

FINAL REPORT

A Novel Method For Handwritten Digit Recognition System

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TABLE OF CONTENT

S.No.	Title	Pg.No.
1.	INTRODUCTION	1
1.1	Project Overview	1
1.2	Purpose	2
2.	LITERATURE SURVEY	3
2.1	Existing Problem	3
2.2	References	4
2.3	Problem Statement Definition	4
3.	IDEATION & PROPOSED SOLUTION	6
3.1	Empathy Map Canvas	6
3.2	Ideation & Brainstroming	7
3.3	Proposed Solution	9
3.4	Problem Solution Fit	11
4.	REQUIREMENT ANALYSIS	12
4.1	Functional Requirement	12
4.2	Non-Functional Requirements	13
5.	PROJECT DESIGN	14
5.1	Data Flow Diagrams	14
5.2	Solution & Technical Architecture	14
5.3	User Stories	15

6.	PROJECT PLANNING & SCHEDULING	16
6.1	Sprint Planning & Execution	16
6.2	Sprint Delivery Schedule	17
6.3	Reports From JIRA	19
7.	CODING & SOLUTIONING	21
7.1	Libraries Installed	21
7.2	Uploading of files into Website	21
7.3	Prediction of the digits from uploaded files	22
8.	TESTING	22
8.1	Test Cases	22
8.2	User Acceptance testing	23
8.2	Performance Testing	24
9.	RESULTS	26
9.1	Performance Metrics	26
10.	ADVANTAGES & DISADVANTAGES	27
11.	CONCLUSION	28
12.	FUTURE SCOPE	28
13.	APPENDIX	29
13.1	Source Code	29
13.2	GitHub & Project Demo Links	51

1. INTRODUCTION

Recognition is identifying or distinguishing a thing or an individual from the past experiences or learning. Similarly, Digit Recognition is nothing but recognizing or identifying the digits in any document. Digit recognition framework is simply the working of a machine to prepare itself or interpret the digits. Handwritten Digit Recognition is the capacity of a computer to interpret the manually written digits from various sources like messages, bank cheques, papers, pictures, and so forth and in various situations for web based handwriting recognition on PC tablets, identifying number plates of vehicles, handling bank cheques, digits entered in any forms etc.

1.1 Project Overview:

Machine Learning provides various methods through which human efforts can be reduced in recognizing the manually written digits. Deep Learning is a machine learning method that trains computers to learn through examples. With the utilization of deep learning methods, human attempts can be diminished in perceiving, learning, recognizing and in a lot more regions. The digit recognition model uses large datasets in order to recognize digits from distinctive sources. The task of handwritten digit recognition, using a classifier, has extraordinary significance and use such as – online digit recognition on PC tablets, recognize zip codes on mail, processing bank check amounts, numeric sections in structures filled up by hand and so on. There are diverse challenges faced while attempting to solve this problem. The handwritten digits are not always of the same size, thickness, or orientation and position relative to the margins. The model can actualize a pattern characterization method to perceive the handwritten digits provided in the MINIST data set of images of handwritten digits (0-9).

1.2 Purpose:

Digit Recognition is a noteworthy and important issue. As the manually written digits are not of a similar size, thickness, position and direction, in this manner, various difficulties must be considered to determine the issue of handwritten digit recognition. The uniqueness and assortment in the composition styles of various individuals additionally influence the example and presence of the digits. It is the strategy for perceiving and arranging transcribed digits. It has a wide range of applications, for example, programmed bank checks, postal locations and tax documents and so on. The aim of this project is to implement a classification algorithm to recognize the handwritten digits which makes the process of data entries and other works easier in many domains. This model enables the user to easily obtain the digital copy of handwritten digits in the form of tables that makes data entries easier and efficient.

2. LITERATURE SURVEY

Anuj Dutt in his paper demonstrated that utilizing Deep Learning systems, he had the capacity to get an extremely high measure of accuracy. By utilizing the convolutional Neural Network with Keras and Theano as backend, he was getting a accuracy of 98.72%. In addition, execution of CNN utilizing Tensorflow gives a stunningly better consequence of 99.70%. In a paper published by Saeed AL-Mansoori, Multilayer Perceptron (MLP) Neural Network was implemented to recognize and predict handwritten digits from 0 to 9. The proposed neural system was trained and tested on a dataset achieved from MNIST.

2.1 Existing problems:

Image Recognition is an imperative research area for its generally used applications. In general, the field of pattern recognition, one of the difficult undertakings is the precise computerized recognition of human handwriting. Without a doubt, this is a very difficult issue because there is an extensive diversity in handwriting from an individual to another individual. In spite of the fact that, this difference does not make any issues to people, yet, anyway it is increasingly hard to instruct computers to interpret general handwriting. Handwritten Recognition from the MNIST dataset is well known among scientists as by utilizing different classifiers for various parameters, the error rate has been decreased, for example, from linear classifier (1-layer NN) with 12% to 0.23% by a board of 35 convolution neural systems. The scope of this is to implement a Handwritten Digit Recognition framework and think about the diverse classifiers and different techniques by concentrating on how to accomplish close to human performance. For an undertaking of composing diverse digits (0-9) for various people the general issue confronted would be of digit order issue and the closeness between the digits like 1 and 7, 5 and 6, 3 and 8, 9

and 8 and so forth. Additionally, individuals compose a similar digit from various perspectives, the uniqueness and assortment in the handwriting of various people likewise impact the development and presence of the digits.

2.2 References:

- M. Wu and Z. Zhang, Handwritten Digit Classification using the MNIST Dataset, 2010.
- Dutta and A. Dutta, Handwritten digit recognition using deep learning, International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), vol. 6, no. 7, July 2017.
- Al Maadeed, Somaya, and Abdelaali Hassaine, Automatic prediction of age, gender, and nationality in offline handwriting. EURASIP Journal on Image and Video Processing, no. 1 2014.
- Gaurav Jain, Jason Ko, Handwritten Digits Recognition, Project Report, University of Toronto, 11/21/2008.
- Hamid, Norhidayu Abdul, and NilamNur Amir Sjarif, Handwritten recognition using SVM, KNN and neural network, arXiv preprint arXiv:1702.00723 (2017).
- R.G.Mihalyi, Handwritten digit classification using support vector machines, 2011.
- Z. Dan, C. Xu, The Recognition of Handwritten Digits Based on BP Neural Networks and the Implementation on Android, In: 3rd International Conference on Intelligent System Design and Engineering Applications, pp. 1498-1509, 2013.
- <http://cvisioncentral.com/resourceswall/?resource=135>.

2.3 Problem Statement:

Numerical data entry is an important work in most of the domains which is more hectic to be performed manually and is also a time consuming process resulting in slowing down the rate of

productivity of the workers and the organization. Therefore it is important to develop a model to sort this issue. The main objective handwritten digit recognition model is to provide a solution for this problem and ensure effective and reliable approaches for recognition of handwritten digits and make banking operations easier and error free.

Problem Statement-1:



Problem Statement-2:

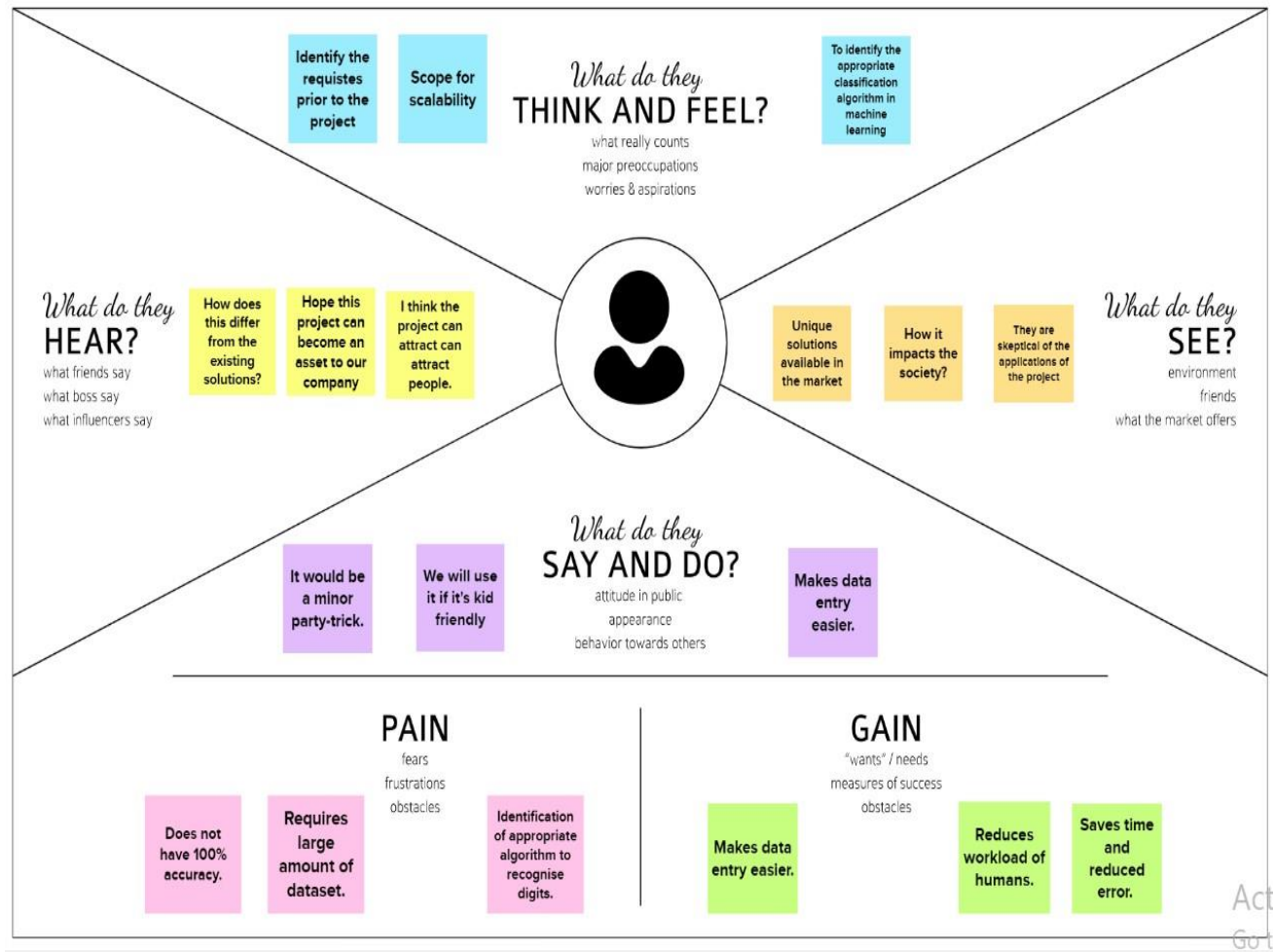


Problem Statement-3:



3. IDEATION AND PROPOSED SOLUTION

3.1 Empathy Map Canvas:



3.2 Ideation and Brainstorm:



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

Numerical data entry is an important work in most of the field which is more hectic to be carried out manually. It also consumes a lot of time thus affecting productivity. Therefore developing a model to sort this issue is necessary.

🕒 5 minutes

PROBLEM

How do we provide an efficient and accurate handwritten digit recognition model?



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.

2

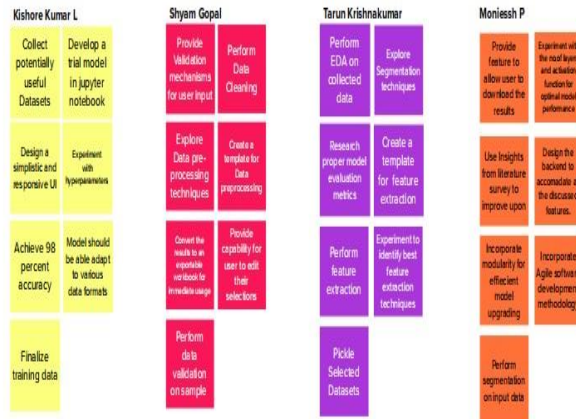
Brainstorm

Write down any ideas that come to mind that address your problem statement.

10 minutes

TIP

You can select a sticky note and hit the pencil (switch to sketch) icon to start drawing!

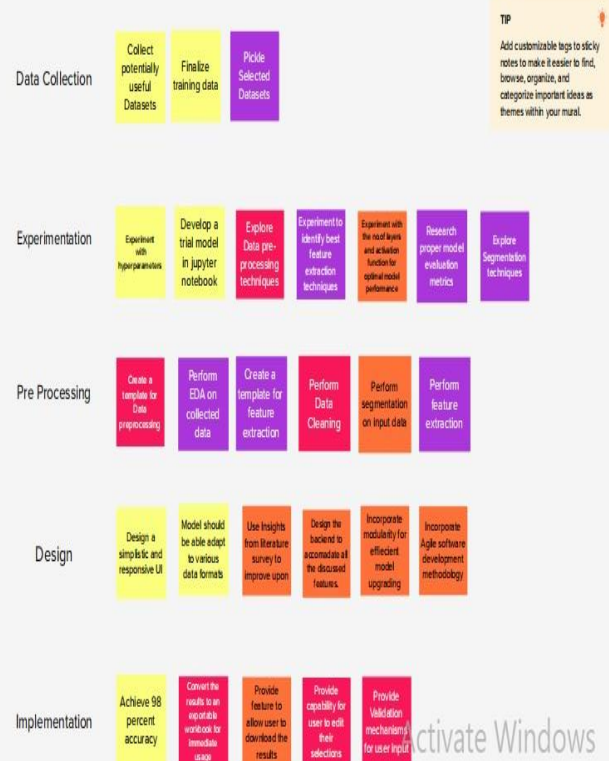


3

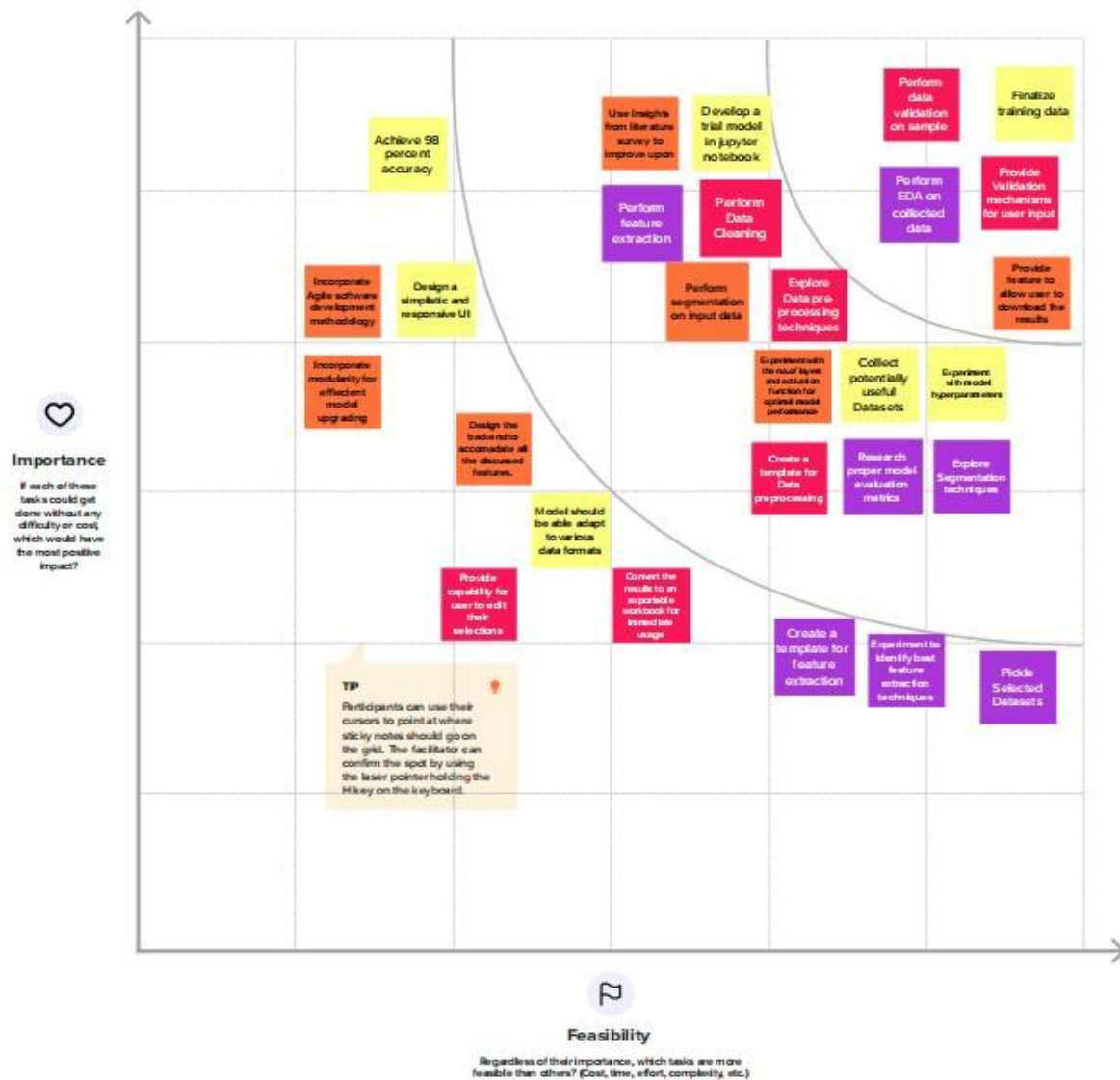
Group ideas

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 can break it up into smaller sub-groups.

20 minutes



Prioritization:



3.3 Proposed Solution:

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Numerical data entry is an important work in most of the field which is more hectic to be carried out manually. It also consumes a lot of time thus affecting productivity. Therefore, developing a model to sort this issue is necessary.
2.	Idea/Solution description	The idea is to develop a hand written digit recognition model using neural network which can recognize the digits written in piece of paper like bank cheque thus making process of entering data into the computer easier.
3.	Novelty/Uniqueness	The model that we proposed has the following uniqueness: <ul style="list-style-type: none">✦ Makes data entry easier.✦ Reduces human workload.✦ Saves time and reduces error.✦ Fast and cost effective.
4.	Social Impact / Customer Satisfaction	The proposed model helps the customer in easy entry of numerical data. It helps them in reducing the error and is cost effective.
5.	Business Model (Revenue Model)	<ul style="list-style-type: none">✦ For government model, it can be made free for the users however for the government organisations we can lease our services for a discounted price.✦ For private model, we can lease our services for the full price and depending on the private organization's guidelines they can charge or make it free for the users
6.	Scalability of the Solution	In the future instead of just recognizing the numbers, our project will be able to recognize letters and words as well as , will be able to distinguish different languages.

3.4 Problem Solution fit:

Define CS, fit into CL	1. CUSTOMER SEGMENT(S) CS Bankers, pharmacists and other professions where writing is required.	6. CUSTOMER LIMITATIONS <small>EG. BUDGET, DEVICES</small> CL Bad network connection, low quality image data	5. AVAILABLE SOLUTIONS <small>PLUSES & MINUSES</small> AS Making people to rewrite the forms which were unclear is an existing solution. But its very time consuming.	Explore AS, differentiate
	2. PROBLEMS / PAINS <small>+ ITS FREQUENCY</small> PR Recognition of vaguely written digits, and providing quick access to computer solution	9. PROBLEM ROOT / CAUSE RC The main problem is that people's handwriting is not always legible so it leads to confusion. Sometimes this can lead to major misunderstanding	7. BEHAVIOR <small>+ ITS INTENSITY</small> BE In order to understand the illegible handwriting our prospective clients either discard the form completely or make the people they deal with rewrite the form.	
Identify strong TR & EM	3. TRIGGERS TO ACT TR Our customers frustration with trying to understand illegible handwriting triggers them to use our product	10. YOUR SOLUTION SL The solution we offer is a software application which takes image input of written digits and then predicts the digits present in the image digitally.	8. CHANNELS of BEHAVIOR CH ONLINE Customers search for solutions in internet forums for their problem.	Extract online & offline CH of BE
	4. EMOTIONS <small>BEFORE / AFTER</small> EM Emotions before were frustration, tiredness etc, after using our product they will feel satisfaction and relief.		OFFLINE Customers try to make people write more clearly.	

4. REQUIREMENT ANALYSIS

4.1 Functional Requirements:

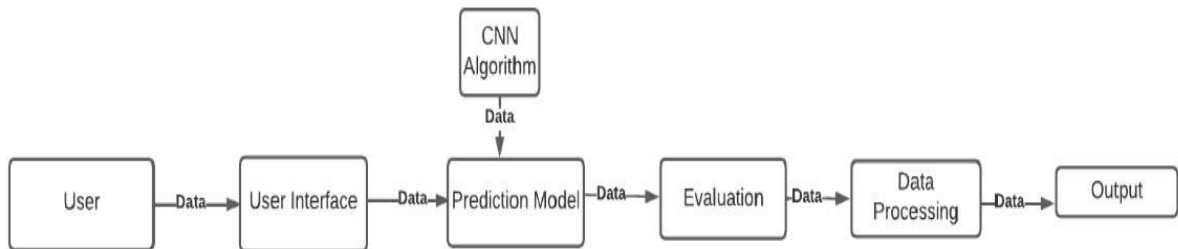
FR No.	Functional Requirement	Sub Requirement(Story/Sub-Task)
FR-1	Image Data	We require image data to recognize what digit is present in the given image.
FR-2	DL Algorithm	We use Deep Learning algorithm to process the handwritten digit in the image into digital numeric format.
FR-3	Website	We require a website as a User Interface for clients to access our services. The website should be user-friendly to engage the clients
FR-4	Modified National Institution of standards and Technology Dataset	The MNIST database (Modified National Institute of Standards and Technology Database) is a large collection of handwritten digits. We have a training set of 60,000 examples and a test set of 10,000 examples. It is a subset of the larger NIST Specialty Database 3 (digits written by U.S. Census Bureau staff) and Specialty Database 1 (digits written by high school students) and contains black and white images of handwritten digits.
FR-5	Cloud	"The cloud" refers to servers that are accessed over the Internet, and the software and databases that run on those servers. Cloud servers are located in data centers all over the world. By using cloud computing, users and companies do not have to manage physical servers themselves or run software applications on their own machines.

4.2 Non-Functional Requirements:

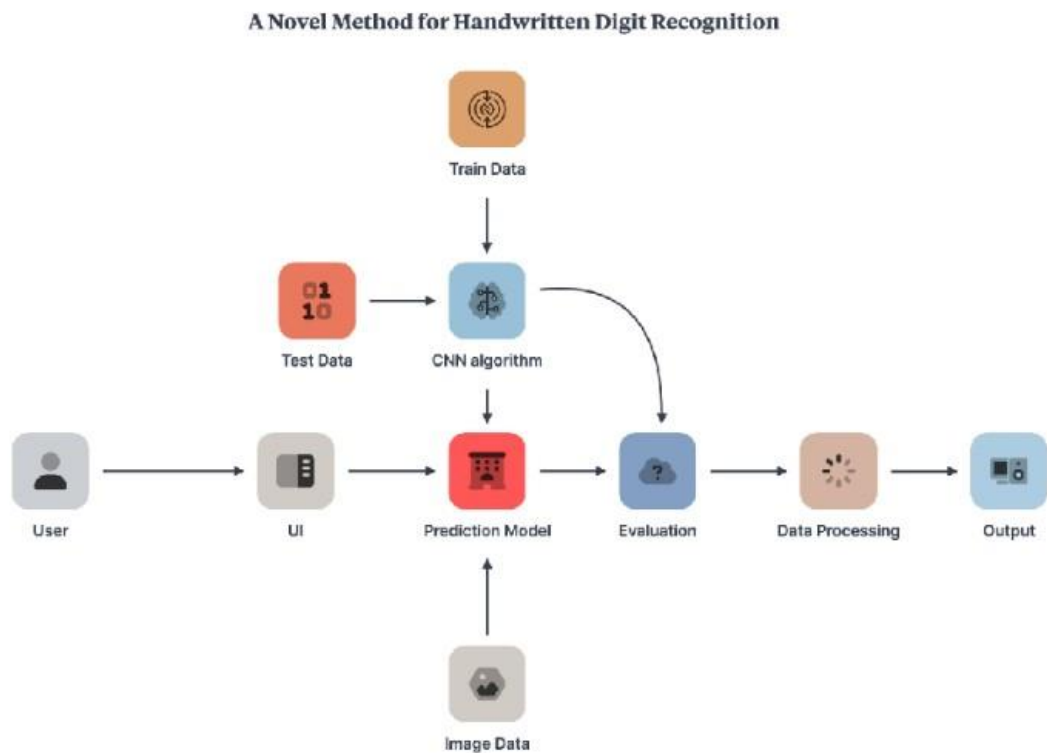
FR No.	Non-Functional Requirement	Description
NFR-1	Usability	The major reason why someone would use our service would be to decrease the hardship faced by employees that have to process handwritten forms such as bank-check processing, address comprehension and soon.
NFR-2	Security	Our service will make use of login authentication to make sure the users have some form of privacy.
NFR-3	Reliability	Algorithm will have an accuracy of 90%, further more the CNN algorithm will decipher the handwritten digits based on the rules defined by us which will be based upon the general handwritten digits.
NFR-4	Performance	Our website will be lightweight, efficient and accurate with minimum discomfort to the user.
NFR-5	Availability	Our website will be made public for everyone to use.
NFR-6	Scalability	In future, the website will be able to retain the knowledge of previous user's data and hasten the process of digit recognition.

5. PROJECT DESIGN

5.1 Data Flow Diagram:



5.2 Solution and Technical Architecture:



5.3 User Stories:

User Type	Functional Requirement(Epic)	User Story Number	User Story/Task	Acceptance criteria	Priority	Release
Customer	Login	USN-1	As a user, I can login to my account	I can access my account	High	Sprint-1
	Image upload	USN-2	As a user I can upload my image with digits for recognition	I can upload my image	High	Sprint-1
	Output Download	USN-3	As a user I can, download the output as a text file	I can see the output file and click on download	High	Sprint-1
		USN-4	As a user I can download the output as an excel sheet	I can download the output	Medium	Sprint-2
	Image Preview	USN-5	As a user I can preview my uploaded image	I can see my image preview	Medium	Sprint-1
	Rating	USN-6	As a user I can rate the service provided by the website	I can see the rating being recorded	Low	Sprint-2
	Registration	USN-7	As a user I can register my information to create an account for the service	I can use my new credentials to access my account	Medium	Sprint-2

6. PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & estimation:

Sprint	Functional Requirement (Epic)	User Story Number	User Story/Task	Story Points	Priority	Team Members
Sprint-1	User Login	USN-1	The user will be presented with two options. 1. Sign-in your account if It already exists. 2. Sign-up if you are new.	1	Low	Moniessh P Kishore Kumar L ShyamGopal TarunK
Sprint-1	Dashboard	USN-2	Go to dashboard and see the available features 1. Open camera(allow permission) 2. Upload picture			Moniessh PKishoreKumar LShyam Gopal TarunK
Sprint-2	Training the model	USN-3	Comparing the input with the existing data.	2	Medium	Moniessh P KishoreKumar L Shyam Gopal TarunK
Sprint-3	Prediction	USN-4	Predict the correct output or get an outputsimilarityof90%.	2	High	Moniessh P KishoreKumarL Shyam Gopal TarunK
Sprint-4	Evaluation Metrics	USN-5	Finally the correct prediction is given as output to the user.	2	High	Moniessh P KishoreKumar L ShyamGopal TarunK
Sprint-1	Exit	USN-6	Click exit button to exit from the application	1	Low	Moniessh P KishoreKuma rL Shyam Gopal Tarun K

6.2 Print Delivery Schedule:

Sprint	Total Story Point	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

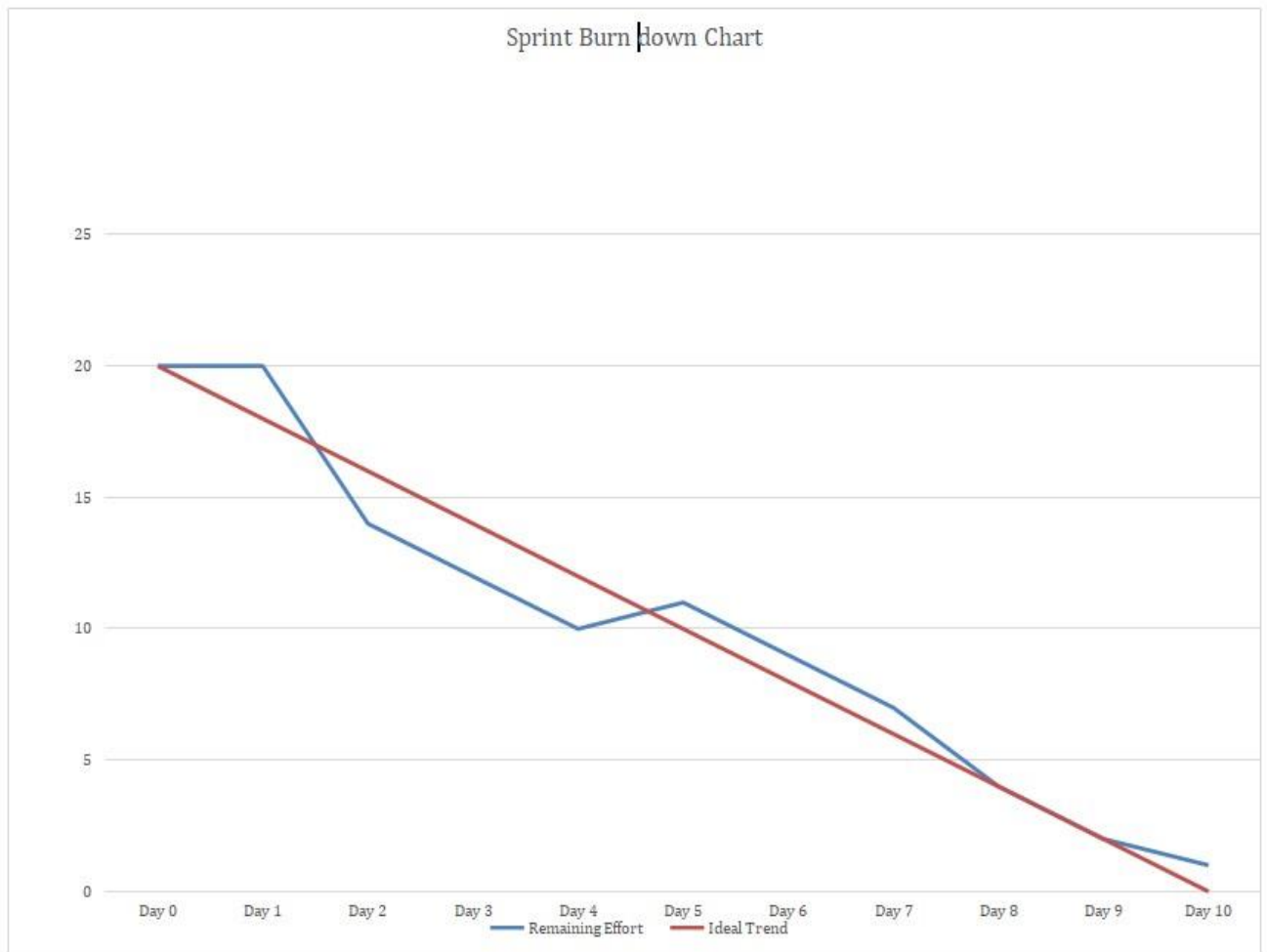
Velocity:

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).

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

Burn down Chart:

A burn down 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:

Coverage Report

Coverage	Test Cases
No Coverage	10 IB-T1 APPROVED Webpage_TC_001
	IB-T2 APPROVED Webpage_TC_002
	IB-T3 APPROVED Fileupload_TC_001
	IB-T4 APPROVED Display_TC_001
	IB-T5 APPROVED Login_TC_001
	IB-T6 APPROVED Predict_TC_001
	IB-T7 APPROVED Webpage_TC_003
	IB-T8 APPROVED Webpage_TC_004
	IB-T9 APPROVED Webpage_TC_005
	IB-T10 APPROVED Login_TC_002

Displaying (1 of 1)

Traceability Report

Coverage	Test Cases	Test Execution Results	Issues
No Coverage	10 IB-T1 APPROVED Webpage_TC_001	1 PASS Executed on: 18/Nov/22 10:56 pm Environment: - Executed by: Shyam Gopal	0 None
	IB-T2 APPROVED Webpage_TC_002	2 PASS Executed on: 18/Nov/22 11:03 pm Environment: - Executed by: Shyam Gopal	0 None
		PASS Executed on: 18/Nov/22 11:07 pm Environment: - Executed by: Shyam Gopal	0 None
	IB-T3 APPROVED Fileupload_TC_001	0 None	None
	IB-T4 APPROVED Display_TC_001	1 PASS Executed on: 18/Nov/22 11:19 pm Environment: - Executed by: Shyam Gopal	0 None
	IB-T5 APPROVED Login_TC_001	1 PASS Executed on: 18/Nov/22 11:25 pm Environment: - Executed by: Shyam Gopal	0 None

IB-T6 APPROVED Predict_TC_001	1	PASS Executed on: 18/Nov/22 11:30 pm Environment: - Executed by: Shyam Gopal	0	None
IB-T7 APPROVED Webpage_TC_003	1	PASS Executed on: 18/Nov/22 11:49 pm Environment: - Executed by: Shyam Gopal	0	None
IB-T8 APPROVED Webpage_TC_004	1	PASS Executed on: 18/Nov/22 11:52 pm Environment: - Executed by: Shyam Gopal	0	None
IB-T9 APPROVED Webpage_TC_005	1	PASS Executed on: 18/Nov/22 11:57 pm Environment: - Executed by: Shyam Gopal	0	None
IB-T10 APPROVED Login_TC_002	1	PASS Executed on: 19/Nov/22 12:01 am Environment: - Executed by: Shyam Gopal	0	None

Activate Windows

Traceability matrix

	Test Cases	IB-T1 - Webpage_TC_001	IB-T2 - Webpage_TC_002	IB-T3 - Fileupload_TC_001	IB-T4 - Display_TC_001	IB-T5 - Login_TC_001	IB-T6 - Predict_TC_001	IB-T7 - Webpage_TC_003	IB-T8 - Webpage_TC_004	IB-T9 - Webpage_TC_005	IB-T10 - Login_TC_002
Coverage											
No Coverage											

Displaying (1 of 1)

Last test execution: ■ Pass ■ Not Executed

Traceability Tree

Traceability	Summary
No Coverage	
└ Covered by Test Case IB-T1	Webpage_TC_001
└ Executed on 18/Nov/22 10:56 pm	PASS Executed by: Shyam Gopal
└ Covered by Test Case IB-T2	Webpage_TC_002
└ Executed on 18/Nov/22 11:03 pm	PASS Executed by: Shyam Gopal
└ Executed on 18/Nov/22 11:07 pm	PASS Executed by: Shyam Gopal
└ Covered by Test Case IB-T3	Fileupload_TC_001
└ Covered by Test Case IB-T4	Display_TC_001
└ Executed on 18/Nov/22 11:19 pm	PASS Executed by: Shyam Gopal
└ Covered by Test Case IB-T5	Login_TC_001
└ Executed on 18/Nov/22 11:25 pm	PASS Executed by: Shyam Gopal

... Covered by Test Case IB-T6	Predict_TC_001
... Executed on 18/Nov/22 11:30 pm	PASS Executed by Shyam Gopal
... Covered by Test Case IB-T7	Webpage_TC_003
... Executed on 18/Nov/22 11:49 pm	PASS Executed by Shyam Gopal
... Covered by Test Case IB-T8	Webpage_TC_004
... Executed on 18/Nov/22 11:52 pm	PASS Executed by Shyam Gopal
... Covered by Test Case IB-T9	Webpage_TC_005
... Executed on 18/Nov/22 11:57 pm	PASS Executed by Shyam Gopal
... Covered by Test Case IB-T10	Login_TC_002
... Executed on 19/Nov/22 12:01 am	PASS Executed by Shyam Gopal

Displaying (1 of 1)

Activate Windows
Go to Settings to activate Windows

7. CODING AND SOLUTIONING

7.1 Libraries Installed:

pip install flask pip

install numpy pip

install keras pip

install tensorflow pip

install kerasmodel

7.2 Uploading of files into Website (for Digit Recognition):

Digit recognition is one of the noteworthy and important issue. When it comes to data entry the recognition of handwritten digits becomes a hectic process and is time consuming. It takes a lot of effort to enter the data in digital form. Thus, this project provides solution to such problems where the user can upload the image file from his device which is detected by the system and the predicted output is displayed for the user.

7.3 Prediction of the digits from uploaded files:

The model scans the files uploaded by the user and scans for digits in it. The model is a convolutional neural network with weights saved to HDF5 file in the data folder relative to the module's path. The handwritten digits are recognized and predicted and the output is displayed in the screen.

8. TESTING

8.1 Test Cases:

- Verify if the buttons in web page are responsive.
- Verify if the UI elements are getting displayed properly.
- Verify if the user can upload files from his system.
- Verify if the output is displayed.
- Verify if the user can login using his credentials.
- Verify if the model predicts the input accurately.
- Verify if the user is getting redirected to home page after sign in.
- Verify if the UI elements are being displayed.
- Verify if the user can navigate to other pages in navigation bar.
- Verify if the user can exit the home to sign page.

8.2 UAT Testing:

2. Defect Analysis

This report shows the number of resolved or closed bugs at each severity level, and how they were resolved

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	10	8	3	1	22
Duplicate	1	0	2	0	3
External	3	2	2	1	8
Fixed	12	3	3	10	28
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	1	2
Won't Fix	1	0	0	0	1
Totals	27	13	15	13	65

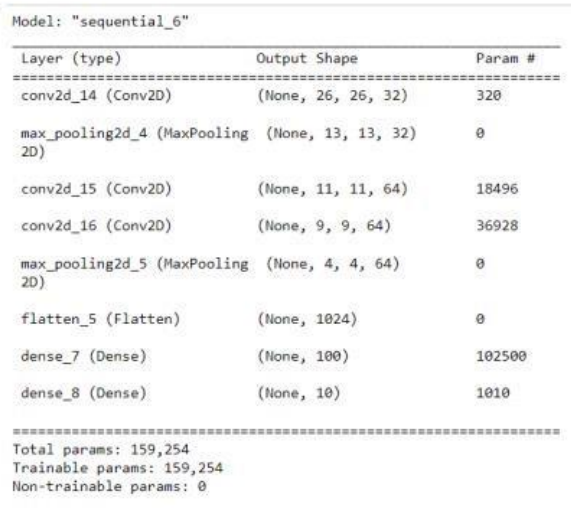
3. Test Case Analysis

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

Section	Total Cases	Not Tested	Fail	Pass
Print Engine	6	0	0	6
Client Application	15	0	0	15
Security	2	0	0	2

Outsource Shipping	3	0	0	3
Exception Reporting	8	0	0	8
Final Report Output	6	0	0	6
Version Control	2	0	0	2

8.3 Performance Testing:

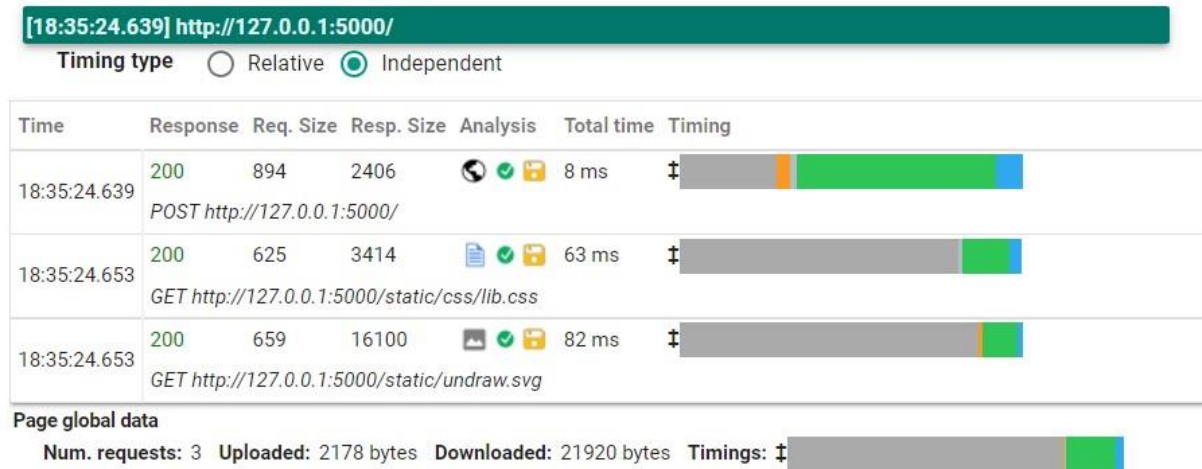
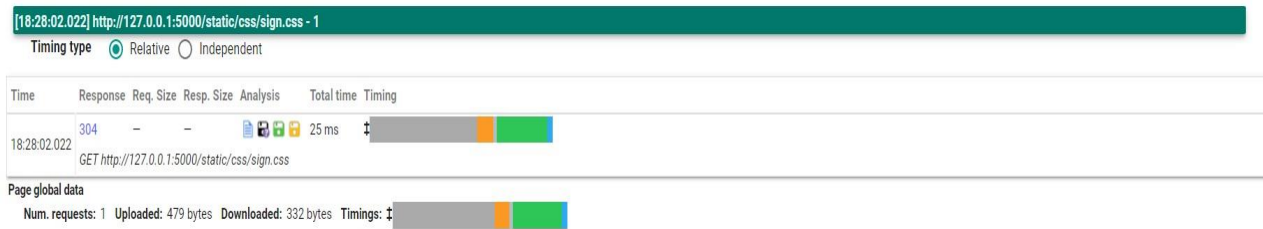
S.No.	Parameter	Values	Screenshot
1.	Model Summary	Total params: 159,254 Trainable params: 159,254 Non-trainable params: 0	 <pre> Model: "sequential_6" Layer (type) Output Shape Param # ----- conv2d_14 (Conv2D) (None, 26, 26, 32) 320 max_pooling2d_4 (MaxPooling (None, 13, 13, 32) 0 2D) conv2d_15 (Conv2D) (None, 11, 11, 64) 18496 conv2d_16 (Conv2D) (None, 9, 9, 64) 36928 max_pooling2d_5 (MaxPooling (None, 4, 4, 64) 0 2D) flatten_5 (Flatten) (None, 1024) 0 dense_7 (Dense) (None, 100) 102500 dense_8 (Dense) (None, 10) 1010 ----- Total params: 159,254 Trainable params: 159,254 Non-trainable params: 0 </pre>

2.	Training Accuracy	Training Accuracy: 0.9593	<pre> Epoch 1/10 1875/1875 [=====] - 44s 23ms/step - loss: 0.1276 - accuracy: 0.9593 Epoch 2/10 1875/1875 [=====] - 44s 24ms/step - loss: 0.0422 - accuracy: 0.9870 Epoch 3/10 1875/1875 [=====] - 46s 25ms/step - loss: 0.0299 - accuracy: 0.9901 Epoch 4/10 1875/1875 [=====] - 47s 25ms/step - loss: 0.0207 - accuracy: 0.9934 Epoch 5/10 1875/1875 [=====] - 44s 24ms/step - loss: 0.0160 - accuracy: 0.9947 Epoch 6/10 1875/1875 [=====] - 44s 26ms/step - loss: 0.0118 - accuracy: 0.9962 Epoch 7/10 1875/1875 [=====] - 39s 21ms/step - loss: 0.0085 - accuracy: 0.9974 Epoch 8/10 1875/1875 [=====] - 38s 21ms/step - loss: 0.0072 - accuracy: 0.9978 Epoch 9/10 1875/1875 [=====] - 44s 23ms/step - loss: 0.0044 - accuracy: 0.9987 Epoch 10/10 1875/1875 [=====] - 40s 21ms/step - loss: 0.0042 - accuracy: 0.9987 <keras.callbacks.History at 0x13c090cc700> </pre>
3.	Evaluation Accuracy	Evaluation Accuracy: 99.050	<pre> 313/313 [=====] - 5s 7ms/step - loss: 0.0337 - accuracy: 0.9905 Accuracy > 99.050 </pre>

9. RESULTS

9.1 Performance Metrics:

The following images can be studied to understand the performance metrics of our system.



10. ADVANTAGES AND DISADVANTAGES

Advantages:

- Easy recognition and prediction of handwritten digits in an image or pdf.
- Makes the process of data entry easier.
- Saves time and is more efficient.
- Friendly UI.

Disadvantages:

- There may be slight mistakes in predictions.
- As there are wide range of handwriting styles and pattern it is difficult to train the model using all the digits.
- There may be slight lag in the use of website.
- User may not be able to upload multiple files at once.

11. CONCLUSION

Digit recognition plays a important part in various processes and functions in every domain in our day to day lives. It mainly helps in the process of data entry in many workplaces like banks, billing processes and so on. But it requires a lot of effort and consumes more time. A convolution neural network has been used to build a model that is trained on various hand motions. Utilizing this concept, an app is created. Thus our project provides a solution to this problem by helping the users to detect the digits in an uploaded files making the process of data entry easier and efficient.

12. FUTURE SCOPE

The following are the features that can be added in our application:

- Increase in accuracy of prediction.
- Enabling the user to upload more than one file at a time.
- Conversion of the digits in a file to tabular form making data entry easier.
- A recognition app with same features can be developed in which we may add a addition feature that pronounces the predicted digit from the image uploaded.
- We may also add a feature where the files with any format can be uploaded and the digit is predicted accordingly.

13. APPENDIX

Source Code

•Model Building:

```
from keras.models import Sequential from
keras.layers import Dense, Conv2D, Flatten
import matplotlib.pyplot as plt from keras.datasets
import mnist from tensorflow.keras.utils import
to_categorical from tensorflow.keras.layers import
MaxPooling2D from tensorflow.keras.optimizers
import SGD import numpy as np
%matplotlib inline

(x_train, y_train), (x_test, y_test) = mnist.load_data()

x_train = x_train.reshape(60000,28,28,1) x_test
= x_test.reshape(10000,28,28,1)

x_train.shape

y_train = to_categorical(y_train)
y_test = to_categorical(y_test)
```



```
y_train[0]
```

```
x_train = x_train.astype('float32') x_test
```

```
= x_test.astype('float32')
```

```
x_train = x_train/255.0 x_test
```

```
= x_test/255.0
```

```
model1 = Sequential()
```

```
model1.add(Conv2D(32, (3, 3), activation='relu', kernel_initializer='he_uniform',  
input_shape=(28, 28, 1))) model1.add(MaxPooling2D((2, 2)))
```

```
model1.add(Conv2D(64, (3, 3), activation='relu', kernel_initializer='he_uniform'))
```

```
model1.add(Conv2D(64, (3, 3), activation='relu', kernel_initializer='he_uniform'))
```

```
model1.add(MaxPooling2D((2, 2))) model1.add(Flatten())
```

```
model1.add(Dense(100, activation='relu', kernel_initializer='he_uniform'))
```

```
model1.add(Dense(10, activation='softmax'))
```

```
# compile model opt = SGD(learning_rate=0.01, momentum=0.9)
```

```
model1.compile(optimizer=opt, loss='categorical_crossentropy', metrics=['accuracy'])
```

```
model1.fit(X_train, y_train, epochs=10, batch_size=32)
```

```
model1.save("final_model.h5")
```

- **Model Testing:**

```
img = Image.open('6.png')
img = img.resize((28,28))
img = np.array(img)
img = tf.image.rgb_to_grayscale(img)
img = img.numpy() img =
np.invert(img) img =
img.astype('float') img = img/255.0
img = np.expand_dims(img,axis=0)
pred = model1.predict(img)
prediction = np.argmax(pred)
```

- **Flask App Building:**

```
import os from
flask import
```

```
Flask,request,render_template,send_from_directory,url_for
r from wtforms import SubmitField from flask_cors import
CORS from keras_preprocessing import image from
keras.models import load_model
import tensorflow as tf from
PIL import Image
import numpy as np
```

```
app = Flask(__name__)
CORS(app)
```

```
model = load_model('final_model.h5')
```

```
user_list = ['ned','jon','arya','bran'] pass_list
= ['head','snow','stark','wolf']
```

```
valid = "
@app.route("/",methods=['GET','POST']) def
login():
    username = request.form.get('username')
    password = request.form.get('password')
    print(username,password)
```

```
    for i in range(len(user_list)):
    if(username == user_list[i]):
    if(password == pass_list[i]):
    return render_template("lib.html")
    else:
```

```

        valid = 'invalid credentials'
        return render_template("Signin.html",valid=valid)
valid = 'invalid credentials'
    return render_template("Signin.html",valid=valid)

@app.route("/Contact",methods=['GET','POST'])
def Contact():
    return
render_template("Contact.html")

@app.route("/About",methods=['GET','POST']) def
About():
    return render_template("About.html")

@app.route("/predict",methods=['GET','POST'])
def predict():
    basepath = "    filepath = "    if
request.method=='POST':
    f =
request.files['image']
    print('current path')
    basepath = os.path.dirname(__file__)
    print("current path:",basepath)
    filepath = os.path.join(basepath,'uploads',f.filename)
print('upload folder is',filepath)
    f.save(filepath)

    img = Image.open(filepath)
img = img.resize((28,28))
img = np.array(img)
    img =
tf.image.rgb_to_grayscale(img)
img = img.numpy()
img = np.invert(img)
img = img.astype("float32")
img =
img/255.0
    img = np.expand_dims(img,axis=0)
pred = model.predict(img)
prediction = np.argmax(pred)
    print("PREDICTION :",prediction)

    return render_template('lib.html',prediction=str(prediction))

```

file_url = None app.run(debug=True)

- **HTML Files:**

- 1. Signin.html:**

```
<html>
  <head>
    <title>Login</title>
    <link rel="stylesheet" type="text/css" href="{{ url_for('static',
filename='css/sign.css')}}">
    <header>
      <nav>
        <ul>
          <li class="active"><a href="/">Sign in</a></li>
          <li><a href="Contact">Contact</a></li>
          <li><a href="About">About</a></li>
          <li><a
href="predict">Home</a></li>
        </ul>
      </nav>
    </header>
  </head>
  <body>
    <div class="panels-container">
      <div class="panel left-panel">
        
      </div>
      <div class="panel right-panel">
        <div class="center">
          <h1><b>Sign in</b></h1>

          <form class="login_form" action="/" method="POST" >
            <div class="txt_field">
              <input type="text" name="username" placeholder="Enter
Mail Id or Username" required>
              <span></span>
            </div>
```

```

        <div class="txt_field">
            <input type="password" name="password"
placeholder="Enter Password" required>
            <span></span>
        </div>
        <button value="submit" onsubmit="Alert()" >Sign
in</button>

    </div>
</div>

    <!--<label><input type="checkbox"> Remember me</label>
    <div class="pass">Forgot Password?</div>
    <div class="signup_link">
        Not a member? <a href="#">Signup</a>
</div>-->
</form>
{% if valid == 'invalid credentials' %}
    <script>
        alert("invalid credentials")
    </script>
{% endif %}
</div>

</body>
</html>

```

2. lib.html:

```

<html>
    <head>
        <link
rel="stylesheet"
type="text/css"
href="{{ url_for('static', filename='css/lib.css')}}"
/>

        <title>Home</title>

```



```

        >      <input
type="file"
accept="image/*"
name="image"
id="image"
        onchange="loadFile(event)"
      />
      <button
type="submit"
class="btn btn-primary"
name="action"
        value="upload"
      >
        Submit
      </button>
</form>

<div class="display">
  <p><img id="output" width="200" /></p>
  <script>
    var loadFile = function (event) {
      var image = document.getElementById("output");
image.src =
URL.createObjectURL(event.target.files[0]);
    };
  </script>
</div>
<div class="result">
  {% if prediction %}
  <h2>The predicted digit is,</h2>
  <h2>{{prediction}}</h2>
  {%endif%}
</div>
</div>
<div class="panel right-panel">
  <div class="svg">
    
  </div>
</div>

```



```
</div>
</body>
</html>
```

3. about.html:

```
<html>
<head>
  <link
rel="stylesheet"
type="text/css"
  href="{{ url_for('static', filename='css/about.css')}}"/>
</head>
<nav>
  <ul>
    <li><a href="/">Sign in</a></li>
    <li><a href="Contact">Contact</a></li>
    <li class="active"><a href="About">About</a></li>
    <li><a href="lib.html">Home</a></li>
    <li>HDR</li>
  </ul>
</nav>
</head>
<body>
  <h1><center>HANDWRITTEN DIGIT RECOGNITION
SYSTEM</center></h1>
  <p>
    <center>
      Handwritten digit recognition using MNIST dataset is a
      major project
      made with the help of Neural Network. It basically detects
      the scanned
      images of handwritten digits. We have taken this a step
      further where
      our handwritten digit recognition system not only detects
      scanned images
```

of handwritten digits but also allows writing digits on the screen with the help of an integrated GUI for recognition.

```
</center>
</p>

</html>
```

4. contact.html:

```
<html>
<head>
<link
rel="stylesheet"
type="text/css"
href="{{ url_for('static', filename='css/contact.css')}}"
/>
<nav>
<ul>
<li><a href="/">Sign in</a></li>
<li class="active"><a href="Contact">Contact</a></li>
<li><a href="About">About</a></li>
<li><a href="lib.html">Home</a></li>
<li>HDR</li>
</ul>
</nav>
</head>
<body>
<h1>HANDWRITTEN DIGIT RECOGNITION SYSTEM</h1>
<p>
Team ID : PNT2022TMID24883 Team Lead : Moniessh P
M1 Lead : Kishore Kumar
L M2 Lead : Shyam Gopal M3 Lead : Tarun K
</p>
</body>
</html>
```

- **CSS Files:**

- 1. Sign.css:**

```
* {
    margin: 0;
    padding: 0;
    box-sizing: border-box;
}
nav {
    background-color: rgba(11, 11, 11, 1);
    height: 60px;
    font-family: "Trebuchet MS", "Lucida Sans Unicode", "Lucida
Grande",
    "Lucida Sans", Arial, sans-serif;
}

header {
    width: 100%;
    height: 70px;
}

ul {
    list-style-type: none;
    overflow: hidden;
}
li {
    float: right; display:
inline-block;
} li a { color: aliceblue;
display: block; font-
size: 25px; margin:
10px; text-decoration:
none; border-radius:
60px; padding: 3px
10px;
font-size: large;
}
```

```

body { margin: 0;
padding: 0;
overflow: hidden;
background-image: linear-gradient(150deg, rgb(249, 244, 249)
50%, black 50%); background-
repeat: no-repeat; background-
attachment: fixed;
background-size: 100% 100%;
}
.panels-container {
position: absolute;
height: 100%;
width: 100%; top:
60px; left: 0;
display: grid;
grid-template-columns: repeat(2, 1fr);
}
.panel left-panel { pointer-
events: all; padding: 3rem 17%
2rem 12%;
}
.panel right-panel { pointer-
events: none;
padding: 3rem 12% 3rem 17%;
}
img { height:
550px;
width: 550px;
}
.center { position:
absolute; top:
50%; left: 80%;
transform: translate(-50%, -50%);
width: 420px; height: 420px;
background: rgba(255, 255, 254, 0.612);
border-radius: 30px; padding-top: 50px;
box-shadow: 10px 10px 15px rgba(0, 0, 0, 0.05);
}

```

```

.center h1 { text-align: center;
padding: 20px 0;
}
.center form { padding: 0 40px; box-sizing: border-box;
} form .txt_field
{
position: relative; border-bottom: 2px solid #878585; margin: 30px 0;
}
.txt_field input {
width: 100%;
padding: 0 5px;
height: 40px; font-size: 16px; border: none; background: none;
outline: none;
}

.txt_field input::placeholder {
color: rgb(21, 19, 19);
}

.txt_field input:focus ~ span::before, .txt_field
input:valid ~ span::before {
width: 100%;
}

.pass { margin: 5px 0 20px 5px; color: #4012e5; cursor: pointer; float: right; }
.pass:hover {
text-decoration: underline;
}

```

```

button { width:
100%; height:
50px; border:
1px solid;
/* background: rgb(249, 134, 3,70%); */
background-color: aliceblue; border-
radius: 25px; font-size: 18px; color:
#181e22; font-weight: 700; cursor:
pointer;
outline: none;
}
button:hover {
background: rgb(0, 0, 0);
color: white;
transition: 0.5s;
}
.signup_link {
margin: 30px 0;
text-align: center;
font-size: 16px;
color: #666666;
}
.signup_link a {
color: #2691d9;
text-decoration: none;
}
.signup_link a:hover {
text-decoration: underline;
}
.txt_field span::before {
content: "";
position: absolute;
top: 40px; left: 0;
width: 0%;
height: 2px;
background: #000000;
transition: 0.5s;
} li.active a
{

```

```

        background-color: rgb(245, 245, 245);
        color: black;
    } li a:hover
    {
        background-color: rgb(249, 247, 245);
        color: rgb(0, 0, 0);
    }

```

2. lib.css:

```

h1 { color:
aliceblue;
font-family: "Franklin Gothic Medium", "Arial Narrow", Arial,
sans-serif;
font-size: 30px;
}

/* .n { height:
50px;
margin: 0;
} */
/* .logo {
float: left; font-
size: x-large;
font-family: "Franklin Gothic Medium", "Arial Narrow", Arial,
sans-serif;
height: 70px;
} */
body {
margin: 0;
background-color: aliceblue;
background-image: linear-gradient(225deg, rgb(249, 244, 249)
50%, black 50%); background-
attachment: fixed; max-height: 100 vh;

/* background-image: url('lib.jpg');
background-repeat: no-repeat; background-
attachment: fixed;

```

```

        background-size: 100% 100%; */
    }

.svg img {
    height: 500;
    width: 500;
    /* padding-bottom: 200; */ padding-
left: 100;
    padding-top: 80;
}
header {
    width: 100%;
    height: 60px;
}
.search { background-color:
    aliceblue; height: 50px;
    width: 200;
    border-radius: 60px;
}

input {
    /* background-color: aliceblue; */
    /* border-radius: 45px; */
    margin: 20px; border-style:
    none;
}

nav {
    background-color: rgb(0, 0, 0);
    height: 60px;
    font-family: "Trebuchet MS", "Lucida Sans Unicode", "Lucida
Grande",
        "Lucida Sans", Arial, sans-serif;
}
/* input:focus,
textarea:focus,
select:focus {
    outline: none;
} */

```



```

ul {
  list-style-type: none;
  overflow: hidden;
  height: 60px;
} nav li { float: right;
display: inline-block;
} nav li a { color:
aliceblue; display:
block; font-size: 20px;
margin: 10px; text-
decoration: none;
padding: 3px 10px;
font-weight: 100;
} li.active a
{
background-color: rgb(251, 251, 251);
color: black;
border-radius: 60px;
} li a:hover
{
background-color: rgb(225, 225, 224);
color: rgb(9, 9, 9); text-
decoration: none;
border-radius: 60px;
}
.panels-container {
position: absolute;
height: 100%; width:
100%;
top: 60px;
left: 0;
display: grid;
grid-template-columns: repeat(2, 1fr);
}
.panel left-panel {
pointer-events: all; padding:
3rem 17% 2rem 12%;
}

```

```

.panel right-panel { pointer-
events: none; padding: 3rem
12% 3rem 17%;
}
h1 {
font-size: 50px;
}
h2 { color:
aliceblue;
font-family: "Franklin Gothic Medium", "Arial Narrow", Arial,
sans-serif;
font-size: 40px;
}
button {
background-color: #2f2e41;
border-radius: 0 60px 60px 0;
margin-inline: 5px; color:
white; border: none; height:
50px;
cursor: pointer;
}
.display { border:
white; border-
width: thick;
position: absolute;
height: 200; width:
200; top: 300px;
left: 200px;
}
.result {
padding-top: 300px;
}
form { position:
absolute; height:
10; /* width: 0; */
top: 50%; left:
20%;
transform: translate(-50%, -250%);

```

```

/* width: 320px; */ background-
color: aliceblue; padding-bottom:
50px;
border-radius: 50px;
}

h1 {
font-family: "Trebuchet MS", "Lucida Sans Unicode", "Lucida
Grande",
"Lucida Sans", Arial, sans-serif;
} p
{
color: aliceblue;
}

```

3. about.css:

```

nav {
background-color: rgb(0, 0, 0);
height: 60px;
font-family: "Trebuchet MS", "Lucida Sans Unicode", "Lucida
Grande",
"Lucida Sans", Arial, sans-serif;
}
h1 {
align-content: center;
} p
{
align-content: center;
}
body {
margin: 0;
background-color: aliceblue;
/* background-image: linear-gradient(225deg, rgb(249, 244,
249) 50%, black 50%); */ background-
attachment: fixed; max-height: 100 vh;
}
ul {

```

```

    list-style-type: none;
    overflow: hidden;
    height: 60px;
} nav li { float: right;
display: inline-block;
} nav li a {
color: aliceblue;
display: block;
font-size: 20px;
margin: 10px;
text-decoration:
none; padding:
3px 10px; font-
weight: 100;
} li.active a
{
background-color: rgb(251, 251, 251);
color: black;
border-radius: 60px;
} li a:hover
{
background-color: rgb(225, 225, 224);
color: rgb(9, 9, 9); text-
decoration: none;
border-radius: 60px;
}

```

4. contact.css:

```

nav {
background-color: rgb(0, 0, 0);
height: 60px;
font-family: "Trebuchet MS", "Lucida Sans Unicode", "Lucida
Grande",
"Lucida Sans", Arial, sans-serif;
}
body {
margin: 0;

```

```

    background-color: aliceblue; background-
attachment: fixed; max-height: 100 vh;
}
h1{
    align-content: center;
} p { color: black;
align-content: center;
}
ul { list-style-type:
none; overflow:
hidden; height:
60px;
} nav li {
float: right;
display: inline-block;
} nav li a { color:
aliceblue; display:
block; font-size: 20px;
margin: 10px; text-
decoration: none;
padding: 3px 10px;
font-weight: 100;
}
li.active a {
background-color: rgb(251, 251, 251);
color: black;
border-radius: 60px;
} li a:hover
{
background-color: rgb(225, 225, 224);
color: rgb(9, 9, 9); text-
decoration: none;
border-radius: 60px;
}

```

GitHub Link: [IBM-Project-50371-1660905452/Steps to Create IBM Cloud Account.docx at main · IBM-EPBL/IBM-Project-50371-1660905452 \(github.com\)](https://github.com/IBM-EPBL/IBM-Project-50371-1660905452/blob/main/Steps%20to%20Create%20IBM%20Cloud%20Account.docx)

Video Link: [IBM-Project-50371-1660905452/Steps to Create IBM Cloud Account.docx at main · IBM-EPBL/IBM-Project-50371-1660905452 \(github.com\)](https://github.com/IBM-EPBL/IBM-Project-50371-1660905452/blob/main/Steps%20to%20Create%20IBM%20Cloud%20Account.docx)