

# **A Novel Method for Handwritten Digit Recognition System**

**Team ID :PNT2022TMID14249 Team**

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## **1.Introduction**

### **1.1 Project Overview**

Handwritten digit recognition is the ability of a computer system to recognize the handwritten inputs like digits, characters etc. from a wide variety of sources like emails, papers, images, letters etc. This has been a topic of research for decades. Some of the research areas include signature verification, bank check processing, postal address interpretation from envelopes etc. Here comes the use of Deep Learning. In the past decade, deep learning has become the hot tool for Image Processing, object detection, handwritten digit and character recognition etc. A lot of machine learning tools have been developed like scikit-learn, scipy-image etc. and pybrains, Keras, Theano, Tensorflow by Google, TFLearn etc. for Deep Learning. These tools make the applications robust and therefore more accurate. The Artificial Neural Networks can almost mimic the human brain and are a key ingredient in image processing field. For example, Convolutional Neural Networks with Back Propagation for Image Processing, Deep Mind by Google for creating Art by learning from existing artist styles etc..

### **1.2 Purpose**

This paper deals with the Various pre-processing techniques involved in the character Recognition with different kind of images ranges from a Simple handwritten form based documents and documents Containing colored and complex background and varied Intensities. In this, different preprocessing techniques like Skew detection and correction,image enhancement techniques Of contrast stretching, binarization, noise removal techniques, Normalization and segmentation, morphological processing Techniques are discussed.

It was concluded that using a single Technique for preprocessing, we can't completely process the Image. However, even after applying all the said techniques Might not possible to achieve the full accuracy in a Preprocessing system.

## 2. Literature Survey

### 2.1 Existing Problem

Improving Offline Handwritten Text Recognition With Hybrid HMM/ANN Model

In this paper hybrid Hidden Markov Model (HMM) model is proposed for recognizing unconstrained offline handwritten texts. In this, the structural part of the optical model has been modelled with Markov chains, and a Multilayer Perceptron is used to estimate the emission probabilities. In this paper, different techniques are applied to remove slope and slant from handwritten text and to normalize the size of text images with supervised learning methods. The key features of this recognition system were to develop a system having high accuracy in pre processing and recognition, which are both based on anns. Feature Selection Using Genetic Algorithm.

Presented a work on how to select features for Character Recognition Using Genetic Algorithm. The author proposes a novel method of feature selection for character recognition using genetic algorithms (GA). The proposed method selects only the genes for which the recognition rate of training samples exceeds than the predetermined threshold as a candidate of the parent gene and adopts a reduction ratio in the number of features used for recognition as the fitness value.

### 2.2 References

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[11] Nearest Neighbor Rule: A Short Tutorial. 1995, [http://cgm.cs.mcgill.ca/~soss/cs644/projects/simard/nn\\_theory.htm](http://cgm.cs.mcgill.ca/~soss/cs644/projects/simard/nn_theory.htm)

## **2.3 Problem Statement Definition**

The handwritten digit recognition is the capability of computer applications to recognize the human handwritten digits. It is a hard task for the machine because handwritten digits are not perfect and can be made with many different shapes and sizes.

The handwritten digit recognition system is a way to tackle this problem which uses the image of a digit and recognizes the digit present in the image. Convolutional Neural Network model created using PyTorch library over the MNIST dataset to recognize handwritten digits. Handwritten Digit Recognition is the capability of a computer to fetch the mortal handwritten integers from different sources like images, papers, touch defenses, etc, and classify.

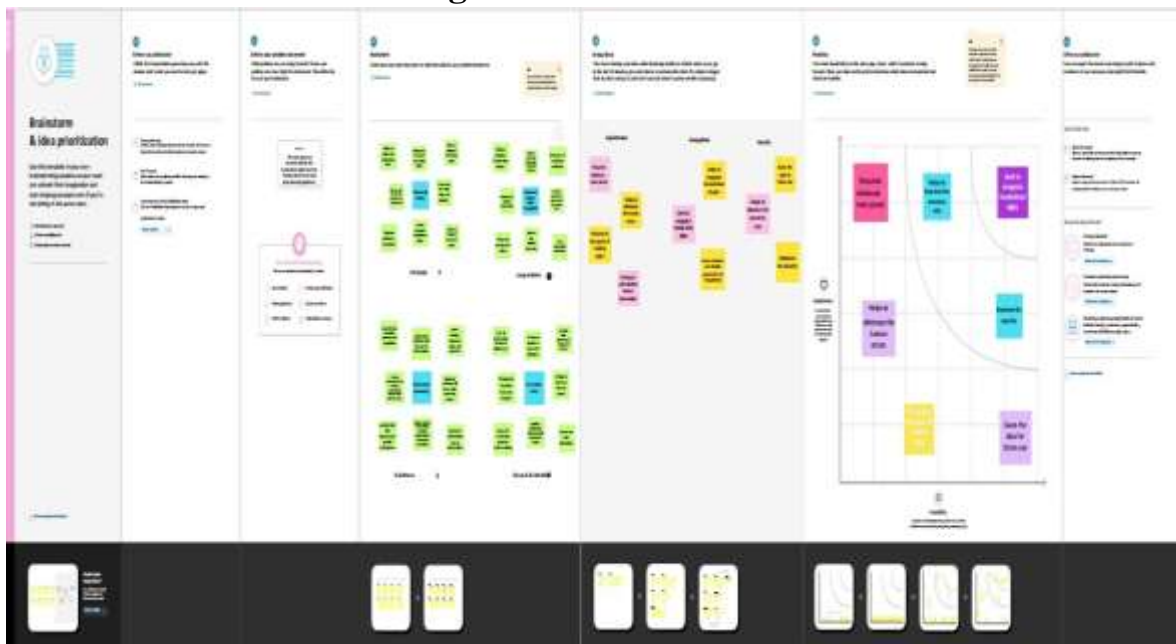
This exploration provides a comprehensive comparison between different machine literacy and deep literacy algorithms for the purpose of handwritten number recognition. For this, we've used Support Vector Machine, Multilayer Perceptron, and Convolutional Neural Network. The comparison between these algorithms is carried out on the basis of their delicacy, crimes, and .testing- training time corroborated by plots and maps that have been constructed using matplotlib for visualization.

## **3. IDEATION & PROPOSED SOLUTION**

### **3.1 Empathy Map Canvas**



### 3.2 Ideation & Brainstorming



### 3.3 Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	<ul style="list-style-type: none"><li>• It is easy for the human to perform task accurately by practicing it repeatedly and memorizing it for the next time. Human brain can process and analyse images easily. Also, recognize the different element present in the images.</li><li>• The <b>handwritten digit recognition</b> is the capability of computer applications to <b>recognize</b> the human <b>handwritten digits</b>.</li><li>• It is a hard task for the <b>machine</b> because <b>handwritten digits</b> are not perfect and can be made with many different shapes and sizes.</li><li>• The <b>handwritten digit recognition system</b> is a way to tackle this problem which uses the image of a <b>digit</b> and recognizes the <b>digit</b> present in the image.</li></ul>

2.	Idea / Solution description	<ul style="list-style-type: none"> <li>• The algorithm used is Convolution Neural Network(CNN). This will prepare the trained model which will be used to classify the digits present in the test data. Thus, we can classify the digits present in the images as: Class 0,1,2,3,4,5,6,7,8,9.</li> <li>• MNIST is a dataset which is widely used for handwritten digit recognition. The dataset consist of 60,000 training images and 10,000 test images.</li> </ul>
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3.	Novelty / Uniqueness	<ul style="list-style-type: none"> <li>• This project introduces an operative strategy for dealing with novelty in the handwritten visual recognition domain. A perfect transcription agent would be able to distinguish known and unknown characters in a picture, as well as determine any aesthetic variations that may occur inside or between texts. The existence of novelty has shown to be a major stumbling block for even the most robust machine learning-based algorithms for these activities.</li> <li>• Novelty in handwritten papers might include, among other things, a change in the writer, character properties, writing attributes, or overall document appearance. Instead of examining each element separately, we believe that an integrated agent capable of processing known characters and novelties concurrently is a superior technique. The handwritten digit recognition problem can be seen as a subtask of the optical character recognition (OCR) problem.</li> </ul>
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4.	Social Impact / Customer Satisfaction	<ul style="list-style-type: none"> <li>There are many benefits associated with the handwriting recognition system. In addition to reading postal addresses and bank check amounts, it is also useful for reading forms. Furthermore, it's used in fraud detection because it makes it easy to compare two texts and determine which one is a copy. As a result, this system fulfills customers' expectations, as it is a novel method for recognizing handwritten digits, ensuring high accuracy for the model and meeting all customer expectations. Users will save a lot of time and effort if the system provides various synonyms for the words recognized. Due to the fact that the users in rural areas will be using their own regional language, this proposed system should be able to detect those digits as well. As the system is being used in socially crowded places such as banks to check amounts, it should be fast and reliable.</li> </ul>
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5.	Business Model (Revenue Model)	<ul style="list-style-type: none"> <li>The applications where these handwritten digit recognition can be used are Banking sector where it can be used to maintain the security pin numbers, it can be also used for blind peoples by using sound output.</li> <li>Some of the research areas include signature verification, bank check processing, postal address interpretation from envelopes etc.</li> </ul>
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6.	Scalability of the Solution	<ul style="list-style-type: none"> <li>One of the approaches to make the handwritten digit recognition system scalable is to make use of cloud-native methods. For example, one of the cloud solutions for making AI scalable is IBM Cloud. IBM Cloud Build helps run and manage AI models, optimize decisions at scale across any cloud. The advantage of using cloud to make solutions scalable is that we can deploy our AI application on the specific cloud environment that best supports our business needs. We can take advantage of built-in security capabilities and AI model monitoring. We can Automate AI lifecycles with ModelOps pipelines, deploy and run models through one-click integration and also prepare and build models visually and programmatically. Looking at these advantages, we can drive better business outcomes by optimizing our decisions and also make our solution scalable using cloud</li> </ul>
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### 3.4 Proposed Solution fit

#### 1. Import the libraries and load the dataset :

- First, we are going to import all the modules that we are going to need for training our model.
- The Keras library already contains some datasets and MNIST is one of them.
- So we can easily import the dataset and start working with it.

#### 2. Preprocess the data :

- The image data cannot be fed directly into the model so we need to **perform some operations and process the data** to make it ready for our neural network.

#### 3. Create the model :

- Now we will **create our CNN model** in Python data science project. A CNN model generally consists of convolutional and pooling layers.
- It works better for data that are represented as grid structures, this is the reason why CNN works well for image classification problems.
- The dropout layer is used to deactivate some of the neurons and while training, it reduces over fitting of the model. We will then compile the model with the Adadelta optimizer.

#### 4. Train the model :



□ The **model.fit()** function of Keras will start the training of the model. It **takes the training data, validation data, epochs, and batch size**. □ It takes some time to train the model.

## 5. Evaluate the model :

□ We have 10,000 images in our dataset which will be used to **evaluate how good our model works**. □ The testing data was not involved in the training of the data therefore, it is new data for our model.

□ The MNIST dataset is well balanced so we can get around 99% accuracy.

## 6. Create GUI to predict digits :

□ Now for the GUI, we have created a new file in which we **build an interactive window to draw digits on canvas** and with a button, we can recognize the digit.

□ The Tkinter library comes in the Python standard library. We have created a function **predict\_digit()** that takes the image as input and then uses the trained model to predict the digit.

□ Then we **create the App class** which is responsible for building the GUI for our app.

□ We create a canvas where we can draw by capturing the mouse event and with a button, we trigger the **predict\_digit()** function and display the results.

## 4. REQUIREMENT ANALYSIS

### 4.1 Functional requirement

Following are the functional requirements of the proposed solution

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	The product essentially converts handwritten digits to digital form.	The user is first asked to draw a number on the canvas, and the model that is built is then utilised to compare the data and provide an output in digitalized form.
FR-2	Recognizing the handwritten digit and displaying.	Recognizing the handwritten digit and displaying.
FR-3	Import dataset file directly to the program from a command that will download the dataset from its website. Save the dataset file in the same directory as the program	Installing packages and applications.
FR-4	Build a Neural Network with a number of nodes in the input layer equal to the number of pixels in the arrays	Nil
FR-5	Activating the Neural Network	Packages – tensorflow

## 4.2 Non Functional requirement

Following are the non functional requirements of the proposed solution

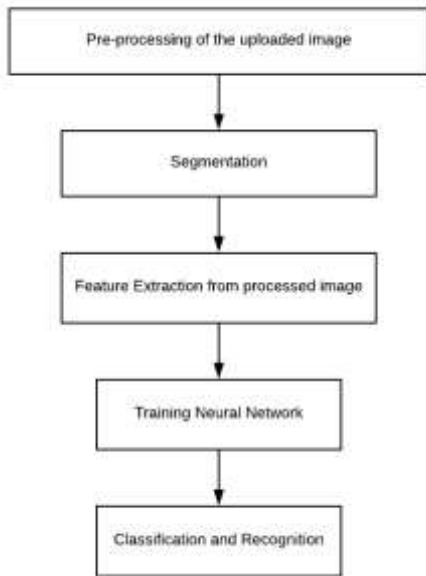
FR No.	Non-Functional Requirement	Description
NFR-1	Usability	System design should be easily understood and user friendly to users. Furthermore, users of all skill levels of users should be able to navigate it without problems.
NFR-2	Security	The system should automatically be able to authenticate all users with their unique username and password
NFR-3	Performance	Should reduce the delay in information when hundreds of requests are given.
NFR-4	Availability	Information is restricted to each users limited access
NFR-5	Scalability	the system should be able to handle 10000 users accessing the site at the same time

## 5. PROJECT DESIGN

### 5.1 Data Flow Diagrams Data

#### Flow Diagrams:

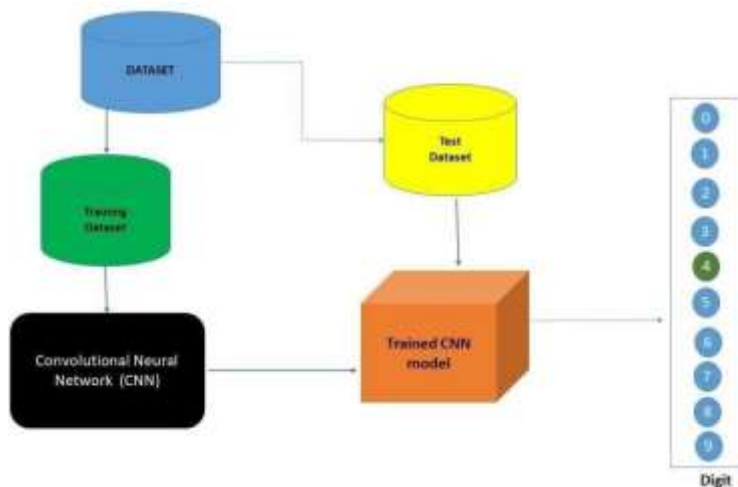
Data flow diagram of the proposed system model. There are two ways to provide input to the system. The user can either upload the image of the digit he wants to detect or the data from the MNIST dataset. The input images are pre-processed. Using the different classifiers the recognized digits' accuracy is compared and the result is obtained. The results obtained are displayed along with the accuracy.



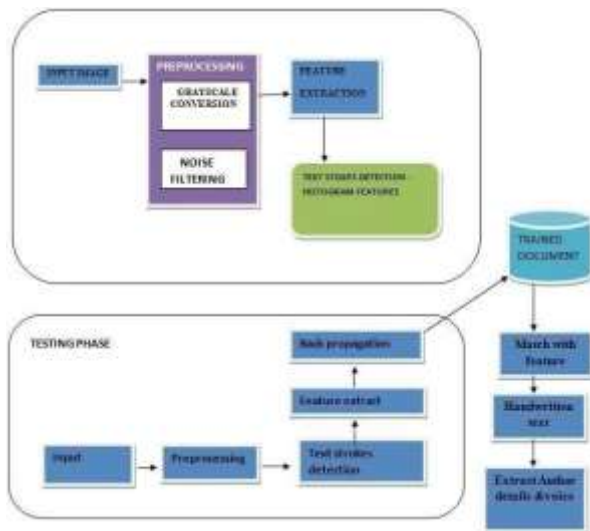
## 5.2 Solution & Technical Architecture

### Technical Architecture:

The architectural diagram of the model is as below and the Technology



Block Diagram



## 6. PROJECT PLANNING & SCHEDULING

### 6.1 Sprint Planning & Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Data Collection	USN-1	As a user, I can collect the dataset from various resources with different handwritings.	10	Low	ERRAPOTHU SNEHA
Sprint-1	Data Preprocessing	USN-2	As a user, I can load the dataset, handling the missing data, scaling and split data into train and test.	10	Medium	APPASAMUDRA M NAGA PRATHIBHA
Sprint-2	Model Building	USN-3	As a user, I will get an application with ML model which provides high accuracy of recognized handwritten digit.	5	High	DEGA SUTHANU
Sprint-2	Add CNN layers	USN-4	Creating the model and adding the input, hidden, and output layers to it.	5	High	DIVYA G

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-2	Compiling the model	USN-5	With both the training data defined and model defined, it's time to configure the learning process.	2	Medium	HARIHTA S
Sprint-2	Train & test the model	USN-6	As a user, let us train our model with our image dataset.	6	Medium	DIVYA G
Sprint-2	Save the model	USN-7	As a user, the model is saved & integrated with an android application or web application in order to predict something.	2	Low	HARITHA S
Sprint-3	Building UI Application	USN-8	As a user, I will upload the handwritten digit image to the application by clicking a upload button.	5	High	DEGA SUTHANU
Sprint-3		USN-9	As a user, I can know the details of the fundamental usage of the application.	5	Low	APPASAMUDRA M NAGA PRATHIBHA
Sprint-3		USN-10	As a user, I can see the predicted / recognized digits in the application.	5	Medium	HARITHA S
Sprint-4	Train the model on IBM	USN-11	As a user, I train the model on IBM and integrate flask/Django with scoring end point.	10	High	DIVYA G
Sprint-4	Cloud Deployment	USN-12	As a user, I can access the web application and make the use of the product from anywhere.	10	High	ERRAPOTHU SNEHA

## 6.2 Sprint Delivery Schedule

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

## 7. CODING & SOLUTIONING

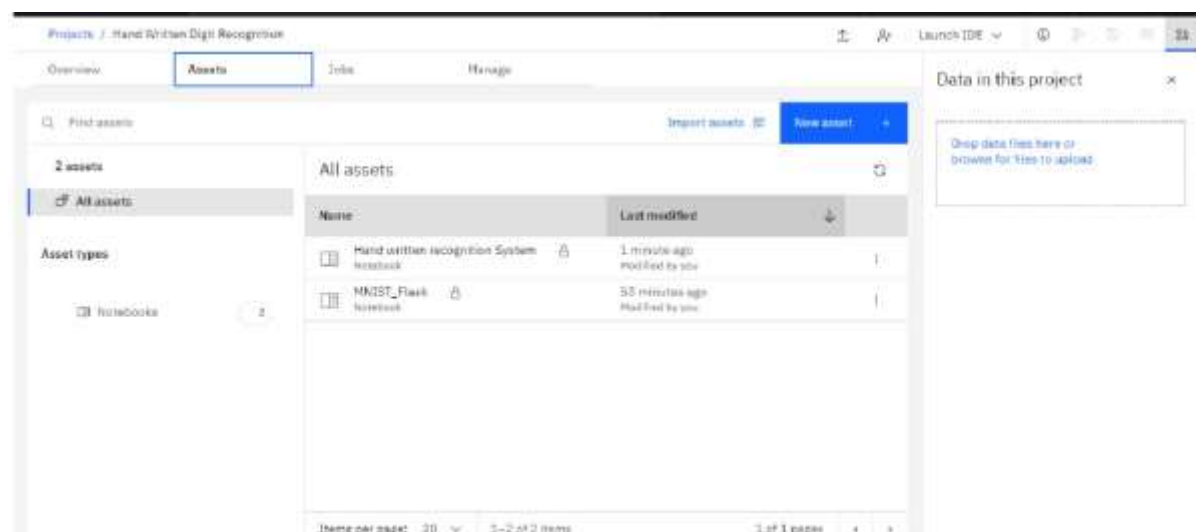
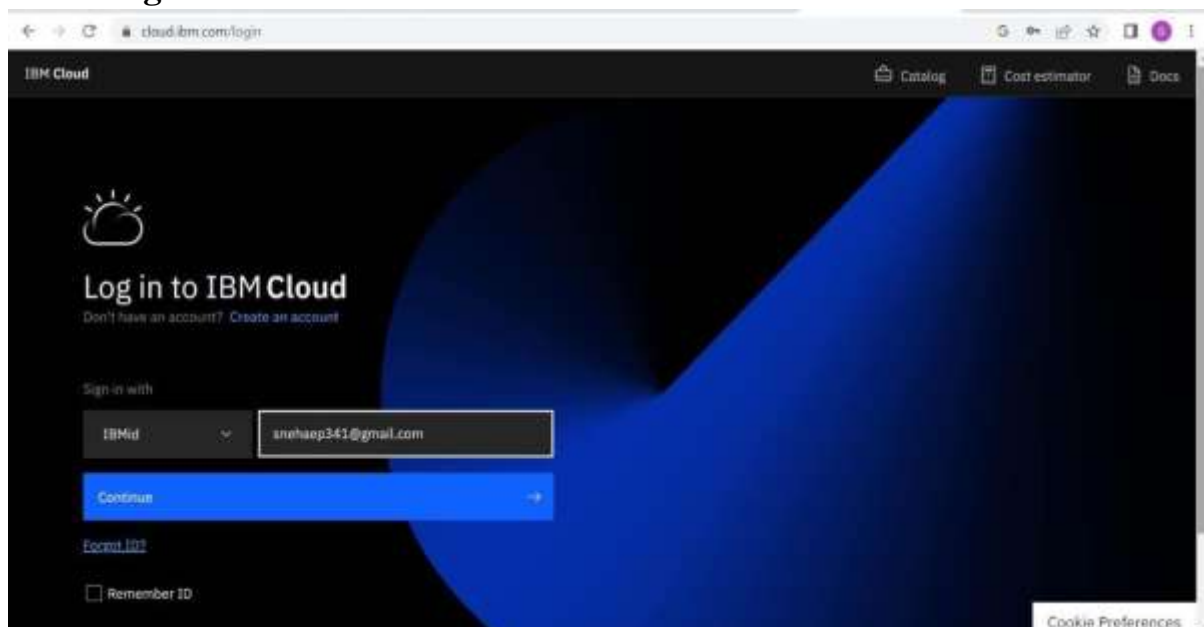
### 7.1 Feature 1

- ☐ IBM
- ☐ Python Cod
- ☐ HTML
- ☐ CSS
- ☐ JS

### 7.2 Feature 2

- ☐ Neural Networ
- ☐ Artificial Intelligence

## 8. Testing And Results



## Prediction



## 9. Advantages

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

## 10. Disadvantages

□ characters look very similar, making it hard for a computer to recognise accurately.

## 11. Conclusion

Using Neural Network system, back-propagation learning, to recognize handwritten digits was very successful. An image, which contained 100 samples of each number, was trained and tested.

## 12. Future Scope

The task of handwritten digit recognition, using a classifier, has great importance and use such as – online handwriting recognition on computer tablets, recognize zip codes on mail for postal mail sorting, processing bank check amounts, numeric entries in forms filled up by hand (for example - tax forms) and so on.

## 13. Appendix

### 13.1 Source Code HTML

```
<!DOCTYPE html>
```

```
<html lang="en">
```



```
<head>

  <meta charset="UTF-8">

  <meta http-equiv="X-UA-Compatible" content="IE=edge">

  <meta name="viewport" content="width=device-width, initial-scale=1.0">

  <title>Handwritten Recognition System</title>

  <link rel="stylesheet" href="style.css">

</head>
```

```
<body>

  <header class="header">

    <nav class="navbar">

      <ul>

        <li>

          <a href="#">Home</a>

        </li>

        <li>

          <a href="recognize.html">Recognize</a>

        </li>

      </ul>

    </nav>

  </header>
```

```
<div class="bg-pic"></div>
```

```
<main class="main">

  <h1 class="main-heading">Handwritten Recognition System</h1>

  <p class="content">

    <em>
```

Handwritten Text Recognition is a technology that is much needed in this world as of today. This digit

Recognition system is used to recognize the digits from different sources like emails, bank cheque,

papers, images, etc. Before proper implementation of this technology we have relied on writing texts

with our own hands which can result in errors. It's difficult to store and access physical data with

efficiency. The project presents recognizing the handwritten digits (0 to 9) from the famous MNIST

dataset. Here we will be using artificial neural networks convolution neural network.

</em>

</p>

</main>

</body>

</html>

**13.2 GitHub** <https://github.com/IBM-EPBL/IBM-Project-37412-1660307401.git>