

IBM PROJECT

**A NOVEL METHOD FOR HANDWRITTEN
DIGIT RECOGNITION SYSTEM**

DOMAIN - ARTIFICIAL INTELLIGENCE

SUBMITTED BY :

| | |
|---------------|----------------|
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Project Report Format

1. INTRODUCTION

- 1.1 Project Overview
- 1.2 Purpose

2. LITERATURE SURVEY

- 2.1 Existing problem
- 2.2 References
- 2.3 Problem Statement Definition

3. IDEATION & PROPOSED SOLUTION

- 3.1 Empathy Map Canvas
- 3.2 Ideation & Brainstorming
- 3.3 Proposed Solution
- 3.4 Problem Solution fit

4. REQUIREMENT ANALYSIS

- 4.1 Functional requirement
- 4.2 Non-Functional requirements

5. PROJECT DESIGN

- 5.1 Data Flow Diagrams
- 5.2 Solution & Technical Architecture
- 5.3 User Stories

6. PROJECT PLANNING & SCHEDULING

- 6.1 Sprint Planning & Estimation
- 6.2 Sprint Delivery Schedule
- 6.3 Reports from JIRA

7. CODING & SOLUTIONING (Explain the features added in the project along with code)

- 7.1 Feature 1
- 7.2 Feature 2
- 7.3 Database Schema (if Applicable)

8. TESTING

- 8.1 Test Cases
- 8.2 User Acceptance Testing

9. RESULTS

- 9.1 Performance Metrics

10. ADVANTAGES & DISADVANTAGES

11. CONCLUSION

12. FUTURE SCOPE

13. APPENDIX Source Code GitHub & Project Demo Link

Chapter 1

1. INTRODUCTION

1.1 Project Overview

- Handwriting recognition is one of the compelling research works going on because every individual in this world has their own style of writing.
- It is the capability of the computer to identify and understand handwritten digits or characters automatically.
- Because of the progress in the field of science and technology, everything is being digitalized to reduce human effort.
- Hence, there comes a need for handwritten digit recognition in many real-time applications.
- MNIST data set is widely used for this recognition process and it has 70000 handwritten digits.
- We use Artificial neural networks to train these images and build a deep learning model.
- Web application is created where the user can upload an image of a handwritten digit.
- This image is analyzed by the model and the detected result is returned on to UI.

1.2 Purpose

- This manuscript aims to propose a novel neural network based framework for handwritten character recognition.
- The proposed neural network based framework, transforms the raw data set to a umPy array to achieve image flattening and feeds the same into a pixel vector before feeding it into the network.

Chapter 2

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

1. Ishani Patel, ViragJagtap and OmpriyaKale."A Survey on Feature Extraction Methods for Handwritten Digits Recognition", International Journal of Computer Applications, vol. 107, no. 12, pp. 11-17, 2014.
2. Viragkumar N. Jagtap , Shailendra K. Mishra,"Fast Efficient Artificial Neural Network for Handwritten Digit Recognition", International Journal of Computer Science and Information Technologies, vol. 52, no. 0975- 9646, pp. 2302-2306, 2014.
3. Saeed AL-Mansoori,"Intelligent Handwritten Digit Recognition using Artificial Neural Network", Int. Journal of Engineering Research and Applications, vol. 5, no. 5, pp. 46-51, 2015.

2.3 Problem Statement Definition

Handwritten digit recognition is very important as it will be very helpful to reduce human effort. As each individual has different handwritings for representing digits, the system should have a capability to identify every handwriting with maximum accuracy. Such a system will be useful to reduce human interventions in identification, as everything is being digitized. The main objective of this work is to ensure effective and reliable approaches for recognition of handwritten digits and make banking operations easier and error free. Handwriting recognition has gained a lot of attention in the field of pattern recognition and machine learning due to its application in various fields. Various techniques have been proposed to for digit recognition in handwriting recognition system.

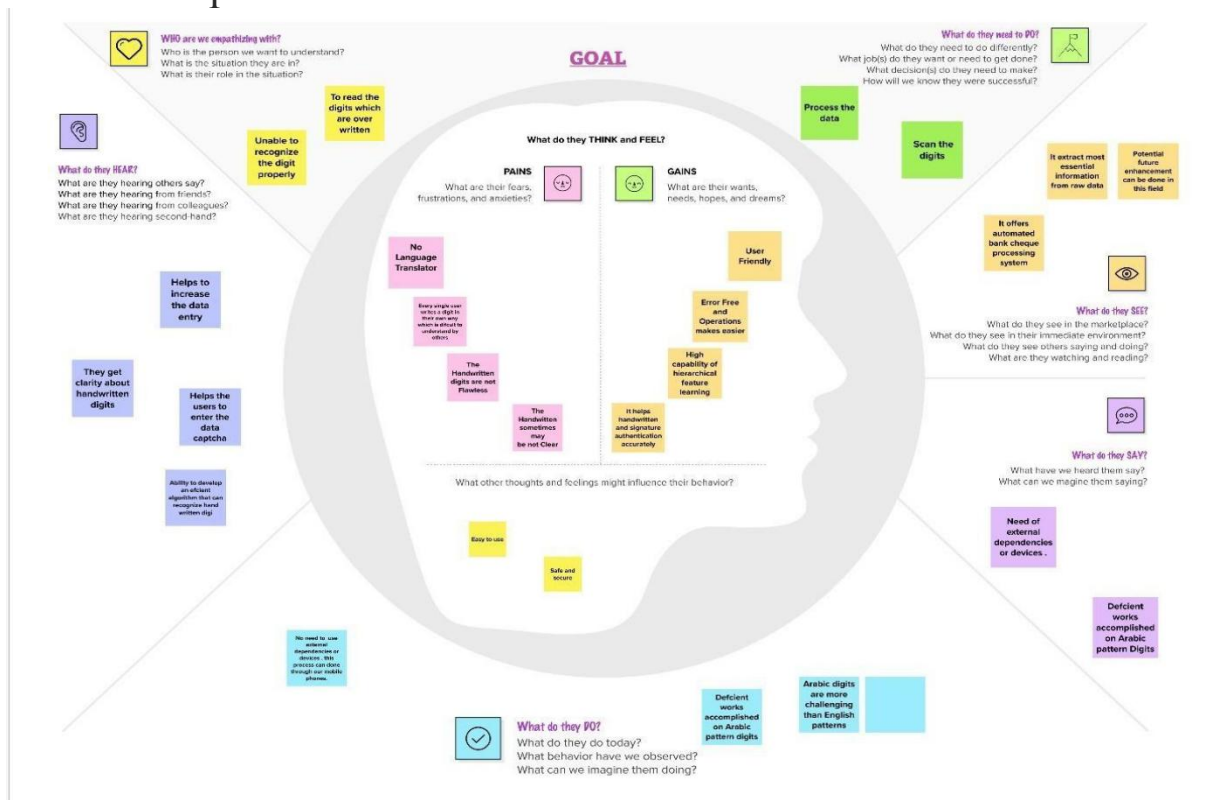
Chapter 3

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas

An empathy map is a simple, easy-to-digest visual that captures knowledge about a user's behaviors and attitudes. It is a useful tool to help teams better understand their users. Creating an effective solution requires understanding the true problem and the person who is experiencing it. The exercise of creating the map helps participants consider things from the user's perspective along with his or her goals and challenges.

Example:



Reference: <https://www.mural.co/templates/empathy-map-canvas>


3.2 Ideation & Brainstorming

Brainstorming provides a free and open environment that encourages everyone within a team to participate in the creative thinking process that leads to problem solving. Prioritizing volume over value, out-of-the-box ideas are welcome and built upon, and all participants are encouraged to collaborate, helping each other develop a rich amount of creative solutions. Use this template in your own brainstorming sessions so your team can unleash their imagination and start shaping concepts even if you're not sitting in the same room.

Reference: <https://www.mural.co/templates/empathy-map-canvas>

Step-1: Team Gathering, Collaboration and Select the Problem Statement

Template



Brainstorm & idea prioritization

Use this template in your own brainstorming sessions so your team can unleash their imagination and start shaping concepts even if you're not sitting in the same room.

- 🕒 10 minutes to prepare
- 🕒 1 hour to collaborate
- 👤 2-8 people recommended

➔

Before you collaborate

A little bit of preparation goes a long way with this session. Here's what you need to do to get going.

🕒 10 minutes

A

Team gathering

Define who should participate in the session and send an invite. Share relevant information or pre-work ahead.

B

Set the goal

Think about the problem you'll be focusing on solving in the brainstorming session.

C

Learn how to use the facilitation tools

Use the Facilitation Superpowers to run a happy and productive session.

[Open article](#) ➔

1


Define your problem statement

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

🕒 5 minutes

PROBLEM

How might we [your problem statement]?

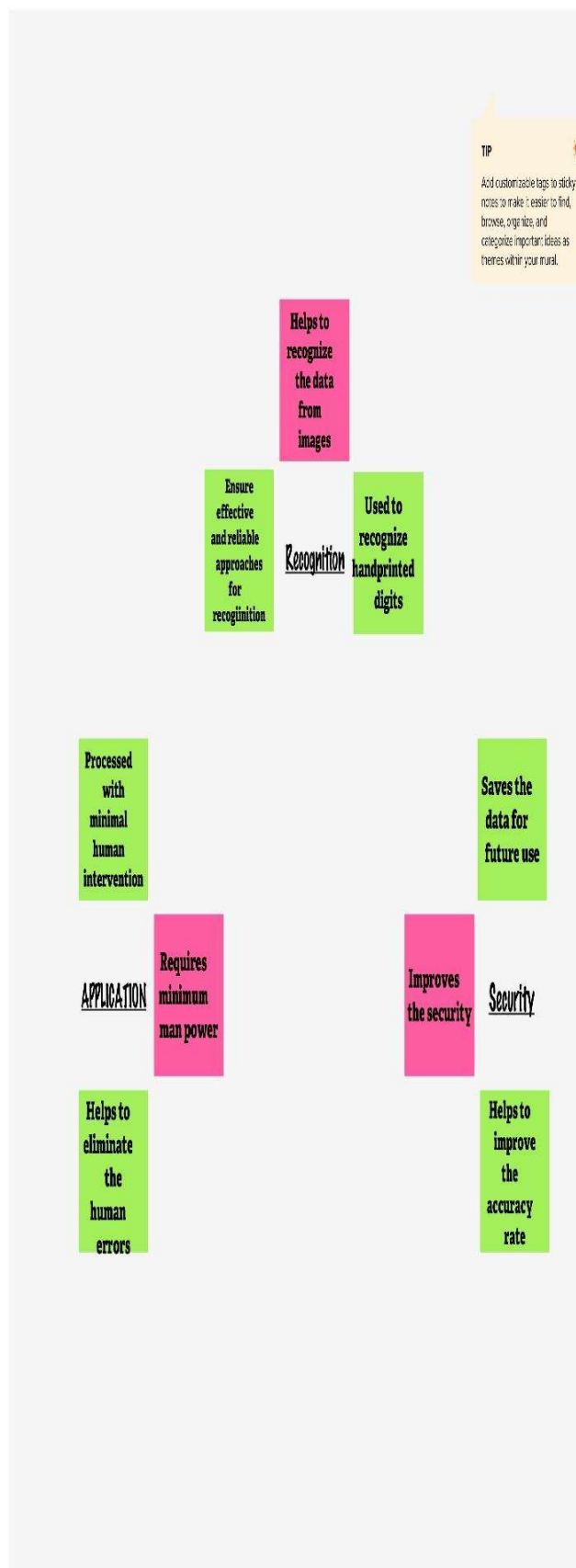
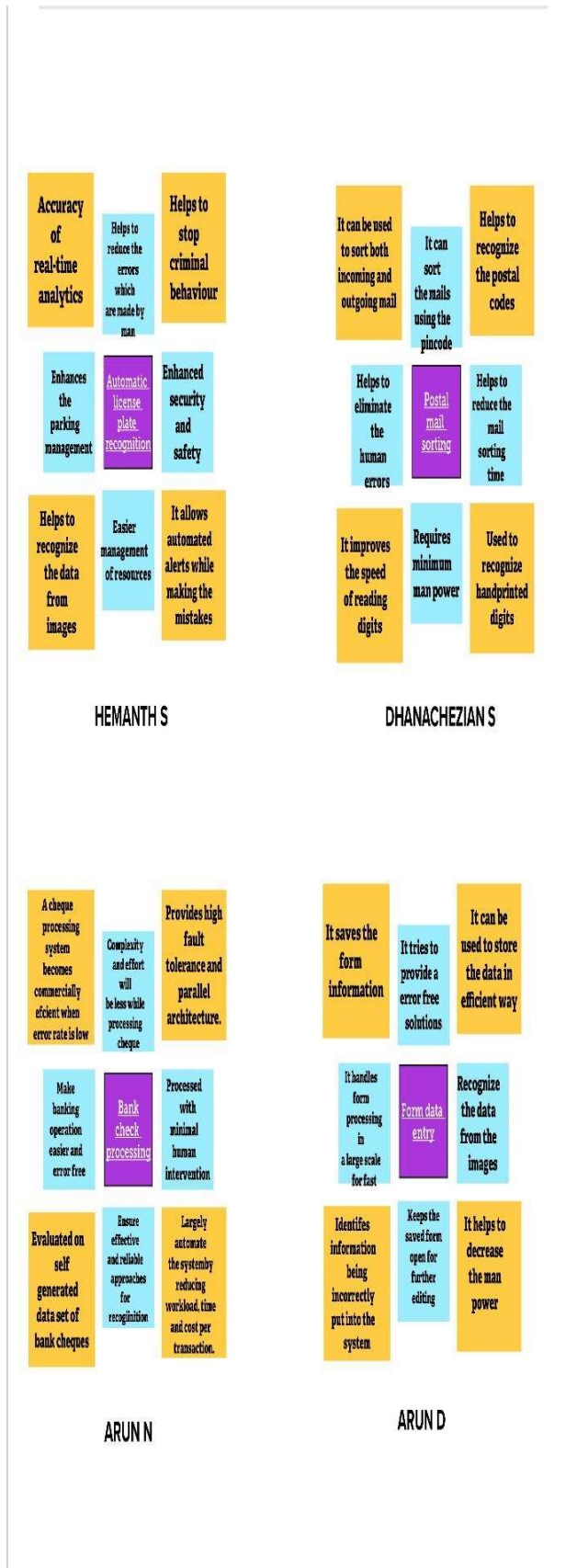


Key rules of brainstorming

To run a smooth and productive session

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

Step-2: Brainstorm, Idea Listing and Grouping



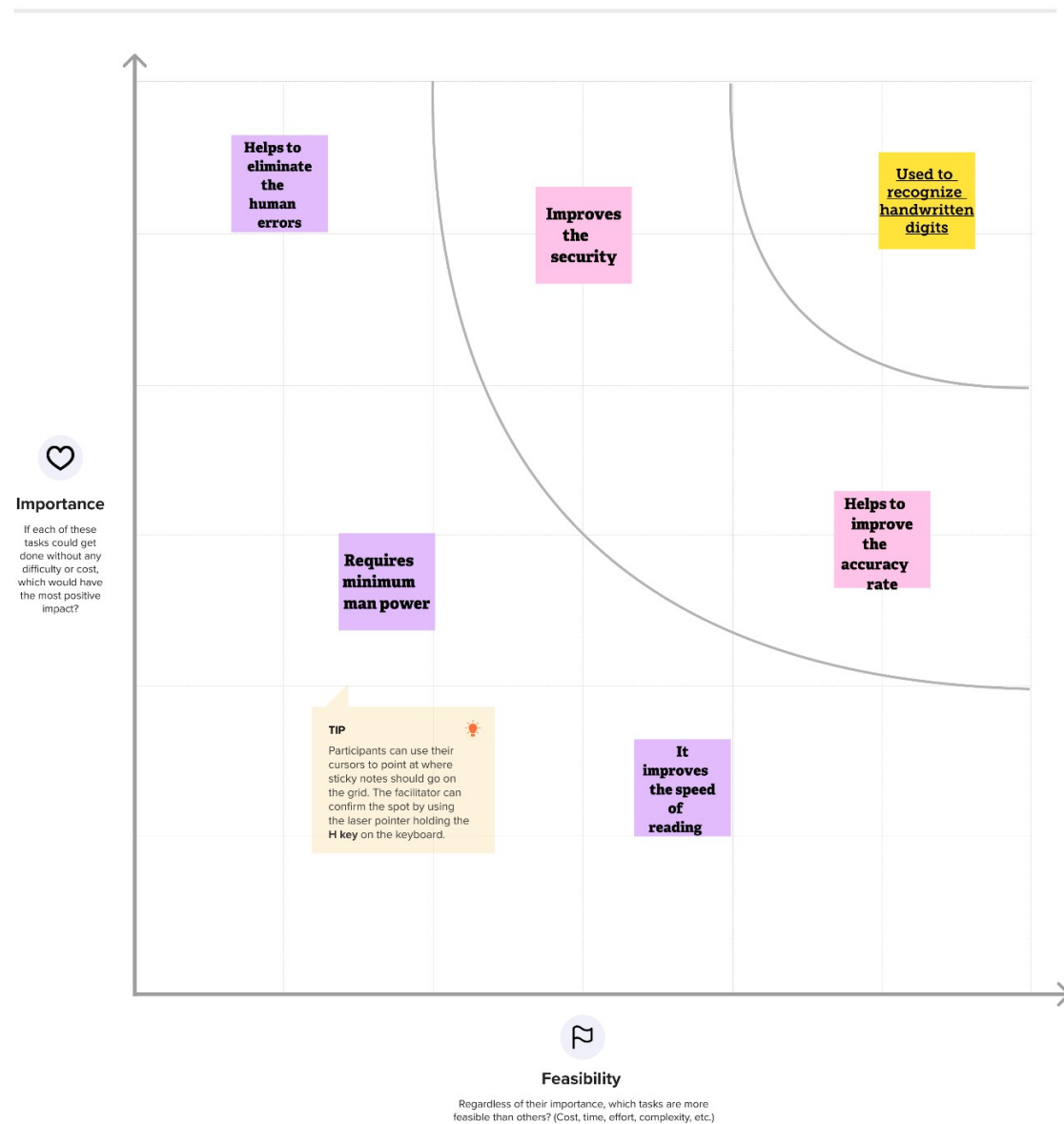
Step-3: Idea Prioritization

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



3.3 Proposed Solution.

| s. no | Parameter | Description |
|------------------|--|--|
| 1 | Problem Statement (Problem to be solved) | <ul style="list-style-type: none">● To make the computer applications to recognize the human handwritten digits for the clear understanding. |
| 2 | Idea / Solution description | <ul style="list-style-type: none">● It is the capability of a computer to identify the mortal handwritten numbers from different sources like images and papers.● The system can get the input either using scanner or uploading the image. Then it compile the file and return the number as output. |
| 3 | Novelty / Uniqueness | <ul style="list-style-type: none">● A perfect transcription would be able to distinguish known and unknown digits in a number.● In handwritten number might include, among other things, a change in the writer, character properties, writing attributes. Instead of examining each element separately, we believe that an integrated agent capable of processing known characters and novelties concurrently is a superior technique. |
| 4 | Social Impact / Customer Satisfaction | <ul style="list-style-type: none">● To reading postal code and bank check amounts, it is also useful for reading forms.● As the system is being used in socially crowded places such as banks to check amounts, it should be fast and reliable. |
| 5 | Business Model (Revenue Model) | <ul style="list-style-type: none">● It can be integrated with Postal system to identify and recognize the pin-code details easily.● This system can be integrated with traffic surveillance cameras to recognize the vehicle's number plates for effective traffic management. |
| 6 | Scalability of the Solution | <ul style="list-style-type: none">● It can able to recognize blurry image even in a noisy environment● The system doesn't worry about the number of digits. It can able to process the number properly |

3.4 Problem Solution fit.

Problem-Solution fit canvas 2.0

Project Title: A Novel Method For Handwritten Digit Recognition System

Team ID -PNT2022TMID29441

TEAM MEMBERS: HEMANTH S , DHANACHEZIAN S , ARUN N , ARUN D

| | | | | |
|---------------------------------------|--|---|--|---------------------------------------|
| Define CS, fit into | 1. CUSTOMER SEGMENT(S) <small>Who is your customer?</small> The main customers for our project are: <ul style="list-style-type: none">Person who wants to recognize the handwritten digit.Person who deals with digit in sector like Schools, Bank, etc. | 6. CUSTOMER <small>What constraints prevent your customers from taking action or limit their choices of solutions? i.e. spend, power, budget, time, skill, network, connection, available devices</small> <ul style="list-style-type: none">It is not possible to give a accurate digit recognition which are written by human all the time. Sometimes it will give an error.It is hard to implement a machine to find a digit. | 5. AVAILABLE SOLUTIONS <small>Which solutions are available to the customers when they face the problem or need to get it done? What is/are they trying to do? What are the pros & cons of these solutions have? i.e. pen and paper is an alternative to digital notetaking</small> The solution is to recognize the numeral and Make notes on paper and a pen. As opposed to employing a system. | Explore AS, |
| | 2. JOBS-TO-BE-DONE / PROBLEMS <small>Which jobs-to-be-done (or problems) do you address for your customers? There could be more than one - explore different sides.</small> <ul style="list-style-type: none">Create a platform to facilitate Handwritten Digit Recognition.A platform to make it simpler to recognize the handwritten words.Make the recognizing complex words written by human simpler | 9. PROBLEM ROOT CAUSE <small>What is the real reason that this problem exists? What is the back story behind the need to do this job? i.e. customers have to do it because of the change in regulations.</small> <ul style="list-style-type: none">In order to recognize handwritten numbers, we must overcome many obstacles. Due to varying writing habits and a lack of Optic character recognition. This study provides a thorough comparison of several machine literacy and Jee, literacy approaches. | 7. BEHAVIOUR <small>What does your customer do to address the problem and get the job done? i.e. directly related: find the right solar panel installer, calculate usage and benefits; indirectly associated: customers spend free time on volunteering work (i.e. Greenpeace)</small> <ul style="list-style-type: none">Finding the finest software to more quickly and accurately recognize digits | |
| Focus on J&P, tap into BE, understand | 3. TRIGGERS <small>What triggers customers to act? i.e. seeing their neighbour installing solar panels, reading about a more efficient solution in the news.</small> <ul style="list-style-type: none">It is necessary to make aware of this system is available among the people and make use of it.How to use this system efficiently | 10. YOUR SOLUTION <small>If you are working on an existing business, write down your current solution first, fill in the canvas, and check how much it fits reality. If you are working on a new business proposition, then keep it blank until you fill in the canvas and come up with a solution that fits within customer limitations, solves a problem and matches customer behaviour.</small> The Handwritten Digit Recognition System, which uses an image of a digit to identify the digit present in the image, offers a solution to this issue. To recognize handwritten numbers, a convolutional neural network model created using PyTorch was deployed to the MNIST dataset. | 8. CHANNELS of BEHAVIOUR 8.1 ONLINE <small>What kind of actions do customers take online? Extract online channels from #7</small> <ul style="list-style-type: none">Use software that is accessible online. 8.2 OFFLINE <small>What kind of actions do customers take offline? Extract offline channels from #7 and use them for customer development.</small> <ul style="list-style-type: none">Obtain current electronics and make sure they function. Extract online & offline CH of B | Focus on J&P, tap into BE, understand |
| | 4. EMOTIONS: BEFORE / AFTER <small>How do customers feel when they face a problem or a job and afterwards? i.e. lost, insecure > confident, in control - use it in your communication strategy & design.</small> <ul style="list-style-type: none">Before: Make sure the system works correctly at most of the time.After. How to find a solution while facing a problem | | | |
| Identify strong TR & EM | | | | Extract online & offline CH of BE |



Problem-Solution fit canvas is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 license created by Daria Nepriukhina / amaltama.com

Chapter 4

4. REQUIREMENT ANALYSIS

4.1 Functional requirement

Following are the functional requirements of the proposed solution.

| FR No. | Functional Requirement (Epic) | Sub Requirement (Story / Sub-Task) |
|---------------|--------------------------------------|---|
| FR-1 | User Input | GUI allows the user to input image by browsing the device storage |
| FR-2 | Model | The MNIST dataset should be trained using CNN to create a trained model |
| FR-3 | Prediction | The trained model has to be tested by using the test data provided by MNIST and the accuracy of the model should be above 90% |
| FR-4 | Evaluation | Ensure that the output produced by the model is Correct |

4.2 Non-Functional requirements

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

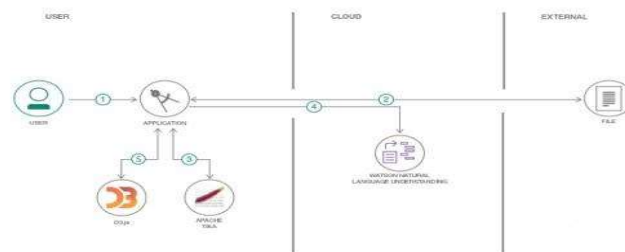
| FR No. | Non-Functional Requirement | Description |
|---------------|-----------------------------------|---|
| NFR-1 | Usability | Can predict digits with accuracy. The model can be used in bank check processing, data entry etc |
| NFR-2 | Security | It ensures security as the uploaded image is not stored in any database |
| NFR-3 | Reliability | Can process confidential information without data leakage as the data is never stored in any database |
| NFR-4 | Performance | Improvement in fast prediction. We use CNN algorithm for accurate prediction |
| NFR-5 | Availability | Available for web and mobile browsers |
| NFR-6 | Scalability | Helps many individuals with low time consumption and high accuracy |

Chapter 5

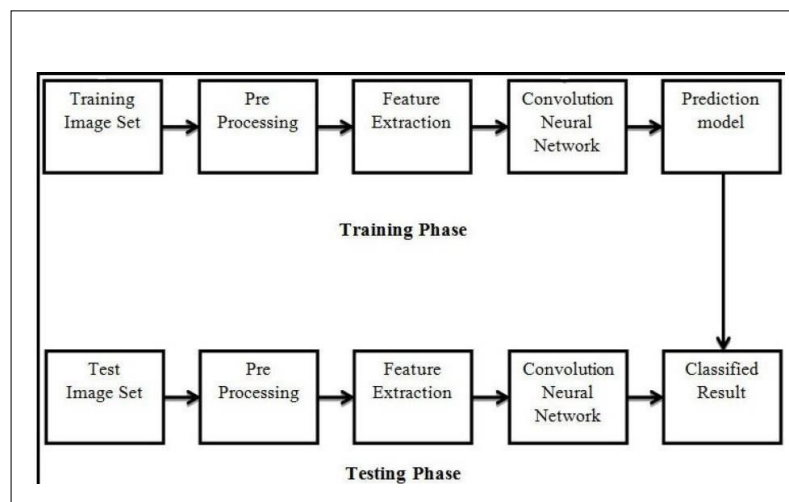
5. PROJECT DESIGN

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.

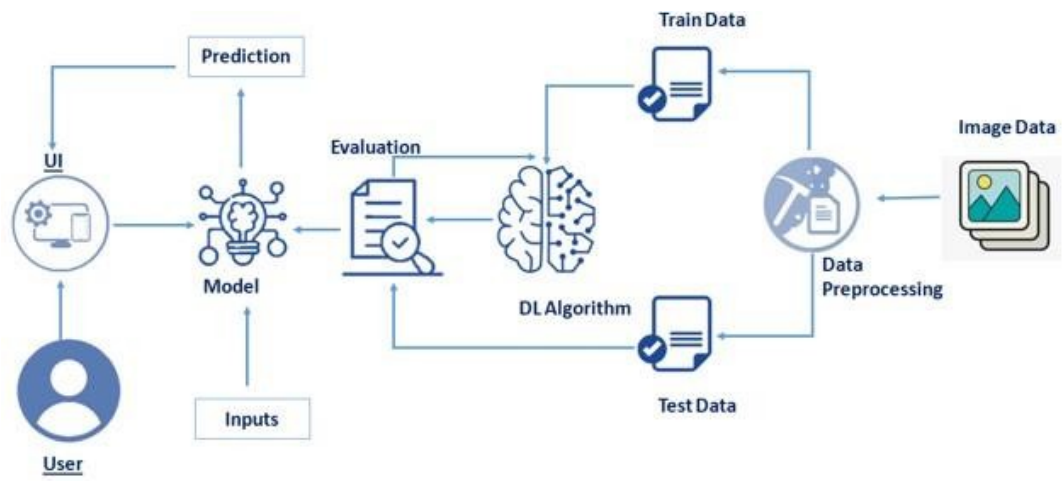
Flow



1. User configures credentials for the Watson Natural Language Understanding service and starts the app.
2. User selects data file to process and load.
3. Apache Tika extracts text from the data file.
4. Extracted text is passed to Watson NLU for enrichment.
5. Enriched data is visualized in the UI using the D3.js library.



5.2 Solution & Technical Architecture



5.3 User Stories:

| User Type | Functional Requirement (Epic) | User Story Number | User Story I Task | Acceptance criteria | Priority | Release |
|---------------------|-------------------------------|-------------------|---|--|----------|----------|
| Customer (Web user) | Home | USN-1 | In the Home Page, I can view the guidelines of how to use the website | I can view the guidelines | low | Sprint-1 |
| | Dashboard | USN-2 | As a user, I can see Home Page & Prediction Page | I can access the dashboard | Low | Sprint-2 |
| | Choose Input | USN-3 | In Prediction Page, I can upload an image of handwritten digit for prediction | I can upload my input by browsing the device storage | Medium | Sprint-3 |
| | | USN-4 | As a user, I can get an accuracy rate with the prediction | I can get different forms of output | High | Sprint-4 |

| | | | | | | |
|------------------------|------------|-------|--|--|--------|----------|
| | Recognize | USN-5 | As a user, I can see that the GUI processing the input using trained model | I can perform handwritten digit prediction | High | Sprint-1 |
| | Prediction | USN-6 | As a user, I can get accuracy rate by pressing the predict button | I can get the accuracy of the output | Medium | Sprint-1 |
| Customer (Mobile user) | Home | USN-7 | As a user, I can access application in mobile phone | I can access the dashboard with mobile | Medium | Sprint-1 |
| | Recognize | USN-8 | I can upload input and retrieve output with accuracy by using the mobile | I can upload input image and get output with a mobile device | High | Sprint-2 |

| | | | | | | |
|-----------------------|----------------|-------|--|--|------|----------|
| Transcription analyst | Pre Processing | USN-1 | Noise in the digital handwritten image can be reduced. | It uses noise filters. | High | Sprint-1 |
| | | USN-2 | Blurred image can be modified. | Sobel filter can be used to sharpen the image. | High | Sprint-3 |

| | | | | | | |
|--|--------------------|-------|--|---|--------|----------|
| | Feature Extraction | USN-3 | How the features can be identified. | By extracting the foreground image from background image. | Low | Sprint-2 |
| | | USN-4 | How shape edges can be detected. | Curves of the letters can be found. | Medium | Sprint-1 |
| | | USN-5 | How words are recognized based on sizes. | By identifying the size of the word. | High | Sprint-3 |
| | Prediction | USN-6 | How letters are predicted. | By comparing the features of each letter with the features of actual letters. | High | Sprint-4 |

Chapter 6

6. PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

Use the below template to create product backlog and sprint schedule

| Sprint | Functional requirement (epic) | User story number | User story/Task | Story points | Priority | Team Members |
|----------|-------------------------------|-------------------|---|--------------|----------|---|
| sprint-1 | Registration and login | USN-1 | As a user , I can register for the applicationby entering my email & password | 2 | High | Arun D Arun N |
| Sprint-2 | Upload image | USN-2 | User can select the image from the localstorage | 2 | High | Dhanachezien S Arun D |
| Sprint-3 | Predict number | USN-3 | After uploading the image it will predict the respective image | 2 | High | Hemanth S Arun N |
| Sprint-4 | Display | USN-4 | The predicted digit will be displayed with accuracy | 2 | High | Hemanth S Arun D Arun N Dhanachezien s |

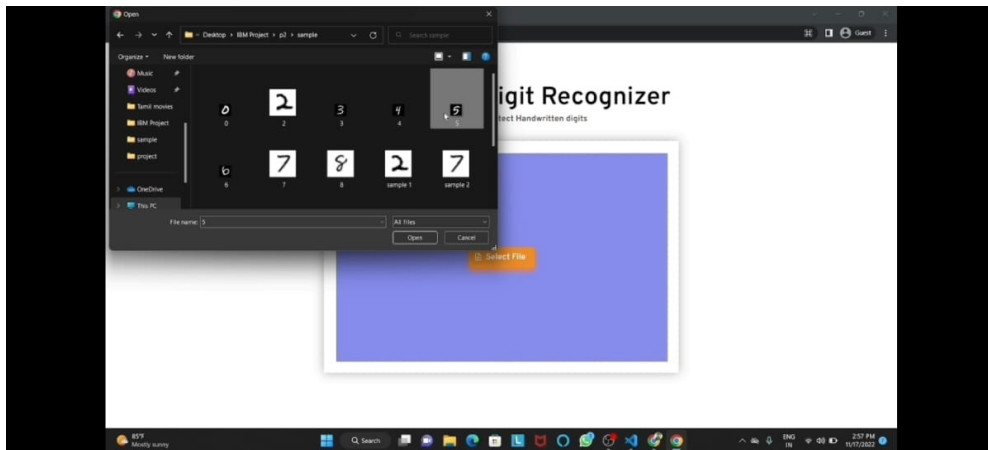
6.2 Sprint Delivery Schedule

| 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 | 26-Oct-22 | 31-Oct-22 | 0 2 | 31-Oct-22 |
| Sprint-2 | 20 | 6 Days | 02-Nov-22 | 07-Nov-22 | 0 2 | 07-Nov-22 |
| Sprint-3 | 20 | 6 Days | 08-Nov-22 | 13-Nov-22 | 0 2 | 13-Nov-22 |
| Sprint-4 | 20 | 6 Days | 14-Nov-22 | 19-Nov-22 | 0 2 | 19-Nov-22 |

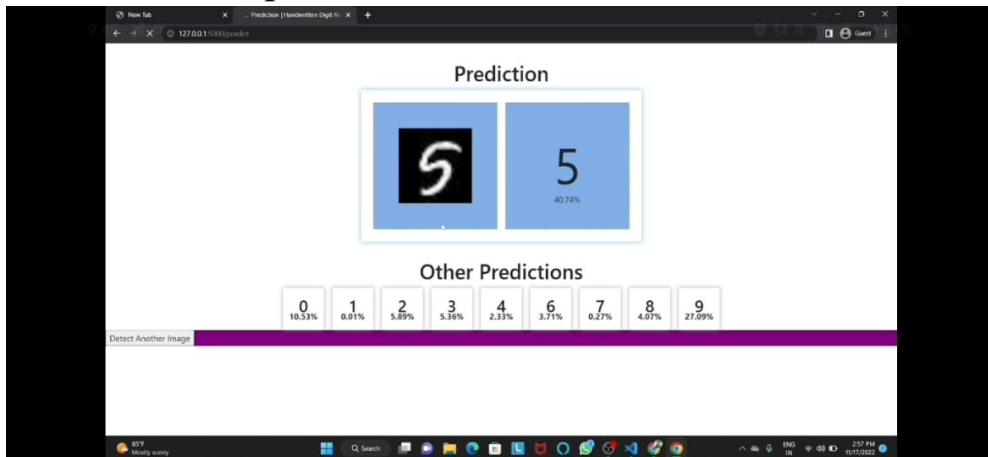
Chapter 7

7. CODING & SOLUTIONING (Explain the features added in the project along with code)

Feature 1 - Input data



Feature 2 - Output data



Chapter 8

8. TESTING

1. Purpose of Document

The purpose of this document is to briefly explain the test coverage and open issues of the [ProductName] project at the time of the release to User Acceptance Testing (UAT).

2. Defect Analysis Section

| 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 |

| Resolution | Severity 1 | Severity 2 | Severity 3 | Severity 4 | Subtotal |
|----------------|------------|------------|------------|------------|----------|
| 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 |
| Totals | 6 | 1 | 4 | 3 | 14 |

1. Purpose of Document

The purpose of this document is to briefly explain the test coverage and open issues of the[ProductName] project at the time of the release to User Acceptance Testing (UAT).

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| Section | Total Cases | Not Tested | Fail | Pass |
|---------------------|-------------|------------|------|------|
| Client Application | 10 | 0 | 3 | 7 |
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| Exception Reporting | 2 | 0 | 0 | 2 |

| Resolution | Severity 1 | Severity 2 | Severity 3 | Severity 4 | Subtotal |
|----------------|------------|------------|------------|------------|----------|
| 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 |
| Totals | 6 | 1 | 4 | 3 | 14 |

3. Test Case Analysis

This report shows the number of test cases that have passed, failed, and untested

Chapter 9

9. RESULTS

9.1 Performance Metrics

Project team shall fill the following information in model performance testing template.

| S.No. | Parameter | Values | Screenshot |
|-------|---------------|---|--|
| 1. | Model Summary | Fitting the Model- □ loss: 0.0254 □ val_loss: 0.1560 | <pre> fitting the model model.compile(optimizer=adam, loss=loss, metrics=[accuracy]) Epoch 1/10 10/10 [====] - loss: 0.1560 - accuracy: 0.9450 - val_loss: 0.0254 - val_accuracy: 0.9797 Epoch 2/10 10/10 [====] - loss: 0.0712 - accuracy: 0.9795 - val_loss: 0.0893 - val_accuracy: 0.9795 Epoch 3/10 10/10 [====] - loss: 0.0590 - accuracy: 0.9846 - val_loss: 0.0892 - val_accuracy: 0.9792 Epoch 4/10 10/10 [====] - loss: 0.0390 - accuracy: 0.9877 - val_loss: 0.0895 - val_accuracy: 0.9800 Epoch 5/10 10/10 [====] - loss: 0.0321 - accuracy: 0.9893 - val_loss: 0.0894 - val_accuracy: 0.9793 Epoch 6/10 10/10 [====] - loss: 0.0279 - accuracy: 0.9916 - val_loss: 0.1173 - val_accuracy: 0.9794 Epoch 7/10 10/10 [====] - loss: 0.0202 - accuracy: 0.9938 - val_loss: 0.1275 - val_accuracy: 0.9796 Epoch 8/10 10/10 [====] - loss: 0.0127 - accuracy: 0.9948 - val_loss: 0.1343 - val_accuracy: 0.9779 Epoch 9/10 10/10 [====] - loss: 0.0177 - accuracy: 0.9959 - val_loss: 0.1333 - val_accuracy: 0.9798 Epoch 10/10 10/10 [====] - loss: 0.0165 - accuracy: 0.9957 - val_loss: 0.1370 - val_accuracy: 0.9796 Epoch 11/10 10/10 [====] - loss: 0.0148 - accuracy: 0.9966 - val_loss: 0.1355 - val_accuracy: 0.9796 Epoch 12/10 10/10 [====] - loss: 0.0102 - accuracy: 0.9957 - val_loss: 0.1560 - val_accuracy: 0.9797 (overfitting detected) </pre> |
| 2. | Accuracy | Training Accuracy – 0.9957 Validation Accuracy -0.9797 | <pre> fitting the model model.compile(optimizer=adam, loss=loss, metrics=[accuracy]) Epoch 1/10 10/10 [====] - loss: 0.1560 - accuracy: 0.9450 - val_loss: 0.0254 - val_accuracy: 0.9797 Epoch 2/10 10/10 [====] - loss: 0.0712 - accuracy: 0.9795 - val_loss: 0.0893 - val_accuracy: 0.9795 Epoch 3/10 10/10 [====] - loss: 0.0590 - accuracy: 0.9846 - val_loss: 0.0892 - val_accuracy: 0.9792 Epoch 4/10 10/10 [====] - loss: 0.0390 - accuracy: 0.9877 - val_loss: 0.0895 - val_accuracy: 0.9800 Epoch 5/10 10/10 [====] - loss: 0.0321 - accuracy: 0.9893 - val_loss: 0.0894 - val_accuracy: 0.9793 Epoch 6/10 10/10 [====] - loss: 0.0279 - accuracy: 0.9916 - val_loss: 0.1173 - val_accuracy: 0.9794 Epoch 7/10 10/10 [====] - loss: 0.0202 - accuracy: 0.9938 - val_loss: 0.1275 - val_accuracy: 0.9796 Epoch 8/10 10/10 [====] - loss: 0.0127 - accuracy: 0.9948 - val_loss: 0.1343 - val_accuracy: 0.9779 Epoch 9/10 10/10 [====] - loss: 0.0177 - accuracy: 0.9959 - val_loss: 0.1333 - val_accuracy: 0.9798 Epoch 10/10 10/10 [====] - loss: 0.0165 - accuracy: 0.9957 - val_loss: 0.1370 - val_accuracy: 0.9796 Epoch 11/10 10/10 [====] - loss: 0.0148 - accuracy: 0.9966 - val_loss: 0.1355 - val_accuracy: 0.9796 Epoch 12/10 10/10 [====] - loss: 0.0102 - accuracy: 0.9957 - val_loss: 0.1560 - val_accuracy: 0.9797 (overfitting detected) </pre> |

Chapter 10

10. ADVANTAGES & DISADVANTAGES

1) Advantages

- The main advantage is the ability to scan the digits accurately.
- Anyone can able to utilize this resource
- User friendly interface
- Thus saves time and energy

2) Disadvantages

- Limited number of characters offered by it.
- It can be inaccurate.
- If the marks on the sheet are not dark enough, then it would be hard to read the data and generate a result.

Chapter 11

11. CONCLUSION

- ❖ An implementation of Handwritten Digit Recognition using artificial intelligence has been implemented in this project.
- ❖ Additionally, some of the most widely used Machine Learning algorithms i.e. CNN using Tensorflow have been trained and tested on the same data to draw a comparison as to why we require deep learning methods in critical applications like Handwritten Digit Recognition.
- ❖ By make use of this project we can able to identify the unproper handwritten digits in an effective way.
- ❖ These are very usefull in banking sectors to know the correct information from the client even which are not written clearly.

Chapter 12

12. FUTURE SCOPE

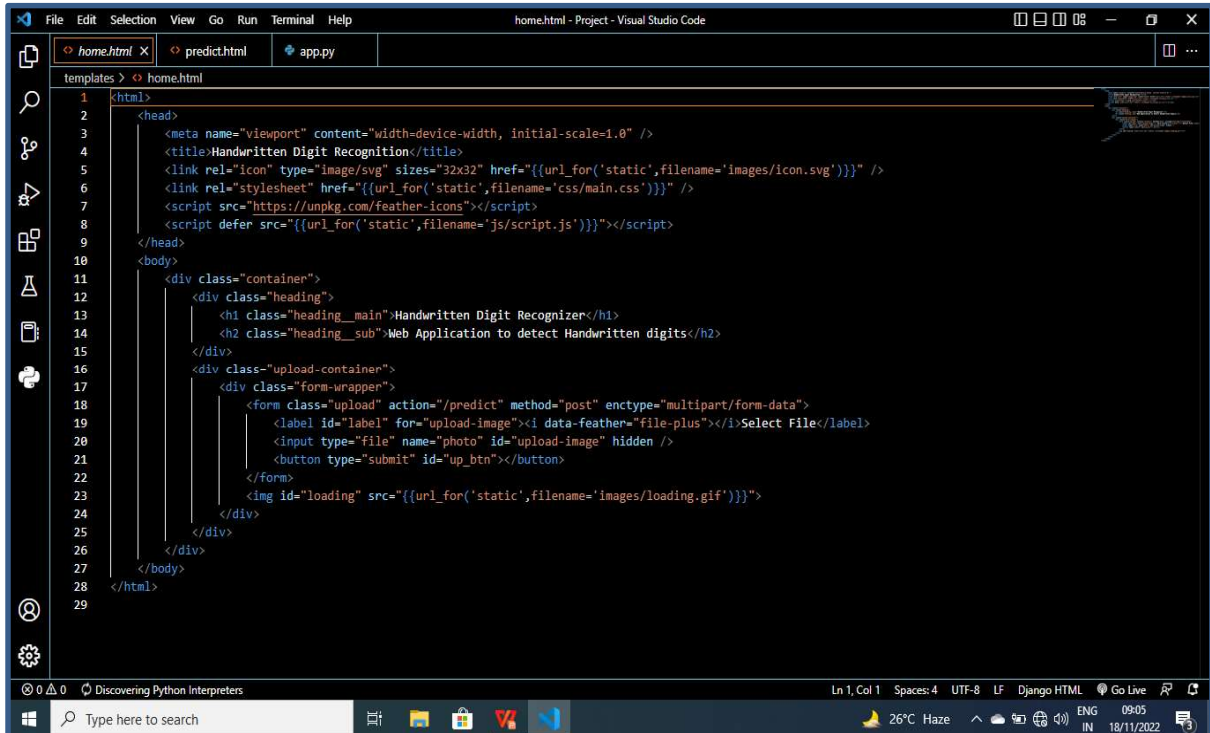
- Addition of a voice assistant
- Auto captcha scanning and auto filling
- Improve the security and authentication

Chapter 13

13.APPENDIX

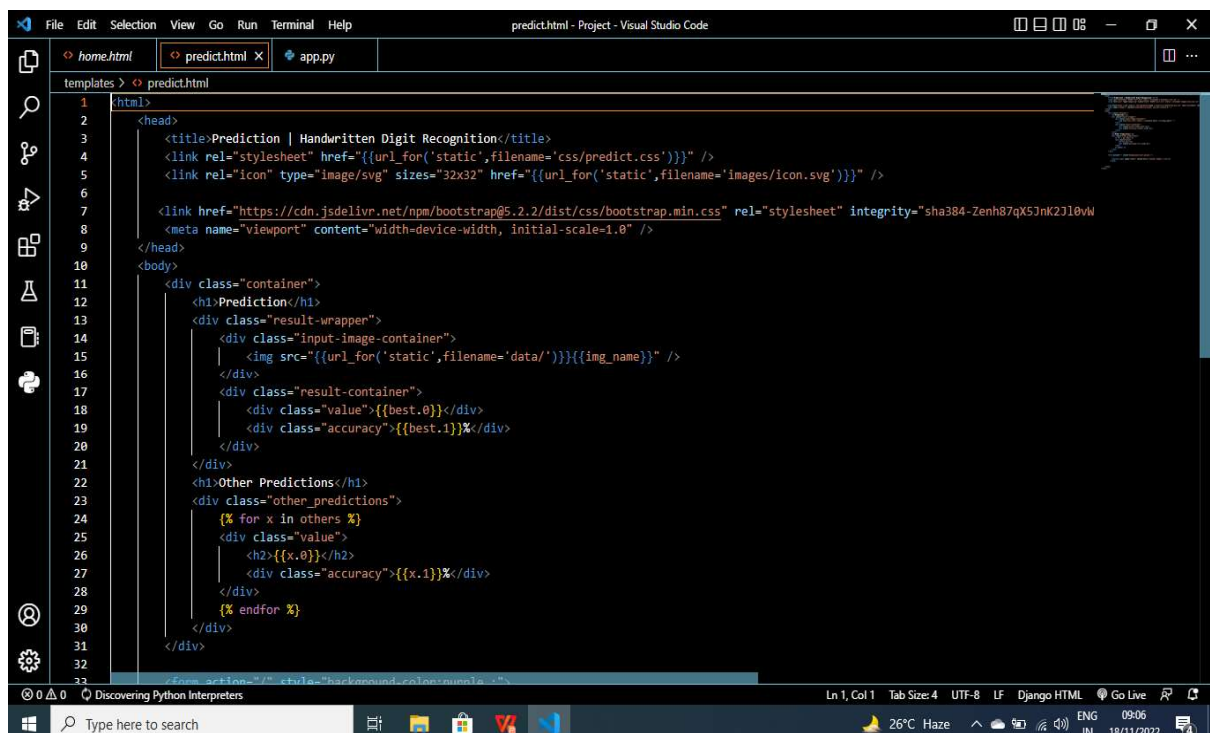
Source Code

i) Home.html



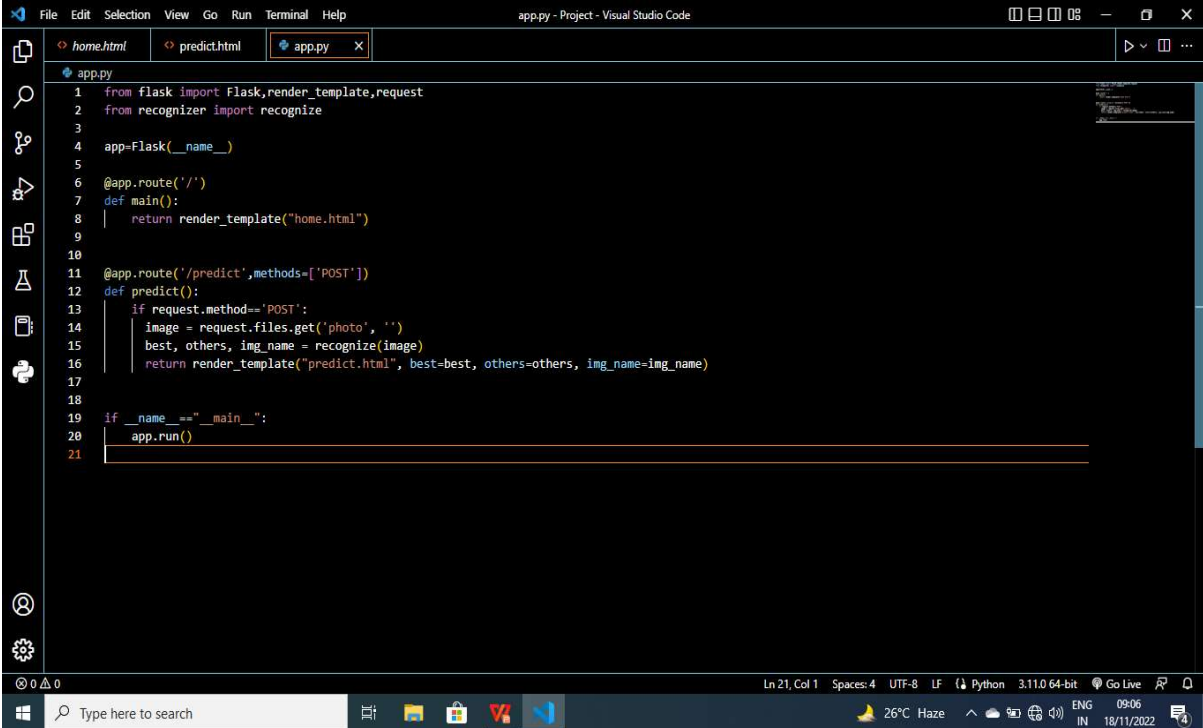
```
1 <html>
2 <head>
3   <meta name="viewport" content="width=device-width, initial-scale=1.0" />
4   <title>Handwritten Digit Recognition</title>
5   <link rel="icon" type="image/svg" sizes="32x32" href="{{url_for('static',filename='images/icon.svg')}}" />
6   <link rel="stylesheet" href="{{url_for('static',filename='css/main.css')}}" />
7   <script src="https://unpkg.com/feather-icons"></script>
8   <script defer src="{{url_for('static',filename='js/script.js')}}"></script>
9 </head>
10 <body>
11   <div class="container">
12     <div class="heading">
13       <h1 class="heading_main">Handwritten Digit Recognizer</h1>
14       <h2 class="heading_sub">Web Application to detect Handwritten digits</h2>
15     </div>
16     <div class="upload-container">
17       <div class="form-wrapper">
18         <form class="upload" action="/predict" method="post" enctype="multipart/form-data">
19           <label id="label" for="upload-image"><i data-feather="file-plus"></i>Select File</label>
20           <input type="file" name="photo" id="upload-image" hidden />
21           <button type="submit" id="up_btn"></button>
22         </form>
23         
24       </div>
25     </div>
26   </div>
27 </body>
28 </html>
29
```

ii) Predict.html



```
1 <html>
2 <head>
3   <title>Prediction | Handwritten Digit Recognition</title>
4   <link rel="stylesheet" href="{{url_for('static',filename='css/predict.css')}}" />
5   <link rel="icon" type="image/svg" sizes="32x32" href="{{url_for('static',filename='images/icon.svg')}}" />
6   <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.2/dist/css/bootstrap.min.css" rel="stylesheet" integrity="sha384-Zenh87qX53nK2Jl0wV" />
7   <meta name="viewport" content="width=device-width, initial-scale=1.0" />
8 </head>
9 <body>
10   <div class="container">
11     <h1>Prediction</h1>
12     <div class="result-wrapper">
13       <div class="input-image-container">
14         
15       </div>
16       <div class="result-container">
17         <div class="value">{{best.0}}</div>
18         <div class="accuracy">{{best.1}}%</div>
19       </div>
20     </div>
21     <h1>Other Predictions</h1>
22     <div class="other_predictions">
23       {% for x in others %}
24       <div class="value">
25         <h2>{{x.0}}</h2>
26         <div class="accuracy">{{x.1}}%</div>
27       </div>
28       {% endfor %}
29     </div>
30   </div>
31 </body>
32 </html>
33
```

iii) App.py



```
1 from flask import Flask, render_template, request
2 from recognizer import recognize
3
4 app = Flask(__name__)
5
6 @app.route('/')
7 def main():
8     return render_template("home.html")
9
10
11 @app.route('/predict', methods=['POST'])
12 def predict():
13     if request.method == 'POST':
14         image = request.files.get('photo', '')
15         best, others, img_name = recognize(image)
16         return render_template("predict.html", best=best, others=others, img_name=img_name)
17
18
19 if __name__ == "__main__":
20     app.run()
21
```

Github link : <https://github.com/IBM-EPBL/IBM-Project-50570-1660916642>

Project Demo Link : <https://photos.app.goo.gl/WjWGS2vnrjSnCYas6>