19CSP14 - PROFESSIONAL READINESS FOR INNOVATION, EMPLOYABILITY AND ENTREPRENEURSHIP

Novel Method for Handwritten Digit Recognition System

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Team member 3: Jegadish M

1 . INTRODUCTION

Project Overview

Machine learning and deep learning play an important role in computer technology and artificial intelligence. Deep learning and machine learning can be used to reduce human effort in perception, learning, prediction, and many other areas.

Handwritten digit recognition is the ability of computer systems to recognize handwritten digits from various sources such as images, documents, and so on. This project aims to help users reduce the manual work of digit recognition using machine learning.

Purpose

Digit recognition systems can recognize digits from a variety of sources such as emails, bank checks, documents, and photographs. Recognize digits in a variety of real-world scenarios, such as online handwriting recognition on computer tablets and systems, vehicle license plate recognition, and bank check processing. For example, filling out handwritten forms (tax forms).

2. LITERATURE SURVEY

1)A novel method for Handwritten Digit Recognition with Neural Networks (MALOTHU NAGU*1, N VIJAY SHANKAR#2, K.ANNAPURNA)

♦ Character recognition plays an important role in the modern world. It can solve more complex problems and makes humans' job easier. An example is handwritten character recognition.

♦ Two techniques researched in this paper are Pattern Recognition and Artificial Neural Network (ANN). Both techniques are defined and different methods for each technique is also discussed.

♦ Neural Network is used to train and identify written digits. After training and testing, the accuracy rate reached 99%.This accuracy rate is very high.

2)An effective result-feedback neural algorithm for handwritten character recognition (Hao Y., Shi Y., Zhang D., Zhu X. 2001)

♦ It is designed as an effective neural network by adding confidence back-propagation and input modification, thus both pre-processing and recognition operations are closely integrated ￼

♦ The convergence of the algorithm is proved and many experiments show that the error rate in such a result-feedback neural network (RFNN) can be greatly reduced as well as the robust to environmental noise.

3)Handwritten numerical recognition based on multiple algorithms (Kimura, F. and Shiridhar, M. (1991))

♦ In this paper, the authors developed two algorithms for application to recognition of unconstrained isolated handwritten numerals.

♦ While both algorithms yielded very low error rates, the authors combined the two algorithms in different ways to study the best polling strategy and realized significant improvement in performance.

4)Recognition of isolated and simply handwritten numberals (M. Shridhar and A. Badreldin -1986)

♦ In this paper the authors describe the results of their investigation into the development of a recognition algorithm for identifying

♦ Using a structural classification scheme, the recognition algorithm is derived as a tree classifier.

♦ In an extensive test experiment, an accuracy of 99% was realized with isolated numerals. When connected numerals were also included a recognition accuracy of 93% was obtained

References

1)A NOVEL METHOD FOR HAND WRITTEN DIGIT RECOGNITION USING DEEP LEARNING Rohini.M1 , Dr.D.Surendran2 1 Assistant Professor,Sri Krishna College of Engineering and Technology, 2 Professor, Sri Krishna College of Engineering and Technology 1 rohinim@skcet.ac.in, 2 surendran@skcet.ac.in

2)AN EFFECTIVE RESULT-FEEDBACK NEURAL ALGORITHM FOR HANDWRITTEN CHARACTER RECOGNITION Authors:Xiaoyan Zhu,Yu Hao,Yifan Shi,David Zhang Neural, Parallel & Scientific Computations Volume 9, Issue 2

3)HANDWRITTEN NUMERICAL RECOGNITION BASED ON MULTIPLE ALGORITHMS

Authors: F.Kimuraa∗ M.Shridhara The University of Michigan-Dearborn, Dearborn, Michigan, U.S.A.

4) RECOGNITION OF ISOLATED AND SIMPLY CONNECTED HANDWRITTEN NUMERALS

Authors: M.ShridharA.Badreldin Department of Electrical Engineering, University of Windsor, Windsor, Ontario, Canada N9B 3

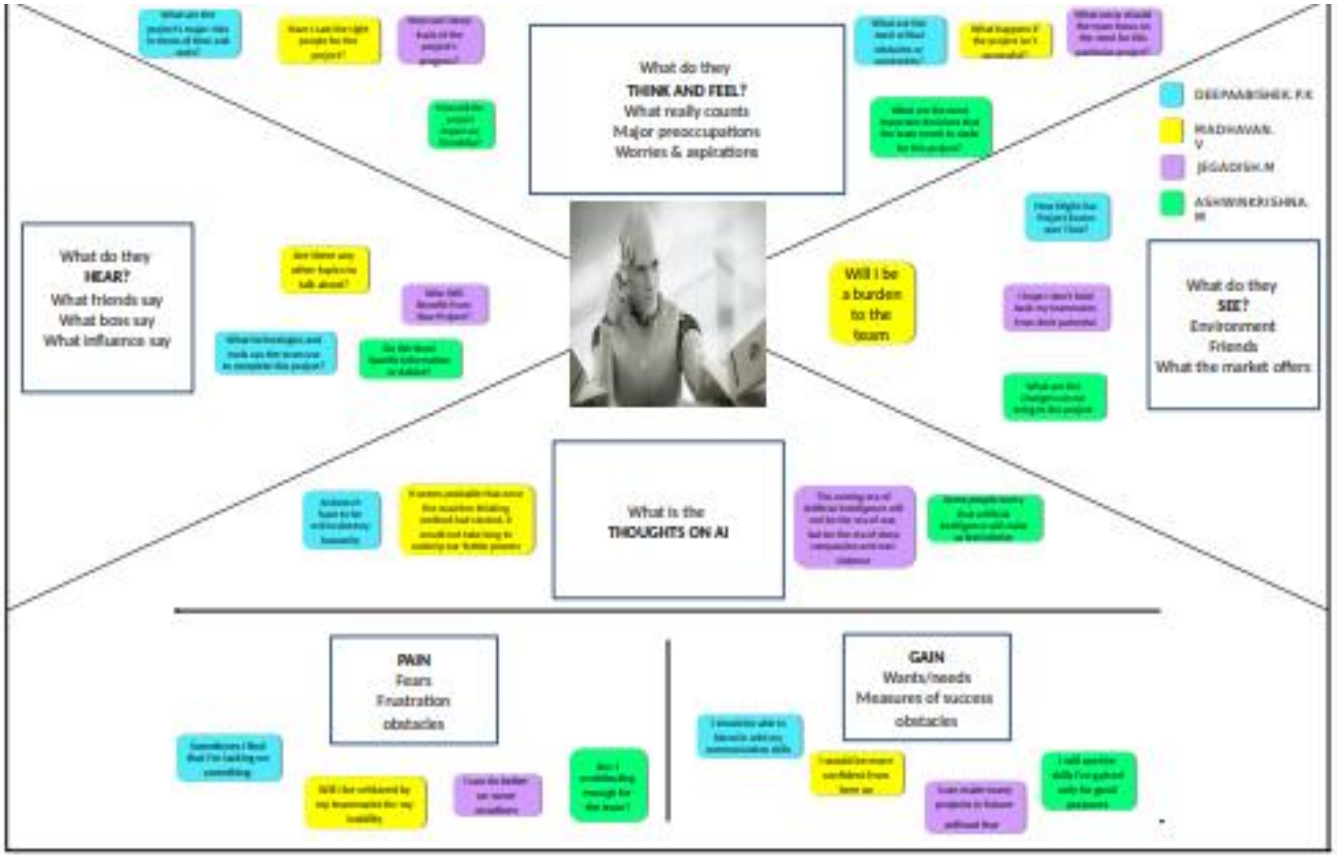
Problem Statement Definition

Handwritten digit recognition is the ability of a computer to recognize digits handwritten by humans. Handwritten digits are imperfect and can be produced in many different flavors, making it a difficult task for machines. The solution to this problem is handwritten digit recognition, which takes images of digits and recognizes the digits in the image. To build a user interface application for scanning a hand written notes to convert digital text in quickly.

3. IDEATION & PROPOSED SOLUTION

Empathy Map Canvas

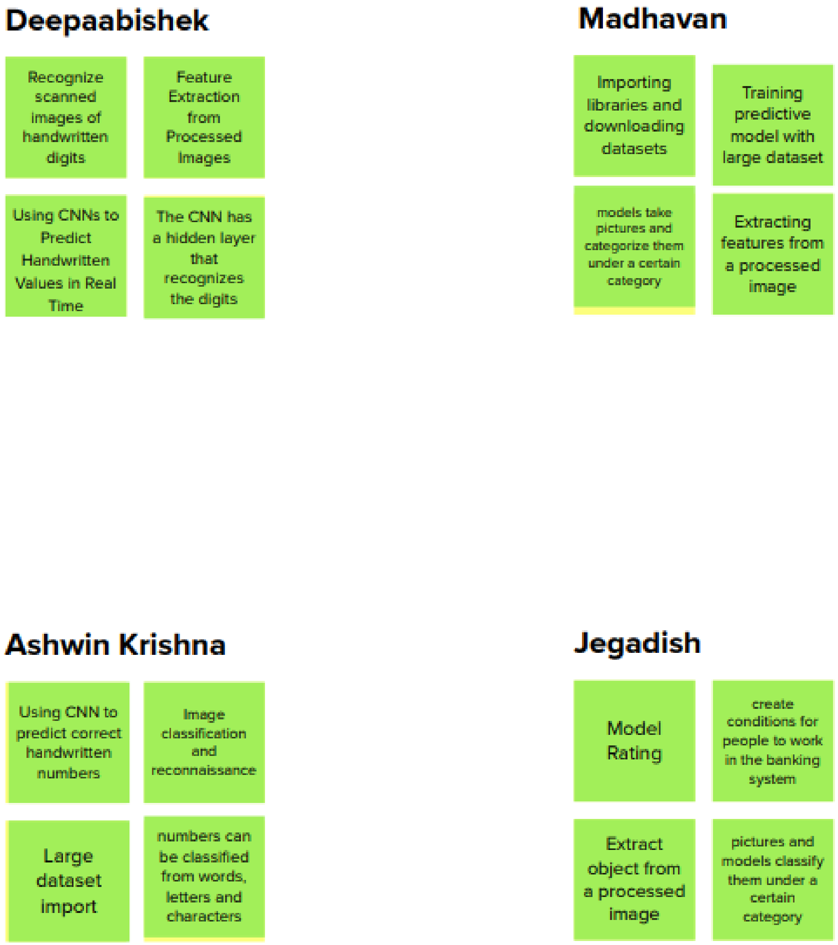
An empathy map is a simple, easy-to-digest visual that captures knowledge about a user's behaviours and attitudes.It is a useful tool to help teams better understand their users. Creating an effective solution requires understanding the true problem and the person whois experiencing it. The exercise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



Ideation and 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.

Brainstorm, Idea Listing and Grouping



Deepaabishek

- Recognize scanned images of handwritten digits
- Feature Extraction from Processed Images
- Using CNNs to Predict Handwritten Values in Real Time
- The CNN has a hidden layer that recognizes the digits

Madhavan

- Importing libraries and downloading datasets
- Training predictive model with large dataset
- models take pictures and categorize them under a certain category
- Extracting features from a processed image

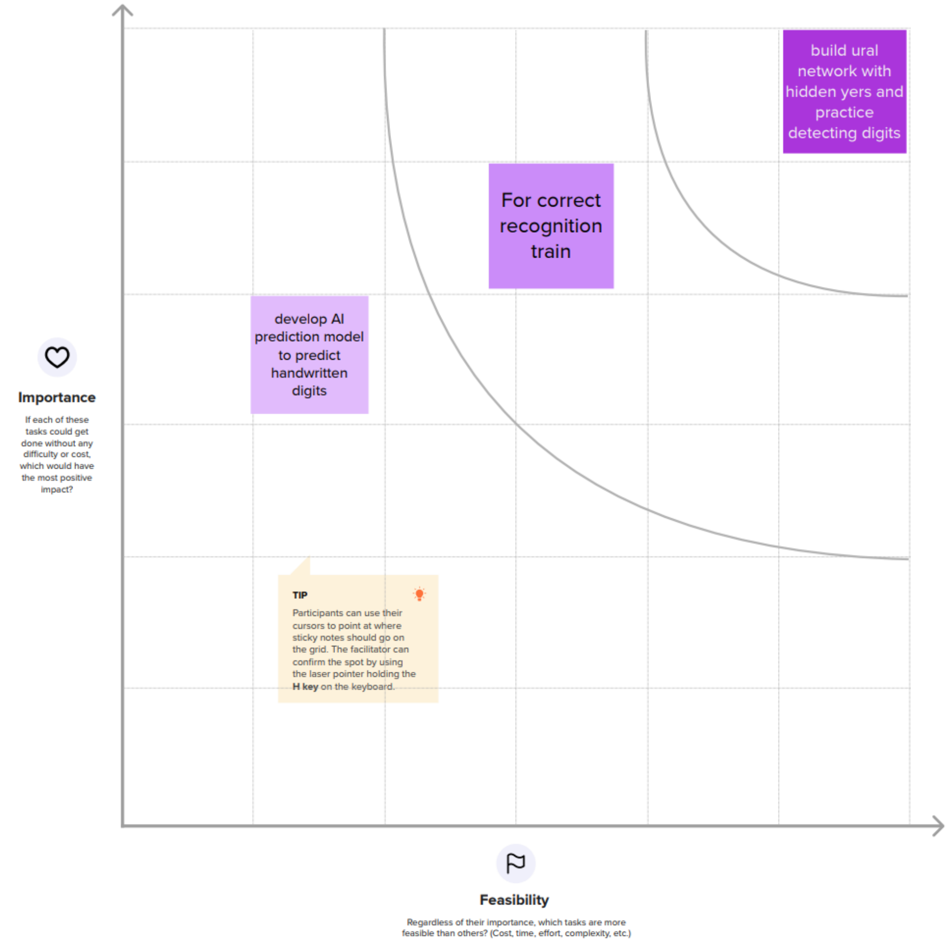
Ashwin Krishna

- Using CNN to predict correct handwritten numbers
- Image classification and reconnaissance
- Large dataset import
- numbers can be classified from words, letters and characters

Jegadish

- Model Rating
- create conditions for people to work in the banking system
- Extract object from a processed image
- pictures and models classify them under a certain category

Idea Prioritization



build ural network with hidden yers and practice detecting digits

For correct recognition train

develop AI prediction model to predict handwritten digits

Importance

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

TIP

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

Feasibility

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

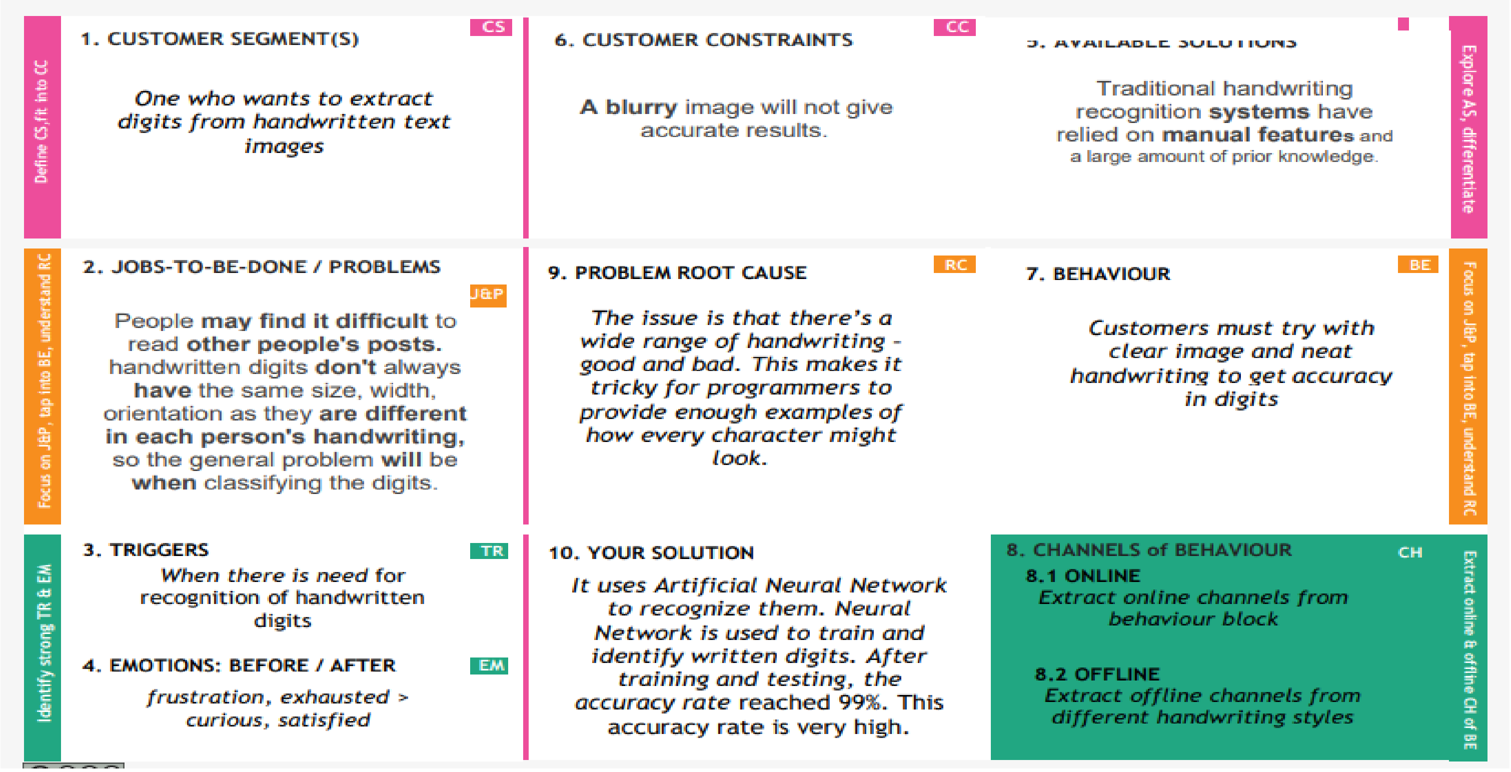
3.4 Proposed Solution

Project team shall fill in the following information in the proposed solution template

S.N o.	Parameter	Description
1	Problem Statement (Problem to be solved)	• This problem is aimed at developing a new handwriting recognition system using ML. • A handwritten digit recognition system is one way to address the problem of taking an image of digits and recognizing the digits present in the image
2.	Idea / Solution description	• Developing an AI prediction model that predicts handwritten digits and builds a neural network with hidden layers to train digit recognition.

3.	Novelty / Uniqueness	• The system generates not only digit classifications, but also rich descriptions of instantiation parameters that can provide information such as typefaces.
4.	Social Impact / Customer Satisfaction	• Handwritten numbers can be recognized easily without strenuous effort. This reduces time and improves everyone's productivity.
5	Business Model (Revenue Model)	• It is used in vehicle number detection, banks to read checks, post offices to sort mail, and many other tasks
6	Scalability of the Solution	• To achieve higher performance in the field of character recognition and pattern recognition, thanks to its excellent feature extraction and acts as the best classifier

3.4 Problem Solution fit


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

1. CUSTOMER SEGMENT(S)

One who wants to extract digits from handwritten text images

6. CUSTOMER CONSTRAINTS

A blurry image will not give accurate results.

5. AVAILABLE SOLUTIONS

Traditional handwriting recognition **systems** have relied on **manual features** and a large amount of prior knowledge.

2. JOBS-TO-BE-DONE / PROBLEMS

People **may find it difficult** to read **other people's posts.** handwritten digits **don't** always **have** the same size, width, orientation as they **are different in each person's handwriting,** so the general problem **will** be **when** classifying the digits.

9. PROBLEM ROOT CAUSE

The issue is that there's a wide range of handwriting - good and bad. This makes it tricky for programmers to provide enough examples of how every character might look.

7. BEHAVIOUR

Customers must try with clear image and neat handwriting to get accuracy in digits

3. TRIGGERS

When there is need for recognition of handwritten digits

4. EMOTIONS: BEFORE / AFTER

frustration, exhausted > curious, satisfied

10. YOUR SOLUTION

It uses Artificial Neural Network to recognize them. Neural Network is used to train and identify written digits. After training and testing, the accuracy rate reached 99%. This accuracy rate is very high.

8. CHANNELS of BEHAVIOUR

8.1 ONLINE

Extract online channels from behaviour block

8.2 OFFLINE

Extract offline channels from different handwriting styles

REQUIREMENT ANALYSIS

Functional requirements

Following are the functional requirements of the proposed solution.

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

Non-Functional requirements

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

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

PROJECT DESIGN

Data Flow Diagrams

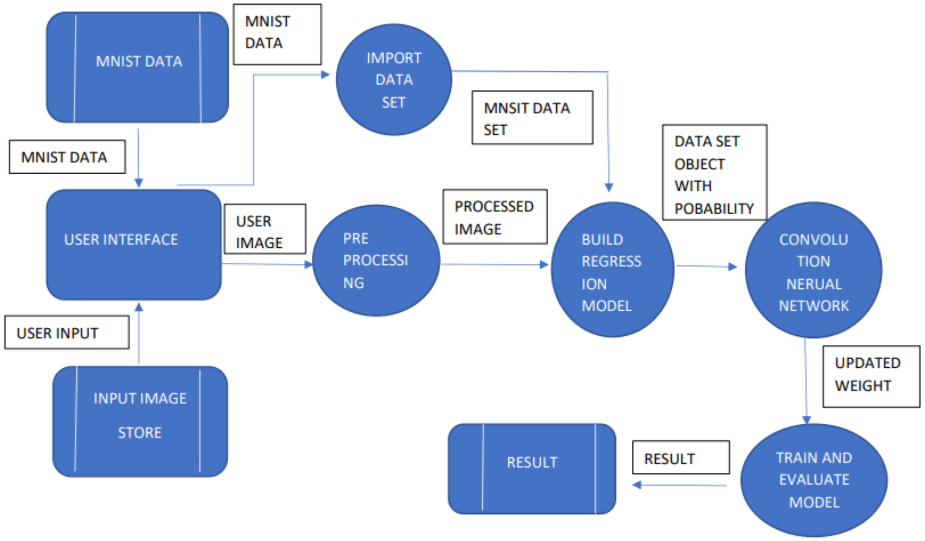
A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.

DFD Level-0

Level DFD-0 includes two external entities, the user interface and output, as well as a process that represents the CNN for digit recognition. The output is obtained after processing.

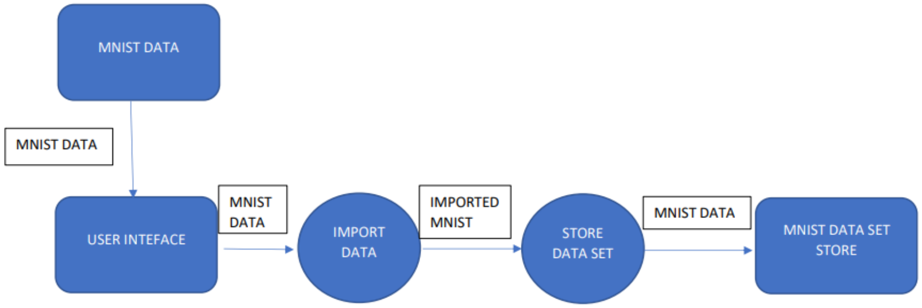
DFD Level-1

Level DFD-1 consists of 2 external entities, a GUI and an output, along with five process blocks and 2 MNIST datastores and input image stores, representing CNN's internal workings for the System. number identification. Block the process of importing MNIST data from the library. The processing block imports the image, processes it, and sends it to the block where the regression model. It sends probabilistic objects to the CNN where the weights are updated and some classes are constructed. Block training and model evaluation to produce outputs.



DFD Level-2

The DFD Level-2 for import data(figure 4) consists of two external data and one entity UI along with three process blocks, representing the three functionalities of the CNN for Digit Recognition System. It imports data from MNIST data store and stores on the system.



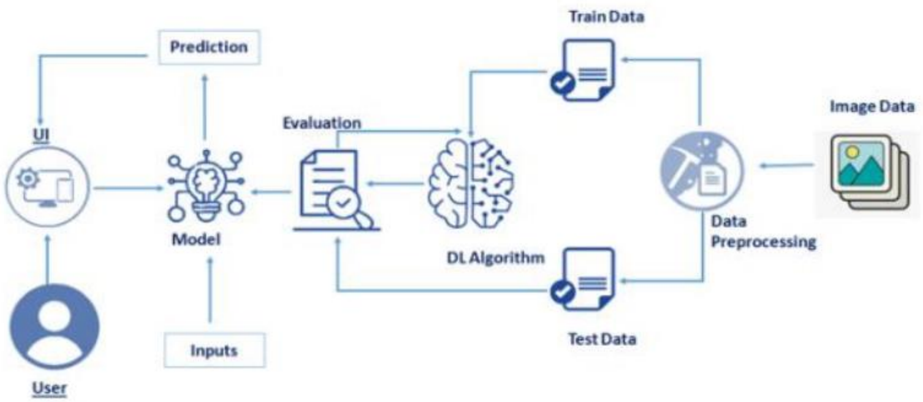
User Stories

Use the below template to list all the user stories for the product.

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Sprint-2
		USN-3	As a user, I can register for the application through gmail or facebook	I can register & access the dashboard with Facebook Login	Medium	Sprint-2
	Login	USN-4	As a user, I can log into the application by entering email & password	I can login to the application	High	Sprint-1
	Dashboard	USN-5	Go to dashboard and refer the content about our project	I can read instructions also and the home page is user-friendly.	Low	Sprint-1
	Upload Image	USN-6	As a user, I can able to input the images of digital documents to the application	As a user, I can able to input the images of digital documents to the application	High	Sprint-3
	Predict	USN-7	As a user I can able to get the recognised digit as output from the images of digital documents or images	I can access the recognized digits from digital document or images	High	Sprint-3

		USN-8	As a user, I will train and test the input to get the maximum accuracy of output.	I can able to train and test the application until it gets maximum accuracy of the result.	Medium	Sprint-4
Customer (Web user)	Login	USN-9	As a user, I can use the application by entering my email, password.	I can access my account	Medium	Sprint-4
Customer Care Executive	Dashboard	USN-10	upload the image	Recognize and get the output	High	Sprint-1
Administrator	Security	USN-11	updated the features	checking the security	Medium	Sprint-1

Solution & Technical Architecture



User Stories Table-1:

Components & Technologies:

S.No	Component	Description	Technology
1.	User Interface	User interacts with the application using the web application.	HTML, CSS, JavaScript / Angular Js / React Js etc.
2.	Application Logic	Login to access the application	Java / Python
5.	Database	Data Type, Configurations etc.	MySQL, NoSQL, etc.
6.	Cloud Database	Database Service on Cloud	IBM DB2, IBM Cloudant etc.
7.	File Storage	Storage of user files of handwritten image	IBM Block Storage or Other Storage Service or Local Filesystem
10.	Machine Learning Model	Machine learning model is used to identify the handwritten image uploaded by users	Object Recognition Model, etc.
11.	Infrastructure (Server / Cloud)	Application Deployment on Local System / AI Local Server Configuration AI Server Configuration	Local, Cloud Foundry, Kubernetes, etc.

Table 2: Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	Machine learning frameworks is used to train a predictive model	PyTorch, Open-cv
2.	Security Implementations	The system will automatically be able to authenticate all users with their unique username and password	Password based login, Authorization
3.	Scalable Architecture	The website traffic limit must be scalable enough to support 2 lakhs users at a time	3-tier
4.	Availability	The system functionality and services are available for use with all operations.	distributed servers
5.	Performance	The app can respond to requests within 5 seconds. It uses fewer features to train the neural network, resulting in faster convergence.	number of requests per sec

5 PROJECT PLANNING AND SCHEDULING

Sprint Planning & Estimation

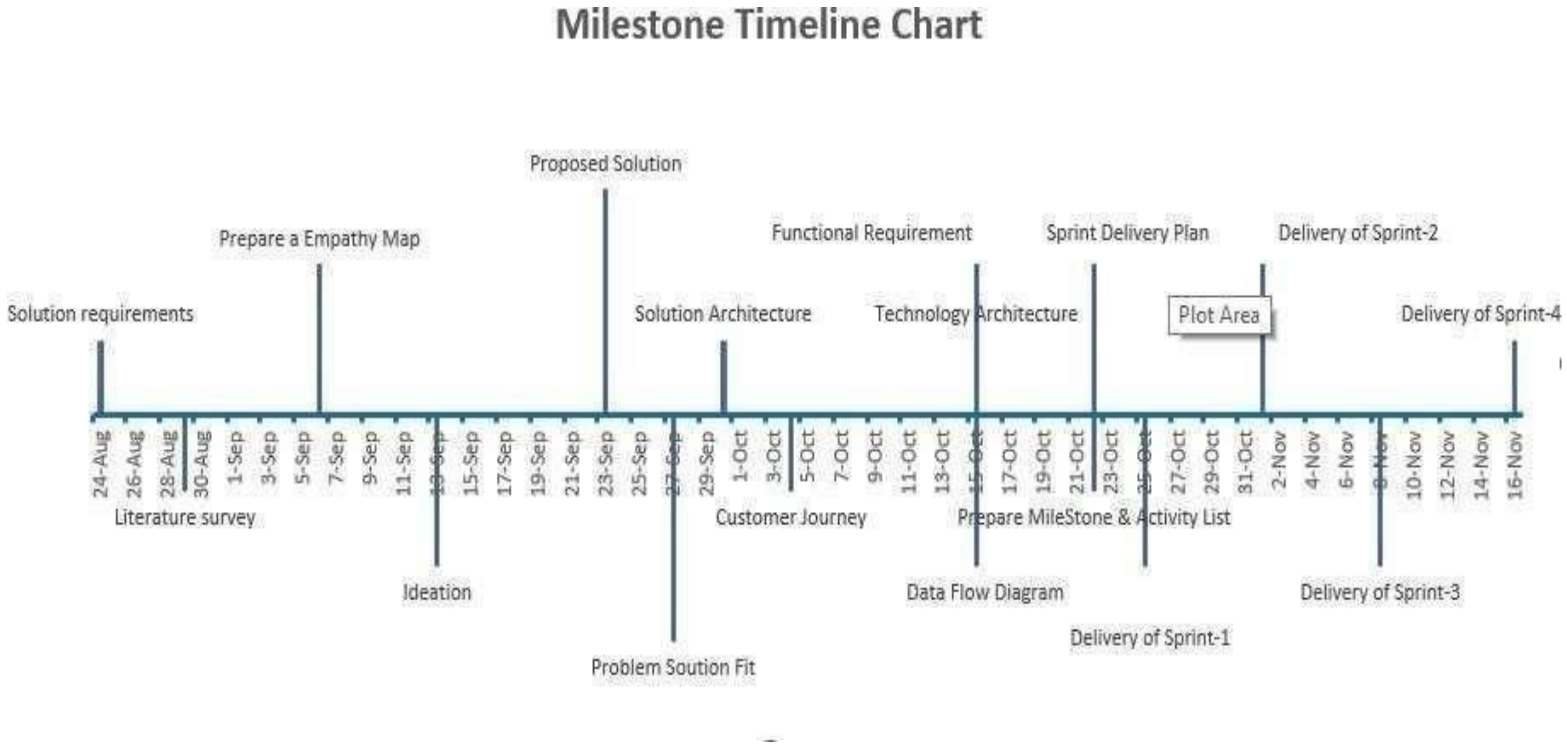
Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Data Collection	USN-1	As a user, I can collect the dataset from various resources with different handwritings.	10	Low	Jegadish M Deepaabishek P K
Sprint-1	Data Preprocessing	USN-2	As a user, I can load the dataset, handling the missing data, scaling and split data into train and test.	10	Medium	Jegadish M Deepaabishek P K
Sprint-2	Model Building	USN-3	As a user, I will get an application with ML model which provides high accuracy of recognized handwritten digit.	5	High	Ashwin Krishna M Madhavan V Deepaabishek P K

Sprint-2	Add CNN layers	USN-4	Creating the model and adding the input, hidden, and output layers to it.	5	High	Ashwin Krishna M Madhavan V Deepaabishek P K
Sprint-2	Compiling the model	USN-5	With both the training data defined and model defined, it's time to configure the learning process.	2	Medium	Ashwin Krishna M Madhavan V

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-2	Train & test the model	USN-6	As a user, let us train our model with our image dataset.	6	Medium	Ashwin Krishna M Madhavan V
Sprint-2	Save the model	USN-7	As a user, the model is saved & integrated with an android application or web application in order to predict something.	2	Low	Madhavan V
Sprint-3	Building UI Applicati on	USN-8	As a user, I will upload the handwritten digit image to the application by clicking a upload button.	5	High	Ashwin Krishna M Deepaabishek P K
Sprint-3	Building UI Applicati on	USN-9	As a user, I can know the details of the fundamental usage of the application.	5	Low	Deepaabishek P K
Sprint-3	Building UI Applicati on	USN-10	As a user, I can see the predicted / recognized digits in the application.	5	Medium	Jegadish M Deepaabishek P K
Sprint-4	Train the model on IBM	USN-11	As a user, I train the model on IBM and integrate flask/Django with scoring end point.	10	High	Deepaabishek P K Ashwin Krishna M Madhavan V
Sprint-4	Cloud Deployment	USN-12	As a user, I can access the web application and make the use of the product from anywhere.	10	High	Jegadish M Deepaabishek P K

6.2 Sprint Delivery Schedule

A milestone schedule, or milestone chart, is a timeline that uses milestones to divide a project schedule into major phases. A milestone chart is a way to visualize the most important steps of our project. Each milestone the team achieves brings us closer to completing the project. As a result, milestones provide a sense of accomplishment and show the team how the work they're doing contributes to the overarching project objective.



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-1	20	2.5 Days	11 Nov 2022	13 Nov 2022	20
Sprint-2	20	2.5 Days	13 Nov 2022	15 Nov 2022	20
Sprint-3	20	2.5 Days	15 Nov 2022	17 Nov 2022	20
Sprint-4	20	2.5 Days	17 Nov 2022	19 Nov 2022	20

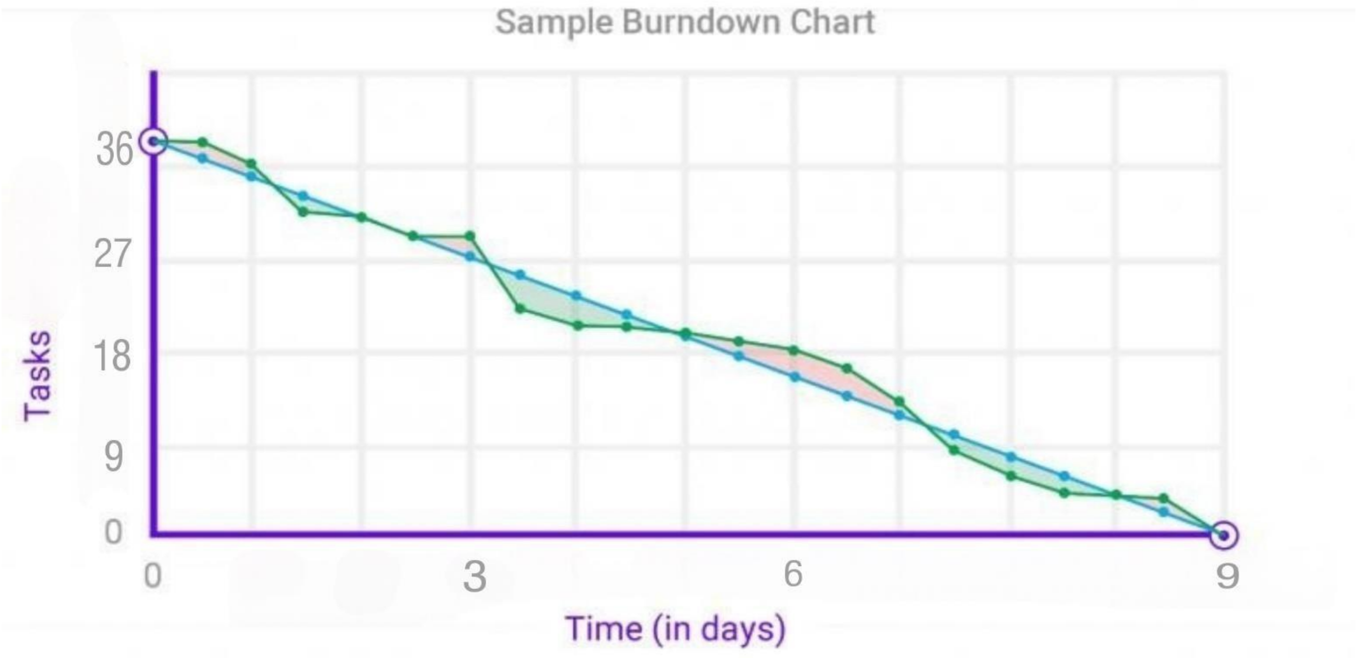
Velocity:

Imagine we've got a 9-day dash duration, and the speed of the group is 20 (factors consistent with dash). Let's calculate the group's common velocity (AV) consistent with generation unit (tale factors consistent with day)

Average Velocity = 9 / 2.5 = 3.6

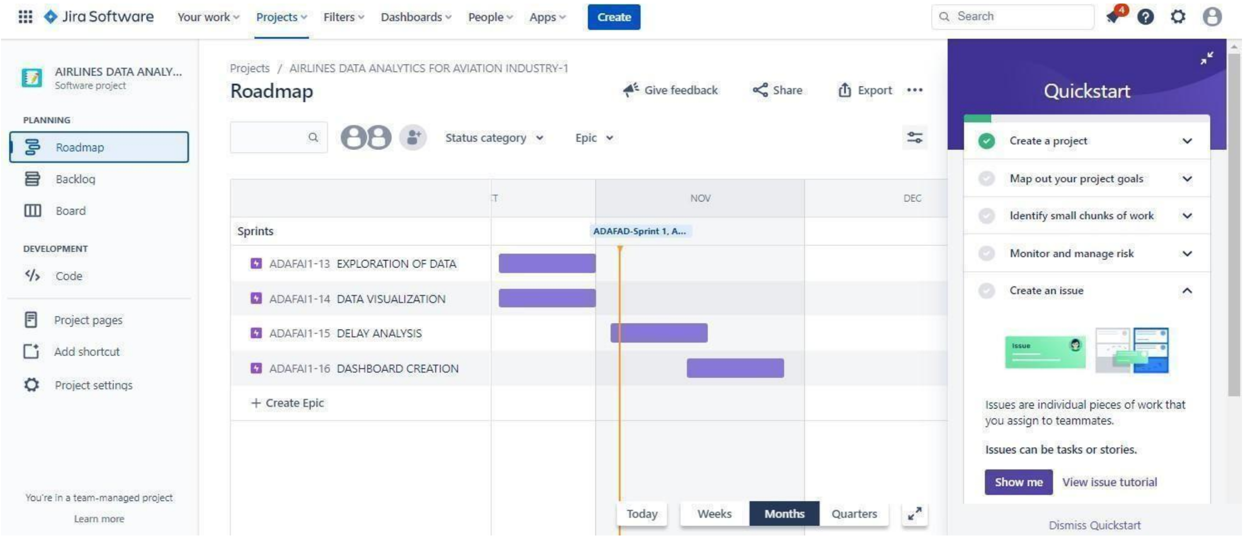
Burndown Chart:

The log chart is a graphical representation of the remaining work to be done as a function of time. It is often used in agile software development methodologies like Scrum. However, log charts can be applied to any project with measurable progress over time.



6. REPORT FROM JIRA

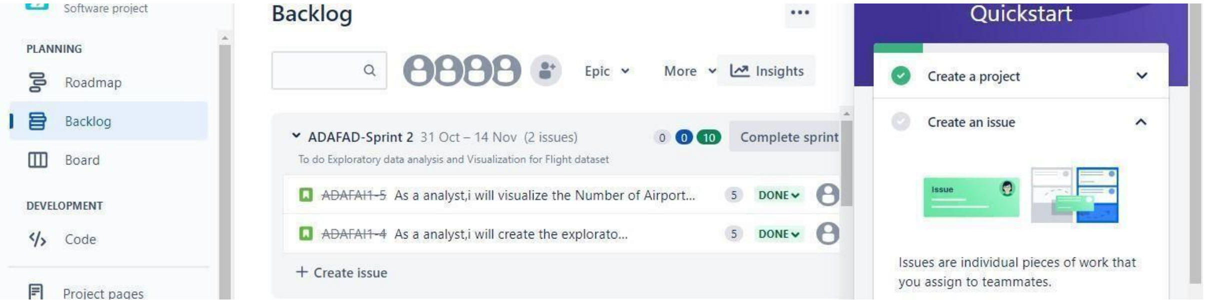
Project RoadMap



Issues are individual pieces of work that you assign to teammates.

Issues can be tasks or stories.

Project Backlog



ADAFAD-Sprint 2 31 Oct – 14 Nov (2 issues) 0 0 10

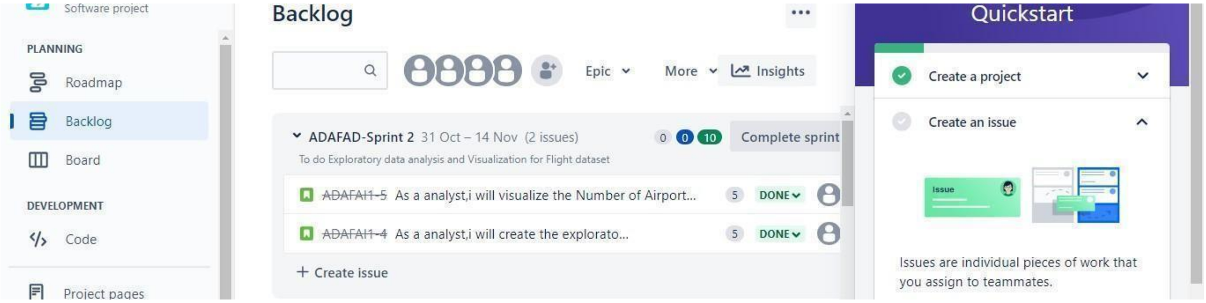
To do Exploratory data analysis and Visualization for Flight dataset

~~ADAFAI1-5~~ As a analyst,i will visualize the Number of Airport... 5 DONE

~~ADAFAI1-4~~ As a analyst,i will create the explorato... 5 DONE

+ Create issue

Issues are individual pieces of work that you assign to teammates.



ADAFAD-Sprint 2 31 Oct – 14 Nov (2 issues) 0 0 10

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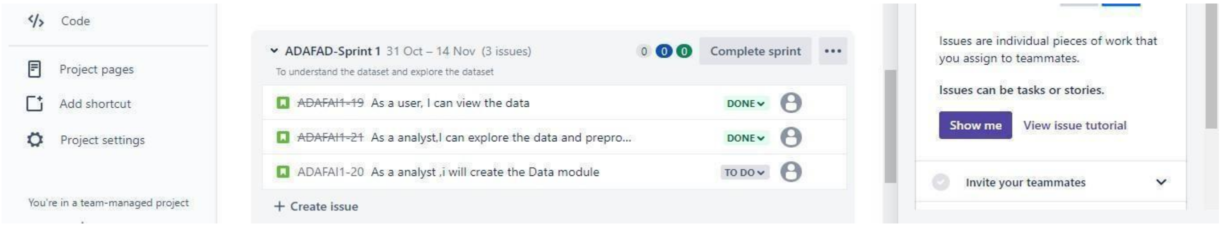
Issues are individual pieces of work that you assign to teammates.



ADAFAD-Sprint 1 31 Oct – 14 Nov (3 issues) 0 0 0

To understand the dataset and explore the dataset

~~ADAFAI1-19~~ As a user, I can view the data DONE

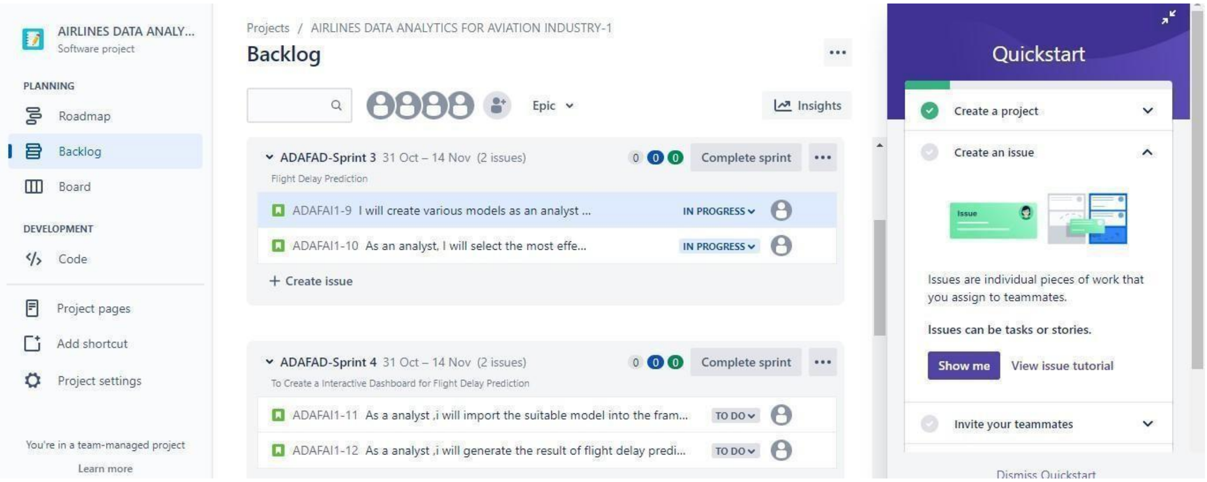
~~ADAFAI1-21~~ As a analyst,I can explore the data and prepro... DONE

ADAFAI1-20 As a analyst ,i will create the Data module TO DO

+ Create issue

Issues are individual pieces of work that you assign to teammates.

Issues can be tasks or stories.



ADAFAD-Sprint 3 31 Oct – 14 Nov (2 issues) 0 0 0

Flight Delay Prediction

ADAFAI1-9 I will create various models as an analyst ... IN PROGRESS

ADAFAI1-10 As an analyst, I will select the most effe... IN PROGRESS

ADAFAD-Sprint 4 31 Oct – 14 Nov (2 issues) 0 0 0

To Create a Interactive Dashboard for Flight Delay Prediction

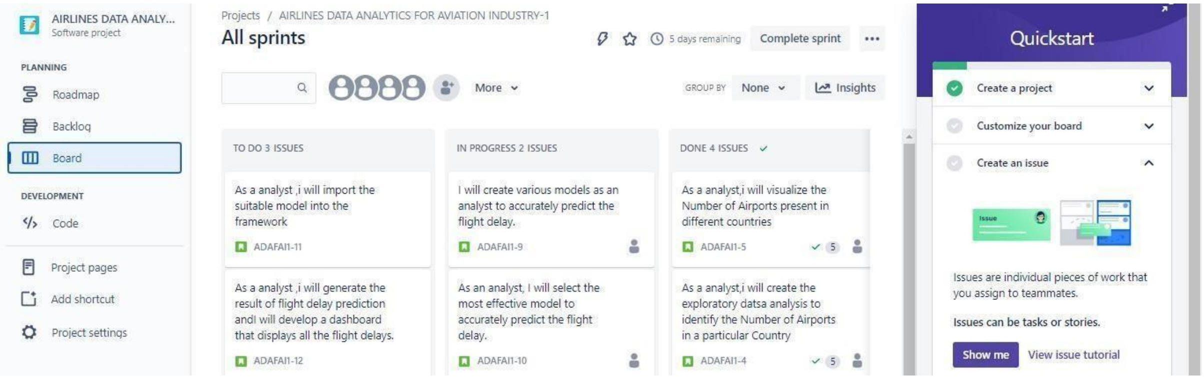
ADAFAI1-11 As a analyst ,i will import the suitable model into the fram... TO DO

ADAFAI1-12 As a analyst ,i will generate the result of flight delay predi... TO DO

Issues are individual pieces of work that you assign to teammates.

Issues can be tasks or stories.

Board



TO DO 3 ISSUES

As a analyst ,i will import the suitable model into the framework
ADAFAI1-11

As a analyst ,i will generate the result of flight delay prediction andI will develop a dashboard that displays all the flight delays.
ADAFAI1-12

IN PROGRESS 2 ISSUES

I will create various models as an analyst to accurately predict the flight delay.
ADAFAI1-9

As an analyst, I will select the most effective model to accurately predict the flight delay.
ADAFAI1-10

DONE 4 ISSUES ✓

As a analyst,i will visualize the Number of Airports present in different countries
ADAFAI1-5 ✓ 5

As a analyst,i will create the exploratory datsa analysis to identify the Number of Airports in a particular Country
ADAFAI1-4 ✓ 5

Issues are individual pieces of work that you assign to teammates.

Issues can be tasks or stories.

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

Feature 1

The user can enter the Elevation feet of the flight to predict whether the delay has occurred or not.

CODE:

```
import numpy as np
import os
from PIL import Image
from flask import Flask, request, render_template
from werkzeug.utils import secure_filename
from keras.models import load_model

UPLOAD_FOLDER = 'C:/Users/Dell/PycharmProjects/A-novel-method-for-digit-recognition-system/flask_app/uploads'

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

model = load_model("mnistCNN.h5")

@app.route('/')
def index():
    return render_template('index.html')

@app.route('/predict', methods=['GET', 'POST'])
def upload():
    if request.method == "POST":
        f = request.files["image"]
        filepath = secure_filename(f.filename)
        f.save(os.path.join(app.config['UPLOAD_FOLDER'], filepath))

        upload_img = os.path.join(UPLOAD_FOLDER, filepath)
        img = Image.open(upload_img).convert("L")  # convert image to monochrome
        img = img.resize((28, 28))  # resizing of input image

        im2arr = np.array(img)  # converting to image
        im2arr = im2arr.reshape(1, 28, 28, 1)  # reshaping according to our requirement

        pred = model.predict(im2arr)
        num = np.argmax(pred, axis=1)  # printing our Labels

        return render_template('predict.html', num=str(num[0]))

if __name__ == '__main__':
    app.run(debug=True, threaded=False)
```

Feature 2

If a delay occurred, the delay is predicted using the Elevation_ft parameter given in the dataset which provides the delay, in minutes.

CODE:

```
<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">&nbsp Clear &nbsp</button>
    </div>
   </form>
   </div>
</section>

function preview() {
  frame.src=URL.createObjectURL(event.target.files[0]);
}
```

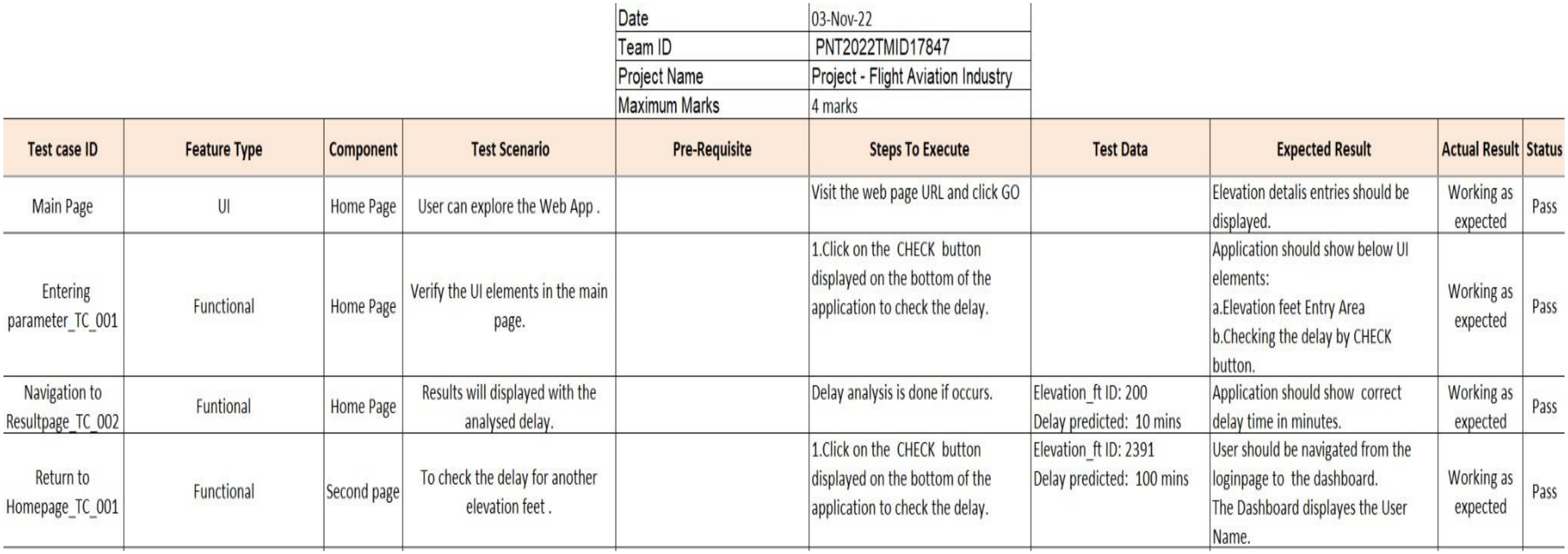
Feature 3

This feature can be used to clear the image if we uploaded a wrong image or if we need to change the image. The clear button clears both the image value and the preview of the image in script tag.

```
<script>


$(document).ready(function() {

     $('#clear_button').on('click', function() {

       $('#image').val(");

       $('#frame').attr('src',"");

      });

    });


</script>
```

8.TESTING

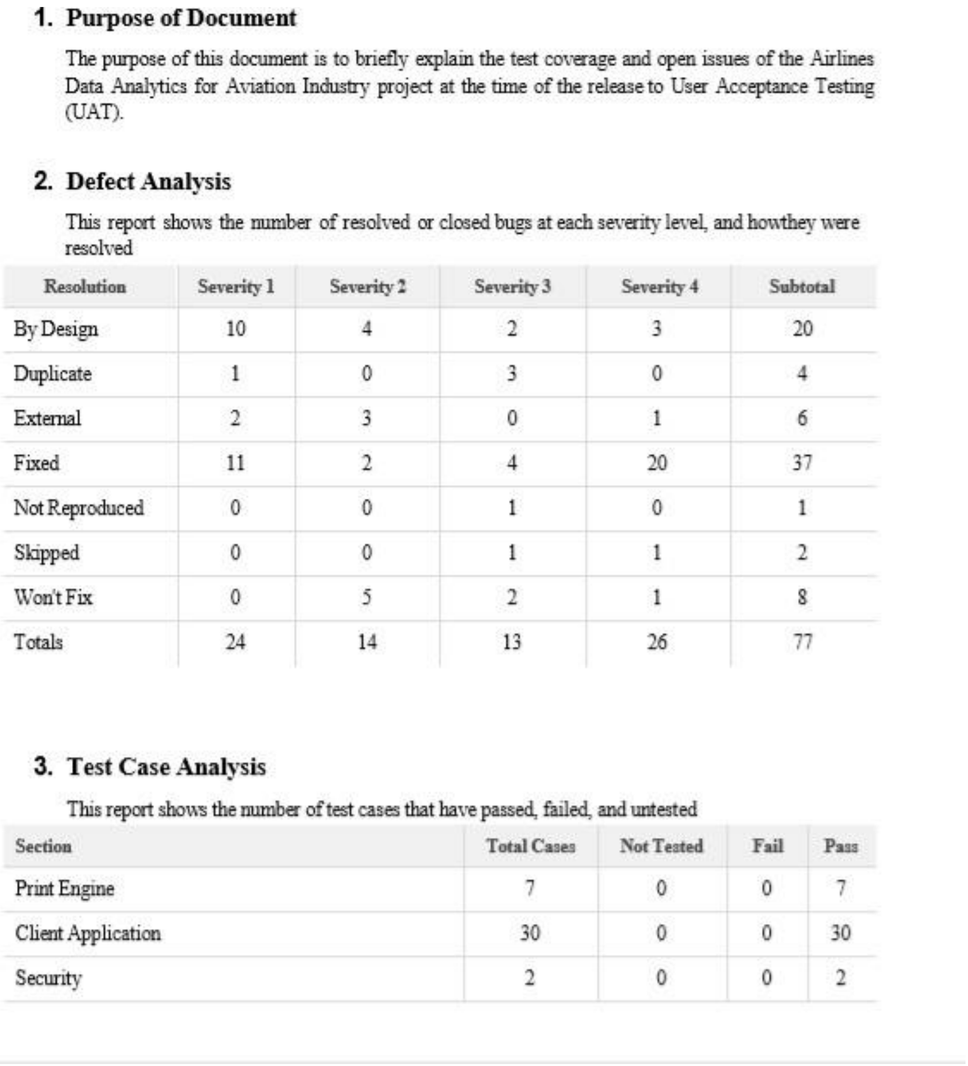
8.1.Test Cases



Date	03-Nov-22
Team ID	PNT2022TMID17847
Project Name	Project - Flight Aviation Industry
Maximum Marks	4 marks

Test case ID	Feature Type	Component	Test Scenario	Pre-Requisite	Steps To Execute	Test Data	Expected Result	Actual Result	Status
Main Page	UI	Home Page	User can explore the Web App .		Visit the web page URL and click GO		Elevation detalis entries should be displayed.	Working as expected	Pass
Entering parameter_TC_001	Functional	Home Page	Verify the UI elements in the main page.		1.Click on the CHECK button displayed on the bottom of the application to check the delay.		Application should show below UI elements: a.Elevation feet Entry Area b.Checking the delay by CHECK button.	Working as expected	Pass
Navigation to Resultpage_TC_002	Funtional	Home Page	Results will displayed with the analysed delay.		Delay analysis is done if occurs.	Elevation_ft ID: 200 Delay predicted: 10 mins	Application should show correct delay time in minutes.	Working as expected	Pass
Return to Homepage_TC_001	Functional	Second page	To check the delay for another elevation feet .		1.Click on the CHECK button displayed on the bottom of the application to check the delay.	Elevation_ft ID: 2391 Delay predicted: 100 mins	User should be navigated from the loginpage to the dashboard. The Dashboard displayes the User Name.	Working as expected	Pass

8.2 User Acceptance Testing:



1. Purpose of Document

The purpose of this document is to briefly explain the test coverage and open issues of the Airlines Data Analytics for Aviation Industry project at the time of the release to User Acceptance Testing (UAT).

2. Defect Analysis

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

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	10	4	2	3	20
Duplicate	1	0	3	0	4
External	2	3	0	1	6
Fixed	11	2	4	20	37
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	1	2
Won't Fix	0	5	2	1	8
Totals	24	14	13	26	77

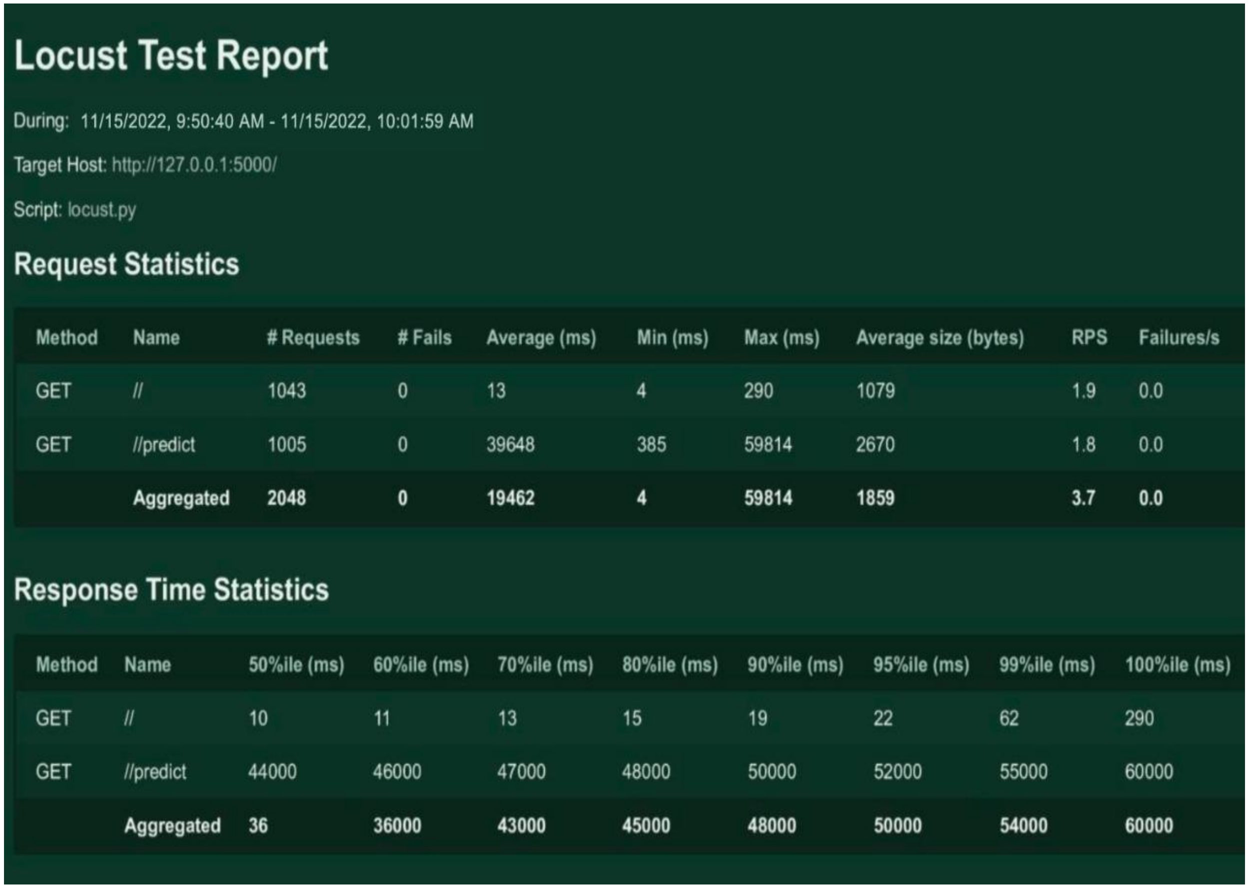
3. Test Case Analysis

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

Section	Total Cases	Not Tested	Fail	Pass
Print Engine	7	0	0	7
Client Application	30	0	0	30
Security	2	0	0	2

8. RESULTS

Performance metrics:



Locust Test Report

During: 11/15/2022, 9:50:40 AM - 11/15/2022, 10:01:59 AM

Target Host: http://127.0.0.1:5000/

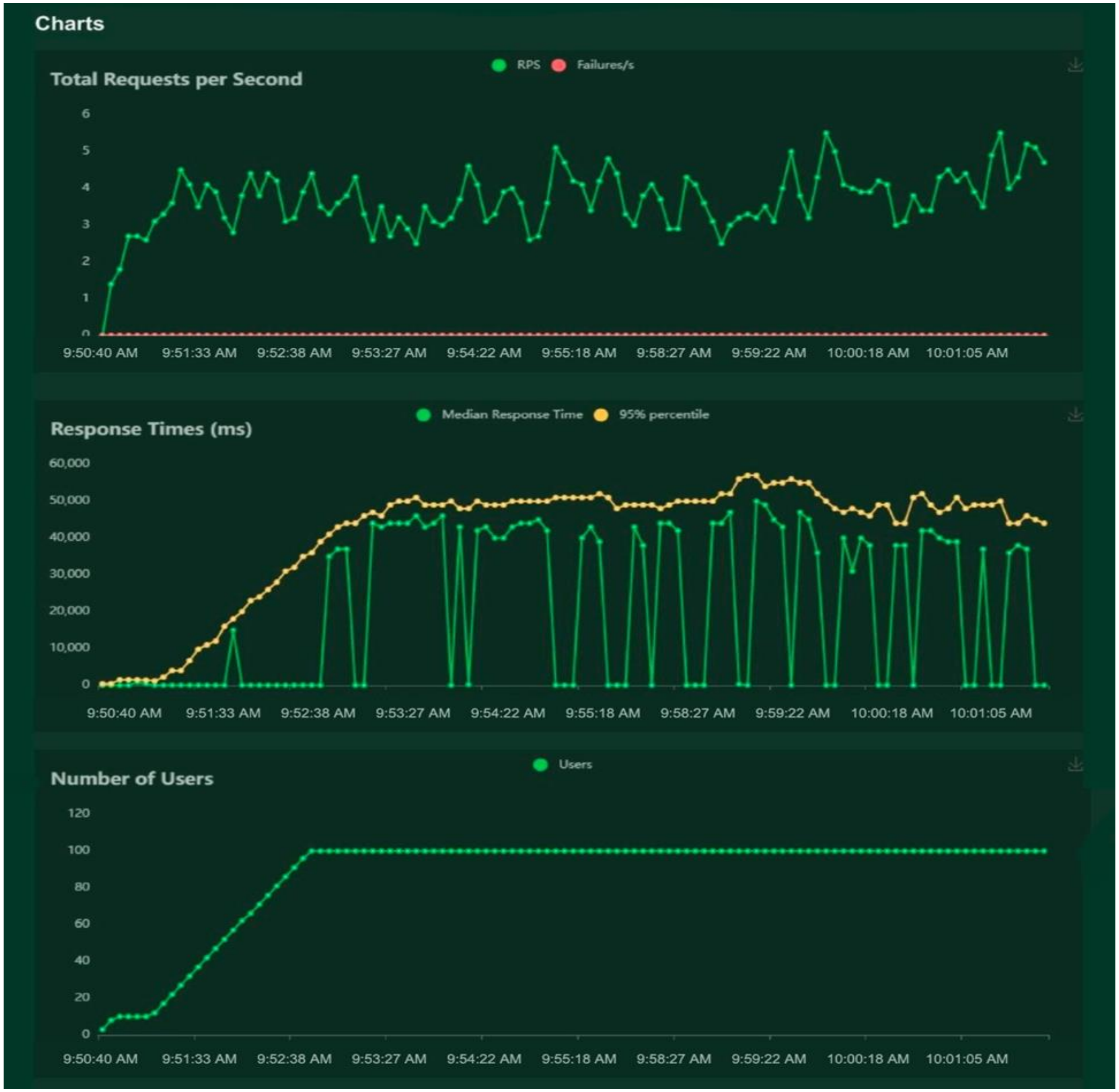
Script: locust.py

Request Statistics

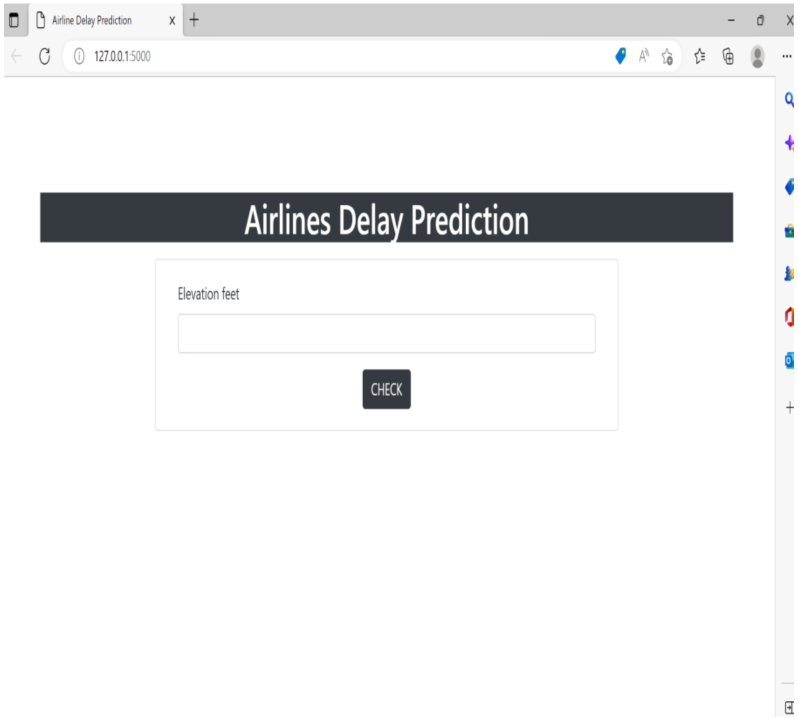
Method	Name	# Requests	# Fails	Average (ms)	Min (ms)	Max (ms)	Average size (bytes)	RPS	Failures/s
GET	//	1043	0	13	4	290	1079	1.9	0.0
GET	//predict	1005	0	39648	385	59814	2670	1.8	0.0
	Aggregated	**2048**	**0**	**19462**	**4**	**59814**	**1859**	**3.7**	**0.0**

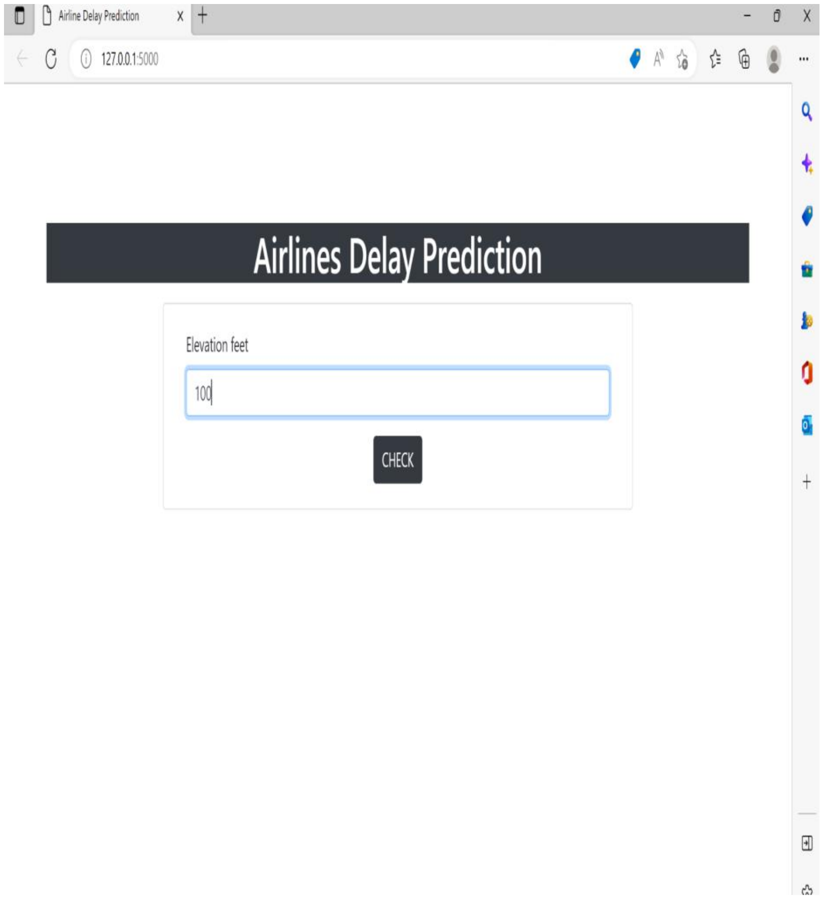
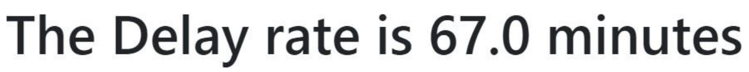
Response Time Statistics

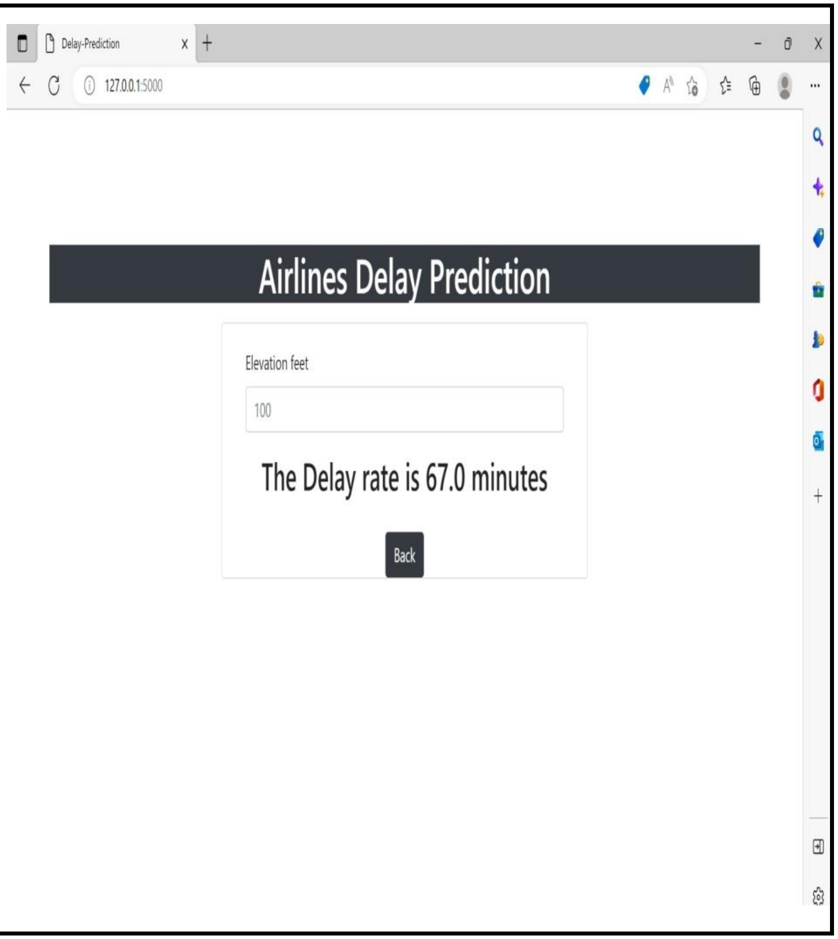
Method	Name	50%ile (ms)	60%ile (ms)	70%ile (ms)	80%ile (ms)	90%ile (ms)	95%ile (ms)	99%ile (ms)	100%ile (ms)
GET	//	10	11	13	15	19	22	62	290
GET	//predict	44000	46000	47000	48000	50000	52000	55000	60000
	Aggregated	**36**	**36000**	**43000**	**45000**	**48000**	**50000**	**54000**	**60000**



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

S.No	Parameter	Screenshot
1	**Dashboard design**	

2	**Data entry**	 Airlines Delay Prediction Elevation feet 100
3	**Data responsiveness**	 The Delay rate is 67.0 minutes

4	**Descriptive report of delay analysis**	 Airlines Delay Prediction Elevation feet 100 The Delay rate is 67.0 minutes

9. ADVANTAGES & DISADVANTAGES

Advantages

- Reduced manual work
- More accurate than the average human
- Can handle large amounts of data
- Available anywhere from any device

Disadvantages

- Cannot handle complex data
- All the data must be in digital format
- Requires a high performance server for faster predictions
- Prone to occasional errors

10. CONCLUSION

This project demonstrated a web application that uses machine learning to recognize handwritten digits. Flask, HTML, CSS, JavaScript, and other technologies were used to create this project. This model uses a CNN network to predict handwritten digits. During testing, the model achieved a recognition rate of 99.61%. The proposed project is scalable and can easily handle large numbers of users. Since it is a web application, it can be used on any device that can run a browser. This project is very useful in real-world scenarios such as recognizing vehicle license plates, processing bank check amounts, and entering numbers in handwriting forms (tax forms). There is a great deal of room for improvement to be implemented in subsequent versions.

11. sssssFUTURE SCOPE

This project is far from finished and there is a lot of room for improvement. Some of the improvements that can be made to this project are:

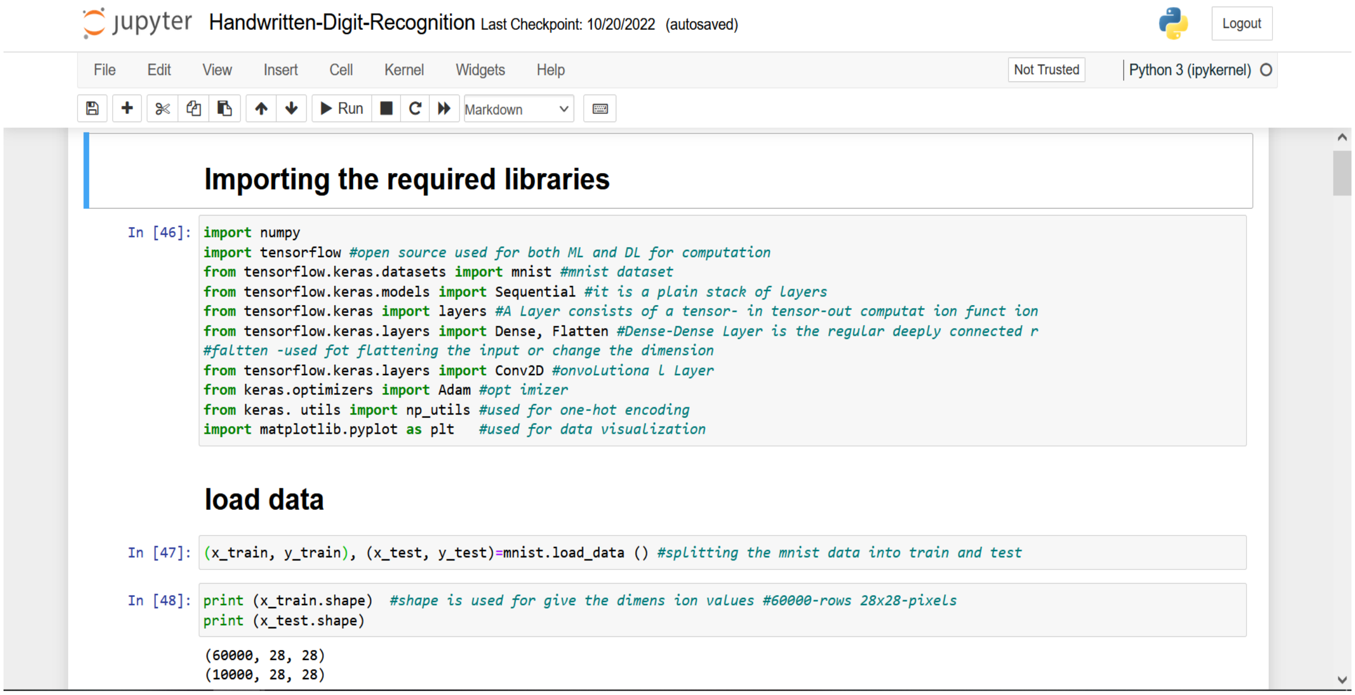
- Add support for digitizing multiple images and saving the results.
- Added support for recognizing multiple digits

- Enhancing the model to recognize digits from complex images
- Add support for different languages to help users around the world

This project has endless possibilities and can always be improved and made better. Implementing this concept in the real world will benefit multiple industries, reduce the workload for many workers, and improve overall work efficiency.

12. APPENDIX

MODEL CREATION:



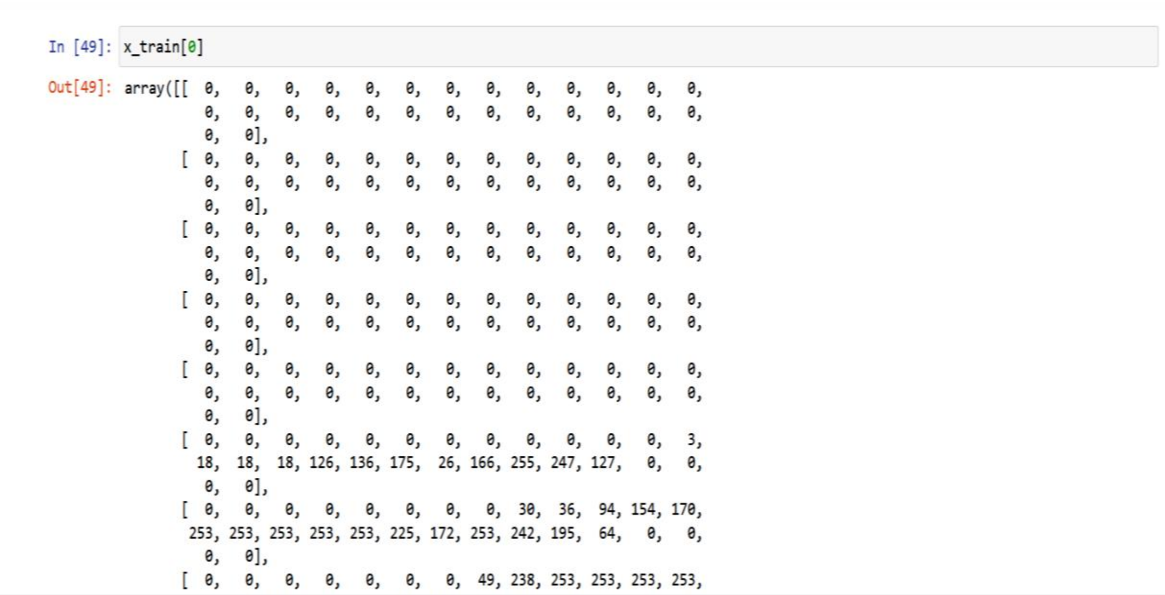
Importing the required libraries

```
In [46]: import numpy
         import tensorflow #open source used for both ML and DL for computation
         from tensorflow.keras.datasets import mnist #mnist dataset
         from tensorflow.keras.models import Sequential #it is a plain stack of layers
         from tensorflow.keras import layers #A Layer consists of a tensor- in tensor-out computat ion funct ion
         from tensorflow.keras.layers import Dense, Flatten #Dense-Dense Layer is the regular deeply connected r
         #faltten -used fot flattening the input or change the dimension
         from tensorflow.keras.layers import Conv2D #onvoLutiona l Layer
         from keras.optimizers import Adam #opt imizer
         from keras. utils import np_utils #used for one-hot encoding
         import matplotlib.pyplot as plt   #used for data visualization
```

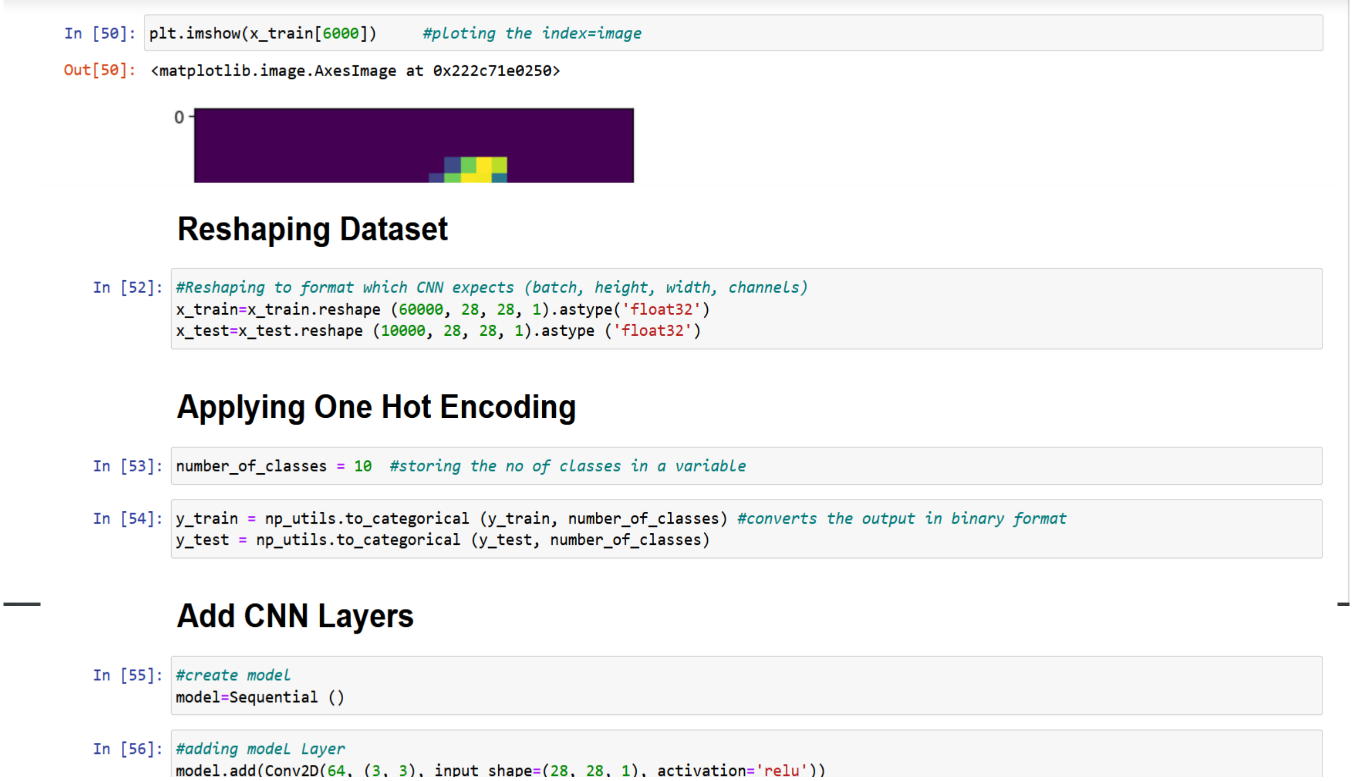
load data

```
In [47]: (x_train, y_train), (x_test, y_test)=mnist.load_data () #splitting the mnist data into train and test
```

```
In [48]: print (x_train.shape)  #shape is used for give the dimens ion values #60000-rows 28x28-pixels
         print (x_test.shape)

         (60000, 28, 28)
         (10000, 28, 28)
```



```
In [49]: x_train[0]

Out[49]: array([[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
                  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
                  0,   0],
                [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
                  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
                  0,   0],
                [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
                  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
                  0,   0],
                [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
                  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
                  0,   0],
                [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
                  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
                  0,   0],
                [  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   3,
                 18,  18,  18, 126, 136, 175,  26, 166, 255, 247, 127,   0,   0,
                  0,   0],
                [  0,   0,   0,   0,   0,   0,   0,   0,  30,  36,  94, 154, 170,
                253, 253, 253, 253, 253, 225, 172, 253, 242, 195,  64,   0,   0,
                  0,   0],
                [  0,   0,   0,   0,   0,   0,   0,  49, 238, 253, 253, 253, 253,
```



```
In [50]: plt.imshow(x_train[6000])      #ploting the index=image

Out[50]: <matplotlib.image.AxesImage at 0x222c71e0250>
```

Reshaping Dataset

```
In [52]: #Reshaping to format which CNN expects (batch, height, width, channels)
         x_train=x_train.reshape (60000, 28, 28, 1).astype('float32')
         x_test=x_test.reshape (10000, 28, 28, 1).astype ('float32')
```

Applying One Hot Encoding

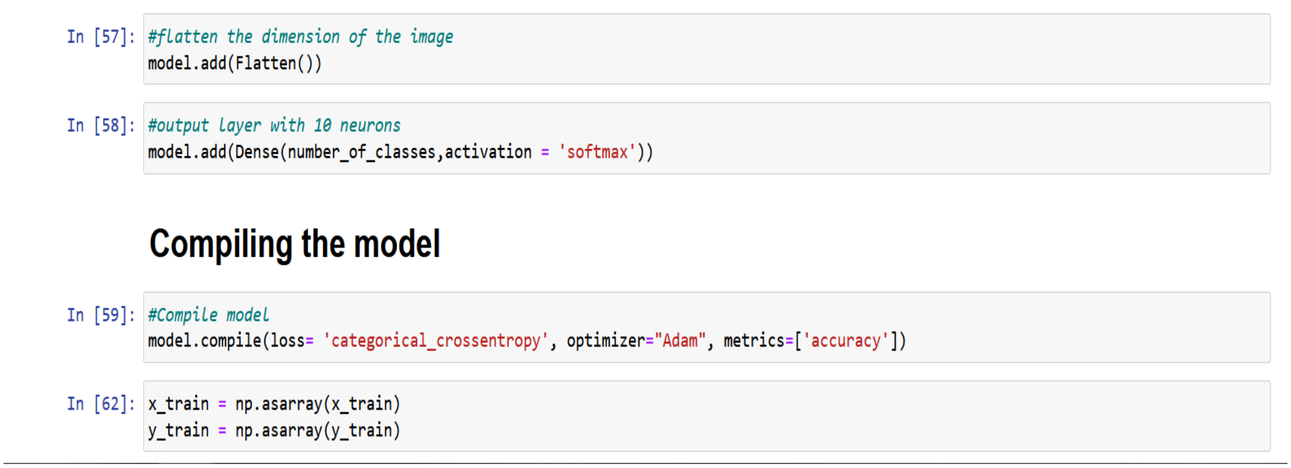
```
In [53]: number_of_classes = 10  #storing the no of classes in a variable
```

```
In [54]: y_train = np_utils.to_categorical (y_train, number_of_classes) #converts the output in binary format
         y_test = np_utils.to_categorical (y_test, number_of_classes)
```

Add CNN Layers

```
In [55]: #create model
         model=Sequential ()
```

```
In [56]: #adding model Layer
         model.add(Conv2D(64, (3, 3), input_shape=(28, 28, 1), activation='relu'))
```



```
In [57]: #flatten the dimension of the image
         model.add(Flatten())
```

```
In [58]: #output layer with 10 neurons
         model.add(Dense(number_of_classes,activation = 'softmax'))
```

Compiling the model

```
In [59]: #Compile model
         model.compile(loss= 'categorical_crossentropy', optimizer="Adam", metrics=['accuracy'])
```

```
In [62]: x_train = np.asarray(x_train)
         y_train = np.asarray(y_train)
```

Train the model

```
In [63]: #fit the model
         model.fit(x_train, y_train, validation_data=(x_test, y_test), epochs=5, batch_size=32)
```

```
Epoch 1/5
1875/1875 [==============================] - 88s 47ms/step - loss: 0.2299 - accuracy: 0.9506 - val_loss: 0.0899 - val_accuracy:
0.9730
Epoch 2/5
1875/1875 [==============================] - 81s 43ms/step - loss: 0.0682 - accuracy: 0.9796 - val_loss: 0.0765 - val_accuracy:
0.9780
Epoch 3/5
1875/1875 [==============================] - 80s 43ms/step - loss: 0.0493 - accuracy: 0.9838 - val_loss: 0.0888 - val_accuracy:
0.9755
Epoch 4/5
1875/1875 [==============================] - 80s 43ms/step - loss: 0.0357 - accuracy: 0.9887 - val_loss: 0.0835 - val_accuracy:
0.9791
Epoch 5/5
1875/1875 [==============================] - 89s 48ms/step - loss: 0.0288 - accuracy: 0.9907 - val_loss: 0.1145 - val_accuracy:
0.9708
```

```
Out[63]: <keras.callbacks.History at 0x222d90d9db0>
```

Observing the metrics

```
In [64]: # Final evaluation of the model
         metrics = model.evaluate(x_test, y_test, verbose=0)
         print("Metrics (Test loss &Test Accuracy) : ")
         print(metrics)
```

```
Metrics (Test loss &Test Accuracy) :
[0.1144733875989914, 0.97079998254776]
```

Test The Model

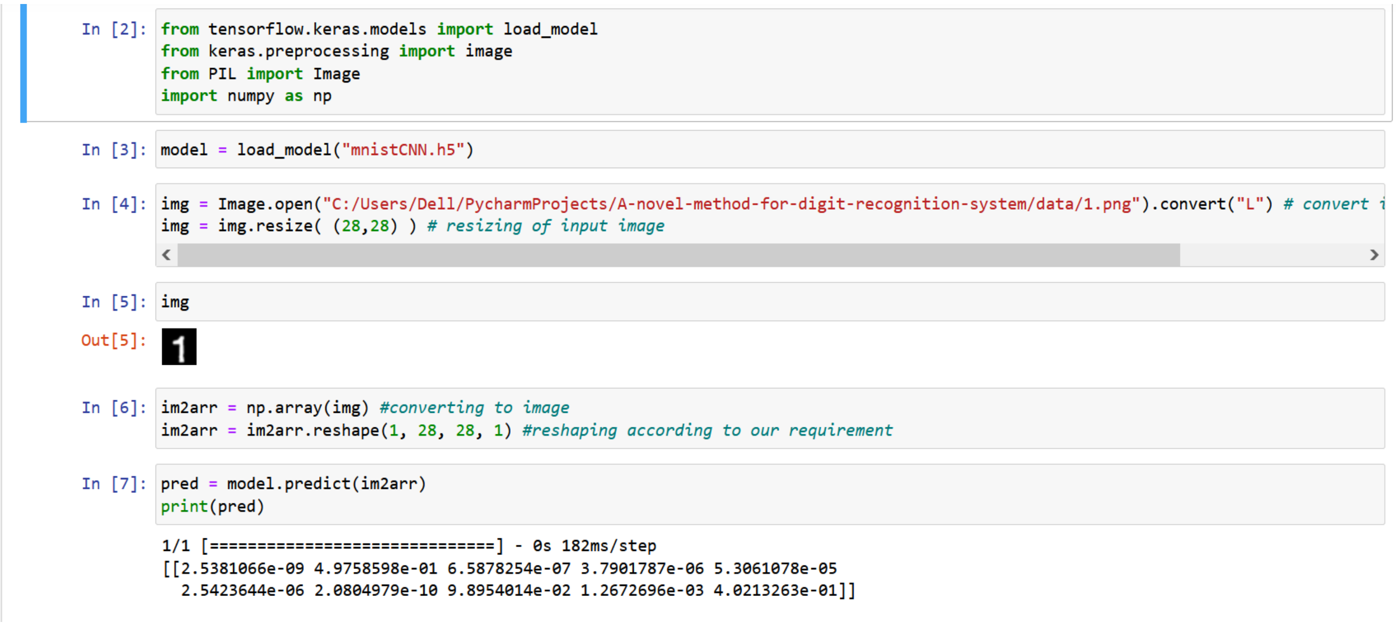
```
In [65]: prediction=model.predict(x_test[6000:6001])
         print(prediction)
```

```
1/1 [==============================] - 0s 84ms/step
[[1.4689527e-14 1.8748821e-17 2.3109615e-13 9.5624716e-07 3.1683821e-04
  2.4785629e-07 6.1842380e-18 6.2185841e-06 8.8746788e-07 9.9967492e-01]]
```

Save The model

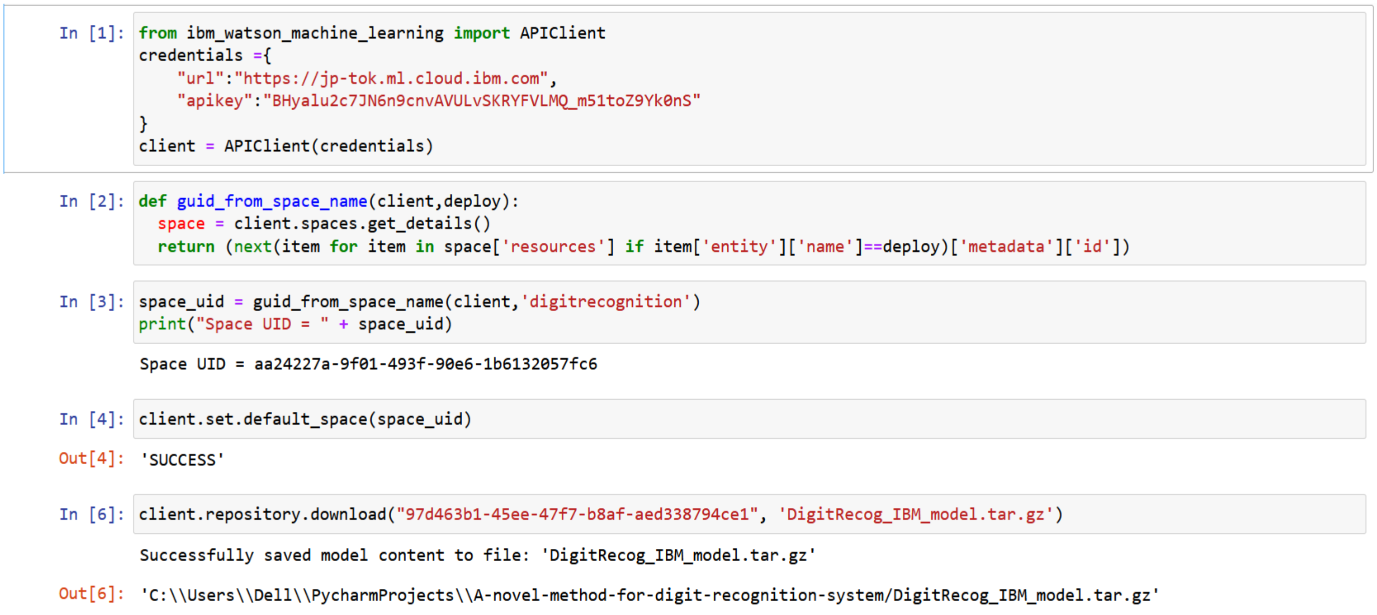
```
In [70]: # Save the model
         model.save('models/mnistCNN.h5')
```

CNNPREDICTION:



```
In [2]: from tensorflow.keras.models import load_model
        from keras.preprocessing import image
        from PIL import Image
        import numpy as np

In [3]: model = load_model("mnistCNN.h5")

In [4]: img = Image.open("C:/Users/Dell/PycharmProjects/A-novel-method-for-digit-recognition-system/data/1.png").convert("L") # convert i
        img = img.resize( (28,28) ) # resizing of input image

In [5]: img

Out[5]:

In [6]: im2arr = np.array(img) #converting to image
        im2arr = im2arr.reshape(1, 28, 28, 1) #reshaping according to our requirement

In [7]: pred = model.predict(im2arr)
        print(pred)

        1/1 [==============================] - 0s 182ms/step
        [[2.5381066e-09 4.9758598e-01 6.5878254e-07 3.7901787e-06 5.3061078e-05
          2.5423644e-06 2.0804979e-10 9.8954014e-02 1.2672696e-03 4.0213263e-01]]
```

TRAIN THE MODEL ON IBM:



```
In [1]: from ibm_watson_machine_learning import APIClient
        credentials ={
            "url":"https://jp-tok.ml.cloud.ibm.com",
            "apikey":"BHyalu2c7JN6n9cnvAVULvSKRYFVLMQ_m51toZ9Yk0nS"
        }
        client = APIClient(credentials)

In [2]: def guid_from_space_name(client,deploy):
          space = client.spaces.get_details()
          return (next(item for item in space['resources'] if item['entity']['name']==deploy)['metadata']['id'])

In [3]: space_uid = guid_from_space_name(client,'digitrecognition')
        print("Space UID = " + space_uid)

        Space UID = aa24227a-9f01-493f-90e6-1b6132057fc6

In [4]: client.set.default_space(space_uid)

Out[4]: 'SUCCESS'

In [6]: client.repository.download("97d463b1-45ee-47f7-b8af-aed338794ce1", 'DigitRecog_IBM_model.tar.gz')

        Successfully saved model content to file: 'DigitRecog_IBM_model.tar.gz'

Out[6]: 'C:\\Users\\Dell\\PycharmProjects\\A-novel-method-for-digit-recognition-system/DigitRecog_IBM_model.tar.gz'
```

HOME PAGE(HTML) – index.html

```
<html>

<head>
  <title>Digit Recognition WebApp</title>

  <meta name="viewport" content="width=device-width">

  <! —Google Font -->
  <link href="https://fonts.googleapis.com/css2?family=Prompt:wght@600&display=swap"
rel="stylesheet">
  <link href="https://fonts.googleapis.com/css2?family=Varela+Round&display=swap"
rel="stylesheet">
  <link
href="https://fonts.googleapis.com/css2?family=Source+Code+Pro:wght@500&display=swa
p" rel="stylesheet">
  <link
href="https://fonts.googleapis.com/css?family=Calistoga|Josefin+Sans:400,700|Pacifico&disp
lay=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= "{{url_for ('static’,
filename='css/style.css')}}">

  <!—font awesome -->
  <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"></script>

</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: PNT2022TMID27424</div>
  </h1>
  <section id="title">
    <h4 class="heading">Handwritten Digit Recognition Website</h4>
    <br><br>
      <p>
        The website is designed to predict the handwritten digit.
      </p>
    <p>
        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.</p>

      <br>
```

```
   <p> 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 analysed by the model and the detected result is returned on to UI</p>

  </section>

  <section id="content">

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

</body>

</html>
```

HOME PAGE(CSS) – style.css

```
#clear_button{
  margin-left: 15px;
  font-weight: bold;
  color: blue;
}
```

```css
#confidence{
  font-family: 'Josefin Sans', sans-serif;
  margin-top: 7.5%;
}

#content{
  margin: 0 auto;
  padding: 2% 15%;
  padding-bottom: 0;
}

.welcome{
   text-align: center;
   position: relative;
   color: honeydew;
   background-color: greenyellow;
   padding-top: 1%;
   padding-bottom: 1%;
   font-weight: bold;
   font-family: 'Prompt', sans-serif;
}

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

#predict_button{
  margin-right: 15px;
  color: blue;
  font-weight: bold;
}

#prediction_heading{
  font-family: 'Josefin Sans', sans-serif;
  margin-top: 7.5%;
}

#result{
  font-size: 5rem;
}
```

```
#title{
  padding: 1.5% 15%;
  margin: 0 auto;
  text-align: center;
}

.btn {
    font-size: 15px;
    padding: 10px;
    webkit-appearance: none;
    background: #eee;
    border: 1px solid #888;
    margin-top: 20px;
    margin-bottom: 20px;
}

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

.heading{
  font-family: 'Varela Round', sans-serif;
  font-weight: 700;
  font-size: 2rem;
  display: inline;
}

.leftside{
  text-align: center;
  margin: 0 auto;
  margin-top: 2%;
  /* padding-left: 10%; */
}

#frame{
  margin-right: 10%;
}

.predicted_answer{
  text-align: center;
  margin: 0 auto;
  padding: 3% 5%;
  padding-top: 0;
  /* padding-left: 10%; */
}

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

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

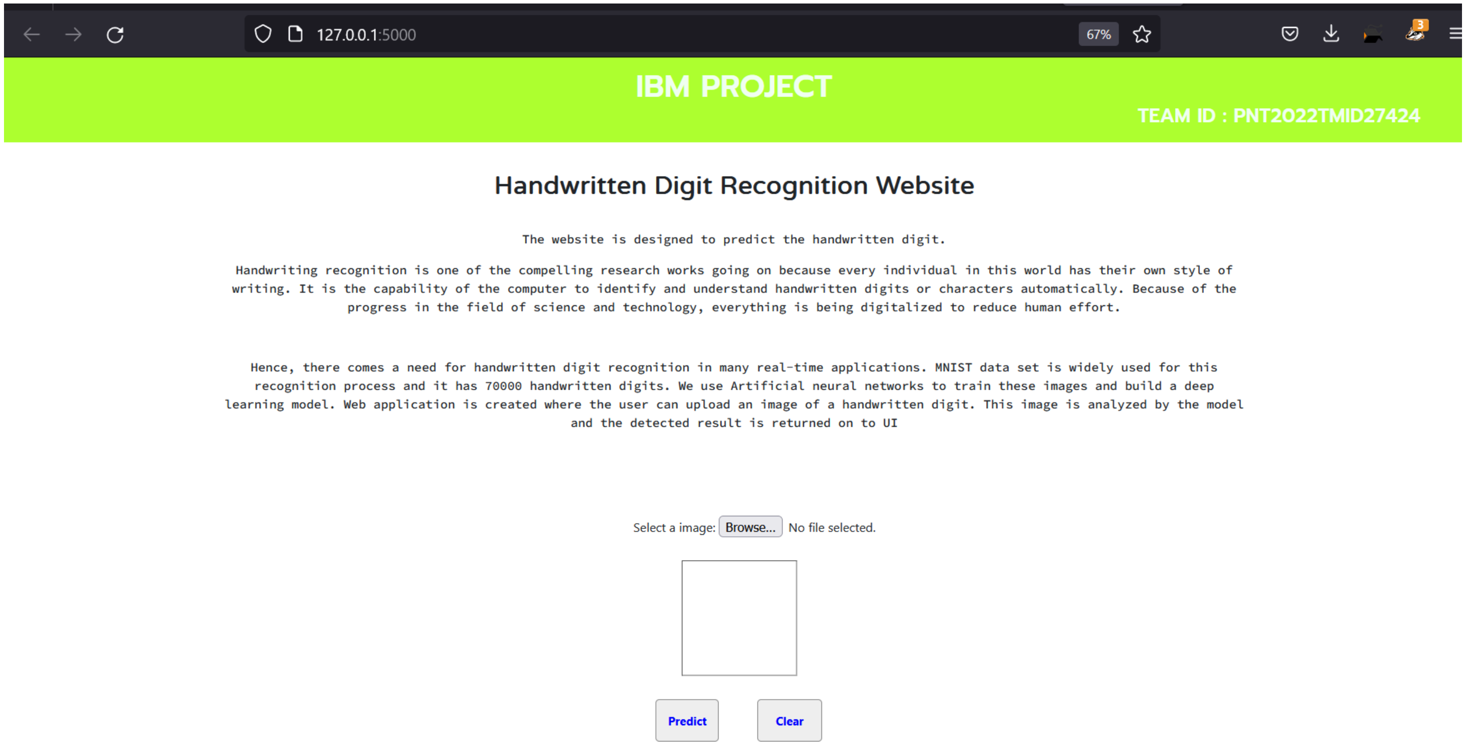
PREDICT PAGE (HTML) – predict.html

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

<style>
    body{
     background-image: url('static/images/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>
```

FLASK APP - app.py

```
import numpy as np
import os
from PIL import Image
from flask import Flask, request, render_template
from werkzeug.utils import secure_filename
from keras.models import load_model

UPLOAD_FOLDER = 'C:/Users/Dell/PycharmProjects/A-novel-method-for-digit-recognition-system/flask_app/uploads'


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

model = load_model("mnistCNN.h5")


@app.route('/')
def index():
    return render_template('index.html')


@app.route('/predict', methods=['GET', 'POST'])
def upload():
    if request.method == "POST":
        f = request.files["image"]
        filepath = secure_filename(f.filename)
        f.save(os.path.join(app.config['UPLOAD_FOLDER'], filepath))

        upload_img = os.path.join(UPLOAD_FOLDER, filepath)
        img = Image.open(upload_img).convert("L")  # convert image to monochrome
        img = img.resize((28, 28))  # resizing of input image

        im2arr = np.array(img)  # converting to image
        im2arr = im2arr.reshape(1, 28, 28, 1)  # reshaping according to our requirement

        pred = model.predict(im2arr)

        num = np.argmax(pred, axis=1)  # printing our Labels

        return render_template('predict.html', num=str(num[0]))


if __name__ == '__main__':
    app.run(debug=True, threaded=False)
```

SCREENSHOTS:



IBM PROJECT

TEAM ID : PNT2022TMID27424

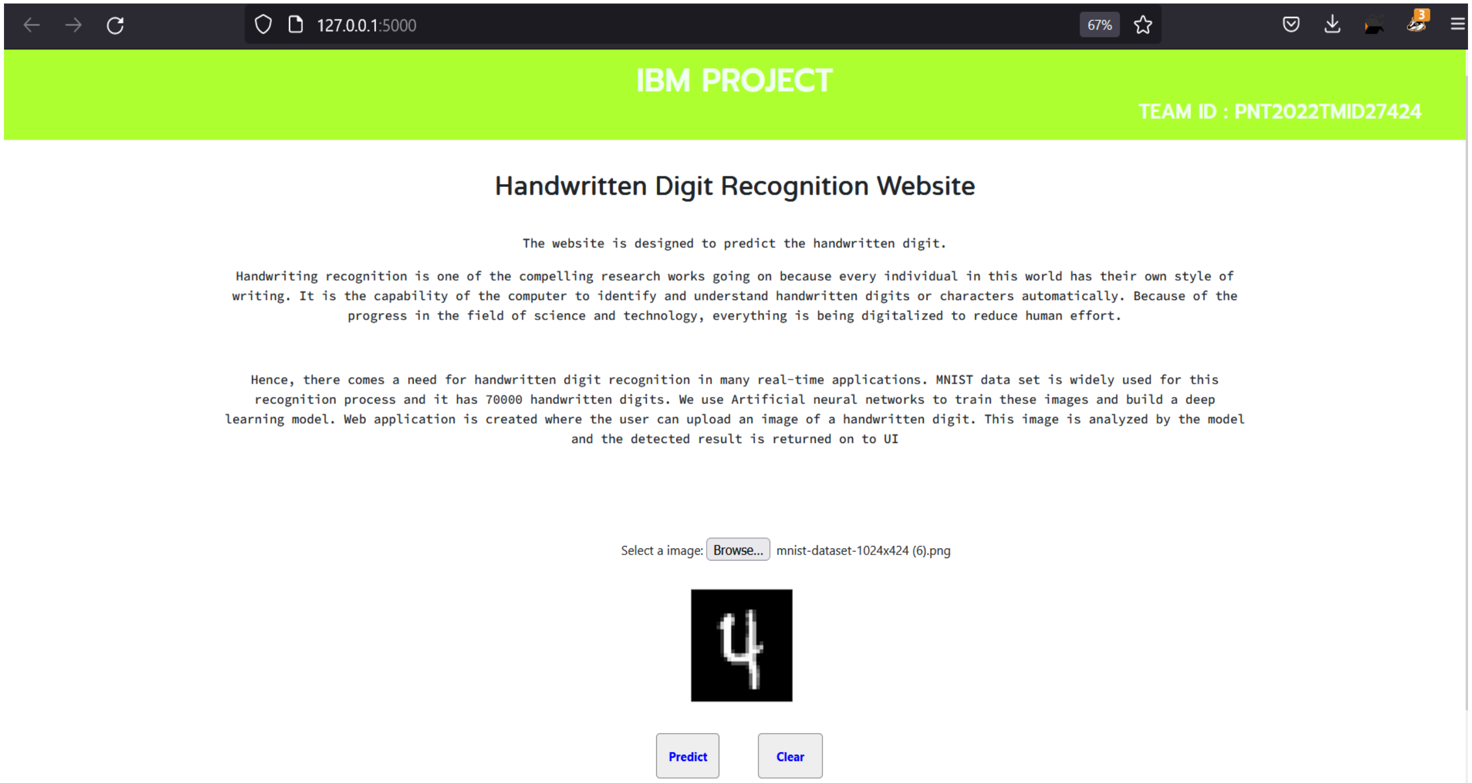
Handwritten Digit Recognition Website

The website is designed to predict the handwritten digit.

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

Select a image: Browse... No file selected.



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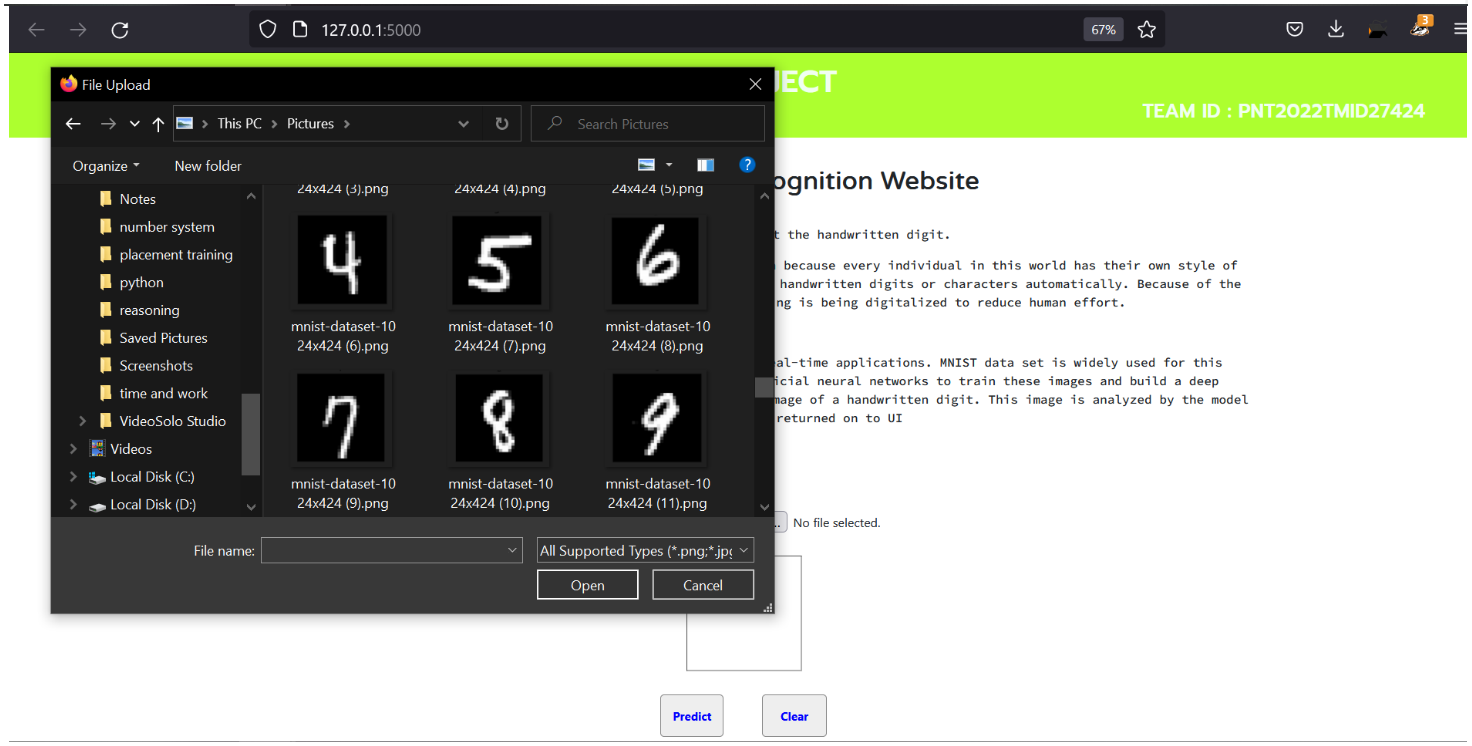
Select a image: Browse... mnist-dataset-1024x424 (6).png



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ognition Website

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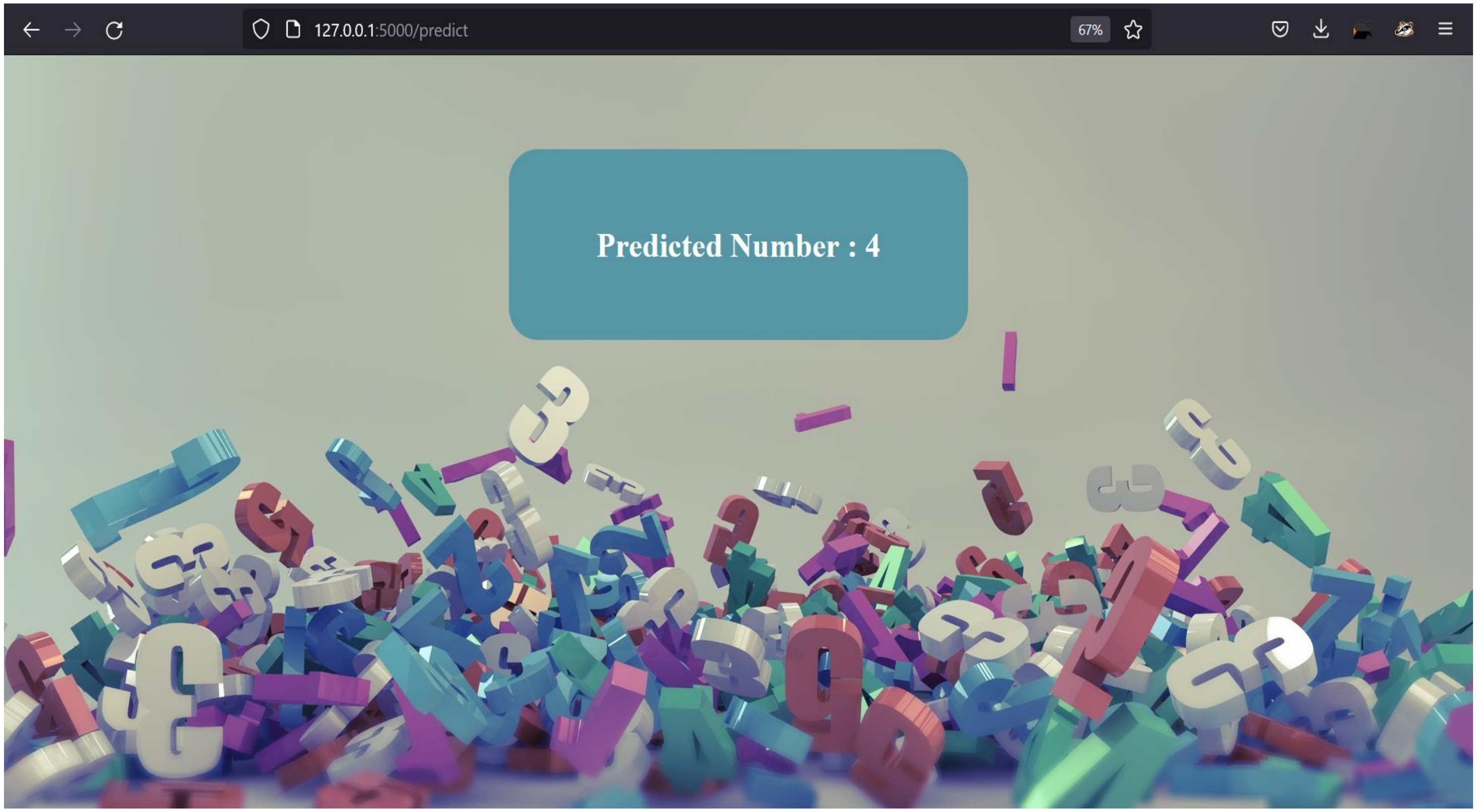
No file selected.



127.0.0.1:5000/predict

Predicted Number : 4

GITHUB LINK:

https://github.com/IBM-EPBL/IBM-Project-20414-1659718946