MAHENDRA INSTITUTE OF TECHNOLOGY

(AUTONOMOUS)

Mahendhirapuri, Mallasamudram,Namakkal- 637 503

Office of the Controller of Examinations

IBM – NALAIYA THIRAN PROJECT

A Novel Method for Handwritten Digit Recognition System

INDUSTRY MENTOR : Pradeepthi

FACULTY MENTOR : M.Premkumar

TEAM ID : PNT2022TMID17708

TEAM LEAD : HARIKRISHNAN P

TEAM MEMBER : AJAY.V

TEAM MEMBER : VISHNUPRIYA S

TEAM MEMBER : SARONJOHNSON A

9. TRAIN THE MODAL ON IBM

9.1 Create an HTML file

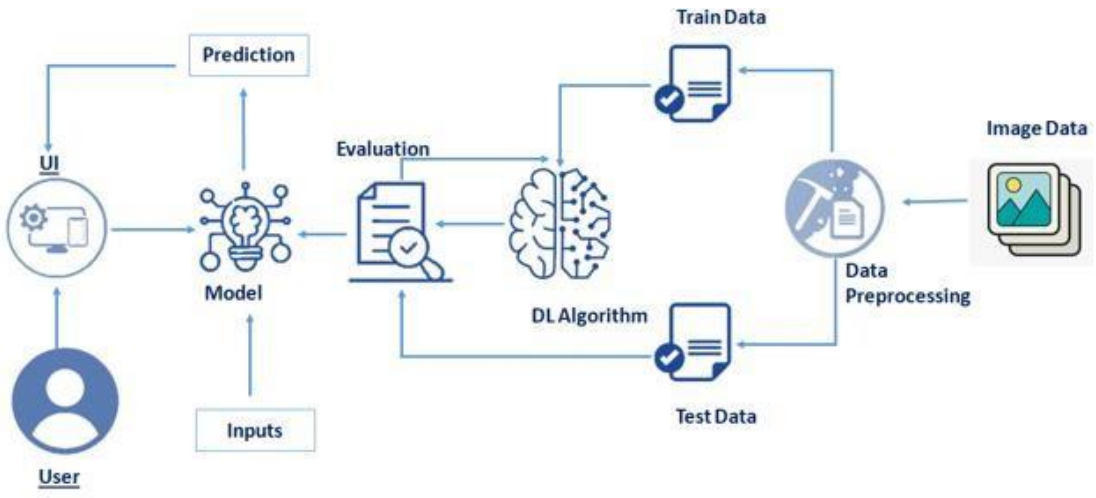
9.2 Build python code (part 1)

1. **INTRODUCTION**

1.1 Project overview

Handwriting recognition is one of the compelling research works going on because every individual in this world has their own style of writing. It is the capability of 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

1.1.1 Technical Architecture:



2. Project Objectives

By the end of this project you will:

- Know fundamental concepts and techniques of the Artificial Neural Network and Convolution Neural Networks
- Gain a broad understanding of image data.
- Work with Sequential type of modeling
- Work with Keras capabilities
- Work with image processing techniques
- know how to build a web application using the Flask framework.

3. Project Flow

Project Flow:

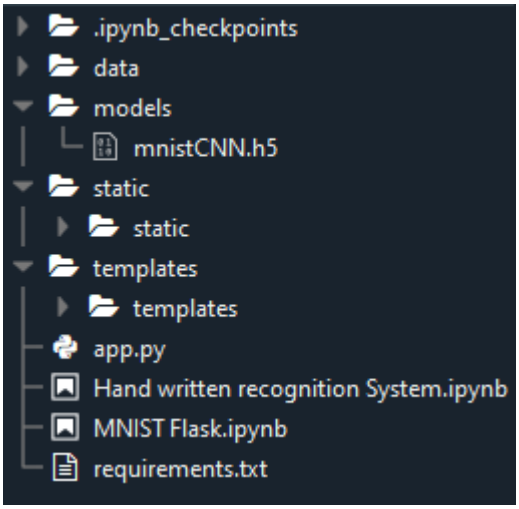
- The user interacts with the UI (User Interface) to upload the image as input
- The uploaded image is analyzed by the model which is integrated
- Once the model analyses the uploaded image, the prediction is showcased on the UI

To accomplish this, we have to complete all the activities and tasks listed below

- Understanding the data.
  - Importing the required libraries
  - Loading the data
  - Analyzing the data
  - Reshaping the data.
  - Applying One Hot Encoding
- Model Building
  - Creating the model and adding the input, hidden and output layers to it
  - Compiling the model
  - Training the model
  - Predicting the result
  - Testing the model by taking image inputs
  - Saving the model
- Application Building
  - Create an HTML file
  - Build Python Code

4. Project Structure

Create a Project folder which contains files as shown below



- We are building a Flask Application which needs HTML pages stored in the templates folder and a python script app.py for server side scripting.
- The model is built in the notebook Hand written recognition system.ipynb
- We need the model which is saved and the saved model in this content is mnistCNN.h5
- The static folder will contain js and css files.
- The templates mainly used here are main.html and index6.html for showcasing the UI

5 . Prerequisites

To complete this project you should have the following software and packages

Anaconda Navigator :

Anaconda Navigator is a free and open-source distribution of the Python and R programming languages for data science and machine learning related applications. It can be installed on Windows, Linux, and macOS. Conda is an open-source, cross-platform, package management system. Anaconda comes with so very nice tools like JupyterLab, Jupyter Notebook, QtConsole, Spyder, Glueviz, Orange, Rstudio, Visual Studio Code. For this project, we will be using Jupiter notebook and spyder

To install Anaconda navigator and to know how to use Jupyter Notebook a Spyder using Anaconda watch the video

To build Deep learning models you must require the following packages

Tensor flow: TensorFlow is an end-to-end open-source platform for machine learning. It has a comprehensive, flexible ecosystem of tools, libraries, and community resources that lets researchers push the state-of-the-art in ML and developers can easily build and deploy ML powered applications.

Keras : Keras leverages various optimization techniques to make high level neural network API easier and more performant. It supports the following features:

- Consistent, simple and extensible API.
- Minimal structure - easy to achieve the result without any frills.
- It supports multiple platforms and backends.
- It is user friendly framework which runs on both CPU and GPU.
- Highly scalability of computation.

Flask: Web frame work used for building Web applications

6. Prior Knowledge

6.1 Understanding the data

ML depends heavily on data, without data, it is impossible for a machine to learn. It is the most crucial aspect that makes algorithm training possible. In Machine Learning projects, we need a training data set. It is the actual data set used to train the model for performing various actions. TensorFlow already has MNist Data set so there is no need to explicitly download or create Dataset
The MNSIT dataset contains ten classes: Digits from 0-9. Each digit is taken as a class

In this activity, let's load the data and understand the features of the data

6.2 Importing the required libraries

Lets first import the libraries

Importing Necessary Libraries

```
import numpy #used for numerical analysis
import tensorflow #open source used for both ML and DL for computation
from tensorflow.keras.datasets import mnist #mnist dataset
from tensorflow.keras.models import Sequential #it is a plain stack of layers
from tensorflow.keras import layers #A layer consists of a tensor-in tensor-out computation function
from tensorflow.keras.layers import Dense, Flatten #Dense-Dense layer is the regular deeply connected n
#Faltten-used fot flattening the input or change the dimension
from tensorflow.keras.layers import Conv2D #Convolutional layer
from keras.optimizers import Adam #optimizer
from keras.utils import np_utils #used for one-hot encoding
```

Importing the required libraries which are required for the model to run. The dataset for this model is imported from the Keras module.

When it comes to Deep Learning, TensorFlow has gained much more momentum that its competitors – Caffe, Theano, Torch, and other well-known frameworks. TensorFlow is extensively used in voice recognition, text-based applications like Google Translate, image recognition, and Video Detection.

Interestingly enough, NASA is developing a predictive model of Near Earth Objects with TensorFlow and Deep Learning. According to the people at NASA, TensorFlow can help design a multilayer model that will be able to recognize and classify the potential of NEOs. TensorFlow is used by some of the biggest data companies in the world – the likes of Airbnb, Airbus, Dropbox, Snapchat, and Uber.
Some of the major applications of TensorFlow are:

- Tensorflow has been successfully implemented in DeepDream – the automated image captioning software – uses TensorFlow.
- Google's RankBrain, backed by TensorFlow, handles a substantial number of queries every minute and has effectively replaced the traditional static algorithm-based search.
- If you've used the Allo application, you must've seen a feature similar to Google's Inbox – you can reply to the last message from a few customized options. All thanks to Machine Learning with TensorFlow. Another feature analyses the images sent to you in order to suggest a relevant responce

Keras is a high-level library that's built on top of Theano or TensorFlow. It provides a scikit-learn type API (written in Python) for building Neural Networks. Developers can use Keras to quickly build neural networks without worrying about the mathematical aspects of tensor algebra, numerical techniques, and optimization methods.

The key idea behind the development of Keras is to facilitate experimentations by fast prototyping. The ability to go from an idea to result with the least possible delay is key to good research.

This offers a huge advantage for scientists and beginner developers alike because they can dive right into Deep Learning without getting their hands dirty with low-level computations. The rise in the demand for Deep Learning has resulted in the rise in demand for people skilled in Deep Learning.

6.3 Loading the data

The dataset for this model is imported from the Keras module.

load data

```
(X_train, y_train), (X_test, y_test) = mnist.load_data() #splitting the mnist data into train and test
```

We split the data into train and test. Using the training dataset we train the model and the testing dataset is used to predict the results.

```
print(X_train.shape)#shape is used for give the dimension values #60000-rows 28x28-pixels
print(X_test.shape)
```

```
(60000, 28, 28)
(10000, 28, 28)
```

We are finding out the shape of X_train and x_test for better understanding. It lists out the dimensions of the data present in it.
in trainset, we have 60000 images, and in the test set we have 10000 images

6.4 Analyzing the data

Let's see the Information of an image lying inside the x_train variable

Understanding the data

```
X_train[0]#printing the first image
```

```
[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   0,   3,
  18,  18,  18, 126, 136, 175,  26, 166, 255, 247, 127,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0,  30,  36,  94, 154, 170,
 253, 253, 253, 253, 253, 225, 172, 253, 242, 195,  64,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,  49, 238, 253, 253, 253, 253,
 253, 253, 253, 253, 251,  93,  82,  82,  56,  39,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,  18, 219, 253, 253, 253, 253,
 253, 198, 182, 247, 241,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0,  80, 156, 107, 253, 253,
 205,  11,   0,  43, 154,   0,   0,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0.,   0.,   0.,   0.,   0.,   0.,   0.,   0.,   0.,  14.,   1., 154., 253.,
```

Basically, the pixel values range from 0-255. Here we are printing the first image pixel value which is index[0] of the training data. As you see it is displayed in the output.

With respect to this image, the label of this image will e stored in y_train let's see what is the label of this image by grabbing it from the y_train variable

```
y_train[0]#printing lable of first image
```

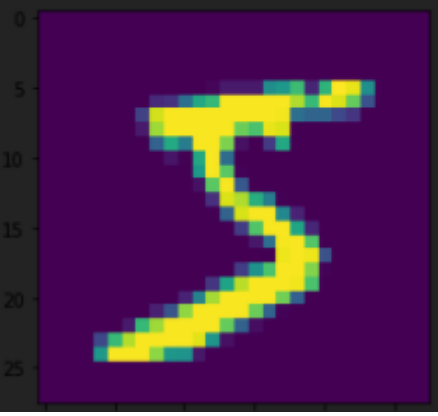
```
5
```

As we saw in the previous screenshot, we get to know that the pixel values are printed. Now here we are finding to which image the pixel values belong to. From the output displayed we get to know that the image is ‘5’.

Lets Plot the image on a graph using the Matplot library

```
import matplotlib.pyplot as plt #used for data visualization
plt.imshow(X_train[0]) #ploting the index=0 image
```

```
<matplotlib.image.AxesImage at 0x1c397af32e0>
```



Matplotlib is a comprehensive library for creating static, animated, and interactive visualizations in Python. By using the Matplotlib library we are displaying the number ‘5’ in the form of an image for proper understanding.

Note: You can see the results by replacing the index number till 59999 as the train set has 60K images

6.5 Reshaping the data

As we are using Deep learning neural network, the input for this network to get trained on should be of higher dimensional. Our dataset is having three-dimensional images so we have to reshape them too higher dimensions

Reshaping Dataset ¶

```
# Reshaping to format which CNN expects (batch, height, width, channels)
X_train = X_train.reshape(60000, 28, 28, 1).astype('float32')
X_test = X_test.reshape(10000, 28, 28, 1).astype('float32')
```

We are reshaping the dataset because we are building the model using CNN. As CNN needs four attributes batch, height, width, and channels we reshape the data.

6.6 Applying One Hot Encoding

If you see our y_train variable contains Labels representing the images containing in x_train. AS these are numbers usually they can be considered as numerical or continuous data, but with respect to this project these Numbers are representing a set of class so these are to be represented as categorical data, and we need to binaries these categorical data that's why we are applying One Hot encoding for y_train set

One-Hot Encoding

```
# one hot encode
number_of_classes = 10 #storing the no. classes in a variable
y_train = np_utils.to_categorical(y_train, number_of_classes) #converts the output in binary format
y_test = np_utils.to_categorical(y_test, number_of_classes)
```

One hot encoding is a process by which categorical variables are converted into a form that could be provided to ML algorithms to do a better job in prediction. We apply One-Hot Encoding in order to convert the values into 0's and 1's. For a detailed point of view, look at this link

Now let's see how our label 5 is index 0 of y_train is converted

7. Model Building

This activity includes the following steps

- Initializing the model
- Adding CNN Layers
- Training and testing the model
- Saving the model

7.1 Add CNN Layers

Creating the model and adding the input, hidden, and output layers to it

Creating the Model

```
# create model
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(Conv2D(32, (3, 3), activation='relu'))
#flatten the dimension of the image
model.add(Flatten())
#output layer with 10 neurons
model.add(Dense(number_of_classes, activation='softmax'))
```

The Sequential model is a linear stack of layers. You can create a Sequential model by passing a list of layer instances to the constracted.

7.2 Compiling the model

With both the training data defined and model defined, it's time to configure the learning process. This is accomplished with a call to the compile () method of the Sequential model class. Compilation requires 3 arguments: an optimizer, a loss function, and a list of metrics.

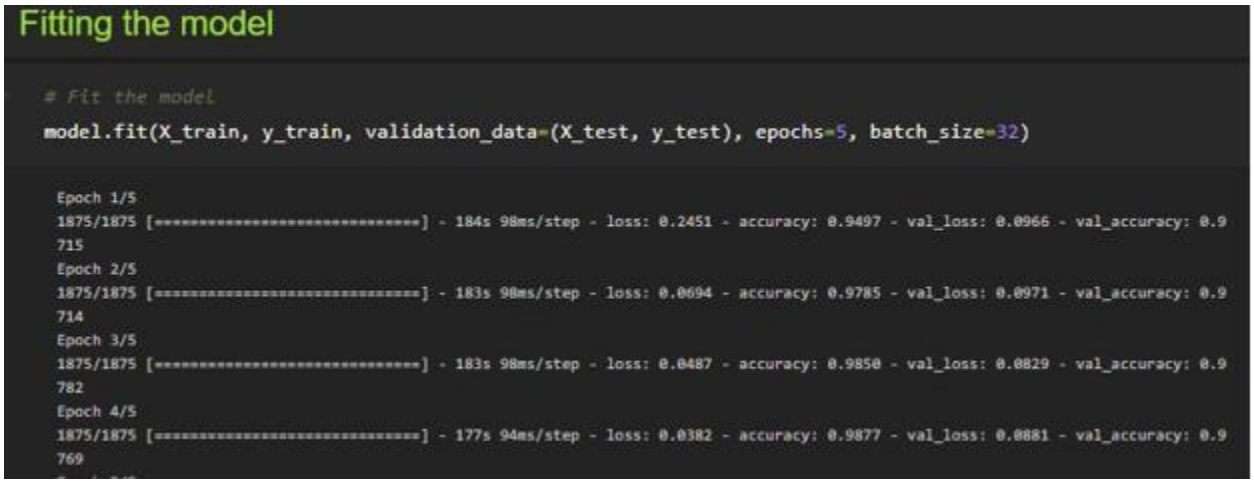
Compiling the model

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

Note: In our project, we have 2 classes in the output, so the loss is binary_crossentropy.
If you have more than two classes in output put “loss = categorical_cross entropy

7.3 Train the model

Now, let us train our model with our image dataset.
Fit: functions used to train a deep learning neural network



Arguments:
steps_per_epoch : it specifies the total number of steps taken from the generator as soon as one epoch is finished and the next epoch has started. We can calculate the value of steps_per_epoch as the total number of samples in your dataset divided by the batch size.

Epochs: an integer and number of epochs we want to train our model for.

Validation_data :

- an inputs and targets list
- a generator
- inputs, targets, and sample_weights list which can be used to evaluate the loss and metrics for any model after any epoch has ended.

validation_steps: only if the validation_data is a generator then only this argument can be used. It specifies the total number of steps taken from the generator before it is stopped at every epoch and its value is calculated as the total number of validation data points in your dataset divided by the validation batch size.

7.4 Observing the metrics

We here are printing the metrics which lists out the Test loss and Test accuracy

- Loss value implies how poorly or well a model behaves after each iteration of optimization.
- An accuracy metric is used to measure the algorithm's performance in an interpretable way.

7.5 Test The Model

Firstly we are slicing the x_test data until the first four images. In the next step we the printing the predicted output.

Predicting the output

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

```
[[5.50544734e-15 7.41999492e-20 5.00876077e-12 1.26642463e-09
  3.52252804e-21 1.54133163e-17 3.15550259e-21 1.00000000e+00
  1.32678888e-13 6.44072333e-14]
 [1.51885260e-08 8.02883537e-09 1.00000000e+00 6.44802788e-13
  6.37117113e-16 3.40490114e-15 2.15804121e-08 2.18907611e-19
  3.38496564e-10 2.07915498e-20]
 [3.14093924e-08 9.99941349e-01 2.01593957e-06 1.45100779e-10
  5.25237965e-06 1.59223120e-07 3.15299786e-08 1.53995302e-07
  5.09846941e-05 1.14552066e-07]
 [1.00000000e+00 1.35018288e-14 2.28308122e-10 1.79766094e-16
  1.28767550e-14 7.12401882e-12 2.92727509e-11 3.52439052e-13
  2.56207252e-12 2.32345068e-12]]
```

```
import numpy as np
print(np.argmax(prediction,axis=1)) #printing our labels from first 4 images
print(y_test[:4]) #printing the actual labels
```

```
[7 2 1 0]
[[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
 [0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]
 [0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
 [1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]]
```

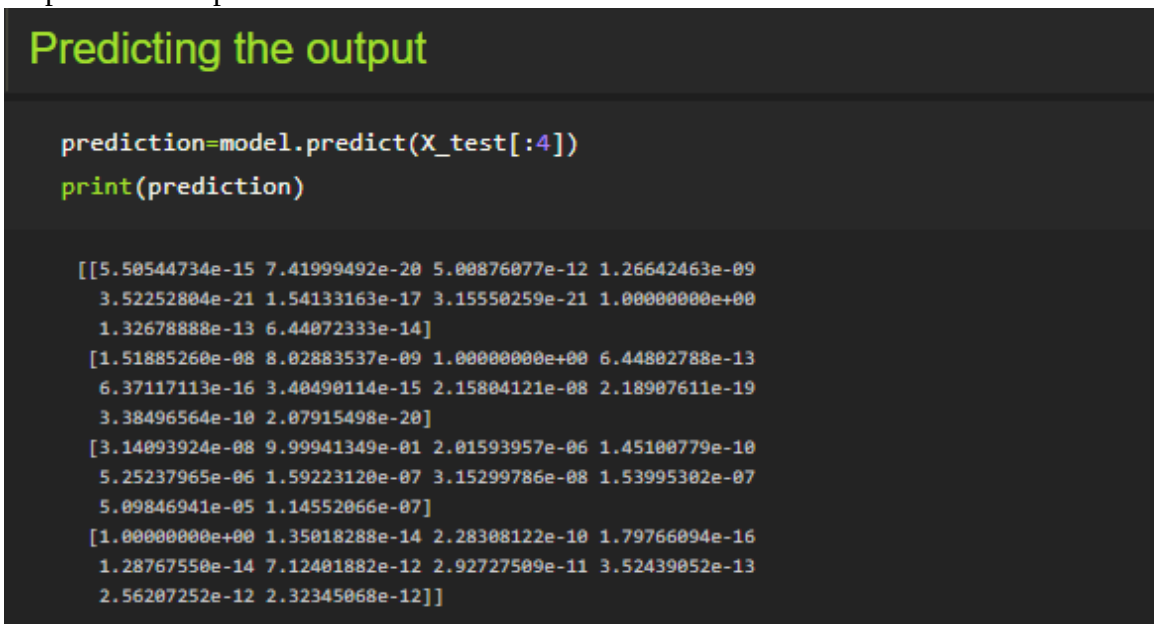
As we already predicted the input from the x_test. According to that by using argmax function here we are printing the labels with high prediction values

Observing the metrics

We here are printing the metrics which lists out the Test loss and Test accuracy

- Loss value implies how poorly or well a model behaves after each iteration of optimization.
- An accuracy metric is used to measure the algorithm's performance in an interpretable way.

Firstly we are slicing the x_test data until the first four images. In the next step we the printing the predicted output.



```
import numpy as np
print(np.argmax(prediction,axis=1)) #printing our labels from first 4 images
print(y_test[:4]) #printing the actual labels
```

```
[7 2 1 0]
[[0. 0. 0. 0. 0. 0. 0. 1. 0. 0.]
 [0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]
 [0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]
 [1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]]
```

As we already predicted the input from the x_test. According to that by using argmax function here we are printing the labels with high prediction values

7.6 Save The model

Your model is to be saved for future purposes. This saved model can also be integrated with an android application or web application in order to predict something.

Saving the model

```
# Save the model
model.save('models/mnistCNN.h5')
```

The model is saved with .h5 extension as follows:
An H5 file is a data file saved in the Hierarchical Data Format (HDF). It contains multidimensional arrays of scientific data.

Now open another jupyter file and write the below code

Taking images as input and checking results

```
# Importing the Keras libraries and packages
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#used for manipulating image uploaded by the user.
import numpy as np#used for numerical analysis
for index in range(4):
    img = Image.open('data/' + str(index) + '.png').convert("L")# convert image to monochrom
    img = img.resize((28,28))# resizing of input image
    im2arr = np.array(img) #converting to image
    im2arr = im2arr.reshape(1,28,28,1) #reshaping according to our requirement
    # Predicting the Test set results
    y_pred = model.predict(im2arr) #predicting the results
    print(y_pred)
```

```
[[1. 0. 0. 0. 0. 0. 0. 0. 0. 0.]]
[[0. 1. 0. 0. 0. 0. 0. 0. 0. 0.]]
[[0. 0. 1. 0. 0. 0. 0. 0. 0. 0.]]
[[0. 0. 0. 1. 0. 0. 0. 0. 0. 0.]]
```

Firstly we are loading the model which was built. Then we are applying for a loop for the first four images and converting the image to the required format. Then we are resizing the input image, converting the image as per the CNN model and we are reshaping it according to the requirement. At last, we are predicting the result.

You can use predict_classes for just predicting the class of an image

8. Application Building

In this section, we will be building a web application that is integrated into the model we built. A UI is provided for the uses where he has uploaded an image. The uploaded image is given to the saved model and prediction is showcased on the UI.
This section has the following tasks

- Building HTML Pages
- Building server-side script

9. TRIN THE MODEL ON IBM

9.1 Create an HTML File

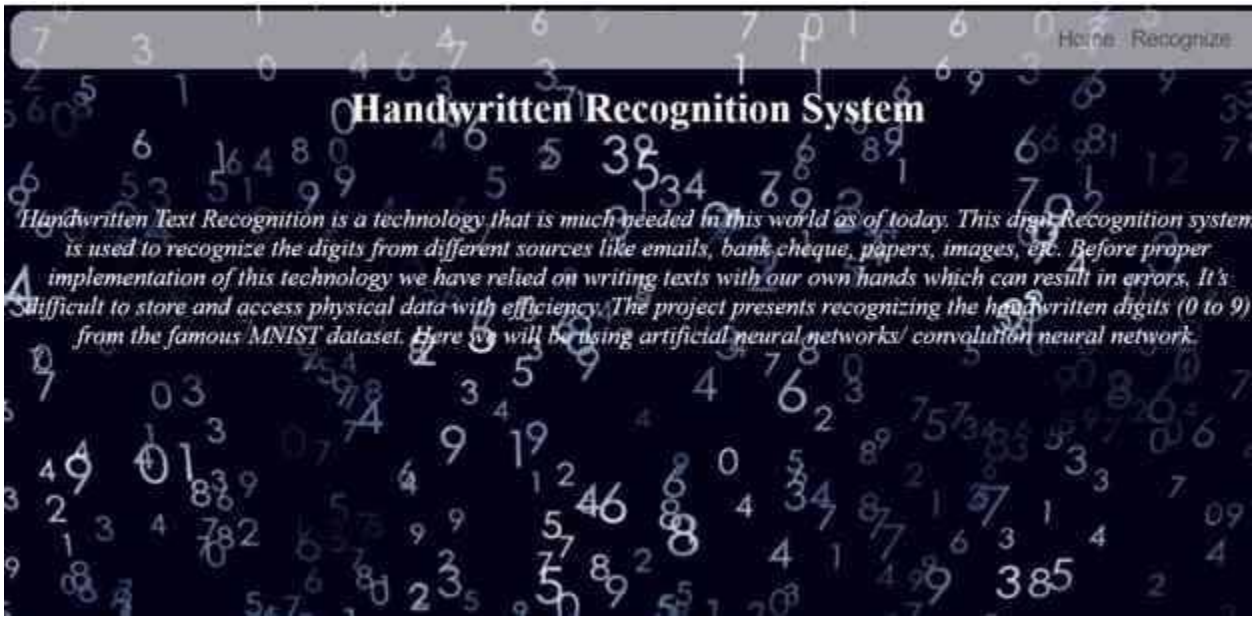
- We use HTML to create the front end part of the web page.
- Here, we created 2 html pages- index.html, web.html.

- index.html displays home page.
- web.html accepts the values from the input and displays the prediction.
- For more information regarding HTML refer the link below

Please refer to the link for HTML code files

Let's see how our index.html file looks like

This is the main page which describes about the project and summarizes it.



Let's see how our web.html page looks like

This is the prediction page where we get to choose the image from our local system and predict the output.

This is the prediction page where we get to choose the image from our local system and predict the output.

9.2 Build Python Code (part 1)

Let us build the flask file 'app.py' which is a web framework written in python for server-side scripting. Let's see step by step procedure for building the backend application.

- App starts running when the "__name__" constructor is called in main.
- render_template is used to return HTML file.
- "GET" method is used to take input from the user.
- "POST" method is used to display the output to the user.

Import Libraries:

```
from flask import Flask, render_template, request# Flask-It is our framework which we are going to use to
run/serve our application.
#request-for accessing file which was uploaded by the user on our application.

from PIL import Image #used for manipulating image uploaded by the user.
import numpy as np #used for numerical analysis
from tensorflow.keras.models import load_model#to load our model trained with MNIST data
import tensorflow as tf#to run our model.
```

Libraries required for the app to run are to be imported.

Routing to the html Page

```
@app.route('/') #default route
def upload_file():
    return render_template('main.html') #rendering html page
@app.route('/about') #Main page route
def upload_file1():
    return render_template('main.html') #rendering html page
@app.route('/upload') #main page route
def upload_file2():
    return render_template('index6.html')
```

We are routing the app to the HTML templates which we want to render.
Firstly we are rendering the main.html template and from there we are navigating to our prediction page that is index6.html

Returning the prediction on UI:

```
@app.route('/predict', methods = ['POST']) #route for our prediction
def upload_image_file():
    if request.method == 'POST':
        img = Image.open(request.files['file'].stream).convert("L")# convert image to monochrome
        img = img.resize((28,28))# resizing of input image
        im2arr = np.array(img)#converting to image
        im2arr = im2arr.reshape(1,28,28,1) #reshaping according to our requirement
        y_pred = model.predict_classes(im2arr) #predicting the results
        print(y_pred) #printing our result in prompt
        #return 'Predicted Number: ' + str(y_pred) #returning our output
```

9.3 Build Python Code (part 2)

Here the route for prediction is given and necessary steps are performed in order to get the predicted output.

```
    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))
    else :
      return render_template("9.html",showcase =  str(y_pred))
 else:
      return None
```

Necessary conditions are given according to the input classes and the app will be returning the templates according to that.

Main Function:
This function runs your app in a web browser
Lastly, we run our app on the localhost. Here we are running it on localhost:8000

```
    else:
        return None
if __name__ == '__main__':
    app.run(host='0.0.0.0', port=8000,debug=True)
    #app.run(debug = True) #running our flask app
```

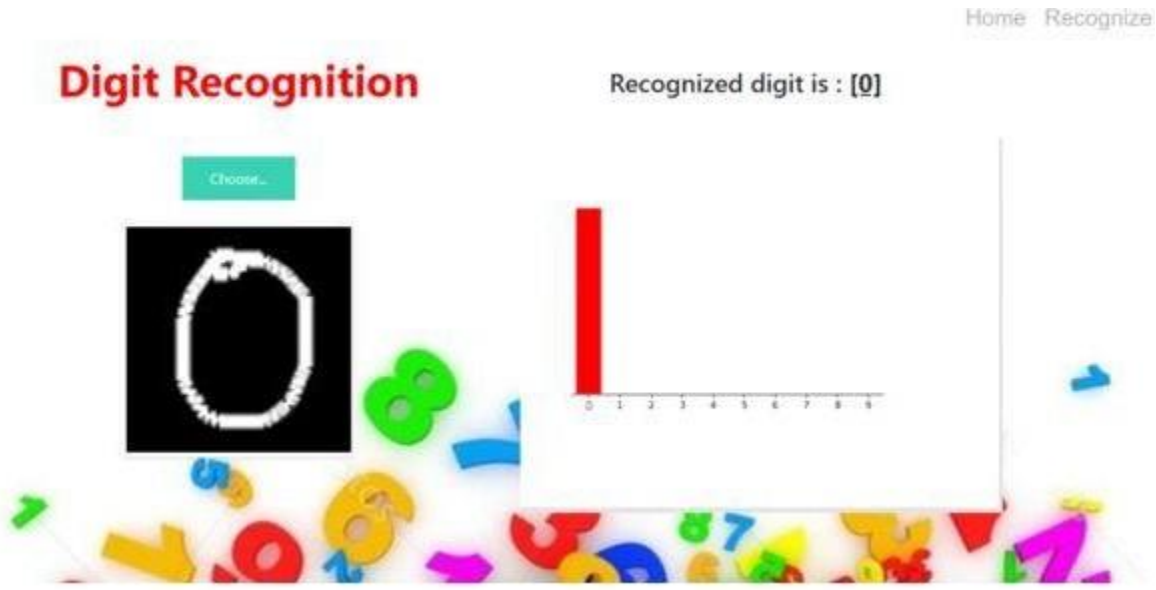
9.4 Run the application

- Open anaconda prompt from the start menu
- Navigate to the folder where your python script is.
- Now type “python app.py” command

```
(base) C:\Users\DELL>cd C:\Users\DELL\Hand_Written_Final

(base) C:\Users\DELL\Hand_Written_Final>python app.py
```

Navigate to the localhost where you can view your web page
Upload an image and see the predicted output on UI your page and output looks like:



10. Ideation Phase

In this milestone you are expected to get started with the Ideation process.

10.1 Literature survey on the selected project & Information Gathering

In this activity you are expected to gather/collect the relevant information on project use case, refer the existing solutions, technical papers, research publications etc.

10.2 Prepare Empathy Map

In this activity you are expected to prepare the empathy map canvas to capture the user Pains & Gains, Prepare list of problem statements.

10.3 Ideation

In this activity you are expected to list the ideas (at least 4 per each team member) by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance.

11. PROJECT DESIGN PHASE -1

11.1 Proposed solution

Having hooked your audience into the problem, now you want to paint a picture of what the world will be like when you solve the problem. **Your proposed solution should relate the current situation to a desired result and describe the benefits that will accrue when the desired result is achieved**. **Assistance GENERAL** INFORMATION In this section of our response, we have closely followed the RFP requirements. For each of the Services, we have provided the following information: Diverse Expertise and Skills • This is primarily CMI's experience. • Where relevant, we have included experience our key staff obtained with other employers. General Approach • For some of the Services, we have shown the specific steps that we will undertake for each task. • For others which may be more global in nature, we will consciously follow the steps of: o listening to the user. o confirming our understanding of the task at hand. o agreeing on the progress/final due date(s) of the deliverable. o agreeing on the format and delivery of the desired report. • We will also maintain flexibility to work with the user if it becomes necessary to change course during the effort. Staffing • We have identified the key individuals who will assist the principal-in-charge to accomplish the task. Their detailed resumes are included in the "Resumes" section of our response. • In the preceding "Experience" section of our response, we have included our Current Staff Matrix that lists additional Key Support Staff. One of these can serve as a back-up for the key individual shown on the Organizational Chart. Depending on the nature of the assignment, we will reach out to this group if necessary.

11.2 Problem solution fit

So you have a great idea for a new business. You're excited to get started and make your mark on the world. But before you do anything, it's important to make sure that there is a demand for your offering in the market. The least glamorous but most important part of starting a successful business is determining whether your idea actually solves a real problem for people. This process is known as finding a problem-solution fit. Here's a guide explaining what problem-solution fit means, why it's so important to the success of your new business, and how to achieve it.

- **Validate that the problem exists:** When you validate your problem hypothesis using real-world data and feedback. That is, you gather information from real users to determine whether or not they care about the pain point you're trying to solve.
- **Validate that your solution solves the problem:** When you validate that the target audience appreciates the value your solution delivers to them.

- **Get a better understanding of your target market:** It helps you identify your target customers, who they are and what matters to them the most.
- **Get a better understanding of the customer tasks and pain points:** Only after getting into the shoes of the customers do you realise their real tasks and the problems that hinder their progress in completing the tasks.
- **Get a better understanding of existing solutions and what they lack**: It helps you understand what gaps exist in the market and how your business can fill those gaps.

11. 3 Solution Architecture

A typical property of Solution Architecture, in contrast to other flavours of Enterprise Architecture, is that it often seeks to define a solution within the context of a project or initiative.[6] This close association to actual projects and initiatives means that solution architecture is the means to execute or realise a technology strategy.

According to Forrester Research, Solution Architecture is one of the key components by which Enterprise Architecture delivers value to the organization. It entails artifacts such as; solution business context, solution vision and requirements, solution options (e.g. through RFIs, RFPs or prototype development) and an agreed optimal solution with build and implementation plans ("road-map").[7]
Since The Open Group does not recognize a unique Solution Architect role a relevant link for these mentioned artifacts can be to the Business and Systems Analyst roles. It is also worth reminding that The Open Group does define Solution Architecture as something larger than Forrester (see aforementioned definition).
Then on, according to the 2013 paper published by the Federation of Enterprise Architecture Professional Organizations, Solution Architecture includes business architecture, information architecture, application architecture, and technology architecture operating at a tactical level and focusing on the scope and span of a selected business problem. In contrast, enterprise architecture, which also includes the aforementioned four types of architecture, operates at the strategic level and its scope and span is the enterprise rather than a specific business problem.

12. PROJECT DESIGN PHASE -2

12.1 customer journey

Today’s consumers have high expectations of the customer experience, and they are equally willing to reward businesses who meet those expectations as they are to walk away from those who fail to deliver. To build loyalty, organizations must create delight at every stage of the customer journey. Many businesses are discovering that the key to delivering those relationship-building human experiences lies, ironically enough, in technology—specifically, in artificial intelligence.

Unlike human employees, AI can access hundreds of sources simultaneously, extract the data needed for a desired task, and transform that data into insights. Using natural language processing (NLP), AI can understand human inputs—text and voice—and “listen” to outside sources (such as social media networks) as well as human conversations to identify opportunities and make recommendations. And it can leverage data to generate predictive analytics, which enables organizations to predict customer behavior and to take a more proactive stance (for example, in preventing customer churn).

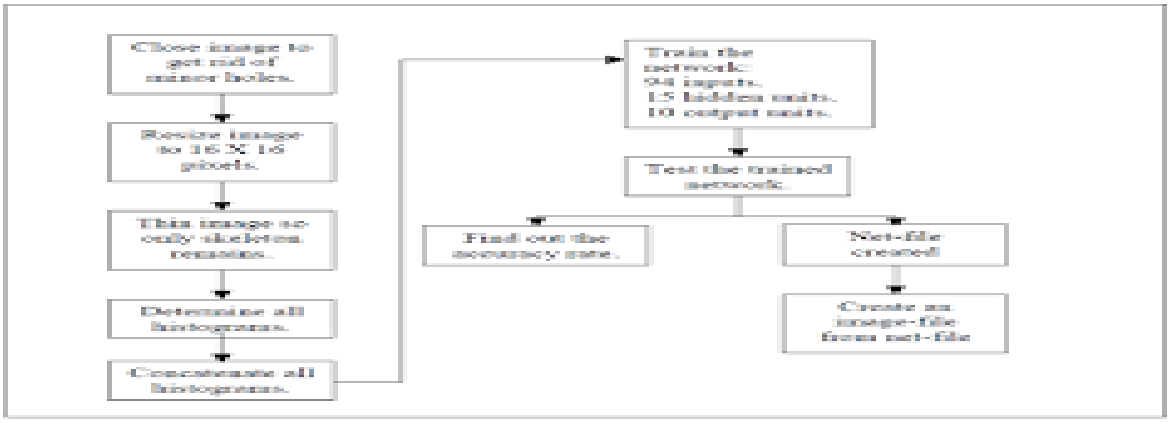
Only recently has AI evolved to the point where it can “tame the customer data beast” to drive delighting experiences throughout the customer journey. Early iterations of AI for customer service were limited by an inability to handle complex situations and a frequent need for maintenance to accommodate new scenarios. Thanks to advancements in machine learning, today’s AI-based customer service applications can learn from a vast array of data resources, including unstructured data.

12.2 Function requirement

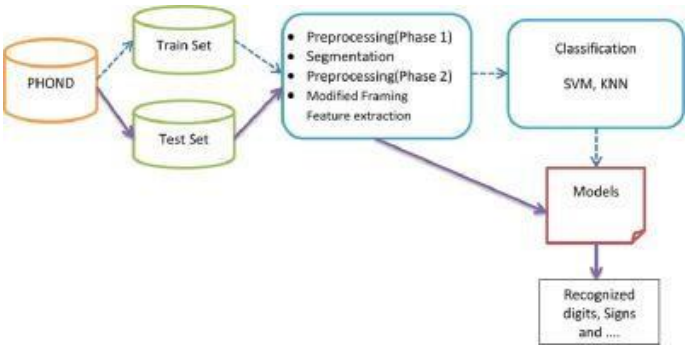
Functional requirements may involve calculations, technical details, data manipulation and processing, and other specific functionality that define what a system is supposed to accomplish**. Behavioral requirements describe all the cases where the system uses the functional requirements, these are captured in use cases.**

A typical functional requirement will contain a unique name and number, a brief summary, and a rationale. This information is used to help the reader understand why the requirement is needed, and to track the requirement through the development of the system.[7] The crux of the requirement is the description of the required behavior, which must be clear and readable. The described behavior may come from organizational or business rules, or it may be discovered through elicitation sessions with users, stakeholders, and other experts within the organization.[7] Many requirements may be uncovered during the use case development. When this happens, the requirements analyst may create a placeholder requirement with a name and summary, and research the details later, to be filled in when they are better known.

12.3 Data flow diagrams



12.4 Technology Architecture



Secondly, unnecessary data leads to misleading results and this, in turn, negatively affects classification accuracy. To guarantee the dataset is free from any redundant or irrelevant variables to the target variable, data preparation is applied before implementing the data classification mission. Thirdly, to decrease the errors of training and validation, and avoid the limitation of datasets, data augmentation has been proposed. Fourthly, to simulate the real-world natural influences that can affect image quality, we propose to add an additive white Gaussian noise with

13. PROJECT PLANNING PHASE

13.1 Prepare milestone& activity list

project milestone; Milestones are checkpoints that highlight the successful completion of major events, tasks, or groups of tasks along your project timeline. Project milestone checkpoints Your team reaches a milestone when you accomplish something notable, such as:

- Finalizing a business plan
- Launching your first marketing campaigns
- Getting your first 100 customer project milestones important

Here are a few more things your team can do with milestones in project management:

- Monitor project progress
- Spot potential bottlenecks
- Identify when the project will be completed

Here are a few common project milestone examples:

- Completing key project deliverables like the first version of your app.
- The start date or end date of an important project phase like the 'planning phase' or 'designing phase'
- An important event that green lights the project like project sponsor approval.

13.2 Sprint delivery plan

Sprint deliveryplan is one timeboxed iteration of a continuous development cycle. Within a Sprint, planned amount of work has to be completed by the team and made ready for review. The term is mainly used in Scrum Agile methodology but somewhat basic idea of Kanban continuous delivery is also essence of Sprint Scrum.

Sprints are timeboxed iterations of a continuous project development cycle—short repeatable phases that last between one and four weeks. Sprints lie at the core of Agile and Scrum methodologies, an approach that takes large, complex product development projects and breaks them down into smaller, more manageable pieces.

Each sprint has the following characteristics:

- It maintains a consistent duration throughout the whole development effort
- A new sprint immediately begins after the successful conclusion of the previous one
- The sprint has a predetermined start and end date

We should probably take a moment and mention a little more about Agile and Scrum. Agile is a method of software development and project management that emphasizes teams delivering work in small, regular increments. Scrum, however, is a subset of Agile—a framework dedicated

14. PROJECT DEVELOPMENT PHASE

14.1 Project development -delivery of sprint-1

The Agile methodology is really about continuous development, so instead of one long project, we actually run a bunch of short, iterative development cycles called sprints. A sprint is **a chunk of time during which a specific amount of work will be done**. Sprints usually last for a week or two.

15. RESULT

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 executed was successfully.