A Novel Method for Handwritten Digit Recognition System

NALAIYA THIRAN PROJECT REPORT 2022

Submitted by

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Project Report

ABSTRACT

Handwritten character recognition is one of the practically important issues in pattern recognition applications. The main purpose of this project is to build an automatic handwritten digit recognition method for the recognition of handwritten digit strings. To accomplish the recognition task, first, the digits will be segmented into individual digits. Then, a digit recognition module is employed to classify each segmented digit completing the handwritten digit string recognition task. The applications of digit recognition include postal mail sorting, bank check processing, form data entry, etc. The heart of the problem lies within the ability to develop an efficient algorithm that can recognize handwritten digits and which is submitted by users by the way of a scanner, tablet, and other digital devices.

1. INTRODUCTION

1.1 PROJECT OVERVIEW

Handwritten digit recognition is the ability of a computer to recognize the human handwritten digits from different sources like images, papers, touch screens, etc, and classify them into 10 predefined classes (0-9). This has been a topic of boundless research in the field of deep learning. Digit recognition has many applications like number plate recognition, postal mail sorting, bank check processing, etc. In Handwritten digit recognition, we face many challenges because of different styles of writing of different peoples as it is not an Optical character recognition. This research provides a comprehensive comparison between different machine learning and deep learning algorithms for the purpose of handwritten digit recognition. For this, we have used Support Vector Machine, Multilayer Perceptron, and Convolutional Neural Network. The comparison between these algorithms is carried out on the basis of their accuracy, errors, and testing-training time corroborated by plots and charts that have been constructed using matplotlib for visualization.

The accuracy of any model is paramount as more accurate models make better decisions. The models with low accuracy are not suitable for real-world applications. Ex- For an automated bank cheque processing system where the system recognizes the amount and date on the check, high accuracy is very critical. If the system incorrectly recognizes a digit, it can lead to major damage which is not desirable. That’s why an algorithm with high accuracy is required in these real-world applications. Hence, we are providing a comparison of different algorithms based on their accuracy so

that the most accurate algorithm with the least chances of errors can be employed in various applications of handwritten digit recognition.

This paper provides a reasonable understanding of machine learning and deep learning algorithms like SVM, CNN, and MLP for handwritten digit recognition. It furthermore gives you the information about which algorithm is efficient in performing the task of digit recognition. In further sections of this paper, we will be discussing the related work that has been done in this field followed by the methodology and implementation of all the three algorithms for the fairer understanding of them. Next, it presents the conclusion and result bolstered by the work we have done in this paper. Moreover, it will also give you some potential future enhancements that can be done in this field. The last section of this paper contains citations and references used.

1.2 PURPOSE

We describe a method of recognizing handwritten digits by fitting generative models that are built from deformable B-splines with Gaussian "ink generators" spaced along the length of the spline. The splines are adjusted using a novel elastic matching procedure based on the expectation maximization algorithm that maximizes the likelihood of the model generating the data. This approach has many advantages: 1) the system not only produces a classification of the digit but also a rich description of the instantiation parameters which can yield information such as the writing style; 2) the generative models can perform recognition driven segmentation; 3) the method involves a relatively small number of parameters and hence training is relatively easy and fast; and 4) unlike many other recognition schemes, it does not rely on some form of pre-normalization of input images, but can handle arbitrary scalings, translations and a limited degree of image rotation. We have demonstrated that our method of fitting models to images does not get trapped in poor local minima. The main disadvantage of the method is that it requires much more computation than more standard OCR techniques.

2. LITERATURE SURVEY

2.1 EXISTING PROBLEM

An early notable attempt in the area of character recognition research is by Grimsdale in 1959. The origin of a great deal of research work in the early sixties was based on an approach known as analysis by-synthesis method suggested by Eden in 1968. The great importance of Eden's work was that he formally proved that all handwritten characters are formed by a finite number of schematic features, a point that was implicitly included in previous works. This notion was later used in all methods in syntactic (structural) approaches of character recognition.

1. **K. Gaurav, Bhatia P. K. ,** his paper deals with the various pre-processing techniques involved in the character recognition with different kind of images ranges from a simple handwritten form-based documents and documents containing coloured and complex background and varied intensities. In this, different pre-processing techniques like skew detection and correction, image enhancement techniques of contrast stretching, binarization, noise removal techniques, normalization and segmentation, morphological processing techniques are discussed.

2. **Sandhya Arora** , used four feature extraction techniques namely, intersection, shadow feature, chain code histogram and straight-line fitting features. Shadow features are computed globally for character image while intersection features, chain code histogram features and line fitting features are computed by dividing the character image into different segments. On experimentation with a data set of 4900 samples the overall recognition rate observed was 92.80% for Devanagari characters.

3. **Brakensiek, J. Rottland, A. Kosmala, J. Rigoll**, in their paper a system for off-line cursive handwriting recognition is described which is based on Hidden Markov Models (HMM) using discrete and hybrid modelling techniques. Handwriting recognition experiments using a discrete and two different hybrid approaches, which consist of a discrete and semi-continuous structure, are compared. It is found that the recognition rate performance can be improved of a hybrid modelling technique for HMMs, which depends on a neural vector quantizer (hybrid MMI), compared to discrete and hybrid HMMs, based on tired mixture structure (hybrid - TP),which may be caused by a relatively small data set.

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

5. **G. Pirlo and D. Impedovo** in his work on , presented a new class of membership functions, which are called Fuzzy membership functions (FMFs), for zoning-based classification. These FMFs can be easily adapted to the specific characteristics of a classification problem in order to maximize classification performance. In this research, a real coded genetic algorithm is presented to find, in a single optimization procedure, the optimal FMF, together with the optimal zoning described by Voronoi tessellation. The experimental results, which are carried out in the field of handwritten digit and character recognition, indicate that optimal FMF

performs better than other membership functions based on abstract level, ranked-level, and measurement-level weighting models, which can be found in the literature.

6. **Sushree Sangita Patnaik and Anup Kumar Panda** May 2011 , this paper proposes the implementation of particle swarm optimization (PSO) and bacterial foraging optimization (BFO) algorithms which are intended for optimal harmonic compensation by minimizing the undesirable losses occurring inside the APF itself. The efficiency and effectiveness of the implementation of two approaches are compared for two different conditions of supply. The total harmonic distortion (THD) in the source current which is a measure of APF performance is reduced drastically to nearly 1% by employing BFO. The results demonstrate that BFO outperforms the conventional and PSO based approaches by ensuring excellent functionality of APF and quick prevail over harmonics in the source current even under unbalanced supply.

7. **M. Hanmandlu, O.V. Ramana Murthy** have presented in their study the recognition of handwritten Hindi and English numerals by representing them in the form of exponential membership functions which serve as a fuzzy model. The recognition is carried out by modifying the exponential membership functions fitted to the fuzzy sets. These fuzzy sets are derived from features consisting of normalized distances obtained using the Box approach. The membership function is modified by two structural parameters that are estimated by optimizing the entropy subject to the attainment of membership function to unity. The overall recognition rate is found to be 95% for Hindi numerals and 98.4% for English numerals.

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

2.2 REFERENCES

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5. https://www.geeksforgeeks.org/python-tkinter-tutorial/

6.https://medium.com/the-andela-way/applying-machine-learning-to-recognize hand written characters- babcd4b8d705

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2.3 PROBLEM STATEMENT DEFINITION

The goal of this project is to create a model that will be able to recognize and determine the handwritten digits from its image by using the concepts of Convolution Neural Network. Though the goal is to create a model which can recognize the digits, it can be extended to letters and an individual's handwriting. The major goal of the proposed system is understanding Convolutional Neural Network, and applying it to the handwritten recognition system.

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

Reference: https://miro.com/app/board/uXjVPNIVgn0=/

Problem Statement (PS)	**I am (Customer)**	**I'm trying to**	**But**	**Because**	**Which makes me feel**
PS-1	A customer	I want to recognize the handwritten digits accuracy	Process getting slow to recognize	Due to Neural Networks the training and testing of images get delayed.	Frustrated
PS-2	A customer	To predict the uploaded digits	Time taken to scan and upload images is slower process.	Lack of scalability, variation in different styles of digits.	Exasperate

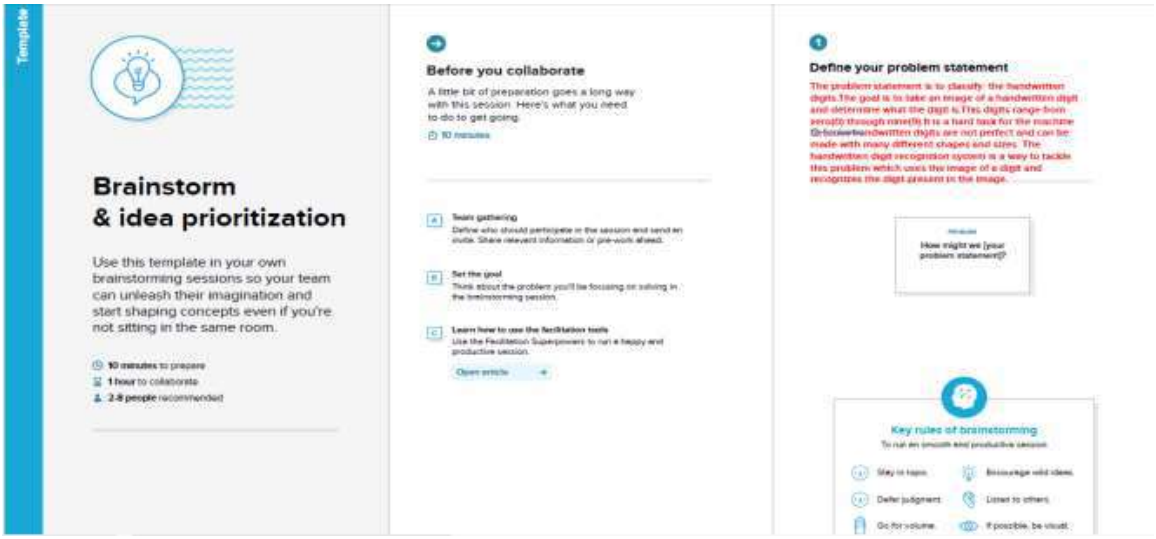
3.IDEATION AND PROPOSED SOLUTION

3.1 EMPATHY MAP CANVAS

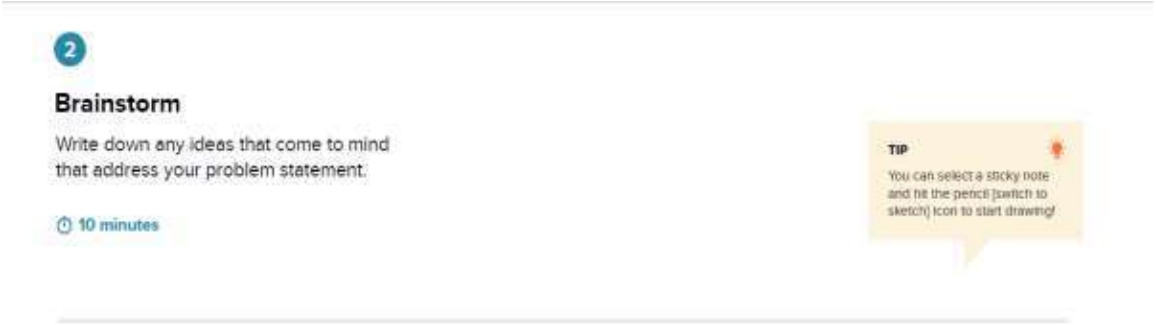
Reference: https://www.mural.co/templates/empathy-map-canvas

3.2 IDEATION & BRAINSTORMING

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



Step-2: Brainstorm, Idea Listing and Grouping




Brindha
affect training time
Dhivya Bharathi
lack of recognition accuracy
complexity of noise from data
variations in character styles
Sathya
Divya
Pattern analysis is complex
It is more expensive method of data entry
Brindha
Dhivya Bharathi
Ability to scan the characters accurately
CNN network is used
Sathya
It is fast
Easy to implement and support
State of art strategy
Divya
Cost effective
Designing documents in this is a friendly way
Flexible to access anywhere

3

Group ideas

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

20 minutes

TIP

Add customizable tags to sticky notes to make it easier to find, browse, organize, and categorize important ideas as themes within your mural.

Feature extraction step varies for every individual language and hence is not scalable

It involved Machine learning methods like Hidden Markov Models(hmm) svm etc.

The performance of artifcial learning models is pretty limited due to manual feature extraction phase and their limited capacity of learning.

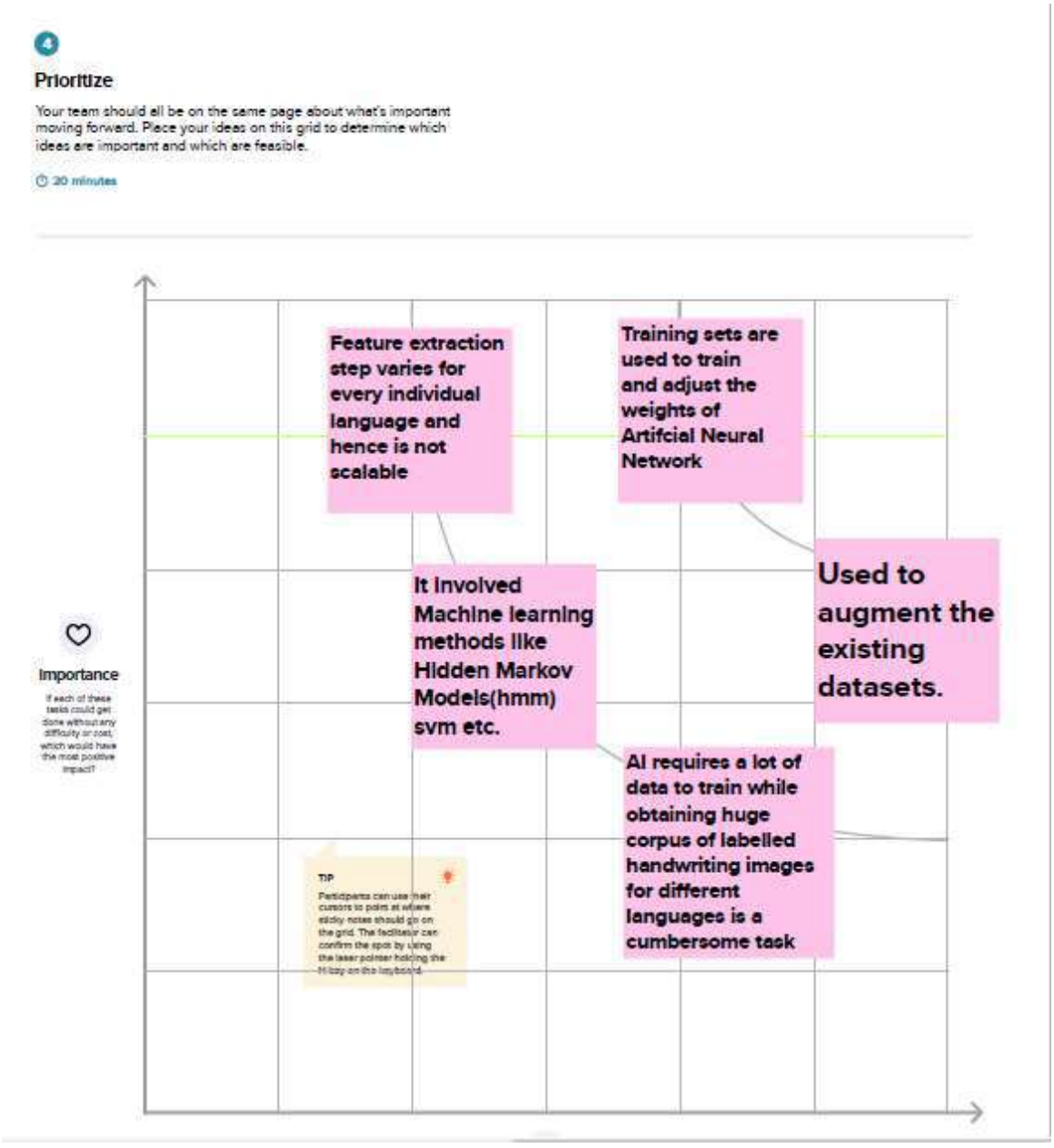
AI requires a lot of data to train while obtaining huge corpus of labelled handwriting images for different languages is a cumbersome task

Used to augment the existing datasets.

With the advent of deep learning came tremendous improvements in accuracy of handwriting recognition.

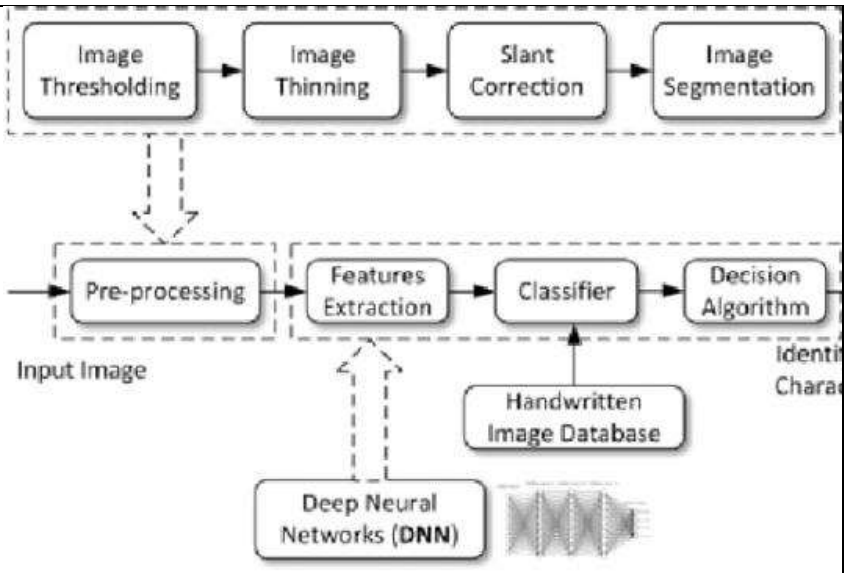
Training sets are used to train and adjust the weights of Artifcial Neural Network

Step-3: Idea Prioritization

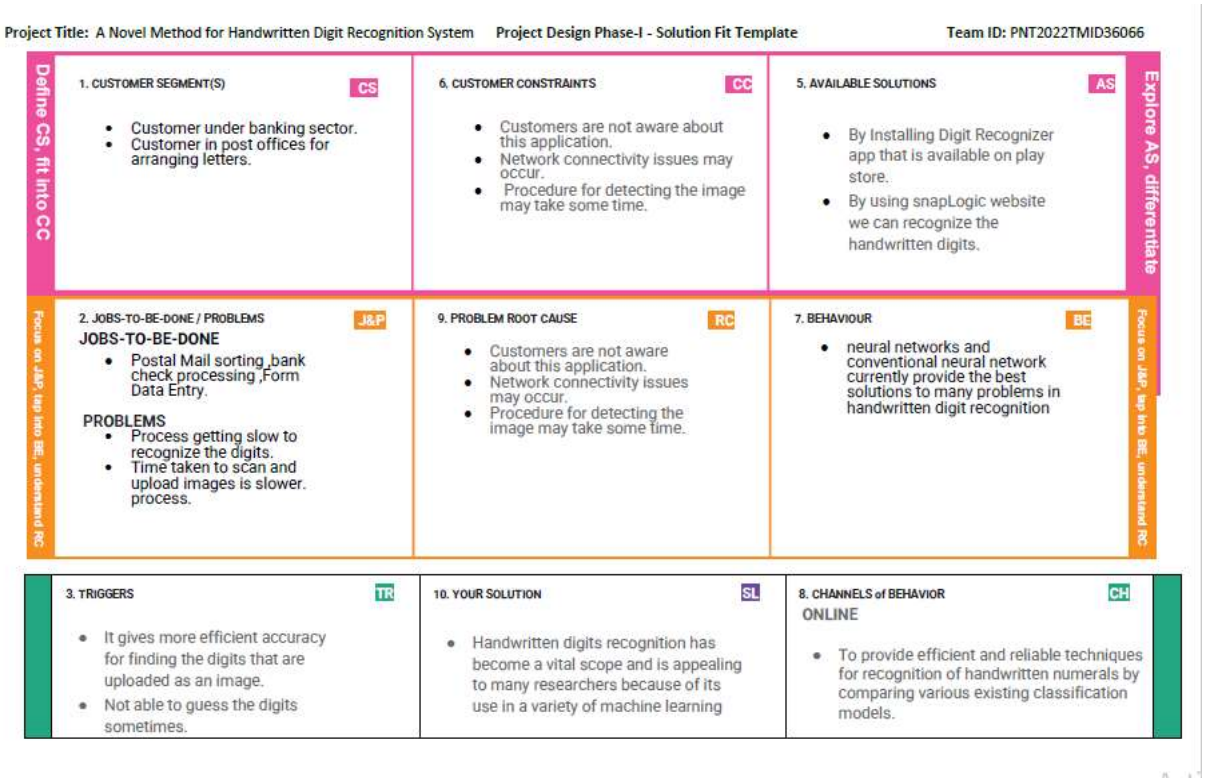


3.3 PROPOSED SOLUTION

S.no	Parameter	Description
1.	Problem Statement (Problem to be solved)	(i) The problem statement is to classify handwritten digits. (ii) The goal is to taken an image of a handwritten digit and determine what that digit is. (iii) The digit range from zero (0) through nine (9).
2.	Idea / Solution description	We propose a novel method to compute the learning rate for training deep neural networks with stochastic gradient descent.
3.	Novelty / Uniqueness	(i) Two techniques used uniquely are Pattern Recognition and Artificial Neural Network (ANN) and Convolution Neural Network (CNN) using MNIST dataset. (ii) Also uses integrated GUI for recognition.
4.	Social Impact / Customer Satisfaction	(i) Machine learning and deep learning plays an important role in computer technology and artificial intelligence. (ii) With the use of deep learning and machine learning, human effort can be reduced in recognizing, learning, predictions and many more areas.

5.	Business Model (Revenue Model)	
6.	Scalability of the Solution	(i) As it uses neural networks, these systems have a respectable success rate in handwritten recognition. (ii) It provides higher than 99% accuracy of the resultant output.

3.4 PROBLEM SOLUTION FIT



4. REQUIREMENT ANALYSIS

4.1 FUNCTIONAL REQUIREMENT

4.1.1 System Configuration:

Software requirements**:**

These are the software configurations used:

Operating system: windows 10.

IDE: Jupyter Notebook.

Python: Python is an interpreted, high-level, general purpose programming language created by Guido Van Rossum and first released in 1991, Python's design philosophy emphasizes code readability with its notable use of significant Whitespace. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects. Python is dynamically typed, and garbage collected. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming.

Jupyter Notebook: Jupyter is a free, open-source, interactive web tool known as a computational notebook, which researchers can use to combine software code, computational output, explanatory text and multimedia resources in a single document. Computational notebooks have been around for decades, but Jupyter in particular has exploded in popularity over the past couple of years. This rapid uptake has been aided by an enthusiastic community of user–developers and a redesigned architecture that allows the notebook.

4.2 NON-FUNCTIONAL REQUIREMENTS

4.2.1 Hardware requirements:

These are the Hardware interfaces used Processor: Intel Pentium 4 or equivalent

RAM: Minimum of 256 MB or higher HDD: 10 GB or higher

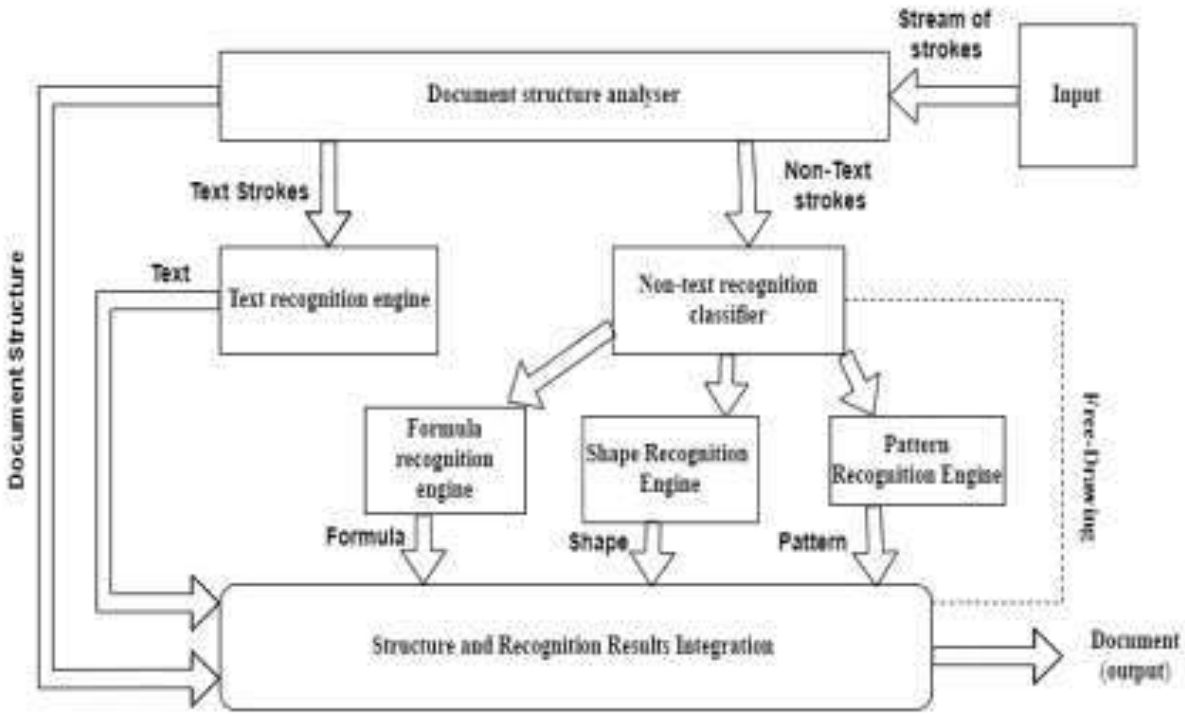
Monitor: 15'' or 17'' colour monitor

Mouse: Scroll or optical mouse

Keyboard: Standard 110 keys keyboard

5. PROJECT DESIGN

5.1 DATA FLOW DIAGRAMS



User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Home	USN-1	As a user, I can view the guide and awareness to use this application.	can view the awareness to use this application and its limitations.	Low	Sprint-1
		USN-2	As a user, I'm allowed to view the guided video to use the	I can gain knowledge to use this application by a	Low	Sprint-1

			interface of this application.	practical method.		
		USN-3	As a user, I can read the instructions to use this application.	I can read instructions also to use it in a user-friendly method.	Low	Sprint-2
	Recognize	USN-10	As a user, I can use the web application virtually anywhere.	I can use the application portably anywhere.	High	Sprint-1
		USN-11	As it is an open source, can use it cost freely.	I can use it without any payment to be paid for it to access.	Medium	Sprint-2
		USN-12	As it is a web application, it is installation free I	I can use it without the installation of the application or any software.	Medium	Sprint-4
	Predict	USN-13	As a user, I'm Allowed to upload and choose the image to be uploaded	I can upload and choose the image from the system storage and also in any virtual storage.	Medium	Sprint-3

5.2 SOLUTION & TECHNICAL ARCHITECTURE

Solution Architecture :

Solution architecture is a complex process – with many sub-processes – that bridges the gap between business problems and technology solutions. 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. Its goals are to:

- 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 analysed by the model and the detected result is returned on to UI.

Technical Architecture :

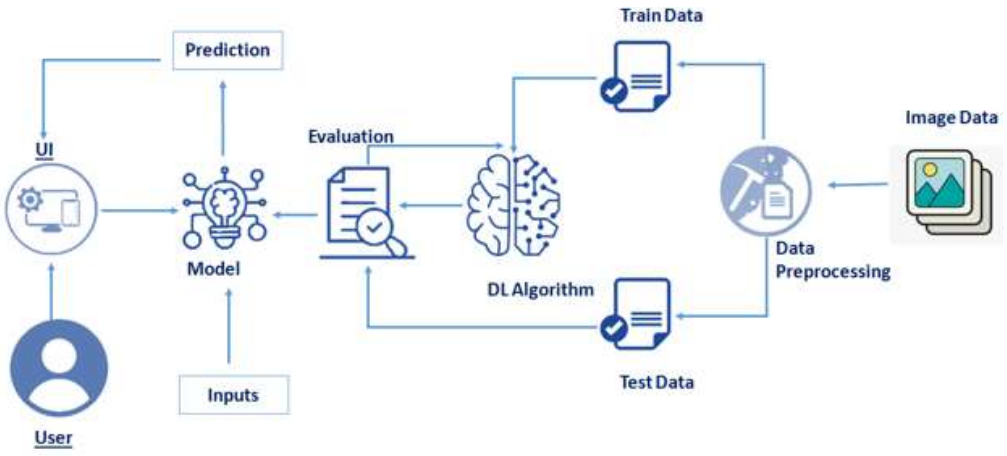
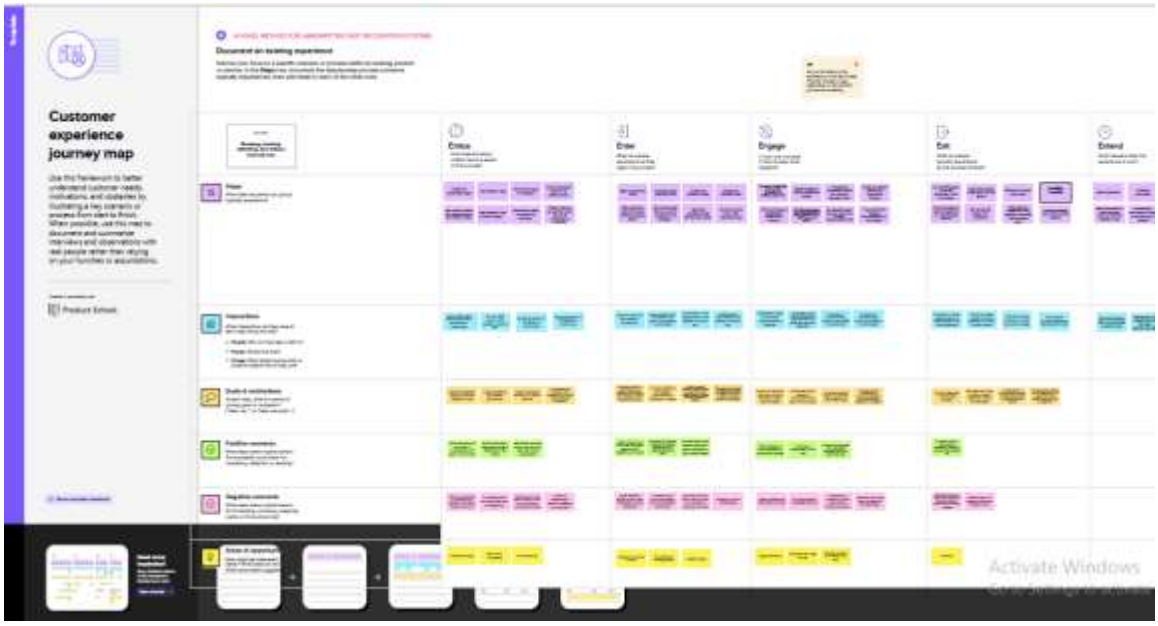


Figure 1: Architecture and data flow of the Handwritten Digit Recognition System.

Reference:

https://careereducation.smartinternz.com/saas-guided-project/3/a-novel-method-for-handwritten-digit-recognition-system

5.3 USER STORIES



6. PROJECT PLANNING & SCHEDULING

6.1 SPRINT PLANNING & ESTIMATION

Product Backlog, Sprint Schedule, and Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Home	USN-1	As a user, I can view the guide and awareness to use this application.	1	Medium	Brindha P, Dhivya Bharathi J, Sathya S, Divya G
Sprint-1		USN-2	As a user, I'm allowed to view the guided video to use the interface of this application.	3	High	Brindha P, Dhivya Bharathi J, Sathya S, Divya G
Sprint-1		USN-3	As a user, I can read the instructions to use this application.	2	Low	Brindha P, Dhivya Bharathi J, Sathya S, Divya G
Sprint-2	Recognize	USN-4	As a user, In this recognition page I get to choose the image.	4	High	Brindha P, Dhivya Bharathi J, Sathya S, Divya G
Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-3	Predict	USN-5	As a user, I'm Allowed to upload and choose the image to be uploaded	3	Low	Brindha P, Dhivya Bharathi J, Sathya S, Divya G

Sprint-3		USN-6	As a user, I will train and test the input to get the maximum accuracy of output.	4	High	Brindha P, Dhivya Bharathi J, Sathya S, Divya G
Sprint-3		USN-7	As a user, I can access the MNIST data set	2	Medium	Brindha P, Dhivya Bharathi J, Sathya S, Divya G

6.2 SPRINT DELIVERY SCHEDULE

Project Tracker, Velocity & Burndown Chart:

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

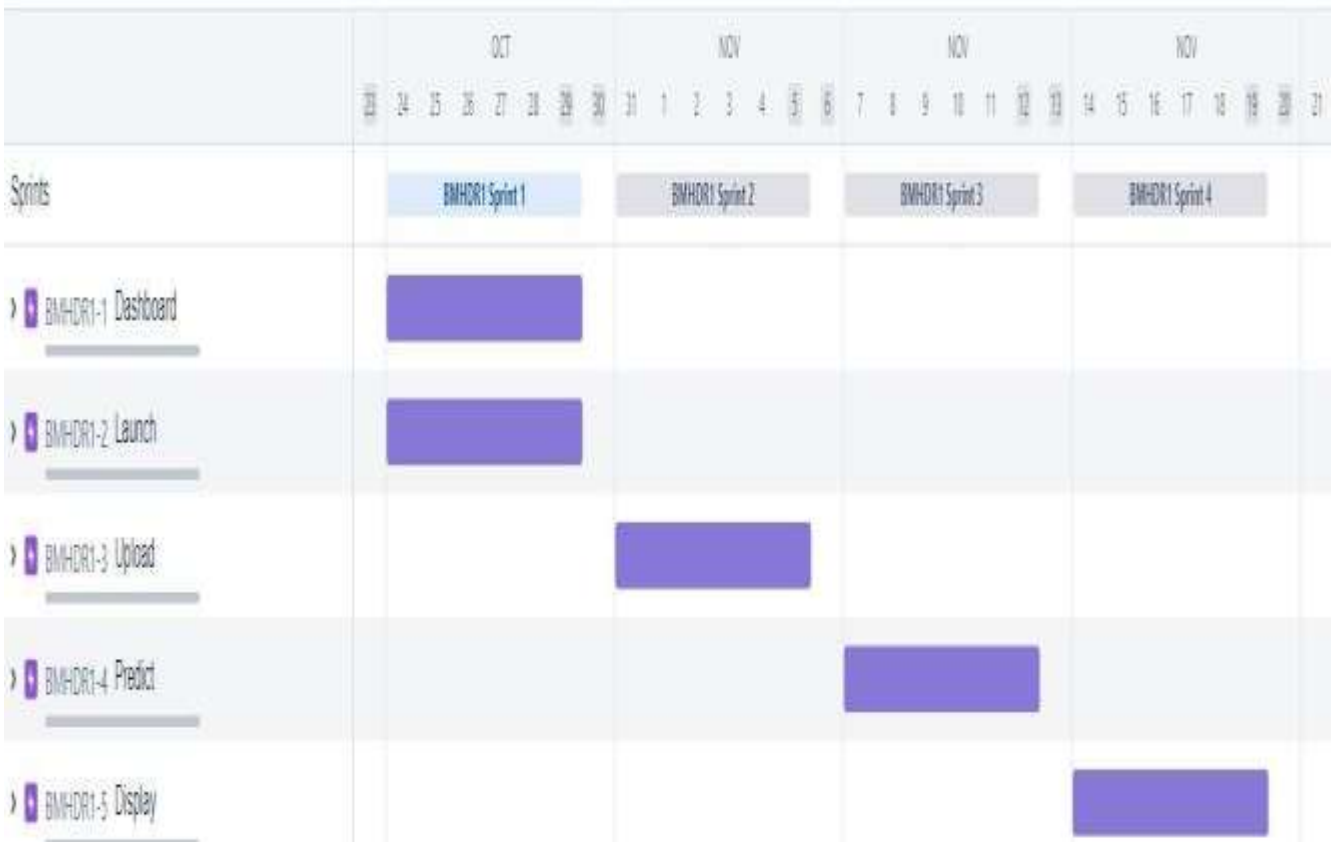
Velocity:

Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) per iteration unit (story points per day)

$$AV = \frac{sprint\ duration}{velocity} = \frac{20}{10} = 2$$

Burndown Chart:

A burndown chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies such as Scrum. However, burn down charts can be applied to any project containing measurable progress over time.



6.3 REPORTS FROM JIRA

Activity Number	Activity Name	Detailed Activity Description	Assigned To	Status / Comments
1.	**Preparation Phase**	Access the resources (courses) in project dashboard Access the guided project workspace Create GitHub account & collaborate with Project Repository in project workspace Set-up the Laptop / Computers based on the prerequisites for each technology track	Brindha P Dhivya Bharathi J Sathya S Divya G	It refers to do the listed activities in the preparation phase and done Prerequisites, Registration, Environment setup
2	**Ideation Phase**	Literature survey on the selected project & Information Gathering Preparation of Empathy Map Canvas to capture the	Brindha P Dhivya Bharathi J Sathya S Divya G	The activities in ideation phase refers to when gathering the idea for project information and picturize in Empathy map, referring the

		user Pains & Gains, Prepare list of problem statements List the ideas by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance		literature survey& brainstorming the ideas for this project.
3	**Project Design Phase -I**			
3.1	Proposed Solution	Preparation of proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalability of solution	Brindha P Dhivya Bharathi J Sathya S Divya G	The solution for the project is prepared as a standard document structure from Team members
3.2	Problem Solution fit	Preparation of problem solution fit	Brindha P Dhivya Bharathi J Sathya S Divya G	Prepared Problem is analysed and make effective solutions for the problem
3.3	Solution Architecture	Prepare an architecture for solution	Brindha P Dhivya Bharathi J Sathya S	Suitable block diagram template used to prepare

			Divya G	Solution architecture
4	**Project Design Phase -II**			
4.1	Requirement Analysis	Prepare the Functional Requirement and Non-Functional Document	Brindha P Dhivya Bharathi J Sathya S Divya G	Listing of functional and non-functional requirements of projects
4.2	Customer Journey	Preparation of customer journey maps to understand the user interactions & experiences with the application (entry to exit)	Brindha P Dhivya Bharathi J Sathya S Divya G	Customer journey maps prepared by suitable template by team members
4.3	Data Flow Diagrams	Prepare a Data Flow Diagram for Project	Brindha P Dhivya Bharathi J Sathya S Divya G	Use suitable data flow diagram rules and standards to prepare DFD
4.4	Technology Architecture	Prepare Technology Architecture	Brindha P Dhivya Bharathi J Sathya S Divya G	We created architecture diagram and technologies used for this project
5	**Project planning phase**			
5.1	Milestones & Tasks	Prepare Milestone & Activity List	Brindha P Dhivya Bharathi J Sathya S Divya G	When project begins then it is expected That project related activities must

				be initiated. In project planning, series of milestones must be established.
5.2	Sprint Schedules	Prepare Sprint Delivery Plan	Brindha P Dhivya Bharathi J Sathya S Divya G	In this, Product Backlog, Sprint Schedule for the Project are estimated.
6	**Project Development Phase**			
6.1	Coding & Solutioning	Sprint-1 Delivery: Develop the Code, Test, and push it to GitHub.	Brindha P Dhivya Bharathi J Sathya S Divya G	In this, we are going to develop & Submit the developed code by testing it.
6.2	Acceptance Testing	Sprint-2 Delivery: Develop the Code, Test, and push it to GitHub. Sprint-3 Delivery: Develop the Code, Test, and push it to GitHub.	Brindha P Dhivya Bharathi J Sathya S Divya G	In this, we are going to develop & Submit the developed code by testing it.

7. CODING & SOLUTIONING

7.1 FEATURE 1

HOME PAGE

```
<html>
<head>
<title>Digit Recognition WebApp</title>
<meta name="viewport" content="width=device-width">
<!-- GoogleFont -->
<link
href="https://fonts.googleapis.com/css2?family=Prompt:wght@60
0&display=swap" rel="stylesheet">
<link
href="https://fonts.googleapis.com/css2?family=Varela+Round&di
splay=swap" rel="stylesheet">
<link
href="https://fonts.googleapis.com/css2?family=Source+Code+Pro
:wght@500&display=swap" rel="stylesheet">
<link
href="https://fonts.googleapis.com/css?family=Calistoga|Josefin+S
ans:400,700|Pacifico&display=swap" rel="stylesheet">
<!-- bootstrap -->
```

```
<link rel="stylesheet" href="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/css/bootstrap.min.css" integrity="sha384-ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcWr7x9JvoRxT2MZw1T" crossorigin="anonymous">
<link rel="stylesheet" type= "text/css" href= "style.css">
<!-- fontawesome -->
<script src="https://kit.fontawesome.com/b3aed9cb07.js" crossorigin="anonymous"></script>
<script src="https://code.jquery.com/jquery-3.3.1.slim.min.js" integrity="sha384-q8i/X+965DzO0rT7abK41JStQIAqVgRVzpbzo5smXKp4YfRvH+8abtTE1Pi6jizo" crossorigin="anonymous"></script>
<script src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.14.7/umd/popper.min.js" integrity="sha384-UO2eT0CpHqdSJQ6hJty5KVphtPhzWj9WO1clHTMGa3JDZwrnQq4sF86dIHNDz0W1" crossorigin="anonymous"></script>
<script src="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/js/bootstrap.min.js" integrity="sha384-JjSmVgyd0p3pXB1rRibZUAYoIIy6OrQ6VrjIEaFf/nJGzIxFDsf4x0xIM+B07jRM" crossorigin="anonymous"></script>
```

```
<script
src="https://cdn.jsdelivr.net/npm/@tensorflow/tfjs@latest"></scrip
t>
</head>
<script>
  function preview() {
    frame.src=URL.createObjectURL(event.target.files[0]);
}
$(document).ready(function() {
          $('#clear_button').on('click', function() {
             $('#image').val('');
             $('#frame').attr('src',"");
           });
        });

</script>
<body> <h1 class="welcome">IBM PROJECT
  <div id="team_id">TEAM ID : PNT2022TMID26131</div>
  </h1>
  <section id="title">
  <h4 class="heading">Handwritten Digit Recognition
Website</h4>
  <br><br>
```

The website is designed to predict the handwritten digit.

Handwriting recognition is one of the fascinating research projects currently underway because everyone

in the world has their own writing style. It is the computer's ability to automatically recognize handwritten

digits or characters. Because of advances in science and technology, everything is being digitalized to reduce human effort.

 As a result, handwritten digit recognition is required in many real-time applications. The MNIST data set,

which contains 70000 handwritten digits, is widely used in this recognition process. To train these images

and create a deep learning model, we use artificial neural networks. A web application is developed that allows

the user to upload an image of a handwritten digit. The model analyses this image and returns the detected result

to the user interface. </section>

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

        <button type="button" class="btn btn-dark"
id="clear_button">  Clear  </button>
        </div>
      </form>
      </div>
  </section>
  </body>
</html>
```

OUTPUT:


TEAM ID : PNT2022TMID36066
Handwritten Recognition System
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
Activate Windows
Type here to search
27°C Mostly sunny

7.2 FEATURE 2

RECOGNIZE PAGE

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

<style>
    body{
     background-image: url('index6.jpg');
     background-repeat: no-repeat;
     background-size: cover;
    }

    #rectangle{
     width:400px;
     height:150px;
     background-color: #5796a5;
     border-radius: 25px;
```

```
    position:absolute;
    top:25%;
    left:50%;
    transform:translate(-50%,-50%);
   }

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

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

OUTPUT:


Home
Recognize
IBM PROJECT
TEAM ID : PNT2022TMID36066
Handwritten Digit Recognition Website
Choose File
Predict
Clear
Type here to search

8. TESTING

8.1 TEST CASES

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

Test case ID	Feature Type	Component	Test Scenario	Steps To Execute	Test Data	Expected Result	Actual Result	Status	BUG ID	Executed By
HP_TC_001	UI	Home Page	Verify UI elements in the Home Page	1) Open the page 2) Check if all the UI elements are displayed	127.0.0.1:8000	The Home page must be displayed properly	Working as expected	PASS		Brindha P Sathya S
HP_TC_002	UI	Home Page	Check if the UI elements are displayed properly in different screen sizes	1) Open the page in a specific device 2) Check if all the UI elements are displayed properly 3) Repeat the above steps with different device sizes	-- Screen Sizes -- 2560 x 1801 1440 x 970 1024 x 840 768 x 630 320 x 630	The Home page must be displayed properly in all sizes	The UI is not displayed properly in screen size 2560 x 1801 and 768 x 630	FAIL	BUG_HP_001	Dhivya Bharathi J Divya G
HP_TC_003	Functional	Home Page	Check if user can upload their file	1) Open the page 2) Click on select button 3) Select the input image	Sample 1.png	The input image should be uploaded to the application successfully	Working as expected	PASS		Dhivya Bharathi J Divya G
HP_TC_004	Functional	Home Page	Check if user cannot upload unsupported files	1) Open the page 2) Click on select button 3) Select a random input file	installer.exe	The application should not allow user toselect a non image file	User is able to upload any file	FAIL	BUG_HP_002	Brindha p Sathya S
HP_TC_005	Functional	Home Page	Check if the page redirects to the resultpage once the input is given	1) Open the page 2) Click on select button 3) Select the input image 4) Check if the page redirects	Sample 1.png	The page should redirect to the results page	Working as expected	PASS		Divya G Sathya S
BE_TC_001	Functional	Backend	Check if all the routes are working properly	1) Go to Home Page 2) Upload the input image 3) Check the reults page	Sample 1.png	All the routes should properly work	Working as expected	PASS		Dhivya Bharathi J Brindha P
M_TC_001	Functional	Model	Check if the model can handle various image sizes	1) Open the page in a specific device 2) Upload the input image 3) Repeat the above steps with different input image	Sample 1.png Sample 1 XS.png Sample 1 XL.png	The model should rescale the image and predict the results	Working as expected	PASS		Sathya S
M_TC_002	Functional	Model	Check if the model predicts the digit	1) Open the page 2) Click on select button 3) Select the input image 4) Check the results	Sample 1.png	The model should predict the number	Working as expected	PASS		Dhivya Bharathi J Sathya S

M_TC_003	Functional	Model	Check if the model can handle complex input image	1) Open the page 2) Click on select button 3) Select the input image 4) Check the results	Complex Sample.png	The model should predict the number in the compex image	The model fails to identify the digit since the model is not builtto handle such data	FAIL	BUG_M_001	Divya G Brindha P
RP_TC_001	UI	Result Page	Verify UI elements in the Result Page	1) Open the page 2) Click on select button 3) Select the input image 4) Checkif all the UI elements are displayed properly	Sample 1.png	The Result page must be displayed properly	Working as expected	PASS	BUG_RP_001	Brindha P
RP_TC_002	UI	Result Page	Check if the input image is displayed properly	1) Open the page 2) Click on select button 3) Select the input image 4) Check if the input image are displayed	Sample 1.png	The input image should be displayed properly	The size of the imput image exceeds the display container	FAIL		Sathya S Divya G
RP_TC_003	UI	Result Page	Check if the result is displayed properly	1) Open the page 2) Click on select button 3) Select the input image 4) Check if the result is displayed	Sample 1.png	The result should be displayed properly	Working as expected	PASS		Brindha P Dhivya Bharathi J Sathya S Divya G
RP_TC_004	UI	Result Page	Check if the other predictions are displayed properly	1) Open the page 2) Click on select button 3) Select the input image 4) Check if all the other predictions are displayed	Sample 1.png	The other predictions should be displayed properly	Working as expected	PASS		Brindha P Divya G

8.2 USER ACCEPTANCE TESTING

PURPOSE OF THE DOCUMENT

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

DEFECT ANALYSIS

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

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

9. RESULTS

9.1 PERFORMANCE METRICS

After implementing all the three algorithms that are SVM, MLP and CNN we have compared their accuracies and execution time with the help of experimental graphs for perspicuous understanding. We have considered the Training and Testing Accuracy of all the models stated above. After executing all the models, we found that SVM has the highest accuracy on training data while on testing dataset CNN accomplishes the utmost accuracy. Additionally, we have compared the execution time to gain more insight into the working of the algorithms. Generally, the running time of an algorithm depends on the number of operations it has performed. So, we have trained our deep learning model up to 30 epochs and SVM models according to norms to get the apt outcome. SVM took the minimum time for execution while CNN accounts for the maximum running time.

10.ADVANTAGES AND DISADVANTAGES

10.1 ADVANTAGES

1. The system not only produces a classification of the digit but also a rich description of the instantiation parameters which can yield information such as writing style.

2. The generative models can perform recognition driven segmentation.

3. Handwriting forces your brain to mentally engage with the information, improving both literacy and reading comprehension.

4. Digitalization

5. Data Collection.

10.2 DISADVANTAGES

1. Despite that there are enormous convolutional neural network algorithms proposed for handwritten digit recognition, issues such as recognition accuracy.

2. Get alternative, less likely predictions when available.

3.Anyway Higher processor is required.

4.High cost

5.Time consuming

6.computation time still require for further improvement.

11.CONCLUSION

Our project HANDWRITTEN DIGIT RECOGNITION deals with identifying the digits. The main purpose of this project is to build an automatic handwritten digit recognition method for the recognition of handwritten digit strings. In this project, different machine learning methods, which are SVM (Support Vector Machine), ANN (Artificial Neural Networks), and CNN (Convolutional Neural Networks) architectures are used to achieve high performance on the digit string recognition problem.

Recognition of characters and digits is viral in today's digitized world, especially in organizations that deal with handwritten documents that they need to analyse using computer systems. Convolutional Neural Network gets trained from the real-time data and makes the model very simple by reducing the number of variables and gives relevant accuracy. A comparison on different Machine Learning algorithms like Random Forest Classifier, Convolutional Neural Network, Linear Regression, K-Nearest Neighbours, Support vector machine is done, in which the accuracy for CNN is 99.63%. It can be used to convert books, newspapers and handwritten notes into digital text format using machine learning models.

12.FUTURE SCOPE

The proposed system takes 28x28 pixel sized images as input. The same system with further modifications and improvements in the dataset and the model can be used to build Handwritten Character Recognition System which recognizes human handwritten characters and predicts the output. The future development of the applications based on algorithms of deep and machine learning is practically boundless. In the future, we can work on a denser or hybrid algorithm than the current set of algorithms with more manifold data to achieve the solutions to many problems.