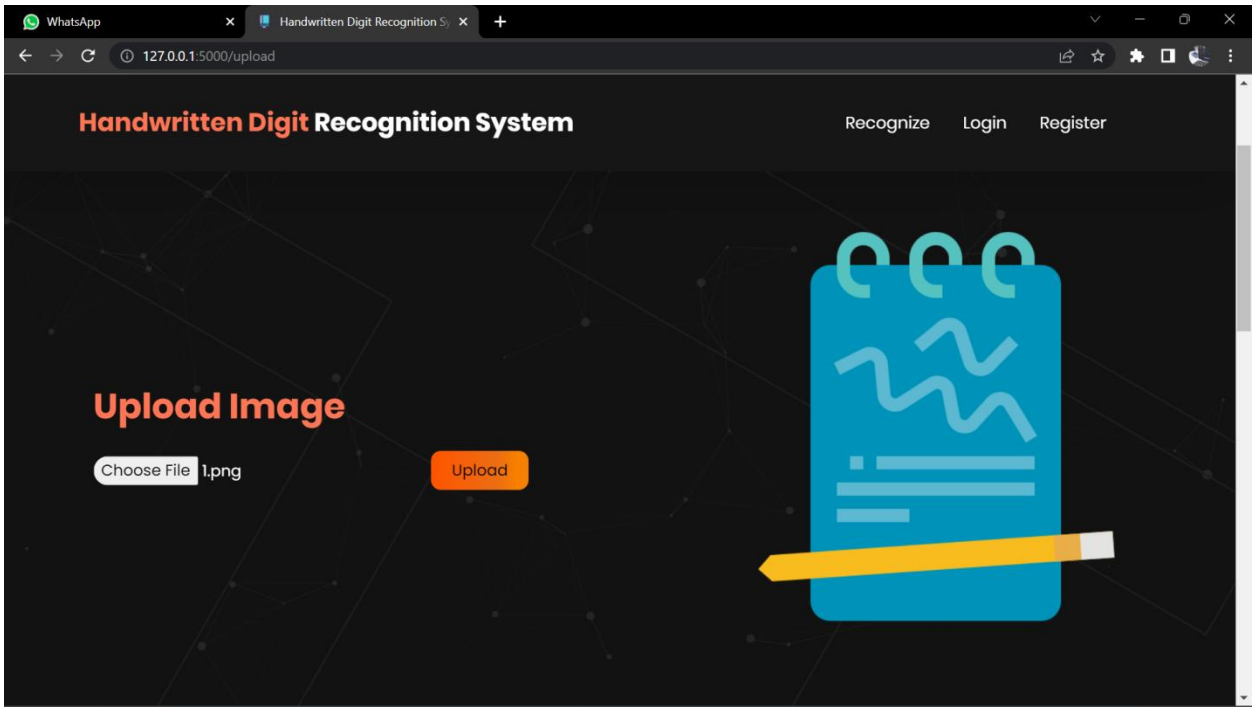


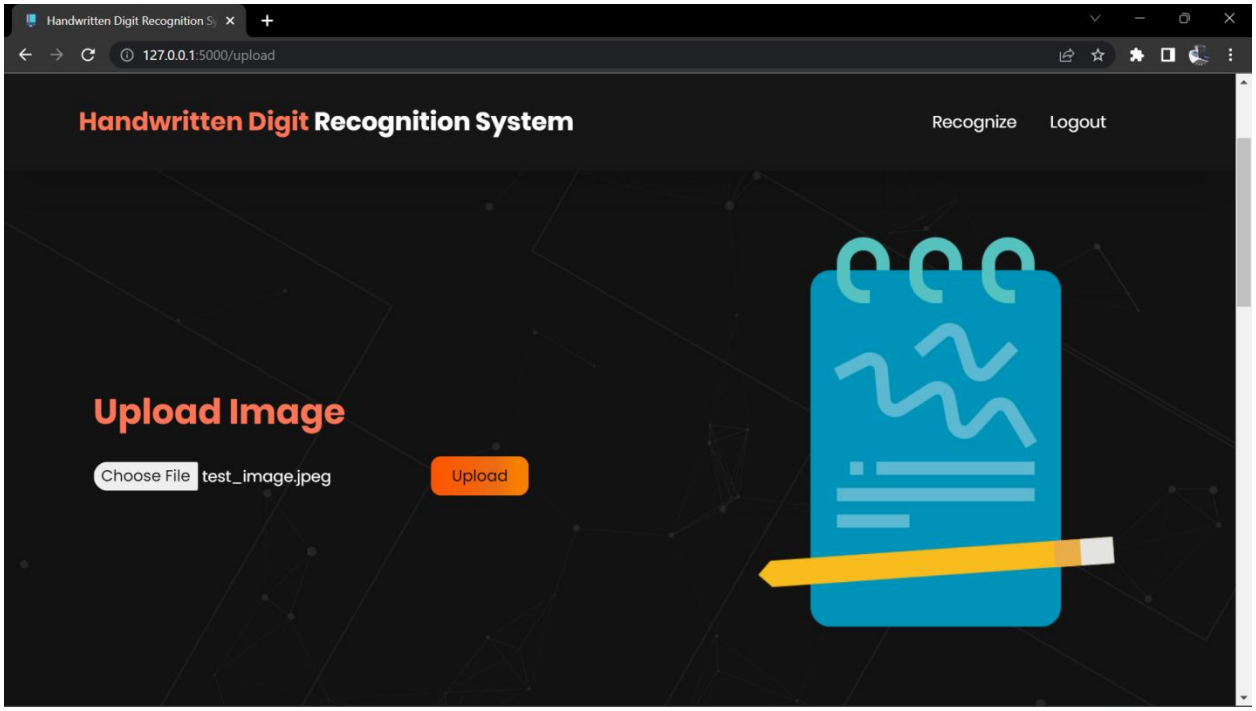

Handwritten Digit Recognition Sy
127.0.0.1:5000
Handwritten Digit Recognition System
Login
Register
Handwriting recognition is the capability of computer applications to recognise the human handwritten digits. It is the capability of the computer to identify and understand handwritten digits or characters automatically

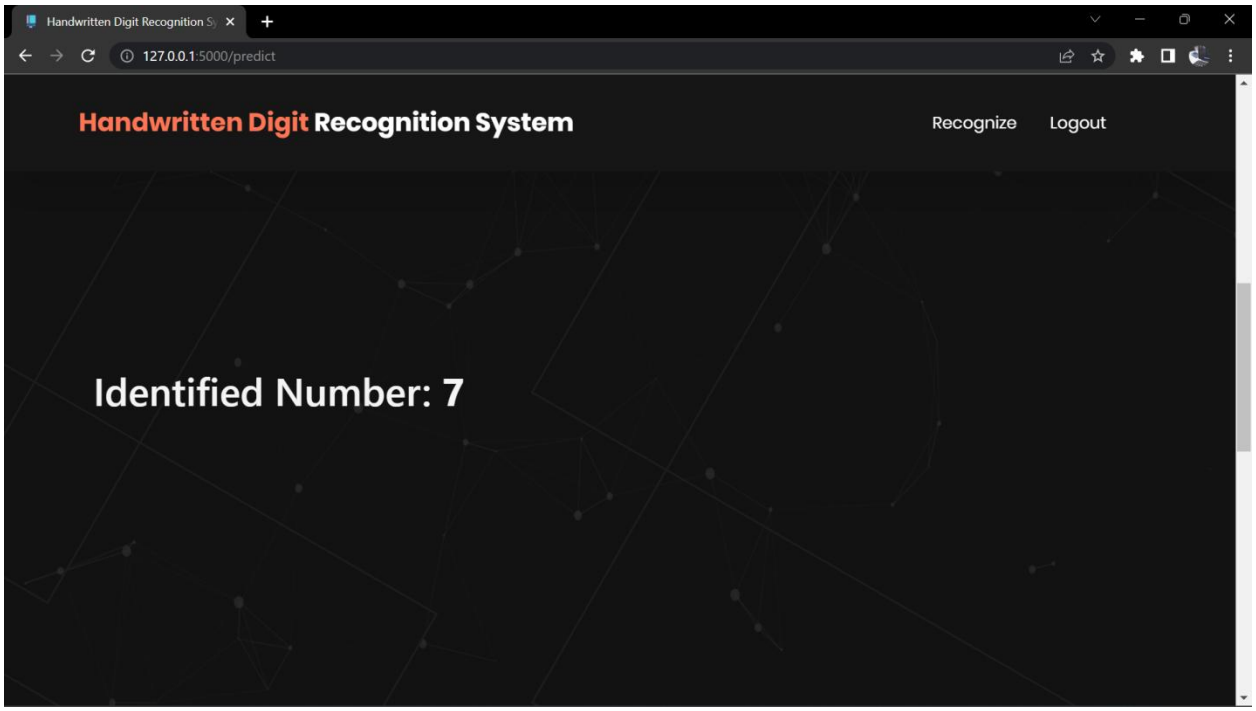

WhatsApp
Handwritten Digit Recognition Sy
127.0.0.1:5000
Handwritten Digit Recognition System
Recognize
Login
Register
Handwriting recognition is the capability of computer applications to recognise the human handwritten digits. It is the capability of the computer to identify and understand handwritten digits or characters automatically
Recognize


WhatsApp
Handwritten Digit Recognition Sy
127.0.0.1:5000/recognize_page?submit=Recognize
Handwritten Digit Recognition System
Recognize
Login
Register
Upload the handwritten Documents in the below link to detect the digits.
Upload


WhatsApp
Handwritten Digit Recognition Sy
127.0.0.1:5000/upload
Handwritten Digit Recognition System
Recognize
Login
Register
Upload Image
Choose File
No file chosen
Upload


WhatsApp
Handwritten Digit Recognition Sy
127.0.0.1:5000/upload
Handwritten Digit Recognition System
Recognize
Login
Register
Upload Image
Choose File
1.png
Upload


Handwritten Digit Recognition Sy
127.0.0.1:5000/upload
Handwritten Digit Recognition System
Recognize
Logout
Upload Image
Choose File
test_image.jpeg
Upload



GitHub & Project Demo Link

GitHub Link

https://github.com/IBM-EPBL/IBM-Project-3892-1658669870

Demo Video

https://drive.google.com/drive/folders/1LL9gH0bFg7IKzoPHgXgy56UjCO-IE4d0?usp=sharing