PROJECT REPORT

A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION

submitted by

PNT2022TMID13343

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CHAPTER 1
INTRODUCTION

1.1 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.

1.2 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

2.1 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.

2.2 REFERENCES

Improved Handwritten Digit Recognition Using Convolutional Neural Networks (CNN) (2020)

Ahlawat, Savita and Choudhary, Amit and Nayyar, Anand and Singh, Saurabh and Yoon, Byungun

This paper's primary goal was to enhance handwritten digit recognition ability. To avoid difficult pre-processing, expensive feature extraction, and a complex ensemble (classifier combination) method of a standard recognition system, they examined different convolutional neural network variations. Their current work makes suggestions on the function of several hyper-parameters through thorough evaluation utilizing an MNIST dataset. They also confirmed that optimizing hyper-parameters is crucial for enhancing CNN architecture performance. With the Adam optimizer for the MNIST database, they were able to surpass many previously published results with a recognition rate of 99.89%. Through the trials, it is made

abundantly evident how the performance of handwritten digit recognition is affected by the number of convolutional layers in CNN architecture. According to the paper, evolutionary algorithms can be explored for optimizing convolutional filter kernel sizes, CNN learning parameters, and the quantity of layers and learning rates.

An Efficient And Improved Scheme For Handwritten Digit Recognition Based On Convolutional Neural Network (2019)

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

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

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.

Handwritten Digit Recognition Using Machine And Deep Learning Algorithms (2021)

Pashine, Samay and Dixit, Ritik and Kushwah, Rishika

In this study, they developed three deep and machine learning-based models for handwritten digit recognition using MNIST datasets. To determine which model was the most accurate, they compared them based on their individual properties. Support vector machines are among the simplest classifiers, making them faster than other algorithms and providing the highest training accuracy rate in this situation. However, due to their simplicity, SVMs cannot categorize complicated and ambiguous images as accurately as MLP and CNN algorithms can. In their research, they discovered that CNN produced the most precise outcomes for handwritten digit recognition. This led them to the conclusion that CNN is the most effective

solution for all types of prediction issues, including those using picture data. Next, by comparing the execution times of the algorithms, they determined that increasing the number of epochs without changing the configuration of the algorithm is pointless due to the limitation of a certain model, and they discovered that beyond a certain number of epochs, the model begins over-fitting the dataset and provides biased predictions.

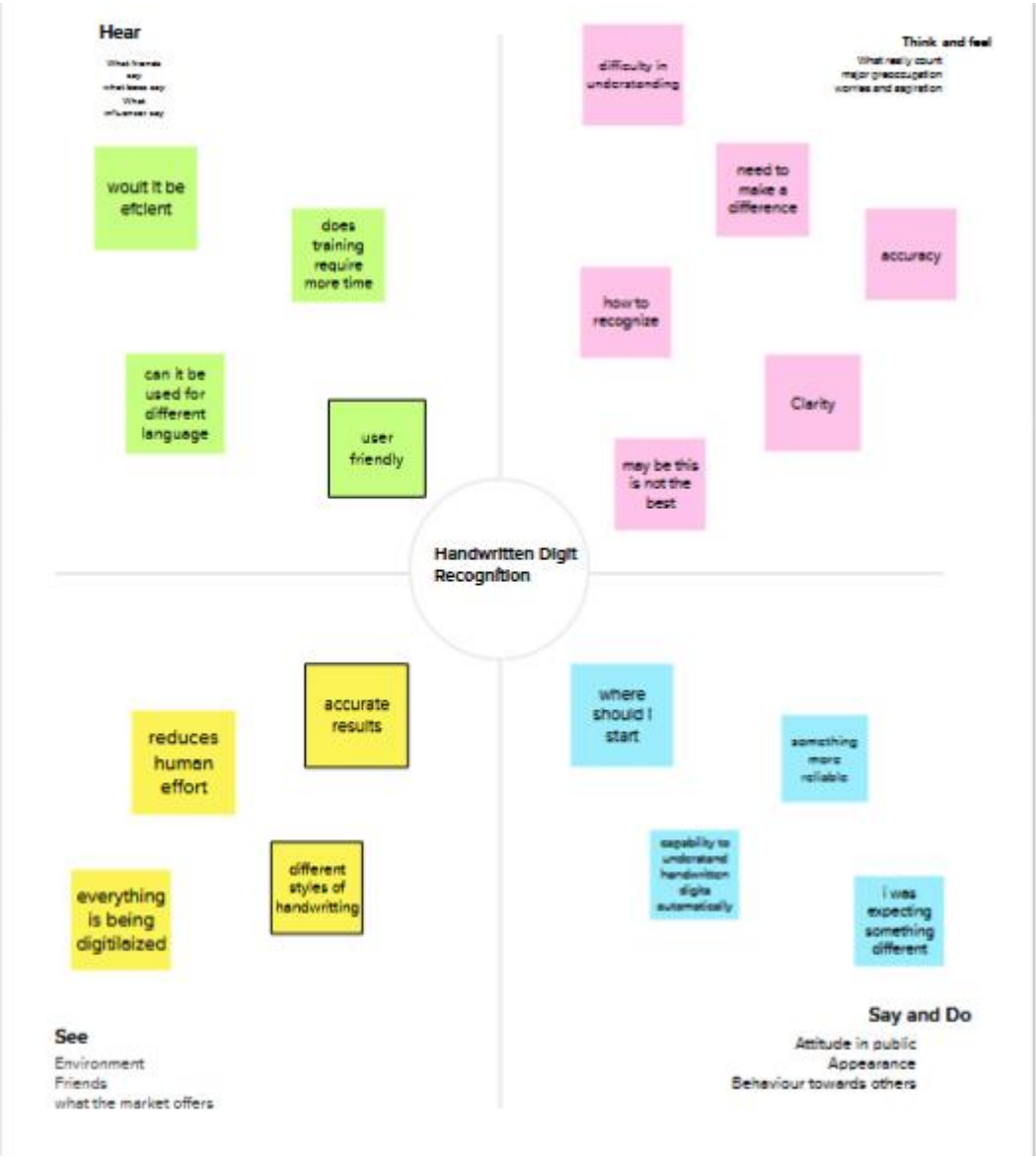
2.3 PROBLEM STATEMENT DEFINITION

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.

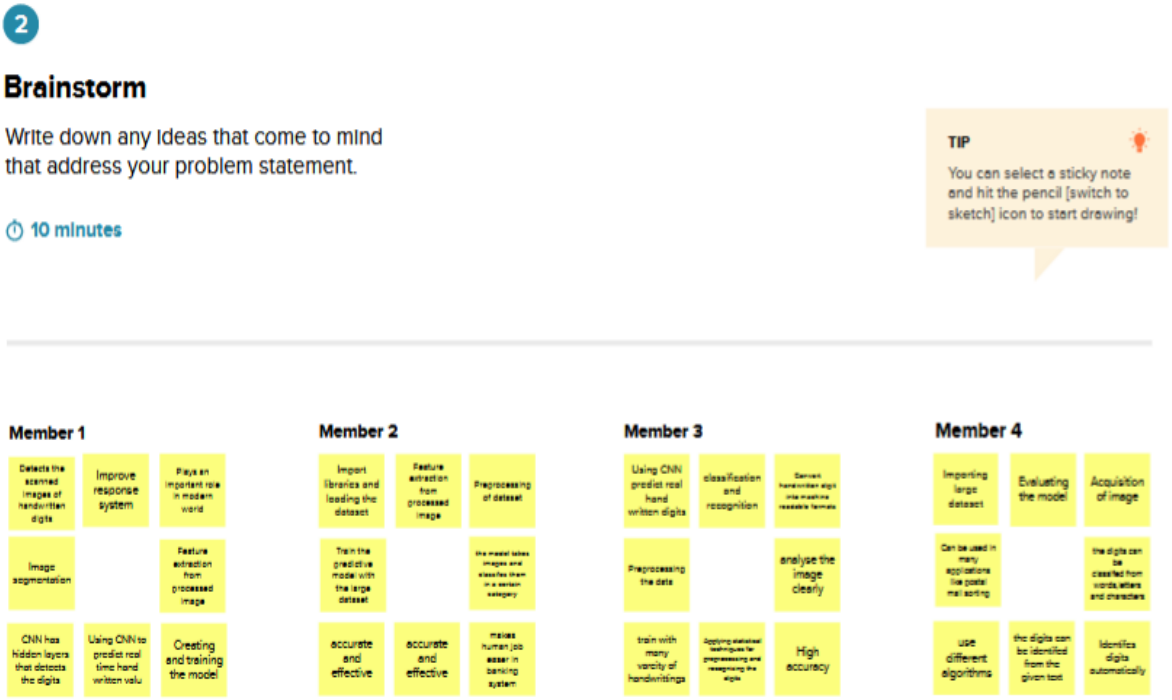
CHAPTER 3

IDEATION AND PROPOSED SOLUTION

3.1 EMPATHY MAP CANVAS



3.2 IDEATION & BRAINSTORMING



3

Group ideas

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

20 minutes

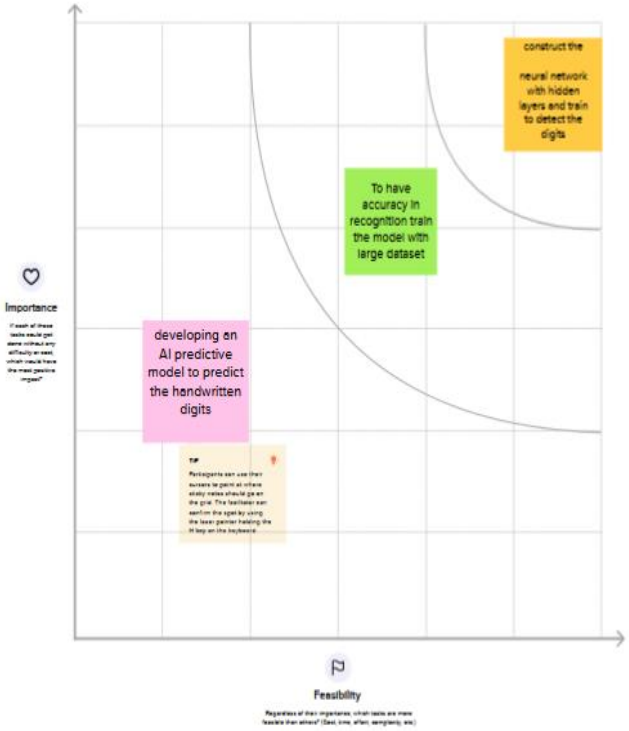
Classification and recognition of digits

4

Prioritize

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

20 minutes

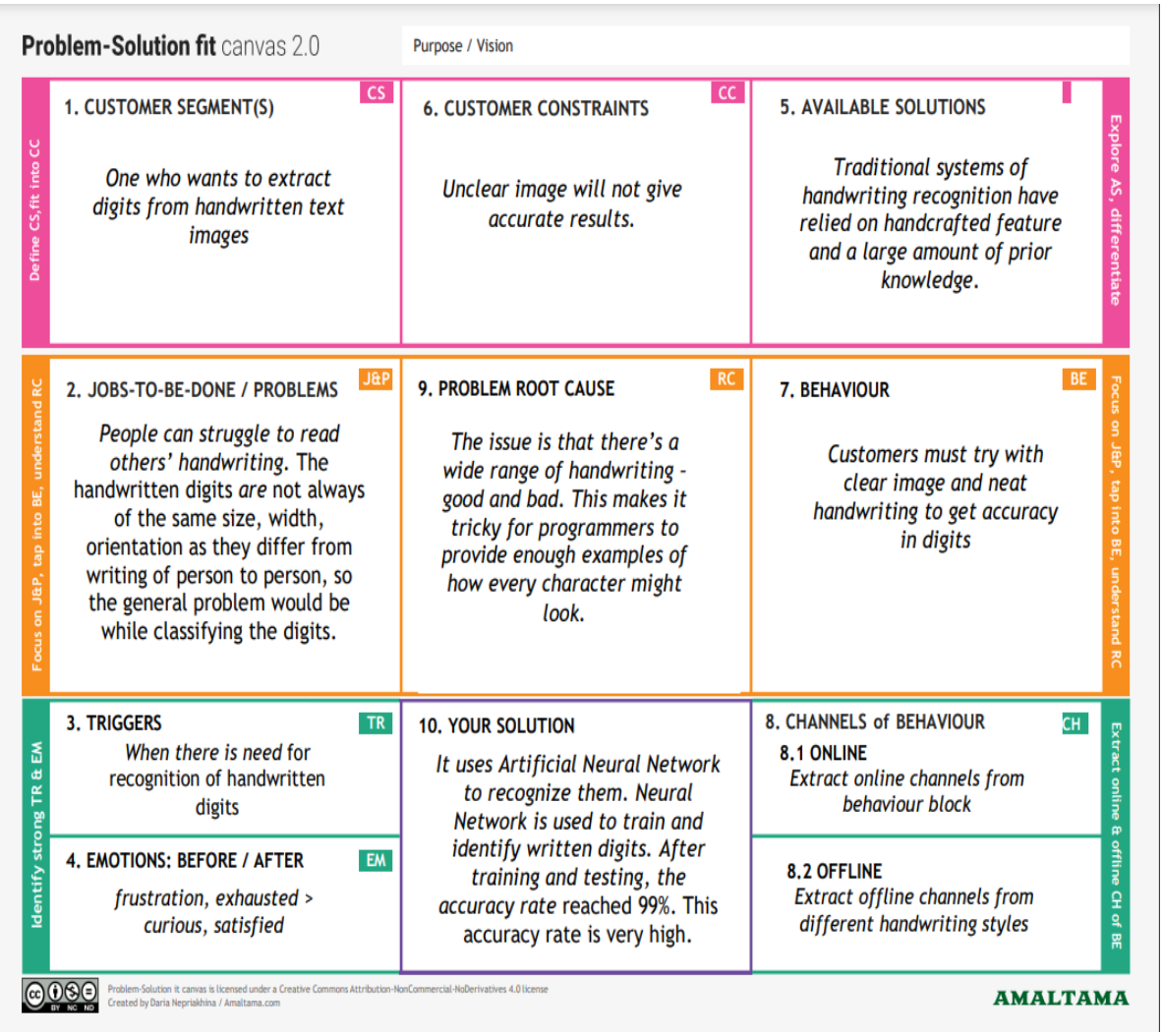


3.3 PROPOSED SOLUTION

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	The problem statement aims at developing a novel handwritten recognition system using ML .The handwritten digit recognition system is a way to tackle the problem which uses the image of a digit and recognizes the digit present in the image .
2.	Idea / Solution description	Developing an AI predictive model to predict the handwritten digits and to construct a neural network with hidden layers and train to detect the digits.
3.	Novelty / Uniqueness	The system not only produces a classification of the digit but also a rich description of the instantiation parameters which can yield information such as the writing style
4.	Social Impact / Customer Satisfaction	Handwritten digits can be recognised easily without any strenuous efforts. This reduces time and improves productivity for people.
5.	Business Model (Revenue Model)	It is used in the detection of vehicle numbers, banks for reading cheques, post offices for arranging letters, and many other tasks.

6.	Scalability of the Solution	To attain higher performances in the domain of character recognition and pattern recognition,due to its excellent feature extraction and working as best classifier characteristics. There is no limit in the number of digits that can be recognized.

3.4 PROBLEM SOLUTION FIT



CHAPTER 4
REQUIREMENT ANALYSIS

4.1 FUNCTIONAL REQUIREMENTS

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form Registration through Gmail Registration through LinkedIN
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	Upload image	Image upload via files Image upload via folders Image upload via drive Image upload via web Image upload via scan/camera
FR-4	Spelling support	Identifies handwriting of different styles and fonts Spelling check
FR-5	Translation	Handwritten digits from the image are extracted. Conversion of handwritten digits into machine readable form
FR-6	Log out	Log out / sign out.

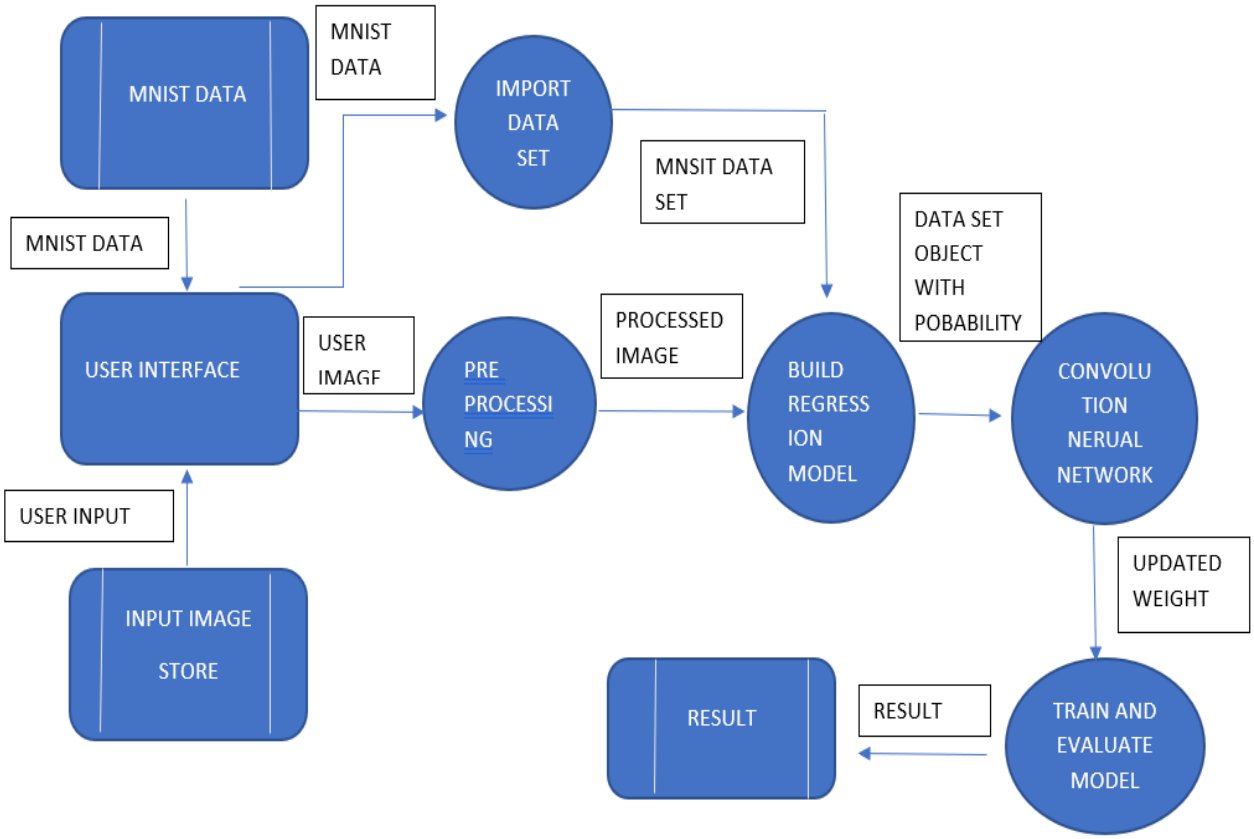
4.2 NON FUNCTIONAL REQUIREMENTS

NFR No.	Non-Functional Requirement	Description
NFR-1	Usability	The proposed system gives good results for images that contain handwritten text written in different styles, different size and alignment with varying background
NFR-2	Security	Only authorized people can access the system data and modify the database.
NFR-3	Reliability	The Database is frequently updated with handwriting of different styles and size and will rollback when any update fails.
NFR-4	Performance	The proposed system is advantageous as it uses fewer features to train the neural network, which results in faster convergence.
NFR-5	Availability	The system functionality and services are available for use with all operations.
NFR-6	Scalability	The website traffic limit must be scalable enough to support 2 lakhs users at a time

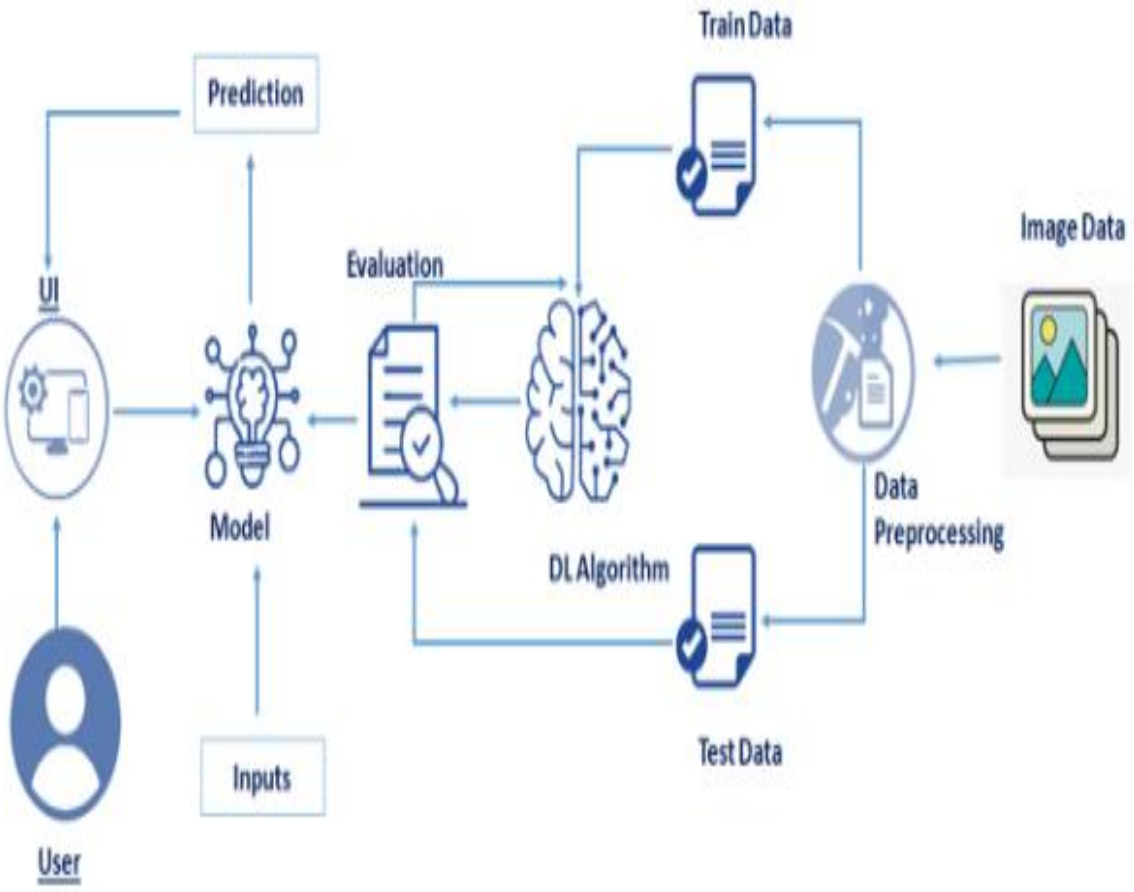
CHAPTER 5

PROJECT DESIGN

5.1 DATA FLOW DIAGRAM



5.2 SOLUTION & TECHNICAL ARCHITECTURE



5.3 USER STORIES

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	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-2
		USN-3	As a user, I can register for the application through gmail or facebook	I can register & access the dashboard with Facebook Login	Medium	Sprint-2
	Login	USN-4	As a user, I can log into	I can login to the	High	Sprint-1

			the application by entering email & password	application		
	Dashboard	USN-5	Go to dashboard and refer the content about our project	I can read instructions also and the home page is user-friendly.	Low	Sprint-1
	Upload Image	USN-6	As a user, I can able to input the images of digital documents to the application	As a user, I can able to input the images of digital documents to the application	High	Sprint-3
	Predict	USN-7	As a user I can able to get the recognised digit as output from the images of digital documents or images	I can access the recognized digits from digital document or images	High	Sprint-3
		USN-8	As a user, I will train and test the	I can able to train and test the	Medium	Sprint-4

			input to get the maximum accuracy of output.	application until it gets maximum accuracy of the result.		
Customer (Web user)	Login	USN-9	As a user, I can use the application by entering my email, password.	I can access my account	Medium	Sprint-4
Customer Care Executive	Dashboard	USN-10	upload the image	Recognize and get the output	High	Sprint-1
Administrator	Security	USN-11	updated the features	checking the security	Medium	Sprint-1

CHAPTER 6

PROJECT PLANNING AND SCHEDULING

6.1 SPRINT PLANNING AND ESTIMATION

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Data Collection	USN-1	As a user, I can collect the dataset from various resources with different handwritings.	10	Low	Praveen A Vignesh M
Sprint-1	Data Preprocessing	USN-2	As a user, I can load the dataset, handling the missing data, scaling and split data into train and test.	10	Medium	Praveen A Vignesh M
Sprint-2	Model Building	USN-3	As a user, I will get an application with ML model which provides high	5	High	Praveen A Vignesh M Prabhu P Premkumar R

			accuracy of recognized handwritten digit.			
Sprint-2	Add CNN layers	USN-4	Creating the model and adding the input, hidden, and output layers to it.	5	High	Praveen A Vignesh M Prabhu P Premkumar R
Sprint-2	Compiling the model	USN-5	With both the training data defined and model defined, it's time to configure the learning process.	2	Medium	Prabhu P Premkumar R
Sprint-2	Train & test the model	USN-6	As a user, let us train our model with our image dataset.	6	Medium	Prabhu P Premkumar R

Sprint-2	Save the model	USN-7	As a user, the model is saved & integrated with an android application or web application in order to predict something.	2	Low	Prabhu P
Sprint-3	Building UI Application	USN-8	As a user, I will upload the handwritten digit image to the application by clicking a upload button.	5	High	Premkumar R Praveen A
Sprint-3		USN-9	As a user, I can know the details of the fundamental usage of the application.	5	Low	Vignesh M
Sprint-3		USN-10	As a user, I can see the predicted / recognized digits in the application.	5	Medium	Praveen A Prabhu P

Sprint-4	Train the model on IBM	USN-11	As a user, I train the model on IBM and integrate flask/Django with scoring end point.	10	High	Praveen A Vignesh M Prabhu P Premkumar R
Sprint-4	Cloud Deployment	USN-12	As a user, I can access the web application and make the use of the product from anywhere.	10	High	Vignesh M Prabhu P

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	29 Oct 2022	03 Nov 2022	20	03 Nov 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 & SOLUTIONING

```
import os

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

UPLOAD_FOLDER = 'C:/Users/Downloads/ibmproject/flask_app/upload'
```

```python
app = Flask(__name__,template_folder='template')
app.config['UPLOAD_FOLDER'] = UPLOAD_FOLDER

model = load_model("mnistCNN.h5")

@app.route('/', methods=['GET'])
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)
```

CHAPTER 8
TESTING

8.1 TEST CASES

Test case ID	Feature Type	Component	Test Scenario	Expected Result	Actual Result	Status
HP_TC_001	UI	Home Page	Verify UI elements in the Home Page	The Home page must be displayed properly	Working as expected	PASS
HP_TC_002	UI	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 is not displayed properly in screen size 2560 x 1801 and 768 x 630	FAIL
HP_TC_003	Functional	Home Page	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	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 any file	FAIL
HP_TC_005	Functional	Home Page	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

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	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

8.2.2 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

9.1 PERFORMANCE METRICS

Locust Test Report

During: 11/12/2022, 7:05:40 AM - 11/12/2022, 7:14:47 AM

Target Host: http://127.0.0.1:5000/

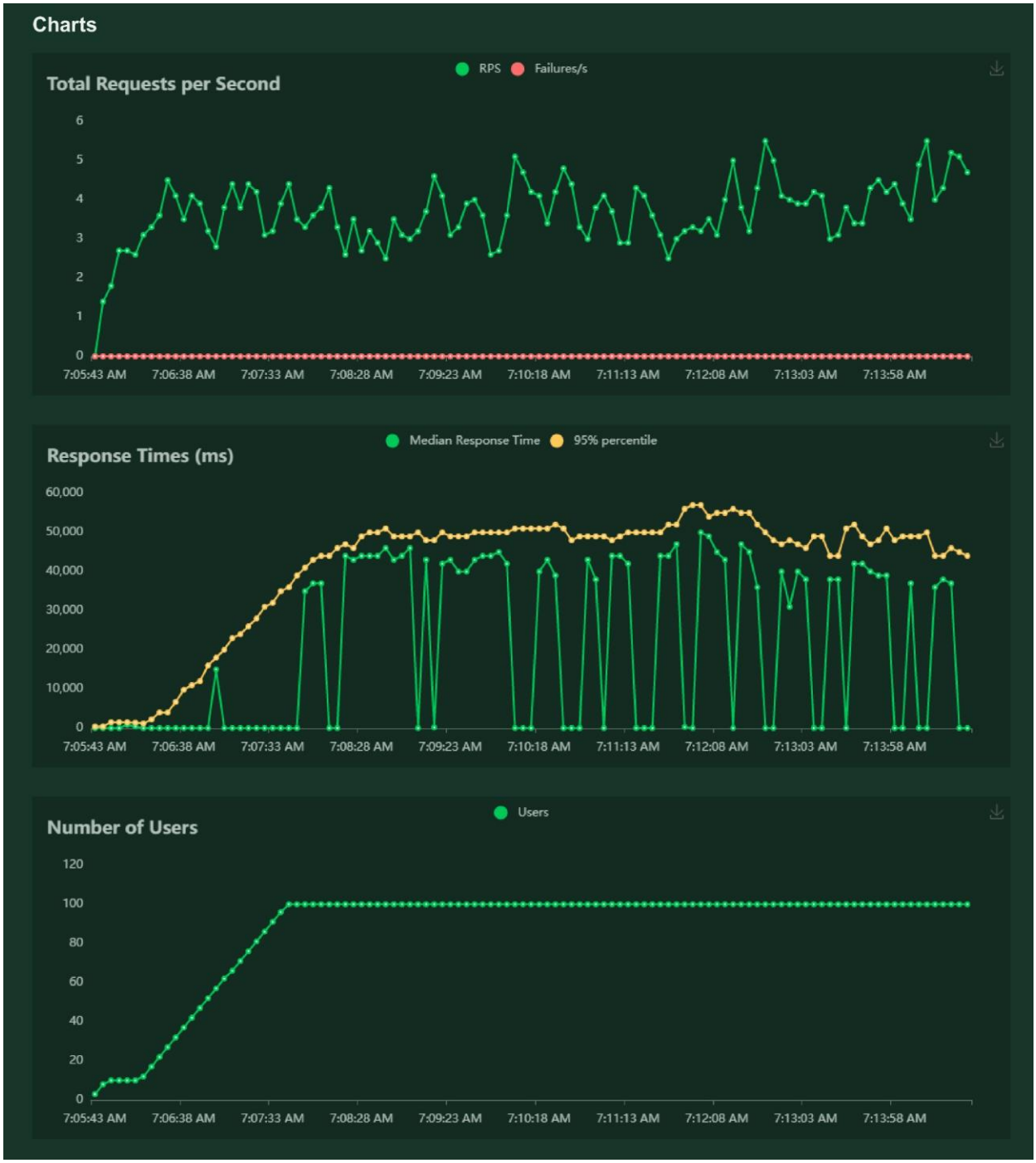
Script: locust.py

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
7:05:43 AM
7:06:38 AM
7:07:33 AM
7:08:28 AM
7:09:23 AM
7:10:18 AM
7:11:13 AM
7:12:08 AM
7:13:03 AM
7:13:58 AM
Response Times (ms)
Median Response Time
95% percentile
60,000
50,000
40,000
30,000
20,000
10,000
0
7:05:43 AM
7:06:38 AM
7:07:33 AM
7:08:28 AM
7:09:23 AM
7:10:18 AM
7:11:13 AM
7:12:08 AM
7:13:03 AM
7:13:58 AM
Number of Users
Users
120
100
80
60
40
20
0
7:05:43 AM
7:06:38 AM
7:07:33 AM
7:08:28 AM
7:09:23 AM
7:10:18 AM
7:11:13 AM
7:12:08 AM
7:13:03 AM
7:13:58 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, 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 numberplates 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
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 keras.optimizers import Adam #opt imizer
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'))
```

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

x_train = numpy.asarray(x_train)
y_train = numpy.asarray(y_train)

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

# 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)

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

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

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

FLASK APP

```
import os

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

UPLOAD_FOLDER = 'C:/Users/k.sivasankari/Downloads/ibmproject/flask_app/upload'

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

model = load_model("mnistCNN.h5")

@app.route('/', methods=['GET'])
def index():
    return render_template('index.html')
```

HOME PAGE (HTML)

```
<body>

  <h1 class="welcome">A Novel Method for Handwritten Digit Recognition
  <div id="team_id">TEAM ID : PNT2022TMID13343</div>
  </h1>
  <section id="title">
    <h4 class="heading">IBM PROJECT</h4>
    <br><br>
      <p>
        The website is designed to predict the handwritten digit.
      </p>
  </section>

  <section id="content">

        <div class="leftside">
        <form action="/predict" method="POST" enctype="multipart/form-data">
        <label>Select a image:</label>
        <input id="image" type="file" name="image" accept="image/png, image/jpeg" onchange="preview()"><br><br>
          <img id="frame" src="" width="100px" height="100px"/>
          <div class="buttons_div">
            <button type="submit" class="btn btn-dark" id="predict_button">Predict</button>
            <button type="button" class="btn btn-dark" id="clear_button">  Clear  </button>
          </div>
        </form>
        </div>
  </section>

</body>

</html>
```

HOME PAGE (SCRIPT)

```
<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>
```

HOME PAGE (CSS)

```css
#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: honeydew;
    background-color: black;
    padding-top: 1%;
    padding-bottom: 1%;
    font-weight: bold;
    font-family: 'Prompt', sans-serif;
}

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

```css
#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;
    -webkit-appearance: none;
    background: #eee;
    border: 1px solid #888;
    margin-top: 20px;
    margin-bottom: 20px;
}

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

```css
.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;
  /* padding-left: 10%; */
}

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

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

PREDICT PAGE (HTML)

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

<style>
    body{
     background-image: url('static/images/image01.jpg');
     background-repeat: no-repeat;
     background-size: cover;
    }

    #rectangle{
     width:400px;
     height:150px;
     background-color: #5796a5;
     border-radius: 25px;
     position:absolute;
     top:25%;
     left:50%;
     transform:translate(-50%,-50%);
    }
```

```
    #ans{
  text-align: center;
  font-size: 40px;
  margin: 0 auto;
  padding: 3% 5%;
  padding-top: 15%;
  color: white;
    }

</style>
<body>
    <div id="rectangle">
        <h1 id="ans">Predicted Number : {{num}}</h1>
    </div>
</body>
</html>
```

Application.py

```
import os

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

UPLOAD_FOLDER = 'C:/Users/Downloads/ibmproject/flask_app/upload'
```

```python
app = Flask(__name__,template_folder='template')
app.config['UPLOAD_FOLDER'] = UPLOAD_FOLDER

model = load_model("mnistCNN.h5")

@app.route('/', methods=['GET'])
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)
```

GITHUB

https://github.com/IBM-EPBL/IBM-Project-26794-1660038011

PROJECT DEMO

https://drive.google.com/file/d/1QxVyP1fU9h6BSrdRqb_4yQLuUXrg-RY0/view?usp=share_link