“HANDWRITTEN DIGIT RECOGNITATION”

Submitted by:

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Year-2022 -2023

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CERTIFICATE

This is to certify that the project entitled **"HANDWRITTEN DIGIT RECOGNITATION"** has been carried out by Prasad Bhasme under my guidance in partial fulfilment of the degree of Bachelor of Technology in Data Science, G.H. Raisoni Institute of Engineering and Business Management, Jalgaon of Kavayitri Bahinabai Chaudhari North Maharashtra University, during the academic year 2022-2023. To the best of my knowledge and belief this work has not been submitted elsewhere for the award of any other degree.

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GUIDE

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HOD

ACKNOWLEDGEMENT

We would take the opportunity to thank **Dr. Preeti Agrawal** Director of G. H. Raisoni Institute of Engineering and Business Management, Jalgaon for her support, extended to me throughout the course. We would also like to thank **Dr. Pranav Charkha** Dean of, G.H. Raisoni Institute of Engineering and Business Management, Jalgaon for his valuable guidance and support. We would like to thank **Mr. Promodgiri Gosavi** HOD, G.H. Raisoni Institute of Engineering and Business Management, Jalgaon, for her scholarly disposition, timely guidance, support and cooperation. We would like to thank **Mrs. Swati Patil** for her kind guidance, keen interest, continuous encouragement and inspiration throughout the project work. Finally, we gratefully thank all the faculty members of G. H. Raisoni Institute of Engineering and Business Management, Jalgaon for their cooperation and support. We also thankful to get constant encouragement, support and guidance from all Teaching and Non-Teaching Staff for their timely support which helped us in successfully completion of our project work.

- **Prasad Bhasme (212DS003)**

CONTENT

ABSTRACT

One of the most practical difficulties in pattern recognition applications is handwritten digit recognition. Digit recognition is used in postal mail sorting, bank check processing, form data entry, and other applications. The capacity to design an efficient algorithm that can recognize handwritten digits and which is submitted by users via scanner, tablet, and other digital devices is at the heart of the problem. Handwritten digit recognition is already widely employed in the automated processing of bank checks, postal addresses, and other types of information. Some of the existing systems use computational intelligence techniques like artificial neural networks or fuzzy logic, while others may simply be massive lookup databases containing possible handwritten digit recognition. Since the 1940s, artificial neural networks have been constructed. We aim to complete this by using CNN and MNIST data set.

Index Terms **–** MNIST Data set, CNN, Computational Intelligence.

CHAPTER 1 - INTRODUCTION

Approval is the identification or distinction of an object or individual from past experience or learning. Similarly, recognizing numbers is nothing more than recognizing or identifying numbers in a document. The number recognition framework is just a task for the machine to prepare itself and interpret the numbers. Handwritten digit recognition interprets manually written numbers from various sources such as messages, bank checks, documents, photos, etc., and in various situations for web-based handwriting recognition on PC tablets, of vehicles. This is a computer function that identifies the license plate. Processes bank checks, numbers entered in any format, etc. Machine learning offers a variety of ways that can reduce the human effort of recognizing manually written numbers. Deep learning is a machine learning method that trains computers to do what humans can easily do. Learn with an example. Deep learning techniques can reduce human attempts in perception, learning, cognition, and many other areas. Using deep learning, computers learn to perform classification tasks using images or the content of any document. Deep learning models can achieve cutting-edge accuracy that goes beyond human performance. The number recognition model uses large datasets to recognize numbers from different sources.

Handwritten digit recognition using MNIST dataset is a major project made with the help of Neural Network. It basically detects the scanned images of handwritten digits.We have taken this a step further where our handwritten digit recognition system not only detects scanned images of handwritten digits but also allows writing digits on the screen with the help of an integrated GUI for recognition

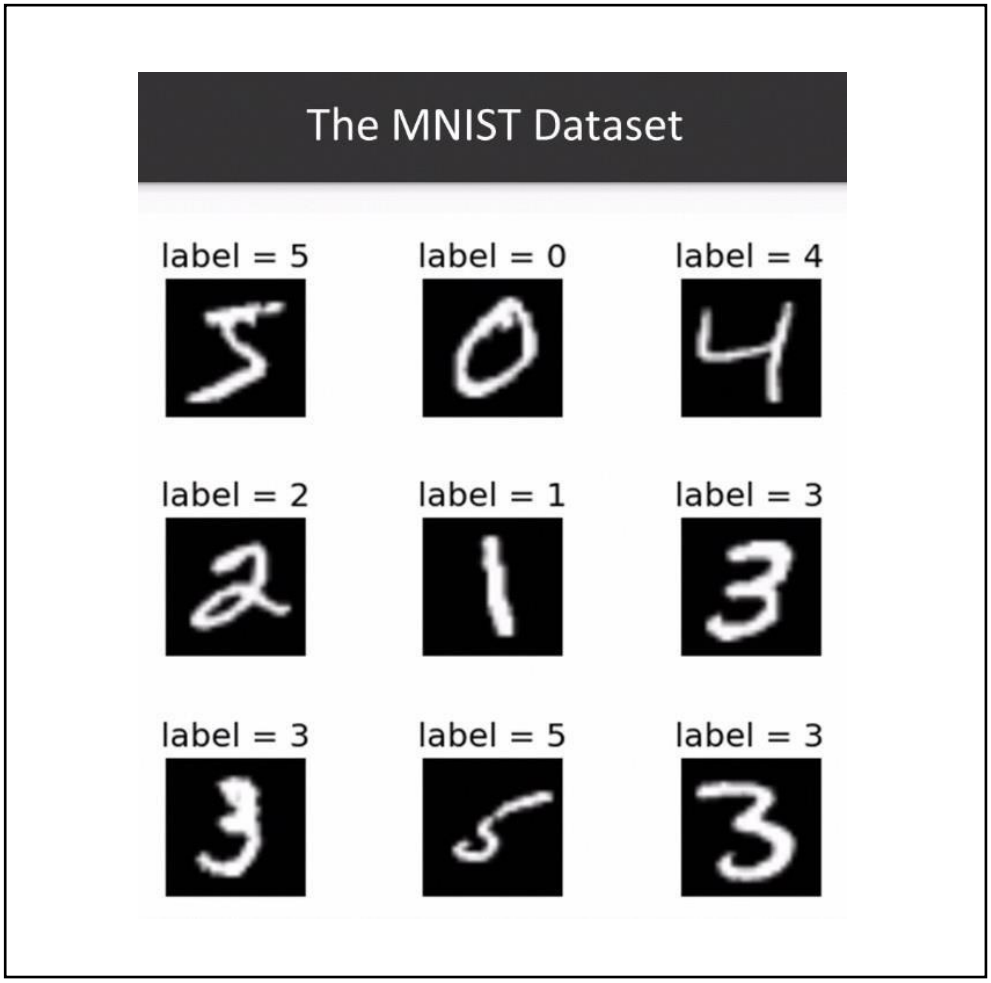

Fig 1.1 MNIST Dataset

The MNIST dataset is an acronym that stands for the Modified National Institute of Standards and Technology dataset. It is a dataset of 60,000 small square 28×28 pixel grayscale images of handwritten single digits between 0 and 9.

The MNIST database contains 60,000 training images and 10,000 testing images.[8] Half of the training set and half of the test set were taken from NIST's training dataset, while the other half of the training set and the other half of the test set were taken from NIST's testing dataset.The original creators of the database keep a list of some of the methods tested on it.In their original paper, they use a support-vector machine to get an error rate of 0.8%.

The term "Artificial Neural Network" is derived from Biological neural networks that develop the structure of a human brain. Similar to the human brain that has neurons interconnected to one another, artificial neural networks also have neurons that are interconnected to one another in various layers of the networks. These neurons are known as nodes.

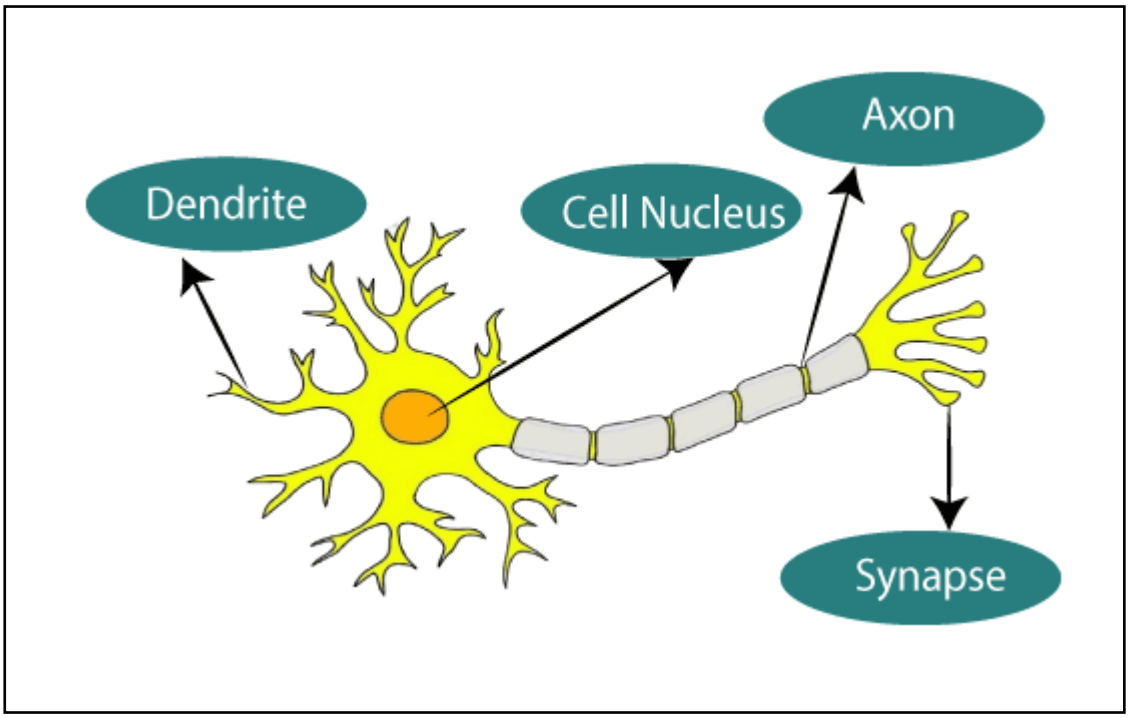

Fig 1.2 Biological Neural Network

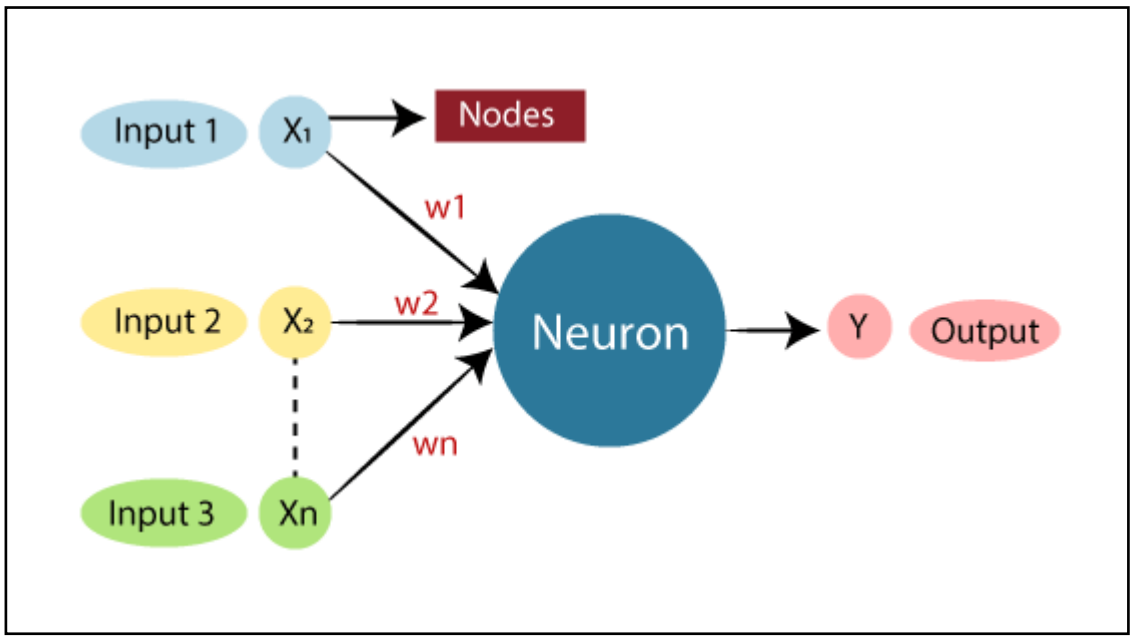

Fig 1.3 Artificial Neural Network

An Artificial Neural Network in the field of Artificial intelligence where it attempts to mimic the network of neurons makes up a human brain so that computers will have an option to understand things and make decisions in a human-like manner. The artificial neural network is designed by programming computers to behave simply like interconnected brain cells.

There are around 1000 billion neurons in the human brain. Each neuron has an association point somewhere in the range of 1,000 and 100,000. In the human brain, data is stored in such a manner as to be distributed, and we can extract more than one piece of this data when necessary from our memory parallelly. We can say that the human brain is made up of incredibly amazing parallel processors.

We can understand the artificial neural network with an example, consider an example of a digital logic gate that takes an input and gives an output. "OR" gate, which takes two inputs. If one or both the inputs are "On," then we get "On" in output. If both the inputs are "Off," then we get "Off" in output. Here the output depends upon input. Our brain does not perform the same task. The outputs to

inputs relationship keep changing because of the neurons in our brain, which are "learning."

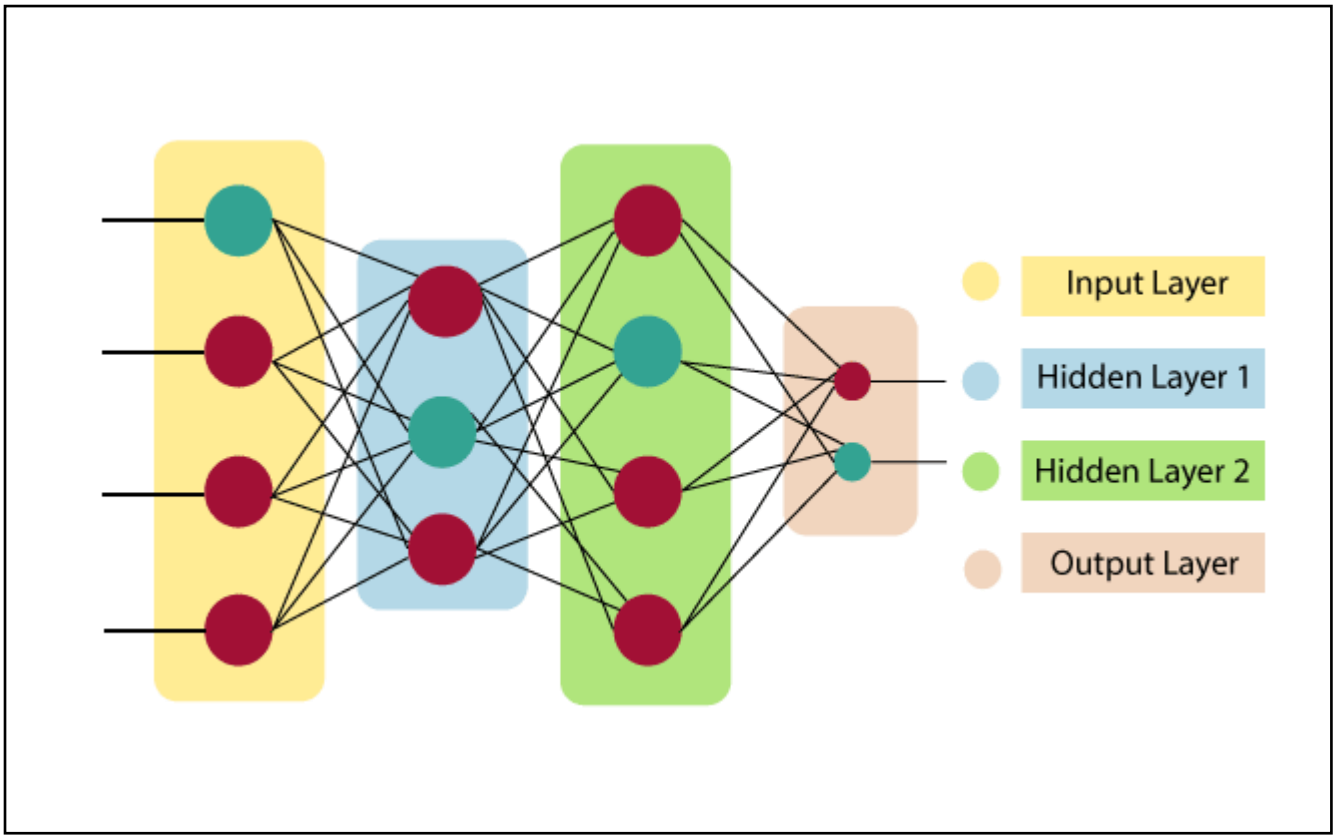

Fig 1.4 Architecture of ANN

To understand the concept of the architecture of an artificial neural network, we have to understand what a neural network consists of. In order to define a neural network that consists of a large number of artificial neurons, which are termed units arranged in a sequence of layers. Lets us look at various types of layers available in an artificial neural network.

1.Input Layer:

As the name suggests, it accepts inputs in several different formats provided by the programmer.

2.Hidden Layer:

The hidden layer presents in-between input and output layers. It performs all the calculations to find hidden features and patterns.

3.Output Layer:

The input goes through a series of transformations using the hidden layer, which finally results in output that is conveyed using this layer.The artificial neural network takes input and computes the weighted sum of the inputs and includes a bias. This computation is represented in the form of a transfer function.

$$\sum_{i=1}^{n} Wi * Xi + b$$

It determines weighted total is passed as an input to an activation function to produce the output. Activation functions choose whether a node should fire or not. Only those who are fired make it to the output layer. There are distinctive activation functions available that can be applied upon the sort of task we are performing.

CHAPTER 2 - LITRATURE REVIEW

In the paper, “Handwritten Digit Recognition Using ANN” the authors, “Prasad Bhasme, Disha Harhare, Samiksha Dube” have compared the results of some of the most widely used Machine Learning Algorithms like KNN & RFC and with Deep Learning algorithm like multilayer CNN using Keras with Theano and TensorFlow. Using these, they were able to get the accuracy of 98.70% using CNN (Keras+Theano) as compared to 97.91% using SVM, 96.67% using KNN, 96.89% using RFC.

The authors of the paper,” Handwritten Digit Recognition: Applications of Neural Network Chips and Automatic Learning”, had applied neural network methods to a large, real-world task. Our results appear to be the state of the art in digit recognition. We demonstrated that a general-purpose neural network chip can be incorporated as an accelerator in a large network. They found that real problems with regularity scale well. They also showed that a network can be trained on a low-level representation of data that has minimal pre-processing.

In the paper, “Handwritten Digit Recognition using ANN and Python” the authors, “Prasad Bhasme, Disha Harhare, Samiksha Dube” presented a simple profile, combined local & global features and majority voting scheme classifier for unconstrained handwritten numeral recognition. Linear discriminant analysis and KNN classifiers are used for classifying these features. A majority voting scheme has been performed with three neural network classifiers and KNN classifiers. The performance is tested on MNIST dataset. The network was trained on 60,000 and tested on 10,000 numeral samples of which 98.05 % test samples are correctly recognized.

The authors,” Prasad Bhasme, Disha Harhare, Samiksha Dube” of Handwritten Digit Recognition by Neural Networks with Single-Layer Training” had introduced the STEPNET procedure, which decomposes the handwritten digit

recognition problem into simpler subproblems that can be solved by linear separators. They presented results from two different databases: a European database comprising 8700 isolated digits, and a zip code database from the U.S. Postal Service comprising 9000 segmented digits.

CHAPTER 3 - METHODOLOGY

3.1 Existing Methodology

Existing System in Place Images are being used by an increasing number of people to communicate data these days. Separating vital data from images is also a major stream function. For its widely utilized applications, image recognition is a critical study topic. One of the most difficult tasks in the realm of pattern recognition is the precise digital recognition of human handwriting. Without a doubt, this is a challenging problem to solve because handwriting differs significantly from one person to the next. Nonetheless, teaching computers to interpret common handwriting is becoming increasingly difficult. It is critical to understand how information is portrayed onto images when dealing with image recognition issues, such as handwritten classification.

3.2 Proposed Methodology

Using shallow networks, handwriting recognition has already achieved excellent results. Many research articles have been published that reveal novel strategies for classifying handwritten digits, characters, and words. The convolutional neural network has revolutionised the field of handwriting recognition, delivering state-of-the-art results in this area. In handwritten DIGIT Recognition, CNN has demonstrated outstanding ability.

The performance of CNNs is largely determined by the hyper-parameters chosen, which are normally determined through trial and error. Activation function, number of epochs, kernel size, learning rate, hidden units, hidden layers, and so on are some of the hyper-parameters. These variables are crucial because they influence how an algorithm learns from data. Hyper-parameters are distinct from model parameters and must be determined prior to the start of training.

CHAPTER 4 - ANALYSIS

4.1 Functional Requirement Specifications

The System after careful analysis has been identified to be present with the following modules.

1. Data Set Collection
2. Data Augmentation
3. Preparing the Model
4. Training the Model
5. Model Evaluation

4.2 Performance Requirements

The output supplied by the application is used to assess performance. The specification of requirements is crucial in the study of a system. It is only possible to develop a system that will fit into the appropriate environment if the requisite specifications are properly supplied. Because they are the ones who will use the system in the end, it is mostly up to the users of the existing system to provide the requirement specifications. This is because the requirements must be known during the early stages of the project so that the system can be designed to meet them. It is extremely difficult to update a system once it has been designed, and building a system that does not meet the needs of the user is even more difficult.

4.3 System Requirements

The requirement specification for any system can be broadly stated as given below:

Software Requirements:

Operating System: Microsoft Windows/Mac-Os/linux

Web browser: Google Chrome (Google Colab)

Python Ide: Jupyter notebook

Hardware Requirements:

Processor: intel 5 ***RAM***: 4

CHAPTER 5 - DESIGN

5.1 System Architecture

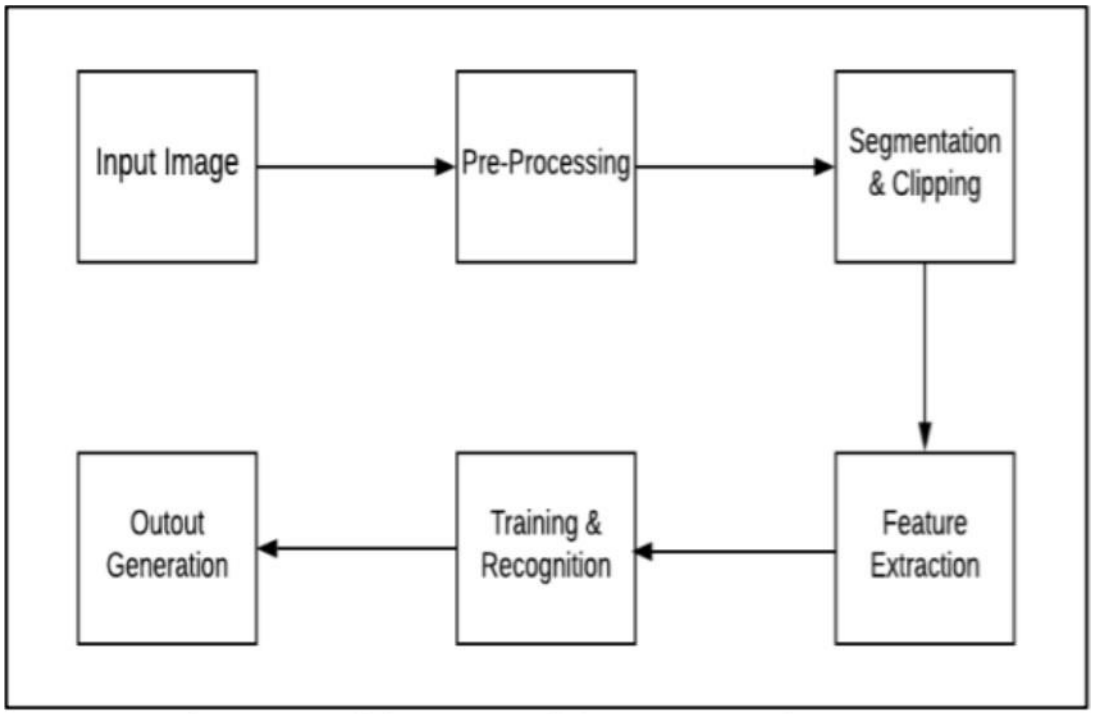

Fig 5.1 System Architecture

Step 1: Give the image/Draw the image i.e. Input Image

Step 2: Then GUI will Pre-process the input image

Step 3: GUI will further do the process of Segmentation & Clipping

Step 4: Using ANN Feature Extraction will take place

Step 5: Using ML algorithm GUI will train the model & also recognize the image.

Step 6: At the end GUI will generates the Output.

5.2 Dataflow Diagram

The proposed system model's data flow diagram is depicted in the diagram below:

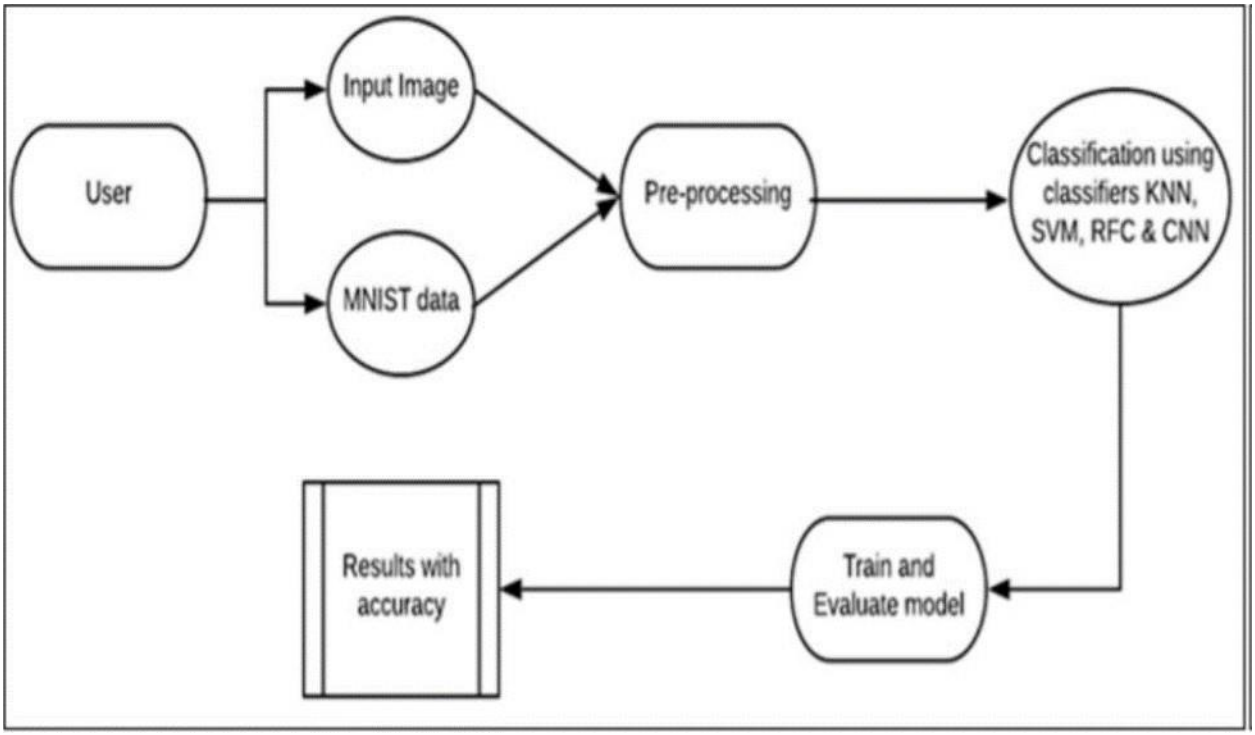

Fig 5.2 DataFlow Diagram

5.3 UML Diagram

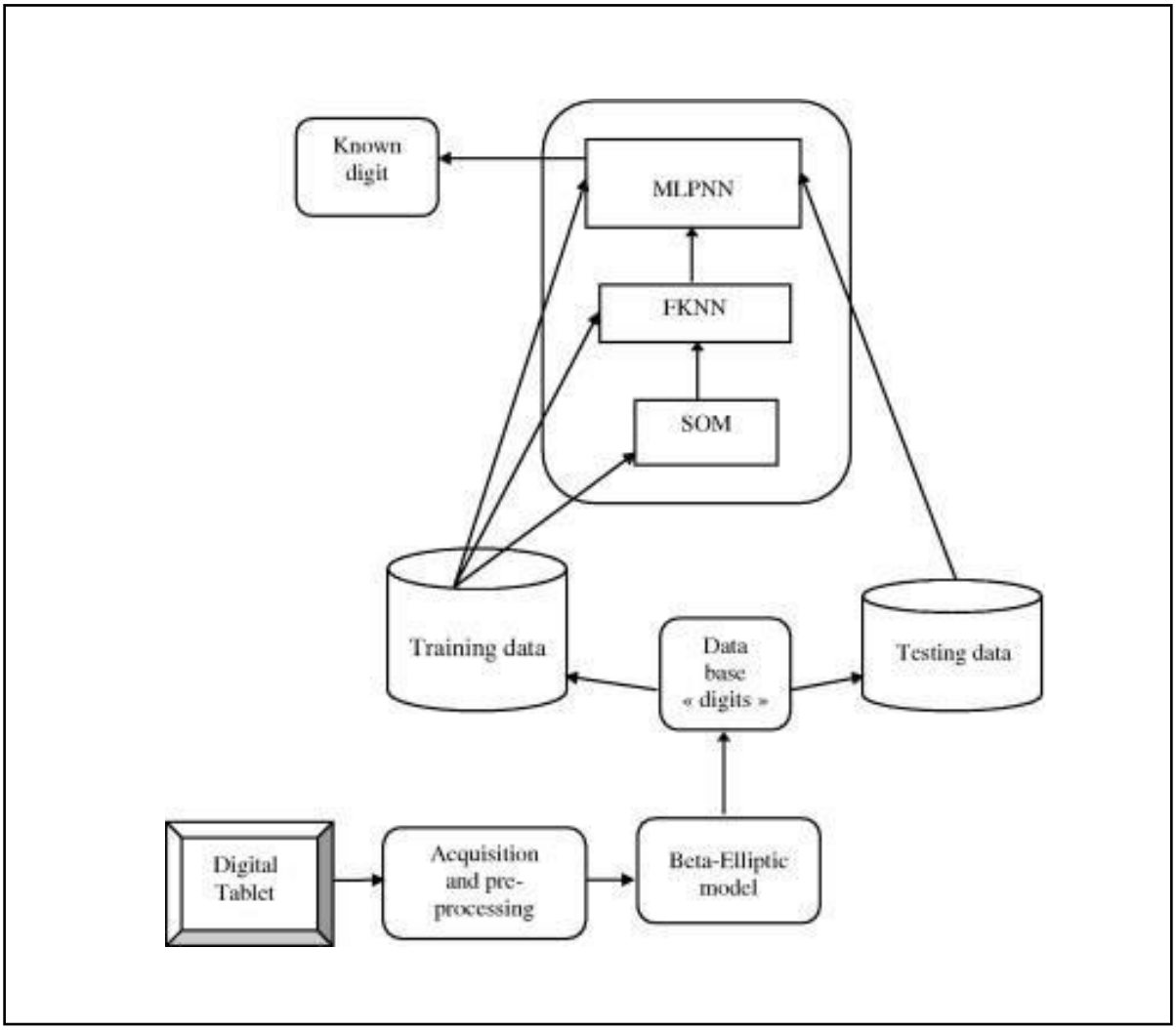

Fig 5.3 UML Diagram

5.4 Use Case Diagram

Use case diagram is basically capture the behaviour of analysis and helps to understand which person do which tasks and how tasks are related to each other.

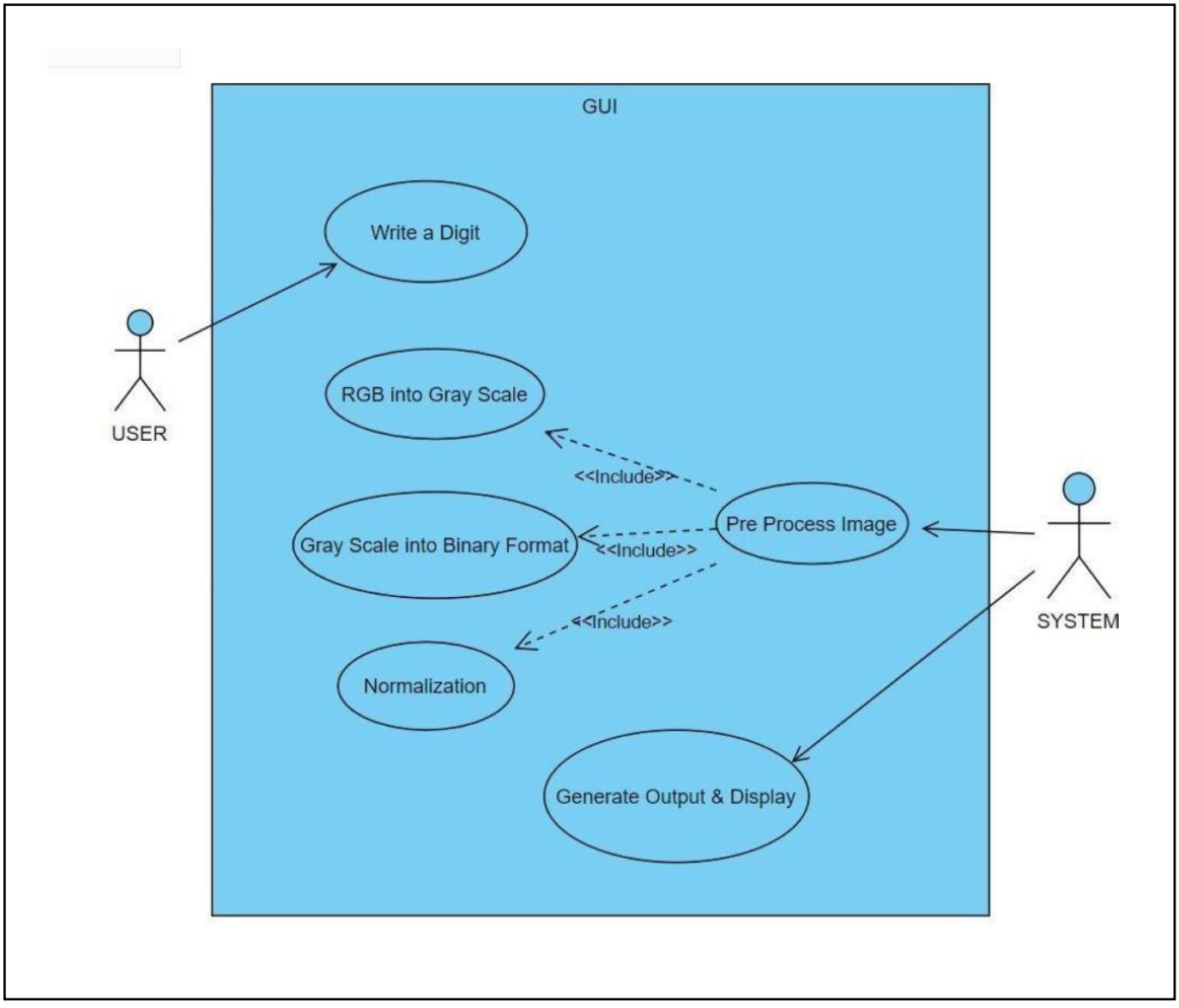

Fig 5.4 Use Case Diagram

5.5 Class Diagram

Class diagram is a static diagram. It depicts an application's static view. A class diagram is used not only for visualising, describing, and documenting many parts of a system, but also for creating executable code for a software program.

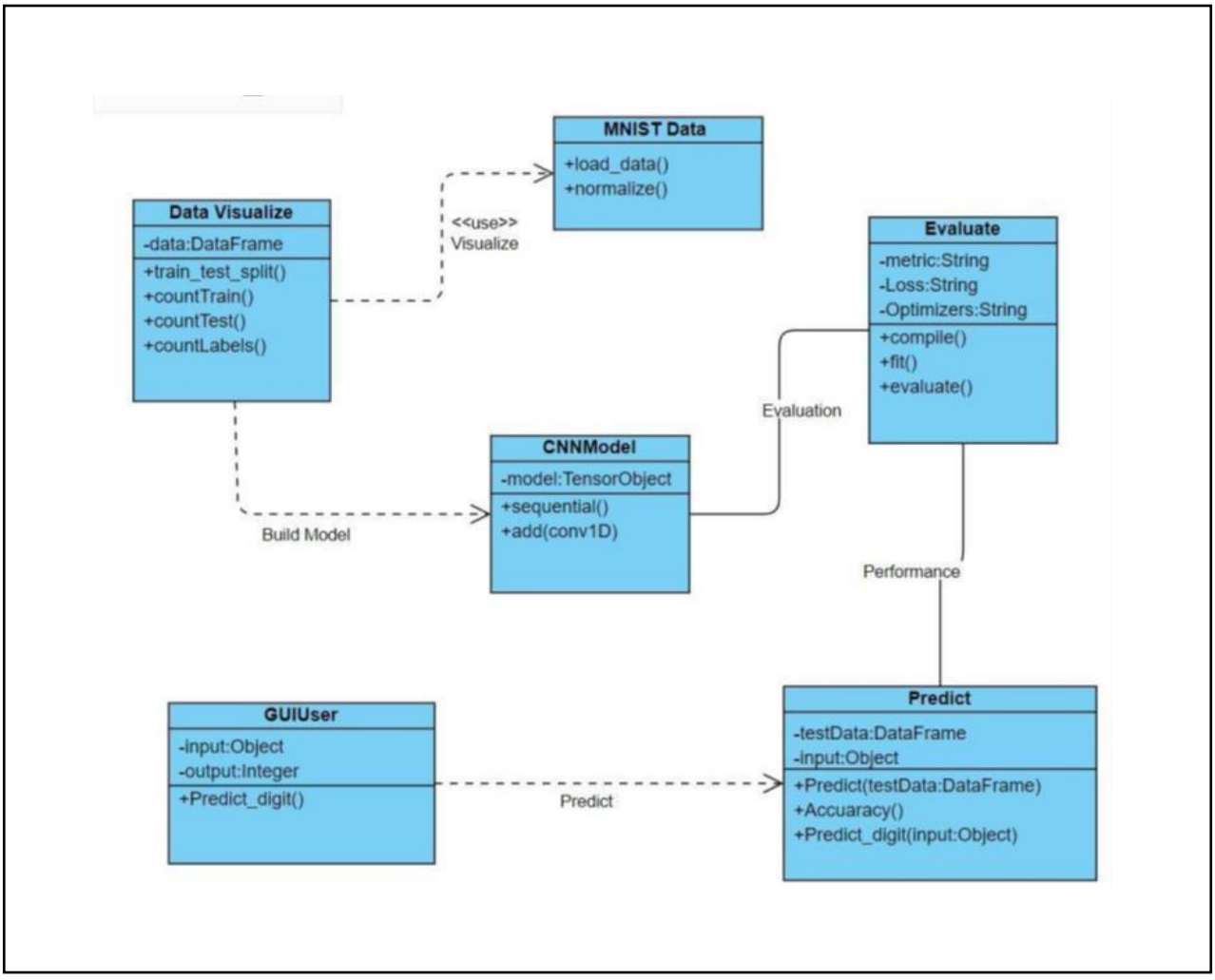

Fig 5.5 Class Diagram

5.6 Activity Diagram

An activity diagram is essentially a flowchart that depicts the movement of information from one action to the next.

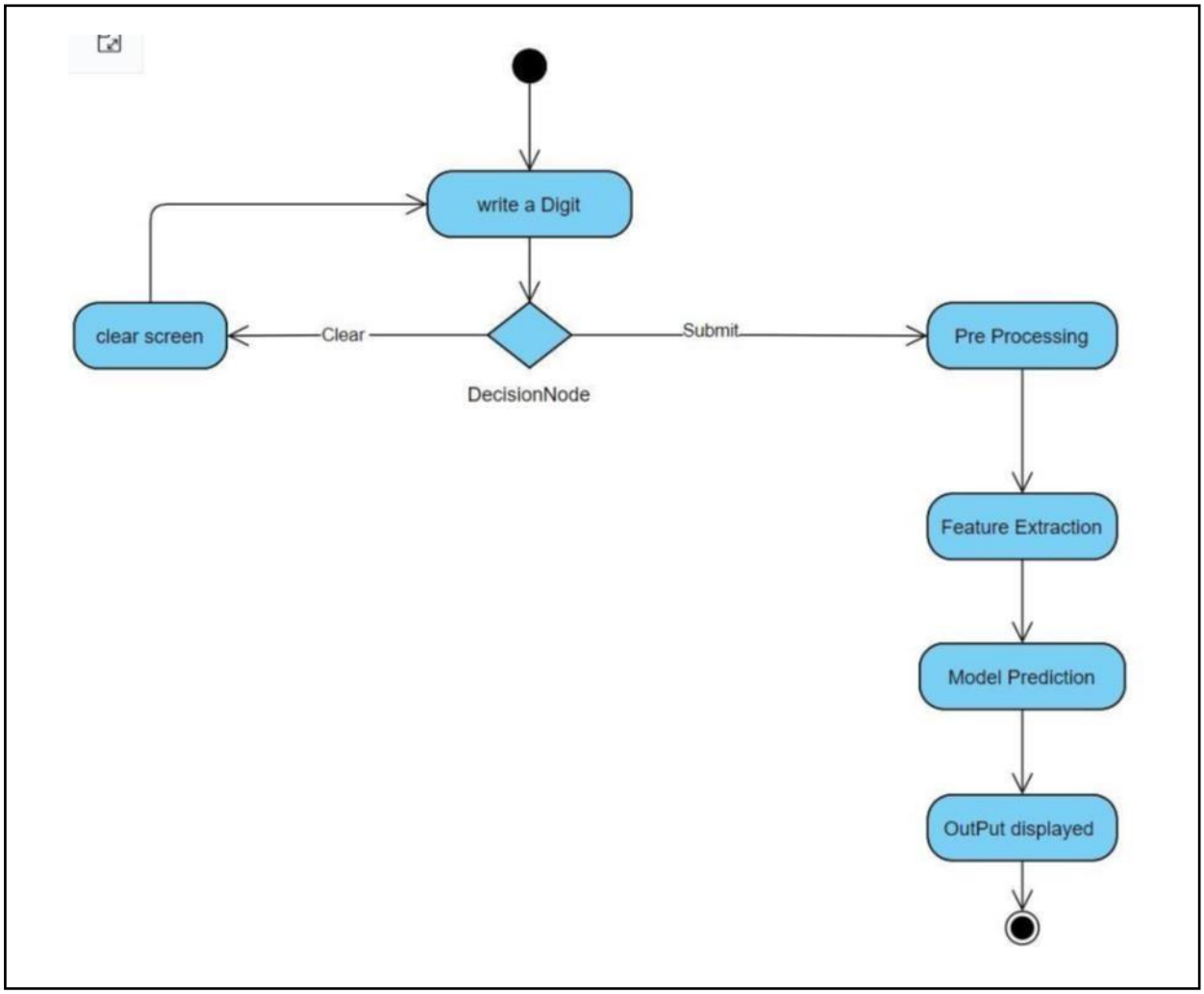

Fig 5.6 Activity Diagram

5.7 Sequence Diagram

A sequence diagram is a type of interaction diagram because it describes how and in what order a group of objects works together.

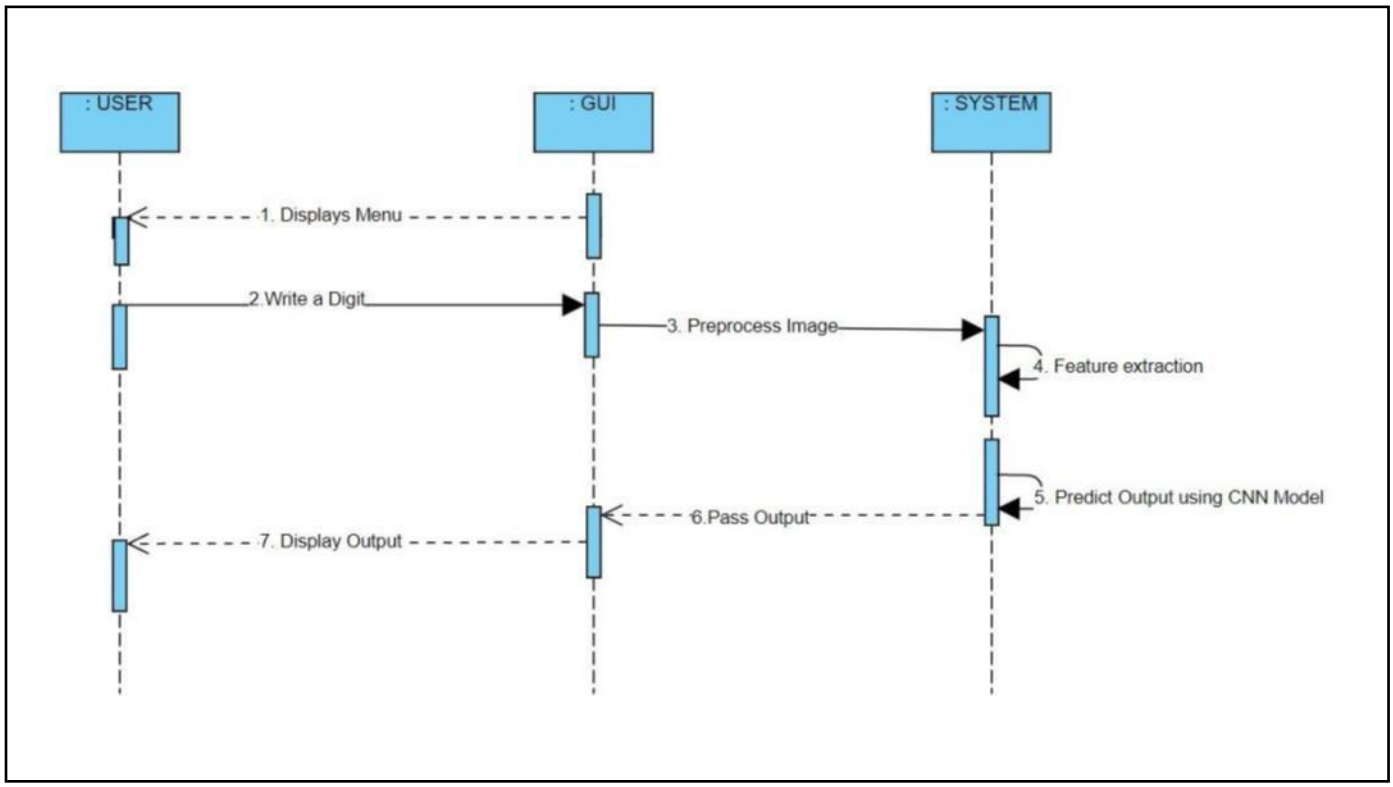

Fig 5.7 Sequence Diagram

CHAPTER 6 - IMPLEMENTATION

6.1 System Implementation

Any project's implementation stage is a true representation of the defining moments that determine whether a project succeeds or fails. The system or system modifications are installed and made operational in a production environment during the implementation stage. After the system has been tested and accepted by the user, the phase begins. This phase continues until the system meets the established user requirements and is ready to go into production.

6.2 Output Screens

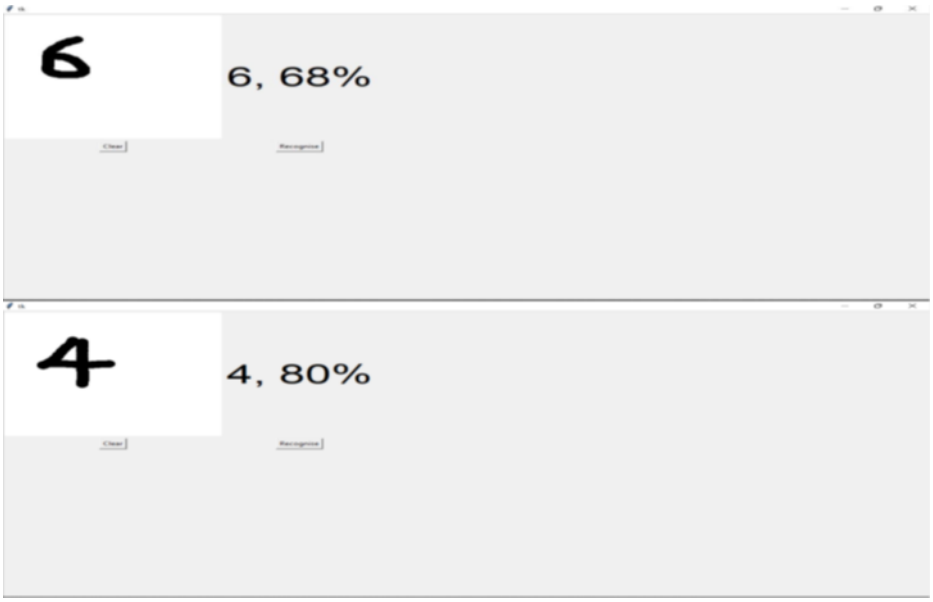

Fig 6.2 Output screens

CHAPTER 7 - SCOPE

Hand writing recognition of characters has been around since the 1980s Handwritten digit recognition using a classifier is important and useful in a variety of applications, including online handwriting recognition on computer tablets, recognizing zip codes on mail for postal mail sorting, processing bank check amounts, numeric entries in handwritten forms (such as tax forms), and so on. When attempting to address this problem, there are a variety of obstacles to overcome. The size, thickness, orientation, and position of the handwritten numbers in relation to the margins are not always consistent. Our goal was to use a pattern classification approach to recognize the handwritten digits in the MINIST data set of images of handwritten digits (09) by using a pattern classification method. The data set for our application is a subset of the MNIST data set [1] and consists of 300 training and 300 testing images (originally composed of 60,000 training images and 10,000 testing images).

Each image is a labelled 28 by 28 grayscale (0255) representation of a single number. The resemblance between digits such as 1 and 7, 5 and 6, 3 and 8, 9 and 8, and so on was the general challenge we thought we would meet in this digit categorization problem. Also, the same digit can be written in a variety of ways; for example, the digit '1' can be written as '1', '1', '1', or '1'. Similarly, the number seven might be written as seven, seven, or seven. Finally, the originality and variety of different people's handwriting has an impact on the construction and look of the digits.

CHAPTER 8 - CONCLUSION

The effectiveness of handwritten digit recognition using a convolutional neural network has been demonstrated to be quite high. It outperforms all other algorithms, even artificial neural networks.

We show a model that can recognise handwritten digits in this video. It can later be expanded to include character recognition and real-time handwriting analysis. The recognition of handwritten digits is the initial step toward the wide field of Artificial Intelligence and Computer Vision.

As may be observed from the outcomes of the experiment, CNN outperforms other classifiers. With more convolution layers and buried neurons, the findings can be made more precise. It has the potential to fully eliminate the necessity for typing. The problem of digit recognition is a good model for learning about neural networks.

It also provides an excellent platform for the development of more advanced deep learning algorithms. We intend to develop a real-time handwritten digit recognition system in the future.

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