

PROJECT REPORT

A NOVEL METHOD FOR HANDWRITTEN DIGITRECOGNITION SYSTEM

Submitted By

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1. INTRODUCTION

1.1. Project Overview

Machine learning and deep learning play an important role in computer technology and Artificial Intelligence. With the use of Deep Learning and Machine learning, human effort can be reduced in recognizing, learning, predictions and in many more areas.

Handwritten Digit Recognition is the ability of Computer systems to recognize handwritten digits from various sources, such as images, documents, and so on. This project aims to let users take advantage of machine learning to reduce manual tasks in recognizing digits.

1.2. Purpose

Digit Recognition system are capable of recognizing the digits from different sources like emails, bank cheques, papers, images, etc. and in different real-world scenarios for online handwriting recognition on computer, tablets or systems, recognize number plates of vehicles, processing bank cheque amounts, numeric entries in forms filled up by hand (tax forms) and so on.

2. LITERATURE

SURVEY 2.1 Existing problem

- ✓ The different architectures of CNN, hybrid CNN, CNN - RNN and CNNHMM models, and domain - specific recognition system, are not thoroughly inquired and evolutionary algorithms are not clearly explored for optimizing CNN learning parameters, the number of layers, learning rate and kernel sizes of convolutional filters.

- ✓ The fluctuation of accuracies for handwritten digits was observed for 15 epochs by varying the hidden layers. There is no clear explanation given for observing variation in the overall classification accuracy by varying the number of hidden layers and batch size.

2. References

S.N O	Author Name	Paper Title	Journal/ Conference title	Page No/ Volume No	Year of Publication	Description
	Rohini.M , Dr.Sure ndran	A Novel Method For Handwritten Digit Recognition System	IEEE Sensors Journal		2020	In this paper, with the aim of improving the performanc e of handwritten digit recognition, they valuated variants of a convolution

						al neural network to avoid complex preprocessi n g, costly feature extraction and a complex ensemble (classifier combinatio n) approach
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						of a traditional recognition system.
	S. M. Shamim, Md Badrul Alam Angona Miah, Angona Sarker, Masud Rana, Abdulla Al Jobair	Handwritten Digit Recognition using CNN	International Journal of Innovative Science and Research Technology	Volume -4 Issue-6	2019	In this paper, the most widely used Machine learning algorithms, KNN, SVM, RFC and CNN have been trained and tested on the same

						data in order acquire the comparison between the classifiers
	Ali Abdullah Yahya	Recognition of Handwritten Digit using Convolutiona l Neural Network in Python with Tensorflow and Comparison of Performance for Various Hidden Layers	5th International Conference on Advances in Electrical Engineering (ICAEE)		2019	In this paper, they observed the variation of accuracies of CNN to classify handwritten digits for 15 epochs using various numbers of hidden layers and epochs and

						<p>to make the comparison between the accuracies. For this performance evaluation of CNN, they performed the experiment using Modified National Institute of Standards and Technology(MNIST) dataset.</p>
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	Ali Abdullah Yahya	Review on Deep Learning Handwritten Digit Recognition using Convolutional Neural Network	International Journal of Recent Technology and Engineering(IJRTE)	Volume -9 Issue- 5	2021	In this paper, Object Character Recognition(OCR) is used on printed or documented letters to convert them into text. The database has training image database of 60,000 images and
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						<p>testing image database of 10,000 images. The KNN algorithm describes categoric al value by making use of majority of votes of K - nearest neighbors , the K value used to differ here.</p>
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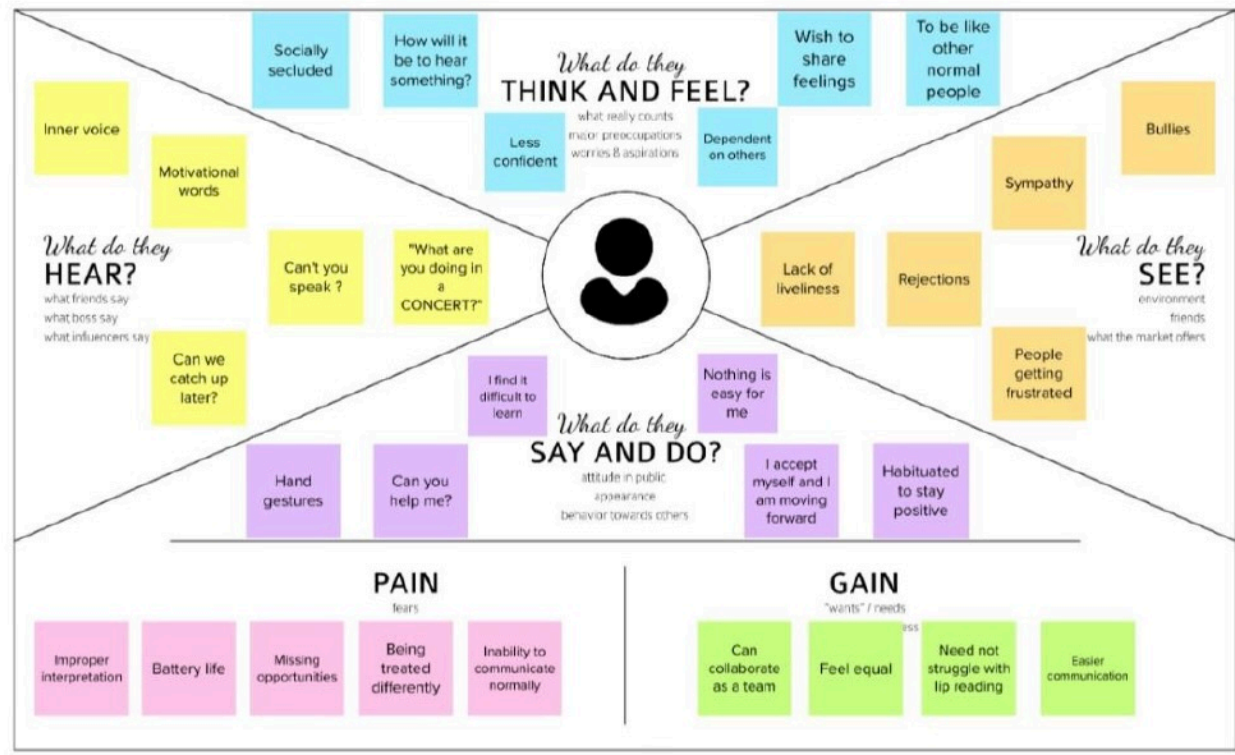
3. Problem Statement Definition

The generative models can perform recognition driven segmentation. The method involves a relatively small number of parameter and hence training is relatively easy and fast. This matter occurs when written by hand digits are not necessarily always of typically the same size, thickness, orientation and validated to margins since they differ coming from writing of personal to individual.

Automating these tasks removes the need for human effort which is error prone in performing these kind of tedious works and improves speed as well as efficiency. Unlike many other recognition schemes, it does not rely on some form of pre-normalization of input images, but can handle arbitrary scalings, translations and a limited degree of image rotation. The digit recognition system is used in postal mail sorting, bank check processing, form data entry

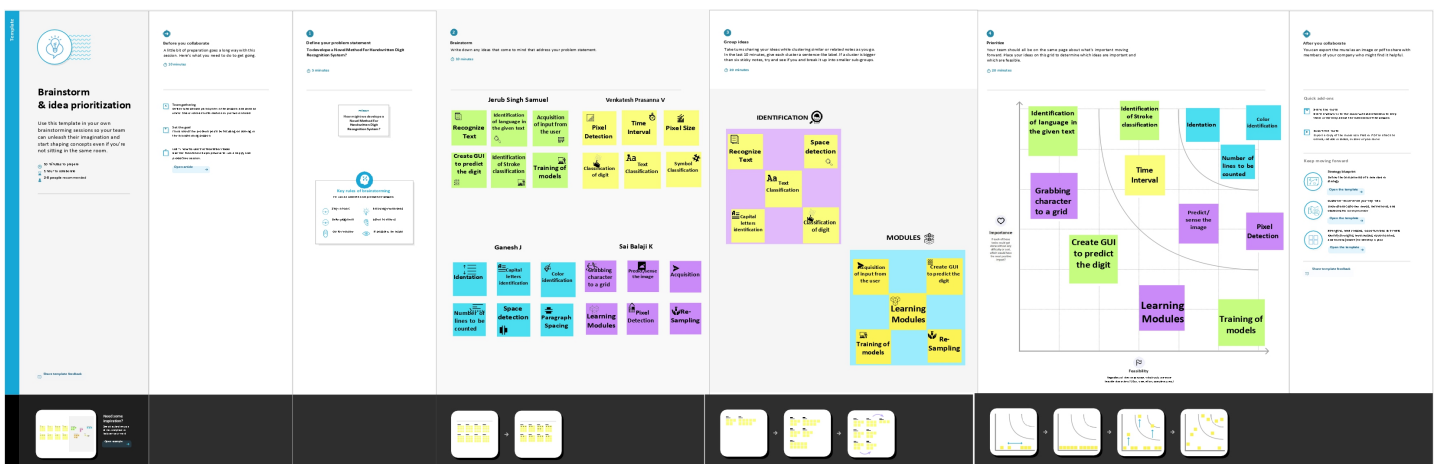
3. IDEATION & PROPOSED SOLUTION

3.1. Empathy Map Canvas



User1 (Person with hearing/speech impairment)

3.2. Ideation & Brainstorming



3.3. Proposed Solution

S.No.	Parameter	Description
1	Problem Statement (Problem to be solved)	<p>Statement-The handwritten digit recognition is the capability of computer applications to recognize the human handwritten digits.</p> <p>Description: It is a hard task for the machine because handwritten digits are not perfect and can be made with many different shapes and sizes.</p>
2	Idea / Solution description	<p>1. It is the capability of a computer to fetch the mortal handwritten integers from different sources like images, papers, touch defences. 2. It allows user to translate all those signature and notes into electronic words in a text</p>

		document format and this data only requires far less physical space than the storage of the physical copies.
3	Novelty / Uniqueness	Accurately recognize the digits rather than recognizing all the characters like OCR.
4	Social Impact / CustomerSatisfaction	1.Artificial Intelligence developed the app called Handwritten digit Recognizer. 2. It converts the written word into digital approximations and utilizes complex algorithms to identify characters before churning out a digital approximation.

5	Business Model (RevenueModel)	<ul style="list-style-type: none"> • This system can be integrated with traffic surveillance cameras to recognize the vehicle's number plates for effective traffic management. • Can be integrated with Postal system to identify and recognize the pin-code details easily.
6	Scalability of the Solution	<ul style="list-style-type: none"> • Ability to recognise digits in more noisy environments. • There is no limit in the number of digits it can be recognized.

3.4. Problem Solution fit

Define CS, fit into CC	<p>1. CUSTOMER SEGMENT(S) CS</p> <p>Who is your customer? i.e. working parents of 0-5 y.o. Kids</p> <p>Organizations who want to recognize the handwritten digits of people</p> <p>Example:</p> <ul style="list-style-type: none"> ✓ Post office, ✓ Data entry offices, ✓ Forensic Departments. 	<p>6. CUSTOMER CONSTRAINTS CC</p> <p>What constraints prevent your customers from taking action or limit their choices of solutions? i.e. spending power, budget, no cash, network connection, available devices.</p> <p>In mobiles and laptop, there are possibilities for lack of stable internet connections and unavailability of devices. It is hard task for the machine to recognize the handwritten digits which are not perfect.</p>	<p>5. AVAILABLE SOLUTIONS AS</p> <p>Which solutions are available to the customers when they face the problem or need to get the job done? What have they tried in the past? What pros & cons do these solutions have? i.e. pen and paper is an alternative to digital note taking. Already there are existing solutions available for handwritten recognition. But, most of them are inaccurate. The solution proposed by our system has more accuracy and it is efficient in recognition of manually written digits.</p>	Explore AS, differentiate
Focus on J&P, tap into BE, understand RC	<p>2. JOBS-TO-BE-DONE / PROBLEMS J&P</p> <p>Which jobs-to-be-done (or problems) do you address for your customers? There could be more than one; explore different sides.</p> <p>Jobs to be done: To identify the digits in the manually written forms,</p> <p>Cheques filled by people in banks, Phone numbers written manually in register notebook of hospitals.</p> <p>Problems: Dim lighting and weak eyesight</p>	<p>9. PROBLEM ROOT CAUSE RC</p> <p>What is the real reason that this problem exists? What is the backstory behind the need to do this job?</p> <p>i.e. customers have to do it because of the change in regulations.</p> <p>Handwritten digits are in different fonts and sizes, hard to recognize the digits due to various factors such as dim lighting, weakening eyesight.</p>	<p>7. BEHAVIOUR BE</p> <p>What does your customer do to address the problem and get the job done?</p> <p>i.e. directly related: find the right solar panel installer, calculate usage and benefits; indirectly associated: customers spend free time on volunteering work (i.e. Greenpeace)</p> <p>customer wants available devices with stable internet connection and quality cameras.</p>	Focus on J&P, tap into BE, understand RC

Identify strong TR & EM	<p>3. TRIGGERS TR</p> <p>What triggers customers to act? i.e. seeing their neighbour installing solar panels, reading about a more efficient solution in the news.</p> <p>Advertisement in the market about the efficient recognition of digits.</p> <p>Articles about the achievements made by our project.</p>	<p>10. YOUR SOLUTION SL</p> <p>If you are working on an existing business, write down your current solution first, fill in the canvas, and check how much it fits reality.</p> <p>If you are working on a new business proposition, then keep it blank until you fill in the canvas and come up with a solution that fits within customer limitations, solves a problem and matches customer behaviour.</p> <p>Our solution aims to recognize handwritten digits using machine learning techniques thereby saving costs to the organization improving employee productivity.</p> <p>In our model we use AlexNet, which is one of the CNN architectures. AlexNet allows for multi-GPU training by putting half of the model's neurons on one GPU and the other half on another GPU. Not only does this mean that a bigger model can be trained, but it also cuts down on the training time. It also reduces the overfitting problem by Data Augmentation and Dropout.</p>	<p>8. CHANNELS of BEHAVIOUR CH</p> <p>8.1 ONLINE</p> <p>What kind of actions do customers take online? Extract online channels from #7</p> <p>Requires Stable internet connection for image processing.</p> <p>8.2 OFFLINE</p> <p>What kind of actions do customers take offline? Extract offline channels from #7 and use them for customer development.</p> <p>Obtain modern electronic devices and check they are working</p>	Identify strong TR & EM
	<p>4. EMOTIONS: BEFORE / AFTER EM</p> <p>How do customers feel when they face a problem or a job and afterwards? i.e. lost, insecure > confident, in control - use it in your communication strategy & design.</p> <p>Defects are common and our project is not an exception</p> <p>When the system failed to recognize the digit,</p> <p>Customer Mentality: Before:(Failure) We would give guarantee that it would work most of the time and if any error occurs, they can contact us at any time. So, customers can feel at ease. After:(Failure) They have no need to panic when the failure occurs They can easily contact us to rectify the error. We would solve the defect as soon as possible.</p>			

4. REQUIREMENT ANALYSIS

4.3.Functional requirement

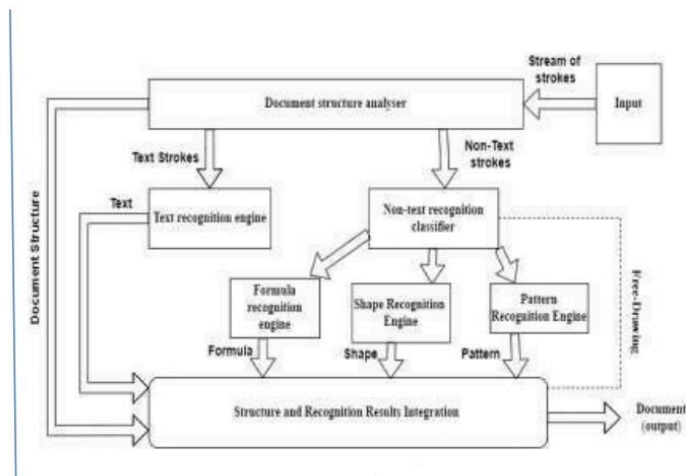
FR No.	Sub Requirement (Story / Sub-Task)
FR-1	Image Data: Handwritten digit recognition refers to a computer's capacity to identify human handwritten digits from a variety of sources, such as photographs, documents, touch screens, etc., and categorise them into ten established classifications (0-9). In the realm of deep learning, this has been the subject of countless studies.
FR-2	Website: Web hosting makes the code, graphics, and other items that make up a website accessible online. A server hosts every website you've ever visited. The type of hosting determines how much space is allotted to a website on a server. Shared, dedicated, VPS, and reseller hosting are the four basic varieties.
FR-3	Digit Classifier Model: To train a convolutional network to predict the digit from an image, use the MNIST database of handwritten digits. get the training and validation data first.
FR-4	Cloud: The cloud offers a range of IT services, including virtual storage, networking, servers, databases, and applications. In plain English, cloud computing is described as a virtual platform that enables unlimited storage and access to your data over the internet.
FR-5	Modified National Institute of Standards and Technology dataset: The abbreviation MNIST stands for the MNIST dataset. It is a collection of 60,000 tiny square grayscale photographs, each measuring 28 by 28, comprising handwritten single digits between 0 and 9.

4. Non-Functional requirements

		reveal information like the writing style, in addition to a categorization of the digit. 2) The generative models are capable of segmentation driven by recognition. 3) The procedure uses a relatively.
NFR-3	Reliability	<p>The samples are used by the neural network to automatically deduce rules for reading handwritten digits. Furthermore, the network may learn more about handwriting and hence enhance its accuracy by increasing the quantity of training instances.</p> <p>Numerous techniques and algorithms, such as Deep Learning/CNN, SVM, Gaussian Naive Bayes, KNN, Decision Trees, Random Forests, etc., can be used to recognise handwritten numbers.</p>
NFR-4	Accuracy	<p>With typed text in high-quality photos, optical character recognition (OCR) technology offers accuracy rates of greater than 99%. However, variances in spacing, abnormalities in handwriting, and the variety of human writing styles result in less precise character identification.</p>
NFR-5	Availability	

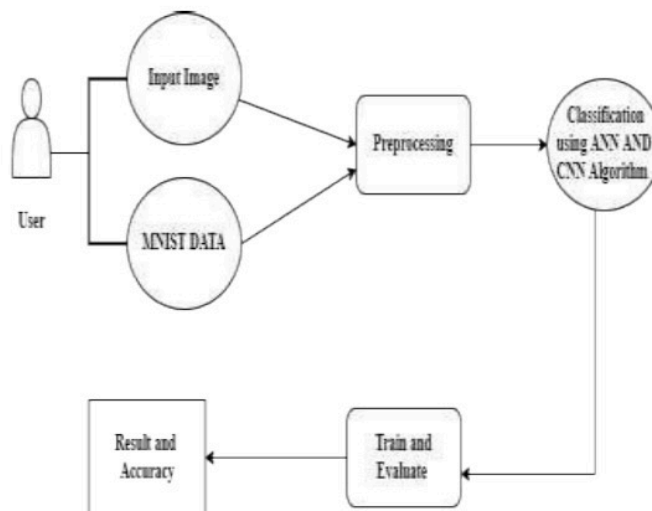
5. PROJECT DESIGN

5.1 Data Flow Diagrams



2. Solution & Technical Architecture

Solution Architecture



Technology Architecture

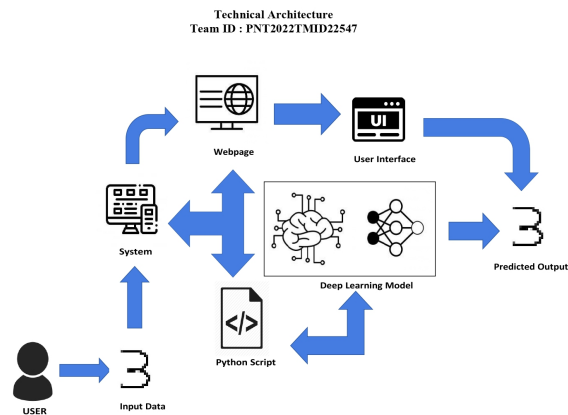


Table-1 : Components & Technologies:

S.No	Component	Description	Technology
1.	User Interface	How user interacts with application e.g. Web UI	HTML, CSS, JavaScript
2.	Application Logic-1	Model is built	Python
3.	Application Logic-2	Python model is deployed	IBM Watson Studio
4.	File Storage	Predicted outputs of the image are stored in a local folder.	Local Filesystem
5.	Machine Learning Model	To predict the image uploaded by the user.	Image Recognition Model
6.	Infrastructure (Server / Cloud)	Application Deployment on Local System / Cloud Local Server Configuration: Flask Cloud Server Configuration : IBM Watson Studio	Local, Cloud Foundry.

Table-2: Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	List the open-source frameworks used	Flask
2.	Security Implementations	List all the security / access controls implemented, use of firewalls etc.	e.g. SHA-256, Encryptions, IAM Controls, OWASP etc.
3.	Scalable Architecture	High workload can be supported without undergoing any major changes.	Technology used in the architecture is that with Python and the IBM cloud.
4.	Availability	Readily available enables the IT Infrastructure to function when some of the components fail.	Technology used is IBM cloud.
5.	Performance	Performance technology is a field which uses various tools, processes and procedures in a systematic and efficient manner to improve the desired outcomes of individuals and organizations.	Technology used is python.

3. 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)	Home	USN-1	As a user, I can view the guide and awareness to use this application.	I can view the awareness to use this application and its limitations.	Low	Sprint-1
		USN-2	As a user, I'm allowed to view the guided video to use the interface of this application.	I can gain knowledge to use this application by a practical method.	Low	Sprint-1
		USN-3	As a user, I can read the instructions to use this application.	I can read instructions also to use it in a user-friendly method.	Low	Sprint-2
	Recognize	USN-4	As a user, In this prediction page I get to choose the image.	I can choose the image from our local system and predict the output.	High	Sprint-2
	Predict	USN-6	As a user, I'm Allowed to upload and choose the image to be uploaded	I can upload and choose the image from the system storage and also in any virtual storage.	Medium	Sprint-3
		USN-7	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.	High	Sprint-4
		USN-8	As a user, I can access the MNIST data set	I can access the MNIST data set to produce the accurate result.	Medium	Sprint-3
Customer (Web user)	Home	USN-9	As a user, I can view the guide to use the web app.	I can view the awareness of this application and its limitations.	Low	Sprint-1
User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Home	USN-1	As a user, I can view the guide and awareness to use this application.	I can view the awareness to use this application and its limitations.	Low	Sprint-1
		USN-2	As a user, I'm allowed to view the guided video to use the interface of this application.	I can gain knowledge to use this application by a practical method.	Low	Sprint-1
		USN-3	As a user, I can read the instructions to use this application.	I can read instructions also to use it in a user-friendly method.	Low	Sprint-2
	Recognize	USN-10	As a user, I can use the web application virtually anywhere.	I can use the application portably anywhere.	High	Sprint-1
		USN-11	As it is an open source, can use it cost freely.	I can use it without any payment to be paid for it to access.	Medium	Sprint-2
		USN-12	As it is a web application, it is installation free	I can use it without the installation of the application or any software.	Medium	Sprint-4
	Predict	USN-13	As a user, I'm Allowed to upload and choose the image to be uploaded	I can upload and choose the image from the system storage and also in any virtual storage.	Medium	Sprint-3

6. PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

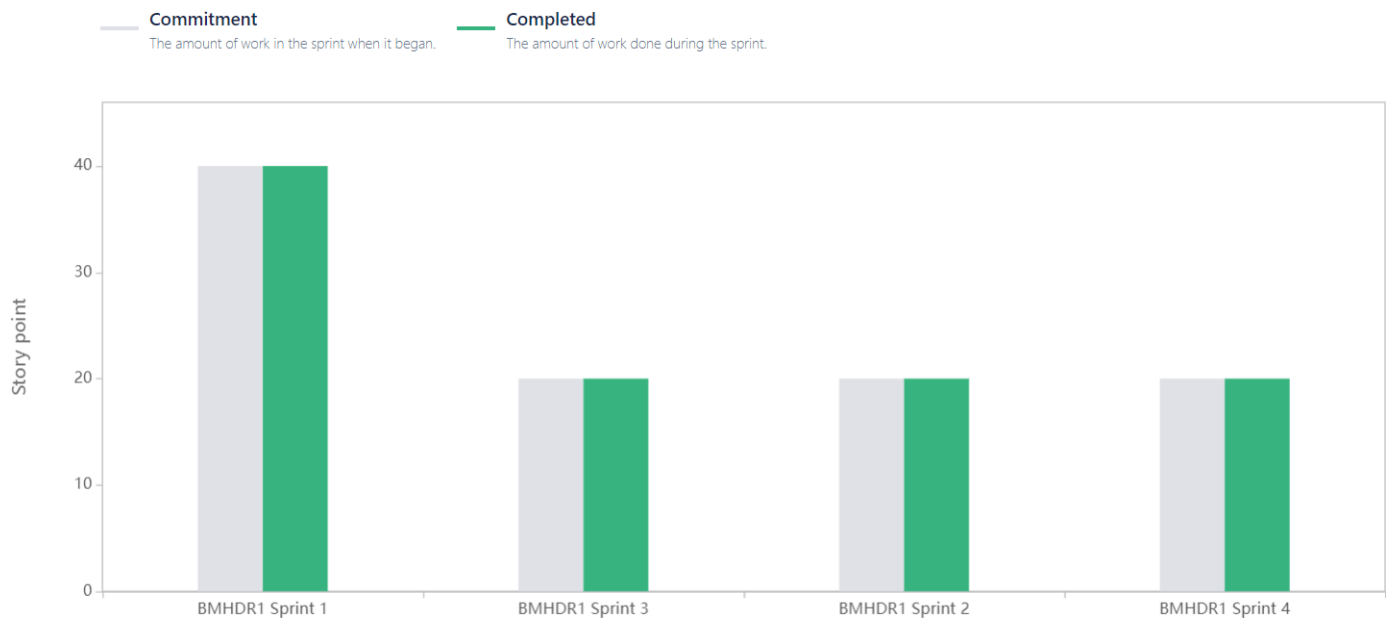
Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Home	USN-1	As a user, I can view the guide and awareness to use this application.	1	Medium	Jerub Singh Samuel
Sprint-1		USN-2	As a user, I'm allowed to view the guided video to use the interface of this application.	3	High	Ganesh J
Sprint-1		USN-3	As a user, I can read the instructions to use this application.	2	Low	Sai Balaji K
Sprint-2	Recognize	USN-4	As a user, In this recognition page I get to choose the image.	4	High	Venkatesh Prasanna V
Sprint-3	Predict	USN-5	As a user, I'm Allowed to upload and choose the image to be uploaded	3	Low	Jerub Singh Samuel
Sprint-3		USN-6	As a user, I will train and test the input to get the maximum accuracy of output.	4	High	Ganesh J, Sai Balaji K
Sprint-3		USN-7	As a user, I can access the MNIST data set	2	Medium	Jerub Singh Samuel, Venkatesh Prasanna V

2. Sprint Delivery Schedule

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

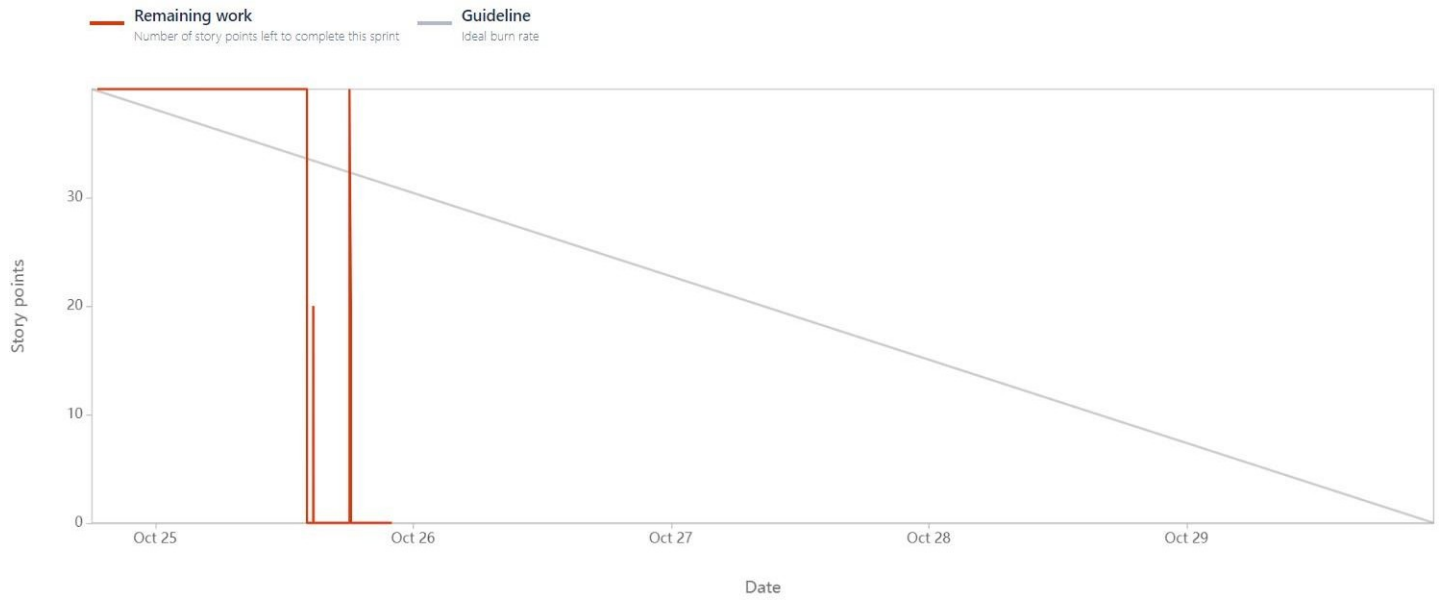
3. Reports from

JIRAVelocity Report



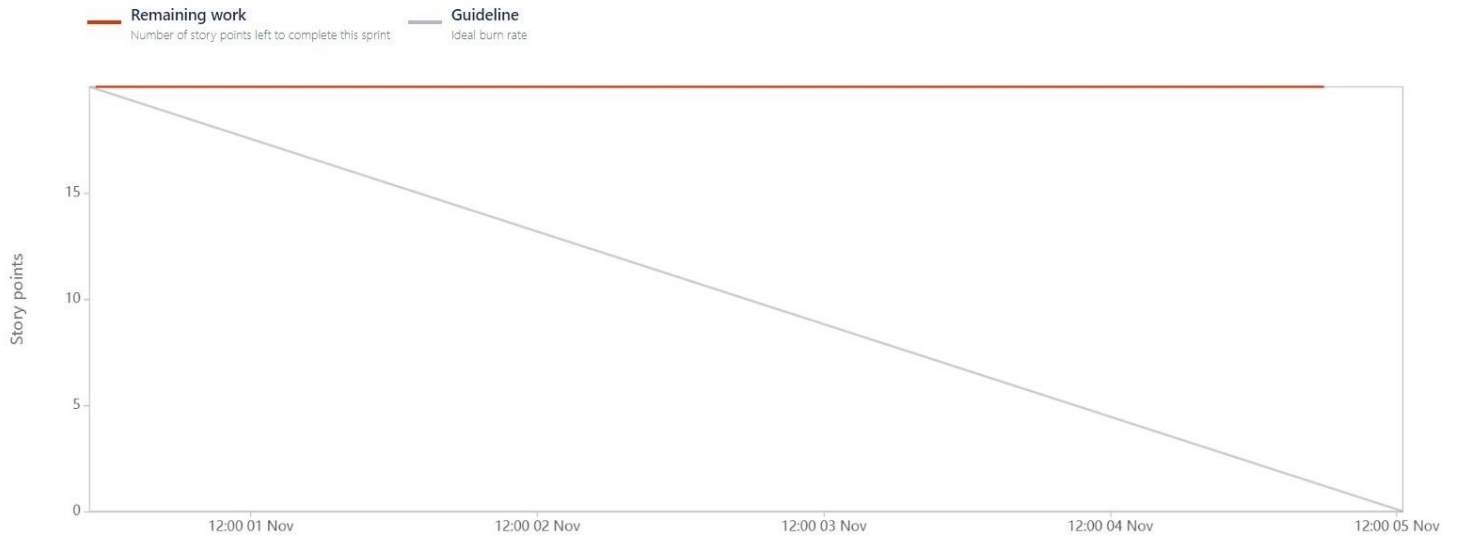
Sprint 1

Date - October 24th, 2022 - October 29th, 2022



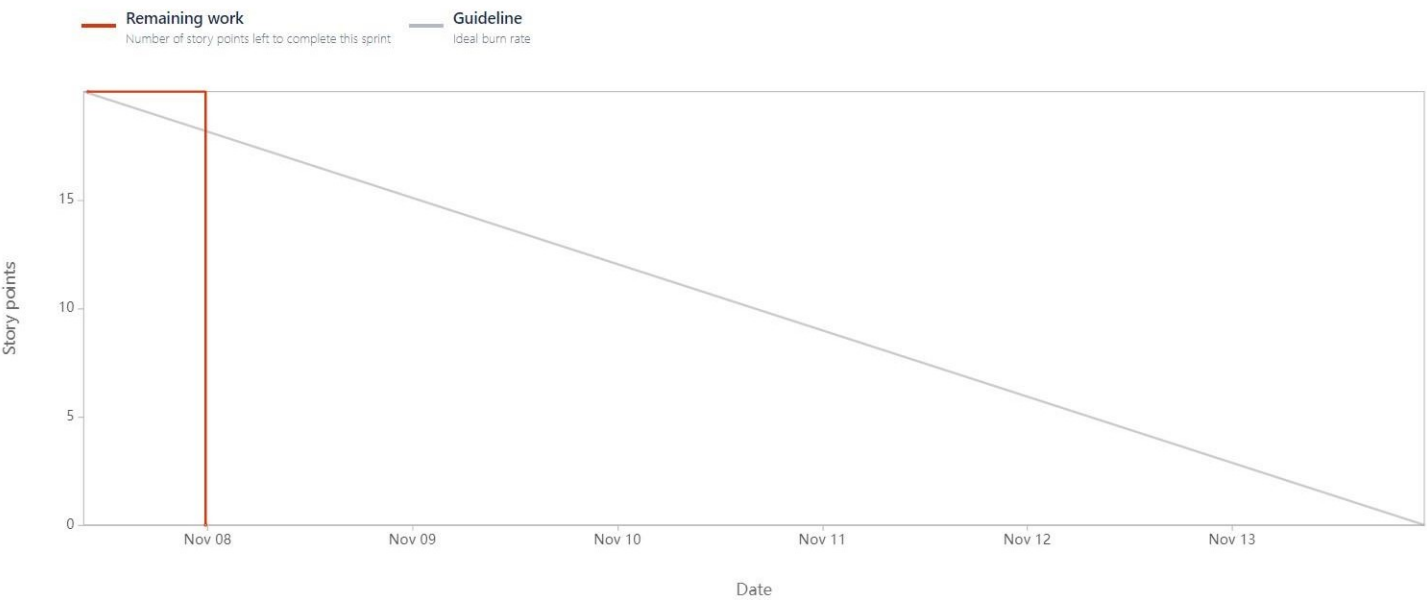
Sprint 2

Date - October 31st, 2022 - November 5th, 2022



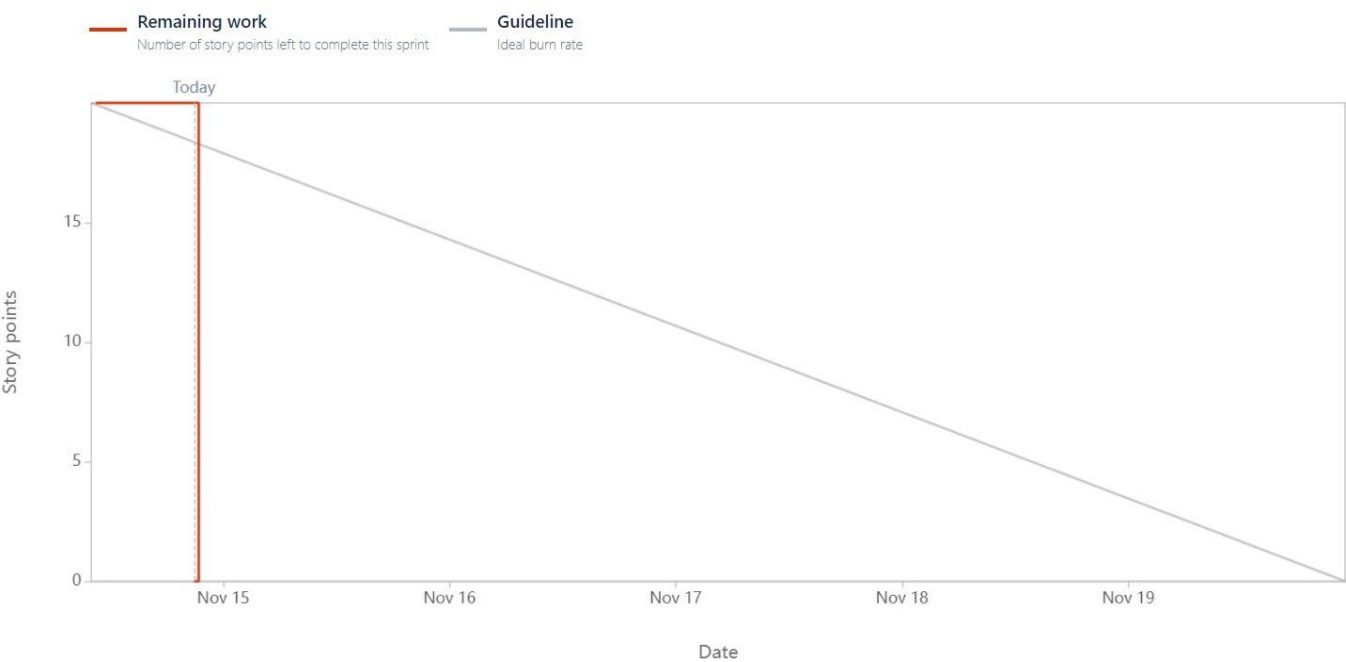
Sprint 3

Date - November 7th, 2022 - November 13th, 2022



Sprint 4

Date - November 14th, 2022 - November 19th, 2022



8. TESTING

8.1.Test Cases

Test case ID	Feature Type	Component	Test Scenario	Expected Result	Actual Result	Status
Homepage_TC_OO1	Functional	Home Page	Verify user is able to see the Homepage when clicked on the link	Home Page should be displayed .	Working as expected	Pass
Homepage_TC_OO2	UI	Home Page	Verify the UI elements in Homepage	Application should show below UI elements: a.choose filebutton b.predict button c.clear button	Working as expected	Pass
Homepage_TC_OO3	Functional	Home Page	Verify user is able to choose file from the local system and click on predict	Choose file popup screen must be displayed and user should be able to click on predict button	Working as expected	Pass

Homepage_TC_OO4	Functional	Home page	Verify user able to select invalid file format	Application won't allow to attach formats other than ".png, .jiff, .pjp, .jpeg, .jpg, .jpeg"	Working as expected	Pass
Predict_TC_OO5	Functional	Predict page	Verify user is able to navigate to the predict to and view the predicted result	User must be navigated to the predict page and must view the predicted result	Working as expected	Pass

8.2.User Acceptance

TestingDefect Analysis

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	0	0	0	0	0
Duplicate	0	0	0	0	0
External	0	0	0	0	0
Fixed	0	0	0	0	0
Not Reproduced	0	0	0	0	0
Skipped	0	0	0	0	0
Won't Fix	0	0	0	0	0
Totals	0	0	0	0	0

Test Case Analysis

Section	Total Cases	Not Tested	Fail	Pas s
Client Application	5	0	0	5
Security	5	0	0	5
Final Report Output	5	0	0	5
Performance	5	0	0	5

9. RESULTS

9.1.Performance

MetricsModel

Summary:

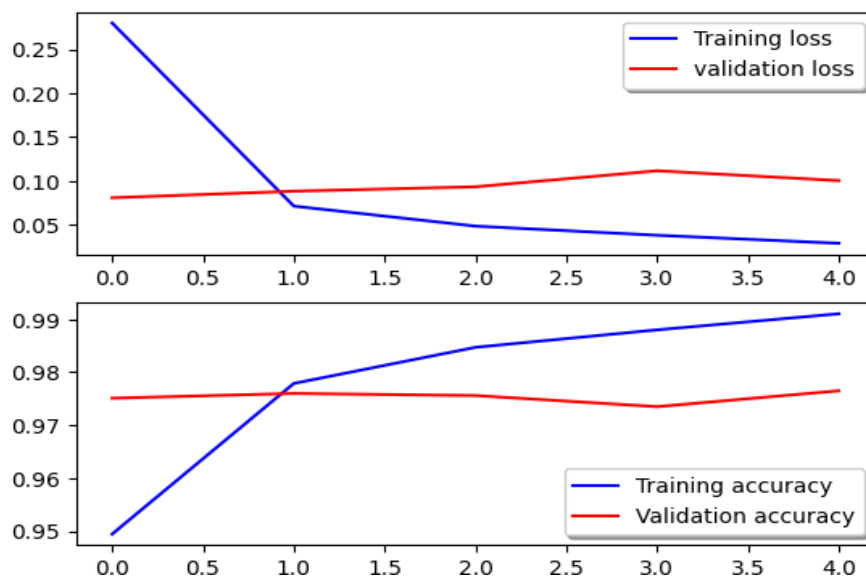
Model: "sequential"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 26, 26, 64)	640
conv2d_1 (Conv2D)	(None, 24, 24, 32)	18464
flatten (Flatten)	(None, 18432)	0
dense (Dense)	(None, 10)	184330

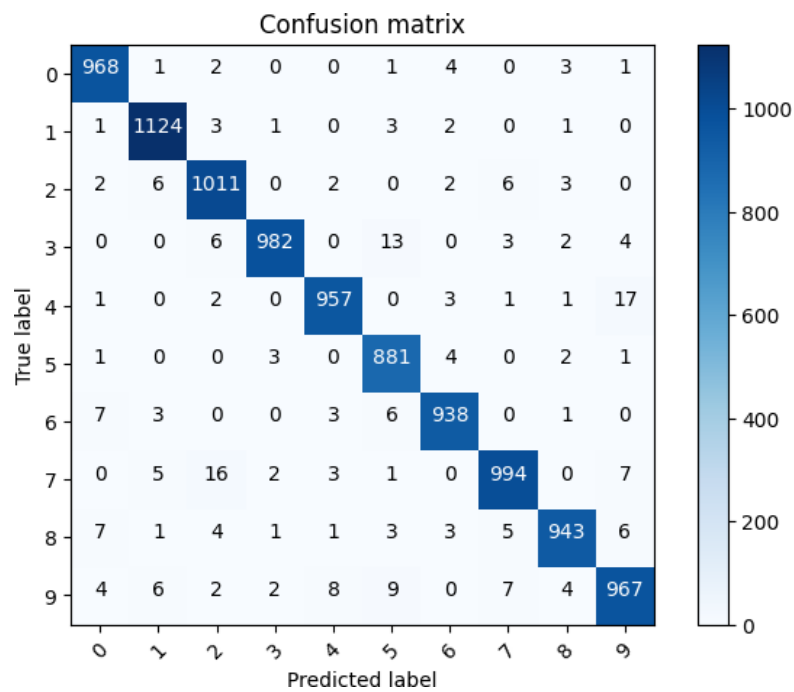
=====
Total params: 203,434
Trainable params: 203,434
Non-trainable params: 0

None

Accuracy:



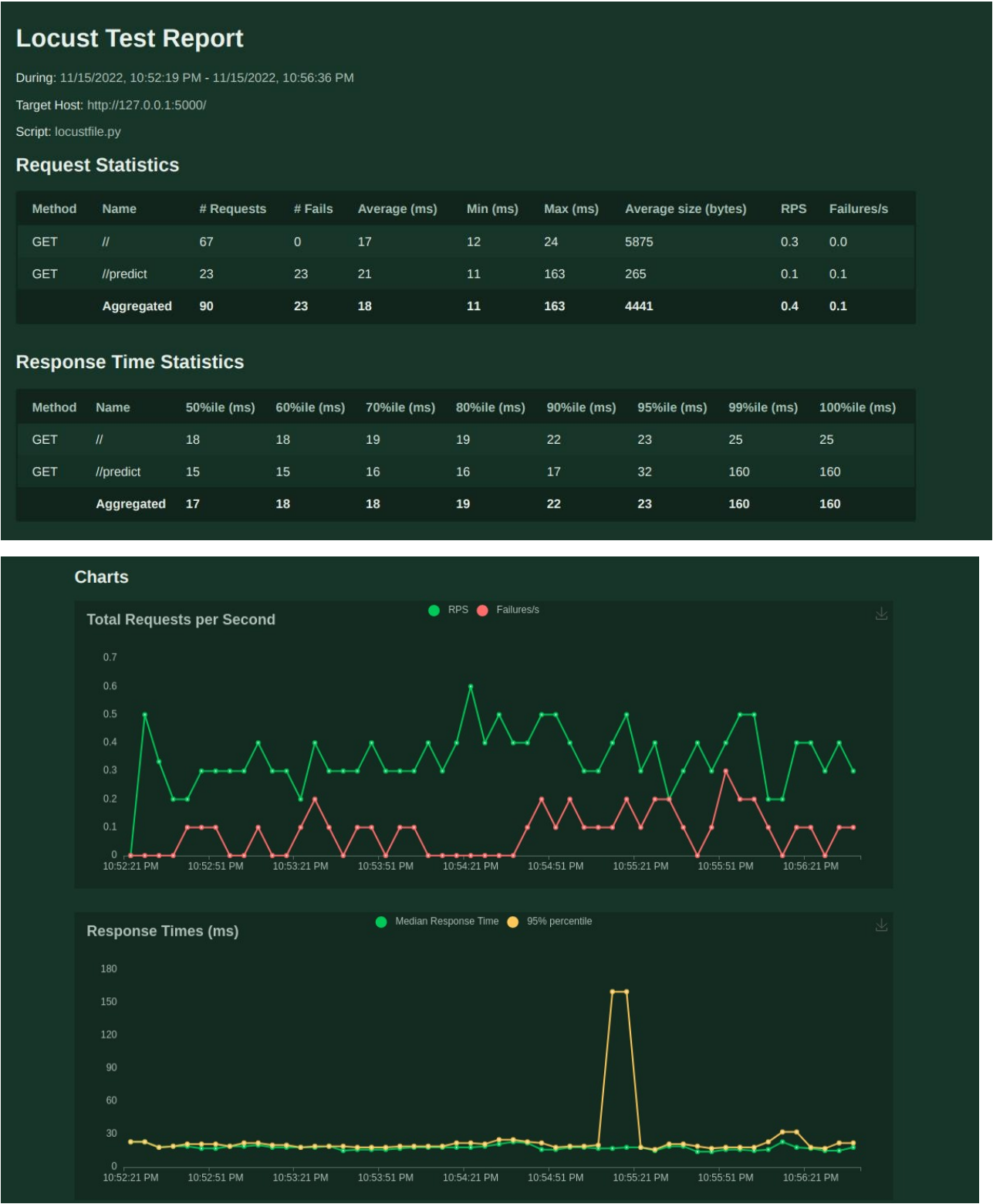
Confusion Matrix:

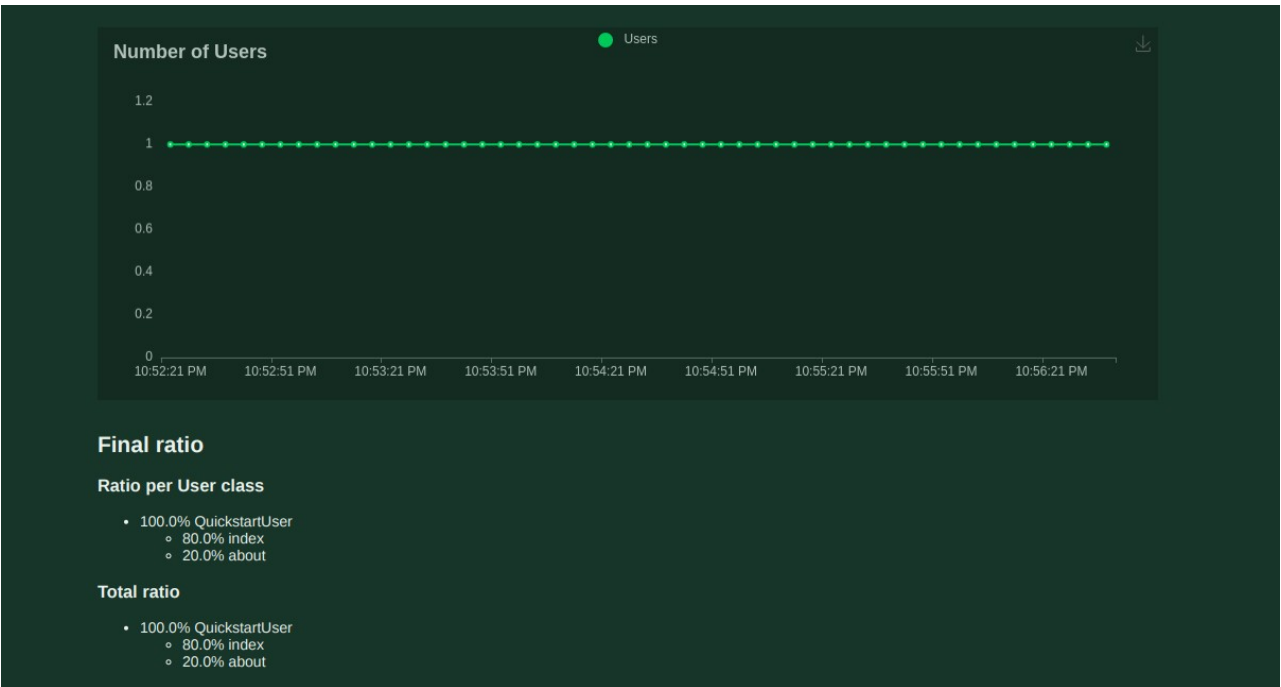


Classification Report:

	precision	recall	f1-score	support
0	0.98	0.99	0.98	980
1	0.98	0.99	0.99	1135
2	0.97	0.98	0.97	1032
3	0.99	0.97	0.98	1010
4	0.98	0.97	0.98	982
5	0.96	0.99	0.97	892
6	0.98	0.98	0.98	958
7	0.98	0.97	0.97	1028
8	0.98	0.97	0.98	974
9	0.96	0.96	0.96	1009
accuracy			0.98	10000
macro avg	0.98	0.98	0.98	10000
weighted avg	0.98	0.98	0.98	10000

Performance Metrics Result:





Gatling report



10.ADVANTAGES & DISADVANTAGES

Advantages

- ✓ Reduces manual work.
- ✓ More accurate than average human.
- ✓ Capable of handling a lot of data.
- ✓ Can be used anywhere from any device.

Disadvantages

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

11.CONCLUSION

This project demonstrated a web application that uses machine learning to recognize handwritten numbers. Flask, HTML, CSS, JavaScript, and a few other technologies were used to create this project. The model predicts the handwritten digit using a CNN network. During testing, the model achieved a 99.61% recognition rate. The proposed project is scalable and can easily handle a huge number of users. Since it is a web application, it is compatible with any device that can run a browser. This project is extremely useful in real- world scenarios such as recognizing number plates of vehicles, processing bank cheque amounts, numeric entries in forms filled up by hand (tax forms) and so on. There is so much room for improvement, which can be implemented in subsequent versions.