RMD.ENGINEERING COLLEGE

A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION

A Novel Method for Handwritten Digit Recognition System

submitted by PNT2022TMID15217

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CHAPTER 1
INTRODUCTION

PROJECT OVERVIEW

Machine learning and deep learning play an important role in computer technology and artificial intelligence. With the use of deep learning and machine learning, human effort can be reduced in recognizing, learning, predictions and in many more areas.

Handwritten Digit Recognition is the ability of computer systems to recognise handwritten 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.

PURPOSE

Digit recognition systems are capable of recognizing the digits from different sources like emails, bank cheque, papers, images, etc. and in different real-world scenarios for online handwriting recognition on computer tablets or system, recognize number plates of vehicles, processing bank cheque amounts, numeric entries in forms filled up by hand (tax forms) and so on.

CHAPTER 2
LITERATURE SURVEY

EXISTING PROBLEM

The fundamental problem with handwritten digit recognition is that handwritten digits do not always have the same size, width, orientation, and margins since they vary from person to person. Additionally, there would be issues with identifying the numbers because of similarities between numerals like 1 and 7, 5 and 6, 3 and 8, 2 and 5, 2 and 7, etc. Finally, the individuality and variation of each individual's handwriting influence the structure and appearance of the digits.

REFERENCES

R. Bajaj, L. Dey, S. Chaudhari et al, employed three different kinds of features, namely, the density features, moment features and descriptive component features for c lassification of Devanagari Numerals. They proposed multi classifier connectionist architecture for increasing the recognition reliability and they obtained 89.6% accuracy for handwritten Devanagari numerals.

Aparna et al, proposed a method to construct a handwritten Tamil character by executing a sequence of strokes. A structure or shape-based representation of a stroke was used in which a stroke was represented as a string of shape features. Using this string

representation, an unknown stroke was identified by comparing it with a database of strokes using a flexible string matching procedure.

Renata F. P. Neves has proposed SVM based offline handwritten digit recognition. Authors claim that SVM outperforms the Multilayer perceptron classifier. Experiment is carried out on NIST SD19 standard dataset. Advantage of MLP is that it is able to segment non-linearly separable classes. However, MLP can easily fall into a region of local minimum, where the training will stop assuming it has achieved an optimal point in the error surface. Another hindrance is defining the best network architecture to solve the problem, considering the number of layers and the number of perceptrons in each hidden layer. Because of these disadvantages, a digit recognizer using the MLP structure may not produce the desired low error rate.

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

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.

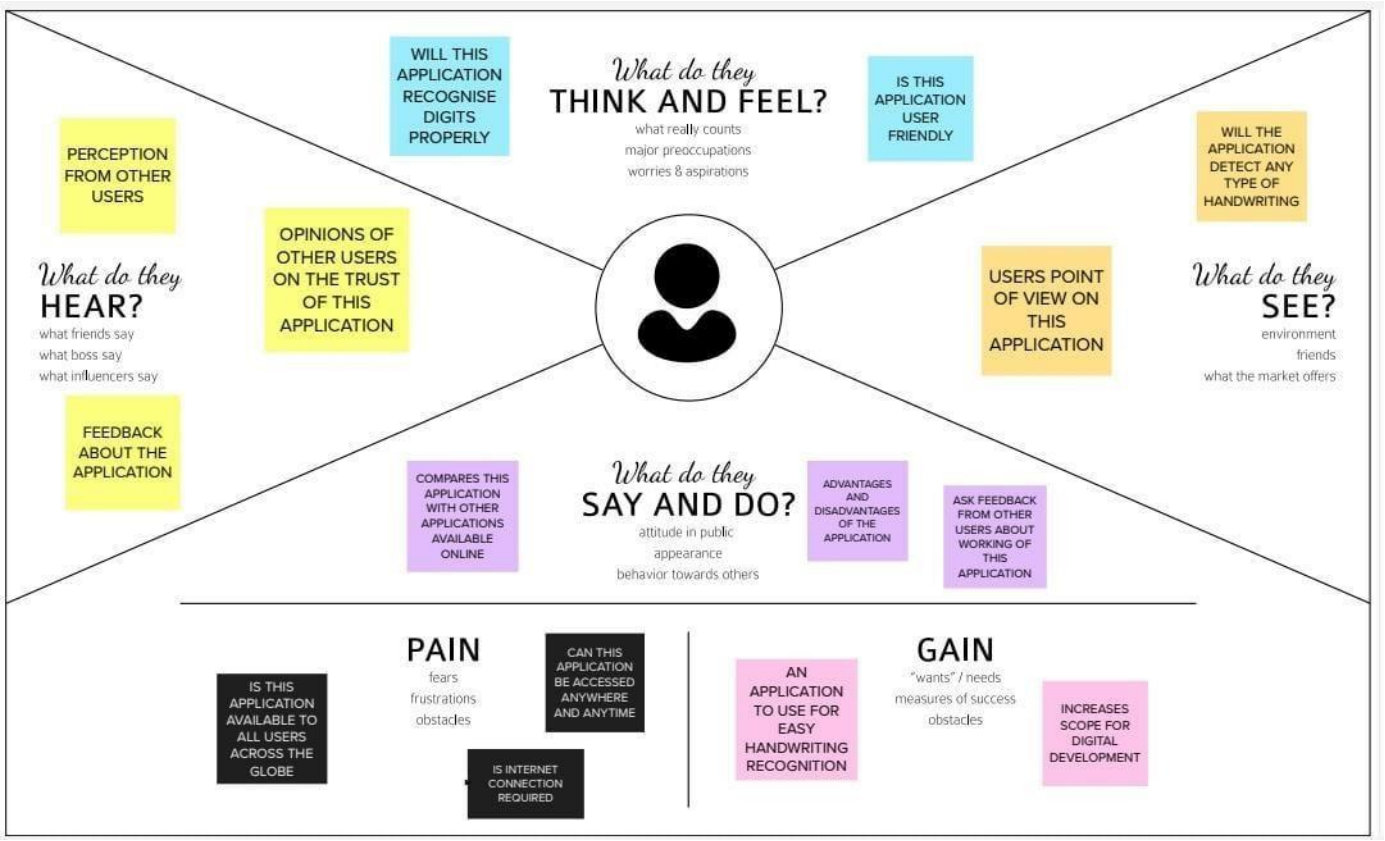
PROBLEM STATEMENT DEFINITION

For years, the traffic department has been combating traffic law violators. These offenders endanger not only their own lives, but also the lives of other individuals. Punishing these offenders is critical to ensuring that others do not become like them. Identification of these offenders is next to impossible because it is impossible for the average individual to write down the license plate of a reckless driver. Therefore, the goal of this project is to help the traffic department identify these offenders and reduce traffic violations as a result.

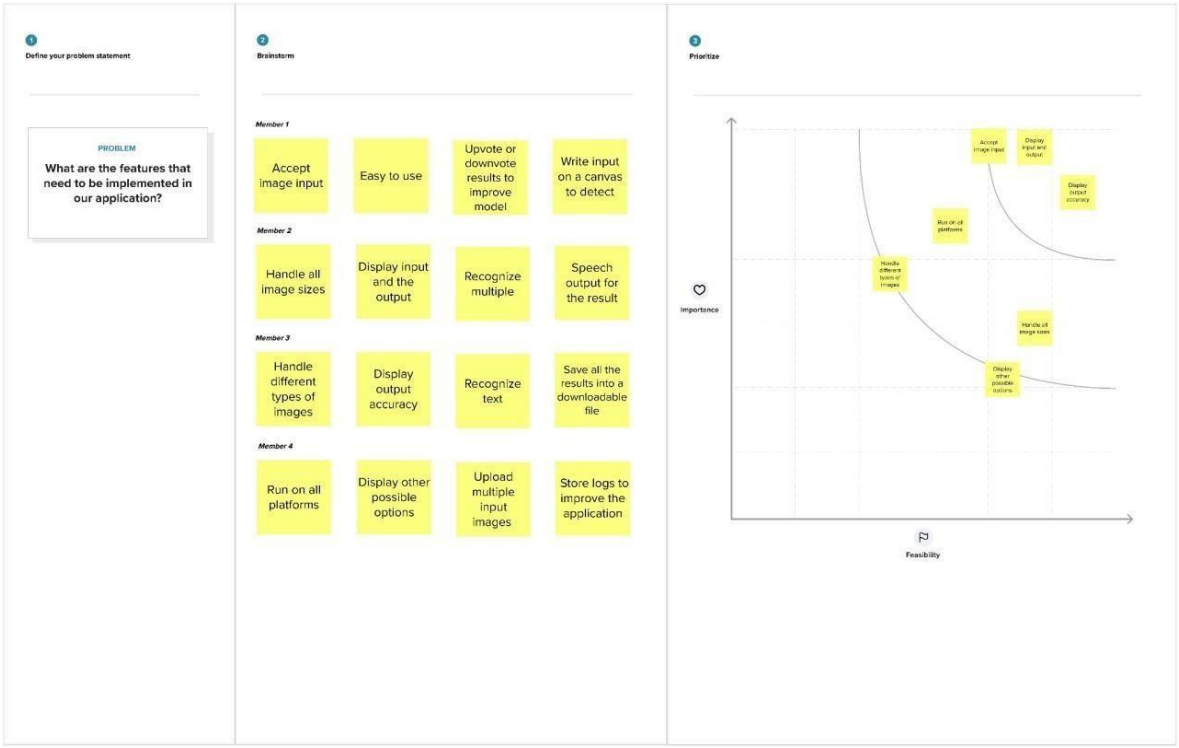
CHAPTER 3

IDEATION AND PROPOSED SOLUTION

EMPATHY MAP CANVAS



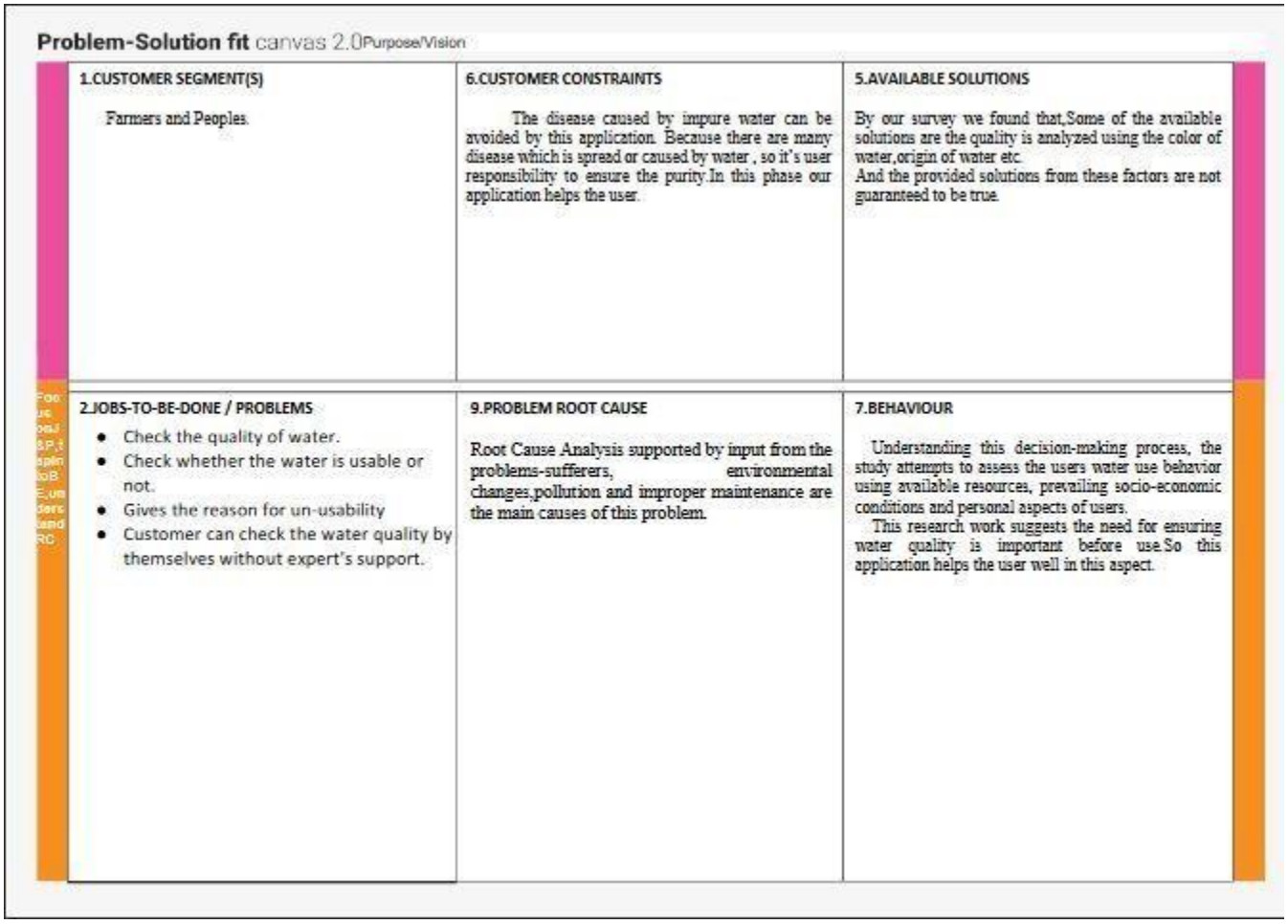
IDEATION & BRAINSTORMING



PROPOSED SOLUTION

S.NO	PARAMETER	DESCRIPTION
1	Problem Statement	To create an application that recognizes handwritten digits
2	Idea / Solution Description	The application takes an image as the input and accurately detects the digits in it.
3	Novelty / Uniqueness	Instead of recognizing every text, the application accurately recognizes only the digits
4	Social Impact / Customer Satisfaction	This application reduces the manual tasks that need to be performed. This improves productivity in the workplace.
5	Business Model	The application can be integrated with traffic surveillance cameras to recognize vehicle number plates The application can be integrated with Postal systems to recognize the pin codes effectively
6	Scalability of the Solution	The application can easily be scaled to accept multiple inputs and process them parallelly to further increase efficiency

PROBLEM SOLUTION FIT



Problem-Solution fit canvas 2.0 Purpose/Vision

1.CUSTOMER SEGMENT(S)

Farmers and Peoples.

6.CUSTOMER CONSTRAINTS

The disease caused by impure water can be avoided by this application. Because there are many disease which is spread or caused by water , so it's user responsibility to ensure the purity.In this phase our application helps the user.

5.AVAILABLE SOLUTIONS

By our survey we found that,Some of the available solutions are the quality is analyzed using the color of water,origin of water etc.
And the provided solutions from these factors are not guaranteed to be true.

2.JOBS-TO-BE-DONE / PROBLEMS

- Check the quality of water.
- Check whether the water is usable or not.
- Gives the reason for un-usability
- Customer can check the water quality by themselves without expert's support.

9.PROBLEM ROOT CAUSE

Root Cause Analysis supported by input from the problems-sufferers, environmental changes,pollution and improper maintenance are the main causes of this problem.

7.BEHAVIOUR

Understanding this decision-making process, the study attempts to assess the users water use behavior using available resources, prevailing socio-economic conditions and personal aspects of users.

This research work suggests the need for ensuring water quality is important before use.So this application helps the user well in this aspect.

Problem-Solution fit canvas 2.0Purpose/Vision

1.CUSTOMER SEGMENT(S)	6.CUSTOMER CONSTRAINTS	5.AVAILABLE SOLUTIONS
Farmers and Peoples.	The disease caused by impure water can be avoided by this application. Because there are many disease which is spread or caused by water , so it's user responsibility to ensure the purity.In this phase our application helps the user.	By our survey we found that,Some of the available solutions are the quality is analyzed using the color of water,origin of water etc. And the provided solutions from these factors are not guaranteed to be true.
2.JOBS-TO-BE-DONE / PROBLEMS • Check the quality of water. • Check whether the water is usable or not. • Gives the reason for un-usability • Customer can check the water quality by themselves without expert's support.	**9.PROBLEM ROOT CAUSE** Root Cause Analysis supported by input from the problems-sufferers, environmental changes,pollution and improper maintenance are the main causes of this problem.	**7.BEHAVIOUR** Understanding this decision-making process, the study attempts to assess the users water use behavior using available resources, prevailing socio-economic conditions and personal aspects of users. This research work suggests the need for ensuring water quality is important before use.So this application helps the user well in this aspect.

CHAPTER 4

REQUIREMENT ANALYSIS

FUNCTIONAL REQUIREMENTS

Following are the functional requirements of the proposed solution.

FR No.	Sub Requirement (Story / Sub-Task)
FR-1	Image Data: Handwritten digit recognition alludes to a PC's ability to recognize human transcribed digits from different sources, for example, photos, reports, contact screens, and so on, and classify them into ten laid out orders (0-9). In the realm of deep learning, this has been the subject of endless examinations.
FR-2	Website: Web facilitating makes the code, illustrations, and different things that make up a site open on the web. A server has each site you've at any point visited. The kind of facilitating decides how much space is designated to a site on a server. Shared, devoted, VPS, and affiliate facilitating are the four fundamental assortments.
FR-3	Digit Classifier Model: To prepare a convolutional network to foresee the digit from a picture, utilize the MNIST information base of manually written digits. get the preparation and approval information first.
FR-4	Cloud: The cloud offers a scope of IT administrations, including virtual capacity, organizing, servers, information bases, and applications. In plain English, cloud computing is portrayed as a virtual stage that empowers limitless capacity and admittance to your information over the web.
FR-5	Modified National Institute of Standards and Technology dataset: The abbreviation MNIST stands for the MNIST dataset. It is a collection of 60,000 tiny square grayscale photographs, each measuring 28 by 28, comprising handwritten single digits between 0 and 9.

NON FUNCTIONAL REQUIREMENTS

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

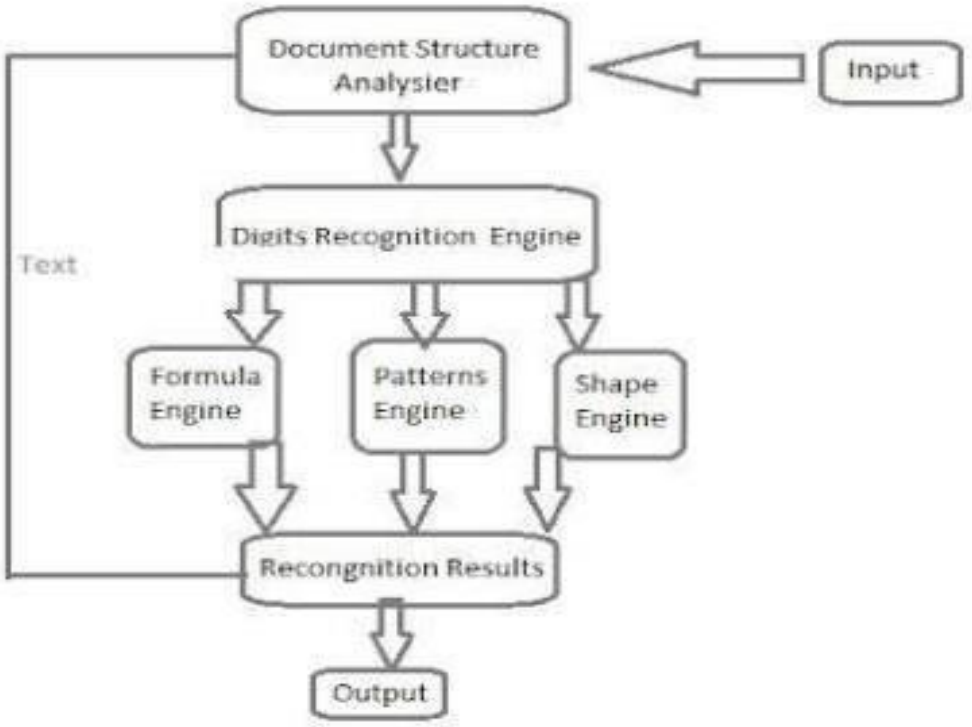
FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	One of the extremely critical issues in design acknowledgment applications is the acknowledgment of written by hand characters. Applications for digit acknowledgment incorporate finishing up structures, handling bank checks, and arranging mail.
NFR-2	**Security**	The framework creates an exhaustive portrayal of the launch boundaries.
NFR-3	**Reliability**	The examples are utilized by the brain organization to reason rules for perusing written by hand digits consequently. Besides, the organization might more deeply study penmanship and subsequently upgrade its exactness by expanding the amount of preparing examples. Numerous techniques and algorithms, such as Deep Learning/CNN, SVM, Gaussian Naive Bayes, KNN, Decision Trees, Random Forests, etc., can be used to recognize handwritten numbers.

NFR-4	**Performance**	The web application is created to provide a smooth user experience and make clients satisfied with the digit recognition service.
NFR-5	**Availability**	The web application will be available for everyone who owns a smart device with internet connection 24/7
NFR-6	**Scalability**	Scalability of the web application depends on the server size and datasets provided to the web application.

CHAPTER 5

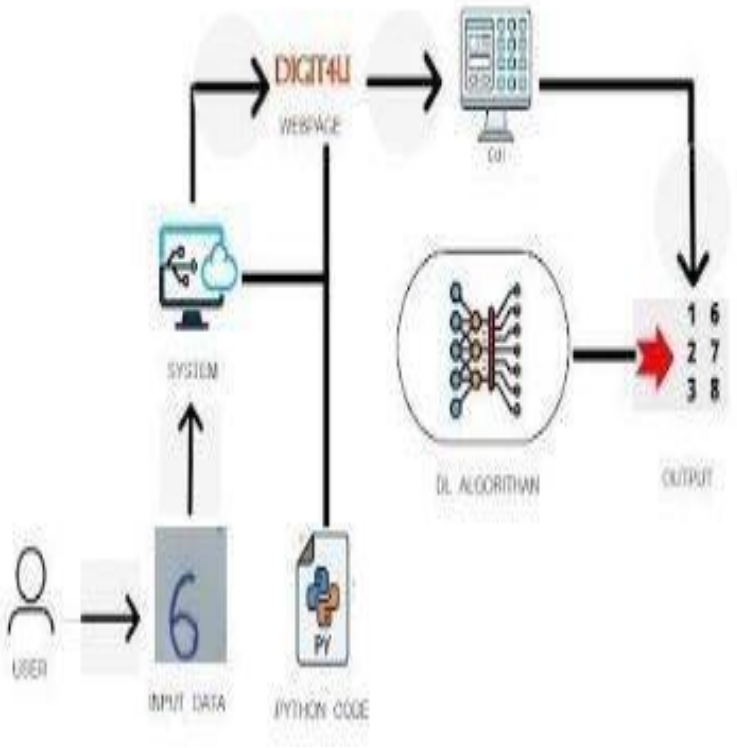
PROJECT DESIGN

DATA FLOW DIAGRAM



SOLUTION & TECHNICAL ARCHITECTURE

Technical Architecture:



USER STORIES

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

CHAPTER 6

PROJECT PLANNING AND SCHEDULING

SPRINT PLANNING AND ESTIMATION

SPRINT	USER STORY / TASK	STORY POINTS	PRIORITY	TEAM MEMBERS
Sprint – I	Get the dataset	3	High	Chidvilas
	Explore the data	2	Medium	Chidvilas dinesh
	Data Pre-Processing	3	High	Charan nikhil
	Prepare training and testing data	3	High	dinesh nikhil
Sprint – II	Create the model	3	High	nikhil
	Train the model	3	High	charan
	Test the model	3	High	dinesh
Sprint – III	Improve the model	2	Medium	Chidvilas charan
	Save the model	3	High	dinesh
	Build the Home Page	3	High	nikhil
	Setup a database to store input images	2	Medium	charan
Sprint – IV	Build the results page	3	High	Chidvilas nikhil

	Integrate the model with the application	3	High	Dinesh charan
	Test the application	3	High	nikhil

SPRINT DELIVERY SCHEDULE

SPRINT	TOTAL STORY POINTS	DURATION	SPRINT START DATE	SPRINT END DATE (PLANNED)	STORY POINTS COMPLETED (AS ON PLANNED DATE)	SPRINT RELEASE DATE (ACTUAL)
Sprint – I	11	6 Days	24 Oct 2022	29 Oct 2022	11	29 Oct 2022
Sprint – II	9	6 Days	31 Oct 2022	05 Nov 2022	9	05 Nov 2022
Sprint – III	10	6 Days	07 Oct 2022	12 Nov 2022	10	12 Nov 2022
Sprint – IV	9	6 Days	14 Nov 2022	19 Nov 2022	9	19 Nov 2022

CHAPTER 7

CODING & SOLUTIONING

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

```

```
UPLOAD_FOLDER = 'C:/Users/Dell/PycharmProjects/A-novel-method-for-digit-recognition-system/flask_app/uploads'


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

model = load_model("mnistCNN.h5")


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


```

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


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

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

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

        pred = model.predict(im2arr)

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

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


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

```

CHAPTER 8
TESTING

TEST CASES

Test case ID	Feature Type	Test Scenario	Expected Result	Actual Result	Status
HP_TC_001	UI	Verify UI elements in the Home Page	The Home page must be displayed properly	Working as expected	FAIL
HP_TC_002	UI	Check if the UI elements are displayed properly in different screen sizes	The Home page must be displayed properly in all sizes	The UI is not displayed properly in screen size 2560 x 1801 and 768 x 630	FAIL
HP_TC_003	Functional	Check if user can upload their file	The input image should be uploaded to the application successfully	Working as expected	PASS
HP_TC_004	Functional	Check if user cannot upload unsupported files	The application should not allow user to select a non image file	User is able to upload any file	FAIL
HP_TC_005	Functional	Check if the page redirects to the result page once the input is given	The page should redirect to the results page	Working as expected	PASS

BE_TC_001	Functional	Backend	Check if all the routes are working properly	All the routes should properly work	Working as expected	PASS
M_TC_001	Functional	Model	Check if the model can handle various image sizes	The model should rescale the image and predict the results	Working as expected	PASS
M_TC_002	Functional	Model	Check if the model predicts the digit	The model should predict the number	Working as expected	PASS
M_TC_003	Functional	Model	Check if the model can 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	FAIL
RP_TC_001	UI	Result Page	Verify UI elements in the Result Page	The Result page must be displayed properly	Working as expected	PASS
RP_TC_002	UI	Result Page	Check if the input image is displayed properly	The input image should be displayed properly	The size of the input image exceeds the display container	FAIL
RP_TC_003	UI	Result Page	Check if the result is displayed properly	The result should be displayed properly	Working as expected	PASS
RP_TC_004	UI	Result Page	Check if the other predictions are displayed properly	The other predictions should be displayed properly	Working as expected	PASS

USER ACCEPTANCE TESTING

DEFECT ANALYSIS

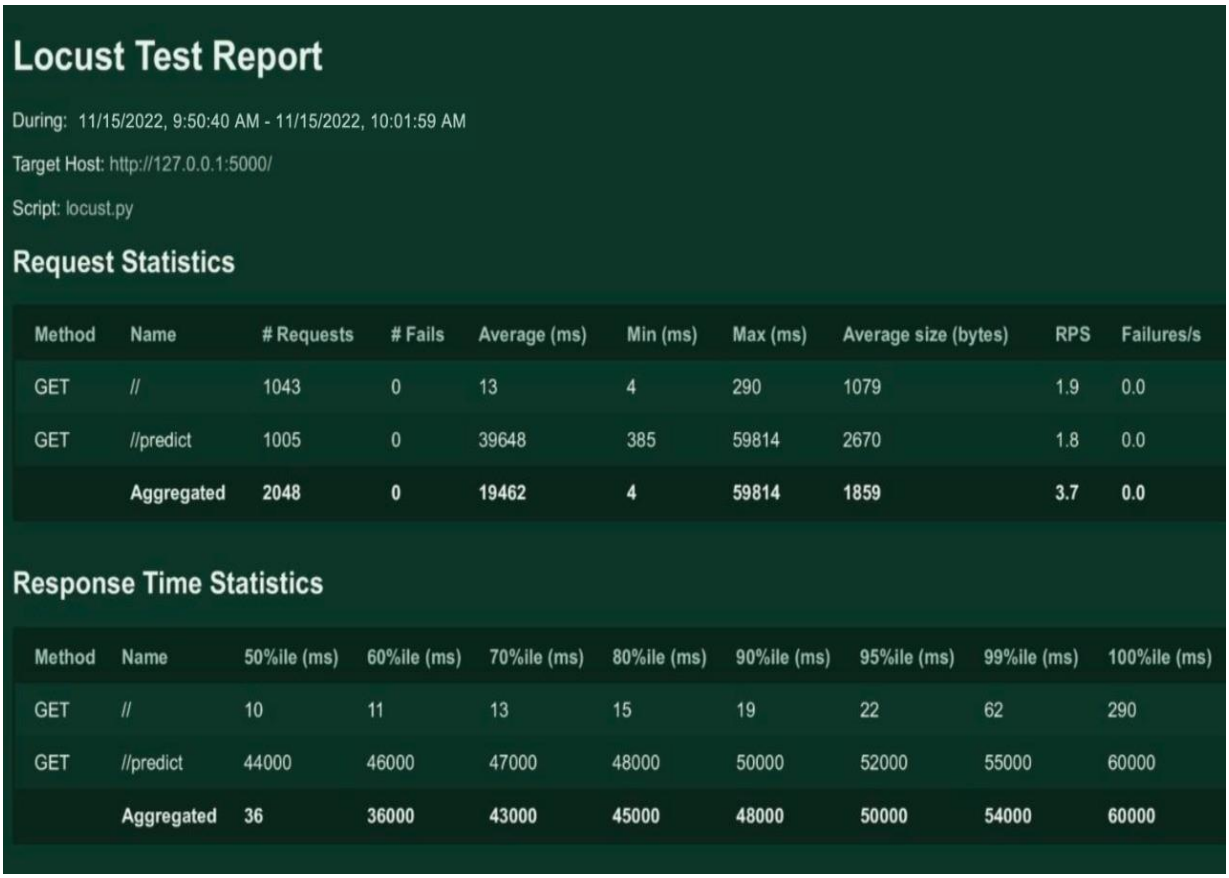
Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Total
By Design	1	0	1	0	2
Duplicate	0	0	0	0	0
External	0	0	2	0	2
Fixed	4	1	0	1	6
Not Reproduced	0	0	0	1	1
Skipped	0	0	0	1	1
Won't Fix	1	0	1	0	2
Total	6	1	4	3	14

TEST CASE ANALYSIS

Section	Total Cases	Not Tested	Fail	Pass
Client Application	10	0	3	7
Security	2	0	1	1
Performance	3	0	1	2
Exception Reporting	2	0	0	2

CHAPTER 9
RESULTS

PERFORMANCE METRICS



Locust Test Report

During: 11/15/2022, 9:50:40 AM - 11/15/2022, 10:01:59 AM

Target Host: http://127.0.0.1:5000/

Script: locust.py

Request Statistics

Method	Name	# Requests	# Fails	Average (ms)	Min (ms)	Max (ms)	Average size (bytes)	RPS	Failures/s
GET	//	1043	0	13	4	290	1079	1.9	0.0
GET	//predict	1005	0	39648	385	59814	2670	1.8	0.0
	Aggregated	**2048**	**0**	**19462**	**4**	**59814**	**1859**	**3.7**	**0.0**

Response Time Statistics

Method	Name	50%ile (ms)	60%ile (ms)	70%ile (ms)	80%ile (ms)	90%ile (ms)	95%ile (ms)	99%ile (ms)	100%ile (ms)
GET	//	10	11	13	15	19	22	62	290
GET	//predict	44000	46000	47000	48000	50000	52000	55000	60000
	Aggregated	**36**	**36000**	**43000**	**45000**	**48000**	**50000**	**54000**	**60000**


Charts
Total Requests per Second
RPS
Failures/s
6
5
4
3
2
1
0
9:50:40 AM
9:51:33 AM
9:52:38 AM
9:53:27 AM
9:54:22 AM
9:55:18 AM
9:58:27 AM
9:59:22 AM
10:00:18 AM
10:01:05 AM
Response Times (ms)
Median Response Time
95% percentile
60,000
50,000
40,000
30,000
20,000
10,000
0
9:50:40 AM
9:51:33 AM
9:52:38 AM
9:53:27 AM
9:54:22 AM
9:55:18 AM
9:58:27 AM
9:59:22 AM
10:00:18 AM
10:01:05 AM
Number of Users
Users
120
100
80
60
40
20
0
9:50:40 AM
9:51:33 AM
9:52:38 AM
9:53:27 AM
9:54:22 AM
9:55:18 AM
9:58:27 AM
9:59:22 AM
10:00:18 AM
10:01:05 AM

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

MODEL CREATION

```
import numpy as np
import tensorflow #open source used for both ML and DL for computation
from tensorflow.keras.datasets import mnist #mnist dataset
from tensorflow.keras.models import Sequential #it is a plain stack of layers
from tensorflow.keras import layers #A Layer consists of a tensor- in tensor-out computat ion funct ion
from tensorflow.keras.layers import Dense, Flatten #Dense-Dense Layer is the regular deeply connected r
#faltten -used fot flattening the input or change the dimension
from tensorflow.keras.layers import Conv2D #onvoLutiona l Layer
from tensorflow.keras.optimizers import Adam #optimizer
from keras. utils import np_utils #used for one-hot encoding
import matplotlib.pyplot as plt   #used for data visualization
```

```
(x_train, y_train), (x_test, y_test)=mnist.load_data ()
x_train=x_train.reshape (60000, 28, 28, 1).astype('float32')
x_test=x_test.reshape (10000, 28, 28, 1).astype ('float32')
number_of_classes = 10  #storing the no of classes in a variable
y_train = np_utils.to_categorical (y_train, number_of_classes) #converts the output in binary format
y_test = np_utils.to_categorical (y_test, number_of_classes)
```

```
#create model
model=Sequential ()
```

```
#adding modeL Layer
model.add(Conv2D(64, (3, 3), input_shape=(28, 28, 1), activation='relu'))
model.add(Conv2D(32, (3, 3), activation = 'relu'))
```

```
#flatten the dimension of the image
model.add(Flatten())
```

```
#output layer with 10 neurons
model.add(Dense(number_of_classes,activation = 'softmax'))
```

Compiling the model

```
#Compile model
model.compile(loss= 'categorical_crossentropy', optimizer="Adam", metrics=['accuracy'])
```

```
x_train = np.asarray(x_train)
y_train = np.asarray(y_train)
```


```
#Compile model
model.compile(loss= 'categorical_crossentropy', optimizer="Adam", metrics=['accuracy'])
```

```
x_train = np.asarray(x_train)
y_train = np.asarray(y_train)
```


Train the model


```
#fit the model
model.fit(x_train, y_train, validation_data=(x_test, y_test), epochs=5, batch_size=32)
```

Observing the metrics

```
# Final evaluation of the model
metrics = model.evaluate(x_test, y_test, verbose=0)
print("Metrics (Test loss &Test Accuracy) : ")
print(metrics)
```

```
prediction=model.predict(x_test[6000:6001])
print(prediction)
```

```
plt.imshow(x_test[6000])
```

```
import numpy as np
print(np.argmax(prediction, axis=1)) #printing our Labels from first 4 images
```

```
[9]
```

```
np.argmax(y_test[6000:6001]) #printing the actual labels
```

```
9
```

Save The model

```
# Save the model
model.save('mnistCNN.h5')
```

FLASK APP

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


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

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

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

        pred = model.predict(im2arr)

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

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


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

HOME PAGE (HTML)

```
<html>

<head>
  <title>Digit Recognition WebApp</title>

  <meta name="viewport" content="width=device-width">
  <!-- GoogleFont -->
  <link href="https://fonts.googleapis.com/css2?family=Prompt:wght@600&display=swap" rel="stylesheet">
  <link href="https://fonts.googleapis.com/css2?family=Varela+Round&display=swap" rel="stylesheet">
  <link href="https://fonts.googleapis.com/css2?family=Source+Code+Pro:wght@500&display=swap" rel="stylesheet">
  <link href="https://fonts.googleapis.com/css?family=Calistoga|Josefin+Sans:400,700|Pacifico&display=swap" rel="stylesheet">
  <!-- bootstrap -->
  <link rel="stylesheet" href="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/css/bootstrap.min.css"  crossorigin="anonymous">
  <link rel="stylesheet" type= "text/css" href= "{{ url_for('static',filename='css/style.css') }}">
  <!-- fontawesome -->
  <script src="https://kit.fontawesome.com/b3aed9cb07.js" crossorigin="anonymous"></script>

  <script src="https://code.jquery.com/jquery-3.3.1.slim.min.js"  crossorigin="anonymous"></script>
  <script src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.14.7/umd/popper.min.js"  crossorigin="anonymous"></script>
  <script src="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/js/bootstrap.min.js"  crossorigin="anonymous"></script>
  <script src="https://cdn.jsdelivr.net/npm/@tensorflow/tfjs@latest"></script>

</head>

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

    $(document).ready(function() {
        $('#clear_button').on('click', function() {
```

```
        });
    });

</script>

<body>

  <h1 class="welcome">IBM PROJECT
  <div id="PNT2022TMID15217">TEAM ID : PNT2022TMID15217</div>
  </h1>
  <section id="title">
    <h4 class="heading">Handwritten Digit Recognition Website</h4>
    <br><br>
      <p>
        The website is designed to predict the handwritten digit.
      </p>
    <p>
        Handwriting recognition is one of the compelling research works going on because every individual in this world
        has their own style of writing. It is the capability of the computer to identify and understand
        handwritten digits or characters automatically. Because of the progress in the field of science and technology,
        everything is being digitalized to reduce human effort.</p>

      <br>
    <p> Hence, there comes a need for handwritten digit recognition in many real-time applications.
        MNIST data set is widely used for this recognition process and it has 70000 handwritten digits.
        We use Artificial neural networks to train these images and build a deep learning model.
        Web application is created where the user can upload an image of a handwritten digit.
        This image is analyzed by the model and the detected result is returned on to UI</p>

  </section>
```

HOME PAGE (CSS)

```
    color: rgb(12, 12, 13);
}

#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: rgb(164, 48, 62);
    background-color: rgb(36, 112, 142);
    padding-top: 1%;
    padding-bottom: 1%;
    font-weight: bold;
    font-family: 'Prompt', sans-serif;
}

#PNT2022TMID15217{
    text-align: right;
    font-size: 25px;
    padding-right: 3%;
}

#predict_button{
    margin-right: 15px;
    color: rgb(95, 165, 172);
    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;
```

```
    color: rgb(12, 12, 13);
}

#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: rgb(164, 48, 62);
    background-color: rgb(36, 112, 142);
    padding-top: 1%;
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    font-family: 'Prompt', sans-serif;
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#PNT2022TMID15217{
    text-align: right;
    font-size: 25px;
    padding-right: 3%;
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#predict_button{
    margin-right: 15px;
    color: rgb(95, 165, 172);
    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;
```

```
}

#frame{
  margin-right: 10%;
}

.predicted_answer{
  text-align: center;
  margin: 0 auto;
  padding: 3% 5%;
  padding-top: 0;
  /* padding-left: 10%; */
}

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

@media (min-width: 720px) {
  .leftside{
    padding-left: 10%;
  }
}
```

HOME PAGE (JS)

```
feather.replace(); // Load feather icons

form = document.querySelector('.upload')
loading = document.querySelector("#Loading")
select = document.querySelector("#upload-image");

select.addEventListener("change", (e) => {
    e.preventDefault();

    form.submit()
    form.style.visibility = "hidden";
    loading.style.display = 'flex';
});
```

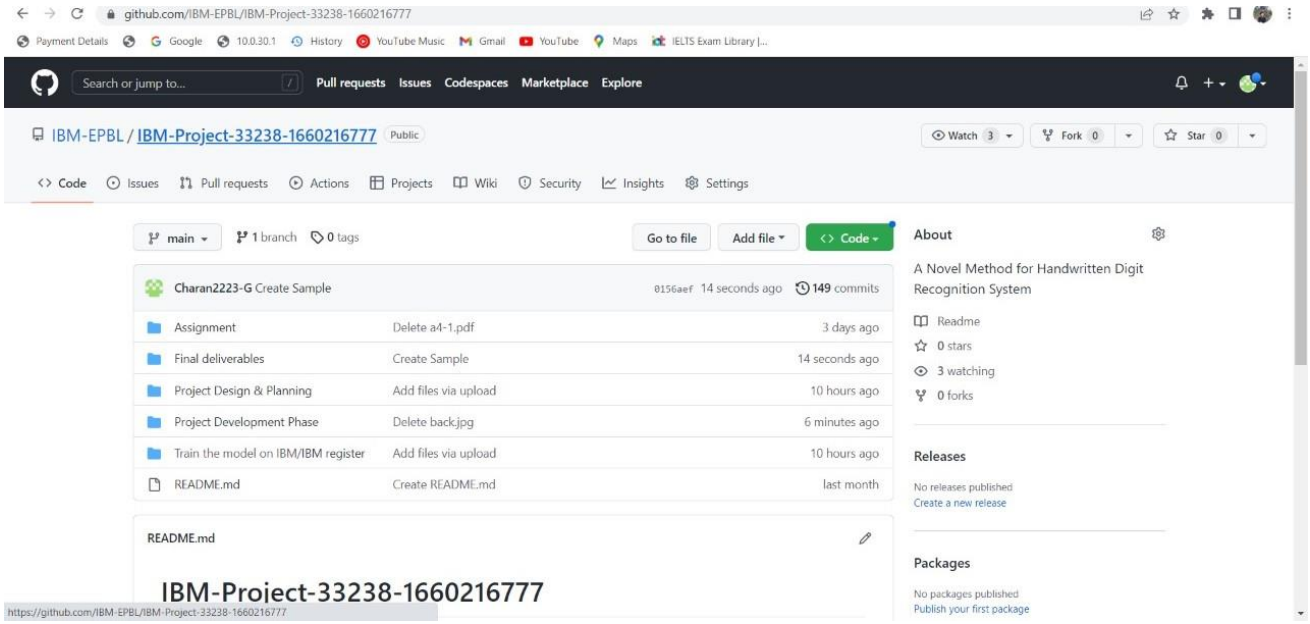
PREDICT PAGE (HTML)

```
<html>
    <head>
        <title>Prediction | Handwritten Digit Recognition</title>
        <link rel="stylesheet" href="{{url_for('static',filename='css/predict.css')}}" />
        <link rel="icon" type="image/svg" sizes="32x32" href="{{url_for('static',filename='images/icon.svg')}}"
 />
        <meta name="viewport" content="width=device-width, initial-scale=1.0" />
    </head>
    <body>
        <div class="container">
            <h1>Prediction</h1>
            <div class="result-wrapper">
                <div class="input-image-container">
                    <img src="{{url_for('static',filename='data/')}}{{img_name}}" />
                </div>
                <div class="result-container">
                    <div class="value">{{best.0}}</div>
                    <div class="accuracy">{{best.1}}%</div>
                </div>
            </div>
            <h1>Other Predictions</h1>
            <div class="other_predictions">
                {% for x in others %}
                <div class="value">
                    <h2>{{x.0}}</h2>
                    <div class="accuracy">{{x.1}}%</div>
                </div>
                {% endfor %}
            </div>
        </div>
    </body>
</html>
```

```css
@import url("https://fonts.googleapis.com/css2?family=Overpass:wght@200;300;400;500;600;700;900&display=swap");

body {
    color: black;
    font-family: "Overpass", sans-serif;
}

h1 {
    padding-top: 2rem;
}

.container {
    display: flex;
    justify-content: center;
    align-items: center;
    flex-direction: column;
}

.result-wrapper {
    width: -webkit-fit-content;
    width: -moz-fit-content;
    width: fit-content;
    height: -webkit-fit-content;
    height: -moz-fit-content;
    height: fit-content;
    box-shadow: 0 0 10px rgb(126, 125, 125);
    padding: 1.5rem;
    display: flex;
    justify-content: center;
    align-items: center;
    -moz-column-gap: 1rem;
    column-gap: 1rem;
}

.result-wrapper .input-image-container,
.result-wrapper .result-container {
    width: 15rem;
    height: 15rem;
    border: 1px dashed black;
    justify-content: center;
    display: flex;
    align-items: center;
    flex-direction: column;
    background-color: rgb(209, 206, 206);
}
```

```css
.result-wrapper .input-image-container img {
    width: 60%;
    height: 60%;
    background-color: aqua;
    background-size: contain;
}

.result-wrapper .result-container .value {
    font-size: 6rem;
}

.result-wrapper .result-container .accuracy {
    margin-top: -1rem;
}

.other_predictions {
    display: flex;
    justify-content: center;
    align-items: center;
    flex-wrap: wrap;
    column-gap: 1rem;
    row-gap: 1rem;
    font-weight: 700;
}

.other_predictions .value {
    display: flex;
    justify-content: center;
    align-items: center;
    flex-direction: column;
    width: 5rem;
    height: 5rem;
    box-shadow: 0 0 7px rgb(158, 157, 157);
}

.other_predictions .value div {
    margin-top: -1.2rem;
}

@media screen and (max-width: 700px) {
    h1 {
        font-size: 2.3rem;
    }

    .result-wrapper .input-image-container,
    .result-wrapper .result-container {
        width: 7rem;
        height: 7rem;
    }

    .result-wrapper .result-container .value {
        font-size: 4rem;
    }
}
```

GITHUB



GITHUB LINK:

https://github.com/IBM-EPBL/IBM-Project-33238-1660216777