NOVEL METHOD FOR HAND WRITTEN DIGIT RECOGNITION SYSTEM

IBM-Project-15699-1659603225

TEAM ID: PNT2022TMID08467

SUBMITTED BY:-

KONDRAGUNTA LEELA PAVAN (810419106025)

DONDAPATI GURU PRASAD (810419106015)

RAYA NARENDRA (810419106049)

PUCHAKAYALA VAMSI PRIYA (810419106041)

In partial fulfillment for the award of the degree

Of

BATCHELOR OF ENGINNERING

In

ELECTRONICS AND COMMUNICATION ENGINEERING

DHANALAKSHMI SRINIVASAN ENGINEERING COLLEGE

(AUTONOMOUS)

PERAMBALUR-621212

1.INTRODUCTION

The aim of this project is to implement a classification algorithm to recognize handwritten digits (0- 9). It is mainly useful for digitalization of hand written digits at places like post office, paper bills to convert into a data base. This model can recognize many type of handwritten digit styles and also different backgrounds. Our model got 98.6 accuracy by using CNN algorithm. In this system we have developed user interface using flask and html where can capture image directly from our mobile. Blur images also processed to give best results.

1.1 Project Overview

Handwriting digits recognition refers to the process of transforming the ordered trajectory generated by writing on handwriting equipment into the internal code of digits. It is actually a mapping process from the coordinate sequence of handwritten trajectory to the internal code of digits. It is one of the most natural and convenient means of human–computer interaction. With the popularity of mobile information tools such as smart phones and handheld computers, handwritten digits recognition technology has entered the era of large-scale application. Handwritten digits recognition enables users to input text in the most natural and convenient way. It is easy to learn and use, and can replace keyboards or mouse. There are many kinds of devices for handwriting inputs, such as electromagnetic induction handwriting boards, pressure-sensitive hand-writing boards, touch screens, touch panels, ultrasonic pens, etc. Handwriting digits recognition belongs to the category of digits recognition and pattern recognition. In terms of the recognition process, digits recognition can be divided into two categories: off-line recognition and on-line recognition. In terms of recognition objects, it can also be divided into two categories: handwriting digits recognition and print digits recognition.

1.2 Purpose

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. The heart of the problem lies within the ability to develop an efficient algorithm that can recognize hand written digits and which is submitted by users by the way of a scanner, tablet, and other digital devices. This paper presents an approach to off-line handwritten digit recognition based on different machine learning technique. The main objective of this paper is to ensure effective and reliable approaches for recognition of handwritten digits.

2. LITERATURE SUREVEY

The handwritten digit recognition is the capability of computer applications to recognize the human handwritten digits. It is a hard task for the machine because handwritten digits are not perfect and can be made with many different shapes and sizes. The handwritten digit recognition system is a way to tackle this problem which uses the image of a digit and recognizes the digit present in the image. Convolutional Neural Network model created using tensor flow library over the MNIST dataset to recognize handwritten digits.

2.1 Existing problems

Following are the constraints faced when computers approach to recognize handwritten digits:

1. The Handwritten digits are not always of the same size, width, orientation and justified to margins as they differ from writing of person to person.

2. The similarity between digits such as 1 and 7, 5 and 6, 3 and 8, 2 and 7 etc. So, classifying between these numbers is also a major problem for computers.

3. The uniqueness and variety in the handwriting of different individuals also influence the formation and appearance of the digits.

2.2 references

[1] Yann LeCun, Corina Cortes, Christopher J.C.Burges," THE MNIST DATABASE of handwritten digits"

[2] Ishani Patel,Virag Jagtap ,Ompriya Kale ,"A Survey on Feature Extraction Methods for Handwritten Digits Recognition", IJCA (0975 – 8887), Volume 107 – No 12, Dec (2015).

[3] K. Gaurav and Bhatia P. K., "Analytical Review of Preprocessing Techniques for Offline Handwritten Character Recognition", 2nd International Conference on Emerging Trends in Engineering & Management, ICETEM, 2014.

2.3 Problem Statement Definition

Handwritten Digit Recognition is the capability of a computer to fete the mortal handwritten integers from different sources like images, papers , touch defenses, etc, and classify. them into 10 predefined classes **(0-9)**. This has been a Content of bottomless- exploration in the field of deep literacy.

Number recognition has numerous operations like number plate recognition, postal correspondence sorting, bank check processing, etc .

In Handwritten number recognition, we face numerous challenges. because of different styles of jotting of different peoples as it is not an Optic character recognition.

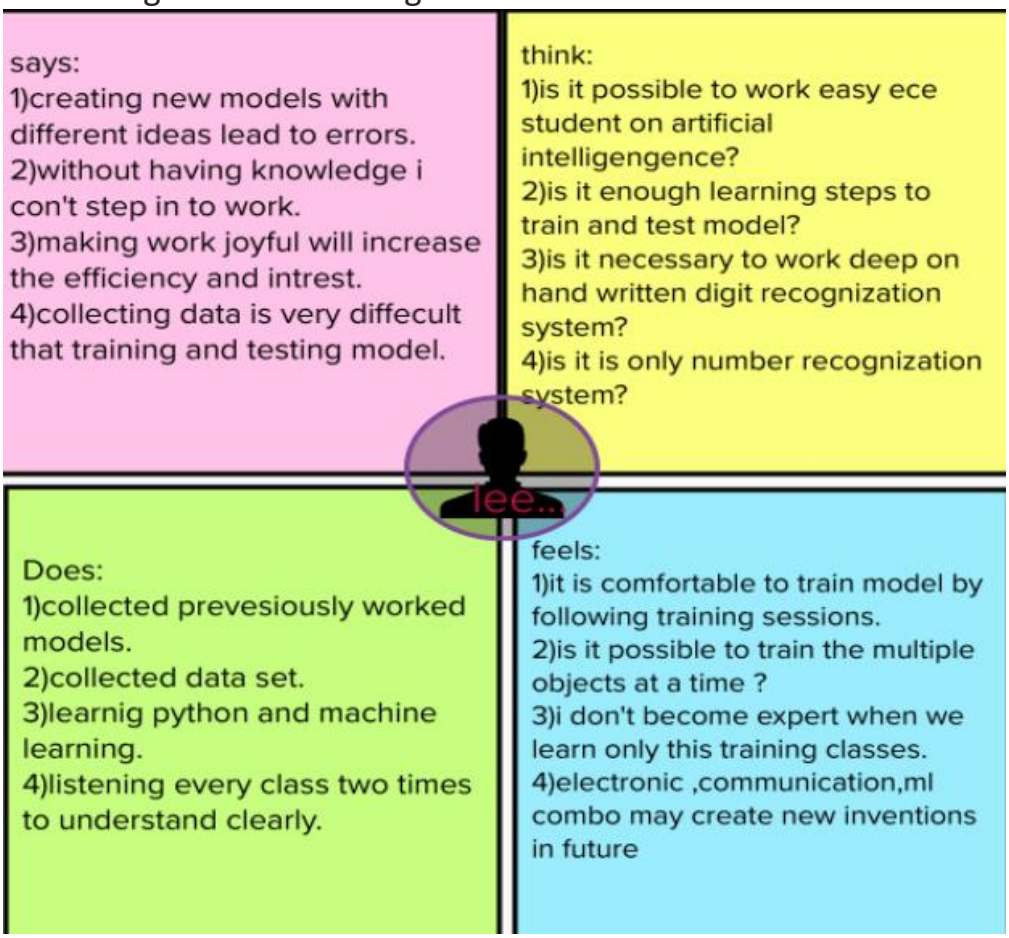
This exploration provides comprehensive comparison between different machine literacy and deep literacy algorithms for the purpose of handwritten number recognition.

For this, we've used Support. Vector Machine, Multilayer Perceptron, and Convolutional. **Neural Network**. The comparison between these algorithms is carried out on the base of their delicacy, crimes, and .testing- training time corroborated by plots and maps that have been constructe d using **matplotlib** for visualization.

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas

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



3.2 IDEATION &BRAINSTROMING

Brainstrome & Idea prioritization	**Team gathering-** **K. Leela pavan-Code writer** **D. Guru Prasad-Data Collector** **P. Vamsi Priya-planning coordinator** **R.Narendra-Report Writer**	**Problem statement-** **Recognition of handwritten digits and convert them into printed letters.** **Solving techniques-** **By using CNN we can train the model and predict the handwritten digits and store in e-document.**
	GOAL ***To recognize novel hand written digit recognition using A.I and CNN algorithm for image training and testing**	

Team lead idea:-By using svm algorithm will get more accuracy.

Team member1:By using cnn algorithm will get more accuracy and less prediction time for mnist dataset.

3.3 Proposed Solutions

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Computer programmes' ability to detect human-written numbers is known as handwritten digit recognition. Because handwritten figures are not always accurate and can take many various forms and sizes, it is a difficult work for the machine
2.	Idea / Solution description	Using data from various sources, including images, documents, and touch defences, a computer is able to celebrate the mortal handwritten numbers. It permits users to convert all of their handwritten notes and signatures into text documents in electronic form, using much less physical space than would be needed to store the physical copies of those documents.

3.	Novelty / Uniqueness	Recognize the digits precisely rather than all the characters like OCR
4.	Social Impact / Customer Satisfaction	The Handwritten Digit Recognizer software was made using artificial intelligence. It approximates the printed word digitally by identifying letters using sophisticated algorithms before producing a digital approximation
5.	Business Model (Revenue Model)	For efficient traffic control, this technology can be connected with traffic surveillance cameras to read licence plates. Pin-code details can be easily identified and recognised by integrating with the postal system.
6.	Scalability of the Solution	The capacity to recognise numbers in more distracting circumstances. The maximum number of digits that can be recognised is unlimited.

3.4 Problem Solution Fit

1. CUSTOMER SEGMENT(S) A officer in a post office receiving letters and couriers in a written format	6. CUSTOMER CONSTRAINTS It is a difficult because most person's handwriting will not similar, scanner or camera work perfect in perfect light condition, It took to much time to process.
2. JOBS-TO-BE-DONE / PROBLEMS J&P He/She Wants To Store The Pincode Or Mobile Number Etc… Into A Storage Space . So A Hand Written Digit Recognition System Is Needed To Solve Those Problems.	7. BEHAVIOUR BE Before Processing The Image Application Should Verify The Photo Was Taken In Correct Angle And Correct Lighting. User Should Completely Aware Of Instruction Of Application
3. TRIGGERS TR To do the work in a efficient manner. So that the officer getting satisfied.	8. CHANNELS of BEHAVIOUR CH 8.1 ONLINE Online handwriting recognition involves the automatic conversion of text as it is written on a special digitizer where a sensor picks up the pen-tip movements as well as pen-up/pen-down switching. 8.2 OFFLINE K-NN combined with preprocessing methods can achieve great performance apart from Neural Network when used as a classification algorithm in offline handwritten digit recognition.

4. REQUIREMENT ANALYSIS-

4.1 FUNCTIONAL REQUIREMENTS:

Following are the functional requirements of the proposed solution

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.

4.2 Non-functional Requirements:

Following are the non-functional requirements of the proposed solution

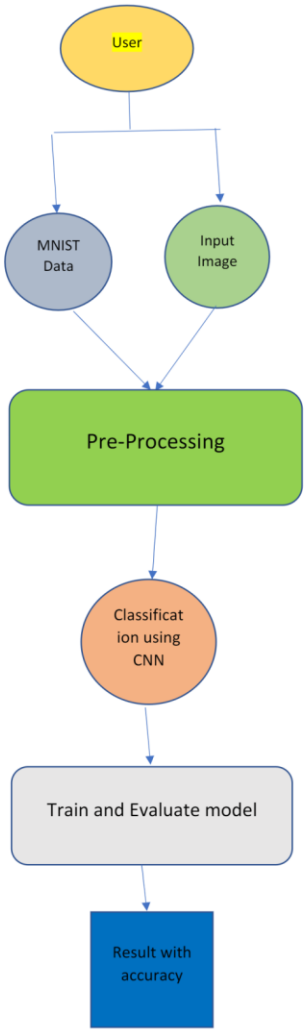
NFR.NO	Non-Functional Requirement	DESCRIPTION
NFR-1	Usability	One of the very significant problems in pattern recognition applications is the recognition of handwritten characters. Applications for digit recognition include filling out forms, processing bank checks, and sorting mail.
NFR-2	Security	1) The system generates a thorough description 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 driven by recognition. 3) The procedure uses a relatively.

NFR-3	Reliability	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. 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.
NFR-4	Accuracy	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.
NFR-5	Availability	

5. PROJECT DESIGN-

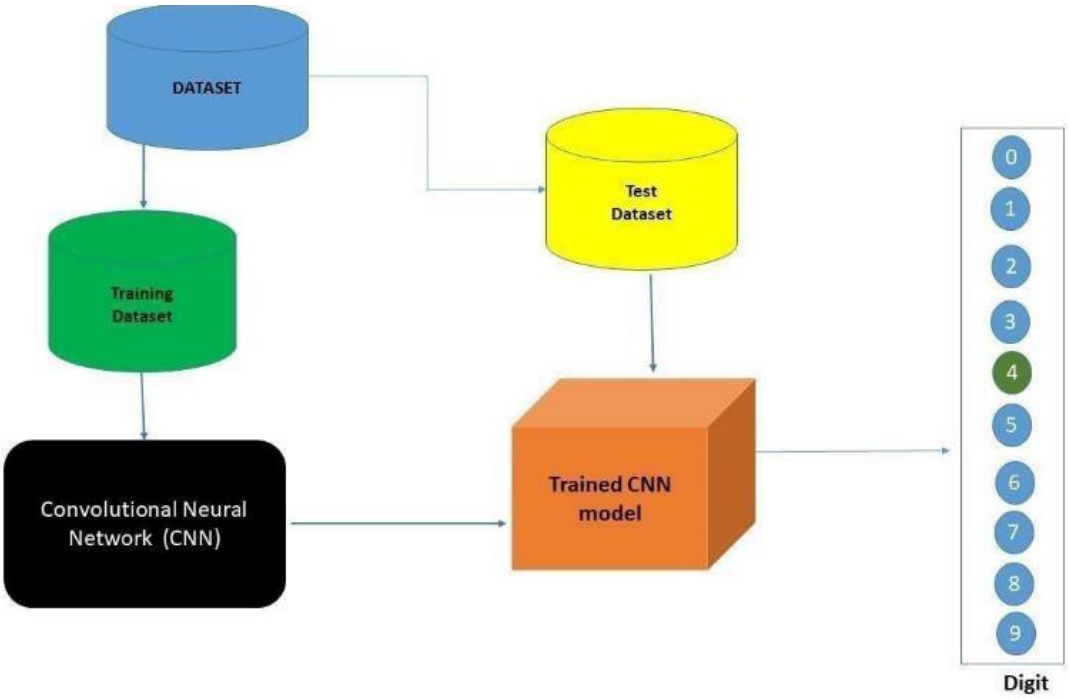
5.1 Data Flow Diagram:

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 &TECHNICAL ARCHITECTURE

The architectural diagram of the model is as below and the Technology used is shown in Table1



S.No	Component	Description	Technology
1.	User interface	How user interface with application e.g.. mobile application	HTML,CSS, flask.
2.	Application Logic -1	Logic for a process in the application	Flask
3.	Application Logic -2	Logic for a process in the application	IBM Watson
4.	Machine Learning mode	Purpose of machine learning Model	Object Recognition Model

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	**Application**	**USN-1**	As a user, I can application by opening it easily.	I can download the application	High	Sprint-1
		USN-2	As a user, I will be given access to the canvas board to draw or write the number	I can access the canvas	High	Sprint-1
		USN-3	As a user, I can change the colour of the pen in	I can use the canvas pen	canvas pen Medium	Sprint-2

6. PROJECT PLANNING AND SCHEDULING

6.1 SPRINT PLANNING & ESTIMATION

Sprint	Functional Requirement(epic)	User story number	User Story/Task	Story priority points	Team members
Sprint-1	**Application**	**USN-1**	As a user, I can application by opening it easily	High	K. leela pavan D.Guru Prasad R.narendra P.vamsi priya
Sprint-1		**USN-2**	As a user, I will be given access to the canvas board to draw or write the number	High	K. leela pavan D.Guru Prasad R.narendra P.vamsi priya
Sprint-2		**USN-3**	As a user, I can change the colour of the pen ink	Medium	K. leela pavan D.Guru Prasad R.narendra P.vamsi priya

6.2 Sprint Delivery Schedule:

Sprint	Total story points	Duration	Sprint start Date	Sprint end date	Story points completed	Sprint Release
Sprint-1	20	5 Days	1 Nov 2022	05 Nov 2022	20	05 Nov 2022
Sprint-2	20	5 Days	06 Nov 2022	10 Nov 2022	20	10 Nov 2022
Sprint-3	20	5 Days	11 Nov 2022	15 Nov 2022	20	15 Nov 2022
Sprint-4	20	5 Days	16 Nov 2022	20 Nov 2022	20	20 Nov 2022

6.3 REPORT FROM JIRA:-

VELOCITY: SPRINT - 1

Sprint duration = 5 days

Velocity of team = 20 points

Average Velocity (AV) = Velocity/ Sprint duration

AV = 20/5 = 4

Average Velocity=4

VELOCITY: Sprint 1 – 4

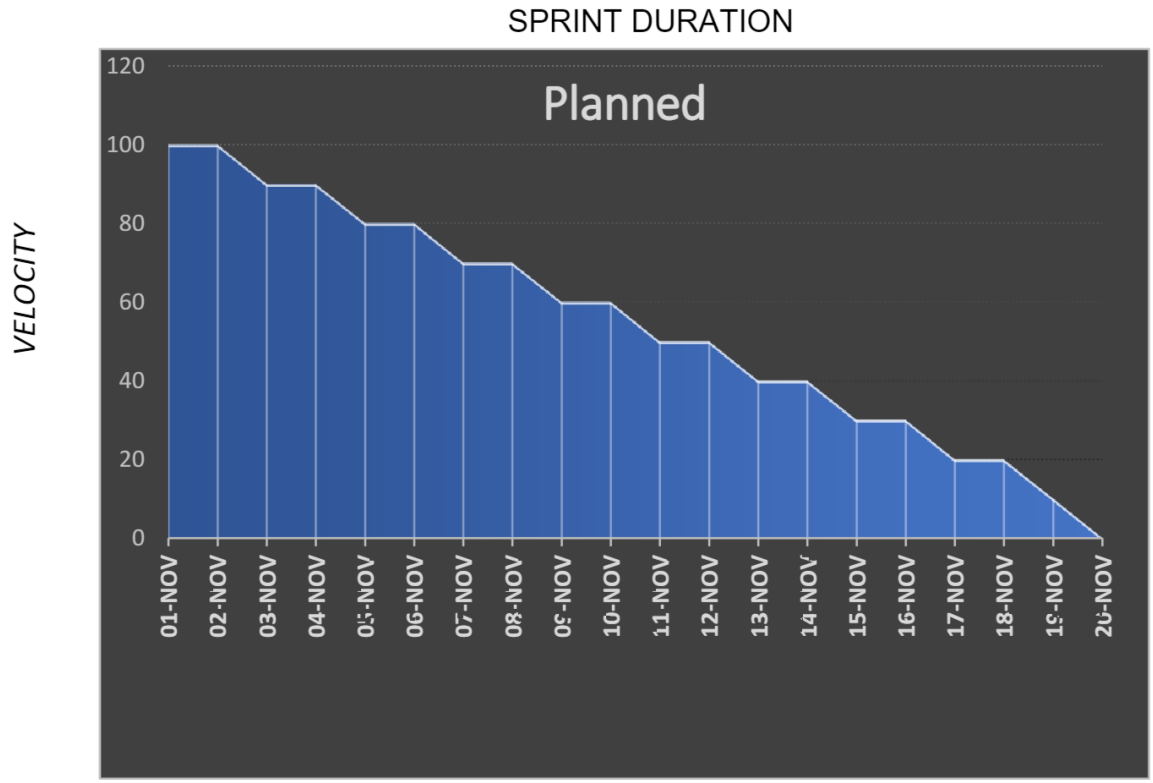
Sprint duration = 20 days

Velocity of team = 80 points

Average Velocity (AV) = Velocity/ Sprint duration

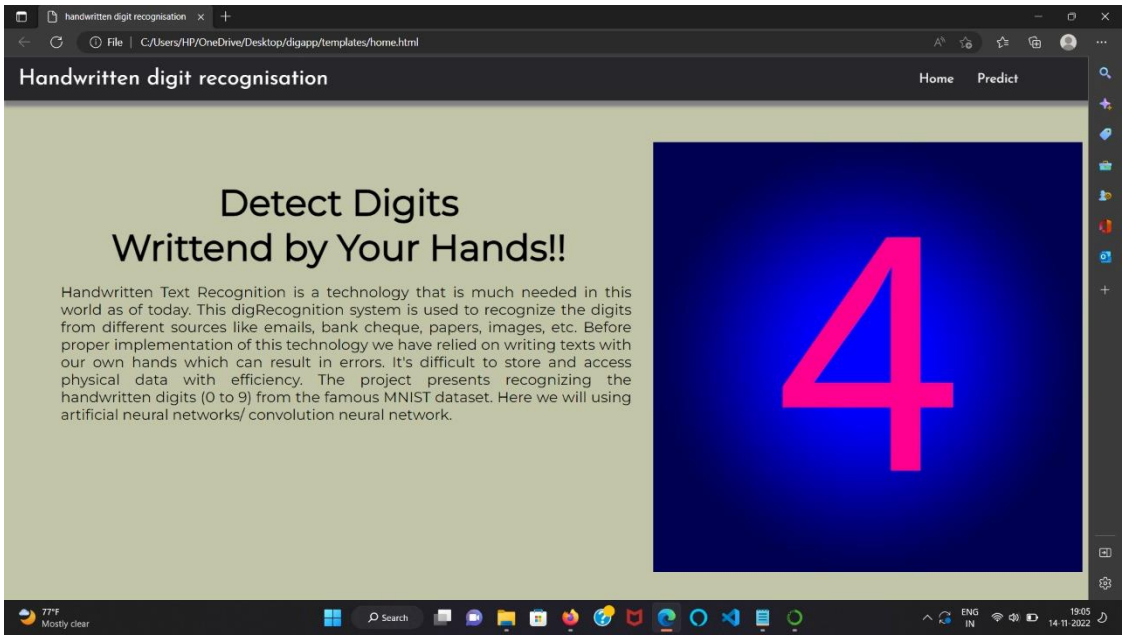
AV = 80/20 = 4

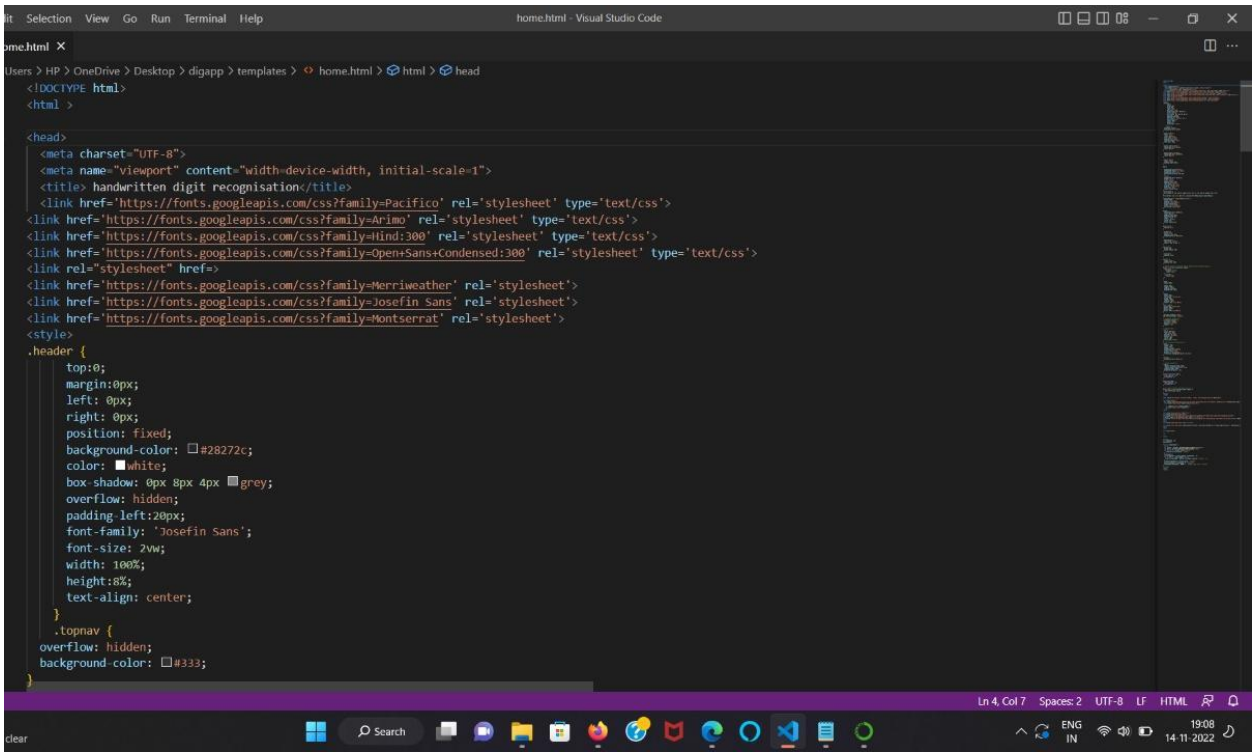
Total Average Velocity=4

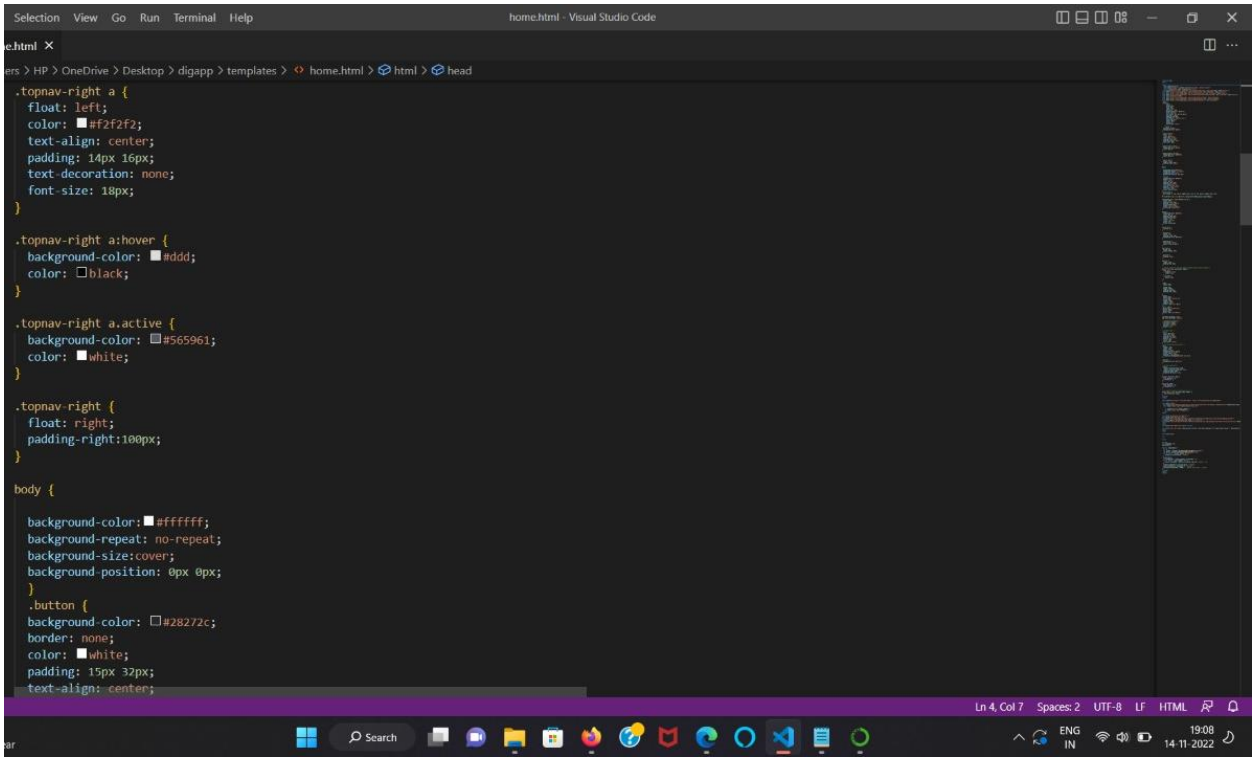


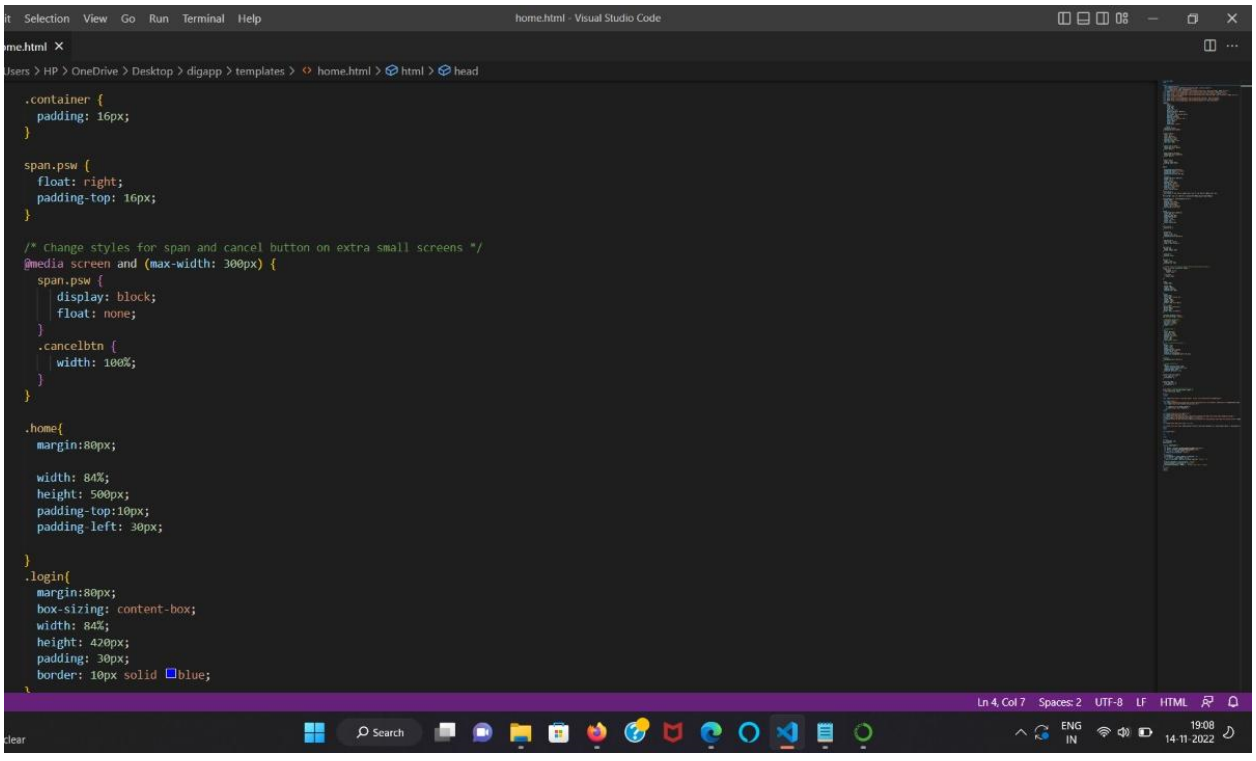
7. CODING & SOLUTIONING:

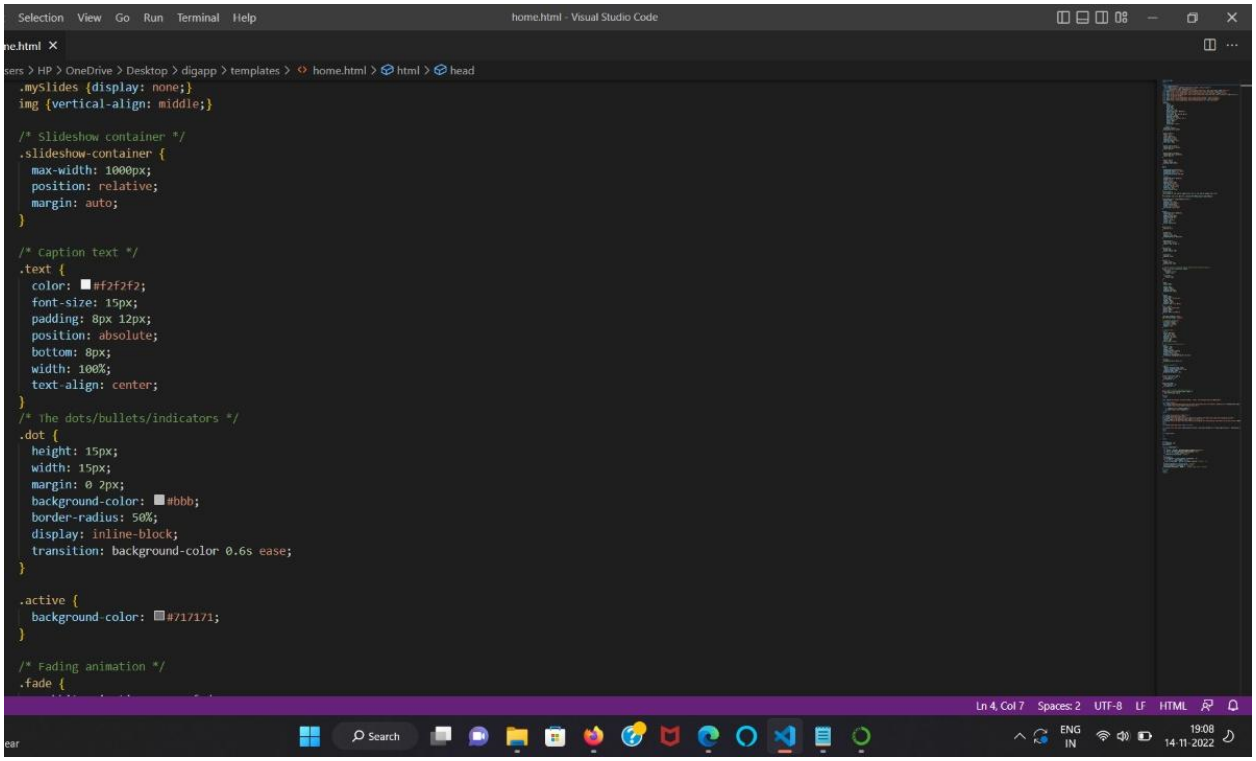
7.1 Home page

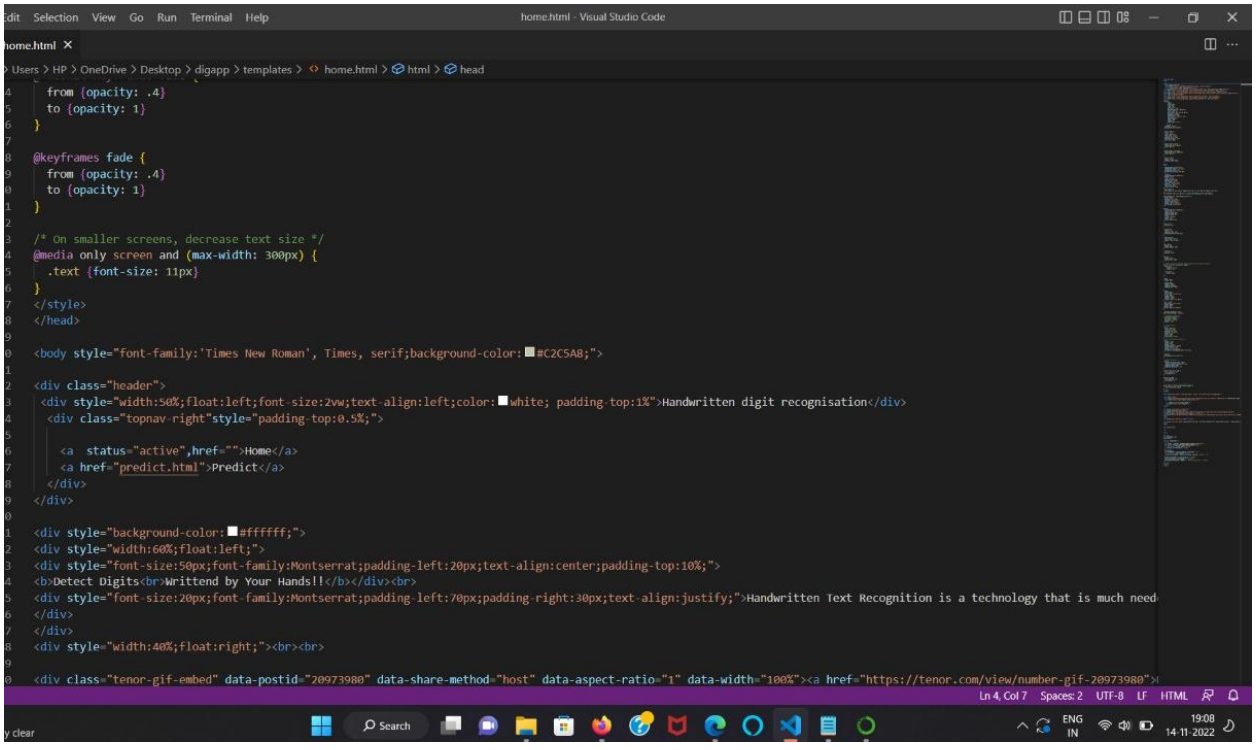





Selection View Go Run Terminal Help
home.html - Visual Studio Code
home.html
Users > HP > OneDrive > Desktop > digapp > templates > home.html > html > head
.topnav-right a {
float: left;
color: #f2f2f2;
text-align: center;
padding: 14px 16px;
text-decoration: none;
font-size: 18px;
}
.topnav-right a:hover {
background-color: #ddd;
color: black;
}
.topnav-right a.active {
background-color: #565961;
color: white;
}
.topnav-right {
float: right;
padding-right:100px;
}
body {
background-color:#ffffff;
background-repeat: no-repeat;
background-size:cover;
background-position: 0px 0px;
}
.button {
background-color: #28272c;
border: none;
color: white;
padding: 15px 32px;
text-align: center;
Ln 4, Col 7 Spaces: 2 UTF-8 LF HTML
Search
ENG
IN
19:08
14-11-2022


Selection View Go Run Terminal Help
home.html - Visual Studio Code
home.html
Users > HP > OneDrive > Desktop > digapp > templates > home.html > html > head
.container {
padding: 16px;
}
span.psw {
float: right;
padding-top: 16px;
}
/* Change styles for span and cancel button on extra small screens */
@media screen and (max-width: 300px) {
span.psw {
display: block;
float: none;
}
.cancelbtn {
width: 100%;
}
}
.home{
margin:80px;
width: 84%;
height: 500px;
padding-top:10px;
padding-left: 30px;
}
.login{
margin:80px;
box-sizing: content-box;
width: 84%;
height: 420px;
padding: 30px;
border: 10px solid blue;
Ln 4, Col 7 Spaces: 2 UTF-8 LF HTML
Search
ENG
IN
19:08
14-11-2022

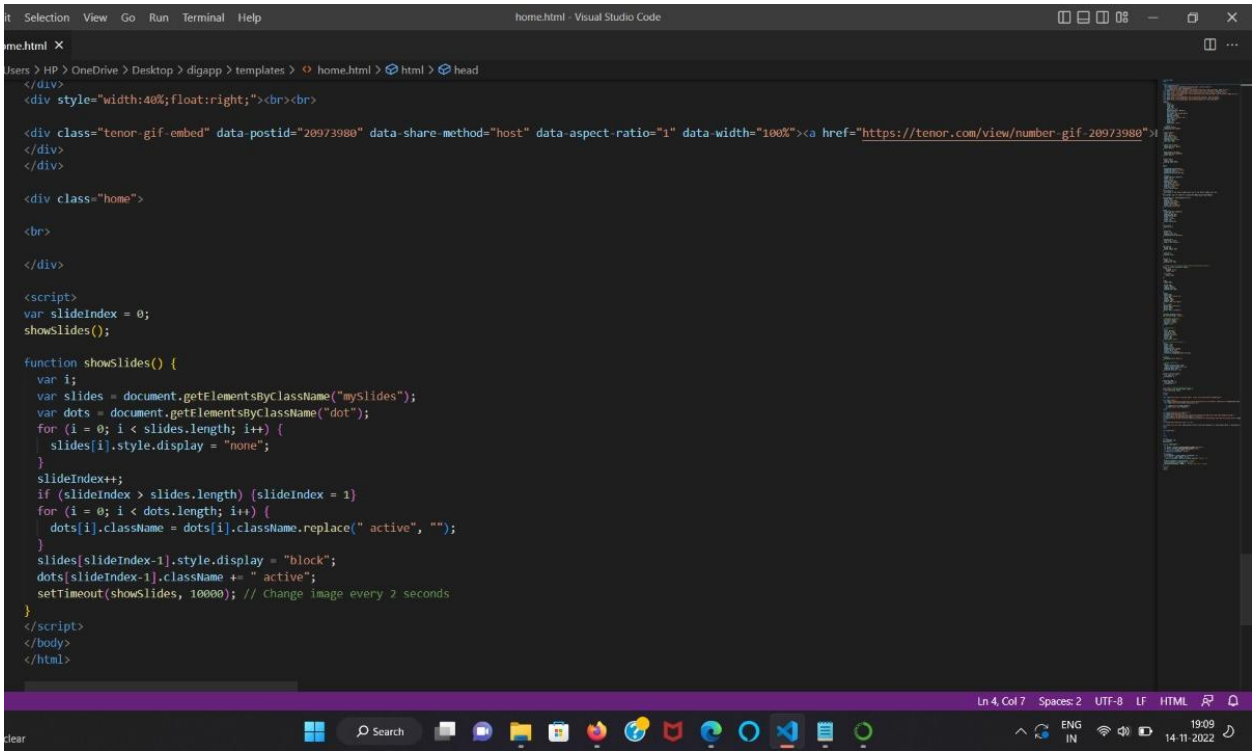

Selection View Go Run Terminal Help
home.html - Visual Studio Code
home.html
Users > HP > OneDrive > Desktop > digapp > templates > home.html > html > head
.mySlides {display: none;}
img {vertical-align: middle;}
/* Slideshow container */
.slideshow-container {
max-width: 1000px;
position: relative;
margin: auto;
}
/* Caption text */
.text {
color: #f2f2f2;
font-size: 15px;
padding: 8px 12px;
position: absolute;
bottom: 8px;
width: 100%;
text-align: center;
}
/* The dots/bullets/indicators */
.dot {
height: 15px;
width: 15px;
margin: 0 2px;
background-color: #bbb;
border-radius: 50%;
display: inline-block;
transition: background-color 0.6s ease;
}
.active {
background-color: #717171;
}
/* Fading animation */
.fade {
Ln 4, Col 7 Spaces: 2 UTF-8 LF HTML
Search
ENG IN
19:08 14-11-2022


Edit Selection View Go Run Terminal Help
home.html - Visual Studio Code
home.html
Users > HP > OneDrive > Desktop > digapp > templates > home.html > html > head
from {opacity: .4}
to {opacity: 1}
}
@keyframes fade {
from {opacity: .4}
to {opacity: 1}
}
/* On smaller screens, decrease text size */
@media only screen and (max-width: 300px) {
.text {font-size: 11px}
}
</style>
</head>
<body style="font-family:'Times New Roman', Times, serif;background-color:#C2C5A8;">

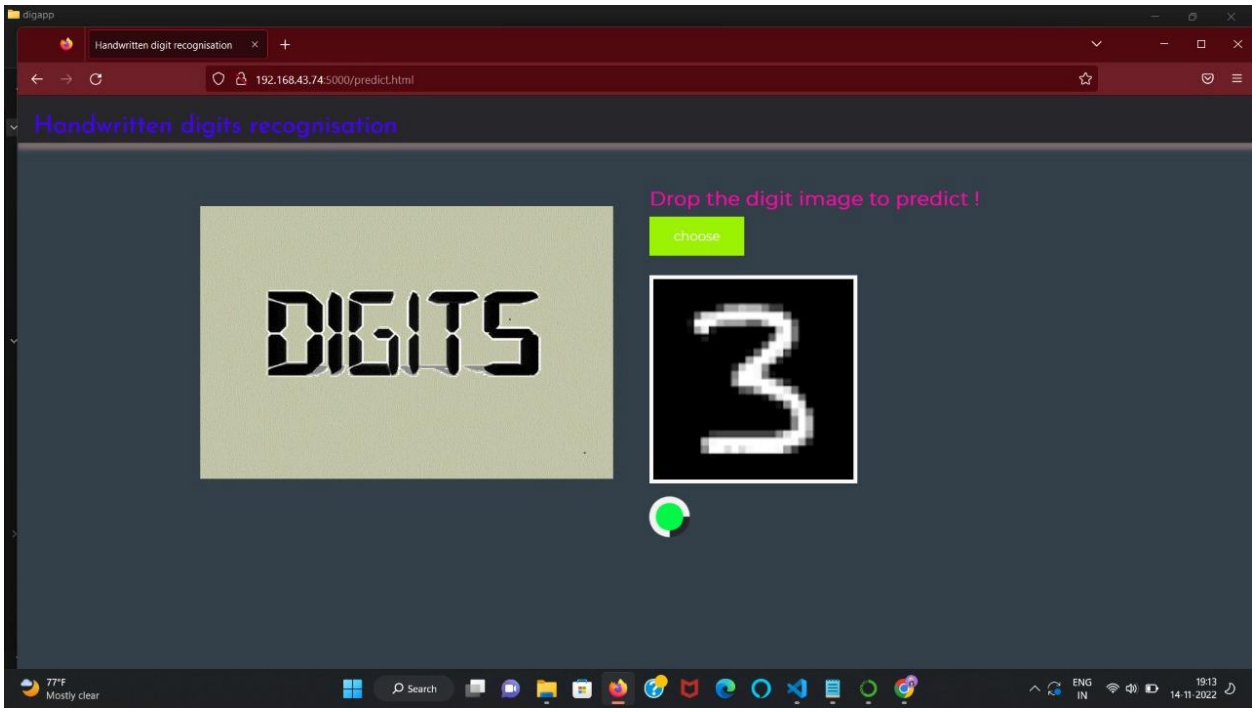
Handwritten digit recognisation
<div class="topnav-right"style="padding-top:0.5%;">
Home
Predict

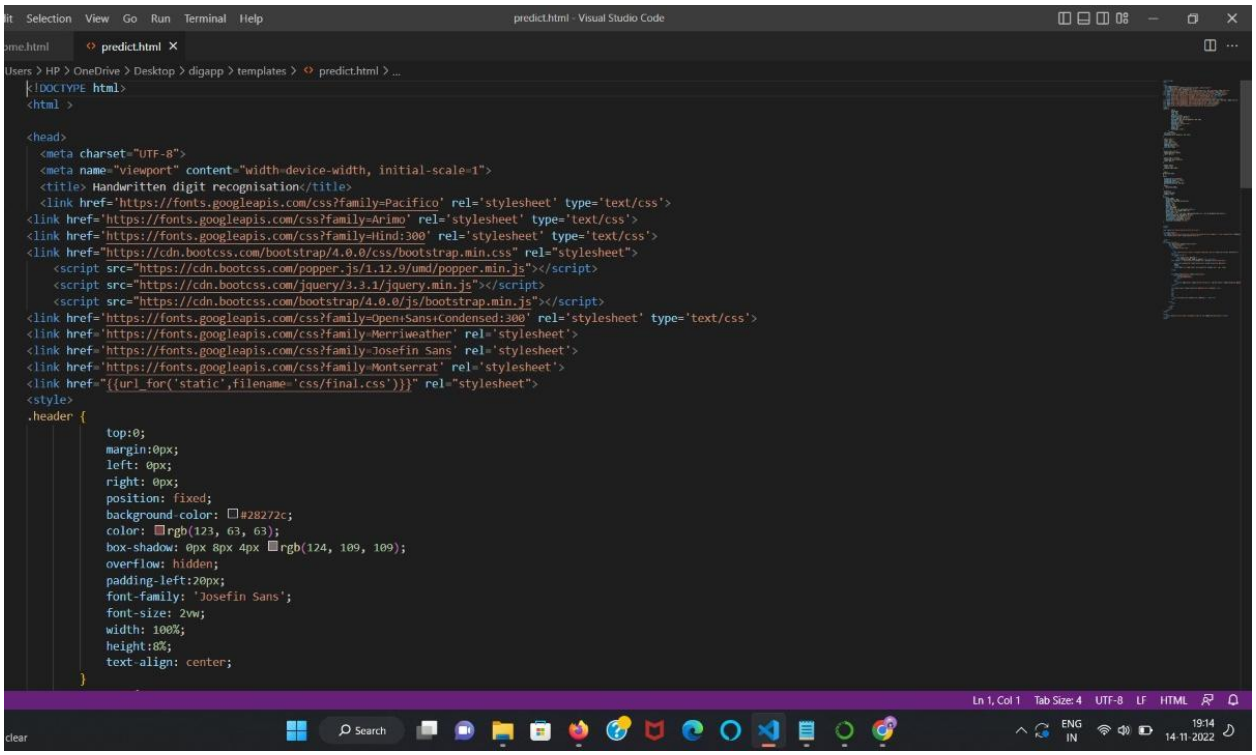
Detect Digits
Writtend by Your Hands!!
Handwritten Text Recognition is a technology that is much need

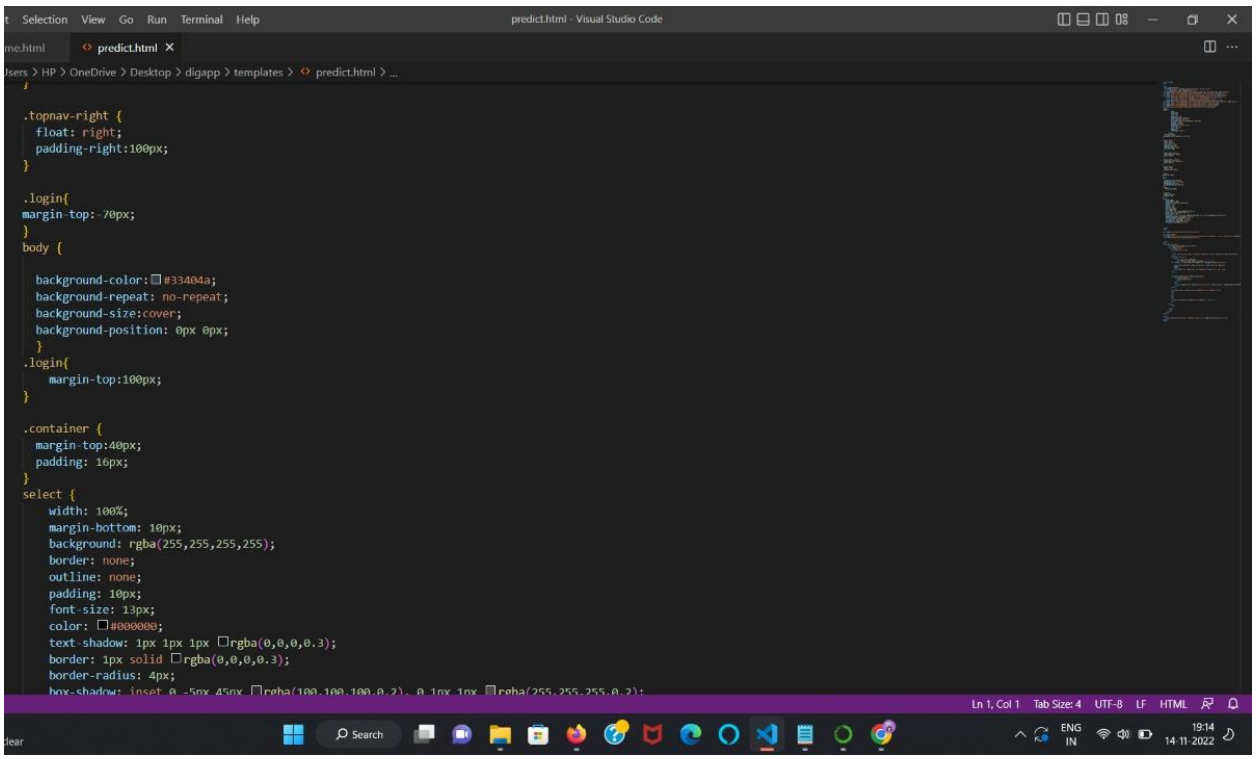
<a href="https://tenor.com/view/number-gif-20973980">
Ln 4, Col 7 Spaces: 2 UTF-8 LF HTML
Search
ENG IN
19:08 14-11-2022

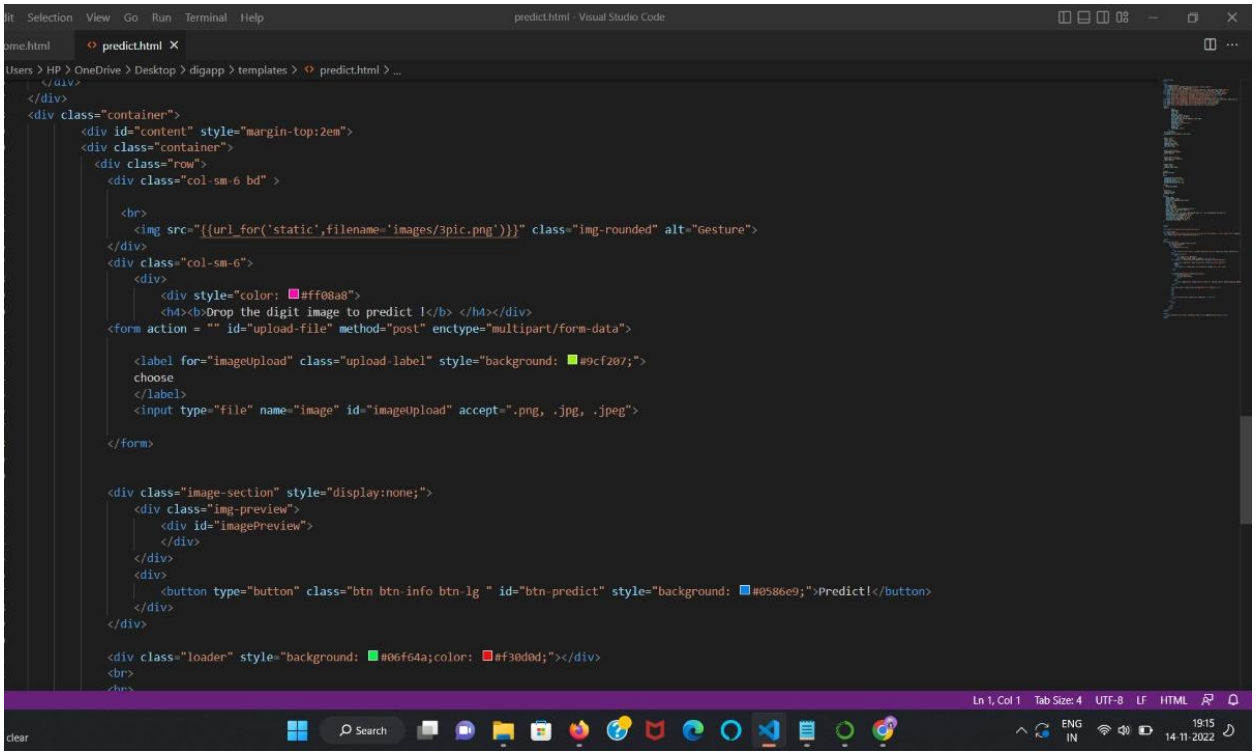


PREDICTION PAGE:-

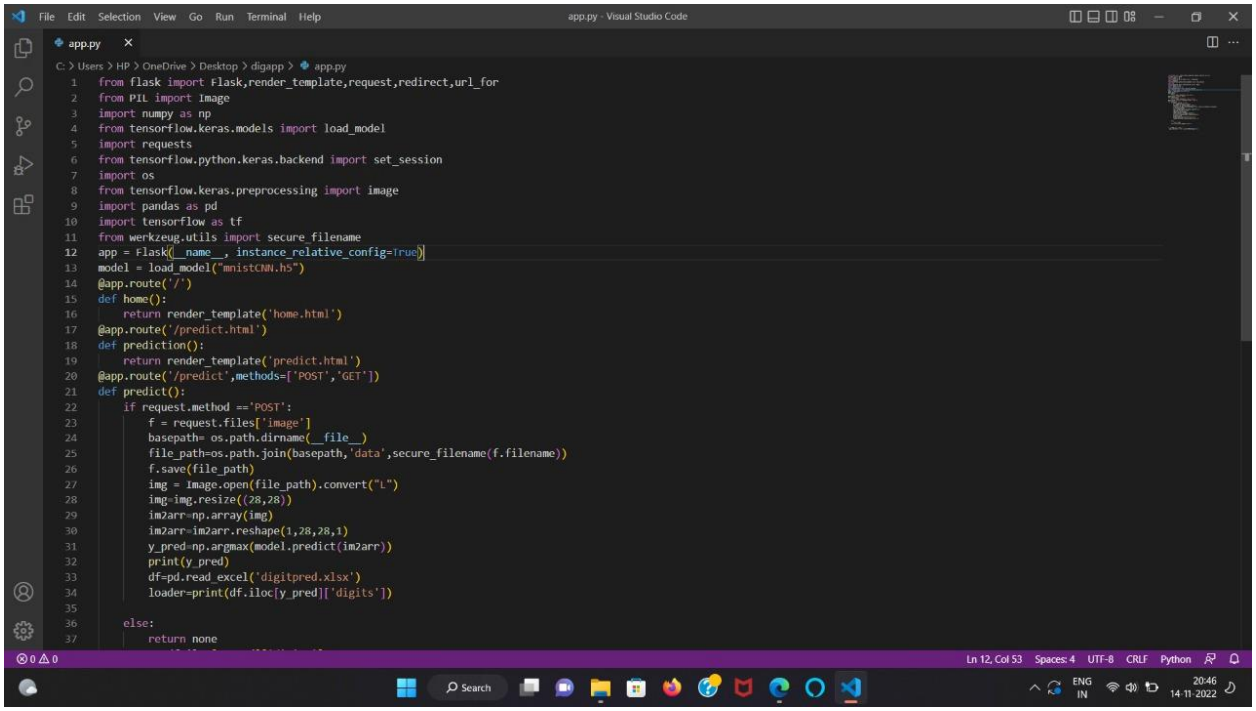


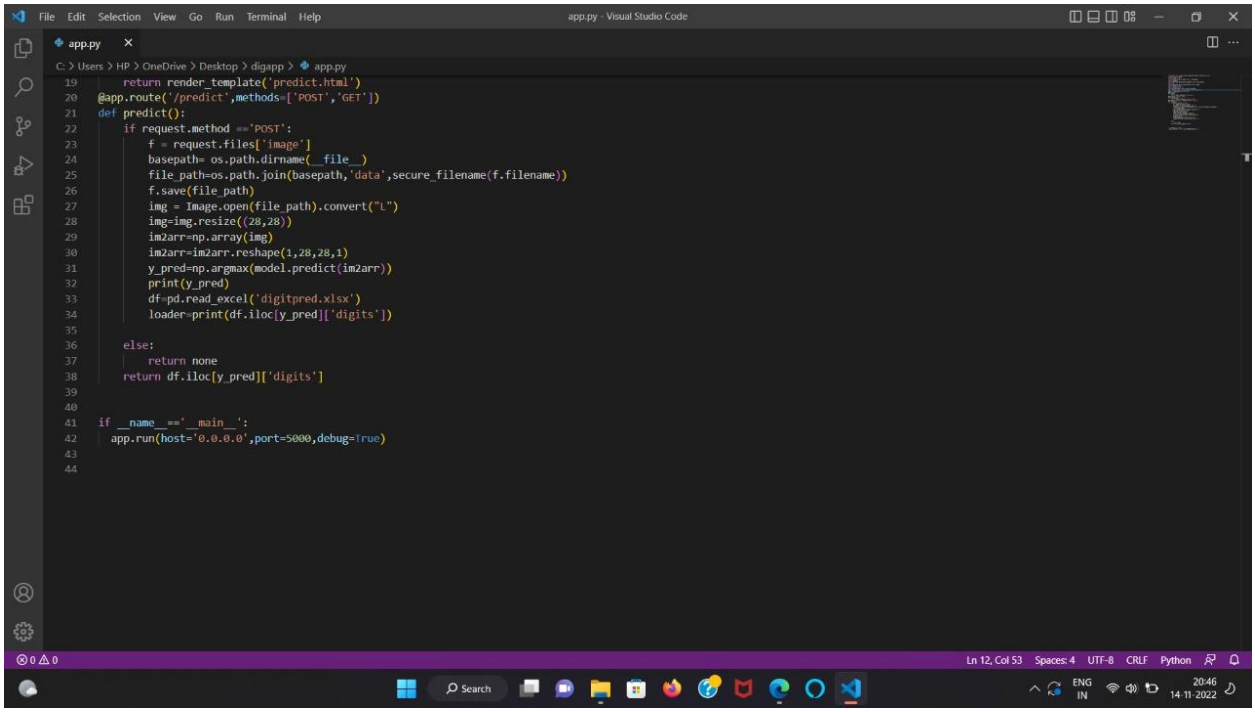

predict.html - Visual Studio Code
predict.html
Users > HP > OneDrive > Desktop > digapp > templates > predict.html > ...
<!DOCTYPE html>
<html >
<head>
<meta charset="UTF-8">
<meta name="viewport" content="width=device-width, initial-scale=1">
<title> Handwritten digit recognisation</title>
<link href='https://fonts.googleapis.com/css?family=Pacifico' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Arimo' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Hind:300' rel='stylesheet' type='text/css'>
<link href="https://cdn.bootcss.com/bootstrap/4.0.0/css/bootstrap.min.css" rel="stylesheet">
<script src="https://cdn.bootcss.com/popper.js/1.12.9/umd/popper.min.js"></script>
<script src="https://cdn.bootcss.com/jquery/3.3.1/jquery.min.js"></script>
<script src="https://cdn.bootcss.com/bootstrap/4.0.0/js/bootstrap.min.js"></script>
<link href='https://fonts.googleapis.com/css?family=Open+Sans+Condensed:300' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Merriweather' rel='stylesheet'>
<link href='https://fonts.googleapis.com/css?family=Josefin Sans' rel='stylesheet'>
<link href='https://fonts.googleapis.com/css?family=Montserrat' rel='stylesheet'>
<link href="{{url_for('static',filename='css/final.css')}}" rel="stylesheet">
<style>
.header {
top:0;
margin:0px;
left: 0px;
right: 0px;
position: fixed;
background-color: #28272c;
color: rgb(123, 63, 63);
box-shadow: 0px 8px 4px rgb(124, 109, 109);
overflow: hidden;
padding-left:20px;
font-family: 'Josefin Sans';
font-size: 2vw;
width: 100%;
height:8%;
text-align: center;
}
Ln 1, Col 1 Tab Size: 4 UTF-8 LF HTML
Search
ENG IN
19:14 14-11-2022


predict.html - Visual Studio Code
predict.html
Users > HP > OneDrive > Desktop > digapp > templates > predict.html > ...
.topnav-right {
float: right;
padding-right:100px;
}
.login{
margin-top:-70px;
}
body {
background-color:#33404a;
background-repeat: no-repeat;
background-size:cover;
background-position: 0px 0px;
}
.login{
margin-top:100px;
}
.container {
margin-top:40px;
padding: 16px;
}
select {
width: 100%;
margin-bottom: 10px;
background: rgba(255,255,255,255);
border: none;
outline: none;
padding: 10px;
font-size: 13px;
color: #000000;
text-shadow: 1px 1px 1px rgba(0,0,0,0.3);
border: 1px solid rgba(0,0,0,0.3);
border-radius: 4px;
box-shadow: inset 0 -5px 45px rgba(100,100,100,0.2), 0 1px 1px rgba(255,255,255,0.2);
Ln 1, Col 1 Tab Size: 4 UTF-8 LF HTML
Search
ENG IN
19:14 14-11-2022



7.2 FLASK CODE:-




File Edit Selection View Go Run Terminal Help
app.py - Visual Studio Code
app.py
C: > Users > HP > OneDrive > Desktop > digapp > app.py
return render_template('predict.html')
@app.route('/predict',methods=['POST','GET'])
def predict():
if request.method =='POST':
f = request.files['image']
basepath= os.path.dirname(__file__)
file_path=os.path.join(basepath,'data',secure_filename(f.filename))
f.save(file_path)
img = Image.open(file_path).convert("L")
img=img.resize((28,28))
im2arr=np.array(img)
im2arr=im2arr.reshape(1,28,28,1)
y_pred=np.argmax(model.predict(im2arr))
print(y_pred)
df=pd.read_excel('digitpred.xlsx')
loader=print(df.iloc[y_pred]['digits'])
else:
return none
return df.iloc[y_pred]['digits']
if __name__=='__main__':
app.run(host='0.0.0.0',port=5000,debug=True)
Ln 12, Col 53 Spaces: 4 UTF-8 CRLF Python
Search
ENG
IN
20:46
14-11-2022

8.TESTING.

8.1.TEST CASE

A test case has components that describe input, action and an expected response , in order to determine if a feature of an application is working correctly. A test case is a set of instruction ”HOW” to validate a particular test objective/target, Which when followed will tell us if the expected behavior of the system is satisfied or not.

Characteristics of good test care:

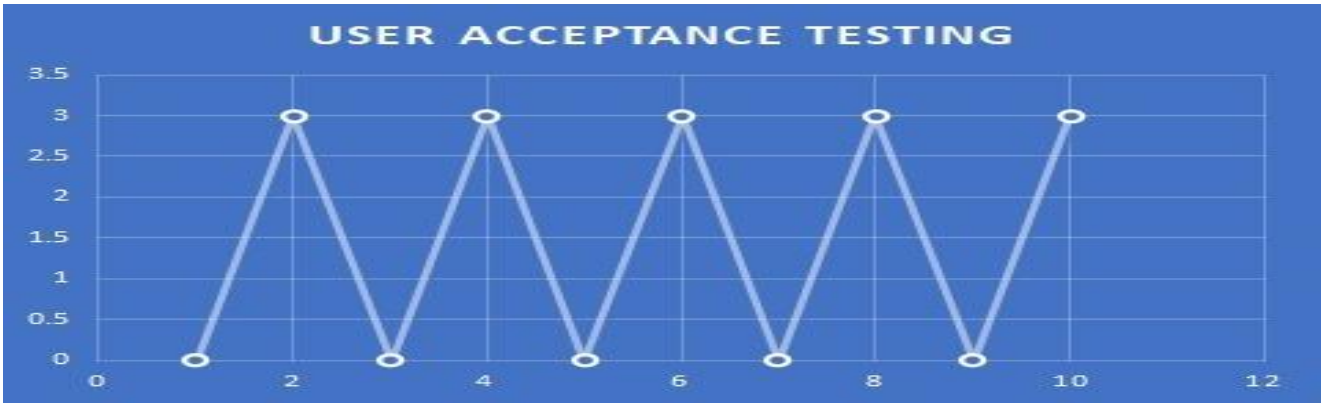
- Accurate: Exacts the purpose.
- Economical: No unnecessary steps or words.
- Traceable : Capable of being traced to requirements.
- Repeatable: Can be used to perform the test over and over.
- Reusable: Can be reused if necessary.

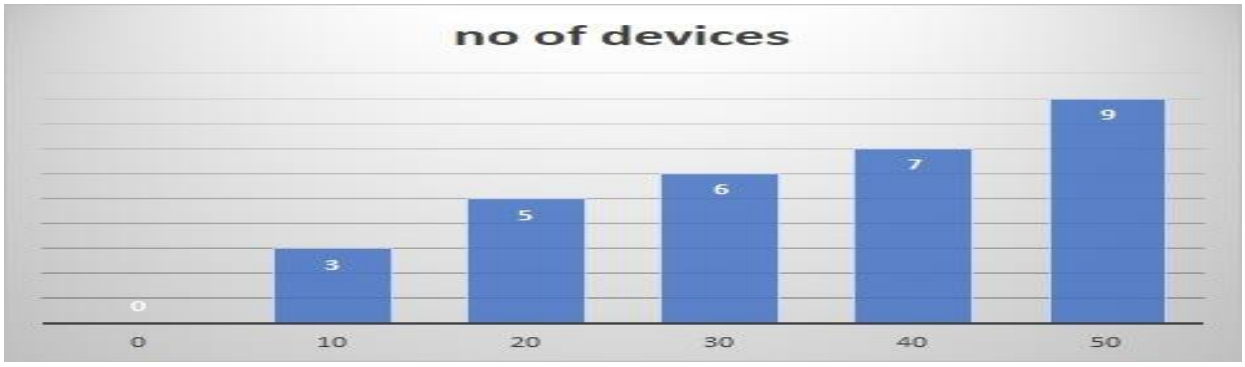
S.No	**Scenario**	**Input**	**Expected output**	**Actual output**
1.	Predict back background image	Black background handwritten digit	Name of the desired digit	Desired output name
2.	White background image	White background handwritten digit	Name of the desired digit	Eight
3.	Unrecognised image	Any background handwritten digit	Name of the desired digit	Eight

8.2 **User Acceptance Testing:**

What is UAT?

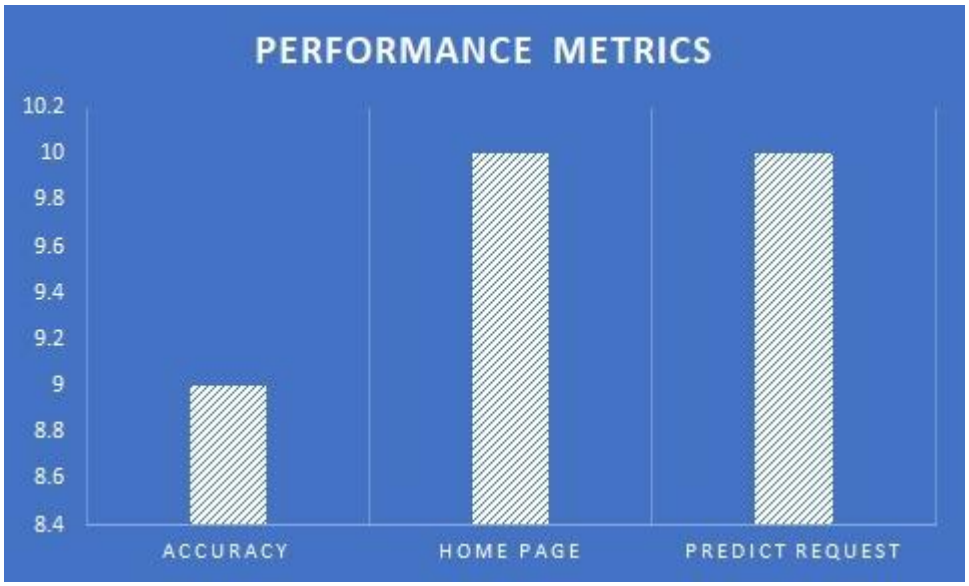
User Acceptance Testing (UAT) is a type of testing performed by the end user or the client to verify/accept the software system before moving the software application to the production environment. UAT is done in the final phase of testing after functional, integration and system testing is done.This sort of testing is carried out by clients, or other authorized bodies to identify the requirements and operational procedures of an applications or piece of software. The most crucial stage of testing is acceptance testing since it determine whether or not the customer will accept the application or programmer. It could entail the application's U I., performance, usability, and usefulness. It is also reffered to as end -user testing . Operational acceptance testing. And user acceptance testing (UAT).





9.RESULTS

9.1.Performance Metrics.



Accuracy is lagging because there are some more situations are to include in to data set and also based on the pic sizes over difference are the main reasons .So by training the model with some more classifications like thickness of letter and blurness of image .

10.ADVANTAGES.

1. The system not only produces a classification of the digit but also a rich description of the instantiation parameters which can yield information such as the writing style.

2.The generative models can perform recognition driven segmentation.

3. The method involves a relatively. .

4.High (99.1) accuracy.

DISADVANTAGES.

1.The main disadvantage of the method is that it requires much more computation than more standard OCR techniques.

2. The handwritten digits are not always of the same size.

3. The uniqueness and variety in the handwriting of different individuals also influence the formation and appearance of the digits.

11. Conclusion

As using machine learning algorithms are used like CNN Neural networks along with different parameters and feature scaling vectors, we also saw the different comparison among the classifiers in terms of the most important feature of accuracy and timing. Accuracy can alter as it depends on the splitting of training and testing data, and this can further be improved if the number of training and testing data is provided. There is always a chance to improve accuracy if the size of data increases. Every classifier has its own accuracy and time consumption. We can also include the fact that if the power of CPU changes to GPU, the classifier can perform with better accuracy and less time and better results can be observed. The performance of the classifier can be measured in terms of ability to identify a condition properly (sensitivity), the proportion of true results (accuracy), number of positive results from the procedure of classification as false positives (positive predictions) and ability to exclude condition correctly (specificity). In this, we saw a brief comparison to the classifiers of Machine learning and deep learning.

12.FUTURE SCOPE.

Till now we considered using the architecture of the convolution network which gave the best result on the MNIST database and the proposed recognition system is implemented on handwritten digits. In future,Such more system can be designed for handwritten characters recognition, object recognition, image segmentation, handwriting recognition, text language recognition, and future studies also might consider on hardware implementation on online digit recognition system with more performance and efficiency with live results from live testing case scenarios.

13. APPENDIX .

Source code.
Building model.

```
import numpy
import tensorflow
from tensorflow.keras.datasets import mnist
from tensorflow.keras.models import Sequential
from tensorflow.keras import layers
from tensorflow.keras.layers import Dense,Flatten
from tensorflow.keras.layers import Conv2D
from keras.optimizers import Adam
from keras.utils import np_utils
(x_train,y_train),(x_test,y_test)=mnist.load_data()
print(x_train.shape)
print(x_test.shape)
x_train=x_train.reshape(60000,28,28,1).astype('float32')
x_test=x_test.reshape(10000,28,28,1).astype('float32')
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)
model=Sequential()
```

```
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'))

model.compile(loss='categorical_crossentropy',optimizer='Adam',metrics=['accuracy'])

model.fit(x_train,y_train,validation_data=(x_test,y_test),epochs=20,batch_size=32)

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)
```

test the save mode.

```
  from tensorflow.keras.models import load_model

model = load_model('mnistCNN.h5')

from PIL import Image

import numpy as np

for index in range(4):

 img=Image.open('Downloads/data/'+str(index)+'.png').convert("L")

 img=img.resize((28,28))
```

```
im2arr=np.array(img)
im2arr=im2arr.reshape(1,28,28,1)
#prediction
y_pred=model.predict(im2arr)
y_pred=np.round(y_pred)
print(y_pred)
```

GitHub :-

https://github.com/IBM-EPBL/IBM-Project-15699-1659603225/tree/main

Demolink:-

https://youtu.be/K6KJZ2lmcmI