A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION SYSTEM

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1.INTRODUCTION

1.1 PROJECT OVERVIEW

Handwriting recognation 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 digit 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 recognation in many real-time applications.MNIST data set is widely used for this recognation process and it has 70000 handwritten digits. We use Artificial neural networks to train these images and build a deep learning model. Webapplication is created where the user can upload an image of a handwritten digit. this image is analyzed by the model and the dected result is returned on to UI

1.2 PURPOSE

- Handwritten Digit recognition is used to recognize the Digit which are written by hand .

- A handwritten Digit recognition system is used to visualise artificial neural network.

- It is already widely used in the automatic proceesing of bank cheques,postal addresses,in mobile phones etc.

2 LITERATURE SURVEY

■ 2.1 EXISTING PROBLEM

Digit recognition system is the working of a machine to train itself or recognizing the digits from different sources like emails,bank cheque,papers,images,etc. and in different real-world scenarios for online handwritting recognition on computer tablets or system,recognize number plates of vehicles,word and letters processing bank cheque amounts ,numeric entries in forms filled up by hand and so on.

■ 2.2 REFERENCES

[1] Non-recursive Thinning Algorithms using Chain Codes Paul C K Mwok Department of Computer Science The University of Calgary Calgary, Canada T2N 1N4

[2] A dynamic shape preserving thinning algorithm Louisa Lam and Ching Y. Suen Centre for Pattern Recognition and Machine Intelligence and Department of Computer Science, Concordia University, 1455 de Maisonneuve Blvd. W., Montrdal, Qudbec H3G 1MS, Canada

[3] Object Contour Detection with a Fully Convolutional Encoder-Decoder Network Jimei Yang Adobe Research jimyang@adobe.com Brian Price Adobe Research bprice@adobe.com Scott Cohen Adobe Research scohen@adobe.com Honglak Lee University of Michigan, Ann Arbor honglak@umich.edu Ming-Hsuan Yang UC Merced mhyang@u

[4] Contour Detection and Image Segmentation by Michael Randolph Maire B.S. (California Institute of Technology) 2003

[5] Three-Dimensiaonal Nonlinear invisible Boundary detection ,IEEE Transaction on Image Processing VassiliKovalev,J,Chen [6] Unconstrained OCR for Urdu using Deep CNN – RNN Hybrid Networks; Mohit Jain, Minesh Mathew et al.

■ 2.3 PROBLEM STATEMENT DEFINITION

The total world is working with the various problems of the machine learning.The goal of the machine learning is to factorize and to manipulate the real life data and the real life part of the human interaction or complex ideas or the problems in the real life.The most curious of those is Handwritten Character Recognition because it is the building block of the human certified and the classification interaction between other humans.

So, the goal was to create an appropriate algorithm that can give the output of the handwritten character by taking just a picture of that character. If one asks about Image processing then this problem can’t be solved because there can be a lot of noises in that taken image which can’t be controlled by human.The main thing is when human write a handwritten character or for our case digit he has no single idea whether he has to draw it in the circulated pixels or just same as a standard image given .A machine can do that but not the human.So by matching only the pixels one can’t recognize that.

The idea of machine learning lies on supervised data.Machine learning algorithm fully dependent on modeled data .If someone models the Image directly, the model will get a lot of flatten values because that picture can be drawn with various RGB format or with various pixels which can’t be modeled accurately due to noise.

So, for this project one has to create a model by image processing and the machine learning. Both the techniques will be needed because these two techniques will enhance the technique of the machine learning and that can shape this project.
Given a set of grey scale isolated numerical images taken from MNIST databases.

- To recognize handwritten digit correctly.

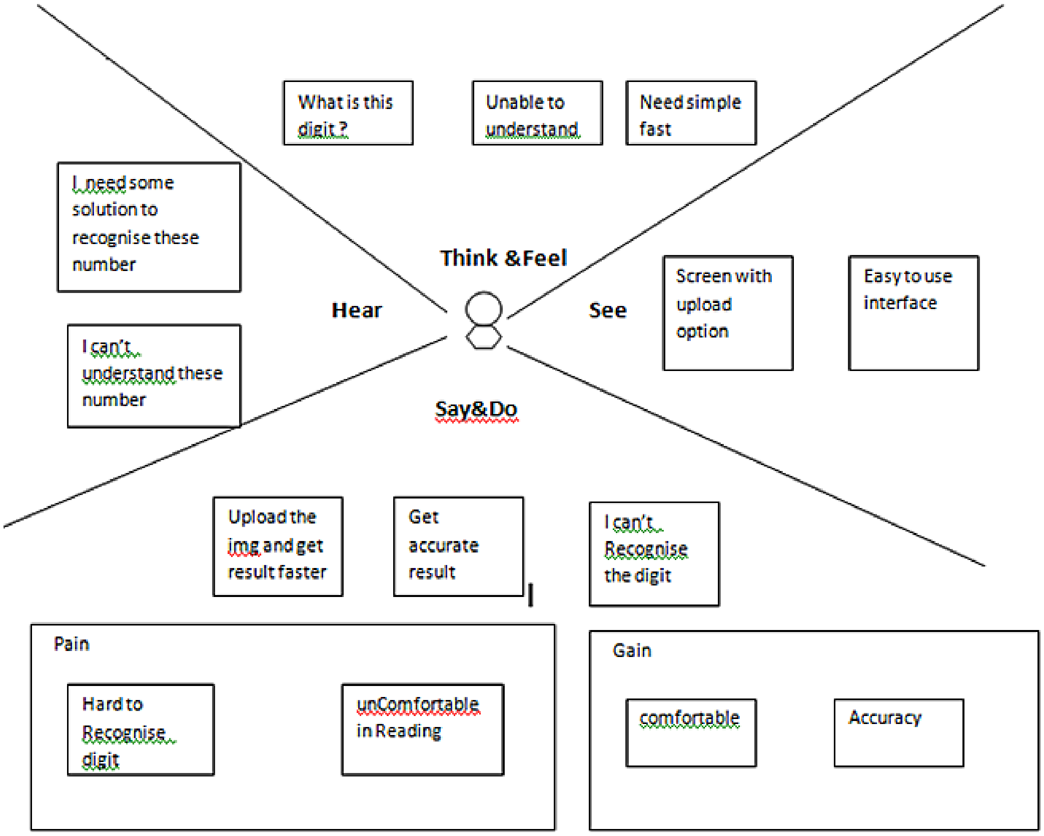
- To improve the accuracy of detection.

- To develop a method which is independent of digit size and writer style independent.

3 IDEATION AND PROPOSED SOLUTION

■ 3.1 EMPATHY MAP CANVAS

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



■ 3.2 IDEATION AND BRAINSTORMING

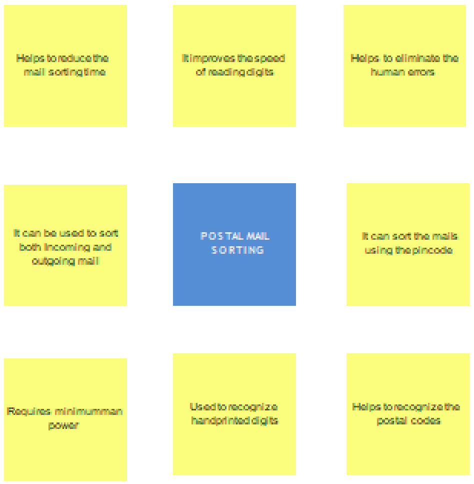
Brainstorming is a technique of generating ideas by a group of people or team members by presenting to them a problem statement and having an open discussion. This technique, when applied to agile projects, can produce interesting solutions and hence is referred to as Agile Brainstorming.

Importance of Brainstorming:-

There are times in an agile team when the team members are unsure of how to tackle a problem and to deliver a solution, there could also be scenarios where a system requirement is too complicated to be broken down by a couple of team members and then there is the need of finding creative ways to do daily work and enhance productivity. All of these and many more can be dealt with using agile brainstorming sessions.

Such sessions -

1. Stimulate the team's creativity.
2. Help with day-to-day productivity.
3. It has been proven that if the team members can present their ideas with freedom, the more comfortable they feel and hence can complete quality work.
4. Encourage collaboration with other team members.
5. Provide interesting solutions to complicated problems



Helps to reduce the mail sorting time

It improves the speed of reading digits

Helps to eliminate the human errors

It can be used to sort both Incoming and outgoing mail

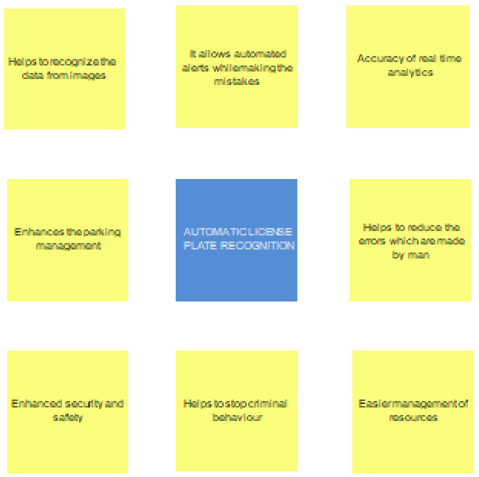
POSTAL MAIL SORTING

It can sort the mails using the pincode

Requires minimumman power

Used to recognize handprinted digits

Helps to recognize the postal codes



Helps to recognize the data from images

It allows automated alerts whilemaking the mistakes

Accuracy of real time analytics

Enhances the parking management

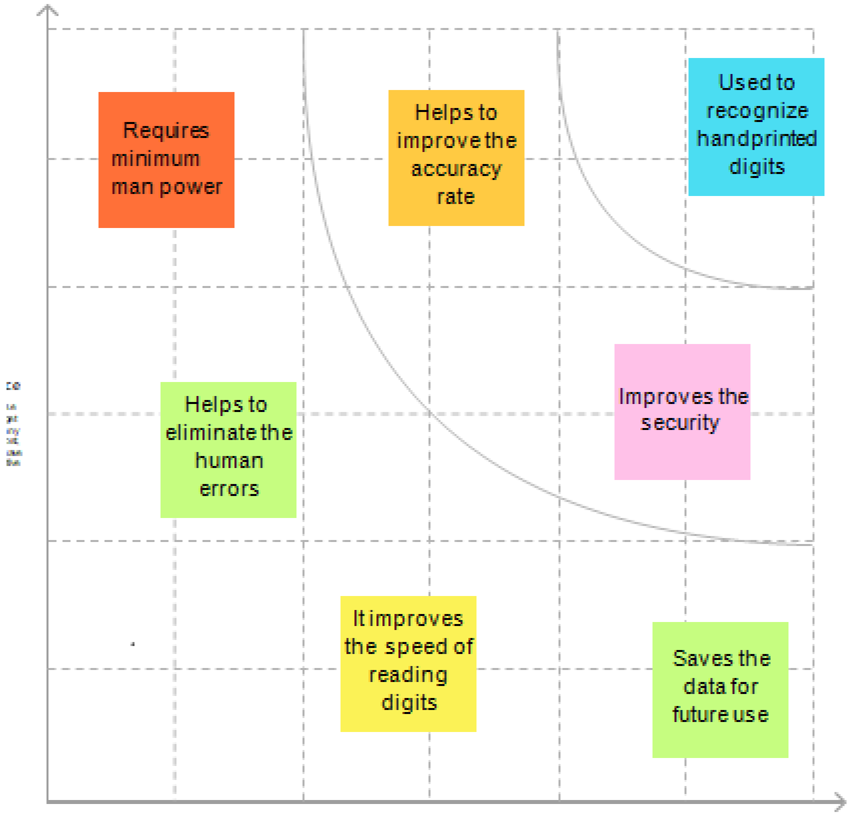
AUTOMATIC LICENSE PLATE RECOGNITION

Helps to reduce the errors which are made by man

Enhanced security and safety

Helps to stop criminal behaviour

Easiermanagement of resources

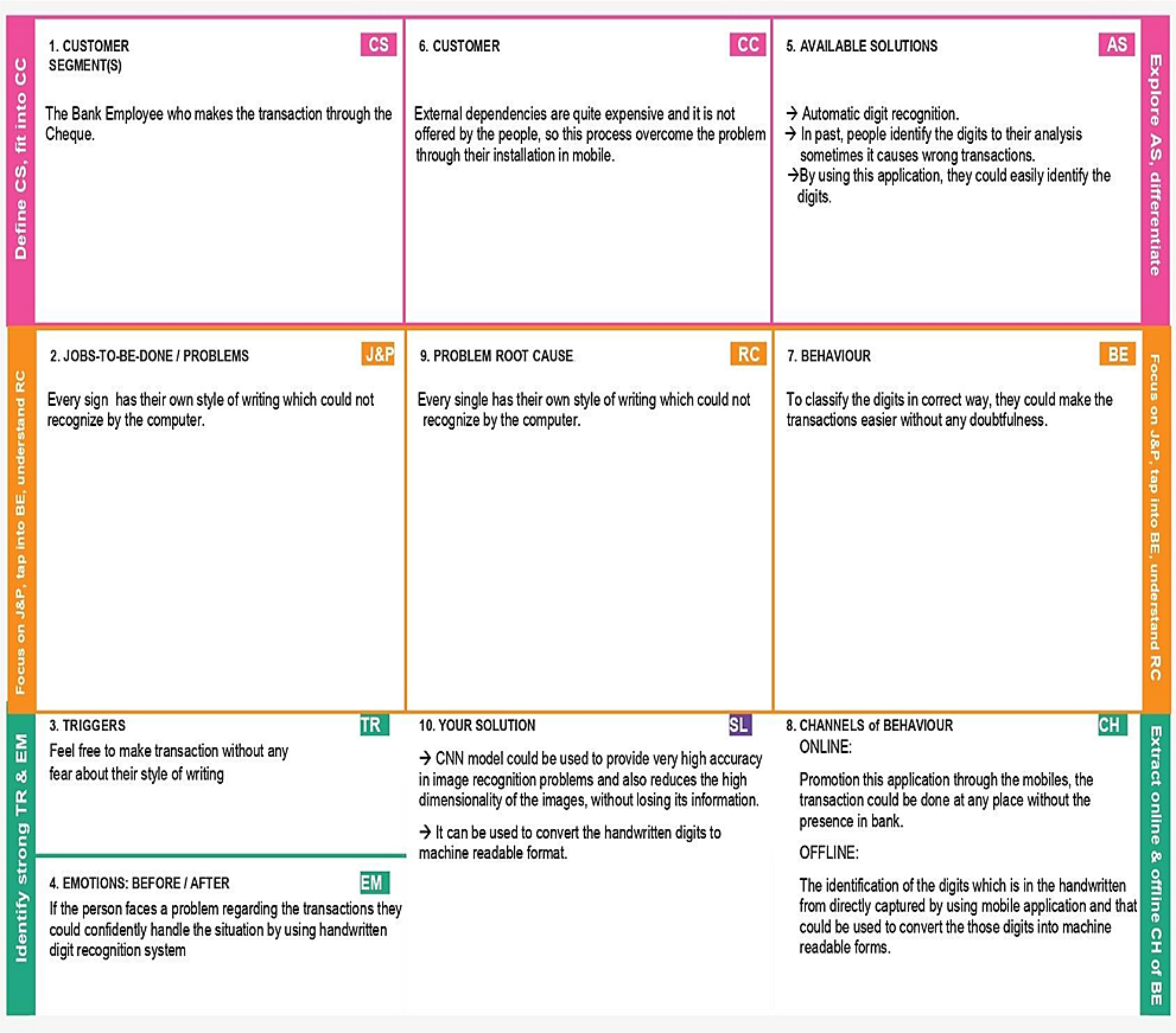

Requires minimum man power
Helps to improve the accuracy rate
Used to recognize handprinted digits
Helps to eliminate the human errors
Improves the security
It improves the speed of reading digits
Saves the data for future use

■ 3.3 PROPOSED SOLUTION

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	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

2.	Idea / Solution description	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
3.	Novelty / Uniqueness	The Digit to be displayd on the screen will be read to the physically challenged people(Blind and Deaf).
4.	Social Impact / Customer Satisfaction	Every individual has their own style of writing. With the help of this application all can have a clear view on others handwritting.Like, Doctors handwriting will be understood by the patient. Students handwriting will be understood by teachers.
5.	Business Model (Revenue Model)	1. Doctors handwriting will be understood by the patient. 2. Students handwriting will be understood by teachers. 3. Cashiers can understand customers handwriting in bank
6.	Scalability of the Solution	The application will be able to process 1 file at a time.

■ 3.4 PROBLEM SOLUTION FIT



Define CS, fit into CC

1. CUSTOMER SEGMENT(S) CS

The Bank Employee who makes the transaction through the Cheque.

6. CUSTOMER CC

External dependencies are quite expensive and it is not offered by the people, so this process overcome the problem through their installation in mobile.

5. AVAILABLE SOLUTIONS AS

→ Automatic digit recognition.
→ In past, people identify the digits to their analysis sometimes it causes wrong transactions.
→By using this application, they could easily identify the digits.

Explore AS, differentiate

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

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

Every sign has their own style of writing which could not recognize by the computer.

9. PROBLEM ROOT CAUSE RC

Every single has their own style of writing which could not recognize by the computer.

7. BEHAVIOUR BE

To classify the digits in correct way, they could make the transactions easier without any doubtfulness.

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

Identify strong TR & EM

3. TRIGGERS TR

Feel free to make transaction without any fear about their style of writing

4. EMOTIONS: BEFORE / AFTER EM

If the person faces a problem regarding the transactions they could confidently handle the situation by using handwritten digit recognition system

10. YOUR SOLUTION SL

→ CNN model could be used to provide very high accuracy in image recognition problems and also reduces the high dimensionality of the images, without losing its information.

→ It can be used to convert the handwritten digits to machine readable format.

8. CHANNELS of BEHAVIOUR CH

ONLINE:

Promotion this application through the mobiles, the transaction could be done at any place without the presence in bank.

OFFLINE:

The identification of the digits which is in the handwritten from directly captured by using mobile application and that could be used to convert the those digits into machine readable forms.

Extract online & offline CH of BE

4 REQUIREMENT ANALYSIS

4.1 FUNCTIONAL REQUIREMENT

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration throughGmail
FR-2	User Confirmation	Confirmation via Email
FR-3	Login	Login pageis displayed
FR-4	Hand written File uploaded	Upload fileto recognize the digit
FR-5	Output display	The Appropriate digit is displayed on screen

4.2 NON-FUNCTIONAL REQUIREMENT

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	Usability is a measure of how well a specific user in a specific context can use a product/design to achieve a defined goal effectively, efficiently and satisfactorily.
NFR-2	**Security**	security officers are tasked with securing the premises and personnel by staying on patrol, monitoring surveillance equipment, performing building inspections, guarding entry points, andverifying visitors

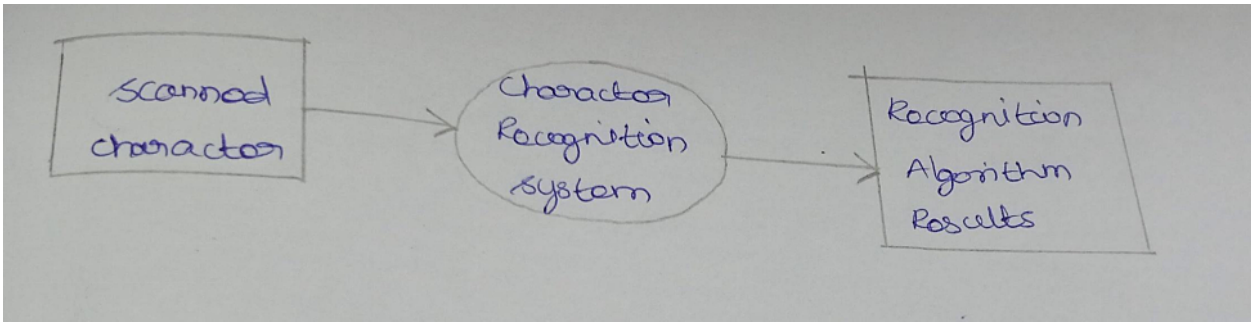
NFR-3	**Reliability**	Reliability refers to how consistently a method measures something. If the same result can be consistently achieved by using the same methods under the same circumstances, the measurement is considered reliable
NFR-4	**Performance**	performance means successful completion of a program required by the department, including an education, work, or other program.
NFR-5	**Availability**	availability is whether someone or somethingcan be accessed or used.
NFR-6	**Scalability**	scalability is the measure of a system's ability to increase or decrease in performance and cost in response to changes in application and system processing demands

5.PROJECT DESIGN

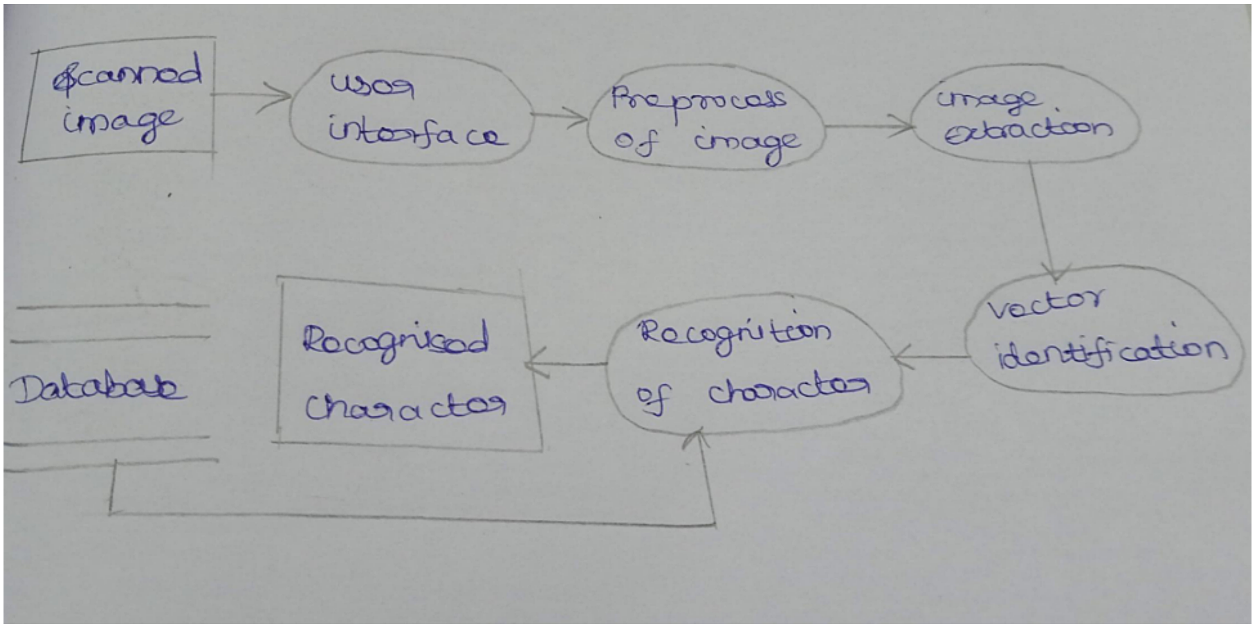
5.1 Data Flow Diagrams

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.

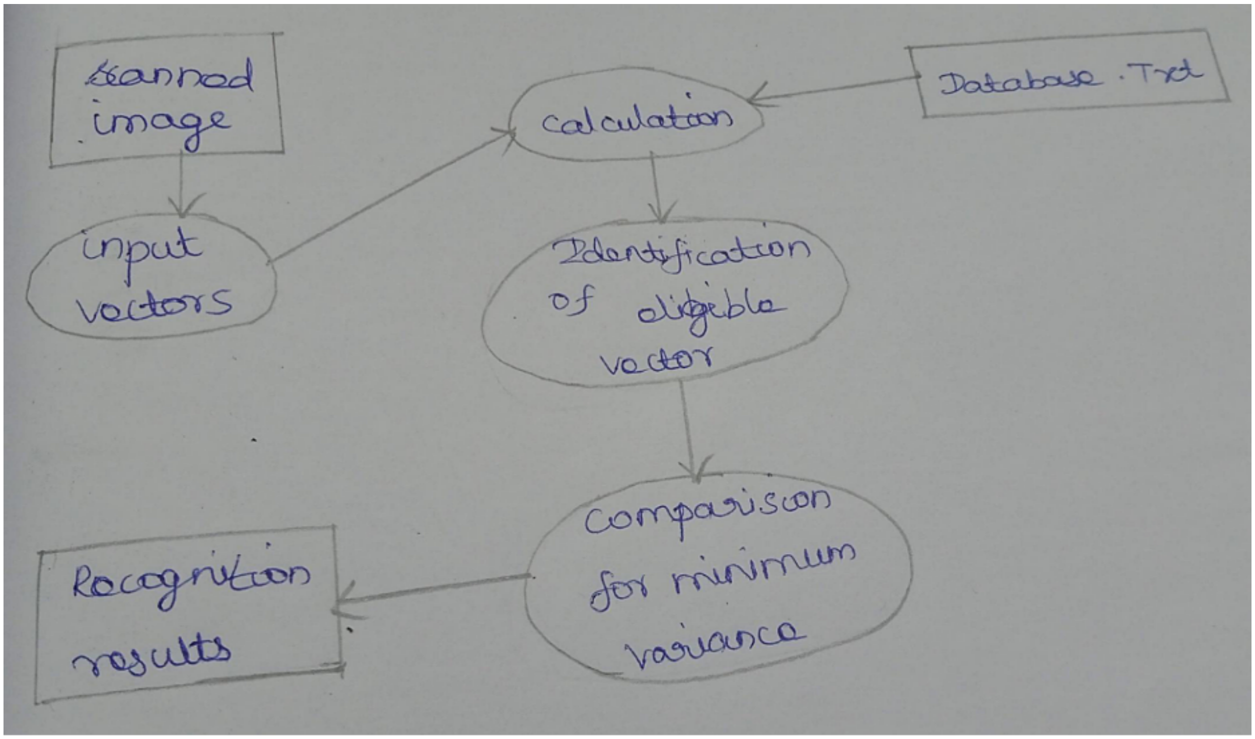
Level 0 DFD



Level 1 DFD



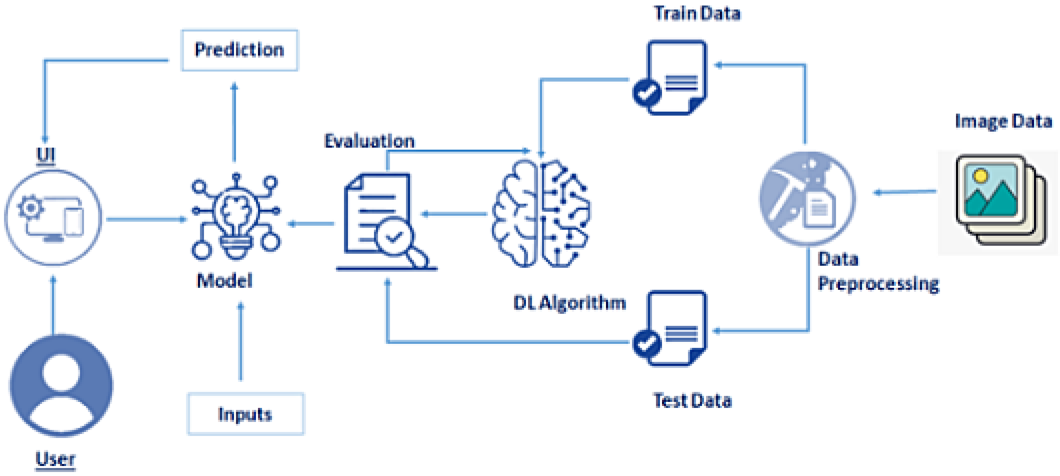
Level 2 DFD



5.2 Solution & Technical Architecture

Solution architecture is a complex process – with many sub-processes – that bridges the gap between business problems and technology solutions. Its goals are to:

- Find the best tech solution to solve existing business problems.
- Describe the structure, characteristics, behavior, and other aspects of the software to project stakeholders.
- Define features, development phases, and solution requirements.
- Provide specifications according to which the solution is defined, managed, and delivered.



Solution & Technical Architecture

5.3 User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Sprint-1
		USN-3	As a user, I can register for the application through Gmail	I can register & access the dashboard with Facebook Login	Medium	Sprint-1
	Login	USN-4	As a user, I can log into the application by entering email & password		High	Sprint-1
	Dashboard	USN-5	Go to dashboard and refer the content about		High	Sprint-1

			our project			
Customer (Web user)	Login	USN-1	As a user, I can use the application by entering my email, password.	I can access my account	High	Sprint-1
Customer Care Executive	Dashboard	USN-1	upload the image	Recognize and get the output	High	Sprint-1
Administrator	Security	USN-1	updated the features	checking the security	Medium	Sprint-1

6.PROJECT PLANNING & SCHEDULING

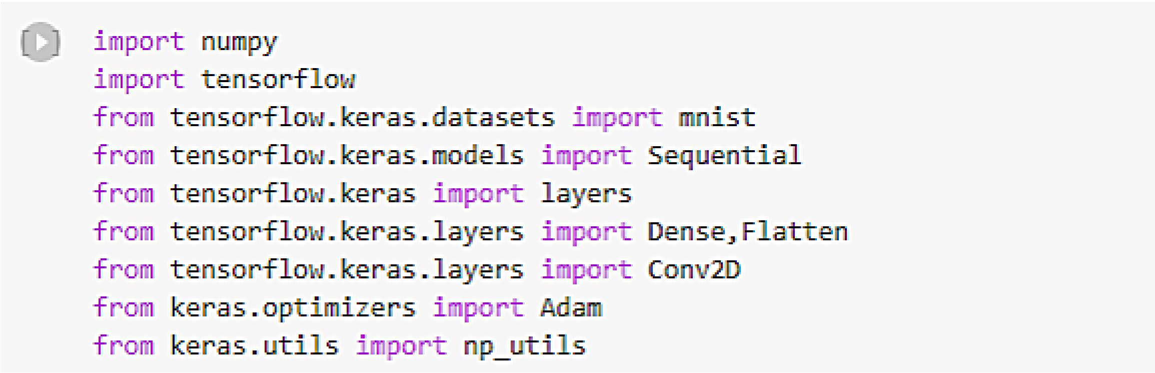
6.1 Sprint Planning & Estimation

Sprint 1	Understanding the data
Sprint 2	Model Building
Sprint 3	Application Building
Sprint 4	Train the model on IBM

Understanding The Data

IMPORTING THE LIBRARIES

Importing the required libraries which are required for the model to run. The dataset for this model is imported from the Keras module.The dataset contains ten classes: Digits from 0-9. Each digit is taken as a class

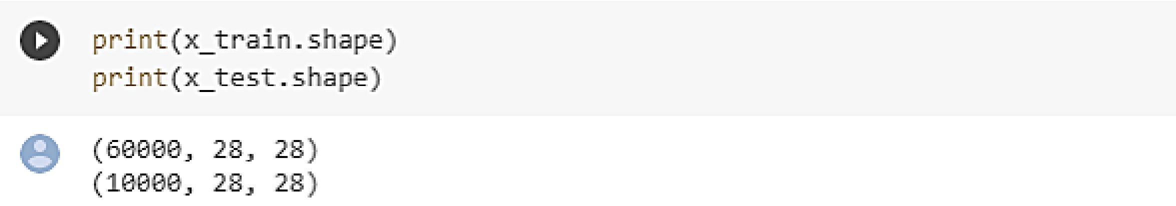


```
import numpy
import tensorflow
from tensorflow.keras.datasets import mnist
from tensorflow.keras.models import Sequential
from tensorflow.keras import layers
from tensorflow.keras.layers import Dense,Flatten
from tensorflow.keras.layers import Conv2D
from keras.optimizers import Adam
from keras.utils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

LOADING THE DATA

The dataset for this model is imported from the Keras module. We split the data into train and test. Using the training dataset we train the model and the testing dataset is used to predict theresults.

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 wehave 10000 images

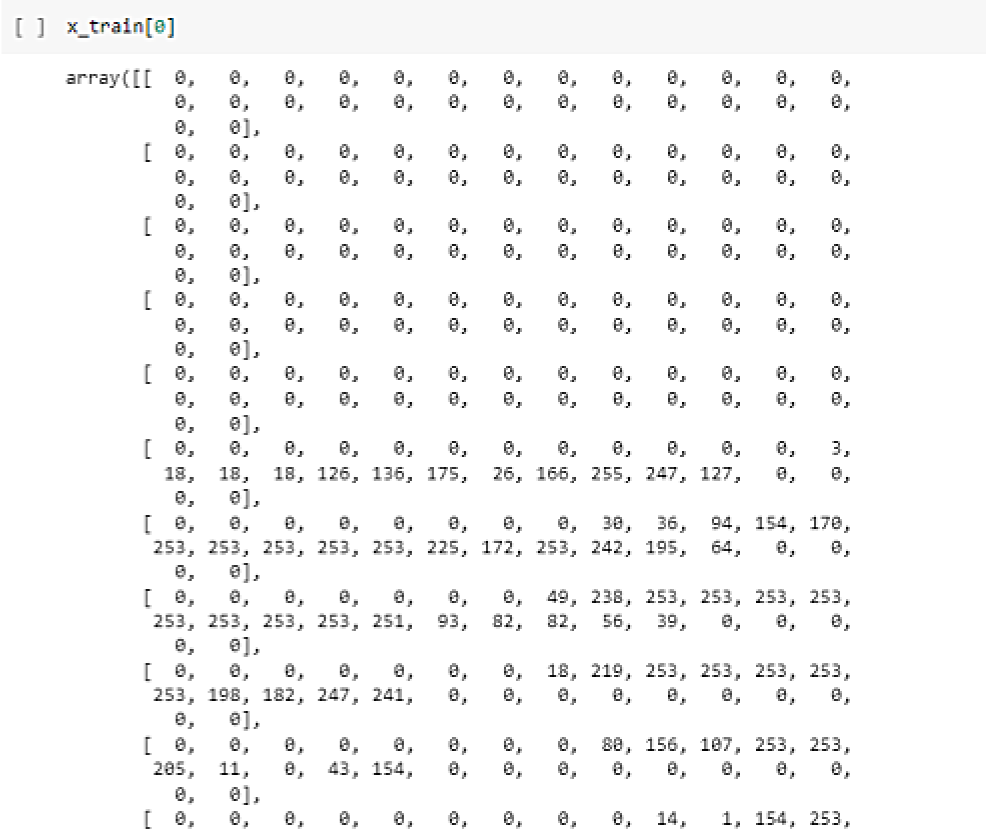


```
print(x_train.shape)
print(x_test.shape)
```

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

Analyzing The Data

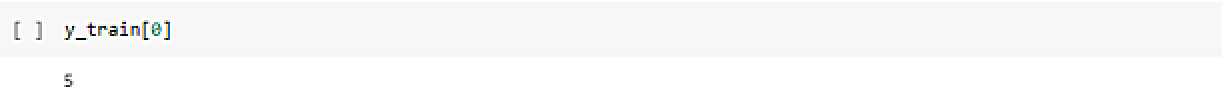
Let's see the Information of an image lying inside the x_train variable



```
[ ]  x_train[0]
```

```
array([[  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,   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. With respect to this image, the label of this image will e stored in y_train we can see the label of this image by grabbing it from the y_train variable

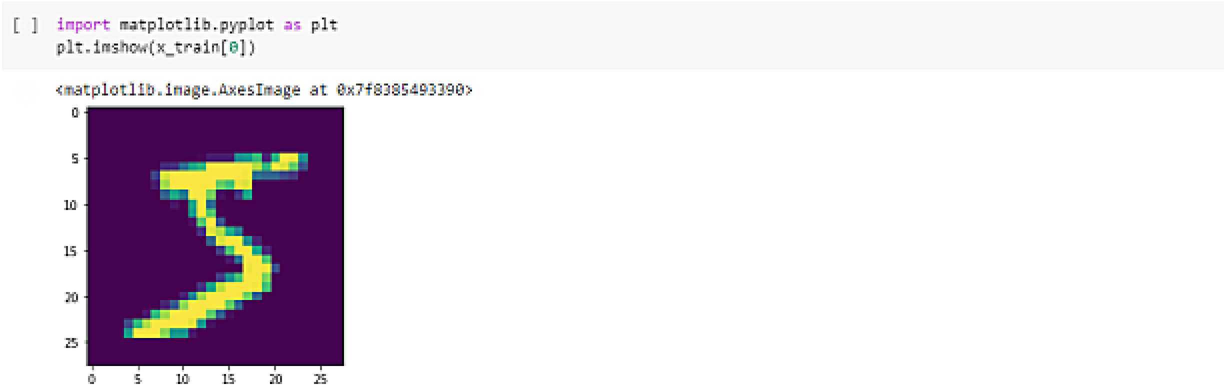


```
[ ]  y_train[0]
```

```
5
```

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 thatthe image is ‘5’.

Lets Plot the image on a graph using the Matplot library



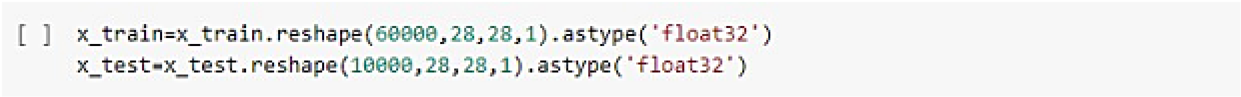
```
[ ]  import matplotlib.pyplot as plt
     plt.imshow(x_train[0])
```

```
<matplotlib.image.AxesImage at 0x7f8385493390>
```

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.

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

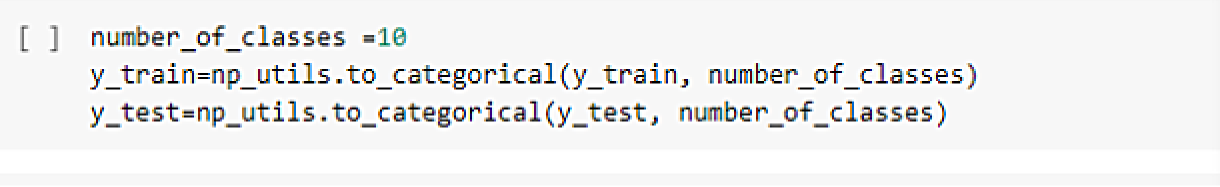


```
[ ]  x_train=x_train.reshape(60000,28,28,1).astype('float32')
     x_test=x_test.reshape(10000,28,28,1).astype('float32')
```

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

One Hot Encoding

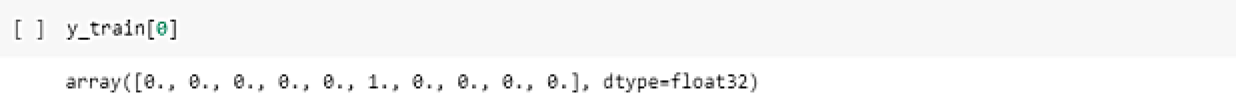
If you see our y_train variable contains Labels representing the images containing in x_train. AS these are numbers usually they can be considered as numerical or continuous data, but with respect to this project these Numbers are representing a set of class so these are to be represented as categorical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



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

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.

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



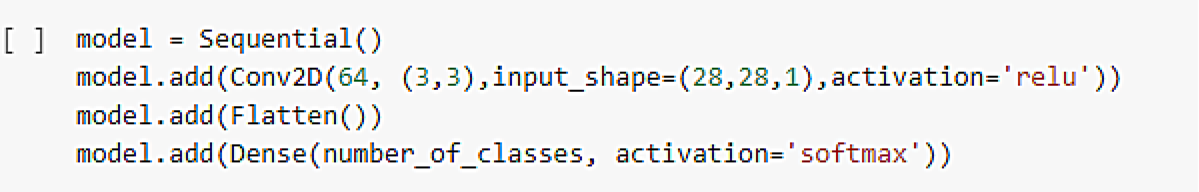
```
[ ]  y_train[0]

     array([0., 0., 0., 0., 0., 1., 0., 0., 0., 0.], dtype=float32)
```

The new the label is printed in the form of 0’s and 1’s and is of type float.

MODEL BUILDING

Add CNN Layers :

The convolution layer is the core building block of the CNN. It carries the main portion of the network’s computational load. This layer performs a dot product between two matrices, where one matrix is the set of learnable parameters otherwise known as a kernel, and the other matrix is the restricted portion of the receptive field. The kernel is spatially smaller than an image but is more in-depth. This means that, if the image is composed of three (RGB) channels, the kernel height and width will be spatially small, but the depth extends up to all three channels.The Sequential model is a linear stack of layers. You can create a Sequential model by passing a list of layer instances to the constructor.

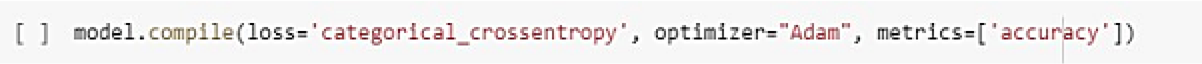


```
[ ]  model = Sequential()
     model.add(Conv2D(64, (3,3),input_shape=(28,28,1),activation='relu'))
     model.add(Flatten())
     model.add(Dense(number_of_classes, activation='softmax'))
```

Compiling The Model

With both the training data defined and model defined, now 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. In our project, we have 2 classes in the output, so the loss is binary cross entropy.

If there are more than two classes in output put “loss = categorical_crossentropy”.



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

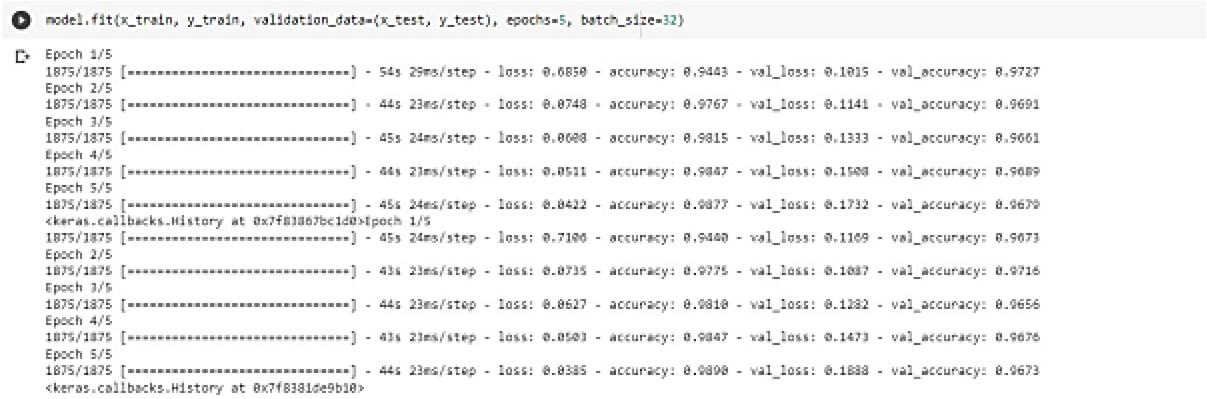
Train the ModelArguments:

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 lista generatorinputs, targets, and sample_weights list which can be used to evaluate the loss and metrics for any model after any epoch hasended.

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.

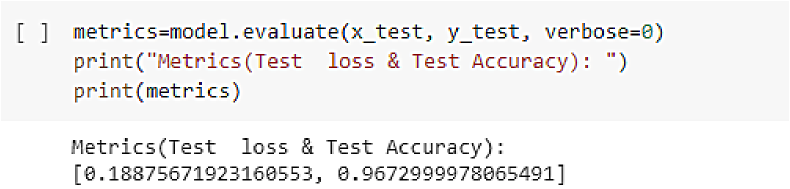


```
model.fit(x_train, y_train, validation_data=(x_test, y_test), epochs=5, batch_size=32)
```

```
Epoch 1/5
1875/1875 [==============================] - 54s 29ms/step - loss: 0.6850 - accuracy: 0.9443 - val_loss: 0.1015 - val_accuracy: 0.9727
Epoch 2/5
1875/1875 [==============================] - 44s 23ms/step - loss: 0.0748 - accuracy: 0.9767 - val_loss: 0.1141 - val_accuracy: 0.9691
Epoch 3/5
1875/1875 [==============================] - 45s 24ms/step - loss: 0.0608 - accuracy: 0.9815 - val_loss: 0.1333 - val_accuracy: 0.9661
Epoch 4/5
1875/1875 [==============================] - 44s 23ms/step - loss: 0.0511 - accuracy: 0.9847 - val_loss: 0.1508 - val_accuracy: 0.9689
Epoch 5/5
1875/1875 [==============================] - 45s 24ms/step - loss: 0.0422 - accuracy: 0.9877 - val_loss: 0.1732 - val_accuracy: 0.9679
<keras.callbacks.History at 0x7f83867bc1d0>Epoch 1/5
1875/1875 [==============================] - 45s 24ms/step - loss: 0.7106 - accuracy: 0.9440 - val_loss: 0.1169 - val_accuracy: 0.9673
Epoch 2/5
1875/1875 [==============================] - 43s 23ms/step - loss: 0.0735 - accuracy: 0.9775 - val_loss: 0.1087 - val_accuracy: 0.9716
Epoch 3/5
1875/1875 [==============================] - 44s 23ms/step - loss: 0.0627 - accuracy: 0.9810 - val_loss: 0.1282 - val_accuracy: 0.9656
Epoch 4/5
1875/1875 [==============================] - 43s 23ms/step - loss: 0.0503 - accuracy: 0.9847 - val_loss: 0.1473 - val_accuracy: 0.9676
Epoch 5/5
1875/1875 [==============================] - 44s 23ms/step - loss: 0.0385 - accuracy: 0.9890 - val_loss: 0.1888 - val_accuracy: 0.9673
<keras.callbacks.History at 0x7f8381de9b10>
```

Observing The Metrics: Printing the metrics which lists out the Test loss and Test accuracy

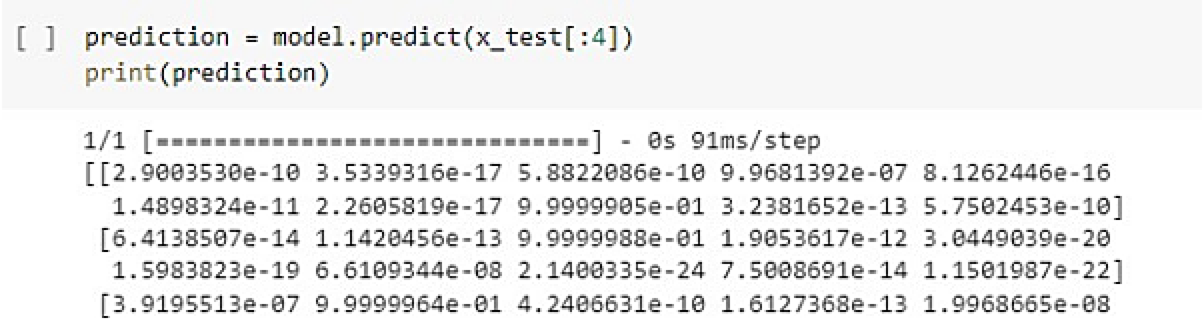
Loss value implies how poorly or well a model behaves after each iteration of optimization.
An accuracy metric is used to measure the algorithm's performance in an interpretable way.



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

     Metrics(Test  loss & Test Accuracy):
     [0.18875671923160553, 0.9672999978065491]
```

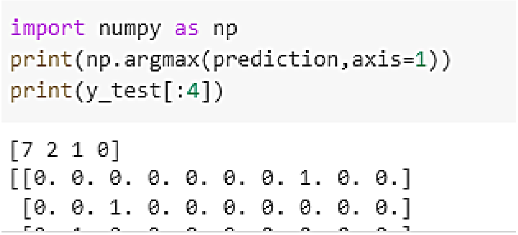
Testing the model

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



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

     1/1 [==============================] - 0s 91ms/step
     [[2.9003530e-10 3.5339316e-17 5.8822086e-10 9.9681392e-07 8.1262446e-16
       1.4898324e-11 2.2605819e-17 9.9999905e-01 3.2381652e-13 5.7502453e-10]
      [6.4138507e-14 1.1420456e-13 9.9999988e-01 1.9053617e-12 3.0449039e-20
       1.5983823e-19 6.6109344e-08 2.1400335e-24 7.5008691e-14 1.1501987e-22]
      [3.9195513e-07 9.9999964e-01 4.2406631e-10 1.6127368e-13 1.9968665e-08
```

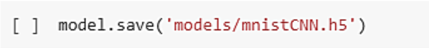
We already predicted the input from the x_test. According to that, by using argmax function here we are printing the labels with high prediction values.



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

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

SAVE THE MODEL

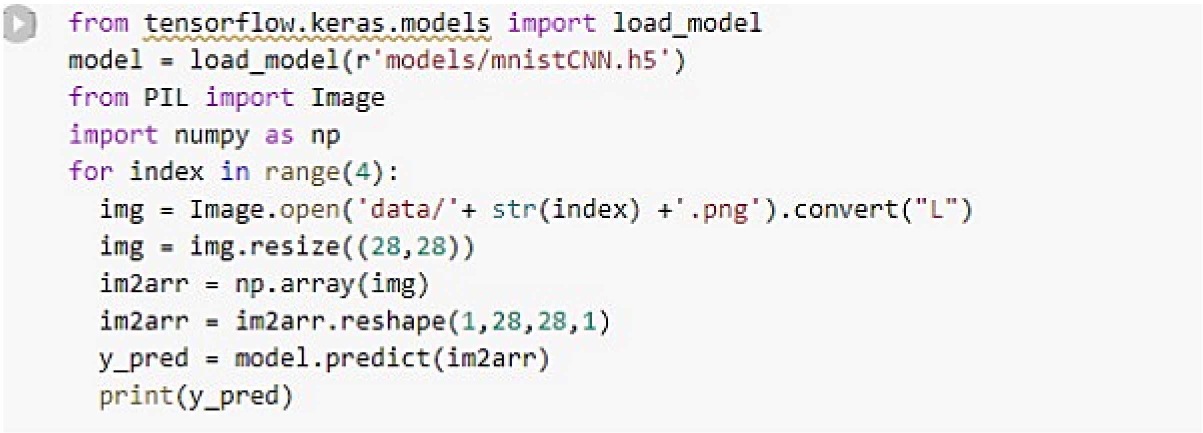
The model is saved with .h5 extension . An H5 file is a data file saved in the Hierarchical Data Format (HDF). It contains multidimensional arrays of scientific data.



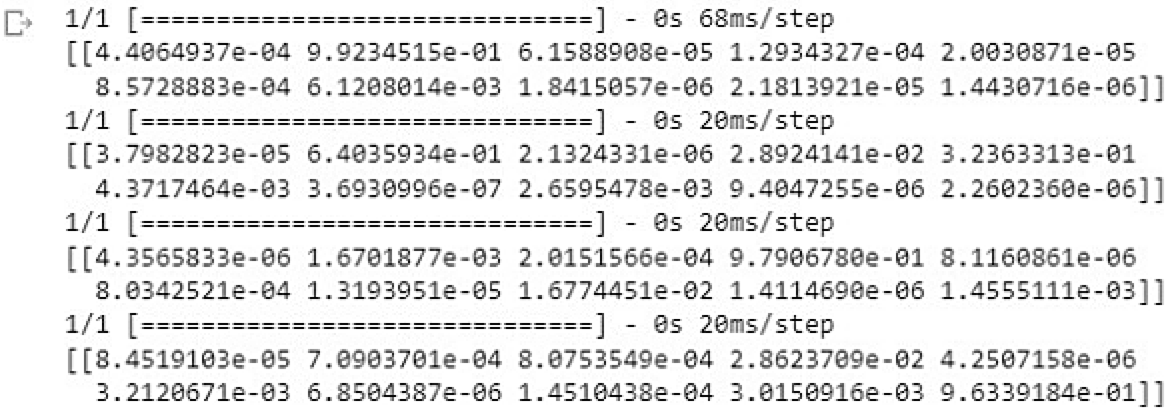
```
[ ]  model.save('models/mnistCNN.h5')
```

TEST WITH SAVED MODEL

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.



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



```
1/1 [==============================] - 0s 68ms/step
[[4.4064937e-04 9.9234515e-01 6.1588908e-05 1.2934327e-04 2.0030871e-05
  8.5728883e-04 6.1208014e-03 1.8415057e-06 2.1813921e-05 1.4430716e-06]]
1/1 [==============================] - 0s 20ms/step
[[3.7982823e-05 6.4035934e-01 2.1324331e-06 2.8924141e-02 3.2363313e-01
  4.3717464e-03 3.6930996e-07 2.6595478e-03 9.4047255e-06 2.2602360e-06]]
1/1 [==============================] - 0s 20ms/step
[[4.3565833e-06 1.6701877e-03 2.0151566e-04 9.7906780e-01 8.1160861e-06
  8.0342521e-04 1.3193951e-05 1.6774451e-02 1.4114690e-06 1.4555111e-03]]
1/1 [==============================] - 0s 20ms/step
[[8.4519103e-05 7.0903701e-04 8.0753549e-04 2.8623709e-02 4.2507158e-06
  3.2120671e-03 6.8504387e-06 1.4510438e-04 3.0150916e-03 9.6339184e-01]]
```

APPLICATION BUILDING

Create An HTML File

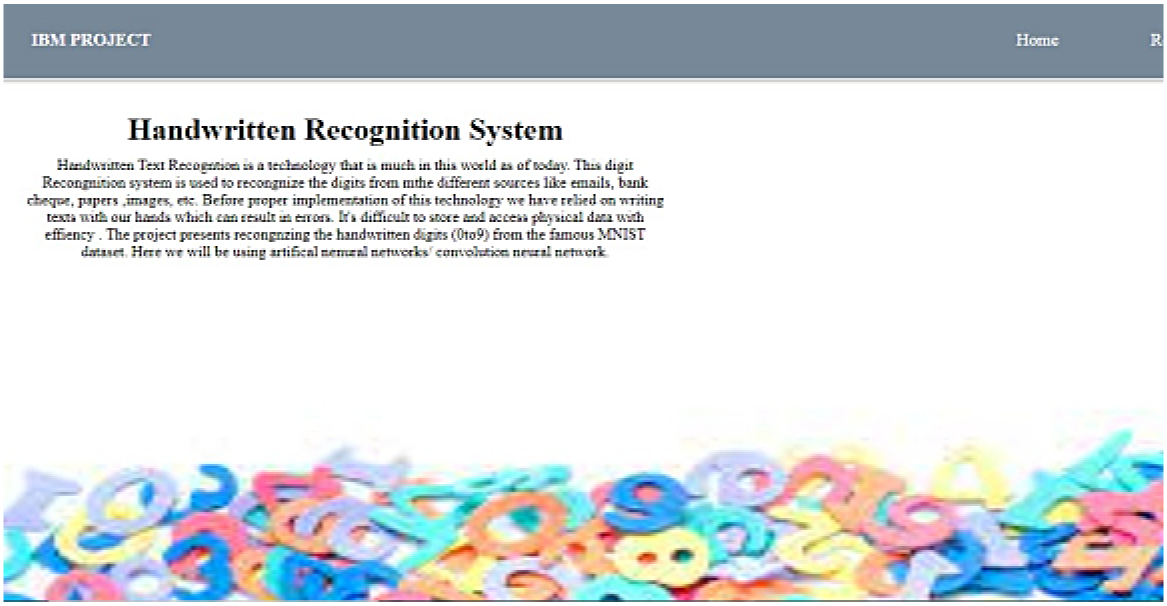
We use HTML to create the front end part of the web page.

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.

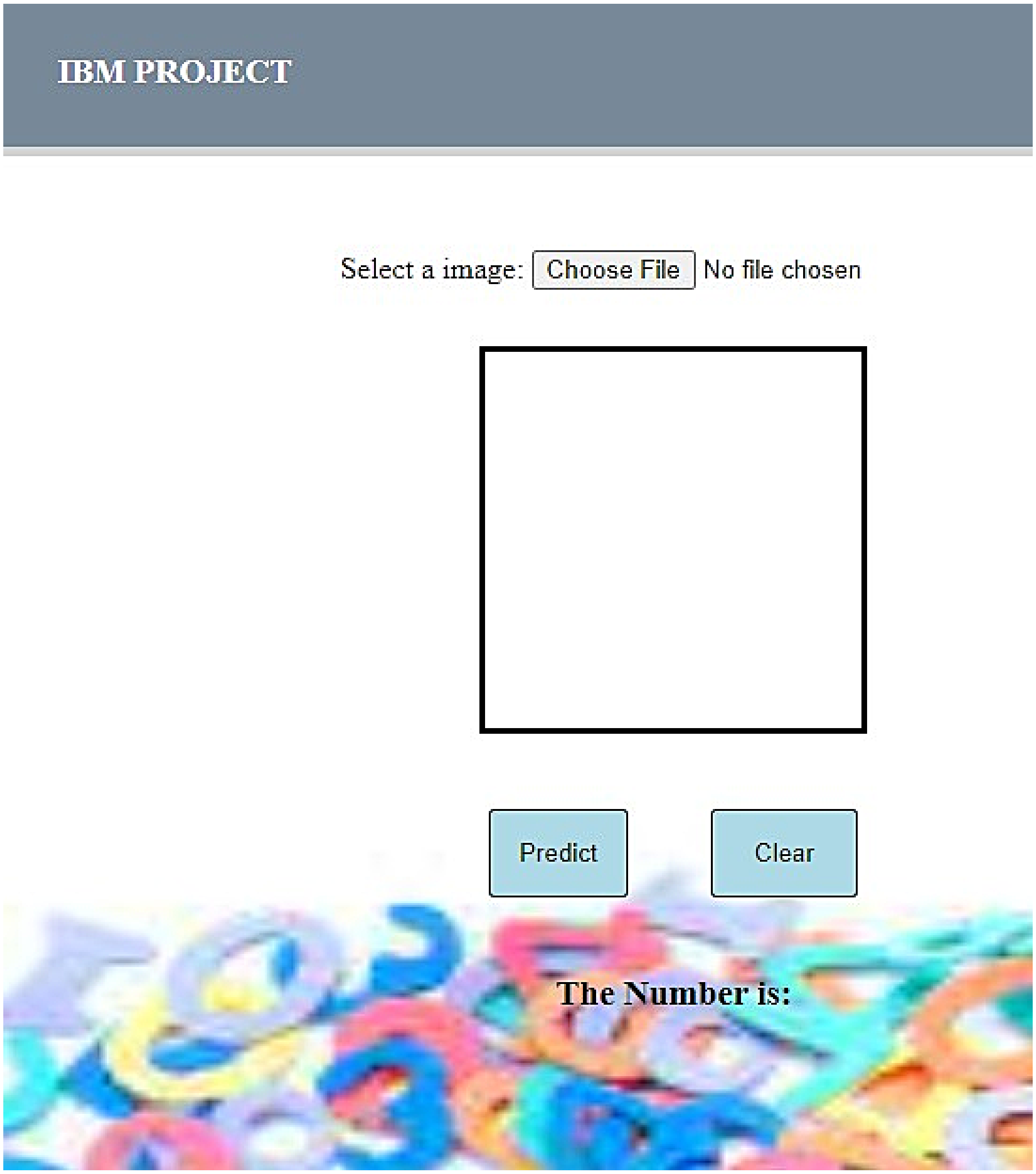
Our index.html file looks like



Handwritten Recognition System

Handwritten Text Recognition is a technology that is much in this world as of today. This digit Recongnition system is used to recongnize the digits from mthe different sources like emails, bank cheque, papers ,images, etc. Before proper implementation of this technology we have relied on writing texts with our hands which can result in errors. It's difficult to store and access physical data with effiency . The project presents recongnzing the handwritten digits (0to9) from the famous MNIST dataset. Here we will be using artifical nemeral networks/ convolution neural network.

This is the main page which describes about the project and summarizes it.
web.html accepts the values from the input and displays the prediction.



Build Python Code (Part 1)

flask file ‘app.py’ which is a web framework written in python for server-side scripting. step by step procedure for building the backend application.

App starts running when the “name” constructor is called in main.

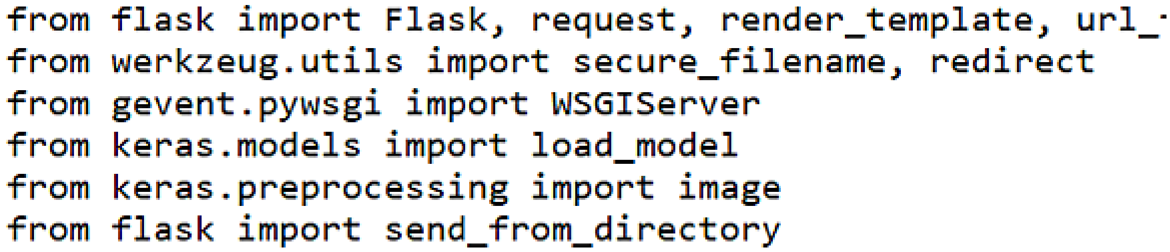
render_template is used to return HTML file.

“GET” method is used to take input from the user.

“POST” method is used to display the output to the user.

Import Libraries:

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

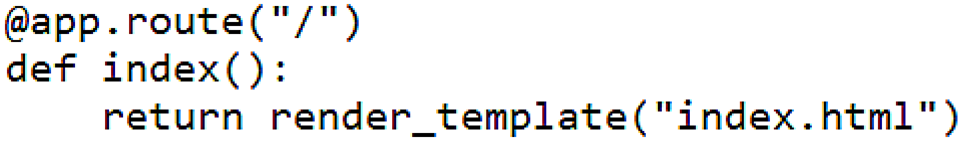


```
from flask import Flask, request, render_template, url_
from werkzeug.utils import secure_filename, redirect
from gevent.pywsgi import WSGIServer
from keras.models import load_model
from keras.preprocessing import image
from flask import send_from_directory
```

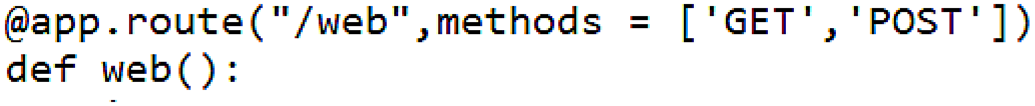
Routing to the html Page

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 toour prediction page that is index.html



```
@app.route("/")
def index():
    return render_template("index.html")
```

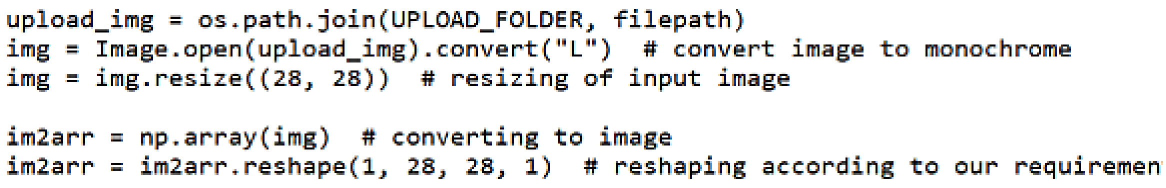


```
@app.route("/web",methods = ['GET','POST'])
def web():
```

Returning the prediction on UI:

Build Python Code (Part 2)

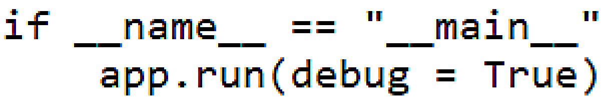
Here the route for prediction is given and necessary steps are performed in order to get the predicted output.Necessary conditions are given according to the input classes and the app will bereturning the templates according to that.



```
upload_img = os.path.join(UPLOAD_FOLDER, filepath)
img = Image.open(upload_img).convert("L")  # convert image to monochrome
img = img.resize((28, 28))  # resizing of input image

im2arr = np.array(img)  # converting to image
im2arr = im2arr.reshape(1, 28, 28, 1)  # reshaping according to our requiremen
```

Main Function:

This function runs your app in a web browser



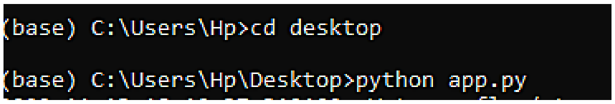
```
if __name__ == "__main__":
    app.run(debug = True)
```

Run The Application

1. Open anaconda prompt from the start menu

2. Navigate to the folder where your python script is.

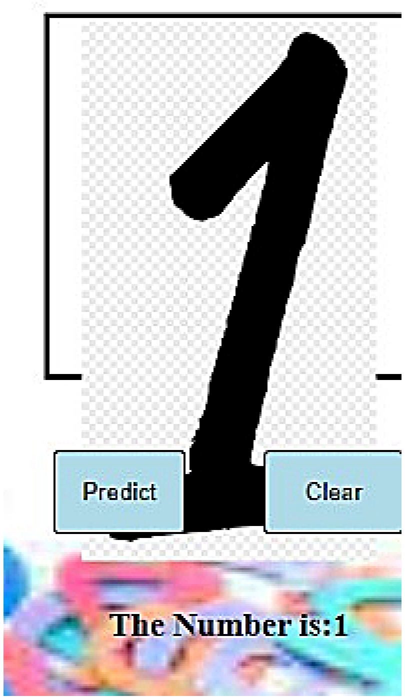
3. Now type “python app.py” command



```
(base) C:\Users\Hp>cd desktop

(base) C:\Users\Hp\Desktop>python app.py
```

Navigate to the localhost where you can view your web page

Upload an image and see the predicted output on UI of your page and result looks like:



The Number is:1

TRAIN THE MODEL ON IBM

Watson studio

Watson is AI from IBM. Created to form your business more intelligent and every worker your best worker. Watson features a range of advanced APIs, specialized tooling, and Software as a Service application. This implies that Watson is made for complex use cases and designed to integrate with platforms that experts utilize in their daily work. Ensuring seamless access to the knowledge you would like to form the right decisions.

IBM Watson Services

1. **Watson Studio** allows you to train, deploy, and manage your AI models, and prepare and analyze information during a single integratedenvironment.
2. **Watson Knowledge Catalog** drives collaboration and transforms information and AI into a trusted enterprise resource through dynamic data policies and requirements.

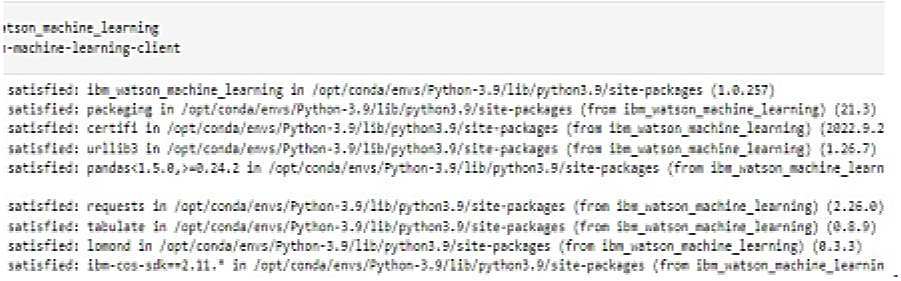
3. **Watson Assistant** helps you construct chatbots and virtual assistants for a spread of channels including mobile devices, messaging platforms, and even robots.
4. **Watson Discovery** unlocks hidden value in information to get answers, monitor trends, and repair patterns with the world's most advanced cloud-native insight engine.
5. **Watson IoT Platform** helps to make and maintain a really efficient IoT infrastructure.
6. **Watson Speech to Text (STT)** helps convert audio/speech to text.
7. **Watson Text to Speech (TTS)** helps convert text to audio/speech.
8. **Watson Language Translator** helps translate between different languages.

9. **Watson language Classifier** helps you classify the natural languages getting used.
10. **Watson's language Understanding** helps you understand natural languages.
11. **Watson Visual Recognition** allows you to rapidly and precisely tag, classify, and train visual content using machine learning.
12. **Watson Tone Analyzer** helps you analyze the tone of sound provide whether the person is angry, happy, or whether the music is pleasant ornot.
13. **Watson Personality Insights** helps you gain insight into personalitytraits.
14. **Data Refinery** provides you with how to show Watson the language of your domain, with custom models that identify entities and relationships unique to your industry.
15. **Watson Machine Learning** empowers you to utilize your own data to make, train, and deploy machine learning and deep learning models.
16. **Deep Learning** helps you build deep learning models.
17. **Watson Compare and Comply** streamlines contract workflows to save lots of

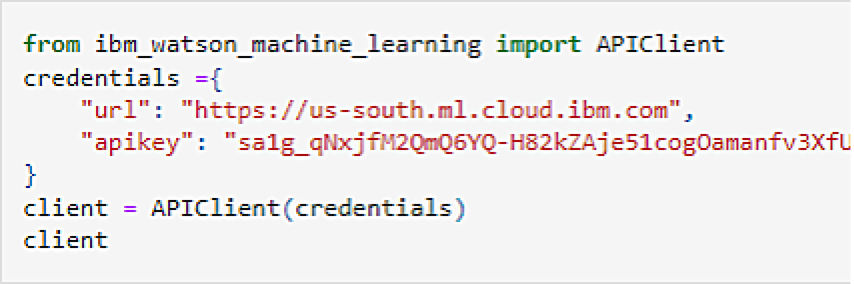
time and improve precision and disentangle contract governance.

Advantages Of Using IBM Watson

1. Watson gives you complete control of what is important to you and therefore the foundation of your competitive advantage, your data, models, learning, and API.
2. Watson learns more from less because of its high learning power.Watson was initially available only on IBM Cloud but is now portable across any cloud-powered business. This prevents customers from being locked into one vendor and enables them to start out deploying AIwherever their data resides.



```
tson_machine_learning
-machine-learning-client

satisfied: ibm_watson_machine_learning in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (1.0.257)
satisfied: packaging in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (21.3)
satisfied: certifi in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (2022.9.2
satisfied: urllib3 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (1.26.7)
satisfied: pandas<1.5.0,>=0.24.2 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learn

satisfied: requests in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (2.26.0)
satisfied: tabulate in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (0.8.9)
satisfied: lomond in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (0.3.3)
satisfied: ibm-cos-sdk==2.11.* in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learnin
```



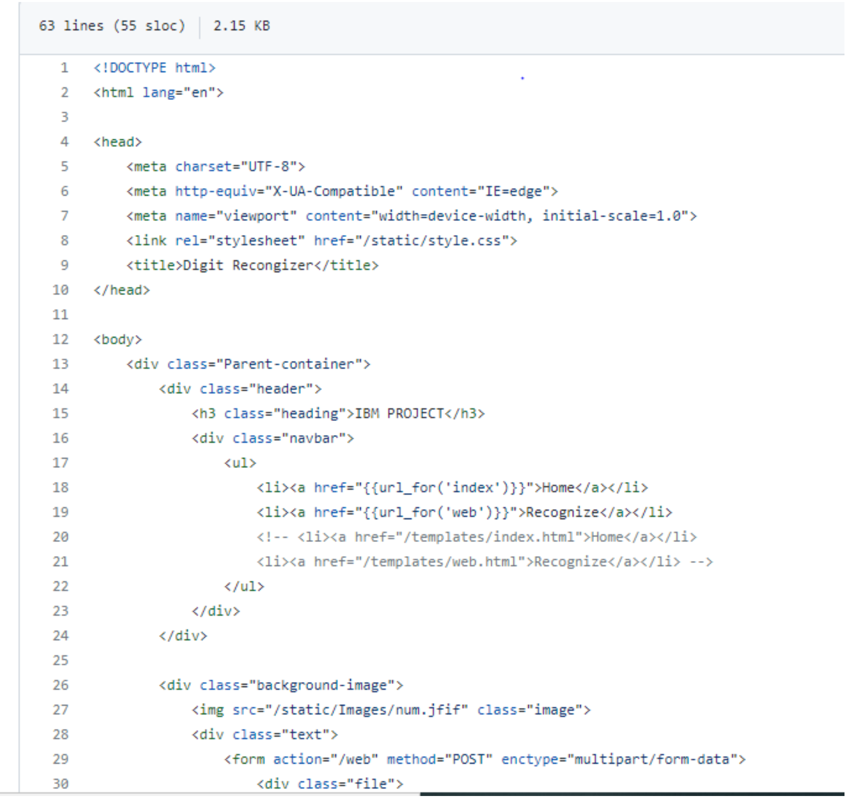
```python
from ibm_watson_machine_learning import APIClient
credentials ={
    "url": "https://us-south.ml.cloud.ibm.com",
    "apikey": "sa1g_qNxjfM2QmQ6YQ-H82kZAje51cogOamanfv3XfU
}
client = APIClient(credentials)
client
```

7.CODING & SOLUTIONING

7.1 Feature

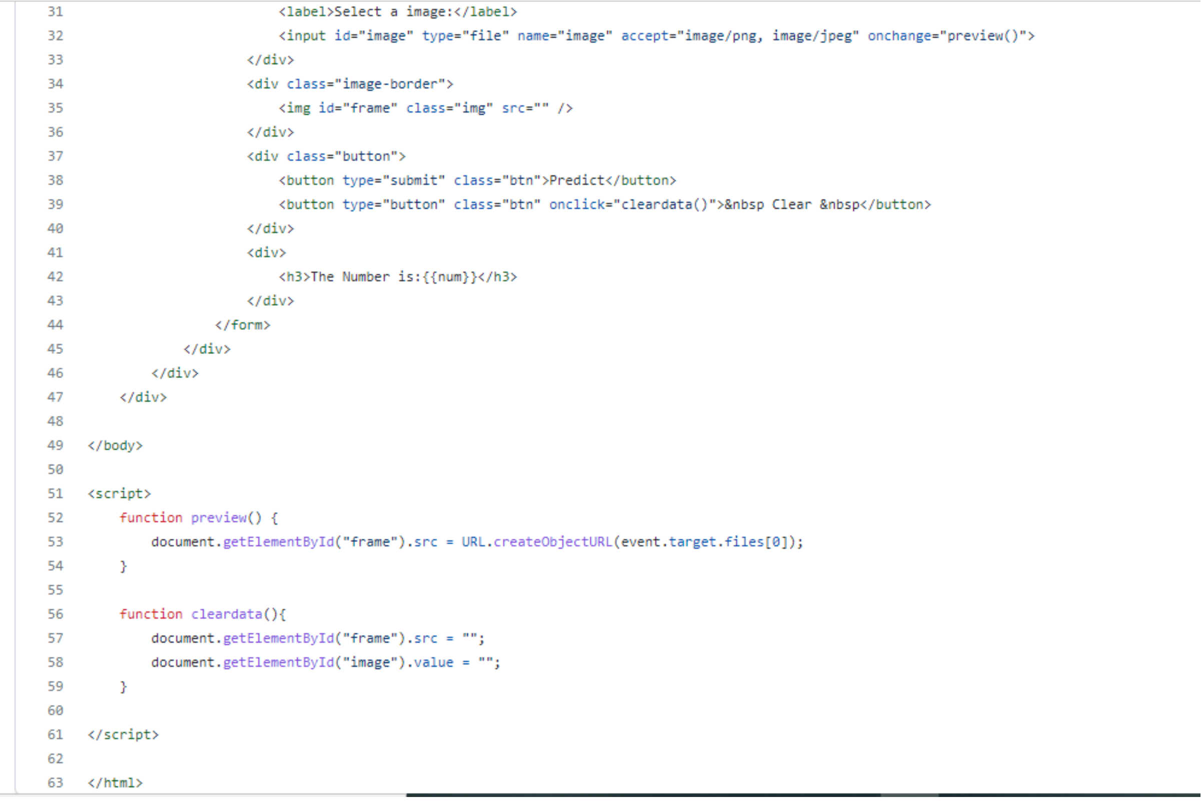
- Prediction button can be used to predict image
- Clear button can be used to clear the image
- Home button to navigate back to home
- User friendly UI
- Highly accurate prediction model

web.html



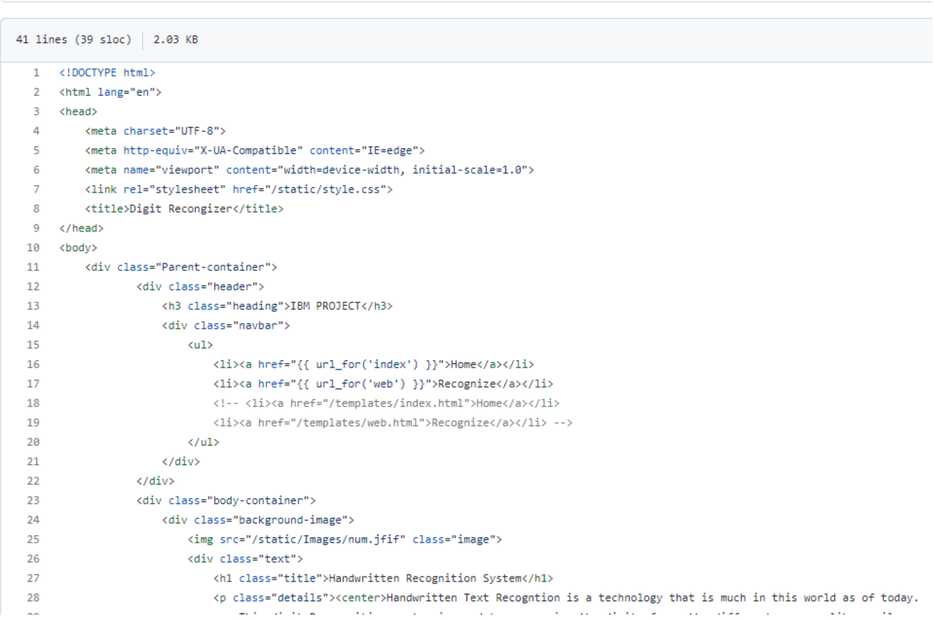
63 lines (55 sloc) | 2.15 KB

```
<!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">
    <link rel="stylesheet" href="/static/style.css">
    <title>Digit Recongizer</title>
</head>

<body>
    <div class="Parent-container">
        <div class="header">
            <h3 class="heading">IBM PROJECT</h3>
            <div class="navbar">
                <ul>
                    <li><a href="{{url_for('index')}}">Home</a></li>
                    <li><a href="{{url_for('web')}}">Recognize</a></li>
                    <!-- <li><a href="/templates/index.html">Home</a></li>
                    <li><a href="/templates/web.html">Recognize</a></li> -->
                </ul>
            </div>
        </div>

        <div class="background-image">
            <img src="/static/Images/num.jfif" class="image">
            <div class="text">
                <form action="/web" method="POST" enctype="multipart/form-data">
                    <div class="file">
```



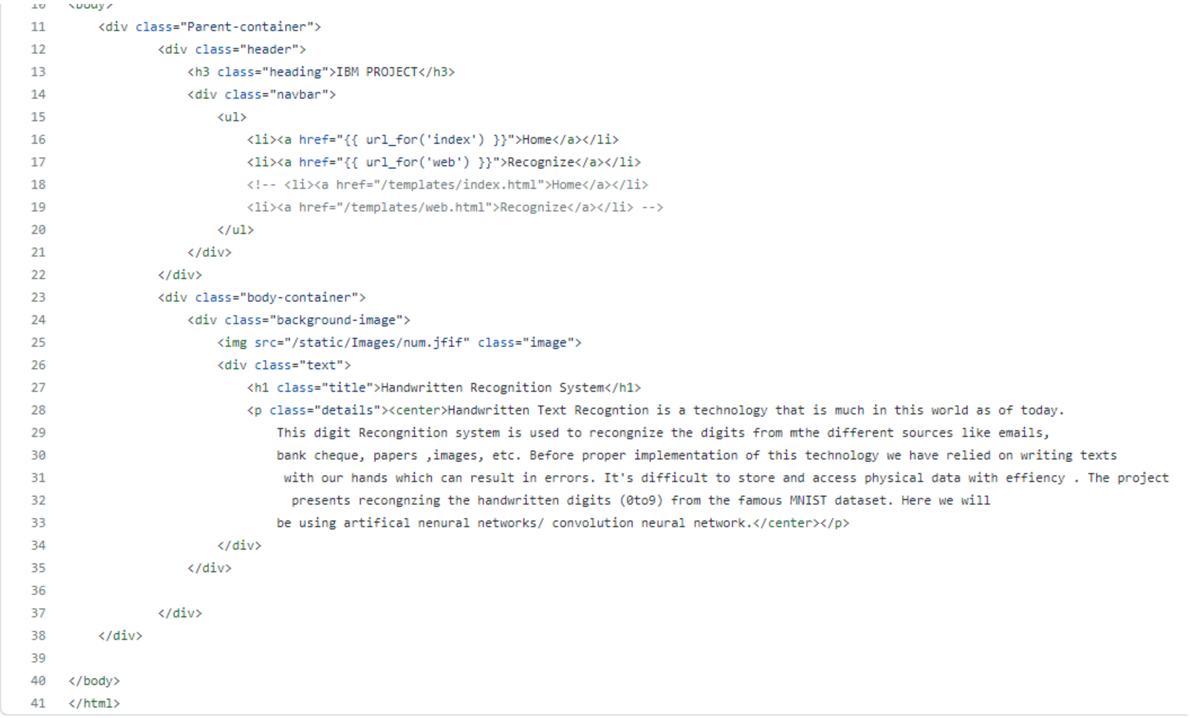
```
                        <label>Select a image:</label>
                        <input id="image" type="file" name="image" accept="image/png, image/jpeg" onchange="preview()">
                    </div>
                    <div class="image-border">
                        <img id="frame" class="img" src="" />
                    </div>
                    <div class="button">
                        <button type="submit" class="btn">Predict</button>
                        <button type="button" class="btn" onclick="cleardata()">&nbsp Clear &nbsp</button>
                    </div>
                    <div>
                        <h3>The Number is:{{num}}</h3>
                    </div>
                </form>
            </div>
        </div>
    </div>

</body>

<script>
    function preview() {
        document.getElementById("frame").src = URL.createObjectURL(event.target.files[0]);
    }

    function cleardata(){
        document.getElementById("frame").src = "";
        document.getElementById("image").value = "";
    }

</script>

</html>
```

index.html



41 lines (39 sloc) | 2.03 KB

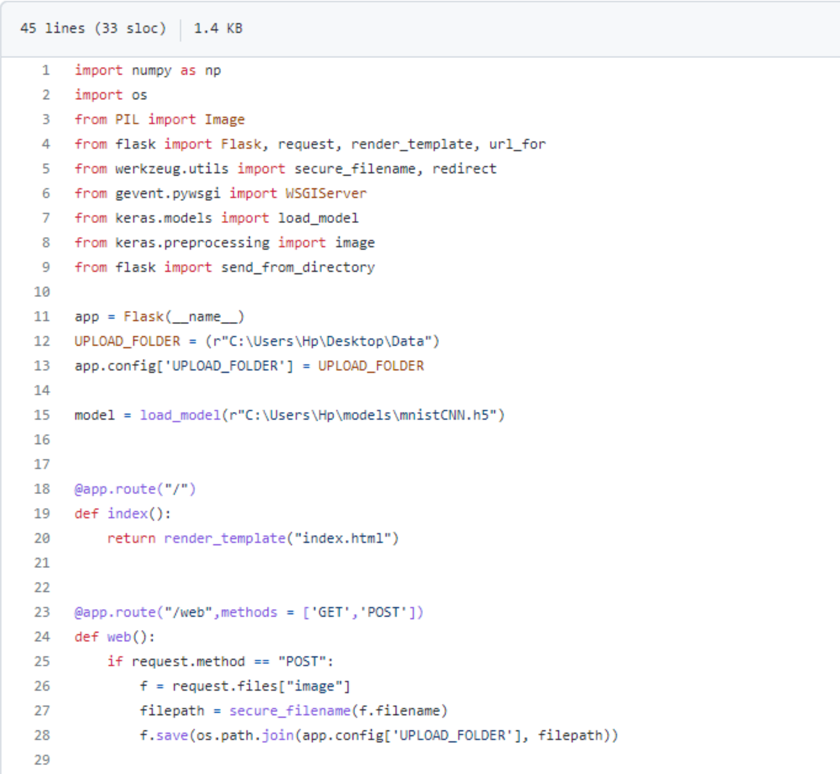
```
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <link rel="stylesheet" href="/static/style.css">
    <title>Digit Recongizer</title>
</head>
<body>
    <div class="Parent-container">
            <div class="header">
                <h3 class="heading">IBM PROJECT</h3>
                <div class="navbar">
                    <ul>
                        <li><a href="{{ url_for('index') }}">Home</a></li>
                        <li><a href="{{ url_for('web') }}">Recognize</a></li>
                        <!-- <li><a href="/templates/index.html">Home</a></li>
                        <li><a href="/templates/web.html">Recognize</a></li> -->
                    </ul>
                </div>
            </div>
            <div class="body-container">
                <div class="background-image">
                    <img src="/static/Images/num.jfif" class="image">
                    <div class="text">
                        <h1 class="title">Handwritten Recognition System</h1>
                        <p class="details"><center>Handwritten Text Recogntion is a technology that is much in this world as of today.
```



```
    <div class="Parent-container">
            <div class="header">
                <h3 class="heading">IBM PROJECT</h3>
                <div class="navbar">
                    <ul>
                        <li><a href="{{ url_for('index') }}">Home</a></li>
                        <li><a href="{{ url_for('web') }}">Recognize</a></li>
                        <!-- <li><a href="/templates/index.html">Home</a></li>
                        <li><a href="/templates/web.html">Recognize</a></li> -->
                    </ul>
                </div>
            </div>
            <div class="body-container">
                <div class="background-image">
                    <img src="/static/Images/num.jfif" class="image">
                    <div class="text">
                        <h1 class="title">Handwritten Recognition System</h1>
                        <p class="details"><center>Handwritten Text Recogntion is a technology that is much in this world as of today.
```

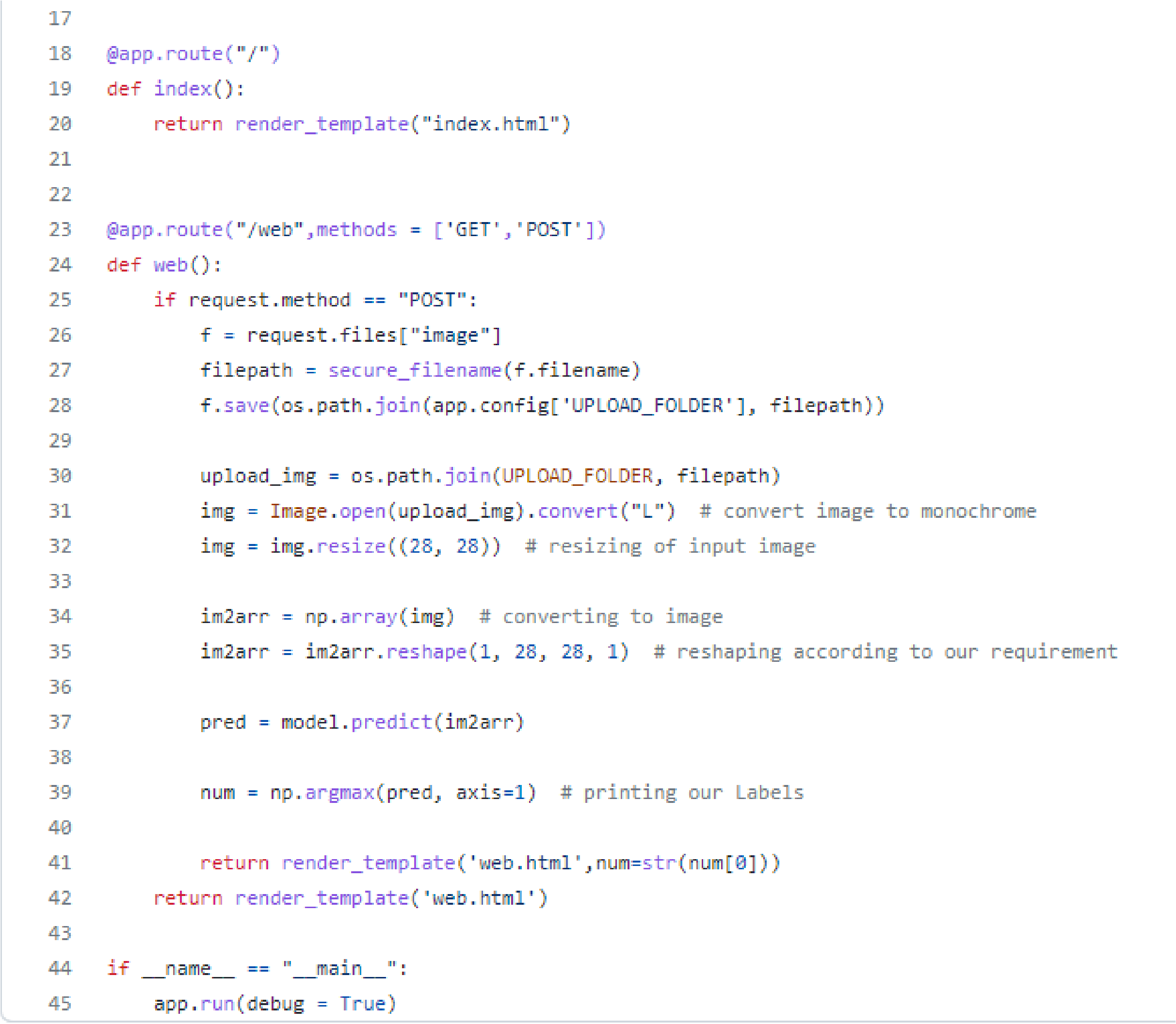
```
                            This digit Recongition system is used to recongnize the digits from mthe different sources like emails,
                            bank cheque, papers ,images, etc. Before proper implementation of this technology we have relied on writing texts
                             with our hands which can result in errors. It's difficult to store and access physical data with effiency . The project
                              presents recongnzing the handwritten digits (0to9) from the famous MNIST dataset. Here we will
                            be using artifical nenural networks/ convolution neural network.</center></p>
                    </div>
                </div>

            </div>
    </div>

</body>
</html>
```

app.py



45 lines (33 sloc) | 1.4 KB

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

app = Flask(__name__)
UPLOAD_FOLDER = (r"C:\Users\Hp\Desktop\Data")
app.config['UPLOAD_FOLDER'] = UPLOAD_FOLDER

model = load_model(r"C:\Users\Hp\models\mnistCNN.h5")


@app.route("/")
def index():
    return render_template("index.html")


@app.route("/web",methods = ['GET','POST'])
def web():
    if request.method == "POST":
        f = request.files["image"]
        filepath = secure_filename(f.filename)
        f.save(os.path.join(app.config['UPLOAD_FOLDER'], filepath))

```



```python

@app.route("/")
def index():
    return render_template("index.html")


@app.route("/web",methods = ['GET','POST'])
def web():
    if request.method == "POST":
        f = request.files["image"]
        filepath = secure_filename(f.filename)
        f.save(os.path.join(app.config['UPLOAD_FOLDER'], filepath))

        upload_img = os.path.join(UPLOAD_FOLDER, filepath)
        img = Image.open(upload_img).convert("L")  # convert image to monochrome
        img = img.resize((28, 28))  # resizing of input image

        im2arr = np.array(img)  # converting to image
        im2arr = im2arr.reshape(1, 28, 28, 1)  # reshaping according to our requirement

        pred = model.predict(im2arr)

        num = np.argmax(pred, axis=1)  # printing our Labels

        return render_template('web.html',num=str(num[0]))
    return render_template('web.html')

if __name__ == "__main__":
    app.run(debug = True)
```

8.TESTING

8.1 Test Case

Purpose of Document

The purpose of this document is to briefly explain the test coverage and open issues of the Handwritten Digit Recognition system project at the time of the release to User Acceptance Testing (UAT).

Defect Analysis

This report shows the number of resolved or closed bugs at each severity level, and howthey were resolved

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	5	4	2	3	14
Duplicate	1	0	3	0	4
External	2	3	0	1	6
Fixed	11	2	4	10	27
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	0	1
Won't Fix	0	0	0	1	1
Totals	19	9	11	15	54

Test Case Analysis

This report shows the number of test cases that have passed, failed, and untested

Section	Total Cases	Not Tested	Fail	Pass
Print Engine	7	0	0	7
Client Application	51	0	0	51
Security	2	0	0	2
Outsource Shipping	3	0	0	3
Exception Reporting	9	0	0	9
Final Report Output	4	0	0	4
Version Control	2	0	0	2

Test Scenarios

- Verify user is able to see login page
- Verify user is able to loginto application or not?
- Verify user is able to navigate to recognize page?
- Verify user is able to upload the image
- Veriify the number is correctly predicted

Search

- Verify user is able to search by entering keywords in search box
- Verify user is able to see suggestions based on keyword entered in search box
- Verify user is able to see related auto suggestions displaying based on keyword entered in search box
- Verify user is able to see no matches found message when no results are matching with entered keyword
- Verify user is able to see seach detailed page when nothing entered in textbox

9 RESULTS

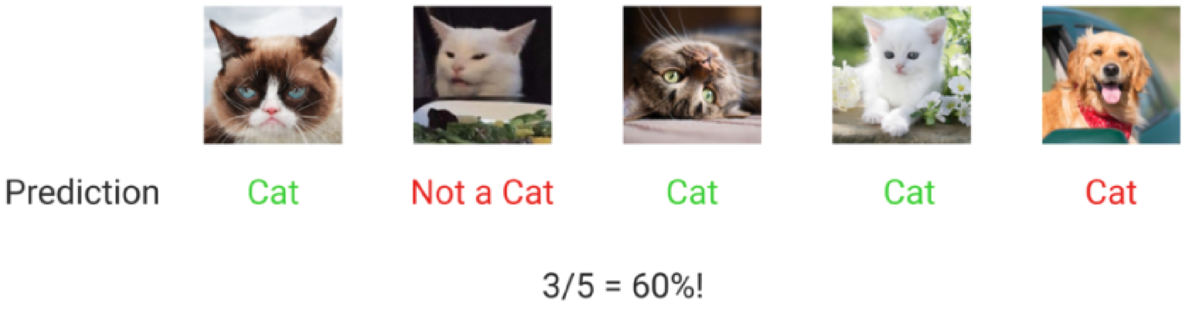
9.1 PERFORMANE METRICS

LOSS: Loss is a value that represents the summation of errors in our model. **It measures how well (or bad) our model is doing**. If the errors are high, the loss will be high, which means that the model does not do a good job. Otherwise, the lower it is, the better our model works.

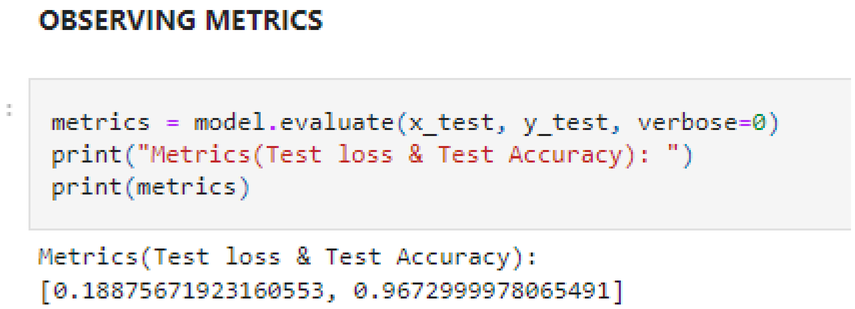
To calculate the loss, a loss or cost function is used. There are several different cost functions to use. Each penalizes errors in different ways, and the problem determines which one is better to use. Cross- Entropy and Mean-Squared Error are the most commonly used for classification and regression problems, respectively.

ACCURACY :Accuracy is more straightforward. **It measures how well our model predicts** by comparing the model predictions with the true values in terms of percentage.

For example, let’s say we have a model for image classification that detects whether or not there is a cat in the image. We have 5 test images. If the model is able to predict correctly whether or not there is a cat in 3 of the images, it results in an accuracy of 60%



Having a low accuracy but a high loss would mean that the model makes big errors in most of the data. But, if both loss and accuracy are low, it means the model makes small errors in most of the data. However, if they're both high, it makes big errors in some of the data. Finally, if the accuracy is high and the loss is low, then the model makes small errors on just some of the data, which would be the ideal case.



OBSERVING METRICS

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

```
Metrics(Test loss & Test Accuracy):
[0.18875671923160553, 0.9672999978065491]
```

In our project we got **loss% of 18%** and **accuracy of 96%.**

10 ADVANTAGES AND DISADVANTAGES

ADVANTAGES:

- The accuracy percentage is 96% , so the output is more accurate
- The output is displayed within fraction of seconds
- The **UI** is user friendly**.**

DISADVANTAGES:

- Only one image can be uploaded and predicted at a time
- There is no facility for disabled (blind and deaf) to view the image

11.Conclusion

- In this project the variations of accuracies for handwritten digit were observed for epochs by varying the hidden layers using CNN model and MNIST digit dataset.

- The maximum accuracy in the performance was found 99.64% and the total lowest test loss is 0.0239 approximately.

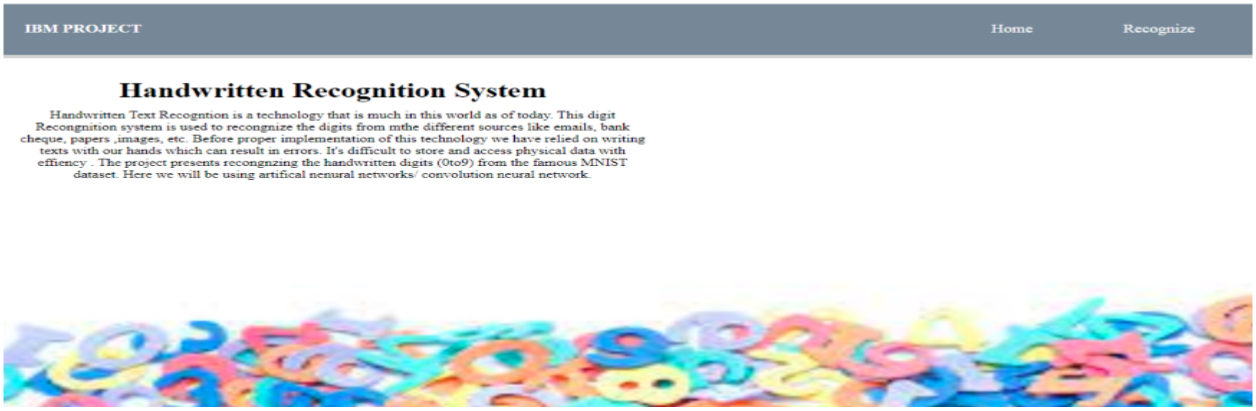
- This type of higher accuracy will cooperate to speed up the performance of the machine more adequately.

- This low loss will provide CNN better performance to attain better image resolution and noise processing.

12. FUTURE SCOPE

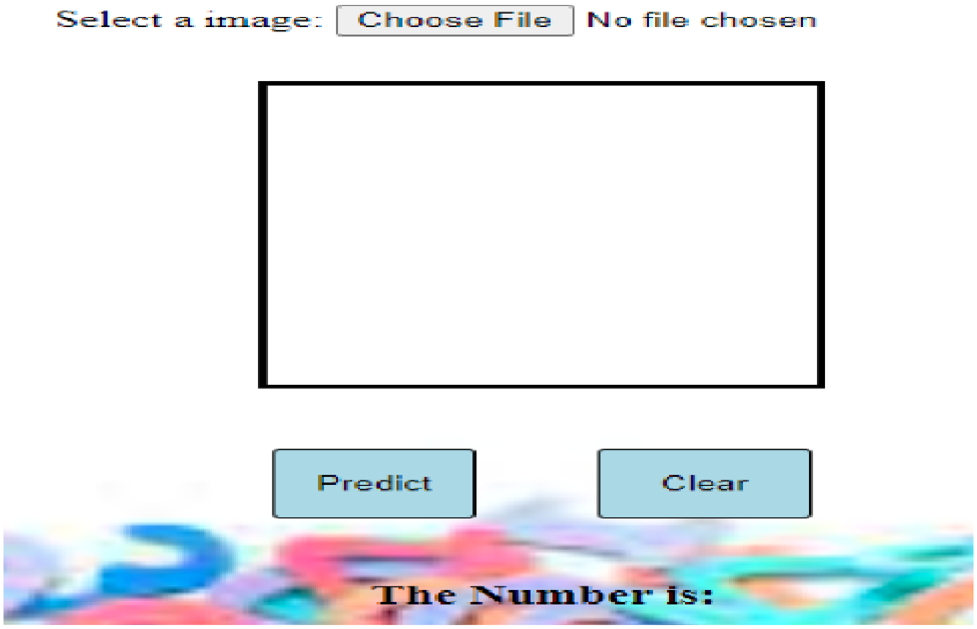
- Makes a CNN model that classifies more accurately by varying the number of hidden layers and batch size for different handwritten style.
- An approach called "Ensemble Model " can give much better accurate prediction in recognizing numbers.
- Include new features that can predict numbers from live or real-time videos.

13.APPENDIX

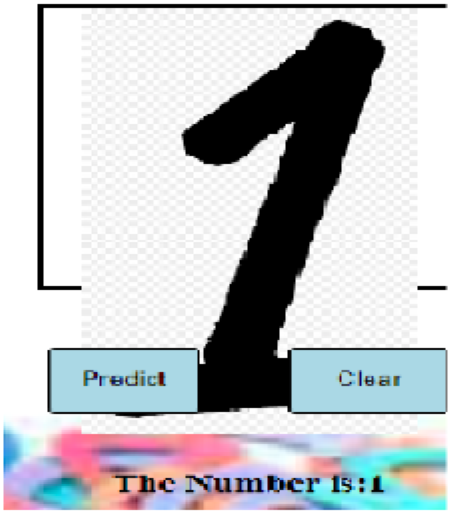


Handwritten Recognition System

Handwritten Text Recogntion is a technology that is much in this world as of today. This digit Recongnition system is used to recongnize the digits from mthe different sources like emails, bank cheque, papers ,images, etc. Before proper implementation of this technology we have relied on writing texts with our hands which can result in errors. It's difficult to store and access physical data with effiency . The project presents recongnzing the handwritten digits (0to9) from the famous MNIST dataset. Here we will be using artifical nenural networks/ convolution neural network.



The Number is:



The Number is:1