**RMK ENGINEERING COLLEGE**

**(An Autonomous Institution)**

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# PROJECT

# A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION SYSTEM

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# INTRODUCTION

## 1.1 PROJECT OVERVIEW

Machine learning and deep learning plays an important role in computer technology and artificial intelligence. With the use of deep learning and machine learning, human effort can be reduced in recognizing, learning, predictions and many more areas. This article presents recognizing the handwritten digits (0 to 9) from the famous MNIST dataset, comparing classifiers like KNN, PSVM, NN and convolution neural network on basis of performance, accuracy, time, sensitivity, positive productivity, and specificity with using different parameters with the classifiers. To make machines more intelligent, the developers are diving into machine learning and deep learning techniques. A human learns to perform a task by practicing and repeating it again and again so that it memorizes how to perform the tasks. Then the neurons in his brain automatically trigger and they can quickly perform the task they have lea rned. Deep learning is also very similar to this. It uses different types of neural network architectures for different types of problems For example object recognition, image and sound classification, object detection, image segmentation, etc. The handwritten digit recognition is the ability of computers to recognize human handwritten digits. It is a hard task for the machine because handwritten digits are not perfect and can be made with many different flavours. The handwritten digit recognition is the solution to this problem which uses the image of a digit andrecognizes the digit present in the image.

## 1.2 PURPOSE

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 realworld scenarios for online handwriting recognition on computer tablets or system, recognize number plates of, numeric entries in forms filled up by hand and soon. Handwritten character recognition is one of the practically important issues in pattern recognition applications. The main purpose of this project is to build an automatic handwritten digit recognition method for the recognition of handwritten digit string s. To accomplish the recognition task, first, the digits will be segmented into individual digits. Then, a digit recognition module is employed to classify each segmented digit completing the handwritten digit string recognition task. The applications of digit recognition include postal mail sorting, bank check processing, form data entry, etc.

Theheart of the problem lies within the ability to develop an efficient algorithm that ca recognizehand written digits and which is submitted by users by the way of a scanner

# 2.literature survey

## EXISTING PROBLEM

Hand writing recognition of characters has been around since the 1980s.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 soon. There are different challenges faced while attempt to solve problem. The handwritten digits are not always of the same size, thickness, or orientation and position relative to the margins. Our goal was to implement a pattern classification method to recognize the handwritten digits provided in the MINIST data set of images of hand written digits (0 to 9).

The data set used for our application is composed of 300 training images and 300 testing images, and is a subset of the MNIST data set. Handwriting digits and character recognitions have become increasingly important in today's digitized world due to their practical applications in various day to day activities. It can be proven by the fact that in recent years, different recognition systems have been developed or proposed to be used in different fields where high classification efficiency is needed. Systems that are used to recognize Handwriting letters, characters, and digits help people to solve more complex tasks that otherwise would be time consuming and costly. A good example is the use of automatic processing systems used in banks to process bank cheques. Without automated bank cheque processing systems, the bank would be required to employ many employees who may not be as efficient as the computerized processing system.

## 2.1 REFERENCES

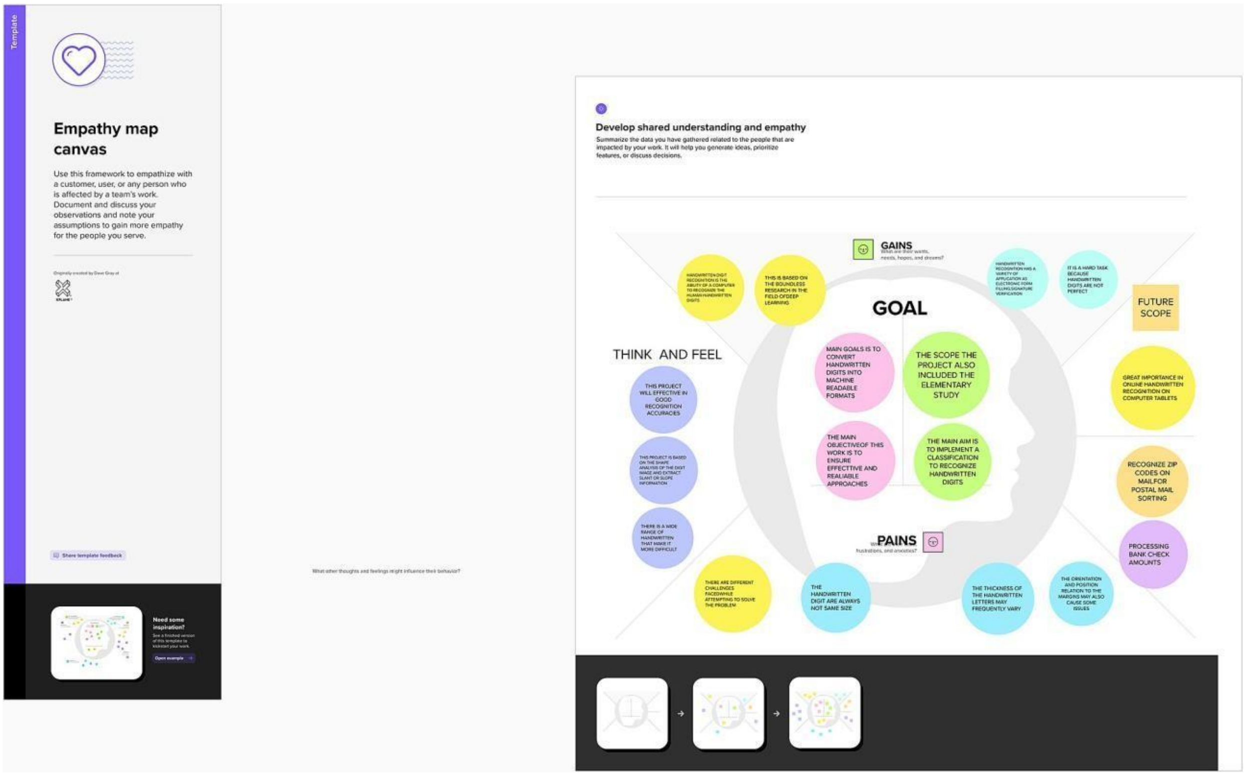
1. K. Gaurav, Bhatia P. K. , his paper deals with the various preprocessing techniques involved in the character recognition with different kind of images ranges from a simple handwritten form based documents an d documents containing colored and complex background and varied intensities .In this, different preprocessin techniques like skew detection and correction, image enhancement techniques of contrast stretching, binarization, noise removal techniques, normalization and segmentation, morphological processing techniques are discussed.

## 2.2 problem statement definition

The goal of this project is to create a model that will be able to recognize and determine the handwritten digits from its image by using the concepts of Convolution Neural Network. Though the goal is to create a model which can recognize the digits, it can be extended to letters and an individual’s handwriting. The major goal of the proposed system is understanding Convolutional Neural Network, and applying it to the handwritten recognition system.

# IDEATION & PROPOSED SOLUTION

## 3.1 EMPATHY MAP CANVAS



**Empathy map canvas**

Use this framework to empathize with a customer, user, or any person who is affected by a team's work. Document and discuss your observations and note your assumptions to gain more empathy for the people you serve.

Originally created by Dave Gray at XPLANE

**Need some inspiration?**

See a finished version of this template to kickstart your work.

What other thoughts and feelings might influence their behavior?

**Develop shared understanding and empathy**

Summarize the data you have gathered related to the people that are impacted by your work. It will help you generate ideas, prioritize features, or discuss decisions.

GAINS

What are their wants, needs, hopes, and dreams?

HANDWRITTEN DIGIT RECOGNITION IS THE ABILITY OF A COMPUTER TO RECOGNIZE THE HUMAN HANDWRITTEN DIGITS

THIS IS BASED ON THE BOUNDLESS RESEARCH IN THE FIELD OFDEEP LEARNING

HANDWRITTEN RECOGNITION HAS A VARIETY OF APPLICATION AS ELECTRONIC FORM FILLING,SIGNATURE VERIFICATION

IT IS A HARD TASK BECAUSE HANDWRITTEN DIGITS ARE NOT PERFECT

GOAL

MAIN GOALS IS TO CONVERT HANDWRITTEN DIGITS INTO MACHINE READABLE FORMATS

THE SCOPE THE PROJECT ALSO INCLUDED THE ELEMENTARY STUDY

THE MAIN OBJECTIVEOF THIS WORK IS TO ENSURE EFFECTTIVE AND REALIABLE APPROACHES

THE MAIN AIM IS TO IMPLEMENT A CLASSIFICATION TO RECOGNIZE HANDWRITTEN DIGITS

THINK AND FEEL

THIS PROJECT WILL EFFECTIVE IN GOOD RECOGNITION ACCURACIES

THIS PROJECT IS BASED ON THE SHAPE ANALYSIS OF THE DIGIT IMAGE AND EXTRACT SLANT OR SLOPE INFORMATION

THERE IS A WIDE RANGE OF HANDWRITTEN THAT MAKE IT MORE DIFFICULT

FUTURE SCOPE

GREAT IMPORTANCE IN ONLINE HANDWRITTEN RECOGNITION ON COMPUTER TABLETS

RECOGNIZE ZIP CODES ON MAILFOR POSTAL MAIL SORTING

PROCESSING BANK CHECK AMOUNTS

PAINS

What are their frustrations, and anxieties?

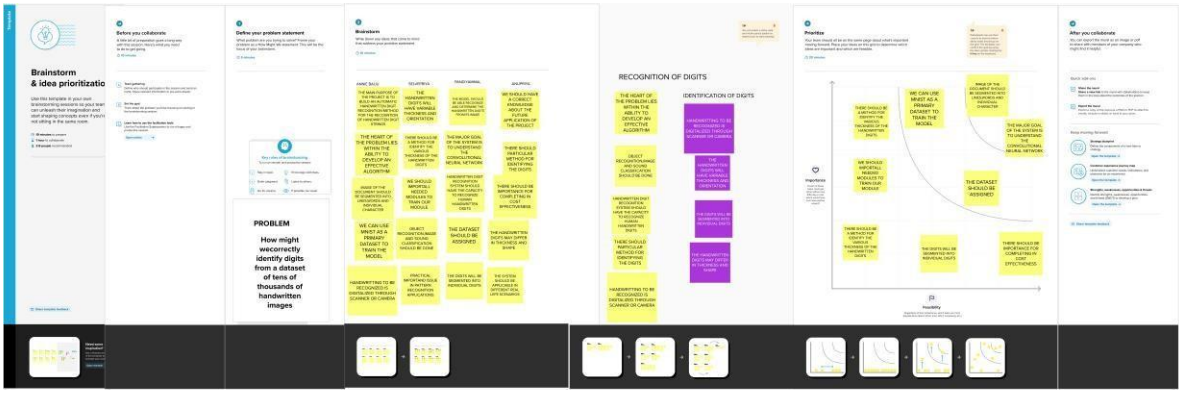
THERE ARE DIFFERENT CHALLENGES FACEDWHILE ATTEMPTING TO SOLVE THE PROBLEM

THE HANDWRITTEN DIGIT ARE ALWAYS NOT SAME SIZE

THE THICKNESS OF THE HANDWRITTEN LETTERS MAY FREQUENTLY VARY

THE ORIENTATION AND POSITION RELATION TO THE MARGINS MAY ALSO CAUSE SOME ISSUES

## 3.2 IDEATION AND BRAINSTORMING



Brainstorm & idea prioritizatio

Before you collaborate

Define your problem statement

PROBLEM

How might wecorrectly identify digits from a dataset of tens of thousands of handwritten images

Brainstorm

ANNE BALU

THE MAIN PURPOSE OF THE PROJECT IS TO BUILD AN AUTOMATIC HANDWRITTEN DIGIT RECOGNITION METHOD FOR THE RECOGNITION OF HANDWRITTEN DIGIT STRINGS

THE HEART OF THE PROBLEM LIES WITHIN THE ABILITY TO DEVELOP AN EFFECTIVE ALGORITHM

IMAGE OF THE DOCUMENT SHOULD BE SEGMENTED INTO LINES,WORDS AND INDIVIDUAL CHARACTER

WE CAN USE MNIST AS A PRIMARY DATASET TO TRAIN THE MODEL

HANDWRITTING TO BE RECOGNIZED IS DIGITALIZED THROUGH SCANNER OR CAMERA

THE HANDWRITTEN DIGITS WILL HAVE VARIABLE THICKNESS AND ORIENTATION

THERE SHOULD BE A METHOD FOR IDENTIFY THE VARIOUS THICKNESS OF THE HANDWRITTEN DIGITS

WE SHOULD IMPORTALL NEEDED MODULES TO TRAIN OUR MODULE

OBJECT RECOGNITION,IMAGE AND SOUND CLASSIFICATION SHOULD BE DONE

PRACTICAL IMPORTAND ISSUE IN PATTERN RECOGNITION APPLICATIONS

THE MODEL SHOULD BE ABLE RECOGNIZE AND DETERMINE THE HANDWRITTEN DIGITS FROM ITS IMAGE

THE MAJOR GOAL OF THE SYSTEM IS TO UNDERSTAND THE CONVOLUTIONAL NEURAL NETWORK

HANDWRITTEN DIGIT RECOGNITION SYSTEM SHOULD HAVE THE CAPACITY TO RECOGNIZE HUMAN HANDWRITTEN DIGITS

THE DATASET SHOULD BE ASSIGNED

THE DIGITS WILL BE SEGMENTED INTO INDIVIDUAL DIGITS

WE SHOULD HAVE A CORRECT KNOWLEDGE ABOUT THE FUTURE APPLICATION OF THE PROJECT

THERE SHOULD PARTICULAR METHOD FOR IDENTIFYING THE DIGITS

THERE SHOULD BE IMPORTANCE FOR COMPLETING IN COST EFFECTIVENESS

THE HANDWRITTEN DIGITS MAY DIFFER IN THICKNESS AND SHAPE

THE SYSTEM SHOULD BE APPLICABLE IN DIFFERENT REAL LIFE SCENARIOS

RECOGNITION OF DIGITS

THE HEART OF THE PROBLEM LIES WITHIN THE ABILITY TO DEVELOP AN EFFECTIVE ALGORITHM

OBJECT RECOGNITION,IMAGE AND SOUND CLASSIFICATION SHOULD BE DONE

HANDWRITTEN DIGIT RECOGNITION SYSTEM SHOULD HAVE THE CAPACITY TO RECOGNIZE HUMAN HANDWRITTEN DIGITS

THERE SHOULD PARTICULAR METHOD FOR IDENTIFYING THE DIGITS

HANDWRITTING TO BE RECOGNIZED IS DIGITALIZED THROUGH SCANNER OR CAMERA

IDENTIFICATION OF DIGITS

HANDWRITTING TO BE RECOGNIZED IS DIGITALIZED THROUGH SCANNER OR CAMERA

THE HANDWRITTEN DIGITS WILL HAVE VARIABLE THICKNESS AND ORIENTATION

THE DIGITS WILL BE SEGMENTED INTO INDIVIDUAL DIGITS

THE HANDWRITTEN DIGITS MAY DIFFER IN THICKNESS AND SHAPE

Prioritize

THERE SHOULD BE A METHOD FOR IDENTIFY THE VARIOUS THICKNESS OF THE HANDWRITTEN DIGITS

WE CAN USE MNIST AS A PRIMARY DATASET TO TRAIN THE MODEL

IMAGE OF THE DOCUMENT SHOULD BE SEGMENTED INTO LINES,WORDS AND INDIVIDUAL CHARACTER

THE MAJOR GOAL OF THE SYSTEM IS TO UNDERSTAND THE CONVOLUTIONAL NEURAL NETWORK

WE SHOULD IMPORTALL NEEDED MODULES TO TRAIN OUR MODULE

THE DATASET SHOULD BE ASSIGNED

THERE SHOULD BE A METHOD FOR IDENTIFY THE VARIOUS THICKNESS OF THE HANDWRITTEN DIGITS

THE DIGITS WILL BE SEGMENTED INTO INDIVIDUAL DIGITS

THERE SHOULD BE IMPORTANCE FOR COMPLETING IN COST EFFECTIVENESS

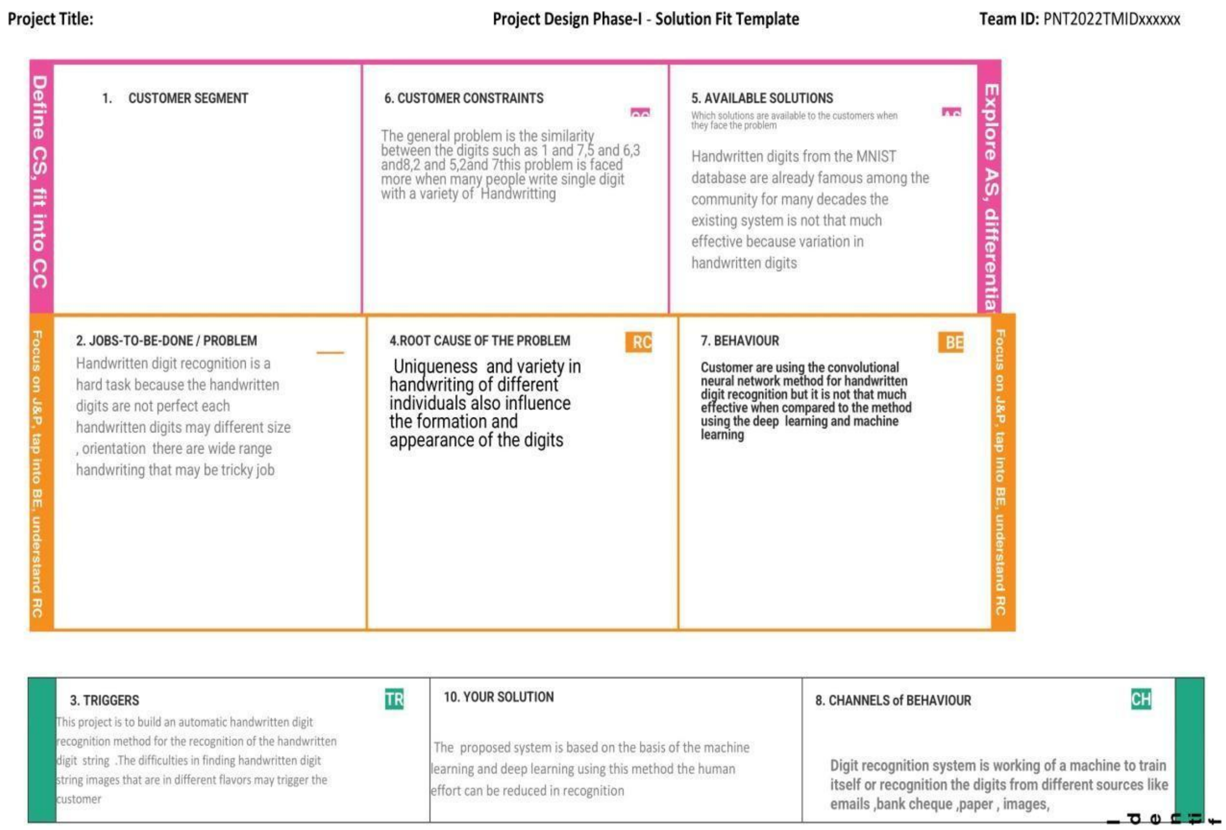
After you collaborate

## 3.3 PROPOSEDSOLUTION

| S. No. | Parameter | Description |
|---|---|---|
| | Problem Statement (Problemto be solved) | Predicting the performance level of cars is an important and interesting problem. The main goal is to predict the performance of the car improve certain behaviours the vehicle.This can significantly help to improve the system'sfuel consumption andincrease efficiency.The performance analysis of the car is based on the engine type, no of engine cylinders, fuel type,horsepower, etc. These are the factors on which thehealth of the car can be predicted. It is an on-going process of obtaining, researching, analysing, and recording health based on the above three factors.<br>The performance objectives like mileage, dependability, flexibility and cost can begrouped together to play avital role in the prediction Engine and engine managementsystem. Thisapproach is a very important step towards understanding the vehicle's performance. |

| | |
|---|---|
| Idea / Solution description | To train the system with thedataset using a regression model and it will be integrated to the web-basedapplication where the user isnotified with the status. |
| Novelty / Uniqueness | Giving the public and the manufacturer the feature toanalyse their vehicle’s performance. |
| Social Impact / Customer Satisfaction | The petrol/diesel cost canbecome lower due to a better mileage performance and the existing vehicle partscan be reused which increases the reusability thusdecreases the cost on new products and the physicallyabled people have better seat comfort because of accessories work. Better mileage and better enginemaintenance provides complete combustion thus emitting less harmfulgases.<br>The web-based applicationhas a friendly UI for the customer to enter their vehicles detail and the system predicts the value within few seconds. |
| Business Model (Revenue Model) | |
| Scalability of the Solution | The project will be scalable when the parts used to measure data in vehicles is feasible and the ML model isfast in processing data. |

# 3.4 PROBLEM SOLUTION FIT



**Project Title:** **Project Design Phase-I - Solution Fit Template** **Team ID:** PNT2022TMIDxxxxxx

Define CS, fit into CC

**1. CUSTOMER SEGMENT**

**6. CUSTOMER CONSTRAINTS**

The general problem is the similarity between the digits such as 1 and 7,5 and 6,3 and8,2 and 5,2and 7this problem is faced more when many people write single digit with a variety of Handwritting

**5. AVAILABLE SOLUTIONS**

Which solutions are available to the customers when they face the problem

Handwritten digits from the MNIST database are already famous among the community for many decades the existing system is not that much effective because variation in handwritten digits

Explore AS, differentia

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

**2. JOBS-TO-BE-DONE / PROBLEM**

Handwritten digit recognition is a hard task because the handwritten digits are not perfect each handwritten digits may different size , orientation there are wide range handwriting that may be tricky job

**4.ROOT CAUSE OF THE PROBLEM** RC

Uniqueness and variety in handwriting of different individuals also influence the formation and appearance of the digits

**7. BEHAVIOUR** BE

**Customer are using the convolutional neural network method for handwritten digit recognition but it is not that much effective when compared to the method using the deep learning and machine learning**

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

**3. TRIGGERS** TR

This project is to build an automatic handwritten digit recognition method for the recognition of the handwritten digit string .The difficulties in finding handwritten digit string images that are in different flavors may trigger the customer

**10. YOUR SOLUTION**

The proposed system is based on the basis of the machine learning and deep learning using this method the human effort can be reduced in recognition

**8. CHANNELS of BEHAVIOUR** CH

Digit recognition system is working of a machine to train itself or recognition the digits from different sources like emails ,bank cheque ,paper , images,

# 4. REQUIREMENT ANALYSIS

## 4.1 FUNCTIONAL REQUIREMENTS

**FR-1**

**Sub Requirement (Story / Sub-Task)**

Image Data: Handwritten digit recognition refers to a computer's capacity to identify human handwritten digits from a variety of sources, such as photographs, documents,touch screens, etc., and categorise them into ten established classifications (0-9).In the realm of deep learning, this has been the subject of countless studies.

**FR-2**

**Website: Web hosting makes the code,**

graphics, and other items that make up a website accessible online. A server hosts every website you've ever visited. The type ofhosting determines how much space is allotted to a website on a server. Shared off

dedicated, VPS, and reseller hosting are thefour basic varieties.

**FR-3**

**Digit Classifier Model:**

To train aconvolutional network to predict the digit from an image, use the MNIST database of handwritten digits. get the training and validation data first.

Cloud: The cloud offers a range of IT services, including virtual storage, networking, servers, databases, and applications. In plain English, cloud computing is described as a virtualplatform that enables unlimited storage andaccess to your data over the internet.

Modified National Institute of Standards and Technology dataset: The abbreviation MNIST stands for the MNIST dataset. It is a collectionof 60,000 tiny square grayscale photographs, each measuring 28 by 28, comprising handwritten single digits between 0 and 9.

Import the libraries: Libraries required are Keras, Tensor flow, Numpy, Pillow, Tkinkter.

- Keras: Keras is a powerful and easy-to-use free opensource Python library for developing and evaluating deep learning models.It wraps the efficient numerical computation libraries Theano and TensorFlow and allows you to define and train neural network models in just a few lines of code. It uses libraries such as Python, C#, C++ or standalone machine learning toolkits. Theano and TensorFlow are very powerful libraries but difficult to understand for creating neural networks. Keras is based on minimal structure that provides a clean and easy way to create deep learning models based on TensorFlow or Theano. Keras is designed to quickly define deep learning models. Well, Keras is an optimal choice for deep learning applications.

- TensorFlow: TensorFlow is a Python library for fast numerical computing created and released by Google. It is a foundation library that can be used to create Deep Learning models directly or by using wrapper libraries that simplify the processbuilt on top of TensorFlow. TensorFlow tutorial is designed for both beginners and professionals. Our tutorial provides all the basic and advanced concept of machine learning and deep learning concept such as deep neural network, image processing and sentiment analysis. TensorFlow is one of the famous deep learning frameworks, developed by Google Team. It is a free and opensource software library and designed in Python programming language, this tutorial is designed in such a way that we can easily implements deep learning project on TensorFlow in an easy and efficient way. Unlike other numerical libraries intended for use in Deep Learning like Theano, TensorFlow was designed for use both inresearch and development and in production systems. It can run on single CPU systems, GPUs as well as mobile devices and largescale distributed systems of hundreds of machines.

- Numpy: NumPy is a Python library used for working with arrays. It also hasfunctions for working in the off
- domain of linear algebra, Fourier transform, andmatrices. Numpy which stands for Numerical Python, is a library consisting of multidimensional array objects and a collection of routines for processing those arrays. Using NumPy, mathematical and logical operations on arrays can beperformed. This tutorial explains the basics of NumPy such as its architecture and environment. It also discusses the various arrayof functions, types of indexing,etc. It is an opensource project and you can use it freely.
  NumPy stands for Numerical Python.
  NumPy aims to provide an array object that is up to 50x faster than traditional Python lists. The array the of object in NumPy is called darray, it provides a lot of supporting functions that make working with the ndarray very easy. Arrays are very frequently used in data science, where speed and resources are very important.

- Pillow: Pillow is a free and open source library for the Python programming language that allows you to easily create &s manipulate digital images. Pillow is built on top of PIL (Python Image Library). PIL is one of the important modules
  for image processing in Py thon. However, the PIL module is not supported since 2011 and doesn’t support python 3. Pillow module gives more functionalities,
  runs on all major operating system and support for python 3. It supports wide variety of images such as “jpeg”, “png”, “bmp”, “gif”, “ppm”, “tiff”. You can do almost anything on digital images using pillow module. Apart from basic image processing functionality, including point operations, filtering images using builtinconvolution kernels, and color space conversions.

- Tkinkt er: Tkinter is the standard and easy way to create Tk GUI toolkit. GUI library for Python. Python when combined with Tkinter provides a fastGUI applications We need to import all the. Tkinter provides a powerful objectoriented interface to the modules that we are going to need for training our model. library already contains some datasets and MNIST is one of them. The Keras So we can easily import the dataset through Keras. The mnist.load_data() method returns the
  training data, its labels along with the testing data and its

  labels. Loading the Data Set:

- MNIST Data Set: modified National Institute of Standards and Technology
  (MNIST) is a large set of computer vision dataset which is extensively used for

training and testing different systems. It was created from the two special datasets of National Institute of Standards a nd Technology (NIST) which holds binary images of handwritten digits. The training set contains handwritten digitsfrom 250 people, among them 50% training dataset was employees from the Census Bureau and the rest of it was from high school students. However, it is often attributed as the first datasets among other datasets to prove the

effectiveness of the neural networks. The database contains 60,000 images used for training as well as few of them can be used for crossvalidation purposes and 10,000 images used for testing. All the digits are grayscale and positioned in a fixed size where the intensity lies at the center of the image with 28×28 pixels. Since all the images are 28×28 pixels, it forms an array which can be flattened into 28*28=784 dimensional vector. Each component of the vector is a binary value which describes the intensity of the pixel.

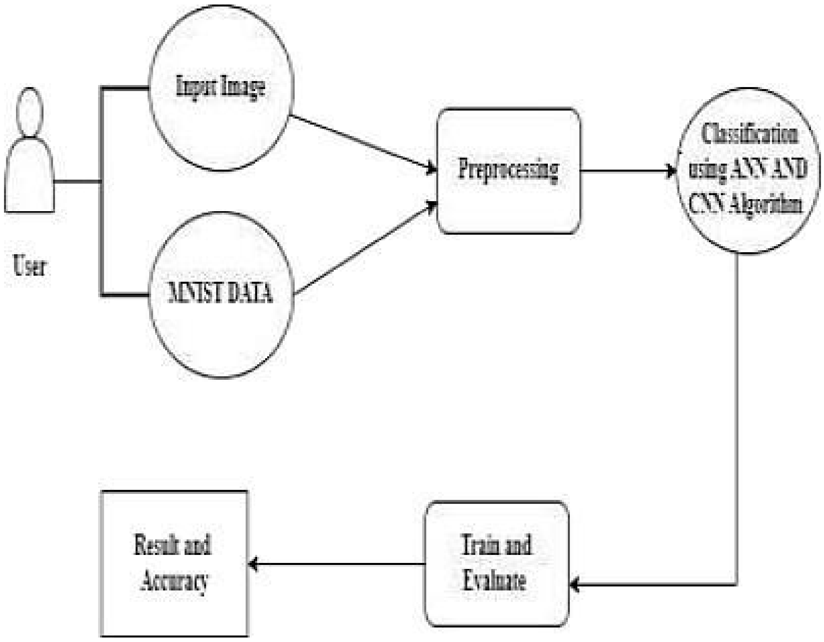
## 4.2 NON-FUNCTIONAL REQIREMENTS

| FR No. | Non-Functional Requirement | Description |
|---|---|---|
| NFR-1 | **Usability** | One of the very significant problems in pattern recognition applications is the recognition of handwritten characters. Applications for digit recognition include filling out forms, processing bank checks, and sorting mail. |
| NFR-2 | **Security** | 1) The system generates a thorough description of the instantiation parameters, which might |
| NFR-3 | **Reliability** | The samples are used by the neural network to automatically deduce rules for reading handwritten digits. Furthermore, the network may learn more about handwriting and hence enhance its accuracy by increasing the quantity of training instances. Numerous techniques and algorithms, such as Deep Learning/CNN, SVM, Gaussian Naive Bayes, KNN, Decision Trees, Random Forests, etc., can be used to recognise handwritten numbers. |

| | | |
|---|---|---|
| NFR-4 | **Accuracy** | With typed text in high-quality photos, optical character recognition (OCR) technology offers accuracy rates of greater than 99%. However, variances in spacing, abnormalities in handwriting, and the variety of human writing styles result in less precise character identification. |
| NFR-5 | | **Availability** |

# 5. PROJECT DESIGN

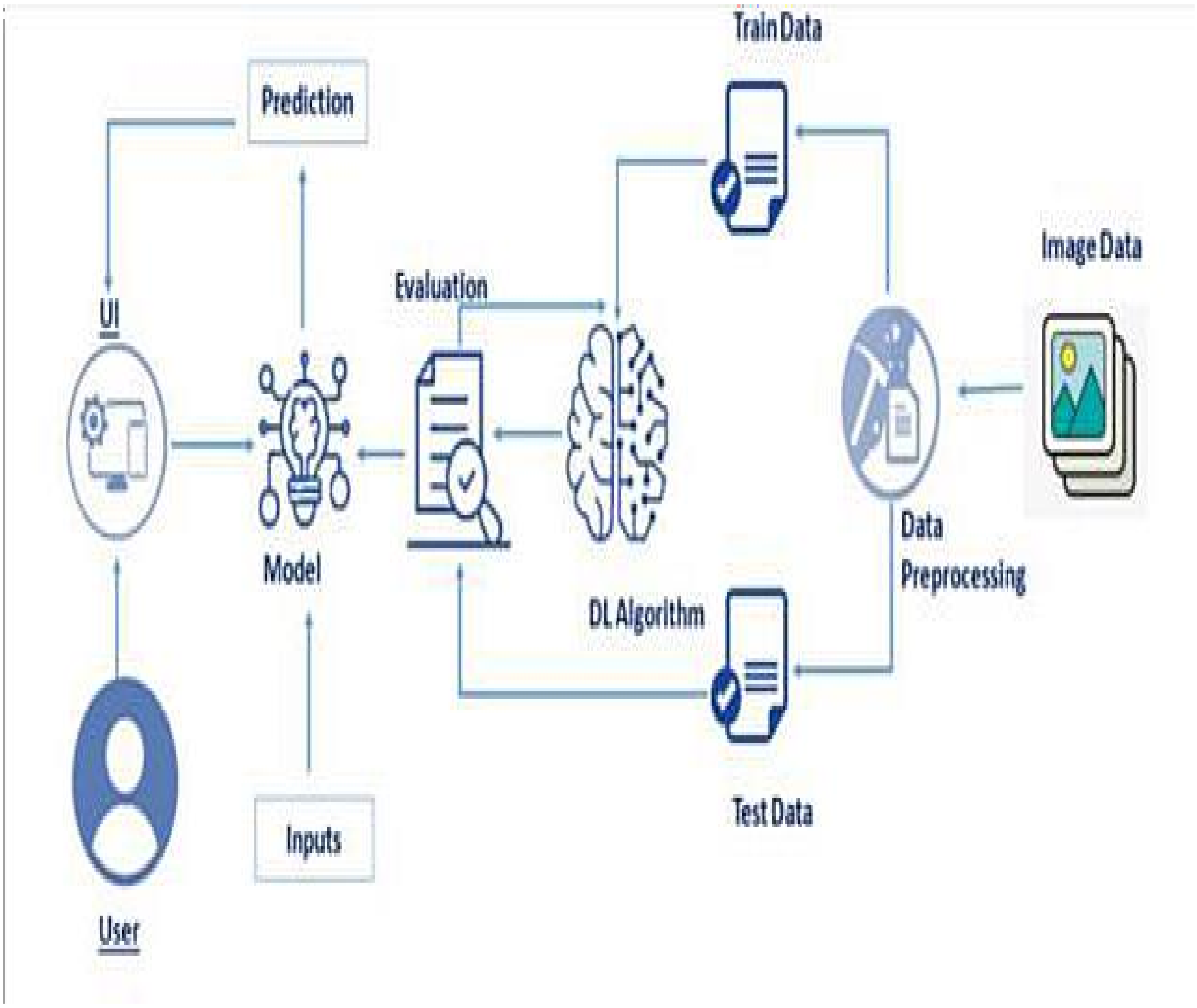
## 5.1 DATA FLOW DIAGRAM



## 5.2 SOLUTION AND TECHNICAL ARCHITECTURE

## SOLUTION ARCHITECTURE

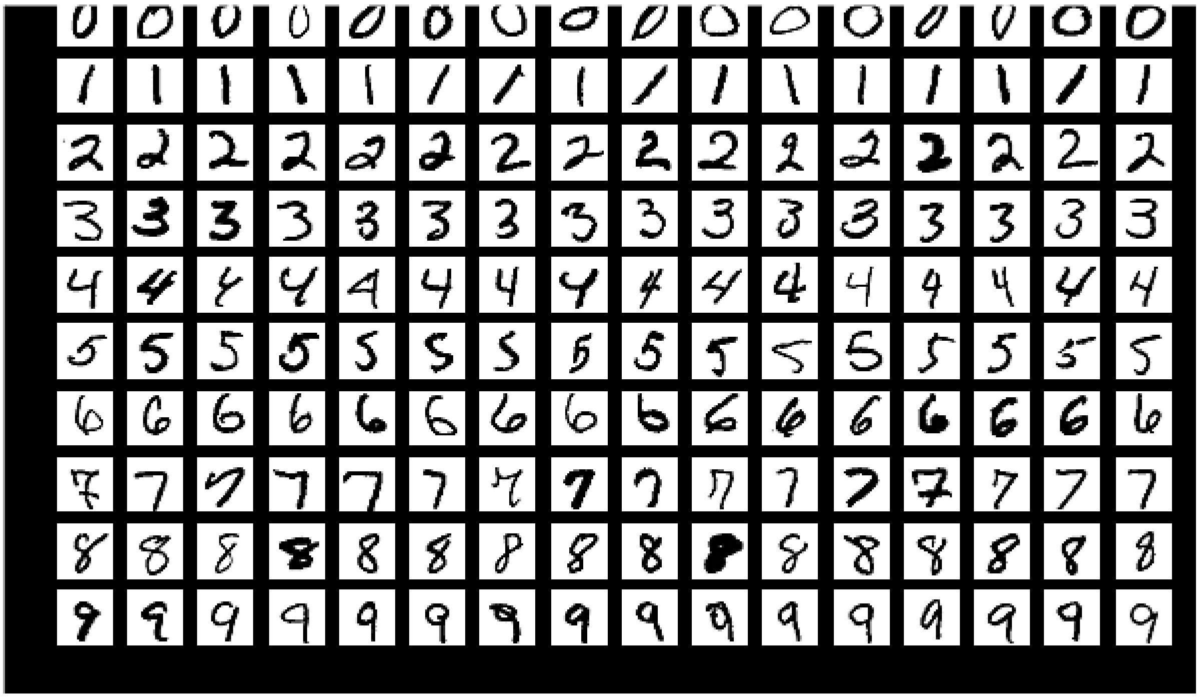
**PROJECT DESCRIPTION:** Given that everyone in the world has their own writing style, handwriting detection is one of the most intriguing research projects now underway. It is the computer's capacity to automatically recognise and understand handwritten figures or letters. Because of advances in science and technology, everything is being digitalized in order to reduce human effort. As a result, handwritten digit identification is required in many real-time applications. The MNIST data collection, which contains 70000 handwritten digits, is commonly employed in this recognition process. To train these photos and create a deep learning model, we use artificial neural networks. A web application is developed that allows the user to uploadan image of a handwritten digit.



## SOLUTION

**MNIST Dataset Description:**

The MNIST Handwritten Digit Recognition Dataset includes 60,000 training and 10,000 testing handwritten digit images. Each image has a height of 28 pixels and a width of 28 pixels, for a total of 784 (2828) pixels. Each pixel is connected with a single pixel value. It indicates how bright or dark that pixel is (larger numbers indicates darker pixel). This pixel value is an integerbetween 0 and 255.



**PROCEDURE:**

1. Install the latest TensorFlow library.
2. Prepare the dataset for the model.
3. Develop Single Layer Perceptron model for classifying the handwritten digits.
4. Plot the change in accuracy per epochs.
5. Evaluate the model on the testing data.
6. Analyse the model summary.
7. Add hidden layer to the model to make it Multi-Layer Perceptron.
8. Add Dropout to prevent overfitting and check its effect on accuracy.
9. Increasing the number of Hidden Layer neuron and check its effect on accuracy.
10. Use different optimizers and check its effect on accuracy.
11. Increase the hidden layers and check its effect on accuracy

MNIST is a dataset which is widely used for handwritten digit recognition. The dataset consists of 60,0000 training images and 10,000 test images. The artificial neural networks can all most mimic the human brain and are a key ingredient in image processing field. 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've taken it a step further, and our handwritten digit recognition technology not only recognises scanned images of handwritten numbers, but also allows you to write digits on thescreen and have them recognised using an integrated GUI.

**Approach:**

We will approach this project by using a three-layered Neural Network.

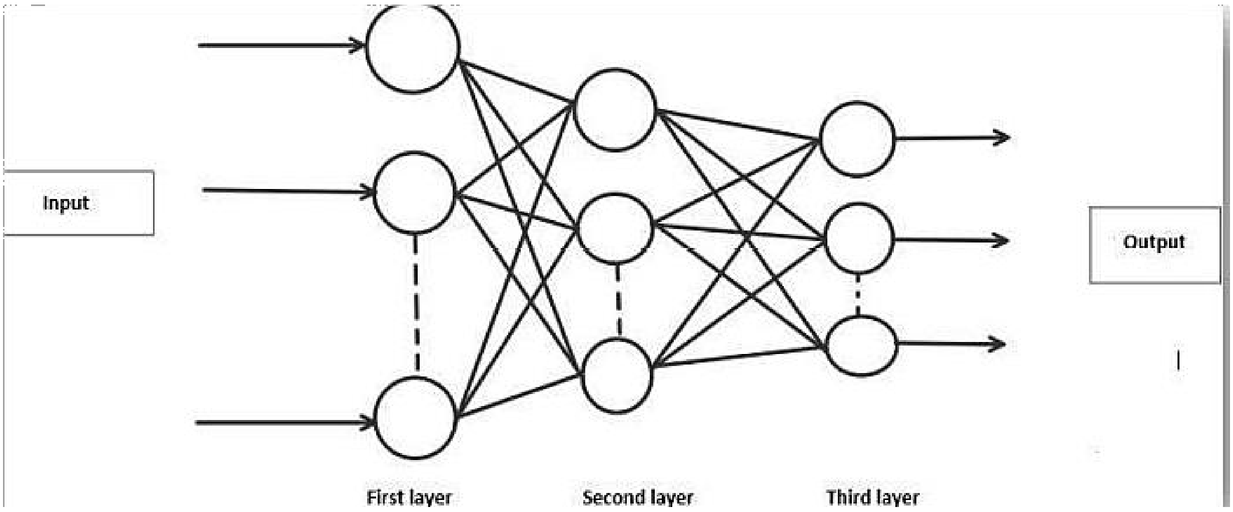
- **The input layer**: It distributes the features of our examples to the next layer for calculation of activations of the next layer.
- **The hidden layer**: They are made of hidden units called activations providing nonlinear ties for the network. A number of hidden layers can vary according to our requirements.
- **The output layer**: The nodes here are called output units. It provides us with the final prediction of the Neural Network on the basis of which final predictions can be made.

A neural network is a model based on how the brain functions. It is made up of several layers with numerous activations, which mirror neurons in our brain. A neural network attempts tolearn a set of parameters from a set of data, which may aid in recognising underlyinglinks. Because neural networks can adapt to changing input, they can produce the best possible results without having to rethink the output criteria.

**METHODOLOGY:**

We created a Neural Network with one hidden layer and 100 activation units (excluding bias units). Data is loaded from a.mat file, then features (X) and labels (Y) are extracted. Then, to avoid overflow during computation, features are divided by 255 and rescaled into a range of [0,1]. The data is divided into 60,000 training instances and 10,000 testing examples.

Feedforward is used with the training set to calculate the hypothesis, followed by backpropagation to reduce the error between the layers. To solve the issue of overfitting, the regularisation parameter lambda is adjusted to 0.1. The optimizer is run 70 times to get the bestfit model.



## ALGORITHM:

## Forward Propagation Architecture:

It is a brief description of how the CNN module will extract features and categorize the image based on them. The network's input layer, hidden layers, and output layer are depicted in the design. The feature extraction phase of the network involves multiple layers, including convolution and resampling.

**Explanation of given system:**

- The first layer of the architecture is the User layer. User layer will comprise of the people who interacts with the app and for the required results.
- The next three layers is the frontend architecture of the application. The application will be developed using which is the open-source platform for HTML, CSS and JavaScript. The application is deployed in the localhost which is shown on the browser. Through the app, the user will be able to upload pictures of the handwritten digits and convert it into the digitalized form.
- The one in between the database and view layer is the business layer which is the logical calculations on the basis of the request from the client side. It also has the service interface.
- The backend layer consists of two datasets: Training Data and Test Data. The MNIST database has been used for that which is already divided into training set of 60,000 examples and test of 10,000examples.
- The training algorithm used is Convolution Neural Network. 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

## WORKING:

- Neural Networks receive an input and transform it through a series of hidden layers.

zzEach hidden layer is made up of a set of neurons, where each neuron is fully connected to all neurons in the previous layer.

- Neurons in a single layer function completely independently.
- The last fully connected layer is called the "output layer.

**Convolution Layer:**

The Convolutional layer is the core building block of a CNN. The layer's parameters consist of a set of learnable filters (or kernels), which have a small receptive field, but extend through the full depth of the input volume. During the forward pass, each filter is convolved across the width and height of the input volume, computing the dot product between the entries of the filter and the input and producing a 2- dimensional activation map of that filter. As a result, the network learns filters that activate when they see some specific type of feature at some spatial position in the input.

**Feature Extraction:**

All neurons in a feature share the same weights. In this way all neurons detect the same featureat different positions in the input image. Reduce the number of free parameters.

**Subsampling Layer:**

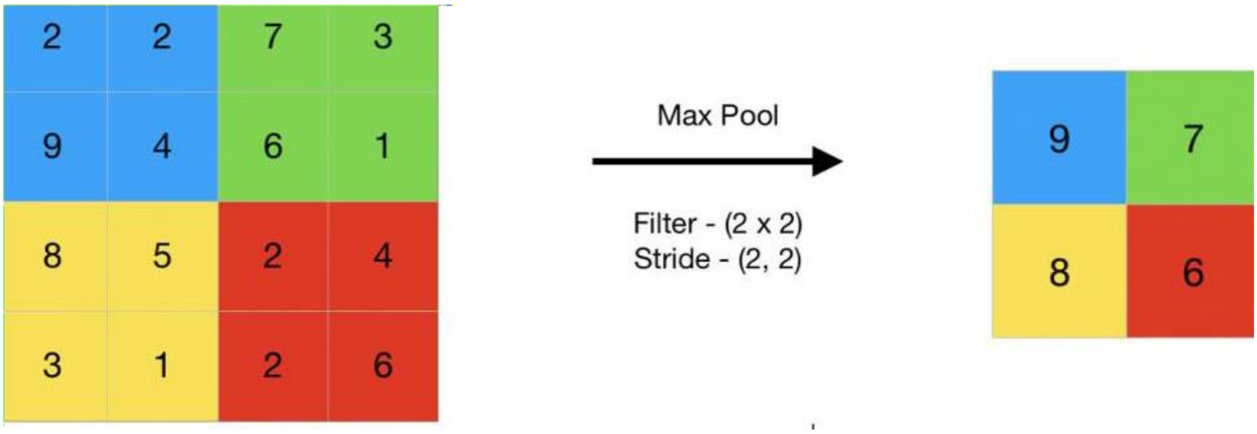
Subsampling, or down sampling, refers to reducing the overall size of a signal The subsampling layers reduce the spatial resolution of each feature map. Reduce the effect of noises and shift or distortion invariance is achieved.

**Pooling layer:**

It is common to periodically insert a Pooling layer in-between successive Conv layer in a Convent architecture. Its function is to progressively reduce the spatial size of the representation to reduce the number of parameters and computation in the network, and hence to also control overfitting. The Pooling Layer operates independently on every depth slice of the input and resizes it spatially, using the MAX operation.

**TensorFlow:**

TensorFlow is an open-source machine learning library for research and production. TensorFlow offers APIs for beginners and experts to develop for desktop, mobile, web, and cloud. See the sections below to get started. By scanning the numerical digit and convert into png format using python3 command in terminal we can get text output and sound output.



| | | | |
|---|---|---|---|
| 2 | 2 | 7 | 3 |
| 9 | 4 | 6 | 1 |
| 8 | 5 | 2 | 4 |
| 3 | 1 | 2 | 6 |

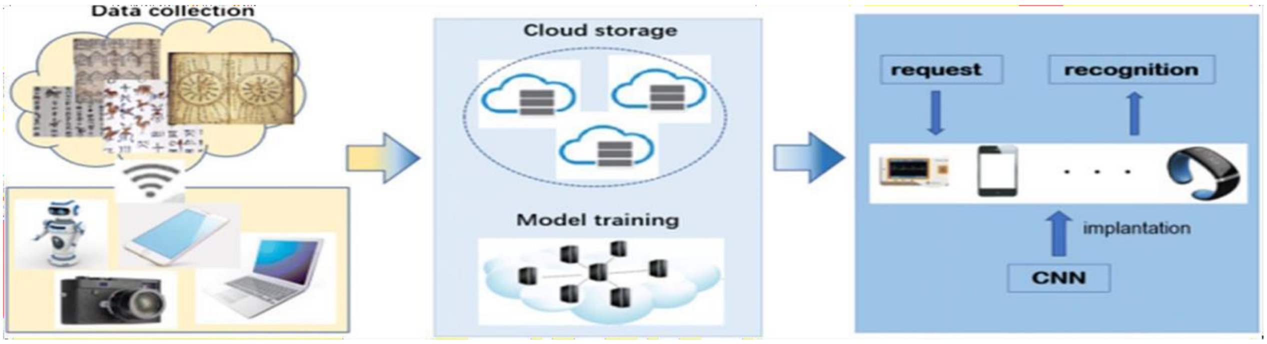
| | |
|---|---|
| 9 | 7 |
| 8 | 6 |

**RESULT:**

As with any study or project undertaken in the field of machine learning and image recognition,We do not consider our results to be perfect after processing. Machine learning is a field that isalways evolving, and there is always room for advancement improvement in your process; therewill always be something new strategy that produces superior outcomes for the same challengeThe application has been submitted.

Three models were used: Multi-Layer Perceptron (MLP), Convolution Neural Network (CNN), and Network (CNN). The accuracy of the classifier varies depending on the model whichdemonstrates which is superior.

# TECHNICAL ARCHITECTURE



# COMPONENTS AND TECHNOLOGIES

| | Component | Description | Technology |
|---|---|---|---|
| | User Interface How user interactswith application<br>e.g. Web UI, MobileApp, Chatbot etc. | | HTML, CSS, JavaScript |
| 2. | 2.Application Logic-1<br>Logic for a process<br>in the application | | Python |
| 3. | 3.Application Logic-2<br>Logic for a process<br>in the application | | IBM Watson STT serviceIBM Watson Assistant |
| 4. | 4.Application Logic-3<br>Logic for a process<br>in the application | | |
| | Database | Data Type, Configurations etc. | MySQL, NoSQL, etc. |

# Application Characteristics

| | S.No Characteristics | Description | Technology |
|---|---|---|---|
| 1. | Open-Source | Frameworks | The open-source frameworks used arelisted. |

|  |  |  |  |
|---|---|---|---|
|  | The technology | of Opensource | framework |
| 2. | Security Implementations | Listing all the security / access controls implemented, use offirewalls etc. | SHA-256, Encryptions, IAM Controls, OWASP |
| 3. | Scalable Architecture | To justify the scalability of architecture used insystem. User friendly and highly flexible. | 3 – tier, Micro-services |

| | | | |
|---|---|---|---|
| | Availability | Figures and abstract. The capabilities for recognizing handwrittendigits have been implemented. These characteristics extract slope or slant information from the digit image based on shape analysis. They are successful in achieving high recognition accuracy. | Distributed servers, IBM cloud |
| 5. | Performance | The handwritten digits are accurately classified with an accuracy of typicalneural network . | number of requests per sec, use of Cache |

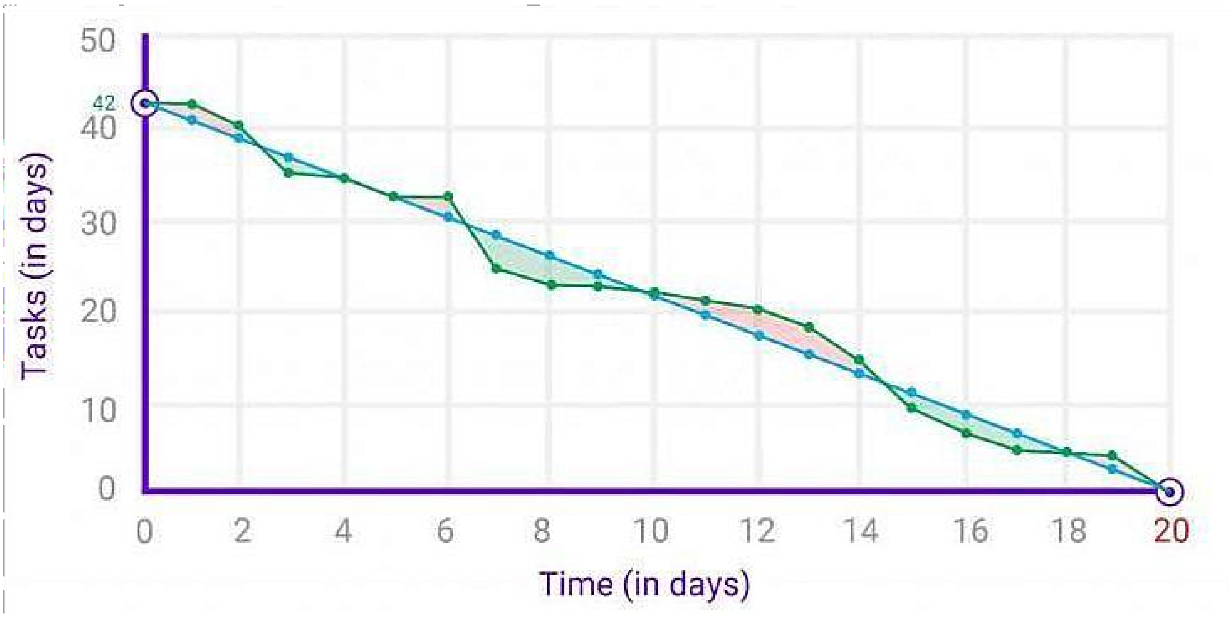
# 6.PROJECT PLANNING AND SCHEDULING

## 6.1 SPRINT PLANNING AND ESTIMATION

**Product Backlog, Sprint Schedule, and Estimation**

| **Sprint** | **Functional Requirement (Epic)** | **User Story Number** | **User Story / Task** | **Story Points** | **Priority** |
|---|---|---|---|---|---|
| Sprint-1 | Data Collection | USN-1 | As a user, I can collect the dataset from various resources with different handwritings. | 10 | Low |
| 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 |
| 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 |
| Sprint-2 | Add CNN layers | USN-4 | Creating the model and adding the input, hidden, and output layers to it. | 5 | High |
| Sprint | Functional Requirement (Epic) | User Story Number | User Story / Task | Story Points | Priority |
| 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 |

| | | | | | |
|---|---|---|---|---|---|
| Sprint-2 | Train & test the model | USN-6 | As a user, let us train our model with our image dataset. | 6 | Medium |
| 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 |
| 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 |
| Sprint-3 | USN-9 | As a user, I can know the details of thefundamental usage of the application. | 5 | | Low |
| Sprint-3 | USN-10 | As a user, I cansee the predicted / recognized digits in the application. | 5 | | Medium |
| 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 |
| 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 |



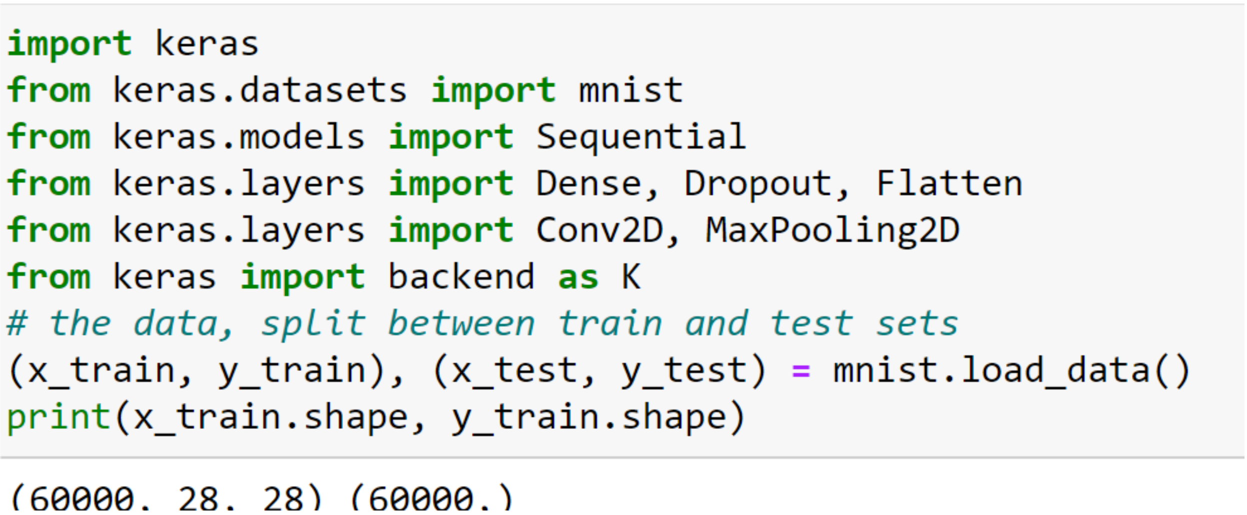
50
42
40
30
20
10
0
Tasks (in days)
0
2
4
6
8
10
12
14
16
18
20
Time (in days)

# 7. CODING AND SOLUTIONING

## 7.1 FEATURE 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
thedataset and start working with it.
The **mnist.load_data()** method returns us the training data, its labels and also the testing dataand its labels

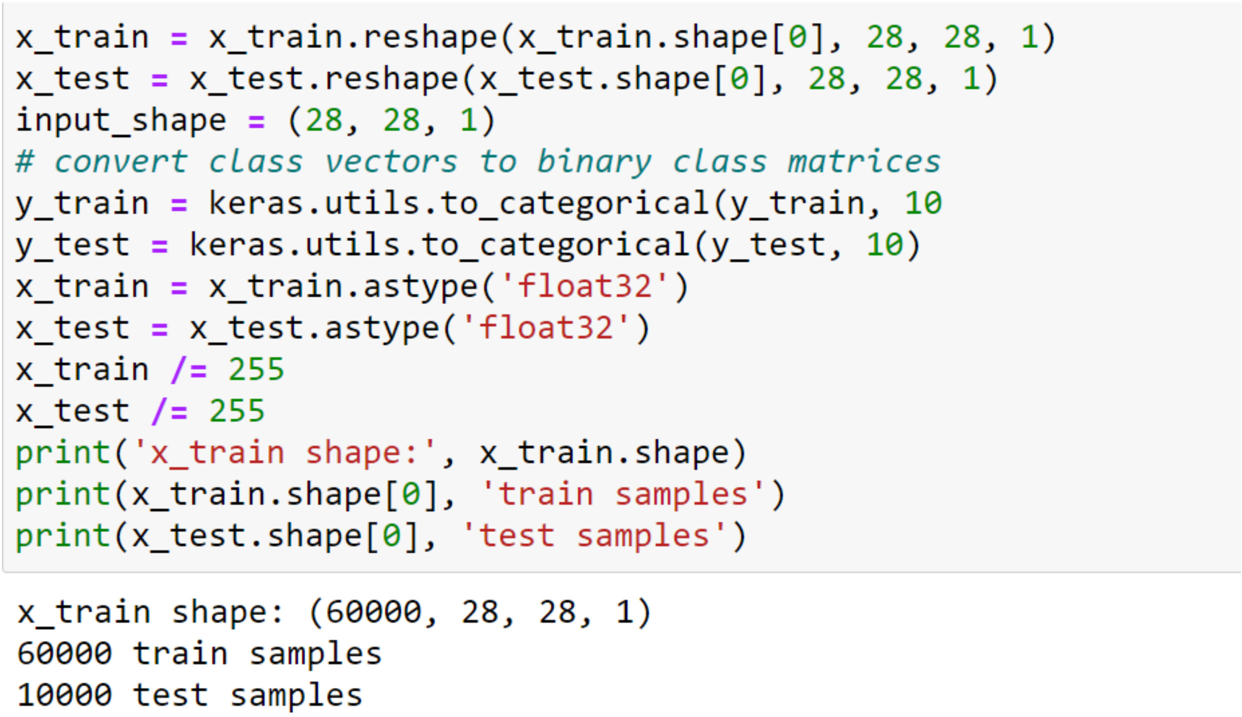


```
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten
from keras.layers import Conv2D, MaxPooling2D
from keras import backend as K
# the data, split between train and test sets
(x_train, y_train), (x_test, y_test) = mnist.load_data()
print(x_train.shape, y_train.shape)
```

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

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. The dimension of the training data
is(60000,28,28). The CNN model will require one more dimension so we reshape the matrix to
shape(60000,28,28,1



```
x_train = x_train.reshape(x_train.shape[0], 28, 28, 1)
x_test = x_test.reshape(x_test.shape[0], 28, 28, 1)
input_shape = (28, 28, 1)
# convert class vectors to binary class matrices
y_train = keras.utils.to_categorical(y_train, 10
y_test = keras.utils.to_categorical(y_test, 10)
x_train = x_train.astype('float32')
x_test = x_test.astype('float32')
x_train /= 255
x_test /= 255
print('x_train shape:', x_train.shape)
print(x_train.shape[0], 'train samples')
print(x_test.shape[0], 'test samples')
```

```
x_train shape: (60000, 28, 28, 1)
60000 train samples
10000 test samples
```

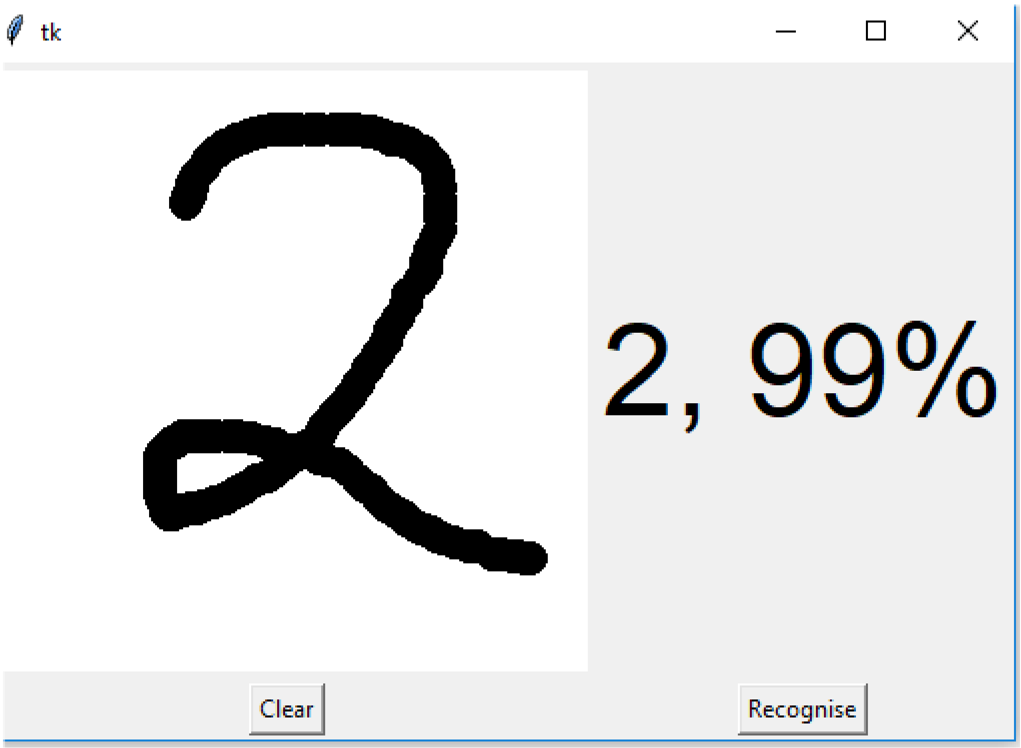
Create the model**:**

Now we will create our CNN model in Python data science project. A CNN model generallyconsists of convolutional and pooling layers.

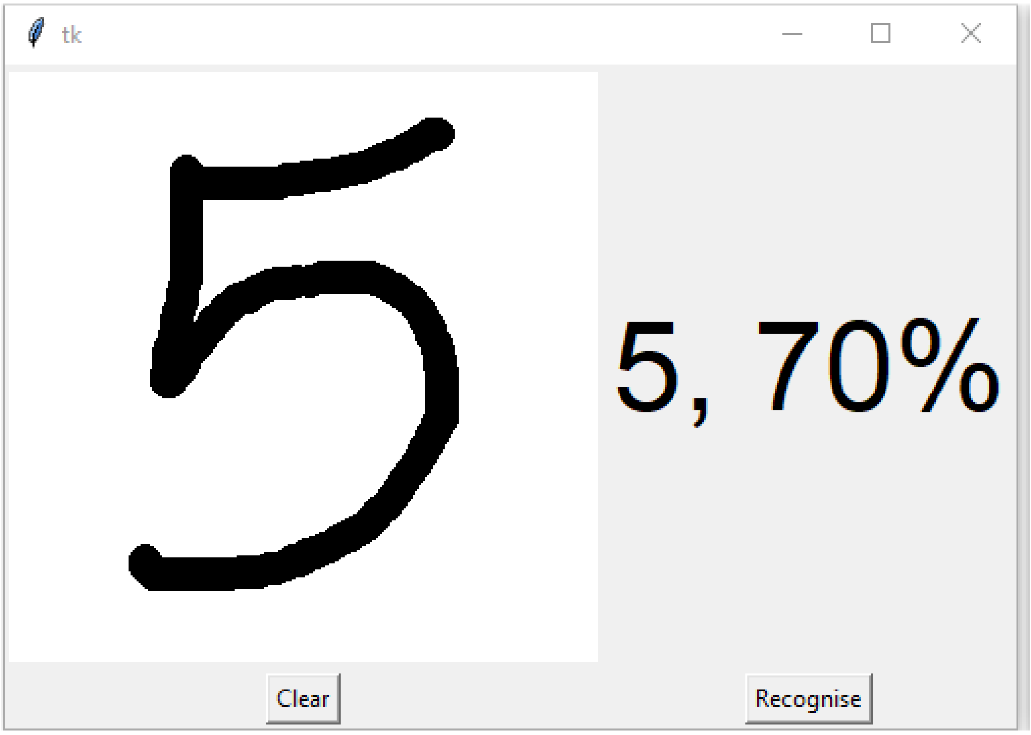
It works better for data that are represented as grid structures, this is the reason why CNN workswell for image classification problems.

The dropout layer is used to deactivate some of the neurons and while training, it reduces offerfitting of the model. We will then compile the model with the **Adadelta** optimizer

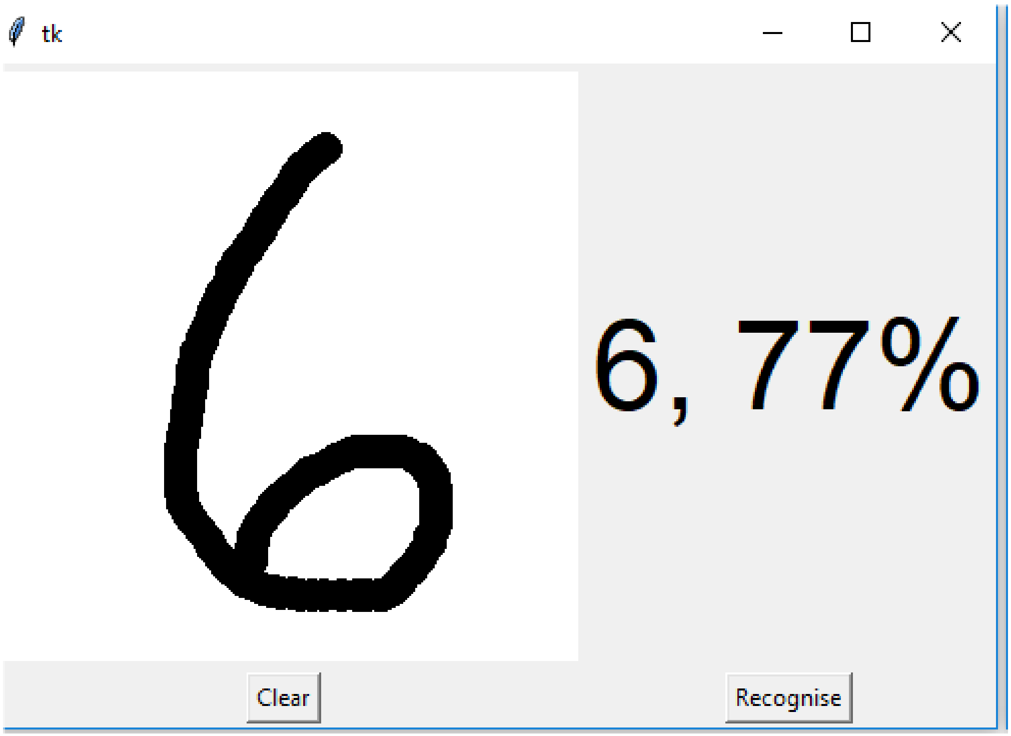
## 7.2 FEATURE 2

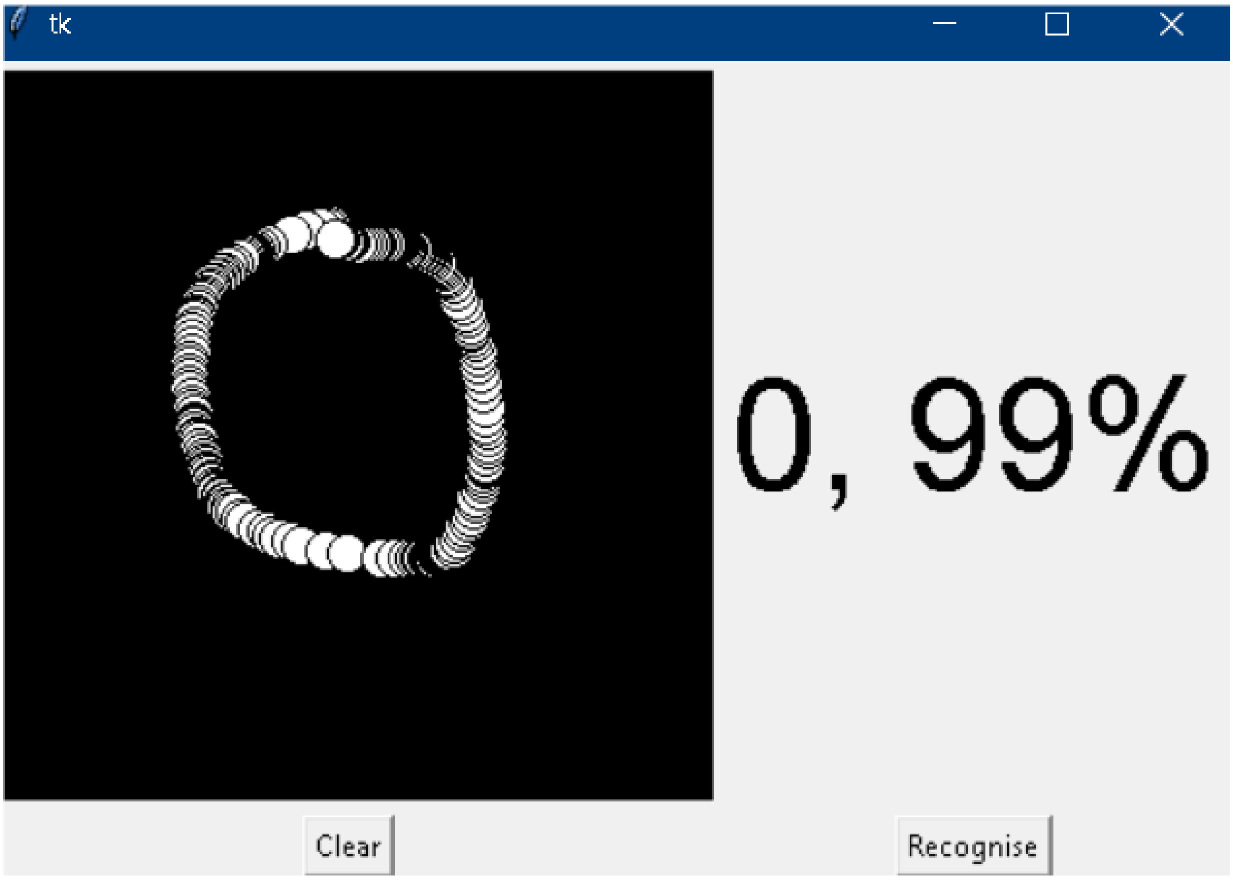


```
2, 99%
```



```
5, 70%
```


tk
6, 77%
Clear
Recognise



tk
0, 99%
Clear
Recognise

# 8. RESULTS

## 8.1 PERFORMANCE METRICS

Our model is built to work on real-world data, and real-world images are not even close to MNIST raster images, a lot of pre-processing was done to make a real image to look like a

rasterimage. Accuracy:

score Our model stopped training at the 2nd epoch as it reached 98.21% training accuracy and 98.51% validation accuracy with 5% training loss and 4% validation loss. The progression of accuracy and loss are representedPrediction:

Our model is able to recognize computer-generated digits as well as handwritten digits. Computer-generated digit prediction is more accurate compared to real-world digit prediction, which can be observed in F

**Model Evaluation & Prediction**

For real-world image classification prediction, we need to do a little image pre-processing on the real-world images as model training was done with greyscale raster images. The steps of image pre-processing are,

1. Loading image
2. Convert the image to greyscale
3. Resize the image to 28x28
4. Converting the image into a matrix form
5. Reshape the matrix into 28x28x1

After pre-processing, we predict the label of the image by passing the pre-processed image through the neural network. The output we get is a list of 10 activation values 0 to 9, respectively. The position having the highest value is the predicted label for the image [18].

**RESULTS AND DISCUSSION**

Our model is built to work on real-world data, and real-worldimages are not even close to MNIST raster images, a lot of pre-processing was done to make a real image to look like a raster image.

# 9. ADVANTAGES AND DISADVANTAGES

Digit recognition system is the working of a machine to train itself or recognizing the digits fromdifferent sources like emails, bank cheque, papers, images, etc. and in different real-world scenariosfor online handwriting recognition on computer tablets or system, recognize number
plates of numeric entries in forms filled up by hand and so on. The handwritten digit recognition is the ability of computers to recognize human handwritten digits.
It is a hard task for the machine because handwritten digits are not perfect and can be made withmany different flavors. The handwritten digit recognition is the solution to this problem which usesthe image of a digit and recognizes the digit present in the image.

The goal of this project is to create a model that will be able to recognize and determine the handwritten digits from its image by using the concepts of Convolution Neural Network.
Thoughthe goal is to create a model which can recognize the digits, it can be extended to letters and an individual's handwriting. The major goal of the proposed system is understanding ConvolutionalNeural Network, and applying it to the handwritten recognition system

# 10.CONCLUTION

Our project HANDWRITTEN DIGIT RECOGNITION deals with identifying the digits.
The main purpose of this project is to build an automatic handwritten digit recognition method for therecognition of handwritten digit strings.
In this project, different machine learning methods, which are SVM (Support Vector Machine), ANN(Artificial Neural Networks), and CNN (Convolutional Neural Networks) architectures are used toachieve high performance on the digit string recognition problem.

# 11. FUTURE SCOPE

The proposed system takes 28x28 pixel sized images as input. The same system with further modifications and improvements in the dataset and the model can be used to build HandwrittenCharacter Recognition System which recognizes human handwritten characters andpredicts the output

# 12. APPENDIX

### Python:

Python is an interpreted, high-level, general purpose programming language created by Guido Van Rossum and first released in 1991, Python's design philosophy emphasizes code Readability with its notable use of significant White space. Its language constructs and object oriented approach aim to help programmers write clear, logical code for small and large-scale projects.
Python is dynamically type and garbage collected. It supports multiple programming paradigms, including procedural, object oriented ,and functional programming.

### Keras :

Keras is a powerful and easy-to-use free open source Python library for developing and evaluating **deep learning** model **.**It wraps the efficient numerical computation libraries **Theano** and **TensorFlow** and allows you to define and train neural network models in just a few lines of code. It uses libraries such as Python, C#,C++ or standalone machine learning toolkits. Theano and TensorFlow are very powerful libraries but difficult to understand neural network.Keras is based on minimal structure that provides a clean and easy way to create deep learning models based on TensorFlow or Theano. Keras is designed to quickly define deep learning models. Well, Keras

is an optimal choice for deep learning applications.

**Steps for creating a keras model:**

1)First we must define a network model.

2) Compile it, which transforms the simple sequence of layers into a complex group of matrix operations.

3)Train or fit the network.

To import: from keras.models import Sequential From keras.layers import Dense, Activation, Dropout

## TensorFlow:

TensorFlow is a Python library for fast numerical computing created and released by Google. Itis a foundation library that can be used to create Deep Learning models directly or by using wrapper librarie sthat simplify the process built on top of **TensorFlow.** TensorFlow tutorial is designed for both beginner and professionals. Our tutorial provides all the basic and advanced concept of machine learning and deep learning concept such as deep neural network, image processing and sentiment analysis. TensorFlow is one of the famous deep learning frameworks,developed by **Google** Team. It is a free and

open source software library and designed in **Python** programming language, this tutorial is designedin such a way that we can easily implements deep learning project on TensorFlow in aneasy andefficient way. Unlike other numerical libraries intended for use in Deep Learning like **Theano**,**TensorFlow** was designed for use both in research and development and in production systems. It canrun on single CPU systems, GPUs as well as mobile devices and largescale distributed systems ofhundreds of machines.

## Numpy:

NumPy is a Python library used for working with arrays. It also has functions for working in domain oflinear algebra, Fourier transform, and matrices. Numpy which stands for Numerical Python, is a libraryconsisting of multidimensional array objects and a collection of routines forprocessing those arrays.Using NumPy, mathematical and logical operations on arrays can be performed. This tutorial explains

the basics of NumPy such as its architecture and environment. It also discusses the various array

functions, types of indexing, etc. It is an opensource project and you can use it freely.
NumPy stands for Numerical Python. NumPyaims to provide an array object that is up to 50x faster than traditional Python lists. The array object inNumPy is called **ndarray**, it provides a lotof supporting functions that make working with **ndarray** very easy. Arrays are very frequently used in data science, where speed and resources arevery important.

## Pillow:

Pillow is a free and ope nsource library for the Python programming language that allows you to easily create &s manipulate digital images. Pillow is built on top of PIL (Python Image Library). PIL is one of the important modules for image processing in Python. However, the PIL module is not supported since 2011 and does n't support python 3.
Pillow module gives more functionalities, runs on all major operating system and support forpython 3. It supports wide variety of images such as "jpeg", "png", "bmp", "gif", "ppm", "tiff". You cando almost anything on digital images using pillow module. Apart from basic image processing functionality, including point operations, filtering images using built-in convolution kernels, andcolor space conversions.

## Tkinkter:

Tkinter is the standard **GUI library** for Python. Python when combined with Tkinter provides a fast and easy way to create **GUI applications**. Tkinter provides a powerful object-oriented interface to the Tk GUI toolkit.We need 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 through Keras. The mnist.load_data() method returns the training data, its labels along with the testing data and its labels.

### Jupyter Notebook:

Jupyter Lab is a web-based interactive development environment for Jupyter notebooks, code, and data. JupyterLab is flexible: configure and arrange the user interface to support a wide rangeof workflows in data science, scientific computing, and machine learning.JupyterLab is extensible and modular: writeplugins that add new components and integrate with existing ones.

### Machine Learning:

Machine learning is a method of data analysis that automates analytical model building. It is abranch of artificial intelligence based on the idea that systems can learn from data, identify patterns and make decisions with minimal human intervention.

## Deep Learning:

Deep learning is an artificial intelligence (AI) function that imitates the workings of the humanbrain in processing data and creating patterns for use in decision making.learning is a subset ofmachine learning in artificial intelligence that has networks capable of learning unsupervised from data that is unstructured or unlabeled. Also known as deep neural learning or deep neuralnetwork.

## Neural Networks:

A neural network is a series of algorithms that endeavors to recognize underlying relationships ina set of data through a process that mimics the way the human brain operates. In this sense, neural networks refer to systems of neurons, either organic or artificial in nature.

### INDEX.HTML

```
<htm
l>
        <head>
        <title>HDR</title>
        <meta name="viewport" content="width=device-width">
        <link href="https://fonts.googleapis.com/css2?family=Prompt:wght@600&display=swap"
        rel="stylesheet">
        <link href="https://fonts.googleapis.com/css2?family=Varela+Round&display=swap"
        rel="stylesheet">
        <link
        href="https://fonts.googleapis.com/css2?family=Source+Code+Pro:wght@500&display=swa
        p" rel="stylesheet">
        <link
        href="https://fonts.googleapis.com/css?family=Calistoga|Josefin+Sans:400,700|Pacifico&dis
        play=swap" rel="stylesheet">
        <link rel="stylesheet"
        href="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/css/bootstrap.min.css"
        integrity="sha384-
        ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcWr7x9JvoRxT2MZw1T"
        crossorigin="anonymous">
        <link rel="stylesheet" type= "text/css" href= "{{ url_for('static',filename='css/style.css') }}">
        <script src="https://kit.fontawesome.com/b3aed9cb07.js"
        crossorigin="anonymous"></script>
        <script src="https://code.jquery.com/jquery-3.3.1.slim.min.js" integrity="sha384-
        q8i/X+965DzO0rT7abK41JStQIAqVgRVzpbzo5smXKp4YfRvH+8abtTE1Pi6jizo"
        crossorigin="anonymous"></script>
        <script src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.14.7/umd/popper.min.js"
        integrity="sha384-
```

```
UO2eT0CpHqdSJQ6hJty5KVphtPhzWj9WO1clHTMGa3JDZwrnQq4sF86dIHNDz0W1"
crossorigin="anonymous"></script>
<script src="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/js/bootstrap.min.js"
integrity="sha384-
JjSmVgyd0p3pXB1rRibZUAYoIIy6OrQ6VrjIEaFf/nJGzIxFDsf4x0xIM+B07jRM"
crossorigin="anonymous"></script>
<script src="https://cdn.jsdelivr.net/npm/@tensorflow/tfjs@latest"></script>
<link rel="stylesheet"
href="https://cdn.jsdelivr.net/npm/bootstrap@4.6.1/dist/css/bootstrap.min.css">
<script src="https://cdn.jsdelivr.net/npm/jquery@3.6.0/dist/jquery.slim.min.js"></script>
<script
src="https://cdn.jsdelivr.net/npm/popper.js@1.16.1/dist/umd/popper.min.js"></script>
<script
src="https://cdn.jsdelivr.net/npm/bootstrap@4.6.1/dist/js/bootstrap.bundle.min.js"></script>
</head>
<style>
body{
background-image: url('static/images/bc1.jpg');
background-repeat: no-repeat;
background-size: cover;
}
</style>
<script>
function preview() {
frame.src=URL.createObjectURL(event.target.files[0]);
}
$(document).ready(function() {
$('#clear_button').on('click', function() {
$('#image').val('');
$('#frame').attr('src',"");
});
});
</script>
<body>
<h1>HandWritten Digit Recognition System</h1>
<div class="container p-3 my-3 bg-dark text-white">
<p>Handwritten Digit 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 email, posts, cheque etc. Before proper implementation of this technology we have relied
on writing text with our own hands which can result in error.It's difficult to store and access
physical data with efficiency.The project presents in representing the recognization of
handwritten digits (0 - 9) from the famous MNIST dataset. Here we will be using AlexNet
which is an architecture of Convolutional Neural Network.</p>
</div>
```

```
<section id="content">
<div class="leftside">
<form action="/predict" method="POST" enctype="multipart/form-data">
<label>Select a image:</label>
<input id="image" type="file" name="image" accept="image/png, image/jpeg" onchange="preview()"><br><br>
<img id="frame" width="100px" height="100px"/>
<div class="buttons_div">
<button type="submit" class="btn btn-light">Predict</button>
<button type="button" class="btn btn-light">&nbsp Clear &nbsp</button>
</div>
</form>
</div>
</section>
<!--
<h1 class="welcome">IBM PROJECT
<div id="team_id">TEAM ID : PNT2022TMID19491</div>
</h1>
<section id="title">
<h4 class="heading">Handwritten Digit Recognition Website</h4>
<br><br>
<p>
The website is designed to predict the handwritten digit.
</p>
<p>
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.</p>
<br>
<p> Hence, there comes a need for handwritten digit recognition in many real-time applications.
MNIST data set is widely used for this recognition process and it has 70000 handwritten digits.
We use Artificial neural networks to train these images and build a deep learning model.
Web application is created where the user can upload an image of a handwritten digit.
This image is analyzed by the model and the detected result is returned on to UI</p>
</section>
-->
<!--<section id="content">
```

```
<div class="leftside">
<form action="/predict" method="POST" enctype="multipart/form-data">
<label>Select a image:</label>
<input id="image" type="file" name="image" accept="image/png, image/jpeg"
onchange="preview()"><br><br>
<img id="frame" width="100px" height="100px"/>
<div class="buttons_div">
<button type="submit" class="btn btn-dark" id="predict_button">Predict</button>
<button type="button" class="btn btn-dark" id="clear_button">&nbsp Clear &nbsp</button>
<button type="submit" class="btn btn-light">Predict</button>
<button type="button" class="btn btn-light">&nbsp Clear &nbsp</button>
</div>
</form>
</div>
</section>-->
</body>
</html>
```

## PREDICT.HTML

```
<!DOCTYPE
html>
                    <html lang="en">
                    <head>
                    <meta charset="UTF-8">
                    <title>Prediction</title>
                    </head>
                    <style>
                    body{
                    background-image: url('static/images/bc1.jpg');
                    background-repeat: no-repeat;
                    background-size: cover;
                    }
                    #rectangle{
                    width:400px;
                    height:150px;
                    background-color: #000000;
                    border-radius: 15px;
                    position:absolute;
                    box-shadow: 0px 0px 10px 5px white;
                    top:25%;
                    left:50%;
                    transform:translate(-50%,-50%);
                    }
                    #head{
                    text-align: center;
                    font-size: 30px;
                    margin: 0 auto;
                    padding: 3% 5%;
                    font-family: Arial, Helvetica, sans-serif;
                    color: white;
                    }
                    #num{
                    font-size: 50px;
                    }
                    </style>
                    <body>
                    <div id="rectangle">
                    <h1 id="head">Predicted Number : <br><center
                    id="num">{{num}}</center></h1>
                    </div>
                    </body>
                    </html>
```

# GitHub LINK

https://github.com/IBM-EPBL/IBM-Project-24169-1659939062

# PROJECT DEMO LINK

https://drive.google.com/file/d/10Cg3PhxwhsQlSebkfpxSpZenV8lyuSoT/view?usp=sharing