

## **BONAFIDE CERTIFICATE**

Certified that this project titled "**A NOVEL METHOD FOR HANDWRITTENDIGIT RECOGNITION**" is the Bonafide work of **HARIPRIYA S(731119106009), PUJA SHREE J(731119106025),MONICA T(731119106018)** and **UMA MEENATCHI SUNDHARI S(731119106037)** who carried out the project work under my supervision.

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# **Project Report Submission**

Team ID : PNT2022TMID44334

Project Name : A Novel Method for Handwritten Digit Recognition System

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# **CHAPTER 1**

## **INTRODUCTION**

Handwritten Digit Recognition is the capability of a computer to process the handwritten integers from different sources like images, papers and transcripts and classify them into 10 predefined classes (0-9). Digit recognition is the process of detecting and recognizing Handwritten digits from the input image and converts it into ASCII or other equivalent machine editable form. Handwritten Digit Recognition System involves analysis and interpretation of handwritten digits by a system. Handwritten digit Recognition has a wide area of study and research due to its enormous applications like automatic bank cheques processing, billing and automatic postal service. Systems that are used to recognize digits help people to solve more complex problems that otherwise it would be time-consuming one. An example is the use of automatic processing systems which are used in banks to process bank cheques. Without automated bank cheque processing systems, the bank would be required to employ many employees who may not be as efficient as the computerized processing system.

### **1.1 Project Overview**

In recent years, different recognition systems have been proposed to be used in various fields where high classification efficiency is needed. In this field, convolutional neural networks have made a substantial breakthrough in visual recognition, especially handwritten digit recognition. These networks have a great ability for learning and extracting image features easily. CNN architectures for image classification have two different types of layers: convolutional layers for extracting image features and fully connected layers for performing the classification task based on the features extracted

by the preceding convolutional layers .The CNN have used MNIST handwritten digits as a dataset. CNN is the most optimal technique to recognize handwritten digits with accuracy of about 95 percentage.

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.

## 1.2 Purpose

The applications where these handwritten digit recognition can be used are Banking sector where it can be used to maintain the security pin numbers, it can be also used for blind peoples by using sound output. For example Convolution Neural networks with back propagation for image processing. Handwritten character recognition is one of the practically important issues in pattern recognition applications. The applications of digit recognition includes in postal mail sorting, bank check processing, form data entry, etc. Handwritten character recognition (HCR) is the detection of characters from images, documents and other sources and changes them in machine-readable shape for further processing.

## **CHAPTER 2**

### **LITERATURE SURVEY**

#### **2.1 Existingproblem**

Digit recognition plays a major role in the modern world. Handwritten digit recognition is a more challenging problem so that the researchers had been study in this area for the recent years. In our study research, there are many terms relate with Handwritten numbers, say for example, cheques in banks or number plates in car or pincode recognition of postal and courier services, the knowledge of recognition of digits emerges. A dedicated system for the recognition of isolated digits may be a suitable approach for handling with such applications. In other words, the computer understand the digital numbers that is written manually by users and analyse them according to the processor. Engineers who have better skills and knowledge in image processing,data analysis and pattern recognition have developed different methods to deal with handwriting number recognition problems such as decision tree, minimum distance, and statistics.The major problem is to correctly identify digits from a dataset of thousands of handwritten images and experiment with different algorithms to learn first-hand what works well and how techniques compare. Converting handwritten digits into digital ones is a major challenge.

#### **2.2 References**

In the year of 2013 Yang Zong-chang,In this study, to the main problem of establishing structure for the Artificial Neural Networks (ANN), from a microscopical perspective, two ideas called the fractal measurement of association multifaceted nature (FDCC) and the fractal measurement of the desire many-sided quality (FDEC) are presented. At that point a paradigm reference for setting up ANN structure taking into account the two

proposed ideas is displayed that, the FDCC won't not be lower than its (FDEC), and when FDCC is equivalent or surmised to FDEC, the ANN structure may be an ideal one. The proposed measure is inspected with great results.

In the year of 2013 Selvi, P.P.; Meyyappan, T, In the Study of the authors propose a method to recognize Arabic numerals using back propagation neural system. Arabic digit are the ten digits that were descended from the Indian numeral system. The recognition phase recognizes the numerals precisely. The prospect technique is implemented with Matlab coding. Model and written descriptions are tested with the proposed method and the results are plotted.

In the year of 2013 Sahu, N.; Raman, N.K., In the Study of Character recognition systems for various languages and script has gain importance in recent decades and is the area of deep interest for a lot of researchers. Their growth is strongly integrated with Neural Networks.

In the year of 2012 Nguang Sing Ping; Yusoff, M.A., Investigated on describes the application of 13-point feature of skeleton for an image-to-character credit. The representation can be a scanned handwritten character or drawn character from any graphic designing tool like Windows Paint clash. The representation is processed through conventional and 13-point feature of skeleton methods to extract the raw data. In the year of 2012 Pradeep, J.; Srinivasan, E.; Himavathi, S., In the Study of, an offline handwritten English character recognition system using hybrid feature extraction technique and neural network classifiers are proposed. Neural Network (NN) topologies, namely, rear spread neural network and radial basis function network are built to classify the font. The k-nearest neighbour network is also built for evaluation. The nosh onward NN topology exhibits the highest recognition accuracy and is identified to be the most suitable classifier.

In the year of 2011 Budiwati, S.D.; Haryatno, J.; Dharma, E.M., Investigated on Japanese language has complex writing systems, Kanji and Kana (Katakana and Hiragana). Each one has different style of writing. One simple way to differentiate is Kanji have more strokes than Kana. Meanwhile, it needs a lot of effort to remember

characters of Katakana and Hiragana, thus it will be very difficult to distinguish handwritten Katakana and Hiragana, since there are a lot of similar characters. This is the reason why we need pattern recognition.

## 2.3 Problem Statement Definition

Data entering by hand takes numerous time. 10,000 to 15,000 keystrokes per hour is a decent rate for entering data from paper documents. Complex facts that require understanding before entry would slowdown the process even more. Thus, it would take an experienced operator between eight and 10 minutes to enter 400 units of data, which is unsatisfactory when the volume of data is considerable.

The main aim for our project is to recognize isolated digits which exist in various applications. For example, different users have different handwriting styles where here the major challenge falls to let the computer system understand these different types of these handwriting styles and recognize them as standard form of writing.

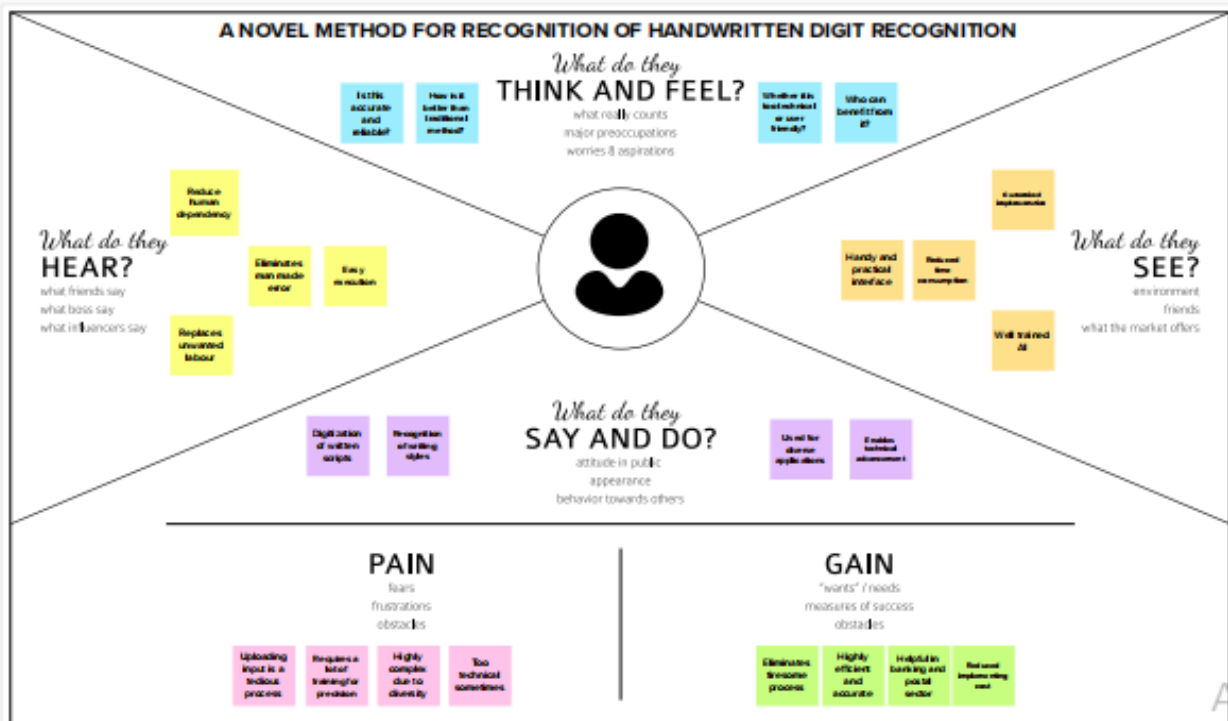


## CHAPTER 3


### IDEATION & PROPOSED SOLUTION

#### 3.1 Empathy Map Canvas

Build empathy and keep your focus on the user by putting yourself in their shoes.



# 3.2 Ideation & Brainstorming



## Brainstorm & idea prioritization

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.

10 minutes to prepare

1 hour to collaborate

2-8 people recommended



### Before you collaborate

A little bit of preparation goes a long way with this session. Here's what you need to do to get going.

10 minutes

- A

**Team gathering**  
Define who should participate in the session and send an invite. Share relevant information or pre-work ahead.
- B

**Set the goal**  
Think about the problem you'll be focusing on solving in the brainstorming session.
- C

**Learn how to use the facilitation tools**  
Use the Facilitation Superpowers to run a happy and productive session.

[Open article](#)

1

**Define your problem statement**  
What problem are you trying to solve? Frame your problem as a How Might We statement. This will be the focus of your brainstorm.  
 5 minutes

PROBLEM

How might we develop an AI model and train it to recognize the handwritten digits?

**Key rules of brainstorming**  
To run a smooth and productive session

Stay in topic.

Encourage wild ideas.

Defer judgment.

Listen to others.

Go for volume.

If possible, be visual.

2

**Brainstorm**  
Write down any ideas that come to mind that address your problem statement.  
 10 minutes

**S HARIPRIYA**

This model can be used in banking and postal sector

Conversion of written text into digital text

Model should be able to process bulk data swiftly

Reduced time consumption for a tedious process

It should be able to recognize styles from different time period.

Results should be precise and accurate.

**T MONICA**

Should be trained for real time recognition

Should be applicable for wide range of languages

Useful for old age people and online form filling

Time saver in public sector

Can be used for digitizing manuscripts

Helpful for online notes taking

**J PUJA SHREE**

Highly useful in touch screen devices.

Data used in this model can be used in AI handwriting generation.

Enables online application process less time consuming.

It should be able to process special characters in handwriting.

Can be used in tracking down vehicles using number plate.

Should be able to digitize large input data.

**S UMA MEENATCHI SUNDHARI**

Should be able to extend for handwritten languages.

It can be highly useful in finding criminal activities or forgery.

If efficient, this method can be used in paper digitization and evaluation

Should be fast and accurate

better if it is an extension rather than web app

Should be user friendly without much complexities

3

### Group Ideas

Take turns sharing your ideas while clustering similar or related notes as you go. In the last 10 minutes, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you can break it up into smaller sub-groups.

20 minutes



4

### Prioritize

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

20 minutes



## 3.3 Proposed Solution

The proposed solution table with problem statement, solution, social impact, scalability of solution and uniqueness will be given below

s.no	Parameter	Description
1.	Problem Statement (Problem to be solved)	The major problem is to correctly identify digits from a dataset of thousands of handwritten images and experiment with different algorithms to learn first-hand what works well and how techniques compare. Converting handwritten digits into digital ones is a major challenge.
2.	Idea / Solution description	Train a model to interpret the handwritten digits. Use CNN (Convolutional Neural Network) model for handwritten digit recognition. Its built-in convolutional layer reduces the high dimensionality of image without losing its information.
3.	Novelty / Uniqueness	CNN can extract informative features from images and eliminates the need of traditional manual image processing methods. CNN is better for training phase with less computational power and less information loss for high accuracy.
4.	Social Impact / Customer Satisfaction	1. Postal department and courier services can easily find the digits written. 2. Old people who have eye sight issues with handwritten digits. 3.Processing of bank cheque books.
5.	Business Model (Revenue Model)	Helps in Banking sector and Postal sector by providing the services.

		Tracking the Number plates of vehicles. Helps in digitalization of libraries.
6.	Scalability of the Solution	

### 3.4 Problem solution fit

Define CS, fit into CL	<b>1. CUSTOMER SEGMENT(S)</b> <b>CS</b> Banking sector Post Office Library/Archives Traffic Controllers Old age people	<b>6. CUSTOMER LIMITATIONS</b> EG. BUDGET, DEVICES <b>CL</b> <b>6.1</b> Smartphones or computers with camera facility is mandatory. <b>6.2</b> Continuous network is required. <b>6.3</b> Cloud or servers are required to be installed for database management.	<b>5. AVAILABLE SOLUTIONS</b> PLUSES & MINUSES <b>AS</b> <b>5.1 Google handwriting recognition app</b> <b>Pros:</b> Wide range of languages. Digitization with immediate translation. <b>Cons:</b> Not user friendly. <b>5.2 Transkribus</b> <b>Pros:</b> Digitization of large data quickly. <b>Cons:</b> Available only for German.	Explore AS, differentiate
	<b>2. PROBLEMS / PAINS</b> +ITS FREQUENCY <b>PR</b> Scanning of documents is not sufficient for digitizing as it can be illegible at times. <i>Very often</i> Due to various handwriting styles there can be lot of confusion while giving scanned input. <i>Occasionally</i> Since there are lot of scripting styles, experts in the specific language scripts are required. This need can be eliminated. <i>Frequently</i> Most of the existing solutions don't have a provision real time input. <i>Very often</i>	<b>9. PROBLEM ROOT / CAUSE</b> <b>RC</b> <i>9.1 Additional human effort is required for digitization.</i> <i>9.2 Hardcopy can be damaged over time so softcopy will be required.</i> <i>9.3 Manual process can be time consuming so a AI model will be a advantage.</i> <i>9.4 Precision and Accuracy can be less in manual process.</i>	<b>7. BEHAVIOR</b> +ITS INTENSITY <b>BE</b> It can be used in both real time and offline. The processing speed depends upon the no. of samples trained and capacity of the system. It reduces the dimensionality of a image without any loss of information. It operates with less computational power.	Focus on PR, tap into BE, understand RC
Identify strong TR & EM	<b>3. TRIGGERS TO ACT</b> <b>TR</b> 1.1 As it reduces time consumption and human effort, it can be widely used in sectors with huge public participation. 1.2 People in literature or documentation fields can be highly benefited.	<b>10. YOUR SOLUTION</b> <b>SL</b> A AI trained model for image processing which converts image to digit is proposed. We use CNN model on MNIST dataset consisting of 70,000 images of handwritten digits. CNN can extract informative features from images and eliminates the need of traditional manual image processing methods. Deep learning and adding CNN layers helps in improving the accuracy of prediction.	<b>8. CHANNELS of BEHAVIOR</b> <b>CH</b> <b>ONLINE</b> 8.1 Real time analysis of input. 8.2 Faster processing of digits. 8.3 Storage is not necessary.	Extraction online & offline CH of BE
	<b>4. EMOTIONS</b> <b>EM</b> Relief from distress Independent Efficient An example for others		<b>OFFLINE</b> 8.4 Input is acquired from image repository. 8.5 Processing is slower when offline. 8.6 Database servers are mandatory.	

## CHAPTER 4

### REQUIREMENT ANALYSIS

#### 4.1 Functional requirement

Functional Requirements: Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form Registration through Gmail Registration through Web Application
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP Confirmation via Password
FR-3	User Login	Login via Registered Username. Login via Email & Password.
FR-4	User Authentication	Authentication through Captcha Banking sector: Authentication through IFSC code & Authentication through finger print Library and postal sector: Authentication through Identification Card .
FR-5	User Input	Upload the input as Scanned image Upload the input from Database Get the input as Real time image
FR-6	System configuration	RAM At least 4GB System with Graphical User Interface Camera with better resolution
FR-7	Business Rules	System provides an error message when the input is not in a required format. Minimum resolution of image should be of 180 DPI. Size of the image should not exceed 1MB.

## 4.2 Non-Functional requirement

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

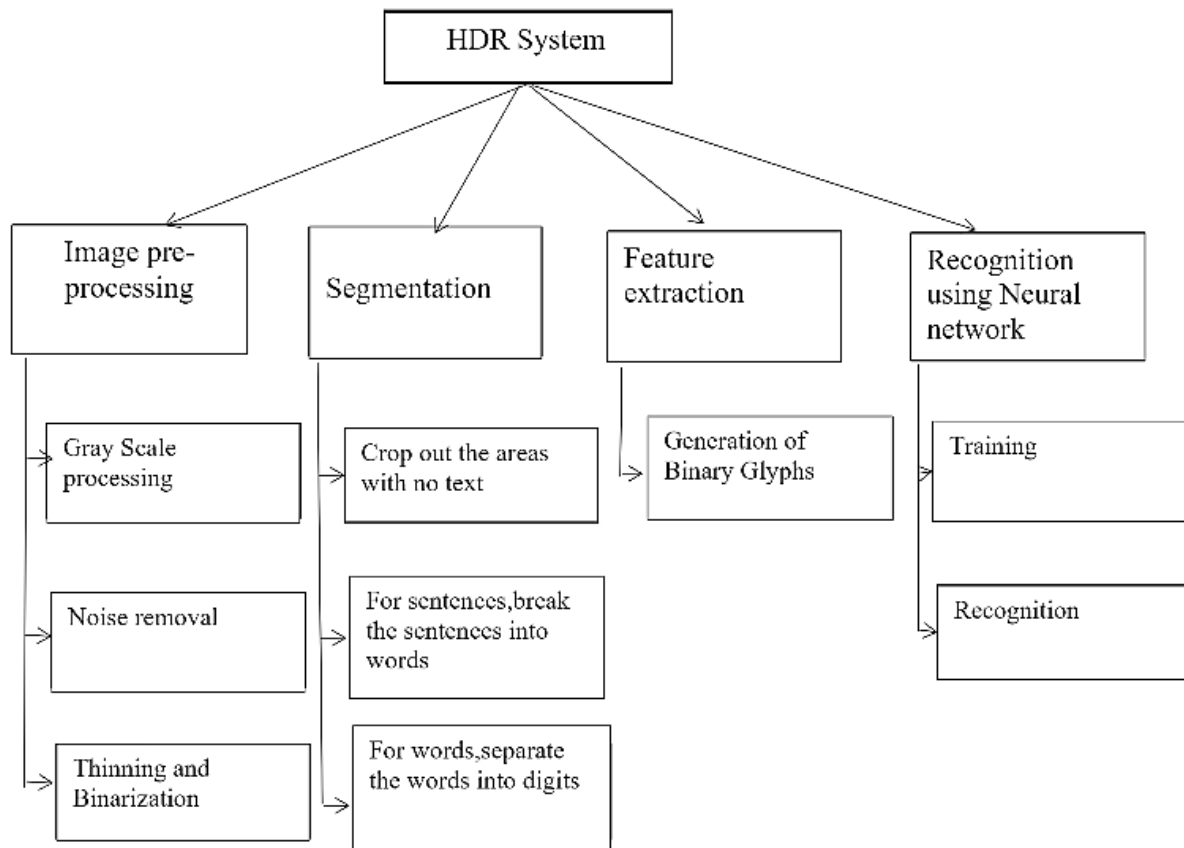
FR No.	Non-Functional Requirement	Description
NFR-1	Usability	Useful for areas that deals with large databases to reduce complexity User friendly.
NFR-2	Security	Access only to authorized persons. Easy to track users.
NFR-3	Reliability	This model is highly trained,accuracy is highly improved.
NFR-4	Performance	Reduces a human supervision and improves Efficiency.
NFR-5	Availability	Available for every users like Banks,Post Office,Library,etc.
NFR-6	Scalability	Model is predicted to have accuracy of 95% and has oppurtunity of extending model to recognize text.

## CHAPTER 5

### PROJECT DESIGN

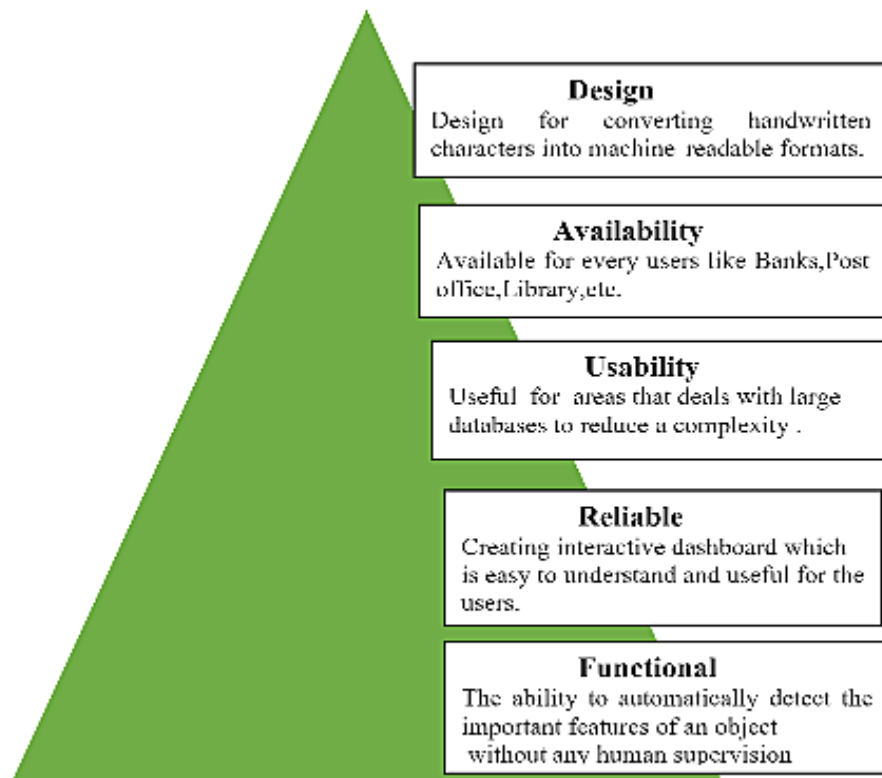
#### 5.1 Data Flow Diagrams

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.

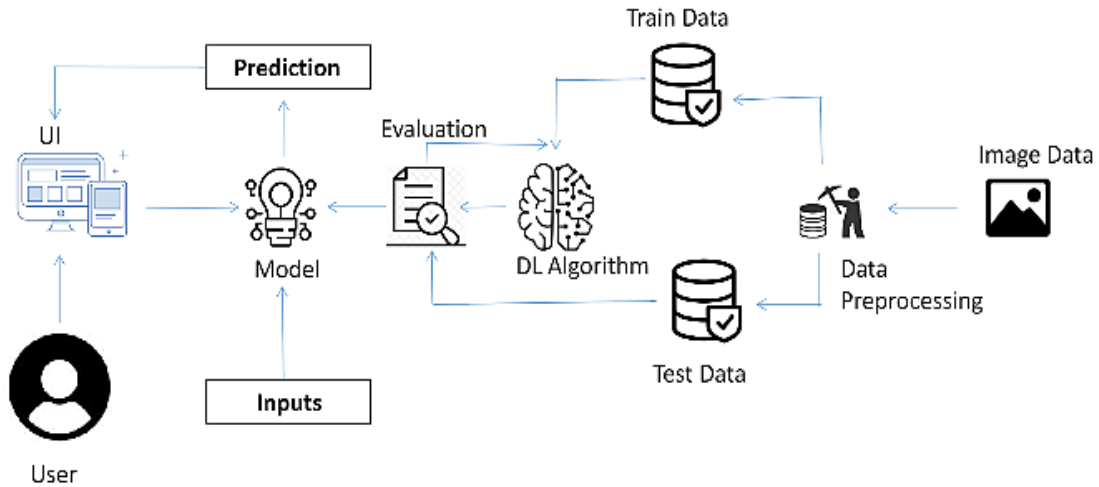




## 5.2 Solution and Technical Architecture



# Technical Architecture



## 5.3 User Stories

User Type	Functional requirement (epic)	User story Number	User story/Task	Acceptance criteria	Priority	Release
Customer(mobile user)	Home	USN-1	As a user,can sign up to create an account and set password.	I can view the awareness to use this application and its limitations.	Low	Sprint-1
		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can gain knowledge to use this application by a practical method.	Low	Sprint-1
		USN-3	As a user, we can upload video to interface.	I can read instructions also to use it in a userfriendly 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-5	As a user, I can log into the application by entering email & password	I can upload and choose the image from the storage	Medium	Sprint-3

		USN-6	I can choose the image from our . local system and predict the output.	I can able to train and test the application until it gets maximum accuracy of the result	High	Sprint-4
		USN-7	As a user, I'm Allowed to upload and choose the image to be uploaded	I can access the MNIST data set to produce the accurate result.	Medium	Sprint-3
Customer(Web user)	Home	USN-8	As a user, I can access the MNIST data set .	I can view the awareness of this application and its limitations.	Low	Sprint-1
	Recognize	USN-9	As a user, I'm allowed to view video .	I can use the application portable anywhere	High	Sprint-1
		USN-10	As a user can install in Free of cost.	I can use it without any payment to be paid for it to access	Medium	Sprint-2
		USN-11	As a user, can use the application virtually anywhere	I can use it without the installation of the application or any software.	Medium	Sprint-4
	Predict	USN-12	As it is an open source, can use it cost freely.	I can upload and choose the image from the storage .	Medium	Sprint-3

## CHAPTER 6

### PROJECT PLANNING AND SCHEDULING

#### 6.1 Sprint Planning & Estimation

TITLE	DESCRIPTION	DATE
Prepare Empathy Map	Prepare Empathy Map Canvas to capture the user Pains & Gains, Prepare list of problem statements	15 SEPTEMBER 2022
Literature Survey & Information Gathering	Literature survey on the selected project & gathering information by referring the, technical papers, research publications etc.	15 SEPTEMBER 2022
Ideation	List the by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance.	18 SEPTEMBER 2022
Proposed Solution	Creation of proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalability of solution, etc	18 SEPTEMBER 2022
Problem Solution Fit	Creation of problem solution fit document.	24 SEPTEMBER 2022
Solution Architecture	Solution Architecture	24 SEPTEMBER 2022

Customer Journey	Prepare the customer journey maps to understand the user interactions & experiences with the application.	18 OCTOBER 2022
Data Flow Diagrams	Draw the data flow diagrams and submit for review	18 OCTOBER 2022
Technology Architecture	Prepare the technology architecture diagram	18 OCTOBER 2022

## 6.2 Sprint Delivery & Schedule

Sprint	Functional Requirement	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	Monica T Uma Meenatchi Sundhari.S
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	Hari Priya.S Puja Shree.J
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	Monica.T Uma Meenatchi Sundhari.S Hari Priya.S Puja Shree.J
Sprint-2	Add CNN layers	USN-4	Creating the model	5	High	Uma Meenatchi

			and adding the input, hidden, and output layers to it			Sundhari.S
Sprint-2	Compiling the mode	USN-5	With both the training data defined and model	2	Medium	Hari Priya.S
Sprint-2	Train and test the model	USN-6	As a user,let us train our model with our image dataset.	6	Medium	Puja Shree.J Haripriya.S Monica.T
Sprint-2	Save the model	USN-7	As a user,the model is saved and integrated as android application or web application inorder to predict something.	2	Low	Monica.T
Sprint-3	Building UI application	USN-8	As a user,I will upload the handwritten digit image to the application through upload option.	10	High	Puja Shree.J Monica.T
Sprint-3		USN-9	As a user,I know the details of the fundamental details of the application.	5	Low	Haripriya.S
Sprint-3		USN-10	As a user,I can see the predicted or recognised digits in the application.	5	Medium	Uma Meenatchi Sundhari.S
Sprint-4	Train the model on IBM	USN-11	As auser,I will train my model on IBM and integrate flask/Django with scoring end point.	10	High	Puja Shree.J
Sprint-4	Cloud deployment .	USN-12	As a user,I can access the web application and make use ofthe product from anywhere	10	High	HariPriya.S

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 5 Days 31 Oct 2022				04 Nov 2022		

### 6.3 Reports from JIRA

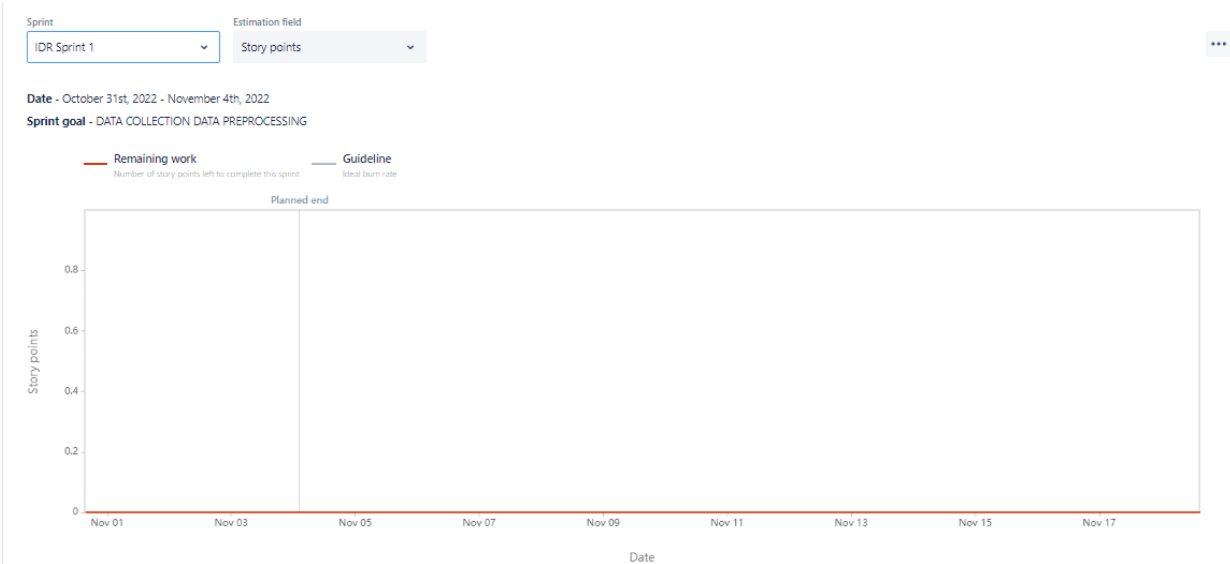
JIRA is a project management tool developed by an Australian based software company known as Atlassian Corporation Plc. Jira Software is part of a family of products designed to help teams of all types manage work. Originally, Jira was designed as a bug and issue tracker. But today, Jira has evolved into a powerful work management tool for all kinds of use cases, from requirements and test case management to agile software development.

JIRA ROADMAP

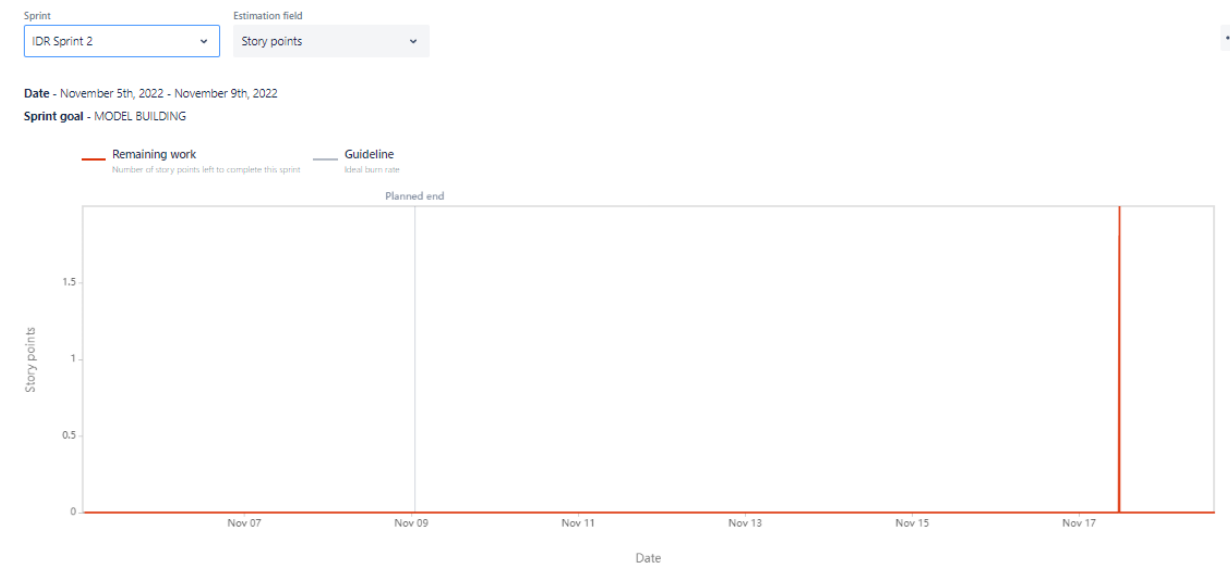
		NOV
Sprints		IDR... IDR... IDR... IDR...
> + IDR-33 Sprint 1: Understanding the data	DONE	<div></div>
▼ + IDR-34 Sprint 2: Model building		<div></div>
✓ IDR-42 Add CNN Layers	DONE	
✓ IDR-43 Compiling The Model	DONE	
✓ IDR-44 Train The Model	DONE	
✓ IDR-45 Observing The Metrics	DONE	
✓ IDR-46 Test The Model	DONE	
✓ IDR-47 Save The Model	DONE	
✓ IDR-48 Test With Saved Model	DONE	
▼ + IDR-35 Sprint 3: Application building	DONE	<div></div>
✓ IDR-49 Create An HTML File	DONE	
✓ IDR-50 Build Python Code	DONE	
✓ IDR-51 Run The Application	DONE	
▼ + IDR-36 Sprint 4: Train the model on IBM	DONE	<div></div>
✓ IDR-52 Register For IBM Cloud	DONE	
✓ IDR-53 Train The Model On IBM	DONE	



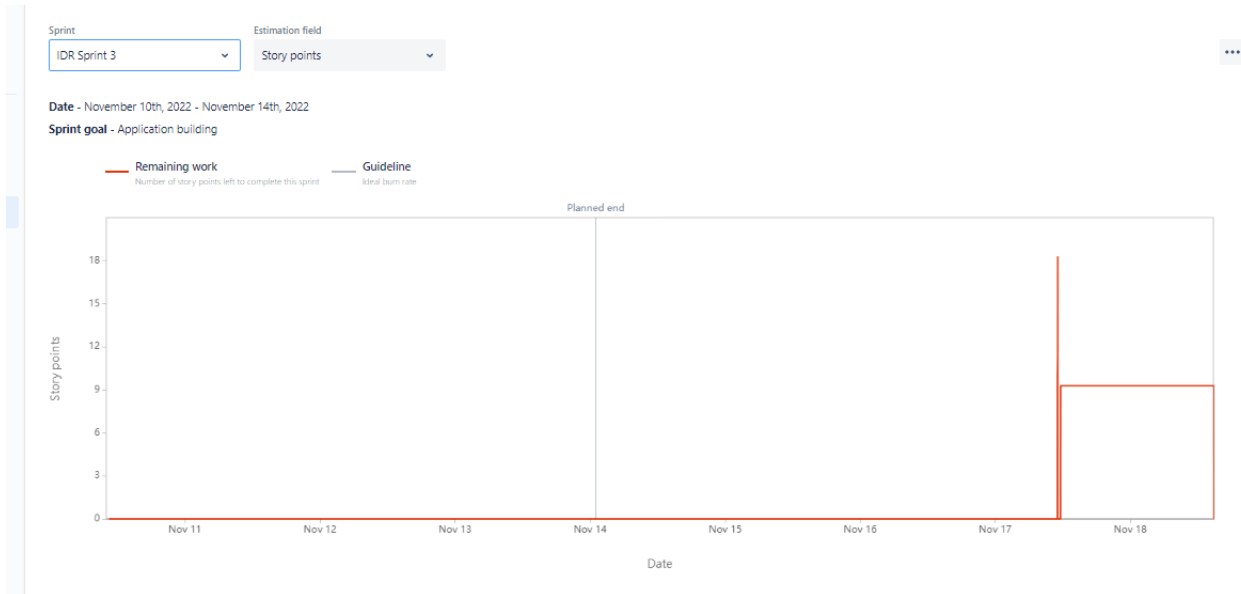
# Sprint Burndown chart - sprint 1



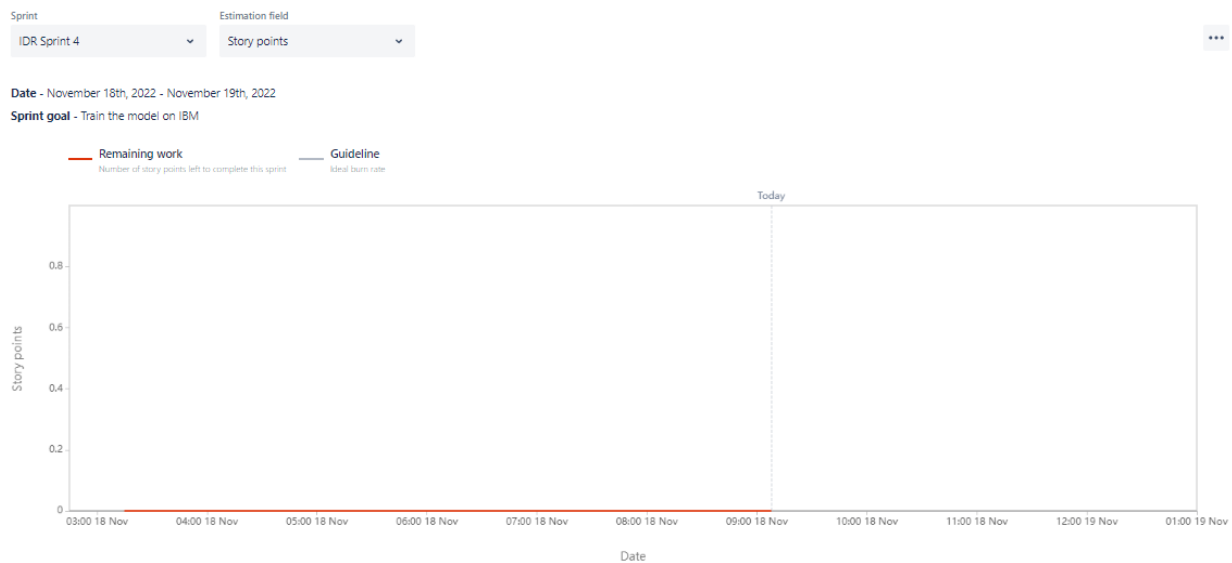
# Sprint Burndown chart - sprint 2



## Sprint Burndown chart - sprint 3



## Sprint Burndown chart - sprint 4



## CHAPTER 7

### CODING & SOLUTIONING

#### 7.1 Import libraries

```
import numpy
import tensorflow
from tensorflow.keras.datasets import mnist
from tensorflow.keras import layers
from tensorflow.keras.layers import Dense, Flatten
from tensorflow.keras.layers import Conv2D
from keras.models import Sequential
from keras.optimizers import Adam
from keras.utils import np_utils
```

#### 7.2 Loading the data

```
(X_train,y_train),(X_test,y_test) = mnist.load_data()
print(X_train.shape)
print(X_test.shape)
```

#### ANALYSING THE DATA

```
X_train[0]
y_train[0]
import matplotlib.pyplot as plt
plt.imshow(X_train[0])
Reshaping the data
```

```
X_train =X_train.reshape(60000,28,28,1).astype('float32')
X_test =X_test.reshape(10000,28,28,1).astype('float32')
```

One Hot Encoding

```
number_of_classes = 10
y_train = np_utils.to_categorical(y_train,number_of_classes)
y_test=np_utils.to_categorical(y_test,number_of_classes)
y_train[0]
```

ADD CNN LAYERS

```
model = Sequential()
#adding model layer
model.add(Conv2D(64,(3,3),input_shape=(28,28,1),activation='relu'))
model.add(Conv2D(32,(3,3),activation='relu'))
model.add(Flatten())
model.add(Dense(number_of_classes,activation='softmax'))
Compiling the model
model.compile(loss='categorical_crossentropy',optimizer='Adam',metrics=['accuracy'])
```

**Train the model**

```
model.fit(X_train,y_train,epochs= 2,validation_data=(X_test,y_test),batch_size=32)
```

**OBSERVING THE METRICS**

```
metrics= model.evaluate(X_test,y_test,verbose=0)
print("Metrics(Test loss & Test Accuracy): ")
print(metrics)
```

**PREDICTING THE OUTPUT**

```
prediction = model.predict(X_test[:4])
```

```

print(prediction)
import numpy as np
print(np.argmax(prediction,axis=1))
print(y_test[:4])
example = X_train[1]
prediction = model.predict(example.reshape(1, 28, 28, 1))
print ("Prediction (Softmax) from the neural network:\n\n {}".format(prediction))
hard_maxed_prediction = np.zeros(prediction.shape)
hard_maxed_prediction[0][np.argmax(prediction)] = 1
print ("\n\nHard-maxed form of the prediction: \n\n {}".format(hard_maxed_prediction))
print ("\n\n----- Prediction ----- \n\n")
plt.imshow(example.reshape(28, 28), cmap="gray")
plt.show()
print("\n\nFinal Output: {}".format(np.argmax(prediction)))

```

#### OBSERVING THE METRICS

```

metrics= model.evaluate(X_test,y_test,verbose=0)
print("Metrics(Test loss & Test Accuracy): ")
print(metrics)
prediction = model.predict(X_test[:4])
print(prediction)

```

```

import numpy as np
print(np.argmax(prediction,axis=1))
print(y_test[:4])

```

#### SAVE THE MODEL

```

import cv2
image = cv2.imread('test_image.jpg')
image = np.full((100,80,3), 12, dtype = np.uint8)
grey = cv2.cvtColor(image.copy(), cv2.COLOR_BGR2GRAY)

```

```

ret, thresh = cv2.threshold(grey.copy(), 75, 255, cv2.THRESH_BINARY_INV)
contours,hierarchy = cv2.findContours(thresh.copy(), cv2.RETR_EXTERNAL,
cv2.CHAIN_APPROX_SIMP
preprocessed_digits = []
for c in contours:
x,y,w,h = cv2.boundingRect(c)
# Creating a rectangle around the digit in the original image (for displaying the digits
cv2.rectangle(image, (x,y), (x+w, y+h), color=(0, 255, 0), thickness=2)
# Cropping out the digit from the image corresponding to the current contours in the for
digit = thresh[y:y+h, x:x+w]
# Resizing that digit to (18, 18)
resized_digit = cv2.resize(digit, (18,18))
# Padding the digit with 5 pixels of black color (zeros) in each side to finally produce
padded_digit = np.pad(resized_digit, ((5,5),(5,5)), "constant", constant_values=0)
# Adding the preprocessed digit to the list of preprocessed digits
preprocessed_digits.append(padded_digit)
print("\n\n\n-----Contoured Image-----")
import os, types
import pandas as pd
def __iter__(self): return 0
print("\n\n\n-----Contoured Image-----")
plt.imshow(image, cmap="gray")
plt.show()
inp = np.array(preprocessed_digits)
SAVE THE MODEL

model.save('model.h5')
TEST WITH SAVED MODEL
from tensorflow.keras.models import load_model

```

```
model=load_model(r'C:/Users/DELL/Hand written recognition  
System/models/mnistCNN.h5)  
from PIL import Image  
import numpy as np  
for index in range(4):  
    img=Image.open('data/' +str(index) + 'png').convert("L")  
    img=img.resize((28,28))  
    im2arr=np.array(img)  
    im2arr=np.array(img)  
    im2arr=im2arr.reshape(1,28,28,1)  
    y_pred=model.predict(im2arr)  
    print(y_pred)
```

## CHAPTER 8

## TESTING

### 8.1 TEST CASES

Test case ID	Feature Type	Component	Test Scenario	Steps To Execute	Test Data	Expected Result	Actual Result	Status	BUG ID	Executed By
LoginPage_TC_O01	Functional	Home Page	Verify user is able to see the Login/Signup popup when user clicked on My account button	1.Enter URL and click go 2.Click on My Account dropdown button 3.Verify login/Signup popup displayed or not	<a href="https://shopenzer.com/">https://shopenzer.com/</a>	Login/Signup popup should display	Working as expected	Pass		
LoginPage_TC_O02	UI	Home Page	Verify the UI elements in Login/Signup popup	1.Enter URL and click go 2.Click on My Account dropdown button 3.Verify login/Signup popup with below UI elements: a.email text box b.password text box c.Login button d.New customer? Create account link e.Last password? Recovery password link	<a href="https://shopenzer.com/">https://shopenzer.com/</a>	Application should show below UI elements: a. email text box b. password text box c. Login button with orange colour d. New customer? Create account link e. Last password? Recovery password link	Working as expected	Fail	BUG-1234	
LoginPage_TC_O03	Functional	Home page	Verify user is able to log into application with Valid credentials	1.Enter URL( <a href="https://shopenzer.com/">https://shopenzer.com/</a> ) and click go 2.Click on My Account dropdown button 3.Enter Valid username/email in Email text box 4.Enter valid password in password text box 5.Click on login button	Username: chalam@gmail.com password: Testing123	User should navigate to user account homepage				
LoginPage_TC_O04	Functional	Home page	Verify user is able to log into application with Invalid credentials	1.Enter URL( <a href="https://shopenzer.com/">https://shopenzer.com/</a> ) and click go 2.Click on My Account dropdown button 3.Enter Invalid username/email in Email text box 4.Enter valid password in password text box 5.Click on login button	Username: chalam@gmail.com password: Testing123	Application should show 'Incorrect email or password' validation message.				
HP_TC_001	UI	Home page	Verify UI elements in the Home Page	1) Open the page 2) Check if all the UI elements are displayed 3) Verify recognize button displayed or not	127.0.0.8000	Display home page	Home page is displayed	Working as expected		Haripriya S, Puja shree J
HP_TC_002	Functional	Home page	Check if user can upload their file	1) Open the page 2) Click on select button 3) Select the input image	1.png	The input image should be uploaded to the application successfully	Image uploaded successfully	Working as expected		Monica T, Uma meenatchi sundhari S
HP_TC_003	Functional	Home page	Check if user can upload their file	1) Open the page 2) Click on select button 3) Select the input image	1.png	The input image should be uploaded successfully	Image uploaded successfully	Working as expected		Haripriya S, Puja shree J
HP_TC_004	Functional	Home Page	Check if user cannot upload unsupported file	1) Open the page 2) Click on select button 3) Select a random PDF file	PDF file	The application should not allow upload of unsupported file	User is able to upload	Pass		Monica T, Uma meenatchi sundhari S
BE_TC_001	Functional	Backend	Check if all the routes are working properly	1) Go to Home Page 2) Upload the input image 3) Check the result	1.png	All the routes should properly work	Working as expected	Fail		Haripriya S, Puja shree J
M_TC_001	Functional	Model	Check if the model can handle various image sizes	1) Open the page in a specific device 2) Upload the input image 3) Repeat the above steps with different input image	1.png, 2.png, 3.png	The model should predict the number	Working as expected	Pass		Monica T, Uma meenatchi sundhari S
M_TC_002	Functional	Model	Check if the model predicts the digit	1) Open the page 2) Click on select button 3) Select the input image 4) Check the results	1.png	The model should predict the number in the complex image	Working as expected	Pass		Haripriya S, Puja shree J
M_TC_003	Functional	Model	Check if the model can handle complex input image	1) Open the page 2) Click on select button 3) Select the input image 4) Check the results	4.png	The Result page must be displayed properly	Working as expected	Pass		Monica T, Uma meenatchi sundhari S
RP_TC_001	UI	Result Page	Verify UI elements in the Result Page	1) Open the page 2) Click on select button 3) Select the input image 4) Check if all the UI elements are displayed properly	1.png	The input image should be displayed properly	Working as expected	Pass		Haripriya S, Puja shree J
RP_TC_002	UI	Result Page	Check if the input image is displayed properly	1) Open the page 2) Click on select button 3) Select the input image 4) Check if the input image are displayed properly	1.png	The result should be displayed properly	Working as expected	Pass		Monica T, Uma meenatchi sundhari S
RP_TC_003	UI	Result Page	Check if the result is displayed properly	1) Open the page 2) Click on select button 3) Select the input image 4) Check if the result is displayed properly	1.png	The result should be displayed properly	Working as expected	Pass		Haripriya S, Puja shree J
RP_TC_004	UI	Result Page	Check if the other predictions are displayed properly	1) Open the page 2) Click on select button 3) Select the input image 4) Check if all the other predictions are displayed properly	1.png	The other predictions should be displayed properly	Working as expected	Pass		monica T, Uma meenatchi sundhari S

### 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 A novel method for handwritten digit recognition 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 how they were resolved.

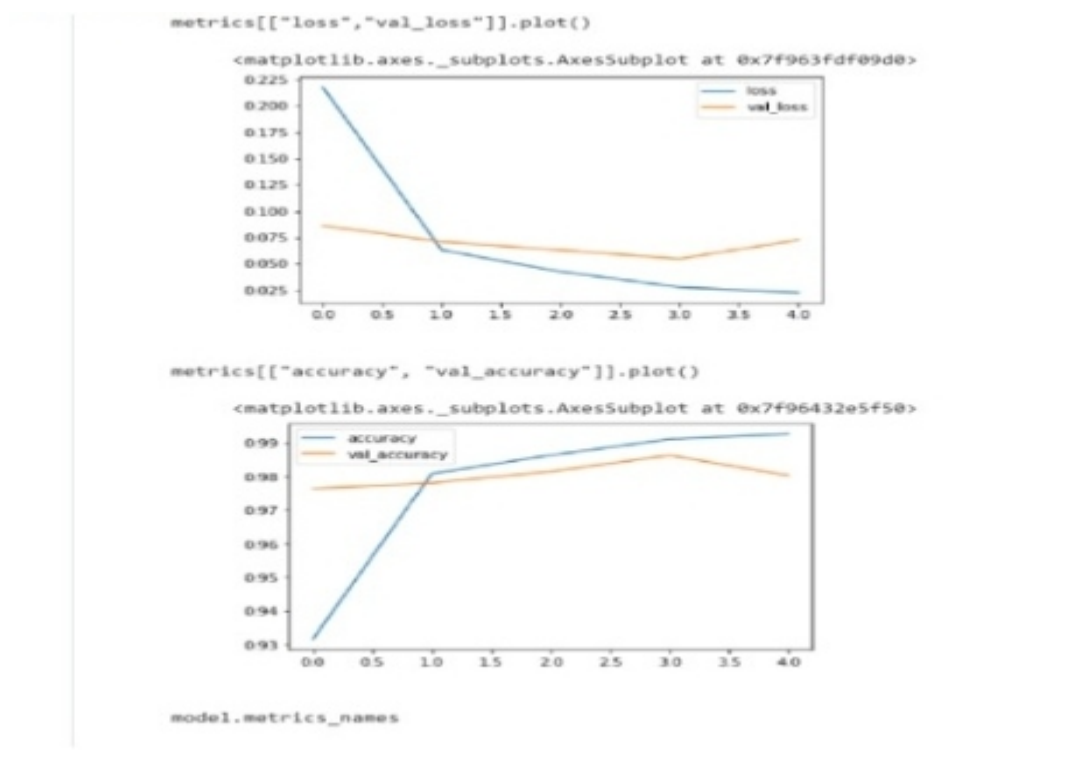
Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	13	4	2	5	24
Duplicate	1	0	0	2	3
External	2	3	1	1	7
Fixed	4	6	4	10	24
Not Reproduced	1	1	1	1	4
Skipped	1	2	0	1	4
Won't Fix	0	5	2	4	11
Totals	22	21	10	24	77

3. Test Case Analysis : This report shows the number of test cases that have passed, failed, and untested

## CHAPTER 9

### RESULTS

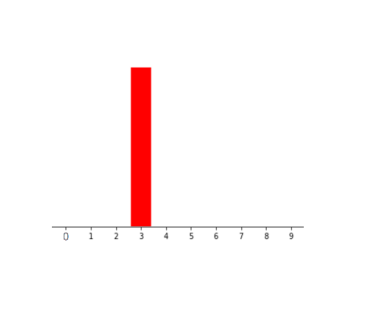
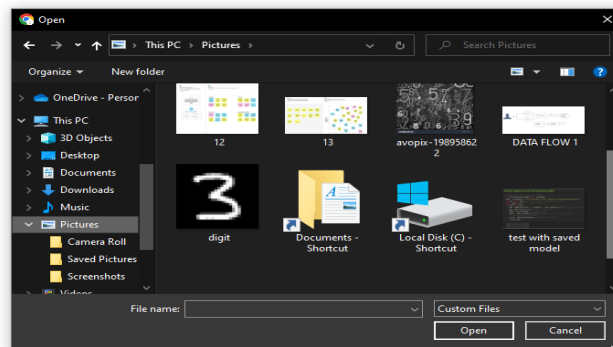
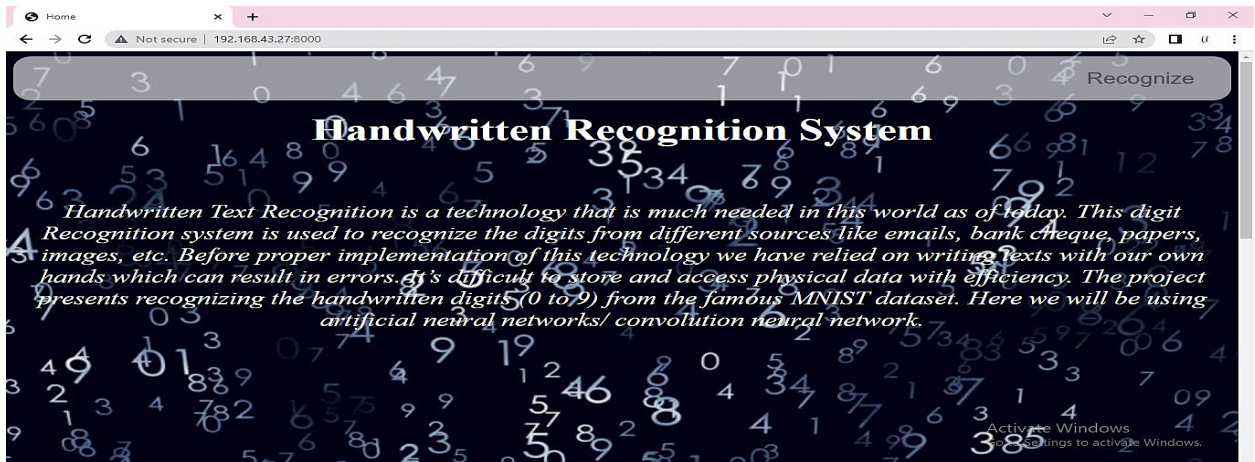
#### PERFORMANCE METRICS:



```
Command Prompt - python app.py
Microsoft Windows [Version 10.0.19044.2130]
(c) Microsoft Corporation. All rights reserved.

C:\Users\admin>cd C:\Users\admin\A-novel-method-for-digit-recognition-system\Flask App

C:\Users\admin\A-novel-method-for-digit-recognition-system\Flask App>python app.py
* Serving Flask app 'app'
* Debug mode: on
WARNING: This is a development server. Do not use it in a production deployment. Use a production WSGI server instead.
* Running on all addresses (0.0.0.0)
* Running on http://127.0.0.1:8000
* Running on http://192.168.43.27:8000
Press CTRL+C to quit
* Restarting with stat
```



Activate Windows  
Go to Settings to activate Windows.



## **CHAPTER 10**

### **ADVANTAGES & DISADVANTAGES**

#### **Advantages:**

- It is highly efficient and accurate
- This method eliminates tiresome process.
- It is very helpful in banking and postal sector.
- The cost of implementation is less in this method.
- The generative models can perform recognition driven segmentation.
- This method not only produces classification of the digit but also rich description of the instantiation parameters.

#### **Disadvantages:**

- In this method, uploading input is a tedious process.
- It requires a lot of training for precision.
- It is highly complex due to diversity.
- Sometimes, it is more technical.
- It is not done in real time as a person writes and therefore not appropriate for immediate text input.

## **CHAPTER 11**

### **CONCLUSION**

An implementation of Handwritten Digit Recognition using Deep Learning has been implemented in this project. Additionally, some of the most widely used Machine Learning algorithms i.e. CNN using Tensorflow have been trained and tested on the same data to draw a comparison as to why we require deep learning methods in critical applications like Handwritten Digit Recognition. In this project, we have shown that that using Deep Learning techniques, a very high amount of accuracy can be achieved. Using the Convolutional Neural Network with Keras as backend, we are able to get an accuracy of 97.48%. Every tool has its own complexity and accuracy. Although, we see that the complexity of the code and the process is bit more as compared to normal Machine Learning algorithms but looking at the accuracy achieved, it can be said that it is worth it. Thus we settled on classifying a given handwritten digit image as the required digit using different algorithms and consequently testing its accuracy. In future we are planning to further explore the topic to recognize people's handwriting.

## **CHAPTER 12**

### **FUTURE SCOPE**

The task of handwritten digit recognition, using a classifier, has great importance and use such as – online handwriting recognition on computer tablets, recognize zip codes on mail for postal mail sorting, processing bank check amounts, numeric entries in forms filled up by hand and so on. The future development of the applications based on algorithms of deep and machine learning is practically boundless. In the future, we can work on a denser or hybrid algorithm than the current set of algorithms with more manifold data to achieve the solutions to many problems. In future, the application of these algorithms lies from the public to high-level authorities, as from the differentiation of the algorithms above and with future development we can attain high-level functioning applications which can be used in the classified or government agencies as well as for the common people, we can use these algorithms in hospitals application for detailed medical diagnosis, treatment and monitoring the patients, we can use it in surveillances system to keep tracks of the suspicious activity under the system, in fingerprint and retinal scanners, database filtering applications, Equipment checking for national forces and many more problems of both major and minor category. The advancement in this field can help us create an environment of safety, awareness and comfort by using these algorithms in day-to-day application and high-level application (i.e., corporate level or Government level). Application-based on artificial intelligence and deep learning is the future of the technological world because of their absolute accuracy and advantages over many major problems.

## CHAPTER 13

### APPENDIX

#### Source Code

#### html code

```
<!DOCTYPE html>
<html>
<head>
<title>Home</title>
<style>
body
{
    background-image: url("../static/home_background.jpg");
    background-size: cover;
}
.pd{
padding-bottom:100%;}
.navbar
{
margin: 0px;
padding:20px;
background-color:white;
opacity:0.6;
```

```
color:black;
font-family:'Roboto',sans-serif;
font-style: italic;
border-radius:20px;
font-size:25px;
}
a
{
color:grey;
float:right;
text-decoration:none;
font-style:normal;
padding-right:20px;
}
a:hover{
background-color:black;
color:white;
border-radius:15px;0
font-size:30px;
padding-left:10px;
}
p
{
color:turquoise;
font-style:italic;
font-size:30px;
}
</style>
</head>
```



```
<body>
<div class="navbar">
<a href="{{url_for('upload_file2')}}">Recognize</a>
<br>
</div>
<br>
<center><b class="pd"><font color="white" size="15" font-family="Comic Sans MS"
>Handwritten Recognition System</font></b></center><br><br>
<div>
<br>
<center>
<p><font color="white">Handwritten Text Recognition is a technology that is much needed
in this world as of today.
This digit Recognition system is used to recognize the digits from different sources like
emails, bank cheque, papers, images, etc.
Before proper implementation of this technology we have relied on writing texts with our
own hands which can result in errors.
It's difficult to store and access physical data with efficiency. The project presents
recognizing the handwritten digits (0 to 9) from the famous MNIST dataset.
Here we will be using artificial neural networks/ convolution neural network.</p>
</center>
</div>
</body>
</html>
```

```
<!DOCTYPE html>
<html>
<body>
```

```
<div style="float:left">
<h2><font color="red" size="15" font-family="sans-serif"><b>Digit
Recognition</b></font></h2><br><br>
```

```
<div>
  <form action="{{ url_for('upload_image_file')}}" method="POST" enctype="multipart/form-
data">
    <label for="imageUpload" class="upload-label">
      Choose...
    </label>
    <input type="file" name="file" id="imageUpload" accept=".png, .jpg, .jpeg">

  </form>
```

```
<center> <div class="image-section" style="display:none;">
  <div class="img-preview">
    <div id="imagePreview">
      </div></center>
  </div>
  <center><div>
    <a href="{{url_for('upload_file1')}}">Recognize</a>

  </center></div>
</div>
```

```
<div class="loader" style="display:none;margin-left: 450px;"></div>
```

```
<h3 id="result">
  <span> </span>
```

```
</h3>
</div>
</div>
</body>
</html>
```

### Python code

```
import flask
from flask import Flask
app = Flask(__name__)
from flask import render_template,request
import PIL
from PIL import Image
import numpy as np
from tensorflow.keras.models import load_model
import tensorflow as tf
@app.route("/")
def upload_file():
    return render_template('main.html')
@app.route("/about")
def upload_file1():
    return render_template('main.html')
@app.route('/upload')
def upload_file2():
    return render_template('index6.html')
@app.route('/predict',methods = ['POST'])
def upload_image_file():
    if request.method == 'post':
        img = Image.open(request.files['file'].stream).convert("L")
```

```

img = img.resize((28,28))
im2arr = np.array(img)
im2arr = im2arr.reshape(1,28,28,1)
y_pred = model.predict_classes(im2arr)
print(y_pred)
if(y_pred==0):
    return render_template("0.html",showcase = str(y_pred))
elif(y_pred == 1):
    return render_template("1.html",showcase = str(y_pred))
elif (y_pred == 2):
    return render_template("2.html", showcase=str(y_pred))
elif (y_pred == 3):
    return render_template("3.html", showcase=str(y_pred))
elif (y_pred == 4):
    return render_template("4.html", showcase=str(y_pred))
elif (y_pred == 5):
    return render_template("5.html", showcase=str(y_pred))
elif (y_pred == 6):
    return render_template("6.html", showcase=str(y_pred))
elif (y_pred == 7):
    return render_template("7.html", showcase=str(y_pred))
elif (y_pred == 8):
    return render_template("8.html", showcase=str(y_pred))
elif (y_pred == 9 ):
    return render_template("9.html", showcase=str(y_pred))
else:
    return none
if __name__=='__main__':
    app.run(host='0.0.0.0', port=8000, debug=True)

```

Git hub link:

<https://github.com/IBM-EPBL/IBM-Project-537-1658305734>

Video link:

