PROJECT REPORT

A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION SYSTEM

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Batch: B7-1A3E

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Project Report

1.INTRODUCTION:

1.1.Project Overview

Handwriting recognition is one of the compelling research works going on because every individual in this world has their own style of writing. It is the capability of cthe computer to identify and understand handwritten digits or characters autocmatically. 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 U

1.2 Purpose

The capacity of a computer to categorise human handwriting into 10 specified categories from various sources, such as photos, sheets, touch defences, etc (0-9). We encounter several difficulties in handwritten number identification. because various people have different writing styles. Based on an examination of the thickness and form of the numerical picture, it can accurately and efficiently identify the digits

2. LITERATURE SURVEY

2.1 Existing problem

Handwritten digits recognition is a challenging problem in recent years. Although many deep learning-based classification algorithms are studied for handwritten digits recognition, the recognition accuracy and running time still need to be further improved. UsingArtificial 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

2.2References

S.No	Author	Title of the Paper	Methodology	Pros (Advantage)	Cons (Disadvantage)
1.	GAGANDEEP KAUR MUHAMMAD PARVEZ QUAMAR. **(IEEE paper 1)**	Handwritten Digit Recognition Using CNN	This paper theconvolutional neural network used . Convolutional neural networkis a type of artificial neural network, which is widely used for image/objectrecognition and classification. Deep Learning thus recognizes objects in an image by using a CNN	IN CNN Very High accuracy in image recognition problems.Automatically detects the important features without any human supervision.	CNN do not encode the position and orientation of object. Lack of ability to be spatially invariant to the input data. Lots of training data is required

2.	Peiyu Ma. **(IEEE paper 2)**	Recognition of handwritten digit using convolutional neural network (cnn)	Although the application of CNN has greatly improved the accuracy of handwriting recognition ,there is no model make the accuracy reach 100% and there are also some restrictions on the recognized sample ,such as the requirements of clarity. Therefore, there is still some space of future update on the CNN	faster and easily recognize the digits with a good accuracy	Lack of ability to be spatially invariant to the input data. Lots of training data is required and the time also is taken more .
3.	FathmaSiddique ,ShadmanSakib , Md. Abu Bakr Siddique **(IEEE paper 3)**	Real time handwritten digit recognition using convolutional neural network	CNN is playing an important role in many sectors like image processing. It has a powerful impact on many fields.Even, in nano-technologies like manufacturing semiconductors, CNN is used for fault detection andclassification . Handwritten digit recognition hasbecome an issue of interest among researchers. There are a large number of papers and articles are being published thesedays about this topic. In research, it is shown that DeepLearning algorithm like multilayer CNN using Keras with Theano and Tensorflow gives the	faster and easily recognize the digits with a good accuracy	Inability of the machine to indicate the blurred and bizarre images and it reduces accuracy

			highest accuracy incomparison with the most widely used machine learningalgorithms like SVM, KNN & RFC		
4.	Kaveti upender , venkata siva kumar pasupuleti	Real time handwritten digits recognition using convolution al neural network	The images are first trained and the test images are sent to the machine and the machine detects the digit with the help of the digits that are present in the data and the output is visible on the screen	Reading handwritten information like examination answer sheets is still a difficult task for many of us because each one have different interpretation style .As the world is moving towards digitalization . Converting it to human readable format	They have some disadvantages that include the accuracy is not enough and the system needs to improved for better accuracy

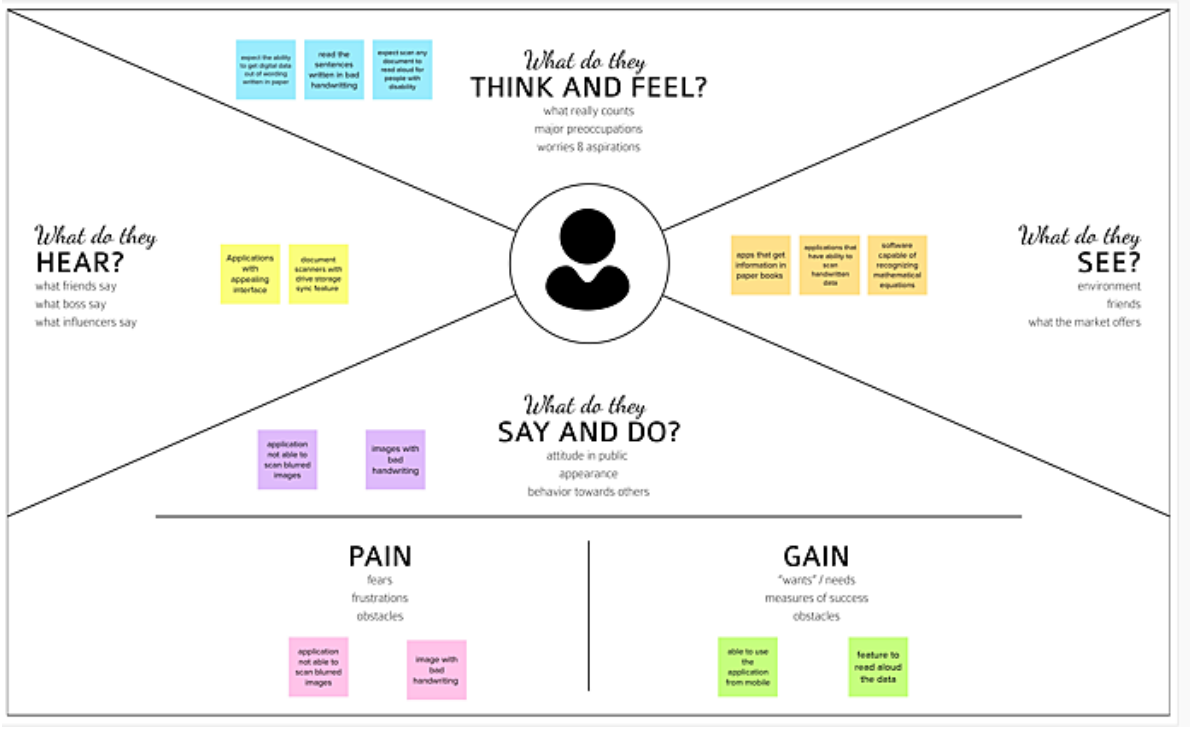
5.	Chao zhang , Zhiyao zhou , Lan lin	Handwritten digits recognition based on convolutional neural network	When the image is uploaded and the digit is recognized . the output is shown on the screen .CNN is playing an important role in many sectors like image processing. It has a powerful impact on many fields.Even, in nano-technologies like manufacturing semiconductors, CNN is used for fault detection andclassification . Handwritten digit recognition hasbecome an issue of interest among researchers. There are a large number of papers and articles are being published these days about this topic.	Faster and easily recognize the digits with a good accuracy	Blurred images cannot be scanned Rtraining was not done properly The accuracy was not sufficient

2.3 Problem Statement Definition

Character handwriting recognition has been around since the 1980s. Handwritten digit recognition using a classifier offers a wide range of applications, including digital digit recognition on PC devices, recognising zip codes on mail, handling bank cheque amounts, numeric portions in structures filled out by hand (for example, tax forms), and so on. There are several difficulties encountered while attempting to address this problem. The digits are not necessarily the same height, width, orientation, or location with respect to the margins. The primary goal was to implement a pattern characterisation approach for perceiving handwritten digits using the MNIST data collection of photographs of handwritten digits (0 - 9). Machine Learning provides a variety of approaches for reducing human effort in detecting manually typednumbers. Deep Learning is a technology that educates computers to do what people do naturally: learning via examples. Human efforts in seeing, learning, recognising, and many other areas can be reduced by using deep learning approaches. The machine learns to do classification tasksfrom images or the text of any document using deep learning. Models using deep learning can achieve state-of-the-art accuracy, outperforming humans.

3.IDEATION & PROPOSED SOLUTION

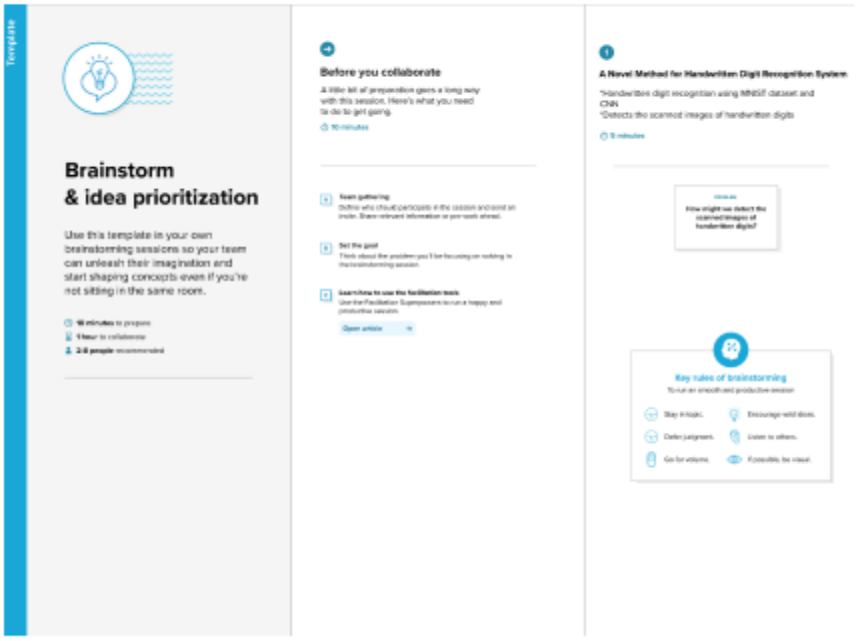
3.1 Empathy Map Canvas



3.2 Ideation & Brainstorming

Brainstorm & Idea Prioritization Template:

Step-1 Team gathering collaboration and select the problem statement



Step-2: Brainstorm, Idea Listing and Grouping

Brainstorm and Idea Listing

2

Brainstorm

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

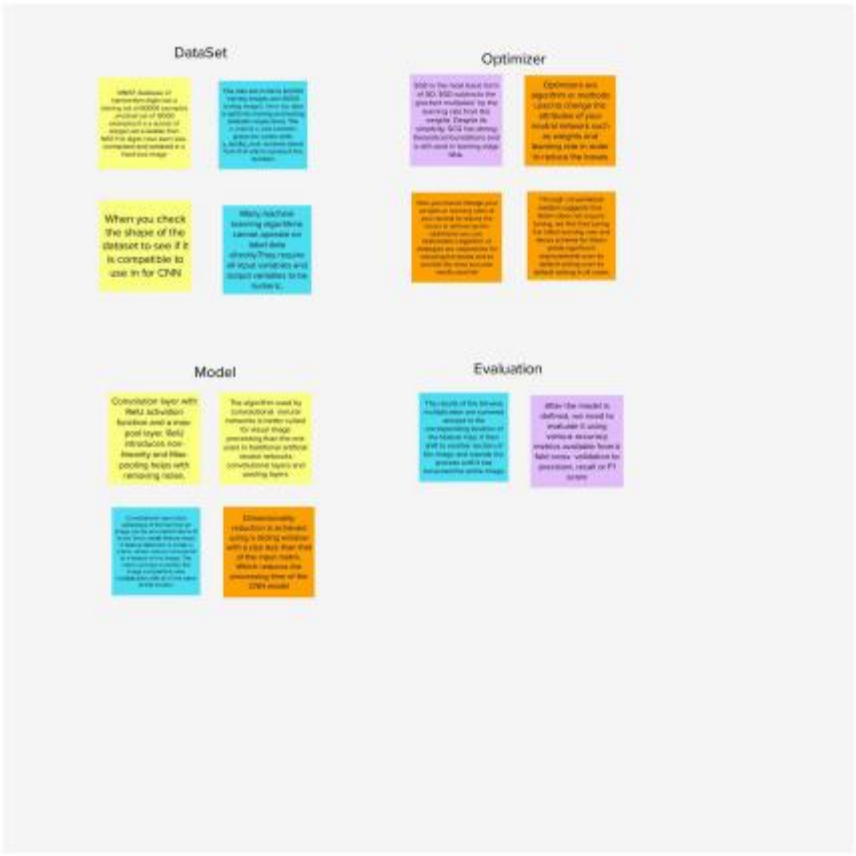
⏱ 10 minutes

3

Group ideas

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

20 minutes



3.3 Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to besolved)	The capacity of computer programmes to detect human handwritten digits is known as handwritten digit recognition. Because handwritten figures are not always accurate and can take many various forms and sizes, it isa difficult work for the machine. A solution to this issue is the handwritten digit recognition system,which uses a picture of a digit to identify the digit that is contained in the image.
2.	Idea / Solution description	The capacity of a computer to categorise human handwriting into 10 specified categoriesfrom various sources, such as photos, sheets, touch defences, etc (0-9). We encounter several difficulties in handwritten number identification. because various people have different writingstyles.
3.	Novelty / Uniqueness	Based on an examination of the thickness and form of the numerical picture, it can accurately and efficiently identify the digits.
4.	Social Impact/ Customer Satisfaction	It is utilised for many other functions, includingthe identification of car numbers, the reading of checks at banks and post offices, and the addressing of letters. It is the fastest approach,but it takes time
5.	Business Model(Revenue Model)	The goal of this is to provide efficient and trustworthy methods for reading handwritten numbers online
6.	Scalability of the Solution	Due to its applicability in several machine learning and computer vision applications, handwritten digitrecognition has become a crucial fieldand is enticing many people

3.4 Problem Solution fit

4.REQUIREMENT ANALYSIS

4.1 Functional requirement

FR No.	Functional requirement	Sub Requirement (Story / Sub-Task)
FR-1	IMAGE DATA	Handwritten digitrecognition refers to a computer's capacity to identifyhuman 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 makesthe code, graphics, and other itemsthat make up awebsite accessible online. A server hosts every website you've ever visited. Thetype of hosting determines how much space is allotted to a website on a server. Shared,dedicated, VPS,and reseller hosting are the fourbasicvarieties.
FR-3	DIGIT CLASSIFIERMODEL	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 asa virtual platform that enables unlimited storage and access to your data over the internet.
FR-5	MNIST DATASET	The abbreviation MNIST stands for Modified National Institute of Standards and Technology dataset.It is a collection of 60,000 tiny square grayscale photographs, each measuring 28 by 28, comprisinghandwritten single digits between 0 and 9.

4.2 Non-Functional requirements

FR No	Non-Functional Requirement	Description
NFR-1	**Usability**	One of the very significant problems in patternrecognition applications is the recognition of handwritten characters. Applications for digit recognition include filling out forms, processing bank checks, andsorting mail.
NFR-2	**Security**	1) The system generates a thoroughdescription of the instantiation parameters, which might reveal information like the writing style, in addition to a categorization of the digit.2)The generative models are capable of segmentation drivenby recognition. 3) The procedure uses a relatively.
NFR-3	**Reliability**	The samples are used by the neural network toautomatically deduce rules for reading handwritten digits. Furthermore, the network may learn more about handwriting and hence enhance its accuracy by increasing the quantityof training instances. Numerous techniques and algorithms, suchasDeep Learning/CNN, SVM, Gaussian Naive Bayes, KNN,Decision Trees, Random Forests, etc.,can be usedto recognizehandwritten numbers.
NFR-4	**Accuracy**	With typedtext in high-quality photos, opticalcharacter recognition (OCR) technology offersaccuracy rates of greater than 99%. However,variances in spacing, abnormalities in handwriting, and the varietyof human writingstyles result in less precise character identification.
NFR-5	**Availability**	Available formobile and web browsers

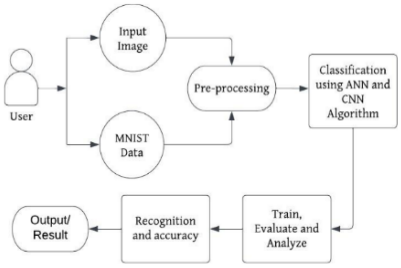
NF R-6	**Scalability**	The scalability in the task of handwritten digit recognition using a classifier has a great importance and it makes use of online handwriting recognition on computer tablets , recognizing zipcodes on mailfor postalmail sorting , processing bank check amountsnumeric entries in forms filledup manua lly (for example tax forms)and so on

5.PROJECT DESIGN

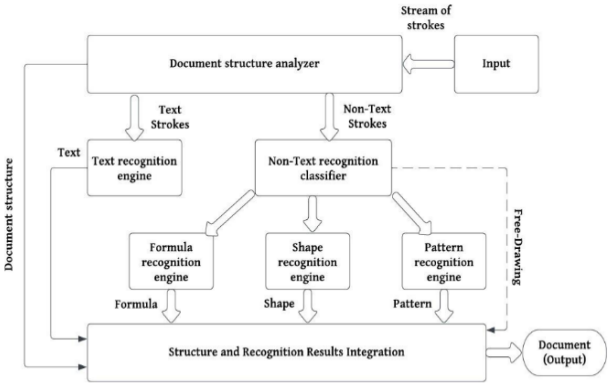
5.1 Data Flow Diagrams

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.

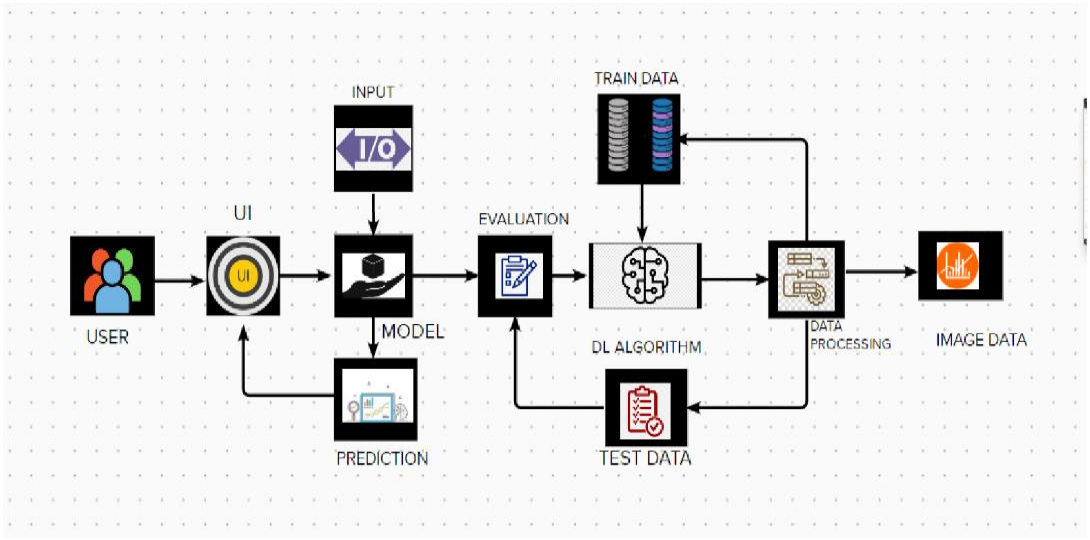
Example: simplified flow



Example: DFD Level 0 (Industry Standard)



5.2 Solution & Technical Architecture



5.3 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 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 be 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)	Dashboard	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
	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 will train and test the input to get the maximum accuracy of output.	I can be able to train and test the application until it gets maximum accuracy of the result.	High	Sprint-4
Customer Care Executive		USN-14	As a user, I can use the web application virtually anywhere.	I can use the application portably anywhere and get the accurate result.	Medium	Sprint-2
Administrator		USN-15	As a user, I can use the web/mobile application virtually anywhere.	I can use the application portably anywhere and get the accurate result.	High	Sprint-2

6.PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

Product Backlog, Sprint Schedule, and Estimation (4 Marks)

Use the below template to create product backlog and sprint schedule

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Data Collection	USN-1	As a user, I need to collect the data with different handwriting to train the model	6	High	Aditya R Harishkumar B Rajaishankar P Akash KV
Sprint-1	Importing libraries	USN-2	As a user, I have to implement necessary libraries in python packages.	4	Low	Aditya R Harishkumar B
Sprint-1	Data preprocessing	USN-3	As a user, I can load the dataset, handle the missing values, scale and split the data.	10	Medium	Rajaishankar P Akash KV
Sprint-2	Model building	USN-4	As a user, I will get an application with ML model which provides high accuracy of recognized handwritten digit.	5	High	Aditya R Harishkumar B Rajaishankar P Akash KV
Sprint-2	Add the CNN layers	USN-5	Add input convolutional layer, max-pooling layer, flatten, hidden and output layers to the model.	5	High	Aditya R Harishkumar B Rajaishankar P Akash KV
Sprint- 2	Compile the model	USN-6	As a user, compile the model for trained dataset.	2	Medium	Aditya R Harishkumar B
Sprint-2	Train and test the model	USN-7	As a user, train and test the model for the dataset collected and data are validated.	4	High	Aditya R Rajaishankar P
Sprint-2	Save the model	USN-8	As a user, the compiled data are saved and integrated with an android application or web application.	2	Low	Rajaishankar P Akash KV
Sprint-3	Building UI application	USN-9	As a user upload the input image that contains handwritten digits.	10	Medium	Rajaishankar P Akash KV
Sprint-3		USN-10	As a user, I can provide the fundamental details about the usage of application to customer.	5	Low	Harishkumar B Akash KV
Sprint-3		USN-11	As a user, I can see the predicted or recognized digits in the application.	5	Medium	Aditya R Harishkumar B
Sprint-4	Train the model on IBM	USN-12	As a user train the model in IBM cloud and integrate the results.	10	High	Rajaishankar P Akash KV

Sprint-4	Cloud Deployment	USN-13	As a user, I can access the web application and make the use of the product from anywhere.	10	High	Rajaishankar P Aditya R

Project Tracker, Velocity & Burndown Chart: (4 Marks)

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	31 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	6 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	13 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

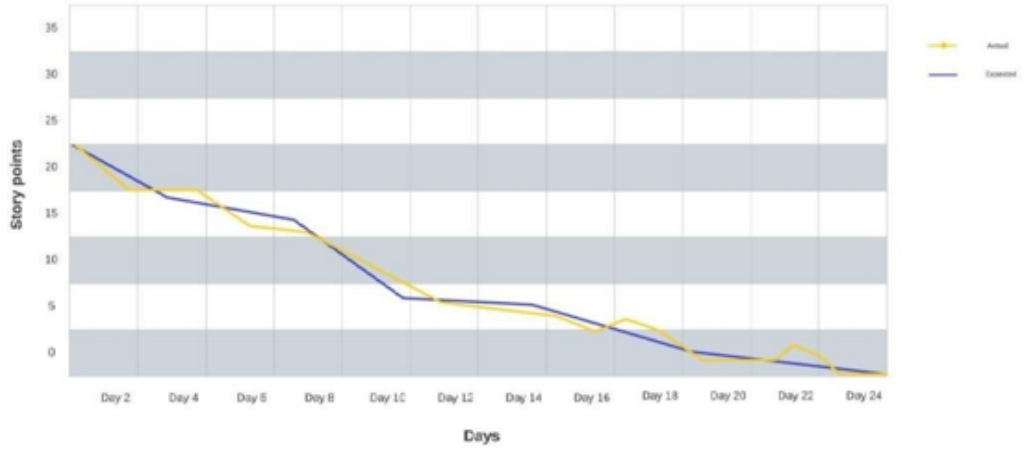
Velocity:

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

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

Burndown Chart:

A 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.



6.2 Sprint Delivery Schedule

Project Tracker, Velocity & Burndown Chart: (4 Marks)

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

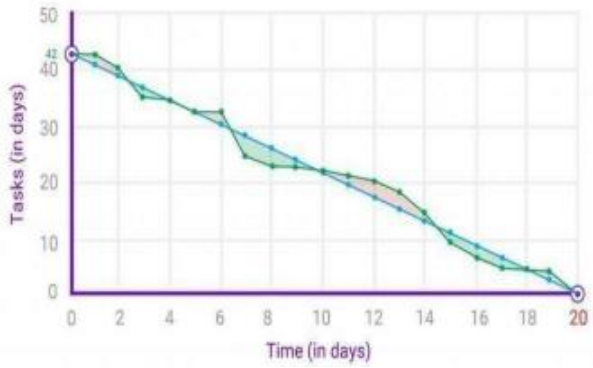
Velocity:

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

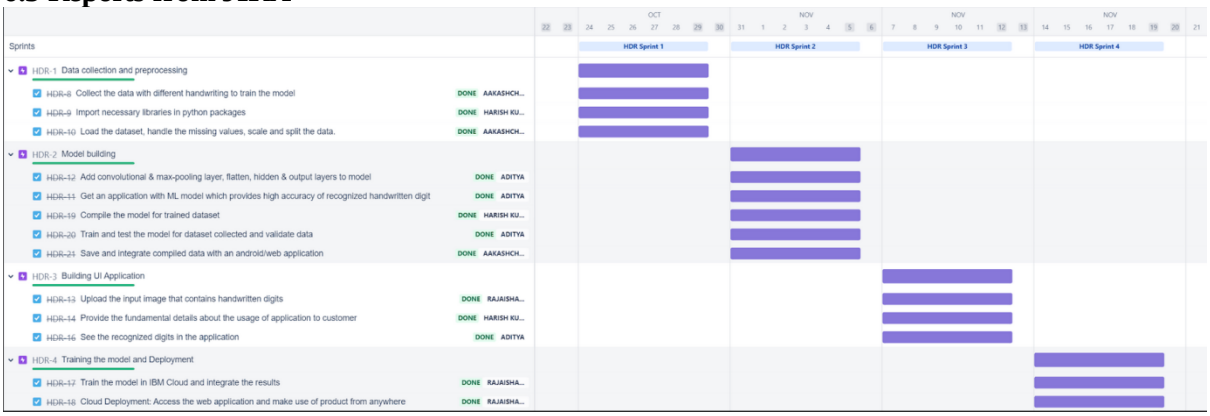
$$\text{Average Velocity} = 20 / 6 = 3.33$$

Burndown 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



7.CODING & SOLUTIONING

7.1 Feature 1

Python Flask

Python Flask is used to develop handwritten digit recognition using python. Flask is mainly used to renderand integrate the digit recognition app and connect the model with the front end application, the suitable server domain link is obtained and run in the browser.

HTML:

The HTML and CSS is used to design the overall digit recognizer UI**.** HTML is used to add UI components and CSS is used to add style to those components. IBM watson studio helps in bui builds the model .

Flask code:

```
import numpy as np
import os
from PIL import Image
from flask import Flask, request, render_template, url_for
from werkzeug.utils import secure_filename, redirect
from gevent.pywsgi import WSGIServer
from keras.models import load_model
from keras.preprocessing import image
from flask import send_from_directory

UPLOAD_FOLDER = 'D:/flask apps/uploads'

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

model = load_model("model.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)
```

7.2 Feature 2

Model building was done in the project to build a model which can predict the uploaded image and let us know what number is displayed in the image

```
 from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Convolution2D,MaxPooling2D,Flatten,Dense
model = Sequential()
model.add(Convolution2D(64, (3,3), input_shape=(28,28,1),activation='relu'))
model.add(Convolution2D(32,(3,3),activation='relu'))
model.add(Flatten())
model.add(Dense(num_classes, activation='softmax'))
```

8.TESTING

8.1 Test Cases

SNO.	TEST CASE SCENARIO
1	Verify user is able to see the Homepage when clickedon the link
2	Verify the UI elements in Homepage
3	Verify user is able to choose file from thelocal system andclick on predict
4	Verify user ableto select invalid file format
5	Verify user is able to navigate to the predict to and view the predicted result

a.

8.2User Acceptance Testing

Test case ID	Feature Type	Component	Test Scenario	Steps To Execute	Test Data	Expected Result	Actual Result	Status	TC for Automation(Y/N)	Executed By
Homepage_TC_OO 1	Functional	Home Page	Verify user is able to see the Homepage when clicked on thelink	1. Enter URL and click go Verify Homepage displayed or not	127.0.0.1:5000	Home Page should be displayed.	Working as expected	Pass	N	R.ADITYA HARISH KUMAR
Homepage_TC_OO 2	UI	Home Page	Verify the UI elements in Homepage	Verify home screenUI elements		Application should show below UI elements: a.choose file button b.predict button c.clear button	Working as expected	Pass	N	RAJAI SHANKAR AKASH KV
Homepage_TC_OO 3	Functional	Home Page	Verify user is able to choose file from the local system and click on predict	1.Enter URL and click go 2.Click on Choose button 3.choose a file in valid format 4.Click on Predict	1.png	Choose file popup screen mustbe displayed and user should be able to click on predict button	Working as expected	Pass	N	RAJAI SHANKAR
Homepage_TC_OO 4	Functional	Home page	Verify user able to select invalid file format	1.Enter URL and click go 2.Click on Choose button choose a file in invalid format click on Predict	2.txt	Application won't allow to attach formats other than ".png, .jiff, .pjp, .jpeg, .jpg, .pjpeg"	Working as expected	Pass	N	R.ADITYA
Predict_TC_OO5	Functional	Predict page	Verify user is able to navigate to the predict to and view the predicted result	1.Enter URL and click go 2.Click on Choose button	1.png	User must be navigated to the predict page and must view the predicted result	Working as expected	Pass	N	AKASH KV

9. RESULTS

9.1Performance Metrics

S.No.	Parameter	Values	Screenshot

1.	Model Summary	The handwritten digit recognizer helps in predicting the number on the image . We use the libraries from tensor flow for building the model .This the model that was built using convolutional neural network(CNN) .	`[ ] from tensorflow.keras.models import Sequential`
			`from tensorflow.keras.layers import Convolution2D,MaxPooling2D,Flatten,Dense`
			`model = Sequential()`
			`model.add(Convolution2D(64, (3,3), input_shape=(28,28,1),activation='relu'))`
			`model.add(Convolution2D(32,(3,3),activation='relu'))`
			`model.add(Flatten())`
			`model.add(Dense(number_of_classes, activation='softmax'))`

2.	Accuracy	Training Accuracy – 99%
		
		Validation Accuracy -100%
			`[ ] metrics = model.evaluate(X_test, Y_test, verbose=0)`
			`print("Metrics(Test loss & Test Accuracy):")`
			`print(metrics)`
			
			`Metrics(Test loss & Test Accuracy):`
			`[0.030196590349807818, 0.9907000064849854]`

10.ADVANTAGES & DISADVANTAGES

Advantage:

- IN CNN Very High accuracy in image recognition problems.Automatically detects the important features without any human supervision.
- faster and easily recognize the digits with a good accuracy
- Reading handwritten information like examination answer sheets is still a difficult task for many of us because each one have different interpretation style .As the world is moving towards digitalization . Converting it to human readable format

Disadvantage:

- CNN do not encode the position and orientation of object. Lack of ability to be spatially invariant to the input data. Lots of training data is required
- They have some disadvantages that include the accuracy is not enough and the system needs to improved for better accuracy
- Lack of ability to be spatially invariant to the input data. Lots of training data is required and the time also is taken more .

11.CONCLUSION

Thus a model was built using convolutional neural network and we understood how the neurons are connected and helping the machine learn the digits and help us in predicting the numbers

12.FUTURE SCOPE

In the future the machine will be trained for alphabets also. The machine would be able to tell the handwritten alphabets written and we can use this in may industy practises for making our work easier and more efficient . we can use this model in post offices and also in data entry level places where machine will be able to detect the handwritten documents and enter the data in the machine format

13.APPENDIX

SOURCE CODE

APP.PY:

```
import numpy as np
import os
from PIL import Image
from flask import Flask, request, render_template, url_for
from werkzeug.utils import secure_filename, redirect
from gevent.pywsgi import WSGIServer
from keras.models import load_model
from keras.preprocessing import image
from flask import send_from_directory

UPLOAD_FOLDER = 'D:/flask apps/uploads'


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

model = load_model("model.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)
```

INDEX.HTML

```
<html>

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

  <meta name="viewport" content="width=device-width">
  <!-- GoogleFont -->
  <link    href="https://fonts.googleapis.com/css2?family=Prompt:wght@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&dis
play=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" href= "static/style.css">
  <!-- fontawesome -->
  <script                                          src="https://kit.fontawesome.com/b3aed9cb07.js"
crossorigin="anonymous"></script>

  <script          src="https://code.jquery.com/jquery-3.3.1.slim.min.js"          integrity="sha384-
q8i/X+965DzO0rT7abK41JStQIAqVgRVzpbzo5smXKp4YfRvH+8abtTE1Pi6jizo"
crossorigin="anonymous"></script>
  <script          src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.14.7/umd/popper.min.js"
integrity="sha384-
UO2eT0CpHqdSJQ6hJty5KVphtPhzWj9WO1clHTMGa3JDZwrnQq4sF86dIHNDz0W1"
crossorigin="anonymous"></script>
```

```
  <script src="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/js/bootstrap.min.js"
integrity="sha384-
JjSmVgyd0p3pXB1rRibZUAYoIIy6OrQ6VrjIEaFf/nJGzIxFDsf4x0xIM+B07jRM"
crossorigin="anonymous"></script>
  <script src="https://cdn.jsdelivr.net/npm/@tensorflow/tfjs@latest"></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 style=" background: linear-gradient(too right,light blue 30%,light pink 60%)"> <br>


  <h1 class="welcome">IBM PROJECT
  <div id="team_id">TEAM ID : PNT2022TMID27796</div>
  </h1>
  <section id="title">
    <h4 class="heading">A NOVEL METHOD FOR HANDWRITTEN DIGIT
RECOGNITION </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>


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

 </section>
<center>
<div>_____
_____</div
>


<p><label for="file" style="font-weight : bold; font-size:21px;">Upload Image</label></p>

<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>


 <section id="content">

      <div class="leftside">


      <form action="/predict" method="POST" enctype="multipart/form-data">

      <input id="image" type="file" name="image" accept="image/png, image/jpeg" onchange="preview()"><br><br>
        <img id="frame" src="" width="200px" height="200px"/>


        <div class="buttons_div">
          <button type="submit" class="btn btn-yellow" id="predict_button">Predict</button>
          <button type="button" class="btn btn-dark" id="clear_button">  Clear  </button>
```

```
            </div>
          </form>
          </div>
      </section>

    </body>

    </html>
```

PREDICT .HTML

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

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

STYLE.CSS:

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

#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:  black;
   background-color: BA94D1;
   padding-top: 1%;
   padding-bottom: 1%;
   font-weight: bold;
   box-shadow:0px 2px 5px  black;
   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%;
  color:black;
}

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

IBM PROJECT

TEAM ID : PNT2022TMID27796

A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION

The website is designed to predict the handwritten digit.

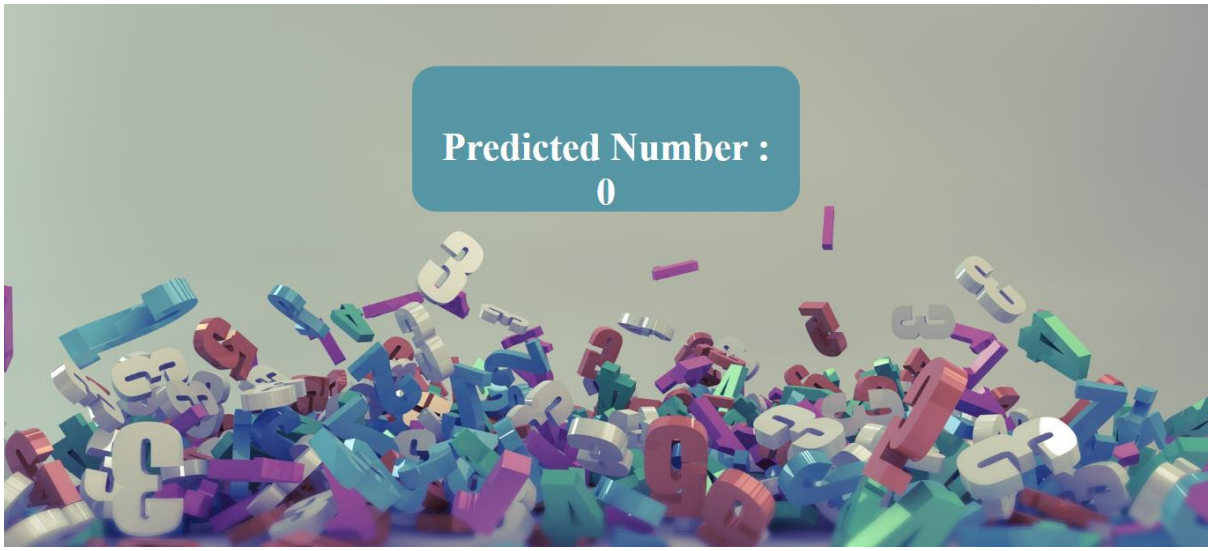
Handwriting recognition is one of the compelling research works going on because every individual in this world has their own style of writing. It is the capability of the computer to identify and understand handwritten digits or characters automatically. Because of the progress in the field of science 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

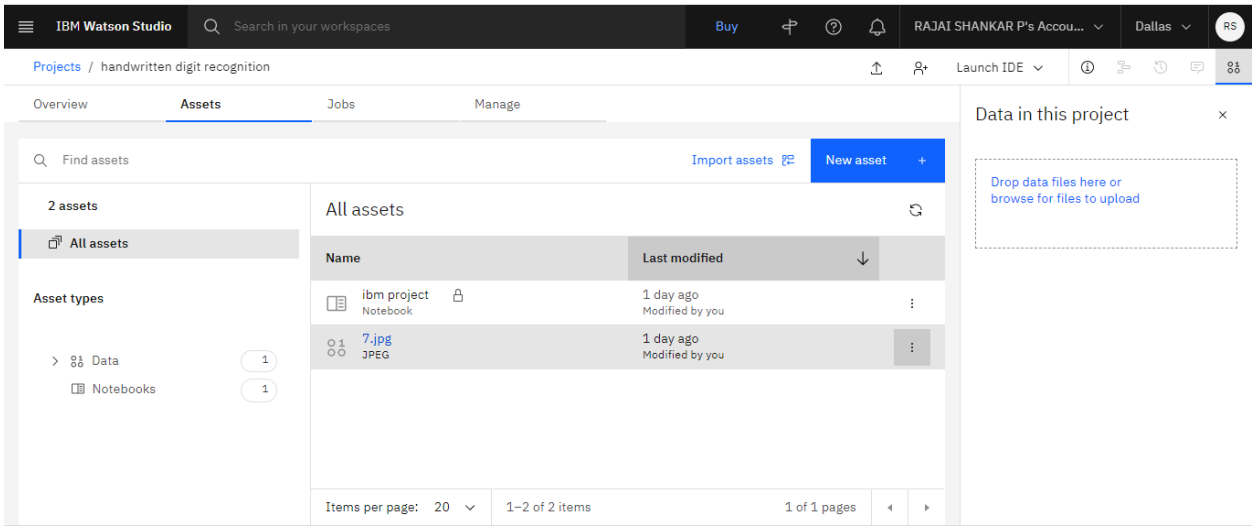
Upload Image

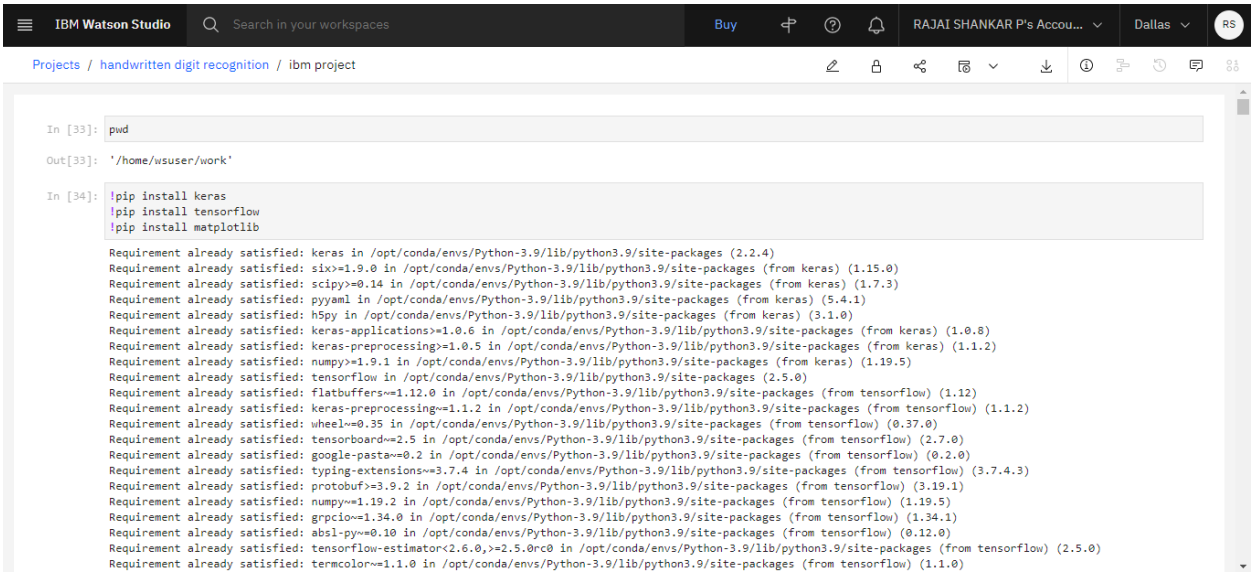
Choose File img_111.jpg

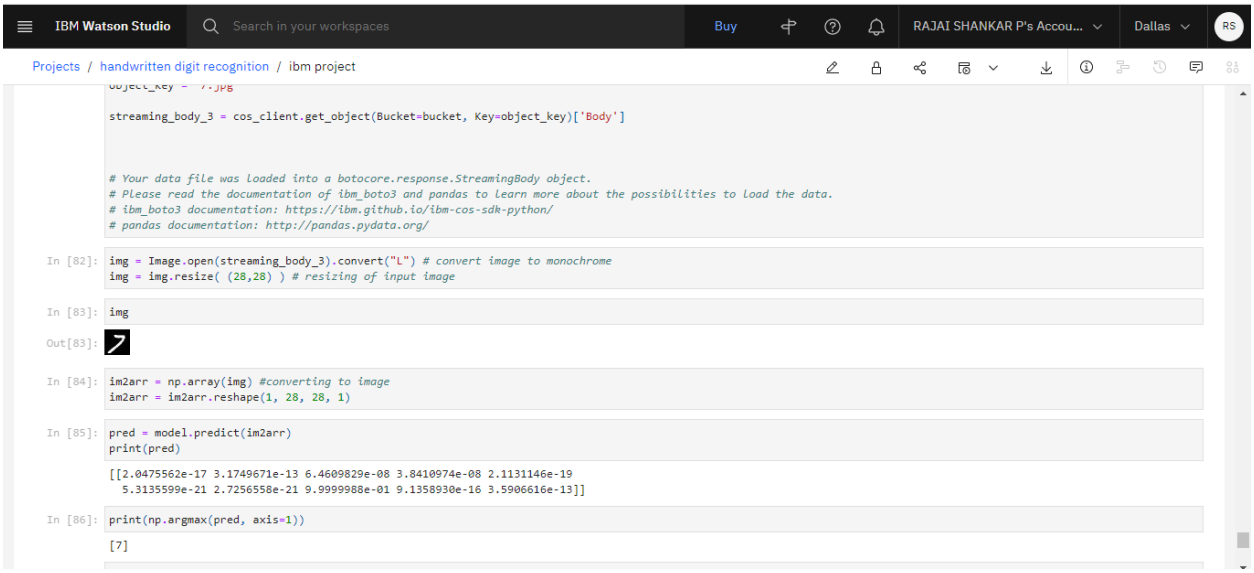
Predict Clear



TRAIN THE MODEL ON IBM







GITHUB LINK-https://github.com/IBM-EPBL/IBM-Project-21613-1659785875

DEMO LINK- https://www.youtube.com/watch?v=k1zJw0S1ZTc