# PROJECT REPORT

# Early Detection of Chronic Kidney Disease using Machine Learning

***submitted by***

***PT2022TMID52708***


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# CHAPTER 1
# INTRODUCTION

## 1.1 PROJECT OVERVIEW

Machine learning and deep learning play an important role in computer technology and artificial intelligence. With the use of deep learning and machine learning, human effort can be reduced in recognizing, learning, predictions and in many more areas.

Chronic Kidney Disease (CKD) is a major medical problem and can be cured if treated in the early stages. Usually, people are not aware that medical tests we take for different purposes could contain valuable information concerning kidney diseases. Consequently, attributes of various medical tests are investigated to distinguish which attributes may contain helpful information about the disease. The project aims to measure the severity of the problem and we make use of such information to build a machine learning model that predicts Chronic Kidney Disease.

## 1.2PURPOSE

Common people may have some illness and need to detect and predict the disease at an early stage so that effective treatment can be done at the right time so our project helps the patients may be cured at the earliest without having to undergo complex and costly procedures for testing and diagnosis.

# CHAPTER 2
# LITERATURE SURVEY

## 2.1 EXISTING PROBLEM

When people develop chronic kidney disease (CKD), their kidneys become damaged and over time may not clean the blood as well as healthy kidneys. If kidneys do not work well, toxic waste and extra fluid accumulate in the body and may lead to high blood pressure, heart disease, stroke, and early death.CKD can be diagnosed using blood and urine tests. These tests look for high levels of certain substances in your blood and urine that are signs your kidneys aren't working properly.

If you're at a high risk of developing kidney disease (for example, you have a known risk factor such as high blood pressure or diabetes), you may be advised to have regular tests to check for CKD so it's found at an early stage

## 2.1 REFERENCES

**Title: A Comprehensive Performance Assessment of Deep Learning Models in Early Prediction and Risk Identification of Chronic Kidney Disease**

**Author:**Shamima Akter; Ahsan Habib; Md. Ashiqul Islam; Md. Sagar Hossen

This paper presents the incidence of chronic kidney disease (CKD) is rising rapidly around the globe. Asymptomatic CKD is common and guideline-directed monitoring to predict CKD by various factors is underutilized. Computer-aided automated diagnostic (CAD) can play a major role to predict CKD. CAD systems such as deep learning algorithms are pivotal in disease diagnosis due to their high classification accuracy. In this paper, various clinical features of CKD were utilized and seven state-of-the-art deep

learning algorithms (ANN, LSTM, GRU, Bidirectional LSTM, Bidirectional GRU, MLP, and Simple RNN) were implemented for the prediction and classification of CKD. The proposed algorithms were applied based on artificial intelligence by extracting and evaluating features using five different approaches from pre-processed and fitted CKD datasets. In this study, we have measured accuracy, precision, recall, and calculated the loss and validation loss in prediction.

**Title: A Comprehensive Unsupervised Framework for Chronic Kidney Disease Prediction**

**Author:** Linta Antony, Sami Azam, Eva Ignatious

This work developed an approach for improved prediction and detection of Chronic Kidney Disease based on various unsupervised machine learning approaches including autoencoder, Isolation forest, DB-scan and Kmeans. For considering all the 24 features resulted in a 91% accuracy for I-forest, 94% for DB-Scan, 97.5% for Autoencoder and, 99.3% for K-means clustering. To reduce the time and financial expenses of CKD diagnosis, six feature selection strategies, which fall into four distinct categories of feature selection methods, were used. The best features were selected using a set-theory-based rule, which combines multiple feature selection approaches. The data were then classified and validated. For the reduced feature set also Kmeans outperformed other unsupervised algorithms with 99% accuracy. The suggested technique can assist clinicians in managing numerous patients and providing CKD diagnoses more quickly. Organizations can use the suggested machine learning architecture in regional clinics with reduced medical expert retention over time, allowing patients in regional locations to receive early diagnosis. As an extension of this work, detection of the five different stages of Chronic Kidney Disease in a similar manner can be done. Thus, would support the medical community in just to detecting the existence of the disease, but also in identifying the stages of the disease.

**Title: Early Prediction of Chronic Kidney Disease: A Comprehensive Performance Analysis of Deep Learning Models.**

**Author:** Chaity Mondol,F. M. Javed Mehedi Shamrat Md. Robiul Hasan.

Chronic kidney disease (CKD) is one of the most life-threatening disorders. To improve survivability, early discovery and good management are encouraged. In this paper, CKD was diagnosed using multiple optimized neural networks against traditional neural networks on the UCI machine learning dataset, to identify the most efficient model for the task. The study works on the binary classification of CKD from 24 attributes. The study works on the binary classification of CKD from 24 attributes. For classification, optimized CNN (OCNN), ANN (OANN), and LSTM (OLSTM) models were used as well as traditional CNN, ANN, and LSTM models. With various performance matrixes, error measures, loss values, AUC values, and compilation time, the implemented models are compared to identify the most competent model for the classification of CKD.

**Title:Prediction of Chronic Kidney Disease Using Adaptive Hybridized Deep Convolutional Neural Network on the Internet of Medical Things Platform**

**Author:** Guozhen Chen,Chenguang Ding.

In this paper, to examine the ability of various deep learning methods an Adaptive hybridized Deep Convolutional Neural Network (AHDCNN) has been proposed for the early detection of Kidney disease efficiently and effectively. Classification technology efficiency depends on the role of the data set. To enhance the accuracy of the classification system by reducing the feature dimension an algorithm model has been developed using CNN. These high-level properties help to build a supervised tissue classifier that discriminates between the two types of tissue. The experimental process on the Internet of medical things platform (IoMT)concludes, with the aid of predictive

analytics, that advances in machine learning which provides a promising framework for the recognition of intelligent solutions to prove their predictive capability beyond the field of kidney disease.

**Title: Comparative Study of Classifier for Chronic Kidney Disease prediction using Naive Bayes, KNN and Random Forest**

**Author:**R Devika; Sai Vaishnavi Avilala; V. Subramaniyaswamy

Chronic kidney disease (CKD), is also known as chronic nephritic sickness. It defines constrains which affects your kidneys and reduces your potential to stay healthy. There will be various complication concerns like increased levels in your blood, anemia (low blood count), weak bones, and nerve injury. Detection and treatment should be done prior so it will typically keep chronic uropathy from obtaining a worse condition. Data processing is the term used for information discovery from big databases. The task of knowledge mining is to generate regular patterns from historical data and emphasize future conclusions, follows from the convergence of many recent trends: the decreased value of huge knowledge storage devices and therefore the tremendous ease of aggregation knowledge over networks; the development of robust and economical machine learning algorithms to method this data; and therefore the decrease value of machine power, enabling use of computationally intensive strategies for knowledge analysis.

## 2.3 PROBLEM STATEMENT DEFINITION

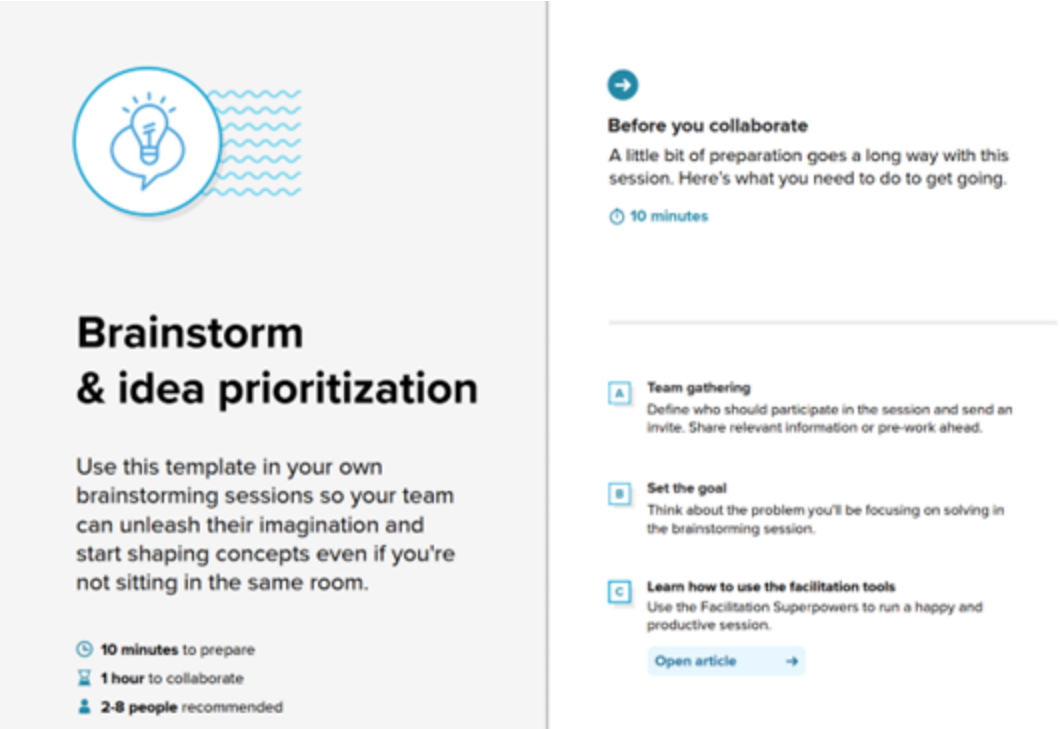
- Noncommunicable illnesses are the leading cause of early death, and CKD is the leading noncommunicable disease.
- Chronic Kidney Disease is a major concern for the global health care system.
- People with CKD must focus on implementing proven, cost-effective therapies to as many people as possible while taking into consideration restricted needs, human and financial resources.
- Chronic kidney disease (CKD) is now wreaking havoc on society and is spreading at an alarming rate.
- Various efforts have been undertaken to advance early therapy to prevent the condition from progressing to chronic disease.
- Recent research suggests that some of the negative outcomes can be avoided with early identification and treatment.

# CHAPTER 3

# IDEATION AND PROPOSED SOLUTION

## 3.1 EMPATHY MAP CANVAS

## 3.2 IDEATION & BRAINSTORMING




**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 and break it up into smaller sub-groups.

20 minutes

## Ideas suggesting Machine Learning approach

- Ensure accuracy in prediction by using ML
- To create an MI model to prevent manual errors.
- Precise prediction

## Ideas suggesting Early detection

- Diagnose CKD through test results of other diseases.
- Detect the disease in it's early stages
- Quick analysis of parameters
- To detect disease quickly

## Ideas suggesting easy usability

- Make it Easily accessible to all
- Make it openly available to all
- Provide User-friendly Interface
- To design user friendly UI

**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

**After you collaborate**
You can export the mural as an image or pdf to share with members of your company who might find it helpful.

## Quick add-ons

**Share the mural**
**Share a view link** to the mural with stakeholders to keep them in the loop about the outcomes of the session.

**Export the mural**
Export a copy of the mural as a PNG or PDF to attach to emails, include in slides, or save in your drive.

## Keep moving forward

**Strategy blueprint**
Define the components of a new idea or strategy.
Open the template →

**Customer experience journey map**
Understand customer needs, motivations, and obstacles for an experience.
Open the template →

**Strengths, weaknesses, opportunities & threats**
Identify strengths, weaknesses, opportunities, and threats (SWOT) to develop a plan.
Open the template →

Share template feedback

## 3.3 PROPOSED SOLUTION

| S. No. | Parameter | Description |
|---|---|---|
| 1. | Problem Statement (Problem to besolved) | Many people suffer from Chronic Kidney Disease(CKD) which is life-threatening when identified in a serious stage and needseffective treatment at an earlystage. |
| 2. | Idea / Solution description | The aim of this project is to detect Chronic Kidney Disease even before there are symptoms so that effective treatment can be given at the righttime. |
| 3. | Novelty / Uniqueness | This projectuses parameters fromvarious test results other than thosefor CKD to diagnose the disease. |
| 4. | Social Impact/ Customer Satisfaction | As this solution predicts the disease at an early stage the patientscan get the right treatment at the righttime. Also It helps doctors to quicklydiagnose the disease. |
| 5. | Business Model(Revenue Model) | This project can be kept open for people to have easy access as a website so that anyone can get quick diagnosis at the earliest. Hencerevenue can be generated fromthe use of thiswebsite as a tool byDoctors and common public as well. |
| 6. | Scalability of the Solution | It can be improved by reducing the number of parameters needed for this prediction and alsoincrease theaccuracy. Further thissolution can be applied to detect variousother diseases inthe future. |

# 3.4 PROBLEM SOLUTION FIT

Project Title: Early Detection of Chronic Kidney Disease using Machine Learning | Project Design Phase-I - Solution Fit Template | Team ID: PNT2022TMID52708

Define CS, fit into CC

**1. CUSTOMER SEGMENT(S)** CS

Who is your customer?
i.e. working parents of 0-5 y.o. kids

The main users of this project are doctors, nurses, patients and also common people who have some symptoms or like to get tested for CKD.

**6. CUSTOMER CONSTRAINTS** CC

What constraints prevent your customers from taking action or limit their choices of solutions? i.e. spending power, budget, no cash, network connection, available devices.

-Costly tests for diagnosis
-Longer time to Detect diseases
-Human error due to negligence
-Lack of skilled doctors

**5. AVAILABLE SOLUTIONS** AS

Which solutions are available to the customers when they face the problem or need to get the job done? What have they tried in the past? What pros & cons do these solutions have? i.e. pen and paper is an alternative to digital notetaking

Diagnosis by doctors and lab technicians manually with the help of various test results

Explore AS, differentiate

Focus on J&P, tap into BE, understand RC

**2. JOBS-TO-BE-DONE / PROBLEMS** J&P

Which jobs-to-be-done (or problems) do you address for your customers? There could be more than one; explore different sides.

-Diagnose the disease in the early stage
-Ensure accurate prediction results
-Design a user friendly interface
-Make the application easily accessible to the customers

**9. PROBLEM ROOT CAUSE** RC

What is the real reason that this problem exists? What is the back story behind the need to do this job?
i.e. customers have to do it because of the change in regulations.

-Expensive tests for diagnosis
-Unavailability of facilities in hospitals
-Human error in manual diagnosis
-Lack of experience of doctors

**7. BEHAVIOUR** BE

What does your customer do to address the problem and get the job done?
i.e. directly related: find the right solar panel installer, calculate usage and benefits; indirectly associated: customers spend free time on volunteering work (i.e. Greenpeace)

-Visit the hospital for diagnosis and treatment
-Discuss with friends and relatives about the symptoms
-Search through internet to get insights on the symptoms

Focus on J&P, tap into BE, understand RC

Identify strong TR & EM

**3. TRIGGERS** TR

What triggers customers to act? i.e. seeing their neighbour installing solar panels, reading about a more efficient solution in the news.

Imprecise and expensive test results that make diagnosis slower.

**4. EMOTIONS: BEFORE / AFTER** EM

How do customers feel when they face a problem or a job and afterwards?
i.e. lost, insecure > confident, in control - use it in your communication strategy & design.

Before: Frustrated, hopeless, Insecured
After: Confident, Peaceful, Positive attitude

**10. YOUR SOLUTION** SL

If you are working on an existing business, write down your current solution first, fill in the canvas, and check how much it fits reality.
If you are working on a new business proposition, then keep it blank until you fill in the canvas and come up with a solution that fits within customer limitations, solves a problem and matches customer behaviour.

An ML model to prevent manual errors in diagnosis of CKD through test results of other diseases thereby detecting the disease in its early stages accurately.

**8. CHANNELS of BEHAVIOUR** CH

**8.1 ONLINE**
What kind of actions do customers take online? Extract online channels from #7

Search through the internet to get insights on the disease and symptoms

**8.2 OFFLINE**
What kind of actions do customers take offline? Extract offline channels from #7 and use them for customer development.

- Visit the hospital for diagnosis and treatment
- Discuss with friends and relatives about the symptoms

Identify strong TR & EM

# CHAPTER 4

# REQUIREMENT ANALYSIS

## 4.1FUNCTIONAL REQUIREMENTS

| FR No. | Functional Requirement (Epic) | Sub Requirement (Story / Sub-Task) |
|---|---|---|
| FR-1 | User Registration | Registration through FormRegistration through Gmail |
| FR-2 | User Confirmation | Confirmation via Email Confirmation via OTP |
| FR-3 | Data Collection | Input data through Form Storethe data in database |
| FR-4 | Data Analysis | Pre-process the data Check correctformat of Input |
| FR-5 | Prediction of disease | Evaluate the ML modelwith the dataStore the resultin database |
| FR-6 | Provide output to theuser | Display the prediction result in UI |

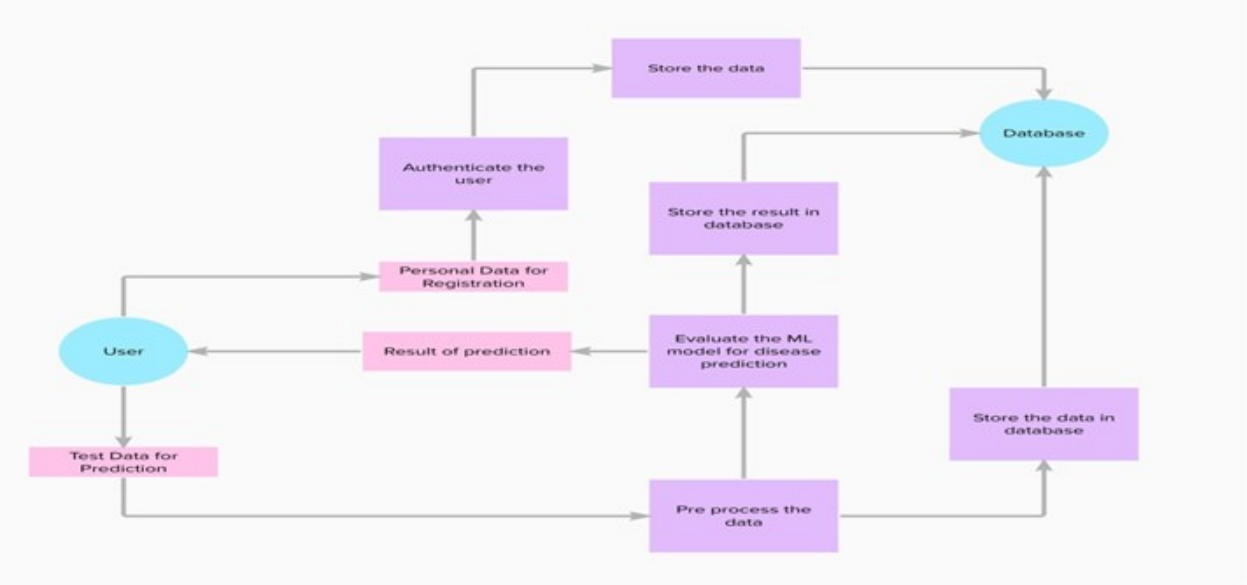
## 4.2 NON FUNCTIONAL REQUIREMENTS

| FR No. | Non-Functional Requirement | Description |
|---|---|---|
| NFR-1 | **Usability** | The Web UI is simple and easy fornavigation and understanding even by common people with thehelp of known labelsand descriptions. |
| NFR-2 | **Security** | The users are required to register so that onlyverified users can use the application. |
| NFR-3 | **Reliability** | The prediction result is expected to be accurate andfree fromerror. |
| NFR-4 | **Performance** | The webpage must load quickly even with slowinternet connection.<br>The ML model must predict the result withgreataccuracy andspeed. |
| NFR-5 | **Availability** | The website should be without any downtime forupdates. |
| NFR-6 | **Scalability** | This simple web application must have high scalability forsupporting large numberof users. |

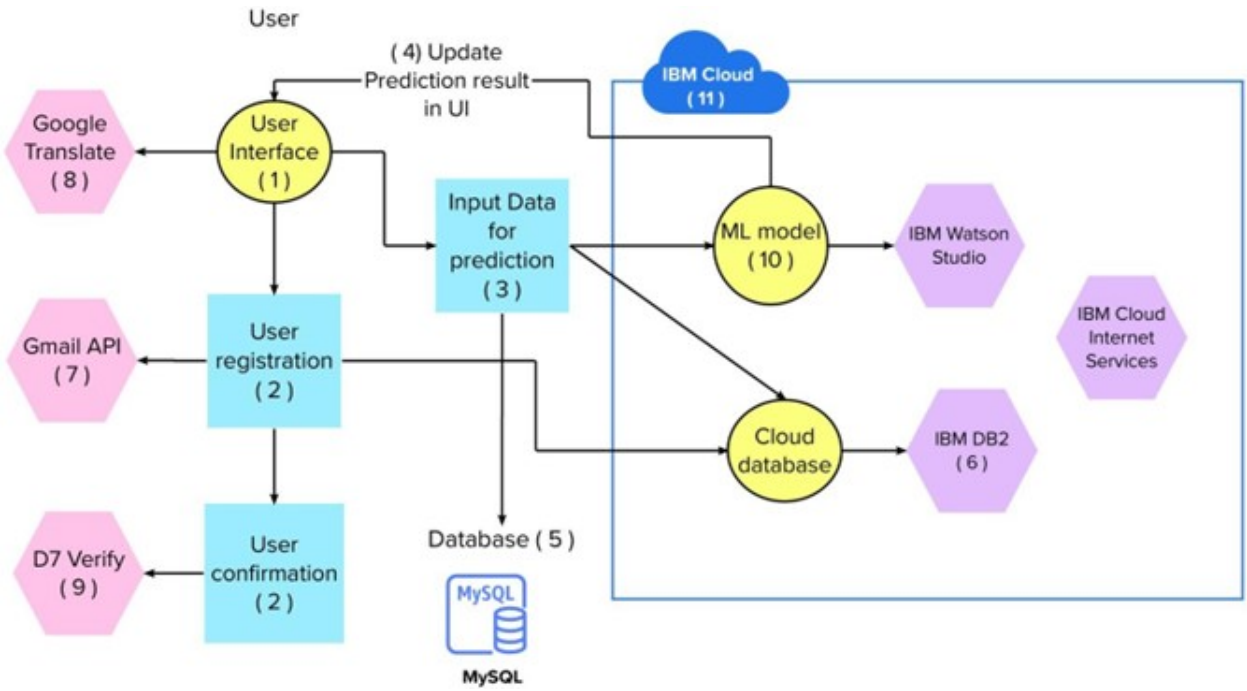
# CHAPTER 5

# PROJECT DESIGN

## 5.1 DATA FLOW DIAGRAM




## 5.2 SOLUTION & TECHNICAL ARCHITECTURE




## 5.3 USER STORIES

| User Type | Functional Requirement (Epic) | User Story Number | User Story / Task | Acceptance criteria | Priority | Release |
|---|---|---|---|---|---|---|
| Web user (customer) | Access web page | USN-1 | As a user, anyone can access the web page to upload the handwritten image | I can access my web page through online at any time | High | Sprint-1 |
| | Usage of handwritten data | USN-2 | As per the style of the handwriting, it is easy to predict the input | Prediction can be done in an easy way | High | Sprint-2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Accuracy of the handwriting | USN-3 | By using the prediction model, the user can check whether the digit is recognized correctly | Prediction of handwritten digit will be accurate | High | Sprint-3 |
| | View the result | USN-4 | As a user, he/she can view the digitalized form of the input | Final result will be displayed | High | Sprint-3 |
| Customer Care Executive | Upload clear image/ draw clearly | USN-5 | As a user, he/she need to upload clear and neat image to increase accuracy | Result will be accurate | High | Sprint-3 |

# CHAPTER 6

# PROJECT PLANNING AND SCHEDULING

## 6.1 SPRINT PLANNING AND ESTIMATION

| Sprint | Functional Requirement (Epic) | User Story Number | User Story / Task | Story Points | Priority | Team Members |
|---|---|---|---|---|---|---|
| Sprint-3 | Provide output to the user | USN-6 | As a user, I will get the result of disease prediction in the dashboard. | 10 | High | Naveen V<br>Kaviyarasan R<br>Nagadeepan G S<br>Neha S |
| Sprint-3 | Data Analysis | USN-7 | As the admin, I will develop modules to preprocess and store the data. | 10 | High | Naveen V<br>Kaviyarasan R<br>Nagadeepan G S<br>Neha S |
| Sprint-4 | Prediction of disease | USN-8 | As the admin, I will build a Machine Learning model to predict the disease | 10 | High | Naveen V<br>Kaviyarasan R<br>Nagadeepan G S<br>Neha S |
| Sprint-4 | Final Delivery | USN-9 | Deploy the application in IBM cloud and make it available for use. | 10 | High | Naveen V<br>Kaviyarasan R<br>Nagadeepan G S<br>Neha S |

| Sprint | Functional Requirement (Epic) | User Story Number | User Story / Task | Story Points | Priority | Team Members |
|---|---|---|---|---|---|---|
| Sprint-1 | User Registration | USN-1 | As a user, I can register for the application by entering my name, mobile number, email, password, and confirming my password. | 10 | High | Naveen V<br>Kaviyarasan R<br>Nagadeepan G S<br>Neha S |
| Sprint-2 | | USN-2 | As a user, I can register for the application through Gmail | 5 | Medium | Naveen V<br>Kaviyarasan R<br>Nagadeepan G S<br>Neha S |
| Sprint-1 | User Confirmation | USN-3 | As a user, I will receive confirmation email once I have registered for the application | 10 | High | Naveen V<br>Kaviyarasan R<br>Nagadeepan G S<br>Neha S |
| Sprint-2 | | USN-4 | As a user, I will receive confirmation otp to verify the identity. | 5 | High | Naveen V<br>Kaviyarasan R<br>Nagadeepan G S<br>Neha S |
| Sprint-2 | Data Collection | USN-5 | As a user, I will enter the input data for disease prediction in the form | 10 | High | Naveen V<br>Kaviyarasan R<br>Nagadeepan G S<br>Neha S |

## 6.2 SPRINT DELIVERY SCHEDULE

| Sprint | Total Story Points | Duration | Sprint StartDate | Sprint End Date (Planned) | Story Points Completed (as on PlannedEnd Date) | Sprint ReleaseDate (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 |

# CHAPTER 7

## CODING & SOLUTIONING

```python
import os
import random
import string
from pathlib import Path
import numpy as np
from tensorflow.keras.models import load_model
from PIL import Image, ImageOps
import cv2

```

```python

def recognize(image: bytes) -> int:
    """
    Predicts the digit in the image.

    Args:
        image (bytes): The image data.

    Returns:
        tuple: The best prediction, other predictions and file name
    """

    model=load_model(Path("./model/digit.h5"))
    image = cv2.imread(image)
    grey = cv2.cvtColor(image.copy(), cv2.COLOR_BGR2GRAY)
    ret, thresh = cv2.threshold(grey.copy(), 75, 255, cv2.THRESH_BINARY_INV)
    contours, _  = cv2.findContours(thresh.copy(), cv2.RETR_EXTERNAL, cv2.CHAIN_APPROX_SIMPLE)
    preprocessed_digits = []
    for c in contours:
        x,y,w,h = cv2.boundingRect(c)
        cv2.rectangle(image, (x,y), (x+w, y+h), color=(0, 255, 0), thickness=2)
        digit = thresh[y:y+h, x:x+w]
        resized_digit = cv2.resize(digit, (18,18))
        padded_digit = np.pad(resized_digit, ((5,5),(5,5)), "constant", constant_values=0)
        preprocessed_digits.append(padded_digit)
    for digit in preprocessed_digits:
        prediction = model.predict(digit.reshape(1, 28, 28, 1))
        best= np.argmax(prediction)



    return best, "1.jpg"
```

# CHAPTER 8
# TESTING

## 8.1TEST CASES

| Test case ID | Feature Type | Component | Test Scenario | Expected Result | Actual Result | Status |
|---|---|---|---|---|---|---|
| HP_TC_001 | UI | Home Page | Verify UI elements in the Home Page | The Home page must be displayed properly | Working as expected | PASS |
| HP_TC_002 | UI | Home Page | Check if the UI elements are displayed properly in different screen sizes | The Home page must be displayed properly in all sizes | The UI is not displayed properly in screen size 2560 x 1801 and 768 x 630 | FAIL |
| HP_TC_003 | Functional | Home Page | Check if user can upload their file | The input image should be uploaded to the application successfully | Working as expected | PASS |
| HP_TC_004 | Functional | Home Page | Check if user cannot upload unsupported files | The application should not allow user to | User is able to upload any file | FAIL |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | select a non image file | | |
| HP_TC_005 | Functional | Home Page | Check if the page redirects to the result page once the input is given | The page should redirect to the results page | Working as expected | PASS |

| | | | | | | |
|---|---|---|---|---|---|---|
| BE_TC_001 | Functional | Backend | Check if all the routes are working properly | All the routes should properly work | Working as expected | PASS |
| M_TC_001 | Functional | Model | Check if the model can handle various image sizes | The model should rescale the image and predict the results | Working as expected | PASS |
| M_TC_002 | Functional | Model | Check if the model predicts the digit | The model should predict the number | Working as expected | PASS |
| M_TC_003 | Functional | Model | Check if the model can handle complex input image | The model should predict the number in the complex image | The model fails to identify the digit since the model is not built to handle such data | FAIL |
| RP_TC_001 | UI | Result Page | Verify UI elements in the Result Page | The Result page must be displayed properly | Working as expected | PASS |

| | | | | | | |
|---|---|---|---|---|---|---|
| RP_TC_002 | UI | Result Page | Check if the input image is displayed properly | The input image should be displayed properly | The size of the input image exceeds the display container | FAIL |
| RP_TC_003 | UI | Result Page | Check if the result is displayed properly | The result should be displayed properly | Working as expected | PASS |
| RP_TC_004 | UI | Result Page | Check if the other predictions are displayed properly | The other predictions should be displayed properly | Working as expected | PASS |

## 8.2USER ACCEPTANCE TESTING

### i. DEFECT ANALYSIS

| Resolution | Severity 1 | Severity 2 | Severity 3 | Severity 4 | Total |
|---|---|---|---|---|---|
| By Design | 1 | 0 | 1 | 0 | 2 |
| Duplicate | 0 | 0 | 0 | 0 | 0 |
| External | 0 | 0 | 2 | 0 | 2 |
| Fixed | 4 | 1 | 0 | 1 | 6 |
| Not Reproduced | 0 | 0 | 0 | 1 | 1 |
| Skipped | 0 | 0 | 0 | 1 | 1 |
| Won’t Fix | 1 | 0 | 1 | 0 | 2 |

| | | | | | |
|---|---|---|---|---|---|
| Total | 6 | 1 | 4 | 3 | 14 |

## ii. TEST CASE ANALYSIS

| Section | Total Cases | Not Tested | Fail | Pass |
|---|---|---|---|---|
| Client Application | 10 | 0 | 3 | 7 |
| Security | 2 | 0 | 1 | 1 |
| Performance | 3 | 0 | 1 | 2 |
| Exception Reporting | 2 | 0 | 0 | 2 |

# CHAPTER 9

# RESULTS

## 9.1 PERFORMANCE METRICS

### CONFUSION MATRIX:

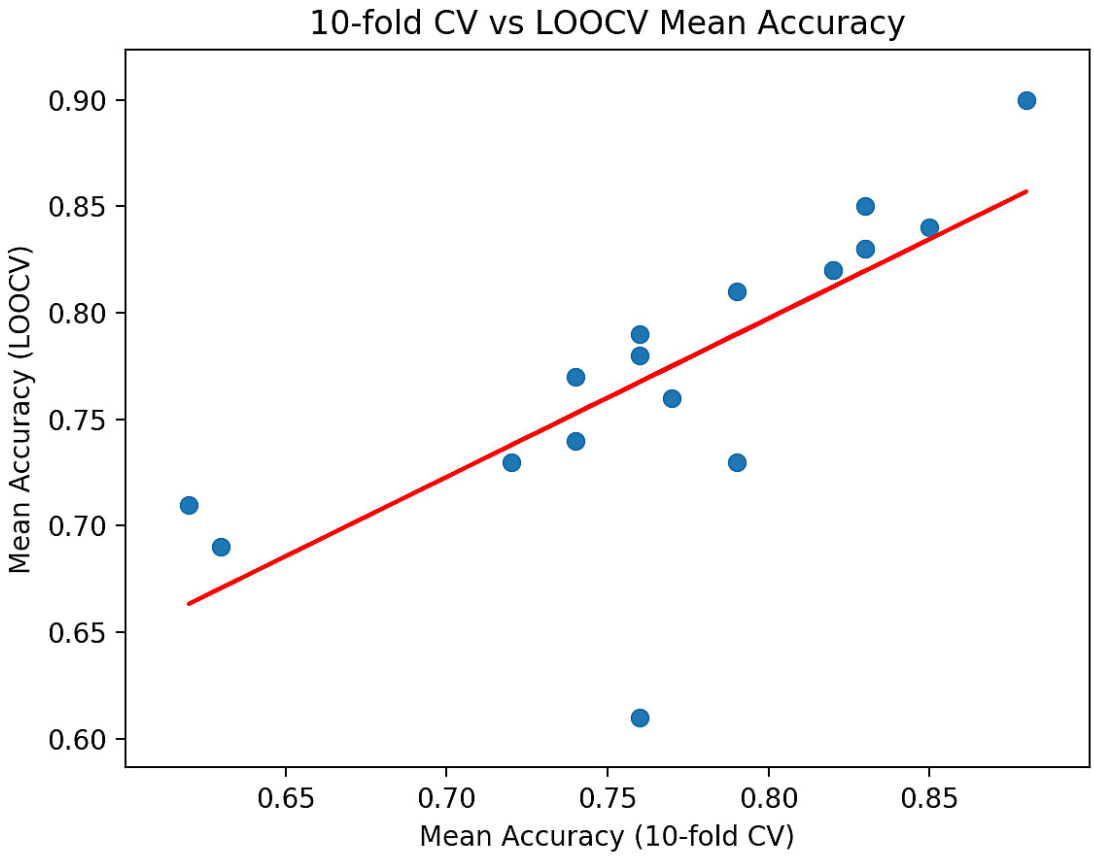
```
confusion_mat = confusion_matrix(y_test,y_pred)
confusion_mat
```

```
array([[51,  3],
       [ 3, 23]], dtype=int64)
```

```
In [37]: accuracy_score(y_test,y_pred)
```

```
Out[37]: 0.925
```

**CROSS- VALIDATION:**



# CHAPTER 10

# ADVANTAGES & DISADVANTAGES

## 10.1 ADVANTAGES

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

## 10.2 DISADVANTAGES

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

# CHAPTER 11

# CONCLUSION

This project demonstrated a web application that uses machine learning to recognise handwritten numbers. Flask, HTML, CSS, JavaScript, and a few other technologies were used to create this project. The model predicts the handwritten digit using a CNN network. During testing, the model achieved a 98% recognition rate. The proposed project is scalable and can easily handle a huge number of users. Since it is a web application, it is compatible with any device that can run a browser. This project is extremely useful in real-world scenarios such as recognizing number plates of vehicles, processing bank cheque amounts, numeric entries in forms filled up by hand (tax forms) and so on. There is so much room for improvement, which can be implemented in subsequent versions.

# CHAPTER 12
# FUTURE SCOPE

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

i. Add support to detect digits from manual writing in canvas
ii. Add support to detect multiple digits
iii. Improve model to detect digits from complex images
iv. Add support to different languages to help users from all over the world

This project has endless potential and can always be enhanced to become better. Implementing this concept in the real world will benefit several industries and reduce the workload on many workers, enhancing overall work efficiency.

# APPENDIX

## SOURCE CODE:

## MODEL CREATION:

```
from keras.datasets import mnist
import matplotlib.pyplot as plt
from keras.utils import np_utils
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D,Dense,Flatten
from tensorflow.keras.optimizers import Adam
(X_train,y_train),(
X_test,y_test) =mnist.load_data()
print(X_train.shape)
print(X_test.shape)
print(y_test.shape)
print(y_train.shape)
print("The label value is ",y_test[10]) #Value in y_test
plt.imshow(X_test[10])
print("The label value is ",y_test[65]) #Value in y_test
plt.imshow(X_test[65])
X_train.shape
X_test.shape
 X_train1 = X_train.reshape(60000, 28, 28, 1).astype('float32')
X_test1 = X_test.reshape(10000, 28, 28, 1).astype('float32')
number_of_classes= 10
y_train1 = np_utils.to_categorical(y_train,number_of_classes)
y_test1 = np_utils.to_categorical(y_test,number_of_classes)
print("After encoding the value",y_test[10] ,"become", y_test1[10])
print("After encoding the value",y_test[100] ,"become", y_test1[100])
 print("After encoding the value",y_test[65] ,"become", y_test1[65])
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_train1, y_train1, batch_size=32, epochs=5, validation_data=(X_test1,y_test1))
metrics = model.evaluate(X_test1, y_test1, verbose=0)
print("Metrics (Test Loss & Test Accuracy): ")
print(metrics)
prediction = model.predict(X_test1[:4])
print(prediction)
import numpy as np
print(np.argmax(prediction, axis=1))
print(y_test1[:4])
model.save("model.h5")
from tensorflow.keras.models import load_model
model=load_model("model.h5")
 model.summary()
```

## FLASK APP:

```
from flask import Flask, render_template, request,redirect,session, url_for
from flask_mail import Mail, Message
from itsdangerous import URLSafeTimedSerializer, SignatureExpired
import mysql.connector
import os
from flask_mysqldb import MySQL
from recognize import recognize
import requests
from io import BytesIO
from werkzeug.utils import secure_filename
app = Flask(__name__)
app.secret_key=os.urandom(24)
app.config['MYSQL_HOST'] = 'localhost'
```

```
app.config['MYSQL_USER'] = 'root'
app.config['MYSQL_PASSWORD'] = ''
app.config['MYSQL_DB'] = 'digit_recognition'
mysql = MySQL(app)
@app.route('/')
def index():
    return render_template('index.html')
@app.route('/login')
def login():
    return render_template('login.html')

@app.route('/register/')
def about():
    return render_template('form.html')
@app.route('/home')
def home():
    if 'email' in session:
        return render_template('home.html')
    else:
        return redirect('/')
@app.route('/login_validation',methods=['POST'])
def login_validation():
    if request.method == "POST":
       email=request.form.get('email')
        password=request.form.get('password')
        error = None
        if mysql:
            print("Connection Successful!")
            cursor = mysql.connection.cursor()
            cursor.execute("""SELECT * FROM `users` where `Email` LIKE '{}' """.format(email))
```

```
            users = cursor.fetchall()
            cursor.close()
            cursor1 = mysql.connection.cursor()
              cursor1.execute("""SELECT * FROM `users` where `Email` LIKE '{}' and `Password` LIKE '{}'""".format(email, password))
            users1 = cursor1.fetchall()
            cursor1.close()
        else:
            print("Connection Failed!")
        if len(users)>0:
            if len(users1)>0:
                session['email'] = users[0][1]
                return redirect('/home')
            else:
                error = "Wrong password"
        else:
            error = "Email not available"
    return render_template('login.html',error=error)
@app.route('/add_user',methods=['POST'])
def add_user():
    username=request.form.get('username')
    email = request.form.get('email')
    password = request.form.get('password')
    phone = request.form.get('phone')
    gender = request.form.get('gender')
    if mysql:
        print("Connection Successful!")
        cursor = mysql.connection.cursor()
        cursor.execute(
                    """INSERT INTO `users` (`FullName`,`Email`,`Password`,`PhoneNo`,`Gender`) VALUES ('{}','{}','{}','{}','{}')""".format(username,email, password,phone,gender))
```

```
            mysql.connection.commit()
            cursor.close()
        else:
            print("Connection Failed!")
        return redirect('/login')
@app.route('/logout')
def logout():
    return redirect('/')
@app.route('/predictpage',methods=['POST'])
def predictpage():
    return render_template('prediction.html')
@app.route('/submit',methods=['POST'])
def submit():
    if request.method == 'POST':
        # Upload file flask
        uploaded_img = request.files['image']
        # Upload file to database (defined uploaded folder in static path)
        uploaded_img.save('./static/data/1.jpg')
        # Storing uploaded file path in flask session
        session['uploaded_img_file_path'] = "./static/data/1.jpg"
        return render_template('prediction.html')
@app.route('/prediction',methods=('POST', "GET"))
def predict():
        # Retrieving uploaded file path from session
        img_file_path = session.get('uploaded_img_file_path', None)
        best, img1 = recognize(img_file_path)
        return render_template("prediction.html", best=best, img_name=img1)
if __name__=="__main__":
    app.run(debug=True)
```

**RECOGNIZER(PYTHON):**

```
import os
import random
import string
from pathlib import Path
import numpy as np
from tensorflow.keras.models import load_model
from PIL import Image, ImageOps
import cv2
def recognize(image: bytes) -> int:
    """
    Predicts the digit in the image.

    Args:
        image (bytes): The image data.
    Returns:
        tuple: The best prediction, other predictions and file name
    """
    model=load_model(Path("./model/digit.h5"))
    image = cv2.imread(image)
    grey = cv2.cvtColor(image.copy(), cv2.COLOR_BGR2GRAY)
    ret, thresh = cv2.threshold(grey.copy(), 75, 255, cv2.THRESH_BINARY_INV)
                contours, _ = cv2.findContours(thresh.copy(), cv2.RETR_EXTERNAL,
cv2.CHAIN_APPROX_SIMPLE)
    preprocessed_digits = []
    for c in contours:
        x,y,w,h = cv2.boundingRect(c)
        cv2.rectangle(image, (x,y), (x+w, y+h), color=(0, 255, 0), thickness=2)
        digit = thresh[y:y+h, x:x+w]
        resized_digit = cv2.resize(digit, (18,18))
        padded_digit = np.pad(resized_digit, ((5,5),(5,5)), "constant", constant_values=0)
        preprocessed_digits.append(padded_digit)
    for digit in preprocessed_digits:
        prediction = model.predict(digit.reshape(1, 28, 28, 1))
        best= np.argmax(prediction)
    return best, "1.jpg"
```

**FORM PAGE(HTML):**

```
<!doctype html>
<html lang="en">
  <head>
    <!-- Required meta tags -->
    <meta charset="utf-8">
    <meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">
<link rel="stylesheet" type="text/css" href="{{ url_for('static',filename='css/style.css')}}">
    <!-- Bootstrap CSS -->
                                                    <link rel="stylesheet"
 href="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/css/bootstrap.min.css"
 integrity="sha384-
 ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcWr7x9JvoRxT2MZw1T"
 crossorigin="anonymous">
<title>Handwritten Digit Recognition</title>
     <img src="{{ url_for('static', filename='images/registerimg2.jpg') }}" alt="" width="600"
 height="650" style="margin-left: 100px;margin-right:0%;">
    <style>
*{
  margin: 0;
  padding: 0;
  box-sizing: border-box;
  font-family: 'Poppins',sans-serif;
}
body{
  height: 100vh;
  display: flex;
  justify-content: center;
  align-items: center;
  padding: 10px;
  background: linear-gradient(135deg, #71b7e6, #9b59b6);
}
.container{
  max-width: 700px;
  margin-left: 0%;
```

```
  width: 100%;
  background-color: #fff;
  padding: 25px 30px;
  border-radius: 5px;
  box-shadow: 0 5px 10px rgba(0,0,0,0.15);
}
.container .title{
  font-size: 25px;
  font-weight: 500;
  position: relative;
}
.container .title::before{
  content: "";
  position: absolute;
  left: 0;
  bottom: 0;
  height: 3px;
  width: 30px;
  border-radius: 5px;
  background: linear-gradient(135deg, #71b7e6, #9b59b6);
}
.content form .user-details{
  display:inline;
  flex-wrap: wrap;
  justify-content: space-between;
  margin: 20px 0 12px 0;
}
 form .input-box span.details{
  display: block;
  font-weight: 500;
  margin-bottom: 5px;
}
.user-details .input-box input{
  height: 45px;
  width: 100%;
  outline: none;
  font-size: 16px;
```

```
  border-radius: 5px;
  padding-left: 15px;
  border: 1px solid #ccc;
  border-bottom-width: 2px;
  transition: all 0.3s ease;
}
.user-details .input-box input:focus,
.user-details .input-box input:valid{
  border-color: #9b59b6;
}
 form .gender-details .gender-title{
  font-size: 20px;
  font-weight: 500;
 }
 form .category{
   display: flex;
   width: 80%;
   margin: 14px 0 ;
   justify-content: space-between;
 }
 form .category label{
   display: flex;
   align-items: center;
   cursor: pointer;
 }
 form input[type="radio"]{
   display: none;
 }
 form .button{
   height: 45px;
   margin: 35px 0
 }
 form .button input{
   height: 100%;
   width: 100%;
   border-radius: 5px;
   border: none;
```

```
  color: #fff;
  font-size: 18px;
  font-weight: 500;
  letter-spacing: 1px;
  cursor: pointer;
  transition: all 0.3s ease;
  background: linear-gradient(135deg, #71b7e6, #9b59b6);
 }
 form .button input:hover{
  /* transform: scale(0.99); */
  background: linear-gradient(-135deg, #71b7e6, #9b59b6);
  }
 @media(max-width: 584px){
 .container{
  max-width: 100%;
}
form .user-details .input-box{
    margin-bottom: 15px;
    width: 100%;
  }
  form .category{
    width: 100%;
  }
  .content form .user-details{
    max-height: 300px;
    overflow-y: scroll;
  }
  .user-details::-webkit-scrollbar{
    width: 5px;
  }
  }
  @media(max-width: 459px){
  .container .content .category{
    flex-direction: column;
  }
}
  </style>
```

```
 </head>
 <body class="bg-nav">
  <div class="container">
   <div class="title">Registration</div><br>
   <div class="content">
    <form method="post" action="/add_user">
     <div class="user-details">
      <div class="input-box">
       <label>Username</label><br>
        <input type = "text" class="form-control" name="username" placeholder="Enter your
name" required>
      </div>
      <div class="input-box">
       <label>Email</label><br>
          <input type = "email" class="form-control" name="email" placeholder="Enter your
email" required>
      </div>
      <div class="input-box">
       <label>Password</label><br>
         <input type="password" class="form-control" name="password" placeholder="Enter
your password" required>
      </div>
      <div class="input-box">
       <label>Phone Number</label><br>
        <input type = "number" class="form-control" name="phone" placeholder="Enter your
number" required>
      </div>
      <div class="input-box">
       <label>Gender</label><br>
          <input type = "text" class="form-control" placeholder="Enter Male/Female/Others"
name="gender" required>
      </div>
      <div class="button">
       <input type="submit" class="btn btn-primary btn-block btn-lg" value="Register">
      </div>
     </div>
              <p style="text-align:center;">Already have an Account?  <a href="/login"
```

```
class="reg">Login</a></h4>
        </form>
     </div>
   </div>
 </body>
```

## INDEX PAGE(HTML):

```
<!DOCTYPE html>
<html lang="en">
<head>
   <meta charset="UTF-8">
   <meta http-equiv="X-UA-Compatible" content="IE=edge">
   <meta name="viewport" content="width=device-width, initial-scale=1.0">
   <title>User Account Dropdown Menu Using Html CSS & Vanilla Javascript</title>
   <link rel="stylesheet" href="style.css">
                                                                                <link
href="https://fonts.googleapis.com/css2?family=Poppins:wght@200;300;400;600&display=sw
ap" rel="stylesheet">
                                                                                <link
href="https://fonts.googleapis.com/css?family=Material+Icons|Material+Icons+Outlined|Materi
al+Icons+Two+Tone|Material+Icons+Round|Material+Icons+Sharp" rel="stylesheet">
   <style>
      *{
         font-family: "poppins", sans-serif;
         margin: 0;
         padding: 0;
      }



.icons-size{
   color: white;
   font-size: 14px;
}
.text{
   position: fixed;
   right: 950px;
```

```
    top:22px
}
.action{
    position: fixed;
    right: 1450px;
    top:20px
}
.action .profile{
    border-radius: 50%;
    cursor: pointer;
    height: 60px;
    overflow: hidden;
    position: relative;
    width: 60px;
}
.action .profile img{
    width: 100%;
    top:0;
    position: absolute;
    object-fit: cover;
    left: 0;
    height: 100%;
}
.action .menu{
    background-color:#FFF;
    box-sizing:0 5px 25px rgba(0,0,0,0.1);
    border-radius: 15px;
    padding: 10px 20px;
    position: absolute;
    left: -10px;
    width: 200px;
    transition: 0.5s;
    top: 120px;
    visibility: hidden;
    opacity: 0;
}
.action .menu.active{
```

```
    opacity: 1;
    top: 80px;
    visibility: visible;
}
.action .menu::before{
    background-color:#fff;
    content: '';
    height: 20px;
    position: absolute;
    right: 190px;
    transform:rotate(45deg);
    top:-5px;
    width: 20px;
}
.action .menu h3{
    color: #555;
    font-size: 16px;
    font-weight: 600;
    line-height: 1.3em;
    padding: 20px 0px;
    text-align: left;
    width: 100%;
}
.action .menu h3 div{
    color: #818181;
    font-size: 14px;
    font-weight: 400;
}
.action .menu ul li{
    align-items: center;
    border-top:1px solid rgba(0,0,0,0.05);
    display: flex;
    justify-content: left;
    list-style: none;
    padding: 10px 0px;
}
.action .menu ul li img{
```

```
    max-width: 20px;
    margin-right: 10px;
    opacity: 0.5;
    transition:0.5s
}
.action .menu ul li a{
    display: inline-block;
    color: #555;
    font-size: 14px;
    font-weight: 600;
    padding-left: 15px;
    text-decoration: none;
    text-transform: uppercase;
    transition: 0.5s;
}
.action .menu ul li:hover img{
    opacity: 1;
}
.action .menu ul li:hover a{
    color:#ff00ff;
}
.msg{
    position: fixed;
    right: 950px;
    left:0px;
    top:250px
}
      .image {
        background-image: url("{{ url_for('static', filename='images/index2.jpg') }}");
        background-color: #cccccc;
        height: 753px;
        width: 1536px;
        background-position: center;
        background-repeat: no-repeat;
        background-size: cover;
       }
    </style>
```

```
</head>
<body>
  <div class="image">
    <div class="action">
      <div class="profile" onclick="menuToggle();">
        <img src="{{ url_for('static', filename='images/user.jpg') }}" alt="">
         </div>
  <div class="menu">
          <h3>
            User Account
          </h3>
          <ul>
            <li>
              <span class="material-icons icons-size">person</span>
              <a href="/register/">Sign-up</a>
            </li>
            <li>
              <span class="material-icons icons-size">mode</span>
              <a href="/login">Sign-in</a>
            </li>
          </ul>
      </div>
     </div>
    <div class="text">
      <h1 style="color: white;">Handwritten digit Recognisor</h1>
    </div>
    <div class="msg">
      <h1 style="color: white;font-size: 50px;">
      <pre>
        Numbers
        Rule
        The
        Universe
      </pre>
      </h1>
    </div>
   </div>
```

```
  <script>
      function menuToggle(){
         const toggleMenu = document.querySelector('.menu');
         toggleMenu.classList.toggle('active')
      }
   </script>
</body>
```

## LOGIN PAGE(HTML):

```
<!doctype html>
<html lang="en">
  <head>
    <!-- Required meta tags -->
    <meta charset="utf-8">
    <meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <link rel="stylesheet" type="text/css" href="{{ url_for('static',filename='css/style.css')}}">
    <!-- Bootstrap CSS -->
                                                    <link                rel="stylesheet"
href="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/css/bootstrap.min.css"
integrity="sha384-
ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcWr7x9JvoRxT2MZw1T"
crossorigin="anonymous">
                                                                                <link
href="https://fonts.googleapis.com/css2?family=Poppins:wght@200;300;400;600&display=sw
ap" rel="stylesheet">
                                                                                <link
href="https://fonts.googleapis.com/css?family=Material+Icons|Material+Icons+Outlined|Materi
al+Icons+Two+Tone|Material+Icons+Round|Material+Icons+Sharp" rel="stylesheet">
    <title>Handwritten Digit Recognition</title>
    <style>
      .image {
        background-image: url("{{ url_for('static', filename='images/loginimg2.jpg') }}");
        background-color: #cccccc;
        height: 753px;
```

```
      background-position: center;
      background-repeat: no-repeat;
      background-size: cover;
      position: relative;
    }
  </style>
 </head>
 <body class="bg-nav">
  <div class="image">
  <div id="content" >
     <div class="container">
      <br><br>
      <h1 style="text-align:center;">Sign In</h1>
      <div class="row">
       <div class="col-md-6" style="margin-left: 300px;">
         <div class="card">
          <div class="card-body" style="border:2px solid black">
           <form class="form" method="post" action="/login_validation">
            <label>Email</label><br>
            <input type = "email" class="form-control" name="email"><br>
            <label>Password</label><br>
            <input type="password" class="form-control" name="password"><br><br>
            {% if error %}
            <p style="text-align: center;"><strong>Error</strong>: {{error}}</p>
            {% endif %}
            <input type="submit" class="btn btn-primary btn-block btn-lg" value="Login">
           </form>
           <br>
                        <p style="margin-top:10px;text-align:center;">Not a member? <a
href="/register/">Create Account</a></p>
          </div>
         </div>
       </div>
      </div>
     </div>
  </div>
  </div>
```

```
<!-- Optional JavaScript -->
<!-- jQuery first, then Popper.js, then Bootstrap JS -->
<script src="https://code.jquery.com/jquery-3.3.1.slim.min.js" integrity="sha384-
q8i/X+965DzO0rT7abK41JStQIAqVgRVzpbz
o5smXKp4YfRvH+8abtTE1Pi6jizo" crossorigin="anonymous"></script>
<script src="https://cdn.jsdelivr.net/npm/popper.js@1.14.7/dist/umd/popper.min.js"
integrity="sha384-
UO2eT0CpHqdSJQ6hJty5KVphtPhzWj9WO1clHTMGa3JDZwrnQq4sF86dIHNDz0W1"
crossorigin="anonymous"></script>
<script src="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/js/bootstrap.min.js"
integrity="sha384-
JjSmVgyd0p3pXB1rRibZUAYoIIy6OrQ6VrjIEaFf/nJGzIxFDsf4x0xIM+B07jRM"
crossorigin="anonymous"></script>
  </body>
</html>
```

## HOME PAGE (HTML):

```
<!DOCTYPE html>
<html lang="en">
<head>
<!-- Required meta tags -->
<meta charset="utf-8">
<meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">
<link rel="stylesheet" type="text/css" href="{{      url_for('static',filename='css/style.css')}}">
<!-- Bootstrap CSS -->
                                                    <link                rel="stylesheet"
href="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/css/bootstrap.min.css"
integrity="sha384-
ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcWr7x9JvoRxT2MZw1T"
crossorigin="anonymous">
<title>Handwritten Digit Recognition</title>
</head>
```

```
<body>
<div class="bg-nav text-light d-flex flex-column flex-md-row align-items-center p-3 px-md-4 mb-3 bg-dark border-bottom shadow-sm" >
  <h5 class="my-0 mr-md-auto" style="color: black;font-weight: bolder;">Handwritten Digit Recognisor</h5>
 <a class="btn btn-outline-primary" href="/logout" style="color: whitesmoke;">Log Out</a>
</div>
<main role="main">
<section class="album py-3 text-center">
  <form action="/predictpage" method="post">
    <div class="button">
          <input type="submit" class="btn btn-primary btn-block btn-lg" value="Proceed to recognise the handwritten digits">
    </div>
  </form>
</section>
<div class="jumbotron py-8 bg-dark">
  <div class="container">
  <div class="row">
      <div class="card mb-2 shadow-sm">
        <div class="card-body" style="border:5px solid black;">
        <h3 style="text-align: center;">Description</h3><br>
         <p class="card-text" style="font-size: 20px;">The handwritten digit recognition is the ability of computers to recognize human handwritten digits.
          It is a hard task for the machine because handwritten digits are not perfect, vary from person-to-person and can be made with many different flavors.
          The handwritten digit recognition is the solution to this problem which uses the image of a digit and recognizes the digit present in the image.</p>
        </div>
      </div><br><br>
    </div>
  </div>
 </div>
```

```
  </main>
  <script src="https://code.jquery.com/jquery-3.3.1.slim.min.js"integrity="sha384-
q8i/X+965DzO0rT7abK41JS
IAqVgRVzpbzo5smXKp4YfRvH+8abtTE1Pi6jizo"  crossorigin="anonymous">
  </script>
  <script src="https://cdn.jsdelivr.net/npm/popper.js@1.14.7/dist/umd/popper.min.js"
  integrity="sha384-
  UO2eT0CpHqdSJQ6hJty5KVphtPhzWj9WO1clHTMGa3JDZwrnQq4sF86dIHNDz0W1"
  crossorigin="anonymous"></script>
<script src="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/js/bootstrap.min.js"
integrity="sha384-JjSmVgyd0p3p
XB1rRibZUAYoIIy6OrQ6VrjIEaFf/nJGzIxFDsf4x0xIM+B07jRM"
crossorigin="anonymous"></script>
  </body>
  </html>
```

**HOME PAGE (CSS)**:

```
  .bg-nav
  {
     background: #e704c9;  /* fallback for old browsers */
      background: -webkit-linear-gradient(to right, #E5E5BE, #db0ac2);  /* Chrome 10-25, Safari
  5.1-6 */
       background: linear-gradient(to right, #E5E5BE, #f104b6); /* W3C, IE 10+/ Edge, Firefox
  16+, Chrome 26+, Opera 12+, Safari 7+ */
  }
  .row{
     margin-top:80px;
  }
```

## PREDICT PAGE (HTML):

```
<!DOCTYPE html>

<html lang="en">

 <head>

   <!-- Required meta tags -->

   <meta charset="utf-8">

   <meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no">

   <link rel="stylesheet" type="text/css" href="{{ url_for('static',filename='css/style.css')}}">

   <!-- Bootstrap CSS -->

   <link rel="stylesheet"
href="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/css/bootstrap.min.css" integrity="sha384-
ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcWr7x9JvoRxT2MZw1T"
crossorigin="anonymous">

  <title>Handwritten Digit Recognition</title>

</head>

<body>

<div class="bg-nav text-light d-flex flex-column flex-md-row align-items-center p-3 px-md-4
mb-3 bg-dark border-bottom shadow-sm" >

<h5 class="my-0 mr-md-auto" style="color: black;font-weight: bolder;">Handwritten Digit
Recognisor</h5>

<a class="btn btn-outline-primary" href="/logout" style="color: whitesmoke;">Log Out</a>

</div>

<main role="main">

 <section class="album py-3 text-center">
```

```
    <form action="/predictpage" method="post">
      <div class="button">
            <input type="submit" class="btn btn-primary btn-block btn-lg" value="Proceed to recognise the handwritten digits">
      </div>
    </form>
</section>
<div class="jumbotron py-8 bg-dark">
    <div class="container">
 <div class="row">
        <div class="card mb-2 shadow-sm">
           <div class="card-body" style="border:5px solid black;">
           <h3 style="text-align: center;">Description</h3><br>
            <p class="card-text" style="font-size: 20px;">The handwritten digit recognition is the ability of computers to recognize human handwritten digits.
                It is a hard task for the machine because handwritten digits are not perfect, vary from person-to-person and can be made with many different flavors.
                The handwritten digit recognition is the solution to this problem which uses the image of a digit and recognizes the digit present in the image.</p>
          </div>
        </div><br><br>
      </div>
    </div>
  </div>
```

```
</main>

<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://cdn.jsdelivr.net/npm/popper.js@1.14.7/dist/umd/popper.min.js" integrity="sha384-UO2eT0CpHqdSJQ6hJty5KVphtPhzWj9WO1clHTMGa3JDZwrnQq4sF86dIHNDz0W1" crossorigin="anonymous"></script>

<script src="https://cdn.jsdelivr.net/npm/bootstrap@4.3.1/dist/js/bootstrap.min.js" integrity="sha384-JjSmVgyd0p3pXB1rRibZUAYoIIy6OrQ6VrjIEaFf/nJGzIxFDsf4x0xIM+B07jRM" crossorigin="anonymous"></script>

</body>

</html>
```

## GITHUB

https://github.com/IBM-EPBL/IBM-Project-13438-1659518447

## PROJECT DEMO

https://drive.google.com/file/d/1-NE0wtK0sHoQZOj4hbIH-6_8yhj3OhJD/view