PROJECT REPORT

A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION

submitted by

PNT2022TMID52735

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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.

1.2PURPOSE

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

Title:Handwritten English Character and Digit Recognition(2021)

Author:Al-Mahmud; Asnuva Tanvin; Sazia Rahman

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

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

Author: Mukesh Kumar Rohil; Raju Singh

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

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

Author:Kaveti Upender; Venkata Siva Kumar Pasupuleti.

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

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

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

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

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

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

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

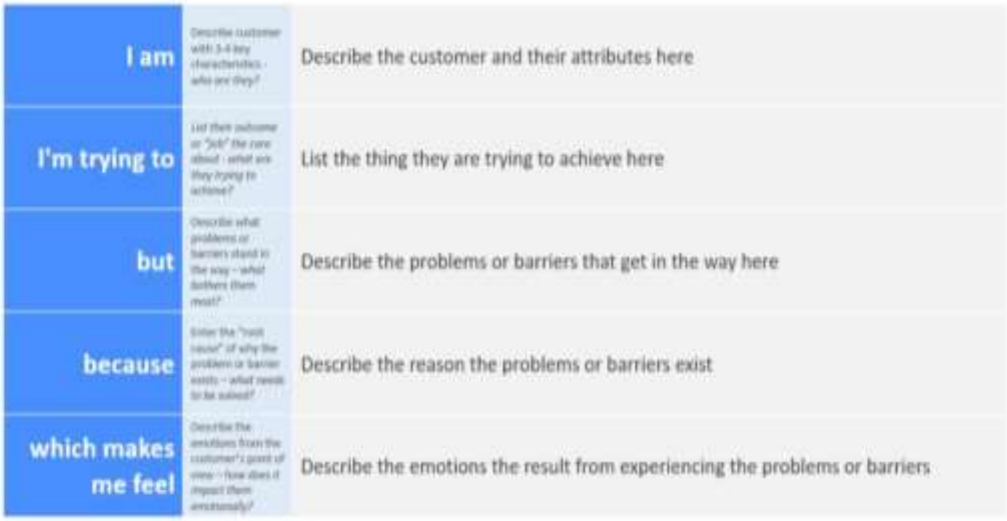
Title:Handwritten Digit Recognition Using Machine And Deep Learning Algorithms (2021)

Author: Pashine, Samay and Dixit, Ritik and Kushwah, Rishi*ka*

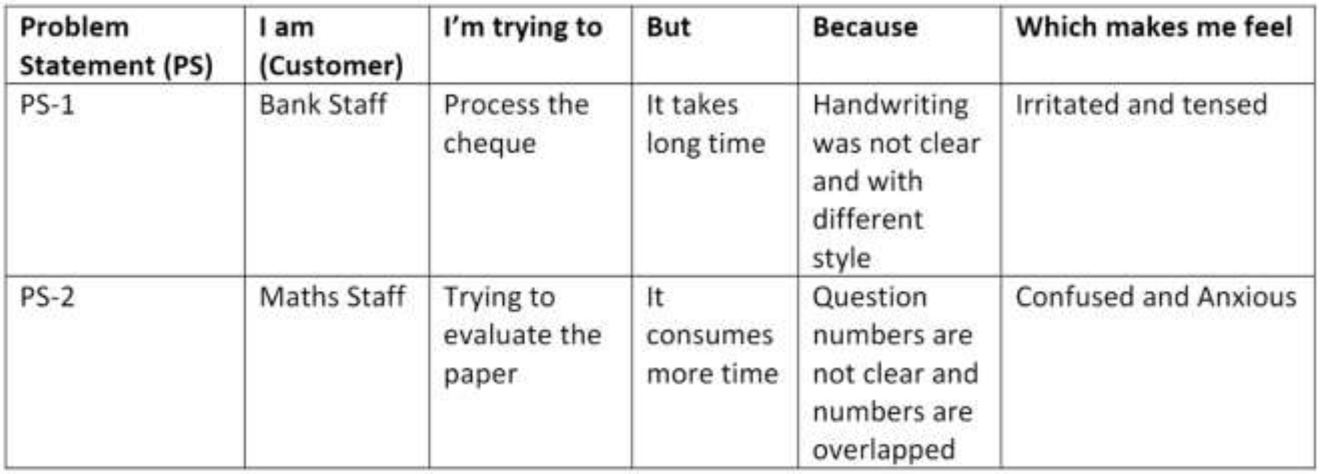
In this study, they developed three deep and machine learning-based models for handwritten digit recognition using MNIST datasets. To determine which model was the most accurate, they compared them based on their individual properties.Support vector machines are among the simplest classifiers, making 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.



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

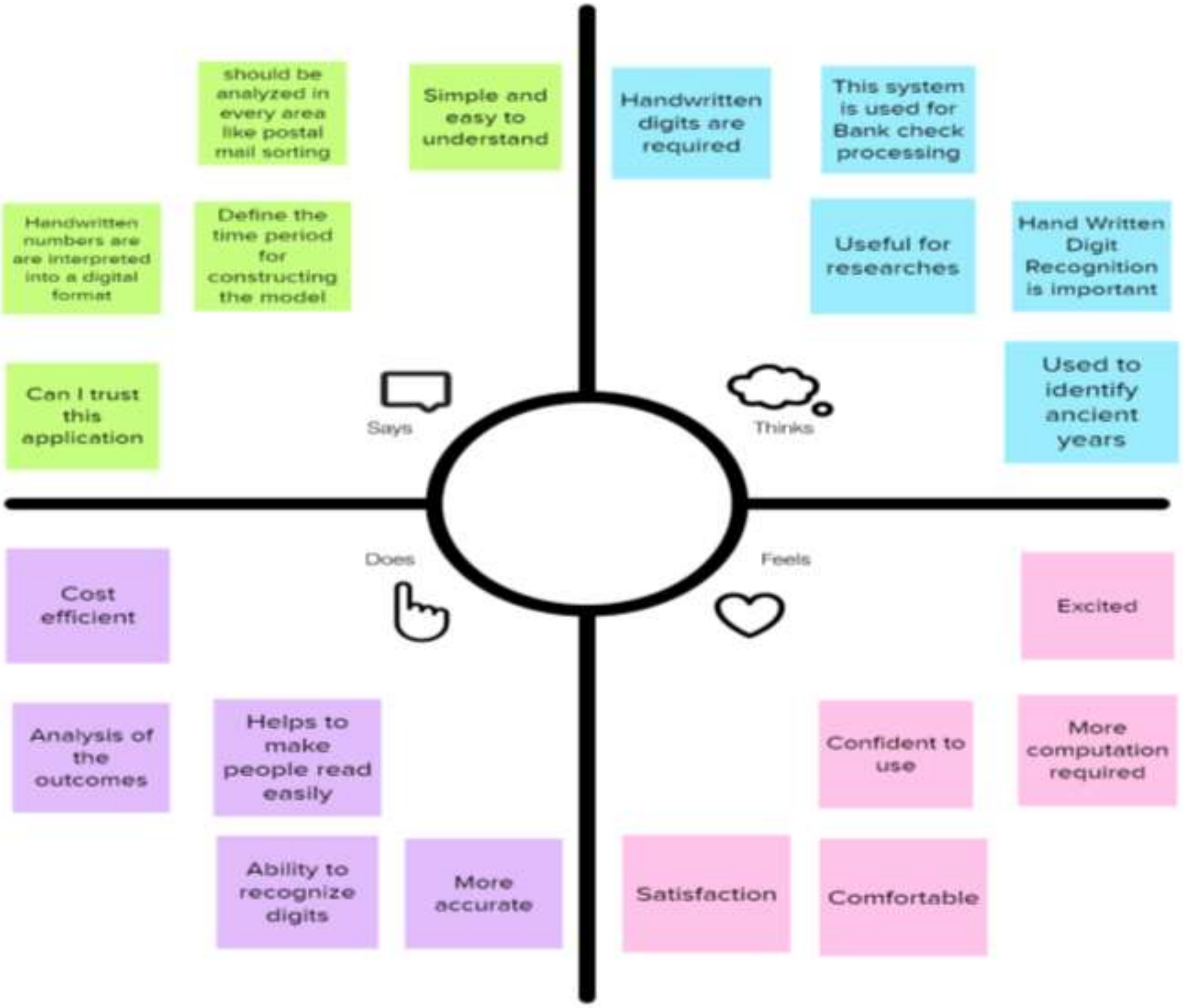


Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	Bank Staff	Process the cheque	It takes long time	Handwriting was not clear and with different style	Irritated and tensed
PS-2	Maths Staff	Trying to evaluate the paper	It consumes more time	Question numbers are not clear and numbers are overlapped	Confused and Anxious

CHAPTER 3

IDEATION AND PROPOSED SOLUTION

3.1 EMPATHY MAP CANVAS


should be analyzed in every area like postal mail sorting
Simple and easy to understand
Handwritten digits are required
This system is used for Bank check processing
Handwritten numbers are are interpreted into a digital format
Define the time period for constructing the model
Useful for researches
Hand Written Digit Recognition is important
Can I trust this application
Says
Thinks
Used to identify ancient years
Does
Feels
Cost efficient
Excited
Analysis of the outcomes
Helps to make people read easily
Confident to use
More computation required
Ability to recognize digits
More accurate
Satisfaction
Comfortable

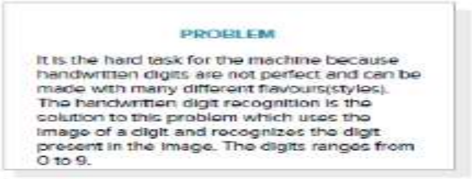
3.2 IDEATION & BRAINSTORMING

1

Define your problem statement

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

5 minutes



PROBLEM

It is the hard task for the machine because handwritten digits are not perfect and can be made with many different flavours(styles). The handwritten digit recognition is the solution to this problem which uses the image of a digit and recognizes the digit present in the image. The digits ranges from 0 to 9.

Key rules of brainstorming

To run an smooth and productive session

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

Brainstorm

Person 1

Person 2

Person 3

Person 4

Group ideas

Training sets are used to train the network

Used to augment the existing dataset

GUI for easy visualization

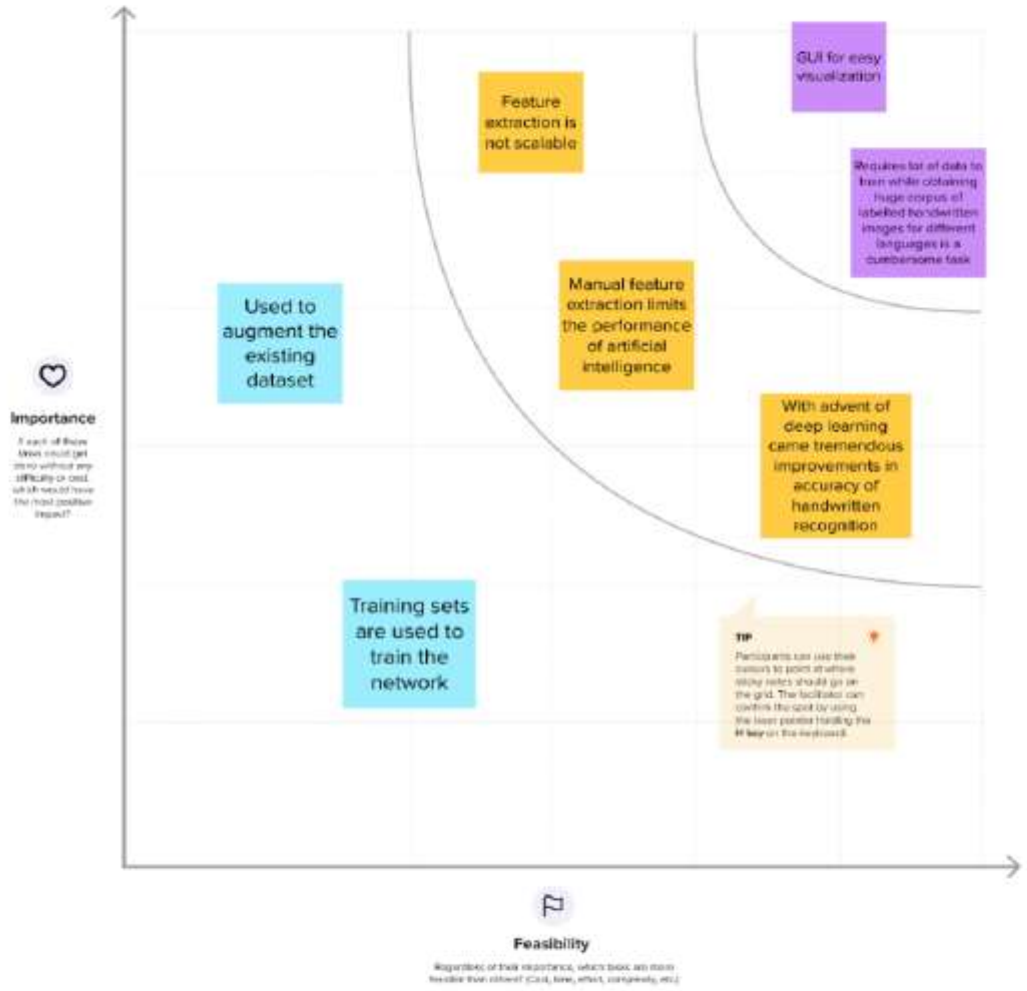
Step-3: Idea Prioritization

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



GUI for easy visualization

Feature extraction is not scalable

Requires lot of data to train while obtaining huge corpus of labelled handwritten images for different languages is a cumbersome task

Used to augment the existing dataset

Manual feature extraction limits the performance of artificial intelligence

With advent of deep learning came tremendous improvements in accuracy of handwritten recognition

Training sets are used to train the network

TIP

Participants can use their cursors to point at where sticky notes should go on the grid. The facilitator can confirm the spot by using the laser pointer holding the **H key** on the keyboard.

Importance

If each of these tasks could get done without any difficulty or cost, which would have the most positive impact?

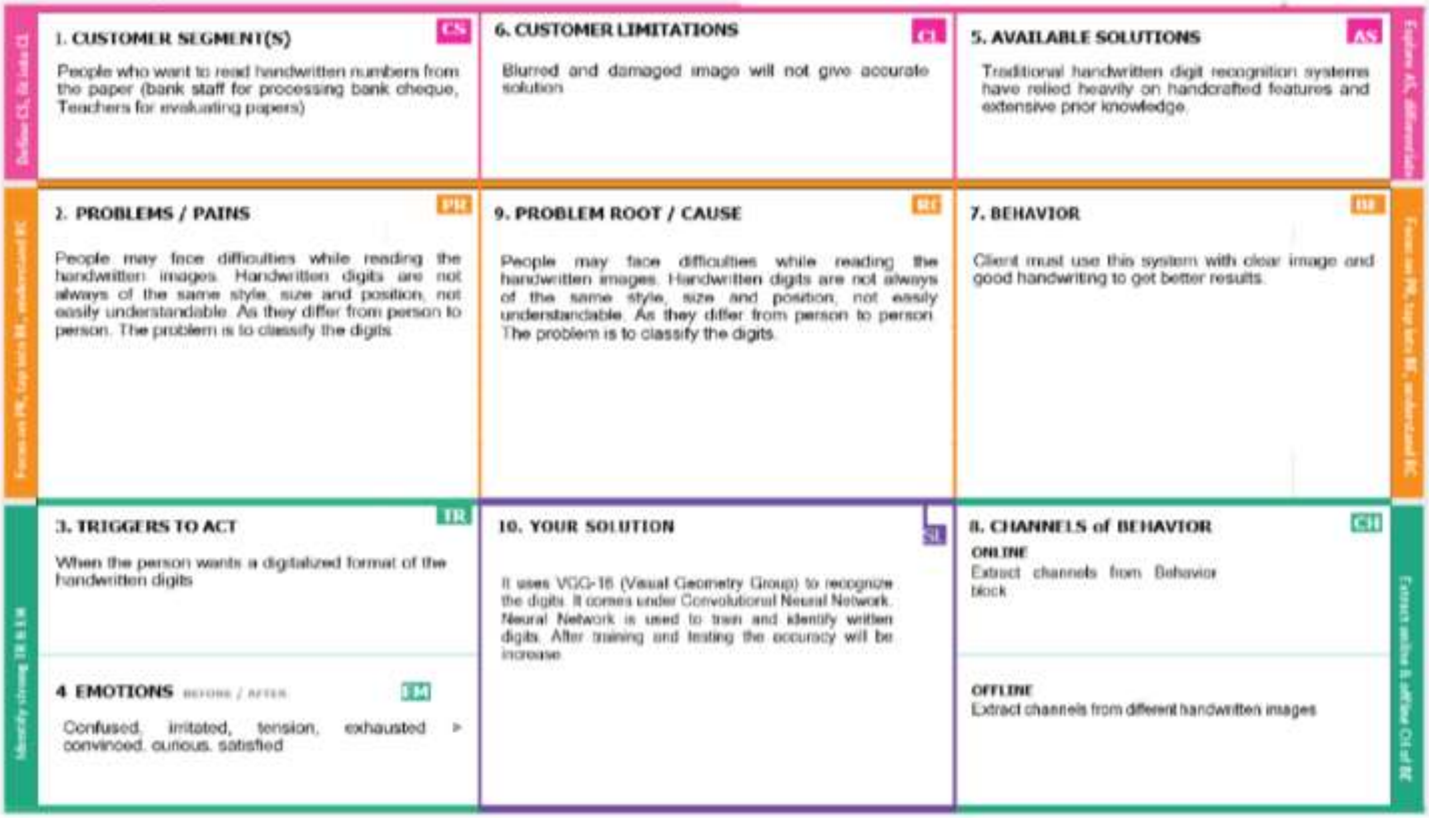
Feasibility

Regardless of their importance, which tasks are more feasible than others? (Cost, time, effort, complexity, etc.)

3.3 PROPOSED SOLUTION

S. No.	Parameter	Description
1	Problem Statement (Problem to be solved)	It is the hard task for the machine because handwritten digits are not perfect and can be made with many different flavours. To extract the digits from the image and recognize the digits.
2	Idea / Solution description	To provide an efficient and feasible system for handwritten digits which uses image of the digit and recognize the digit present in the image.
3	Novelty / Uniqueness	· To create the user interface where the user can register, login and upload image for recognition of handwritten digits
4	Social Impact / Customer Satisfactio n	• To process the bank cheque • To help the researchers • For paper evaluation
5	Business Model (Revenue Model)	By using this solution • Manpower can be reduced. • Help the teachers to evaluate the papers easily without manual correction • · Helps the bank to verify the account number from cheques without manual checking
6	Scalability of the Solution	It can be used and implemented in any device.

3.4 PROBLEM SOLUTION FIT



Define CS, fit into CL
Explore AS, differentiate
Focus on PR, tap into BE, understand RC
Focus on PR, tap into BE, understand RC
Identify strong TR & EM
Extract online & offline CH of BE

1. CUSTOMER SEGMENT(S) CS

People who want to read handwritten numbers from the paper (bank staff for processing bank cheque, Teachers for evaluating papers)

6. CUSTOMER LIMITATIONS CL

Blurred and damaged image will not give accurate solution

5. AVAILABLE SOLUTIONS AS

Traditional handwritten digit recognition systems have relied heavily on handcrafted features and extensive prior knowledge.

2. PROBLEMS / PAINS PR

People may face difficulties while reading the handwritten images. Handwritten digits are not always of the same style, size and position, not easily understandable. As they differ from person to person. The problem is to classify the digits.

9. PROBLEM ROOT / CAUSE RC

People may face difficulties while reading the handwritten images. Handwritten digits are not always of the same style, size and position, not easily understandable. As they differ from person to person. The problem is to classify the digits.

7. BEHAVIOR BE

Client must use this system with clear image and good handwriting to get better results.

3. TRIGGERS TO ACT TR

When the person wants a digitalized format of the handwritten digits

4 EMOTIONS BEFORE / AFTER EM

Confused, irritated, tension, exhausted > convinced, curious, satisfied

10. YOUR SOLUTION SL

It uses VGG-16 (Visual Geometry Group) to recognize the digits. It comes under Convolutional Neural Network. Neural Network is used to train and identify written digits. After training and testing the accuracy will be increase

8. CHANNELS of BEHAVIOR CH

ONLINE

Extract channels from Behavior block

OFFLINE

Extract channels from different handwritten images

CHAPTER 4

REQUIREMENT ANALYSIS

4.1FUNCTIONAL REQUIREMENTS

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	GUI	Allows the user to insert the handwritten image and get the digitized form of the digits. Created for easy virtualization.
FR-2	Uploading image	User can upload the handwritten image
FR-3	Writing in Canvas	User can directly draw/write in the canvas
FR-4	Evaluation	· The MNIST dataset should be trained using CNN to create a trained the model · The trained model has to be tested by using a test data · Predict the output for the input data and display it in a GUI

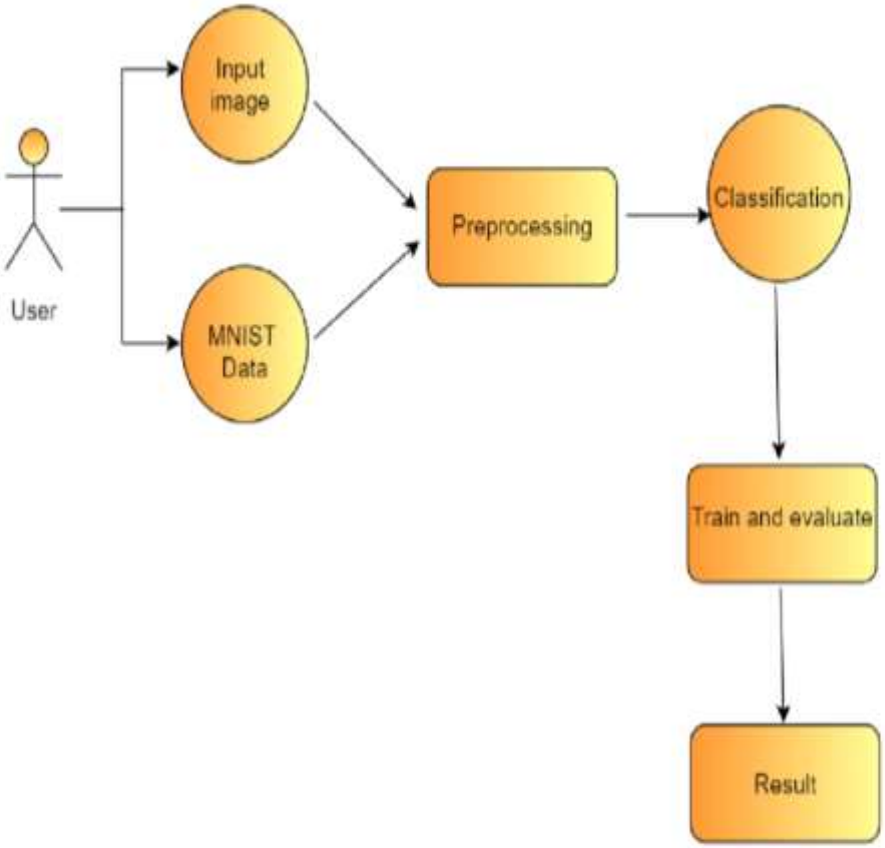
4.2 NON FUNCTIONAL REQUIREMENTS

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	The recognition of handwritten characters is one of the major issues with pattern recognition applications. Filling out forms, processing bank checks, and sorting mail are examples of applications using digit recognition.
NFR-2	**Security**	• The segmentation capabilities of the generative models are powered by recognition. • The method makes use of a relatively.
NFR-3	**Reliability**	• The neural network uses the data to automatically determine rules for reading handwritten numerals. By increasing the number of training instances, the network may also learn more about handwriting and hence improve its accuracy. • To recognise handwritten numbers, a wide range of approaches and algorithms can be employed, including Deep Learning/CNN, SVM, Gaussian
NFR-4	**Performance**	Optical character recognition (OCR) technology gives more accuracy rates for typed text in high-quality pictures.
NFR-5	**Availability**	Available for the user who wants to convert handwritten image to digital format
NFR-6	**Scalability**	The task of handwritten digit recognition using a classifier is of great importance and use in a variety of applications, including online handwriting recognition on computer tablets, the processing of bank check amounts, numeric entries in forms filled out by hand and more.

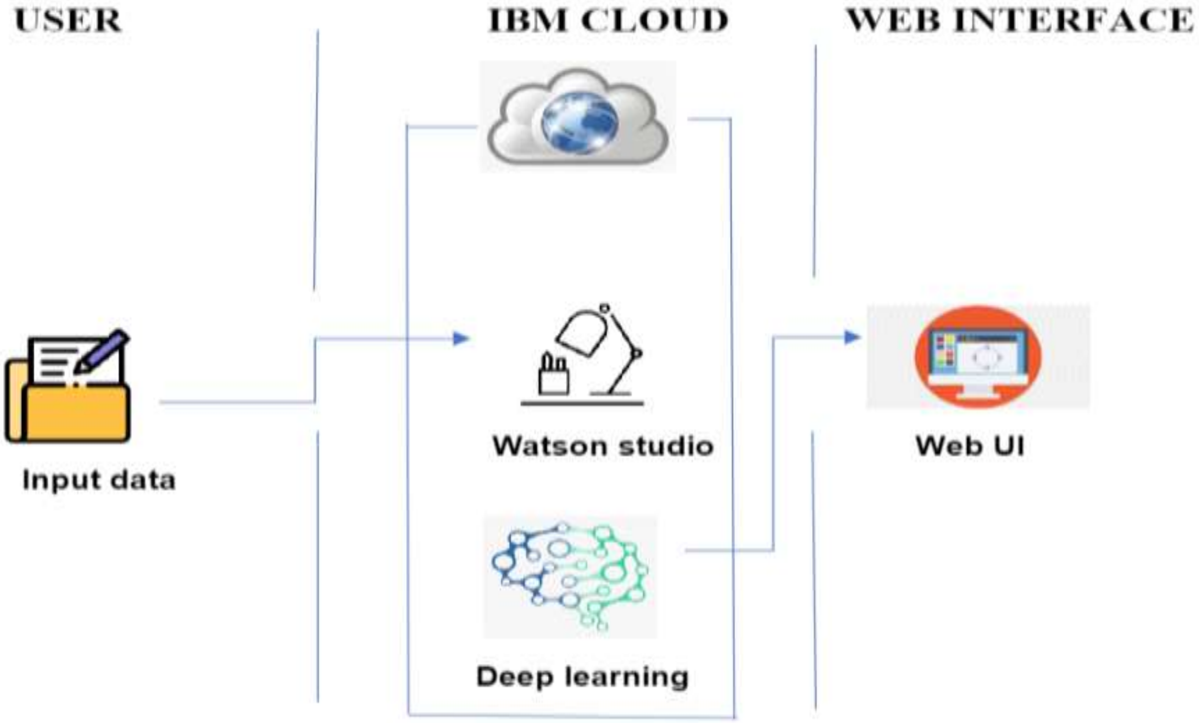
CHAPTER 5

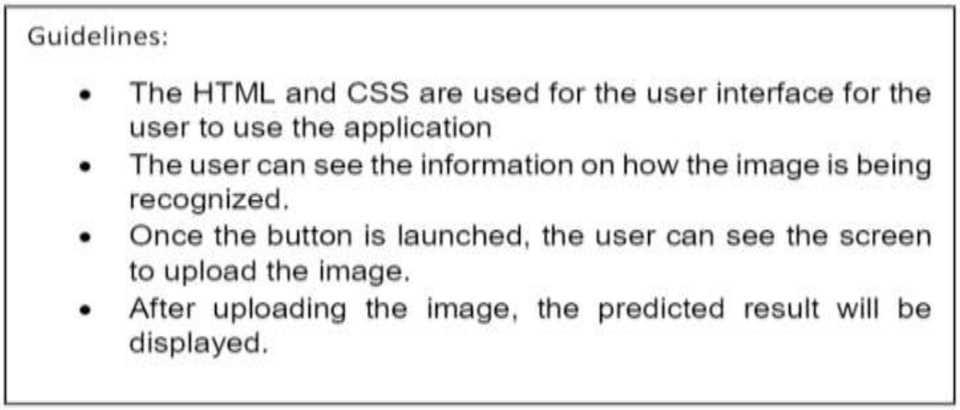
PROJECT DESIGN

5.1DATA FLOW DIAGRAM



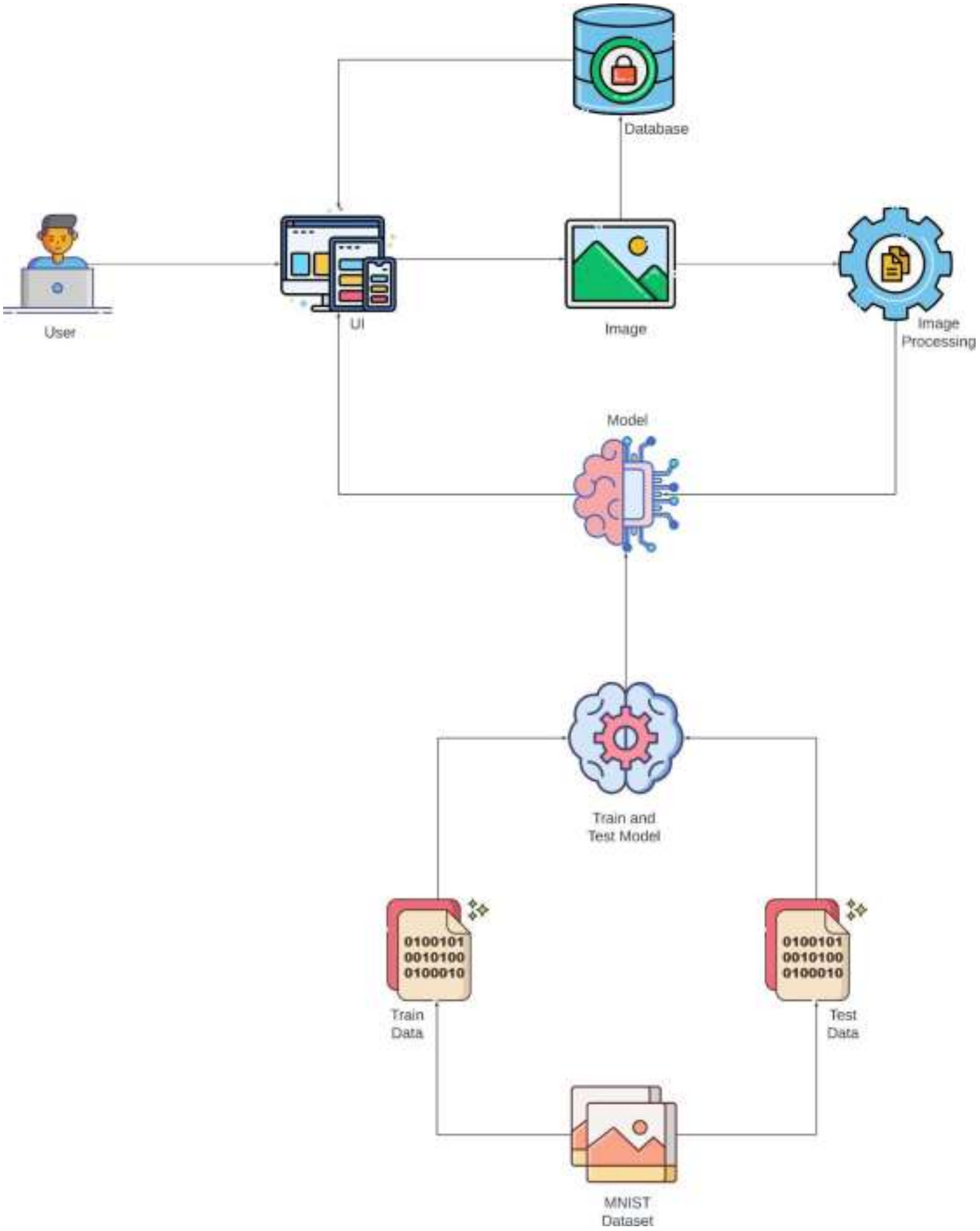
5.2 SOLUTION & TECHNICAL ARCHITECTURE





Guidelines:

- The HTML and CSS are used for the user interface for the user to use the application
- The user can see the information on how the image is being recognized.
- Once the button is launched, the user can see the screen to upload the image.
- After uploading the image, the predicted result will be displayed.


Database
User
UI
Image
Image
Processing
Model
Train and
Test Model
0100101
0010100
0100010
Train
Data
0100101
0010100
0100010
Test
Data
MNIST
Dataset

5.3 USER STORIES

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Web user (customer)	Access web page	USN-1	As a user, anyone can access the web page to upload the handwritten image	I can access my web page through online at any time	High	Sprint-1
	Usage of handwritten data	USN-2	As per the style of the handwriting, it is easy to predict the input	Prediction can be done in an easy way	High	Sprint-2
	Accuracy of the handwriting	USN-3	By using the prediction model, the user can check whether the digit is recognized correctly	Prediction of handwritten digit will be accurate	High	Sprint-3
	View the result	USN-4	As a user, he/she can view the digitalized form of the input	Final result will be displayed	High	Sprint-3
Customer Care Executive	Upload clear image/ draw clearly	USN-5	As a user, he/she need to upload clear and neat image to increase accuracy	Result will be accurate	High	Sprint-3

CHAPTER 6

PROJECT PLANNING AND SCHEDULING

6.1SPRINT PLANNING AND ESTIMATION

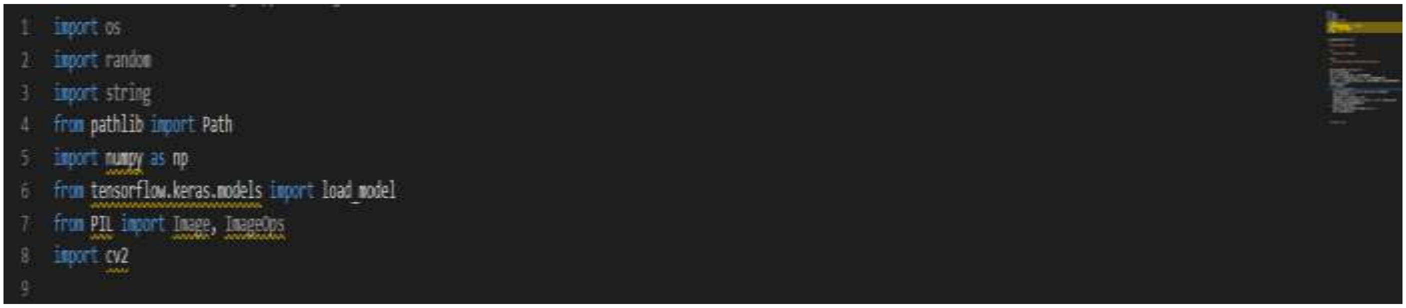
Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration	USN-1	As a user, I can register for application	10	High	Saranya. R
Sprint-1	Log in	USN-2	As a user, I can log in into the application	10	High	Swathi. G
Sprint-2	Model creation	USN-3	As a user, I can use the model for predicting the handwritten digits	10	High	Varsha. S
Sprint-2	Prediction	USN-4	As a user, I can predict the digitalized output	10	High	Vyshnavi.S
Sprint-3	Upload Image of the handwritten document	USN-5	As a user, I can able to upload images of the handwritten digit documents	8	Medium	Saranya. R
Sprint-3	Draw the digits on canvas	USN-6	As a user, I can able to draw the digit in canvas	12	High	Swathi. G
Sprint-4	Digit Recognition	USN-7	As a user, I can able to get the digital output of the digit from uploaded handwritten images	9	Medium	Varsha.S
Sprint-4	Digit Recognition	USN-8	As a user, I can able to get the digital output of the digit from canvas	11	High	Vyshnavi.S

6.2 SPRINT DELIVERY SCHEDULE

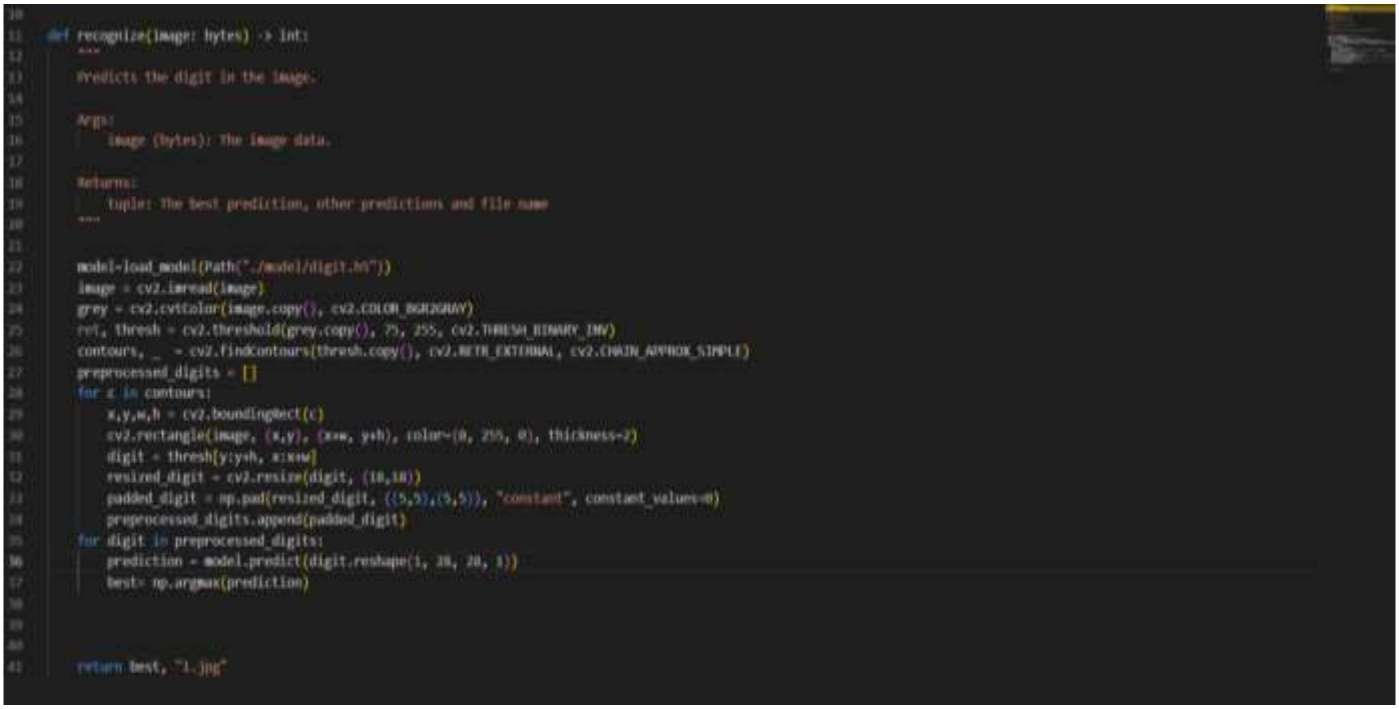
Sprint	**Total Story Points**	**Duration**	**Sprint Start Date**	**Sprint End Date (Planned)**	**Story Points Completed (as on Planned End Date)**	**Sprint Release Date (Actual)**
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	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 & SOLUTIONING



```python
import os
import random
import string
from pathlib import Path
import numpy as np
from tensorflow.keras.models import load_model
from PIL import Image, ImageOps
import cv2

```

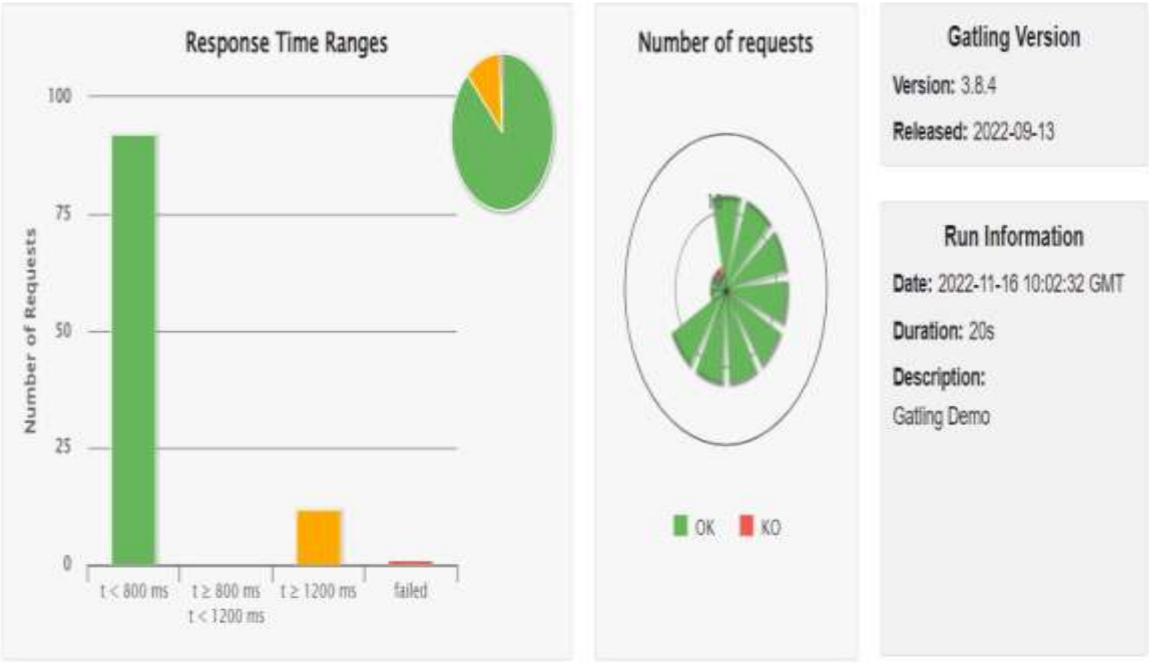


```python

def recognize(image: bytes) -> int:
    """
    Predicts the digit in the image.

    Args:
        image (bytes): The image data.

    Returns:
        tuple: The best prediction, other predictions and file name
    """

    model=load_model(Path("./model/digit.h5"))
    image = cv2.imread(image)
    grey = cv2.cvtColor(image.copy(), cv2.COLOR_BGR2GRAY)
    ret, thresh = cv2.threshold(grey.copy(), 75, 255, cv2.THRESH_BINARY_INV)
    contours, _ = cv2.findContours(thresh.copy(), cv2.RETR_EXTERNAL, cv2.CHAIN_APPROX_SIMPLE)
    preprocessed_digits = []
    for c in contours:
        x,y,w,h = cv2.boundingRect(c)
        cv2.rectangle(image, (x,y), (x+w, y+h), color=(0, 255, 0), thickness=2)
        digit = thresh[y:y+h, x:x+w]
        resized_digit = cv2.resize(digit, (18,18))
        padded_digit = np.pad(resized_digit, ((5,5),(5,5)), "constant", constant_values=0)
        preprocessed_digits.append(padded_digit)
    for digit in preprocessed_digits:
        prediction = model.predict(digit.reshape(1, 28, 28, 1))
        best= np.argmax(prediction)



    return best, "1.jpg"
```

CHAPTER 8

TESTING

8.1TEST CASES



Gatling Version

Version: 3.8.4

Released: 2022-09-13

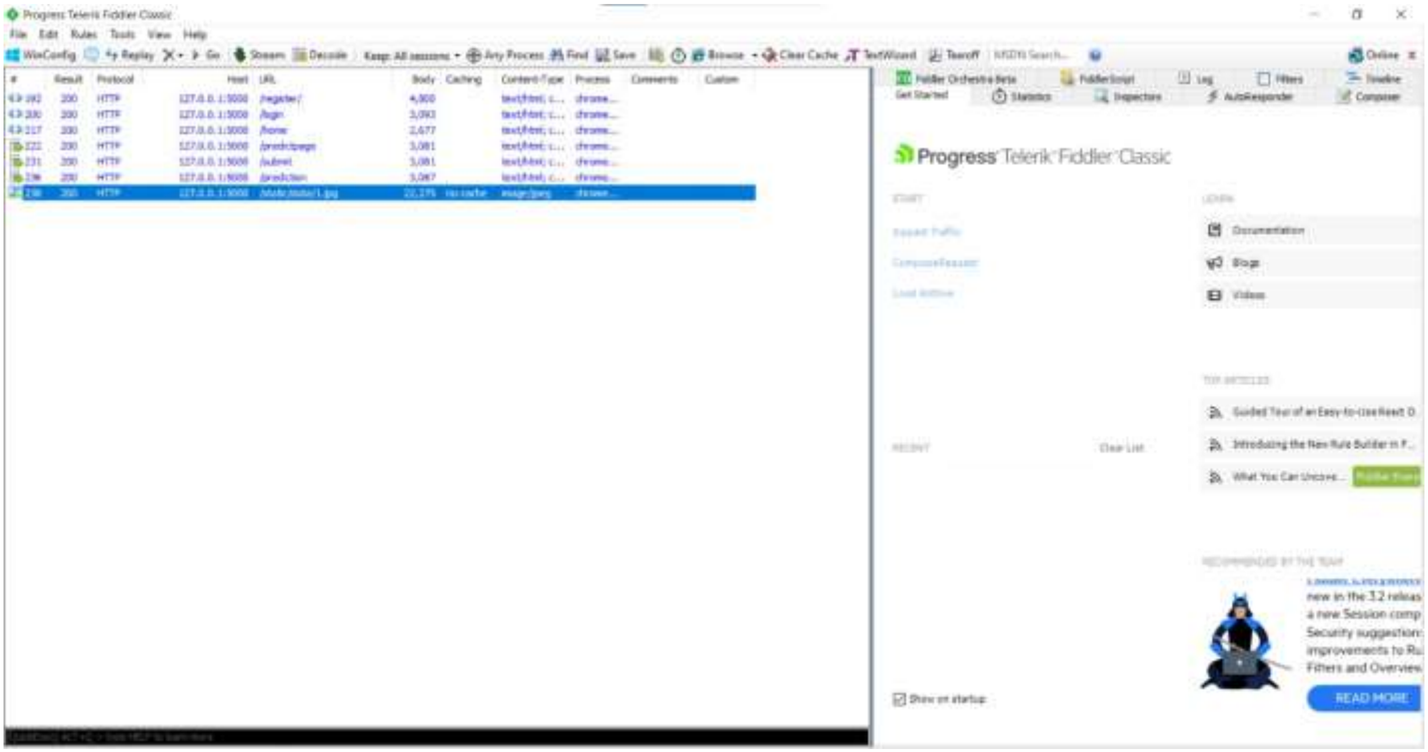
Run Information

Date: 2022-11-16 10:02:32 GMT

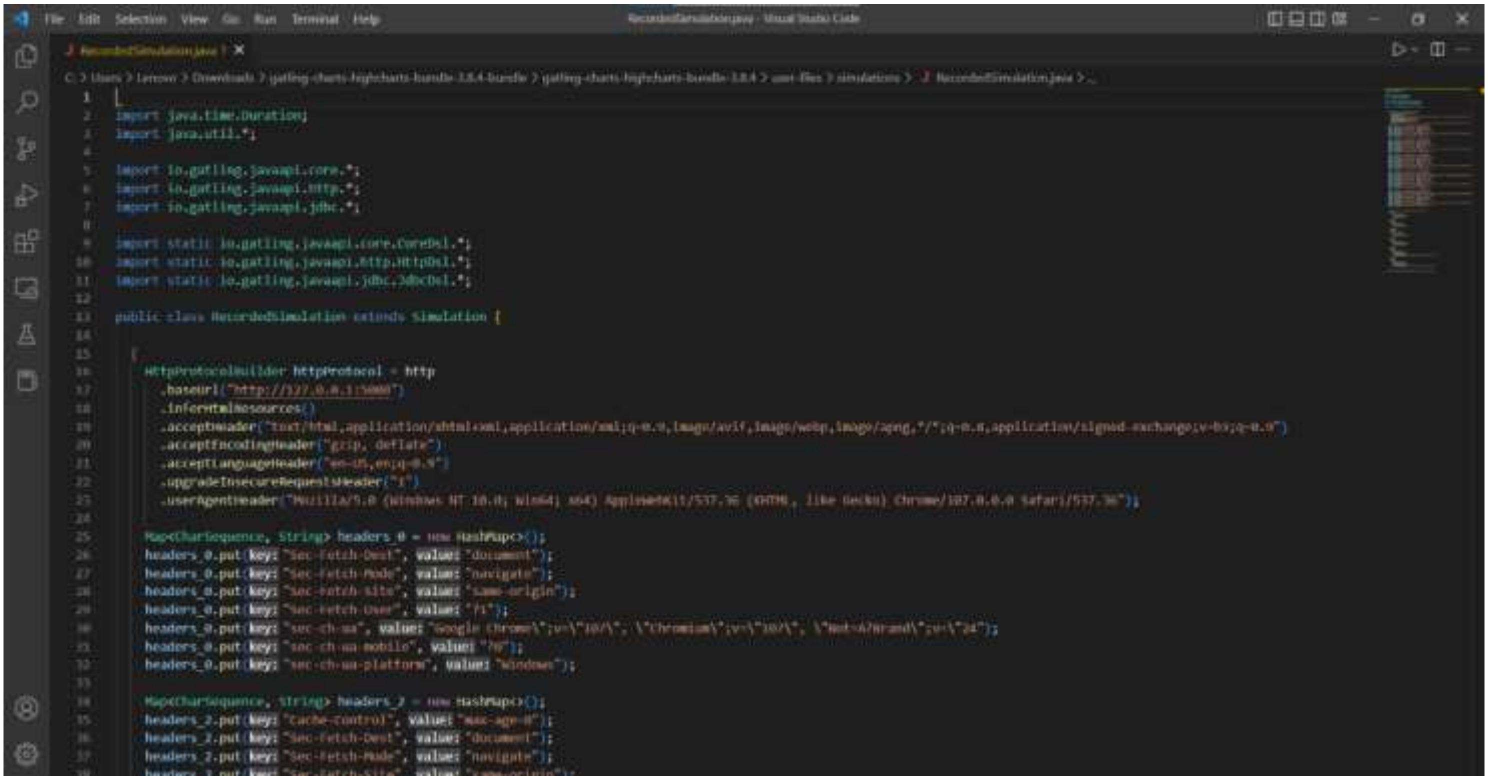
Duration: 20s

Description:

Gatling Demo


Progress Telerik Fiddler Classic
File Edit Rules Tools View Help
WinConfig Replay Go Stream Decode Keep: All sessions Any Process Find Save Browse Clear Cache TextWizard Tearoff MSDN Search... Online
Fiddler Orchestra Beta FiddlerScript Log Filters Timeline
Get Started Statistics Inspectors AutoResponder Composer
Progress Telerik Fiddler Classic
START
LEARN
Documentation
Blogs
Videos
TOP ARTICLES
RECENT
Clear List
RECOMMENDED BY THE TEAM
READ MORE
Show on startup

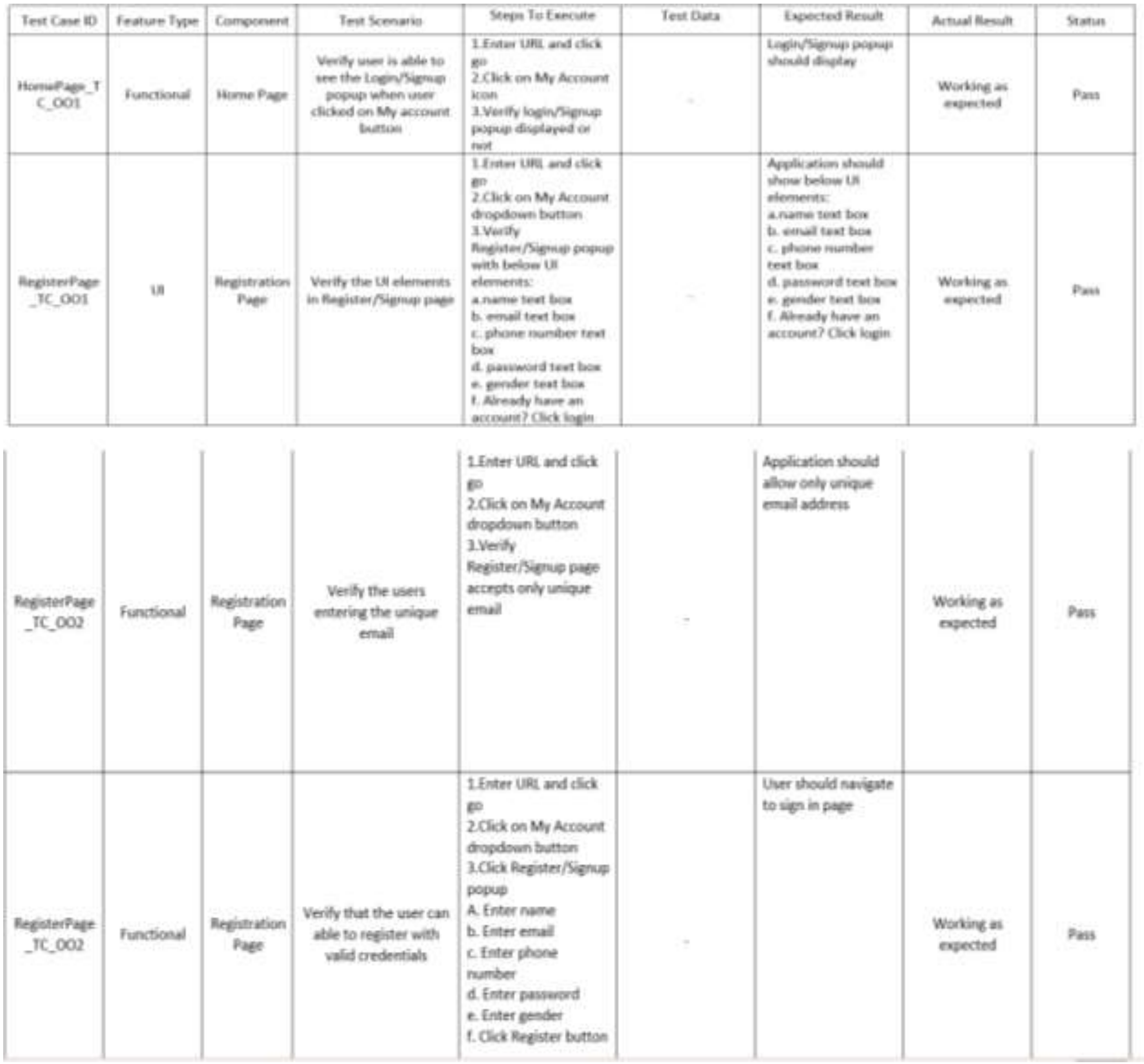
#	Result	Protocol	Host	URL	Body	Caching	Content-Type	Process	Comments	Custom
192	200	HTTP	127.0.0.1:5000	/register/	4,300		text/html; c...	chrome...		
200	200	HTTP	127.0.0.1:5000	/login	3,093		text/html; c...	chrome...		
217	200	HTTP	127.0.0.1:5000	/home	2,677		text/html; c...	chrome...		
222	200	HTTP	127.0.0.1:5000	/predictpage	3,081		text/html; c...	chrome...		
231	200	HTTP	127.0.0.1:5000	/submit	3,081		text/html; c...	chrome...		
236	200	HTTP	127.0.0.1:5000	/prediction	3,067		text/html; c...	chrome...		
238	200	HTTP	127.0.0.1:5000	/static/assets/1.jpg	22,275	no-cache	image/jpeg	chrome...		


File Edit Selection View Go Run Terminal Help
RecordedSimulation.java - Visual Studio Code
RecordedSimulation.java

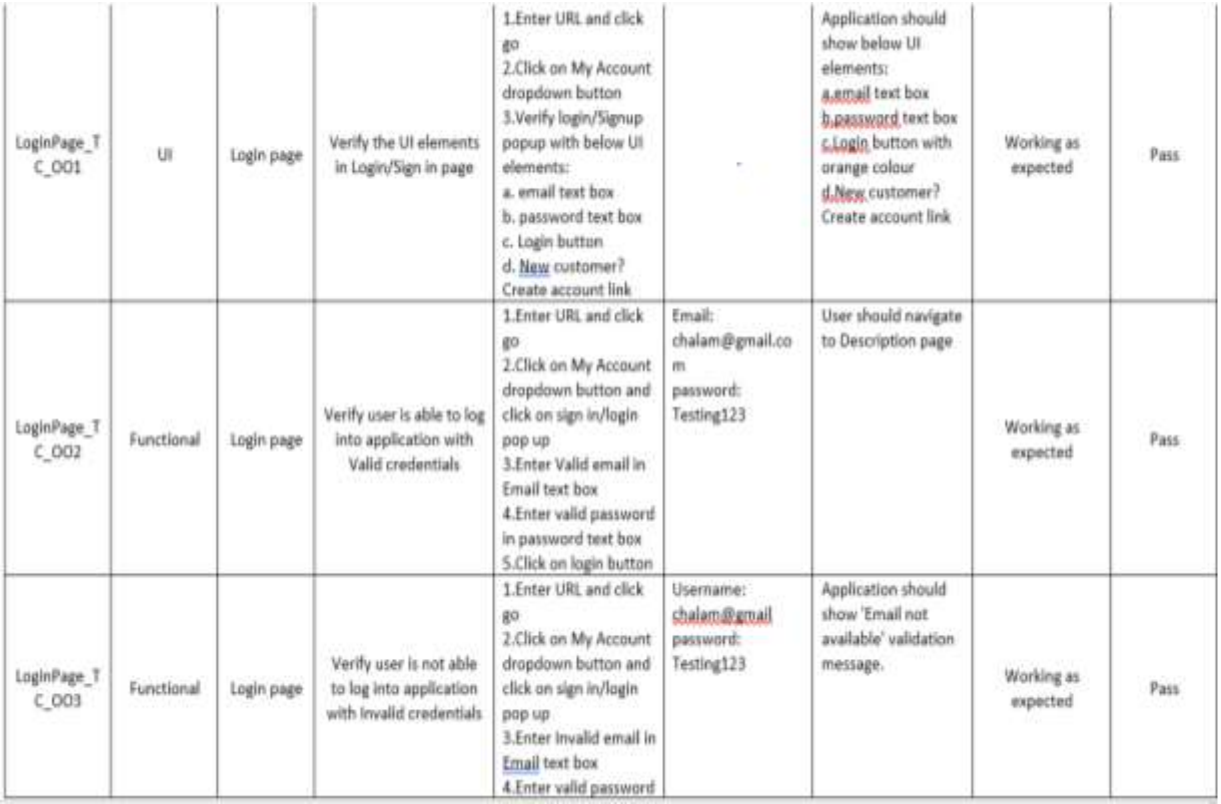
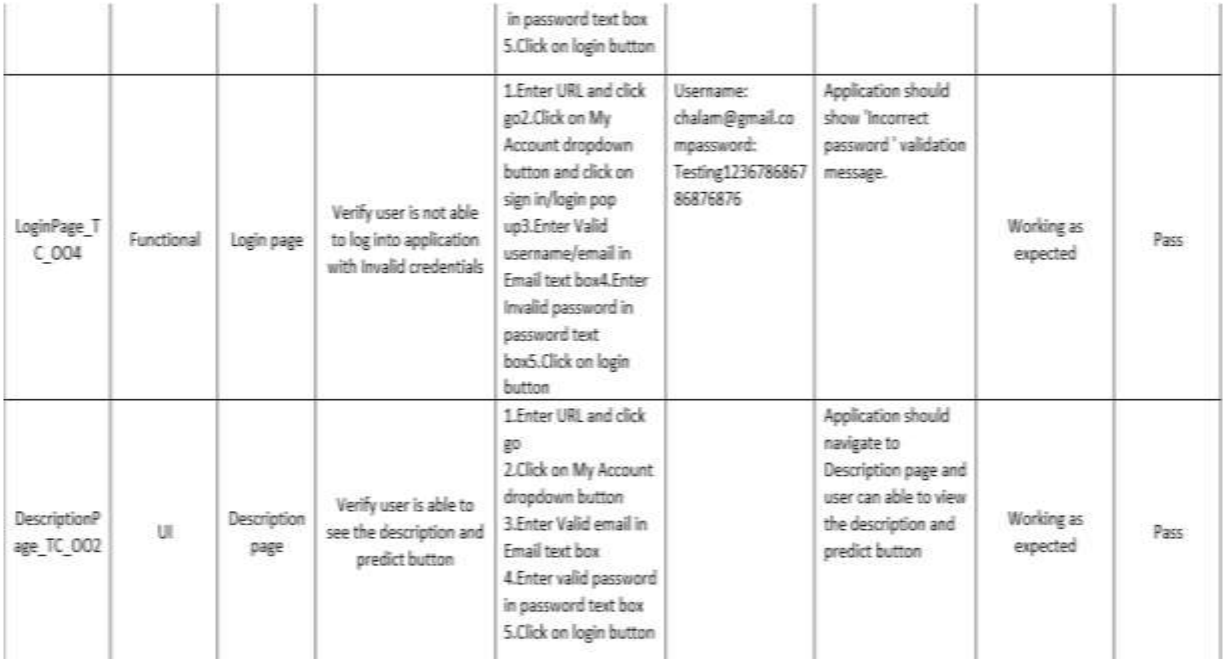
C: > Users > Lenovo > Downloads > gatling-charts-highcharts-bundle-3.8.4-bundle > gatling-charts-highcharts-bundle-3.8.4 > user-files > simulations > RecordedSimulation.java > ...

```java

import java.time.Duration;
import java.util.*;

import io.gatling.javaapi.core.*;
import io.gatling.javaapi.http.*;
import io.gatling.javaapi.jdbc.*;

import static io.gatling.javaapi.core.CoreDsl.*;
import static io.gatling.javaapi.http.HttpDsl.*;
import static io.gatling.javaapi.jdbc.JdbcDsl.*;

public class RecordedSimulation extends Simulation {

  {
    HttpProtocolBuilder httpProtocol = http
      .baseUrl("http://127.0.0.1:5000")
      .inferHtmlResources()
      .acceptHeader("text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,image/apng,*/*;q=0.8,application/signed-exchange;v=b3;q=0.9")
      .acceptEncodingHeader("gzip, deflate")
      .acceptLanguageHeader("en-US,en;q=0.9")
      .upgradeInsecureRequestsHeader("1")
      .userAgentHeader("Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/107.0.0.0 Safari/537.36");

    Map<CharSequence, String> headers_0 = new HashMap<>();
    headers_0.put(key: "Sec-Fetch-Dest", value: "document");
    headers_0.put(key: "Sec-Fetch-Mode", value: "navigate");
    headers_0.put(key: "Sec-Fetch-Site", value: "same-origin");
    headers_0.put(key: "Sec-Fetch-User", value: "?1");
    headers_0.put(key: "sec-ch-ua", value: "\"Google Chrome\";v=\"107\", \"Chromium\";v=\"107\", \"Not=A?Brand\";v=\"24\"");
    headers_0.put(key: "sec-ch-ua-mobile", value: "?0");
    headers_0.put(key: "sec-ch-ua-platform", value: "Windows");

    Map<CharSequence, String> headers_2 = new HashMap<>();
    headers_2.put(key: "cache-control", value: "max-age=0");
    headers_2.put(key: "Sec-Fetch-Dest", value: "document");
    headers_2.put(key: "Sec-Fetch-Mode", value: "navigate");
    headers_2.put(key: "Sec-Fetch-Site", value: "same-origin");
```

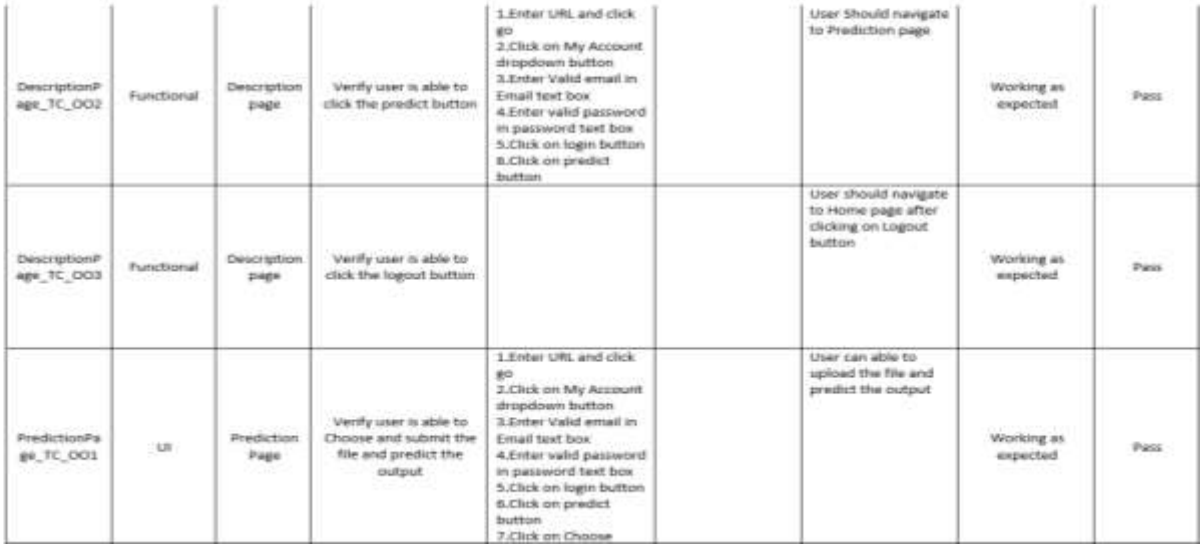
8.2 USER ACCEPTANCE TESTING



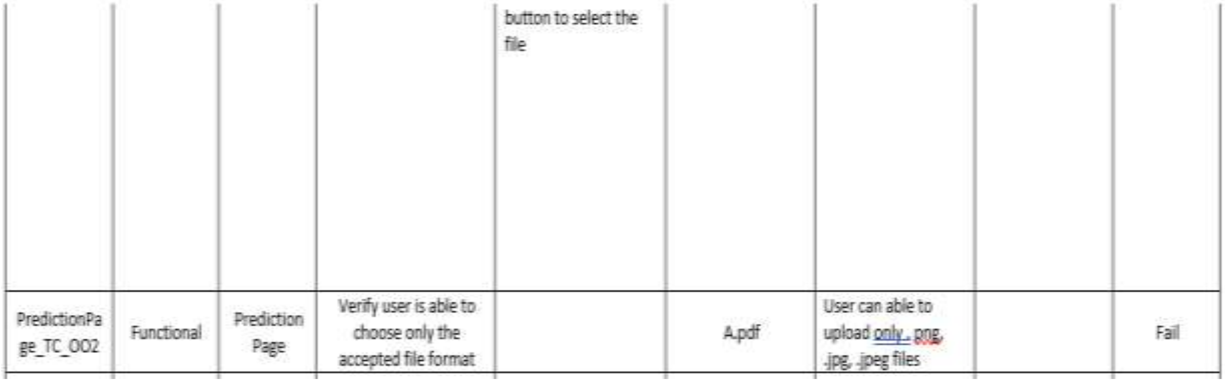
Test Case ID	Feature Type	Component	Test Scenario	Steps To Execute	Test Data	Expected Result	Actual Result	Status
HomePage_TC_OO1	Functional	Home Page	Verify user is able to see the Login/Signup popup when user clicked on My account button	1.Enter URL and click go 2.Click on My Account icon 3.Verify login/Signup popup displayed or not	-	Login/Signup popup should display	Working as expected	Pass
RegisterPage_TC_OO1	UI	Registration Page	Verify the UI elements in Register/Signup page	1.Enter URL and click go 2.Click on My Account dropdown button 3.Verify Register/Signup popup with below UI elements: a.name text box b. email text box c. phone number text box d. password text box e. gender text box f. Already have an account? Click login	-	Application should show below UI elements: a.name text box b. email text box c. phone number text box d. password text box e. gender text box f. Already have an account? Click login	Working as expected	Pass
RegisterPage_TC_OO2	Functional	Registration Page	Verify the users entering the unique email	1.Enter URL and click go 2.Click on My Account dropdown button 3.Verify Register/Signup page accepts only unique email	-	Application should allow only unique email address	Working as expected	Pass
RegisterPage_TC_OO2	Functional	Registration Page	Verify that the user can able to register with valid credentials	1.Enter URL and click go 2.Click on My Account dropdown button 3.Click Register/Signup popup A. Enter name b. Enter email c. Enter phone number d. Enter password e. Enter gender f. Click Register button	-	User should navigate to sign in page	Working as expected	Pass

LoginPage_TC_001	UI	Login page	Verify the UI elements in Login/Sign in page	1.Enter URL and click go 2.Click on My Account dropdown button 3.Verify login/Signup popup with below UI elements: a. email text box b. password text box c. Login button d. New customer? Create account link		Application should show below UI elements: a.email text box b.password text box c.Login button with orange colour d.New customer? Create account link	Working as expected	Pass
LoginPage_TC_002	Functional	Login page	Verify user is able to log into application with Valid credentials	1.Enter URL and click go 2.Click on My Account dropdown button and click on sign in/login pop up 3.Enter Valid email in Email text box 4.Enter valid password in password text box 5.Click on login button	Email: chalam@gmail.com password: Testing123	User should navigate to Description page	Working as expected	Pass
LoginPage_TC_003	Functional	Login page	Verify user is not able to log into application with invalid credentials	1.Enter URL and click go 2.Click on My Account dropdown button and click on sign in/login pop up 3.Enter Invalid email in Email text box 4.Enter valid password in password text box 5.Click on login button	Username: chalam@gmail password: Testing123	Application should show 'Email not available' validation message.	Working as expected	Pass
LoginPage_TC_004	Functional	Login page	Verify user is not able to log into application with Invalid credentials	1.Enter URL and click go2.Click on My Account dropdown button and click on sign in/login pop up3.Enter Valid username/email in Email text box4.Enter Invalid password in password text box5.Click on login button	Username: chalam@gmail.compassword: Testing123678686786876876	Application should show 'Incorrect password ' validation message.	Working as expected	Pass
DescriptionPage_TC_002	UI	Description page	Verify user is able to see the description and predict button	1.Enter URL and click go 2.Click on My Account dropdown button 3.Enter Valid email in Email text box 4.Enter valid password in password text box 5.Click on login button		Application should navigate to Description page and user can able to view the description and predict button	Working as expected	Pass



DescriptionPage_TC_OO2	Functional	Description page	Verify user is able to click the predict button	1.Enter URL and click go 2.Click on My Account dropdown button 3.Enter Valid email in Email text box 4.Enter valid password in password text box 5.Click on login button 8.Click on predict button		User Should navigate to Prediction page	Working as expected	Pass
DescriptionPage_TC_OO3	Functional	Description page	Verify user is able to click the logout button			User should navigate to Home page after clicking on Logout button	Working as expected	Pass
PredictionPage_TC_OO1	UI	Prediction Page	Verify user is able to Choose and submit the file and predict the output	1.Enter URL and click go 2.Click on My Account dropdown button 3.Enter Valid email in Email text box 4.Enter valid password in password text box 5.Click on login button 6.Click on predict button 7.Click on Choose		User can able to upload the file and predict the output	Working as expected	Pass

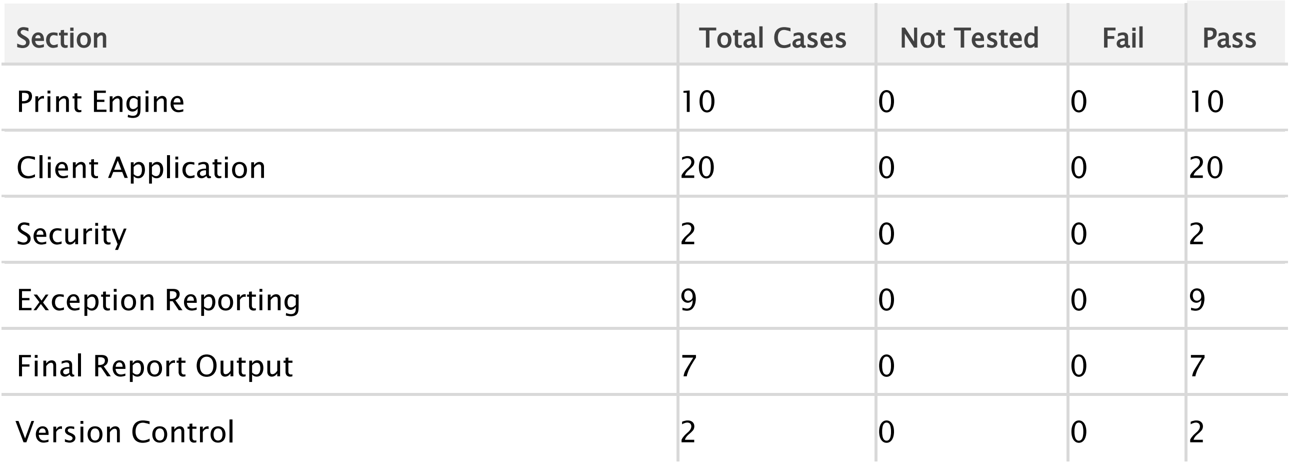


				button to select the file				
PredictionPage_TC_OO2	Functional	Prediction Page	Verify user is able to choose only the accepted file format		A.pdf	User can able to upload only . png, .jpg, .jpeg files		Fail

8.2.1DEFECT ANALYSIS

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	20	4	2	10	36
Duplicate	1	0	0	1	2
External	2	4	1	2	9
Fixed	3	6	4	10	23
Not Reproduced	1	2	1	1	5
Skipped	1	1	0	1	3
Won't Fix	0	5	3	7	15
Totals	28	22	11	32	99

8.2.2TESTCASE ANALYSIS

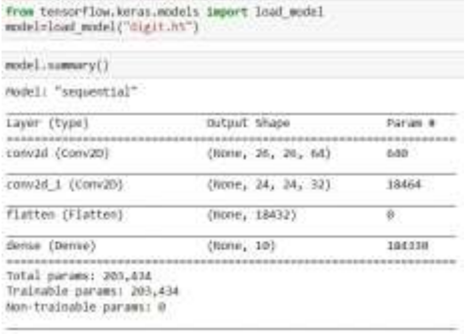
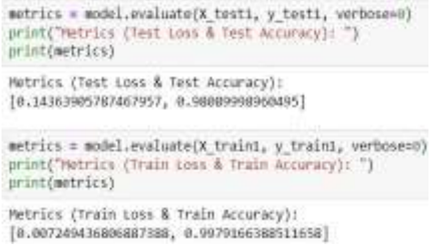
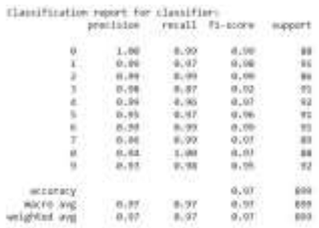


Section	Total Cases	Not Tested	Fail	Pass
Print Engine	10	0	0	10
Client Application	20	0	0	20
Security	2	0	0	2
Exception Reporting	9	0	0	9
Final Report Output	7	0	0	7
Version Control	2	0	0	2

CHAPTER 9

RESULTS

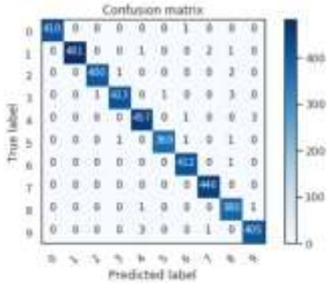
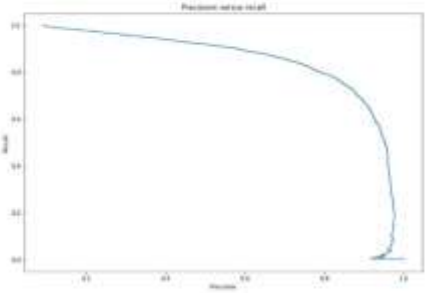
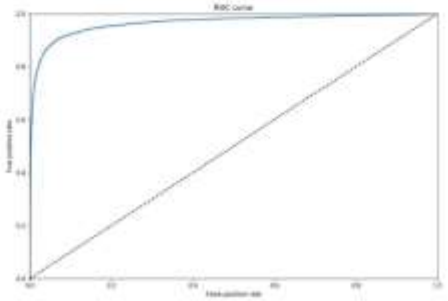
9.1PERFORMANCE METRICS

S.No.	Parameter	Values	Screenshot
1.	Model Summary	Model: "sequential" Layer (type) Output Shape Param # conv2d (Conv2D) (None, 26, 26, 64) 640 conv2d_1 (Conv2D) (None, 24, 24, 32) 18464 flatten (Flatten) (None, 18432) 0 dense (Dense) (None, 10) 184330 Total params: 203,434 Trainable params: 203,434 Non-trainable params: 0	
2.	Accuracy	Training Accuracy -0.9979166388511658 Validation Accuracy -0.98089998960495	
3. `	Metrics	**Classification Model:** precision,recall,f1-score,support	

```
from tensorflow.keras.models import load_model
model=load_model("digit.h5")

model.summary()

Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 26, 26, 64)        640
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 24, 24, 32)        18464
_________________________________________________________________
flatten (Flatten)            (None, 18432)             0
_________________________________________________________________
dense (Dense)                (None, 10)                184330
=================================================================
Total params: 203,434
Trainable params: 203,434
Non-trainable params: 0
_________________________________________________________________
```

```
metrics = model.evaluate(X_test1, y_test1, verbose=0)
print("Metrics (Test Loss & Test Accuracy): ")
print(metrics)

Metrics (Test Loss & Test Accuracy):
[0.14363905787467957, 0.98089998960495]

metrics = model.evaluate(X_train1, y_train1, verbose=0)
print("Metrics (Train Loss & Train Accuracy): ")
print(metrics)

Metrics (Train Loss & Train Accuracy):
[0.007249436806887388, 0.9979166388511658]
```

```
Classification report for classifier:
              precision    recall  f1-score   support

           0       1.00      0.99      0.99        88
           1       0.96      0.97      0.96        91
           2       0.99      0.99      0.99        86
           3       0.98      0.87      0.92        91
           4       0.99      0.96      0.97        92
           5       0.95      0.97      0.96        91
           6       0.99      0.99      0.99        91
           7       0.96      0.99      0.97        89
           8       0.92      1.00      0.96        88
           9       0.97      0.98      0.98        92

    accuracy                           0.97       899
   macro avg       0.97      0.97      0.97       899
weighted avg       0.97      0.97      0.97       899
```

4.	Metrics	Confusion Matrix	
5.	Metrics	Precision-Recall or PR curve	
6.	Metrics	ROC (Receiver Operating Characteristics) 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 98% 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 digits from manual writing in canvas
- 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:

```
from keras.datasets import mnist
import matplotlib.pyplot as plt
from keras.utils import np_utils
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D,Dense,Flatten
from tensorflow.keras.optimizers import Adam
(X_train,y_train),(
X_test,y_test) =mnist.load_data()
print(X_train.shape)
print(X_test.shape)
print(y_test.shape)
print(y_train.shape)
print("The label value is ",y_test[10]) #Value in y_test
plt.imshow(X_test[10])
print("The label value is ",y_test[65]) #Value in y_test
plt.imshow(X_test[65])
X_train.shape
X_test.shape
 X_train1 = X_train.reshape(60000, 28, 28, 1).astype('float32')
X_test1 = X_test.reshape(10000, 28, 28, 1).astype('float32')
number_of_classes= 10
y_train1 = np_utils.to_categorical(y_train,number_of_classes)
y_test1 = np_utils.to_categorical(y_test,number_of_classes)
print("After encoding the value",y_test[10] ,"become", y_test1[10])
print("After encoding the value",y_test[100] ,"become", y_test1[100])
 print("After encoding the value",y_test[65] ,"become", y_test1[65])
```

```
model = Sequential()
model.add(Conv2D(64, (3, 3), input_shape=(28, 28, 1), activation="relu"))
model.add(Conv2D(32, (3, 3), activation="relu"))
model.add(Flatten())
model.add(Dense(number_of_classes, activation="softmax"))
 model.compile(loss='categorical_crossentropy', optimizer="Adam", metrics=["accuracy"])
 model.fit(X_train1, y_train1, batch_size=32, epochs=5, validation_data=(X_test1,y_test1))
metrics = model.evaluate(X_test1, y_test1, verbose=0)
print("Metrics (Test Loss & Test Accuracy): ")
print(metrics)
prediction = model.predict(X_test1[:4])
print(prediction)
import numpy as np
print(np.argmax(prediction, axis=1))
print(y_test1[:4])
model.save("model.h5")
from tensorflow.keras.models import load_model
model=load_model("model.h5")
 model.summary()
```

FLASK APP:

```
from flask import Flask, render_template, request,redirect,session, url_for
from flask_mail import Mail, Message
from itsdangerous import URLSafeTimedSerializer, SignatureExpired
import mysql.connector
import os
from flask_mysqldb import MySQL
from recognize import recognize
import requests
from io import BytesIO
```

```
        from werkzeug.utils import secure_filename
        app = Flask(__name__)
        app.secret_key=os.urandom(24)
        app.config['MYSQL_HOST'] = 'localhost'
        app.config['MYSQL_USER'] = 'root'
        app.config['MYSQL_PASSWORD'] = "
        app.config['MYSQL_DB'] = 'digit_recognition'
mysql = MySQL(app)
@app.route('/')
        def index():
            return render_template('index.html')
@app.route('/login')
        def login():
            return render_template('login.html')
        @app.route('/register/')
        def about():
            return render_template('form.html')
@app.route('/home')
        def home():
            if 'email' in session:
                return render_template('home.html')
            else:
                return redirect('/')
    @app.route('/login_validation',methods=['POST'])
        def login_validation():
            if request.method == "POST":
               email=request.form.get('email')
                password=request.form.get('password')
                error = None
```

```
       if mysql:
            print("Connection Successful!")
            cursor = mysql.connection.cursor()
            cursor.execute("""SELECT * FROM `users` where `Email` LIKE '{}' """.format(email))
            users = cursor.fetchall()
            cursor.close()
            cursor1 = mysql.connection.cursor()
            cursor1.execute("""SELECT * FROM `users` where `Email` LIKE '{}' and `Password` LIKE '{}'""".format(email, password))
            users1 = cursor1.fetchall()
            cursor1.close()
       else:
            print("Connection Failed!")
        if len(users)>0:
            if len(users1)>0:
                session['email'] = users[0][1]
                return redirect('/home')
            else:
                error = "Wrong password"
        else:
            error = "Email not available"
    return render_template('login.html',error=error)
@app.route('/add_user',methods=['POST'])
def add_user():
    username=request.form.get('username')
    email = request.form.get('email')
    password = request.form.get('password')
    phone = request.form.get('phone')
    gender = request.form.get('gender')
    if mysql:
        print("Connection Successful!")
        cursor = mysql.connection.cursor()
        cursor.execute(
            """INSERT INTO `users` (`FullName`,`Email`,`Password`,`PhoneNo`,`Gender`) VALUES
('{}','{}','{}','{}','{}')""".format(username,email, password,phone,gender))
        mysql.connection.commit()
        cursor.close()
    else:
        print("Connection Failed!")
    return redirect('/login')
@app.route('/logout')
def logout():
    return redirect('/')
@app.route('/predictpage',methods=['POST'])
def predictpage():
    return render_template('prediction.html')
@app.route('/submit',methods=['POST'])
def submit():
    if request.method == 'POST':
        # Upload file flask
        uploaded_img = request.files['image']
        # Upload file to database (defined uploaded folder in static path)
        uploaded_img.save('./static/data/1.jpg')
        # Storing uploaded file path in flask session
        session['uploaded_img_file_path'] = "./static/data/1.jpg"
        return render_template('prediction.html')
@app.route('/prediction',methods=('POST', "GET"))
def predict():
        # Retrieving uploaded file path from session
        img_file_path = session.get('uploaded_img_file_path', None)
        best, img1 = recognize(img_file_path)
        return render_template("prediction.html", best=best, img_name=img1)
if __name__=="__main__":
    app.run(debug=True)
```

RECOGNIZER(PYTHON):

```
import os
import random
import string
from pathlib import Path
import numpy as np
from tensorflow.keras.models import load_model
from PIL import Image, ImageOps
import cv2
def recognize(image: bytes) -> int:
    """
    Predicts the digit in the image

    Args:
        image (bytes): The image data.
    Returns:
        tuple: The best prediction, other predictions and file name
    """
    model=load_model(Path("./model/digit.h5"))
    image = cv2.imread(image)
    grey = cv2.cvtColor(image.copy(), cv2.COLOR_BGR2GRAY)
    ret, thresh = cv2.threshold(grey.copy(), 75, 255, cv2.THRESH_BINARY_INV)
    contours, _  = cv2.findContours(thresh.copy(), cv2.RETR_EXTERNAL, cv2.CHAIN_APPROX_SIMPLE)
    preprocessed_digits = []
    for c in contours:
        x,y,w,h = cv2.boundingRect(c)
        cv2.rectangle(image, (x,y), (x+w, y+h), color=(0, 255, 0), thickness=2)
        digit = thresh[y:y+h, x:x+w]
        resized_digit = cv2.resize(digit, (18,18))
        padded_digit = np.pad(resized_digit, ((5,5),(5,5)), "constant", constant_values=0)
        preprocessed_digits.append(padded_digit)
    for digit in preprocessed_digits:
        prediction = model.predict(digit.reshape(1, 28, 28, 1))
        best= np.argmax(prediction)
    return best, "1.jp
```

FORM PAGE(HTML):

```
     <!doctype html>
     <html lang="en">
      <head>
       <!-- Required meta tags -->
       <meta charset="utf-8">
       <meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">
 <link rel="stylesheet" type="text/css" href="{{ url_for('static',filename='css/style.css')}}">
       <!-- Bootstrap CSS -->
       <link rel="stylesheet" href="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/css/bootstrap.min.css"
     integrity="sha384-ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcWr7x9JvoRxT2MZw1T"
     crossorigin="anonymous">
<title>Handwritten Digit Recognition</title>
       <img src="{{ url_for('static', filename='images/registerimg2.jpg') }}" alt="" width="600" height="650"
     style="margin-left: 100px;margin-right:0%;">
        <style>
     *{
      margin: 0;
      padding: 0;
      box-sizing: border-box;
      font-family: 'Poppins',sans-serif;
     }
     body{
      height: 100vh;
      display: flex;
      justify-content: center;
      align-items: center;
      padding: 10px;
```

```
  background: linear-gradient(135deg, #71b7e6, #9b59b6);
}
.container{
  max-width: 700px;
  margin-left: 0%;
  width: 100%;
  background-color: #fff;
  padding: 25px 30px;
  border-radius: 5px;
  box-shadow: 0 5px 10px rgba(0,0,0,0.15);
}
.container .title{
  font-size: 25px;
  font-weight: 500;
  position: relative;
}
.container .title::before{
  content: "";
  position: absolute;
  left: 0;
  bottom: 0;
  height: 3px;
  width: 30px;
  border-radius: 5px;
  background: linear-gradient(135deg, #71b7e6, #9b59b6);
}
.content form .user-details{
  display:inline;
  flex-wrap: wrap;
  justify-content: space-between;
  margin: 20px 0 12px 0;
}
 form .input-box span.details{
  display: block;
  font-weight: 500;
 margin-bottom: 5px;
}
.user-details .input-box input{
 height: 45px;
 width: 100%;
 outline: none;
 font-size: 16px;
 border-radius: 5px;
 padding-left: 15px;
 border: 1px solid #ccc;
 border-bottom-width: 2px;
 transition: all 0.3s ease;
}
.user-details .input-box input:focus,
.user-details .input-box input:valid{
 border-color: #9b59b6;
}
 form .gender-details .gender-title{
 font-size: 20px;
 font-weight: 500;
 }
 form .category{
  display: flex;
  width: 80%;
  margin: 14px 0 ;
  justify-content: space-between;
 }
 form .category label{
  display: flex;
  align-items: center;
  cursor: pointer;
 }
 form input[type="radio"]{
  display: none;
 }
 form .button{
  height: 45px;
  margin: 35px 0
 }
 form .button input{
  height: 100%;
  width: 100%;
  border-radius: 5px;
  border: none;
  color: #fff;
  font-size: 18px;
  font-weight: 500;
  letter-spacing: 1px;
  cursor: pointer;
  transition: all 0.3s ease;
  background: linear-gradient(135deg, #71b7e6, #9b59b6);
 }
 form .button input:hover{
 /* transform: scale(0.99); */
 background: linear-gradient(-135deg, #71b7e6, #9b59b6);
 }
 @media(max-width: 584px){
 .container{
 max-width: 100%;
}
form .user-details .input-box{
    margin-bottom: 15px;
    width: 100%;
 }
 form .category{
    width: 100%;
 }
 .content form .user-details{
    max-height: 300px;
    overflow-y: scroll;
 }
 .user-details::-webkit-scrollbar{
  width: 5px;
 }
 }
 @media(max-width: 459px){
 .container .content .category{
  flex-direction: column;
 }
}
 </style>
 </head>
 <body class="bg-nav">
  <div class="container">
   <div class="title">Registration</div><br>
   <div class="content">
    <form method="post" action="/add_user">
     <div class="user-details">
      <div class="input-box">
       <label>Username</label><br>
       <input type = "text" class="form-control" name="username" placeholder="Enter your name" required>
      </div>
      <div class="input-box">
       <label>Email</label><br>
       <input type = "email" class="form-control" name="email" placeholder="Enter your email" required>
      </div>
      <div class="input-box">
       <label>Password</label><br>
       <input type="password" class="form-control" name="password" placeholder="Enter your password" required>
      </div>
      <div class="input-box">
       <label>Phone Number</label><br>
       <input type = "number" class="form-control" name="phone" placeholder="Enter your number" required>
      </div>
      <div class="input-box">
       <label>Gender</label><br>
       <input type = "text" class="form-control" placeholder="Enter Male/Female/Others" name="gender" required>
      </div>
      <div class="button">
       <input type="submit" class="btn btn-primary btn-block btn-lg" value="Register">
      </div>
     </div>
      <p style="text-align:center;">Already have an Account?   <a href="/login" class="reg">Login</a></h4>
     </form>
   </div>
  </div>
 </body>
```

INDEX PAGE(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>User Account Dropdown Menu Using Html CSS & Vanilla Javascript</title>
  <link rel="stylesheet" href="style.css">
  <link href="https://fonts.googleapis.com/css2?family=Poppins:wght@200;300;400;600&display=swap" rel="stylesheet">
  <link href="https://fonts.googleapis.com/css?family=Material+Icons|Material+Icons+Outlined|Material+Icons+Two+Tone|Material+Icons+Round|Material+Icons+Sharp" rel="stylesheet">
  <style>
    *{
      font-family: "poppins", sans-serif;
      margin: 0;
      padding: 0;
    }
```

```
.icons-size{
   color: white;
   font-size: 14px;
}
.text{
   position: fixed;
   right: 950px;
   top:22px
}
.action{
   position: fixed;
   right: 1450px;
   top:20px
}
.action .profile{
   border-radius: 50%;
   cursor: pointer;
   height: 60px;
   overflow: hidden;
   position: relative;
   width: 60px;
}
.action .profile img{
   width: 100%;
   top:0;
   position: absolute;
   object-fit: cover;
   left: 0;
   height: 100%;
}
.action .menu{
   background-color:#FFF;
   box-sizing:0 5px 25px rgba(0,0,0,0.1);
   border-radius: 15px;
   padding: 10px 20px;
```

```
    position: absolute;
    left: -10px;
    width: 200px;
    transition: 0.5s;
    top: 120px;
    visibility: hidden;
    opacity: 0;
}
.action .menu.active{
    opacity: 1;
    top: 80px;
    visibility: visible;
}
.action .menu::before{
    background-color:#fff;
    content: ";
    height: 20px;
    position: absolute;
    right: 190px;
    transform:rotate(45deg);
    top:-5px;
    width: 20px;
}
.action .menu h3{
    color: #555;
    font-size: 16px;
    font-weight: 600;
    line-height: 1.3em;
    padding: 20px 0px;
    text-align: left;
    width: 100%;
}
.action .menu h3 div{
    color: #818181;
    font-size: 14px;
    font-weight: 400;
}
.action .menu ul li{
    align-items: center;
    border-top:1px solid rgba(0,0,0,0.05);
    display: flex;
    justify-content: left;
    list-style: none;
    padding: 10px 0px;
}
.action .menu ul li img{
    max-width: 20px;
    margin-right: 10px;
    opacity: 0.5;
    transition:0.5s
}
.action .menu ul li a{
    display: inline-block;
    color: #555;
    font-size: 14px;
    font-weight: 600;
    padding-left: 15px;
    text-decoration: none;
    text-transform: uppercase;
    transition: 0.5s;
}
.action .menu ul li:hover img{
    opacity: 1;
}
.action .menu ul li:hover a{
    color:#ff00ff;
}
.msg{
    position: fixed;
    right: 950px;
    left:0px;
    top:250px
}
      .image {
        background-image: url("{{ url_for('static', filename='images/index2.jpg') }}");
        background-color: #cccccc;
        height: 753px;
        width: 1536px;
        background-position: center;
        background-repeat: no-repeat;
        background-size: cover;
      }
    </style>
</head>
<body>
    <div class="image">
        <div class="action">
            <div class="profile" onclick="menuToggle();">
                <img src="{{ url_for('static', filename='images/user.jpg') }}" alt="">
                  </div>
    <div class="menu">
                <h3>
                    User Account
                </h3>
                <ul>
                    <li>
                        <span class="material-icons icons-size">person</span>
                        <a href="/register/">Sign-up</a>
                    </li>
                    <li>
                        <span class="material-icons icons-size">mode</span>
                        <a href="/login">Sign-in</a>
                    </li>
                </ul>
            </div>
```

```
          </div>
        <div class="text">
            <h1 style="color: white;">Handwritten digit Recognisor</h1>
        </div>
        <div class="msg">
            <h1 style="color: white;font-size: 50px;">
            <pre>
                Numbers
                Rule
                The
                Universe
            </pre>
            </h1>
        </div>
      </div>
  <script>
        function menuToggle(){
            const toggleMenu = document.querySelector('.menu');
            toggleMenu.classList.toggle('active')
        }
    </script>
</body>
```

LOGIN PAGE(HTML):

```
<!doctype html>
<html lang="en">
  <head>
    <!-- Required meta tags -->
    <meta charset="utf-8">
    <meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <link rel="stylesheet" type="text/css" href="{{ url_for('static',filename='css/style.css')}}">
    <!-- Bootstrap CSS -->
    <link rel="stylesheet" href="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/css/bootstrap.min.css"
integrity="sha384-ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcWr7x9JvoRxT2MZw1T"
```

```
crossorigin="anonymous">
  <link href="https://fonts.googleapis.com/css2?family=Poppins:wght@200;300;400;600&display=swap"
rel="stylesheet">
  <link
href="https://fonts.googleapis.com/css?family=Material+Icons|Material+Icons+Outlined|Material+Icons+Two+T
one|Material+Icons+Round|Material+Icons+Sharp" rel="stylesheet">
  <title>Handwritten Digit Recognition</title>
  <style>
   .image {
    background-image: url("{{ url_for('static', filename='images/loginimg2.jpg') }}");
    background-color: #cccccc;
    height: 753px;
    background-position: center;
    background-repeat: no-repeat;
    background-size: cover;
    position: relative;
   }
  </style>
 </head>
 <body class="bg-nav">
  <div class="image">
  <div id="content" >
    <div class="container">
     <br><br>
     <h1 style="text-align:center;">Sign In</h1>
     <div class="row">
      <div class="col-md-6" style="margin-left: 300px;">
        <div class="card">
         <div class="card-body" style="border:2px solid black">
          <form class="form" method="post" action="/login_validation">
           <label>Email</label><br>
           <input type = "email" class="form-control" name="email"><br>
           <label>Password</label><br>
           <input type="password" class="form-control" name="password"><br><br>
           {% if error %}
           <p style="text-align: center;"><strong>Error</strong>: {{error}}</p>
           {% endif %}
           <input type="submit" class="btn btn-primary btn-block btn-lg" value="Login">
          </form>
          <br>
           <p style="margin-top:10px;text-align:center;">Not a member? <a href="/register/">Create
Account</a></p>
         </div>
        </div>
      </div>
     </div>
    </div>
  </div>
  </div>
<!-- Optional JavaScript -->
  <!-- jQuery first, then Popper.js, then Bootstrap JS -->
  <script src="https://code.jquery.com/jquery-3.3.1.slim.min.js" integrity="sha384-
q8i/X+965DzO0rT7abK41JStQIAqVgRVzpbzo5smXKp4YfRvH+8abtTE1Pi6jizo"
crossorigin="anonymous"></script>
  <script src="https://cdn.jsdelivr.net/npm/popper.js@1.14.7/dist/umd/popper.min.js" integrity="sha384-
UO2eT0CpHqdSJQ6hJty5KVphtPhzWj9WO1clHTMGa3JDZwrnQq4sF86dIHNDz0W1"
crossorigin="anonymous"></script>
  <script src="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/js/bootstrap.min.js" integrity="sha384-
JjSmVgyd0p3pXB1rRibZUAYoIIy6OrQ6VrjIEaFf/nJGzIxFDsf4x0xIM+B07jRM"
crossorigin="anonymous"></script>
 </body>
</html>
```

HOME PAGE (HTML):

```
    <!DOCTYPE html>
    <html lang="en">
     <head>
      <!-- Required meta tags -->
      <meta charset="utf-8">
      <meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">
<link rel="stylesheet" type="text/css" href="{{ url_for('static',filename='css/style.css')}}">
      <!-- Bootstrap CSS -->
      <link rel="stylesheet" href="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/css/bootstrap.min.css"
    integrity="sha384-ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcWr7x9JvoRxT2MZw1T"
    crossorigin="anonymous">
 <title>Handwritten Digit Recognition</title>
     </head>
    <body>
    <div class="bg-nav text-light d-flex flex-column flex-md-row align-items-center p-3 px-md-4 mb-3 bg-dark
    border-bottom shadow-sm" >
     <h5 class="my-0 mr-md-auto" style="color: black;font-weight: bolder;">Handwritten Digit Recognisor</h5>
     <a class="btn btn-outline-primary" href="/logout" style="color: whitesmoke;">Log Out</a>
    </div>
<main role="main">
<section class="album py-3 text-center">
      <form action="/predictpage" method="post">
       <div class="button">
        <input type="submit" class="btn btn-primary btn-block btn-lg" value="Proceed to recognise the handwritten
    digits">
       </div>
      </form>
     </section>
<div class="jumbotron py-8 bg-dark">
      <div class="container">
    <div class="row">
       <div class="card mb-2 shadow-sm">
         <div class="card-body" style="border:5px solid black;">
         <h3 style="text-align: center;">Description</h3><br>
         <p class="card-text" style="font-size: 20px;">The handwritten digit recognition is the ability of
computers to recognize human handwritten digits.
          It is a hard task for the machine because handwritten digits are not perfect, vary from person-to-person
and can be made with many different flavors.
          The handwritten digit recognition is the solution to this problem which uses the image of a digit and
recognizes the digit present in the image.</p>
        </div>
       </div><br><br>
     </div>
    </div>
  </div>
</main>
<script src="https://code.jquery.com/jquery-3.3.1.slim.min.js" integrity="sha384-
q8i/X+965DzO0rT7abK41JStQIAqVgRVzpbzo5smXKp4YfRvH+8abtTE1Pi6jizo"
crossorigin="anonymous"></script>
    <script src="https://cdn.jsdelivr.net/npm/popper.js@1.14.7/dist/umd/popper.min.js" integrity="sha384-
UO2eT0CpHqdSJQ6hJty5KVphtPhzWj9WO1clHTMGa3JDZwrnQq4sF86dIHNDz0W1"
crossorigin="anonymous"></script>
    <script src="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/js/bootstrap.min.js" integrity="sha384-
JjSmVgyd0p3pXB1rRibZUAYoIIy6OrQ6VrjIEaFf/nJGzIxFDsf4x0xIM+B07jRM"
crossorigin="anonymous"></script>
</body>
</html>
```

HOME PAGE (CSS):

```
.bg-nav
{
    background: #e704c9;  /* fallback for old browsers */
    background: -webkit-linear-gradient(to right, #E5E5BE, #db0ac2);  /* Chrome 10-25, Safari 5.1-6 */
    background: linear-gradient(to right, #E5E5BE, #f104b6); /* W3C, IE 10+/ Edge, Firefox 16+, Chrome 26+,
Opera 12+, Safari 7+ */
}
.row{
    margin-top:80px;
```

PREDICT PAGE (HTML):

```
<!DOCTYPE html>
<html lang="en">
  <head>
    <!-- Required meta tags -->
    <meta charset="utf-8">
    <meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">
    <link rel="stylesheet" type="text/css" href="{{ url_for('static',filename='css/style.css')}}">
    <!-- Bootstrap CSS -->
    <link rel="stylesheet" href="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/css/bootstrap.min.css"
integrity="sha384-ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcWr7x9JvoRxT2MZw1T"
crossorigin="anonymous">
<title>Handwritten Digit Recognition</title>
  </head>
<body>
```

```
 <div class="bg-nav text-light d-flex flex-column flex-md-row align-items-center p-3 px-md-4 mb-3 bg-dark border-bottom shadow-sm" >
  <h5 class="my-0 mr-md-auto" style="color: black;font-weight: bolder;">Handwritten Digit Recognisor</h5>
  <a class="btn btn-outline-primary" href="/logout" style="color: whitesmoke;">Log Out</a>
</div>
<main role="main">
  <section class="album py-3 text-center">
    <form action="/predictpage" method="post">
      <div class="button">
        <input type="submit" class="btn btn-primary btn-block btn-lg" value="Proceed to recognise the handwritten digits">
      </div>
    </form>
  </section>
<div class="jumbotron py-8 bg-dark">
    <div class="container">
 <div class="row">
          <div class="card mb-2 shadow-sm">
              <div class="card-body" style="border:5px solid black;">
              <h3 style="text-align: center;">Description</h3><br>
              <p class="card-text" style="font-size: 20px;">The handwritten digit recognition is the ability of computers to recognize human handwritten digits.
                It is a hard task for the machine because handwritten digits are not perfect, vary from person-to-person and can be made with many different flavors.
```

```
            The handwritten digit recognition is the solution to this problem which uses the image of a digit and recognizes the digit present in the image.</p>

          </div>

        </div><br><br>

     </div>

    </div>

  </div>

</main>

   <script src="https://code.jquery.com/jquery-3.3.1.slim.min.js" integrity="sha384-q8i/X+965DzO0rT7abK41JStQIAqVgRVzpbzo5smXKp4YfRvH+8abtTE1Pi6jizo" crossorigin="anonymous"></script>

    <script src="https://cdn.jsdelivr.net/npm/popper.js@1.14.7/dist/umd/popper.min.js" integrity="sha384-UO2eT0CpHqdSJQ6hJty5KVphtPhzWj9WO1clHTMGa3JDZwrnQq4sF86dIHNDz0W1" crossorigin="anonymous"></script>

    <script src="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/js/bootstrap.min.js" integrity="sha384-JjSmVgyd0p3pXB1rRibZUAYoIIy6OrQ6VrjIEaFf/nJGzIxFDsf4x0xIM+B07jRM" crossorigin="anonymous"></script>

</body>

</html>
```

GITHUB

https://github.com/IBM-EPBL/IBM-Project-13438-1659518447

PROJECT DEMO

https://drive.google.com/file/d/143fBxnCQWcPwa4a0MHkBn8QR6FPWpHzO/view?usp=drivesdk