

ALL INDIA SHRI SHIVAJI MEMERIAL SOCIETY'S POLYTECHNIC, PUNE -1

COMPUTER ENGINEERING DEPARTMENT

VISION AND MISSION OF THE INSTITUTE

❖ VISION:

Achieve excellence in quality technical education by imparting knowledge, skills and abilities to build a better technocrat.

❖ MISSION:

M1: Empower the students by inculcating various technical and soft skills.

M2: Upgrade teaching-learning process and industry-institute interaction continuously.

VISION AND MISSION OF THE COMPUTER DEPARTMENT

❖ VISION:

“Enhance skills by providing value based technical education for fulfilling global needs in the field of computer engineering.”

❖ MISSION:

M1: To provide quality education in computer engineering by improving psychomotor skills.

M2: To develop positive attitude, communication skills, team spirit and entrepreneurship.

M3: To develop awareness about societal and ethical responsibility for Professionalism.

COMPUTER ENGINEERING DEPARTMENT

PROGRAM OUTCOMES (POs)

PO1	Basic and Discipline specific knowledge: Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.
PO2	Problem analysis: Identify and analyses well-defined engineering problems using codified standard methods.
PO3	Design/ development of solutions: Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.
PO4	Engineering Tools, Experimentation and Testing: Apply modern engineering tools and Appropriate technique to conduct standard tests and measurements.
PO5	Engineering practices for society, sustainability and environment: Apply appropriate Technology in context of society, sustainability, environment and ethical practices.
PO6	Project Management: Use engineering management principles individually, as a Team member or a leader to manage projects and effectively communicate about well-defined engineering activities.
PO7	Life-long learning: Ability to analyse individual needs and engage in updating in the context of technological changes.

PROGRAM_SPECIFIC OUTCOMES (PSO)

The Diploma in Computer Engineering will prepare students to attain:

- PSO 1:** Use state-of-the-art technologies for operation and application of computer software and hardware.
- PSO 2:** Maintain computer engineering related software and hardware systems.

A PROJECT REPORT
ON
Handwritten Character Recognition System
IN THE PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE AWARD
OF
DIPLOMA IN COMPUTER ENGINEERING
(2022-2023)
BY

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DEPARTMENT OF COMPUTER ENGINEERING

C E R T I F I C A T E

This is to certify that the project report entitles

“ Handwritten Character Recognition System ”

Submitted by

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Is a bonafide work carried out by them under the supervision of **Ms A. A. Shirode** and it is approved for the partial fulfilment of the requirement of MSBTE for the award of the diploma in Computer Engineering.

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External Examiner

Place: Pune
Date:

Acknowledgement

Acknowledgement

With an immense pleasure and satisfaction, I am presenting this Project report as part of the curriculum of Diploma Computer Engineering. I wish to express my sincere gratitude towards all those who have extended their support right from the stage this idea was conceived.

I am profoundly grateful to **Ms A.A.Shirode** , Project Guide, for his expert guidance and continuous encouragement throughout to see that project work right its target since its commencement to its completion.

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Finally, I am also grateful to Honorable **Prof. S. K. Giram**, Principal, AISSMS POLYTECHNIC, Pune, for his support and guidance that have helped me to expand my horizons of thought and expression.

Signature

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ABSTRACT

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In this project we present an innovative method for Handwritten text detection using deep neural networks. In today world it has become easier to train deep neural networks because of availability of huge amount of data and various Algorithmic innovations which are taking place. Now-a-days the amount of computational power needed to train a neural network has increased due to the availability of GPU's and other cloud based services like Google Cloud platform and Amazon Web Services which provide resources to train a Neural network on the cloud. We have designed a image segmentation based Handwritten character recognition system. In our system we have made use of OpenCV for performing Image processing and have used Jupyter, Tensorflowlite and Keras for training a the neural Network with the. We have developed this system using python programming language.

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1.0 INTRODUCTION

PHASE 1

INTRODUCTION

1.0 IDEA OF THE PROJECT:

In today's world AI(Artificial Intelligence) is the new Electricity. Advancements are taking place in the field of artificial intelligence and deep-learning every day. There are many fields in which deep-learning is being used. Handwriting Recognition is one of the active areas of research where deep neural networks are being utilized. Recognizing handwriting is an easy task for humans but a daunting task for computers. Handwriting recognition systems are of two types: Online and Offline. In an online handwriting recognition system the handwriting of the user is recognized as the user is writing. The information like the order in which the user has made the strokes is also available. But in offline handwriting recognition system, the handwriting of user is available as an image. Handwriting recognition is a challenging task because different people have different styles of writing, and there are lot of characters like Capital letters Small letters, Digits and Special symbols. Thus a large dataset is required to train a near-accurate neural network model. To develop a good A system an accuracy of atleast 98% is required. However even the most modern and commercially available systems have not been able to achieve such a high accuracy. That's why we have chosen our Capstone Project topic as offline handwritten character system which will provide high accuracy rate.

1.1 MOTIVATION OF THE PROJECT:

The motivation behind a handwritten character recognition system project is to create a system that can accurately recognize and interpret handwritten characters. This project is motivated by the need to improve the efficiency and accuracy of tasks that involve handwritten text, such as digitizing handwritten documents, recognizing handwritten text on forms or surveys, or translating handwritten notes into digital text.

The motivation for this project is rooted in the challenges associated with recognizing handwritten characters, which can vary significantly in style and shape from one individual to another. Traditional optical character recognition (OCR) systems may not be able to recognize handwriting accurately, leading to errors and inaccuracies in the output.

The handwriting recognition system can have a significant impact on industries such as healthcare, finance, and education, where handwriting is still used as the primary means of communication or data input. The system can automate the process of transcribing and digitizing handwritten text, saving time and reducing errors.

Overall, the motivation for a handwritten character recognition system project is to improve the efficiency and accuracy of tasks that involve handwritten text and to enable new applications that rely on accurate handwriting recognition

1.2 BREIF DESCRIPTION:

What is Handwritten Character Recognition System ?



Fig 1.1 Logo of Handwritten character recognition system

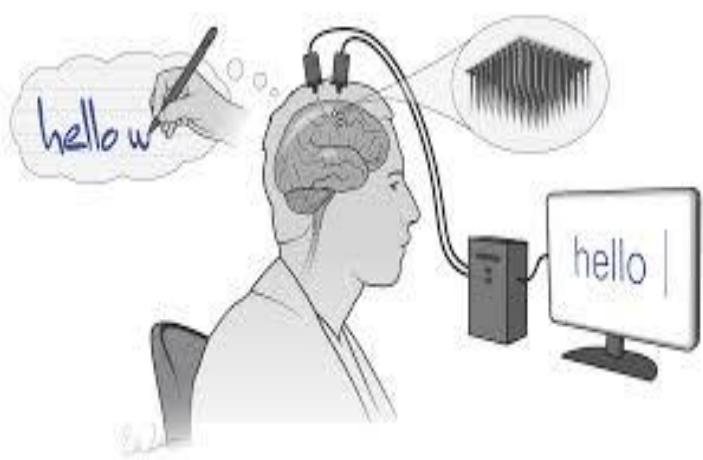


Fig 1.1 Concept of Handwritten character recognition system

Handwritten character recognition is the process of converting handwritten text into digital format. It has become increasingly important in today's world as more and more information is being recorded digitally.

Offline handwritten character recognition system is an innovative technology that can recognize and interpret handwritten characters without the need for an internet connection.

This technology has a wide range of applications, including document analysis, digitization, and data entry.

An offline handwritten character recognition system is a software application that uses machine learning algorithms to recognize handwritten characters from scanned images or photos. The system typically consists of several modules, including image preprocessing, feature extraction, and classification.

The image preprocessing module is used to enhance the quality of the input image, which may include steps such as noise removal, binarization, and segmentation. The feature extraction module is responsible for extracting relevant features from the preprocessed image, such as stroke width, curvature, and orientation. These features are then used by the classification module, which identifies the characters based on the extracted features and a pre-trained model.

The pre-trained model is created using a dataset of handwritten characters, which is used to train the machine learning algorithms. The dataset may be created by collecting data from various sources, such as online handwriting samples, digitized documents, or specialized datasets for specific

languages or scripts.

Once the system identifies the handwritten characters, it may perform additional post-processing steps, such as spell-checking, character segmentation, or handwriting recognition feedback to improve the accuracy of the recognition process.

Overall, an offline handwritten character recognition system can bring significant benefits to various industries by automating the process of reading and analyzing handwritten text, improving efficiency and accuracy, and saving time and resources.

Implementation :

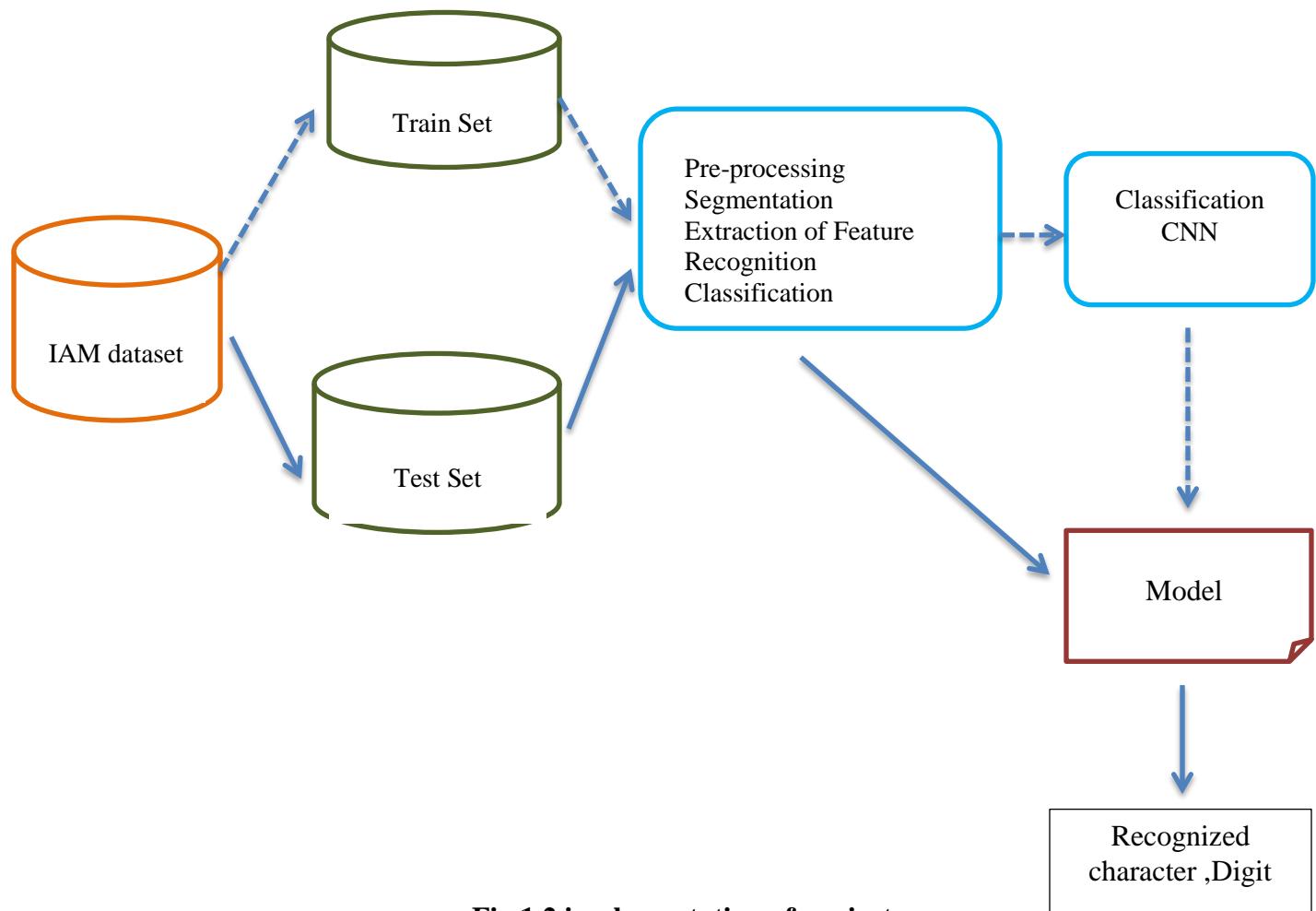


Fig 1.2 implementation of project

The working of offline handwritten character recognition system can be summarized in the following steps:

- ❖ Data Collection: The first step is to collect a large dataset of handwritten characters. This dataset is used to train the model to recognize different characters.
- ❖ Preprocessing: The input image is preprocessed to remove noise, normalize the image size, and

enhance the contrast.

- ❖ Feature Extraction: The preprocessed image is fed into a feature extraction algorithm, such as a convolutional neural network (CNN), to extract the relevant features from the image.
- ❖ Training: The extracted features are used to train a machine learning model, such as a support vector machine (SVM), to recognize the characters.
- ❖ Testing: The trained model is then tested on a separate dataset of handwritten characters to evaluate its accuracy and performance.
- ❖ Deployment: Once the model is trained and tested, it can be deployed in a production environment to recognize characters in real-world applications.
- ❖ Continuous Improvement: The model can be continuously improved by collecting more data, refining the feature extraction algorithm, and fine-tuning the machine learning model. This helps to improve the accuracy and performance of the system over time.

What is CNN ?

Convolutional Neural Networks (CNN) is a deep learning algorithm that is commonly used for image recognition, object detection, and other computer vision tasks. CNNs are particularly effective in processing large amounts of image data, making them ideal for tasks such as image classification, segmentation, and feature extraction.

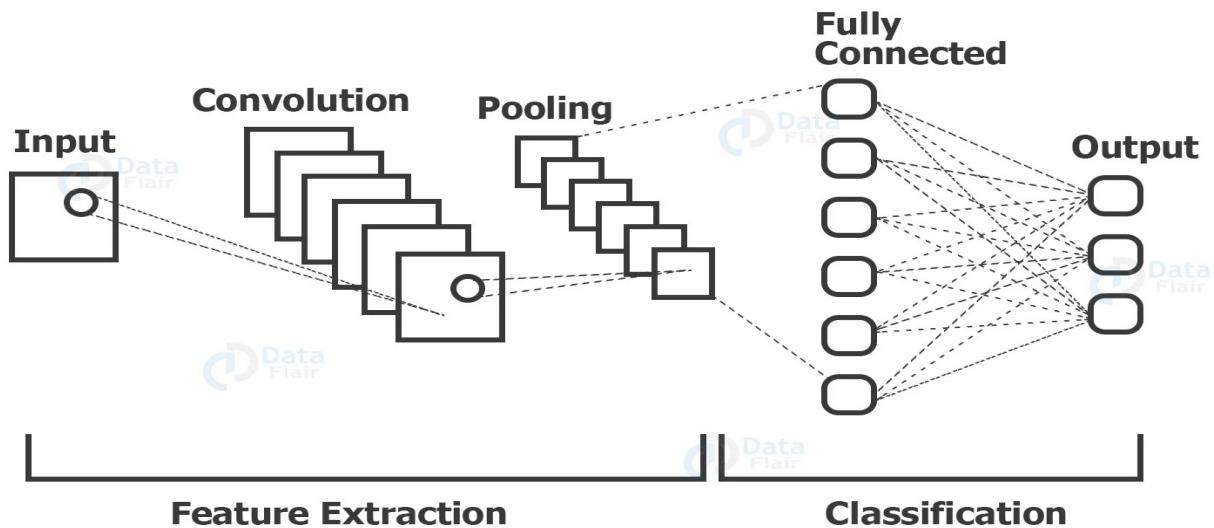


Fig 1.3 CNN algorithm

The architecture of a CNN consists of multiple layers, including convolutional layers, pooling layers, fully connected layers, and activation functions. The first layer of a CNN is a convolutional layer, which applies a set of filters to the input image to detect features such as edges, corners, and textures. Each filter is a small matrix that is convolved with the input image, producing a feature map that represents the response of the filter at each position in the image.

The output of the convolutional layer is then passed through a non-linear activation function, such as ReLU (Rectified Linear Unit), which introduces non-linearity into the model and helps to improve its

accuracy. After the activation function, the output is passed through a pooling layer, which reduces the size of the feature maps by aggregating nearby values. Pooling helps to reduce the computation required for the subsequent layers and makes the model more efficient.

The final layers of a CNN are typically fully connected layers, which are used to classify the input image into one of several categories. The output of the pooling layer is flattened into a one-dimensional vector and passed through several fully connected layers, each of which applies a linear transformation to the input followed by an activation function. The final layer is a softmax layer, which produces a probability distribution over the different classes, indicating the likelihood that the input image belongs to each class. During the training process, the CNN is fed with a large dataset of labeled images, which are used to update the weights of the network using backpropagation. This process involves computing the gradients of the loss function with respect to the weights of the network and adjusting the weights in the direction of the gradient to minimize the loss.

Overall, CNNs have revolutionized the field of computer vision and have led to significant advances in image recognition, processing, and classification. Their ability to automatically learn complex features from raw input data has made them a powerful tool for a wide range of applications.

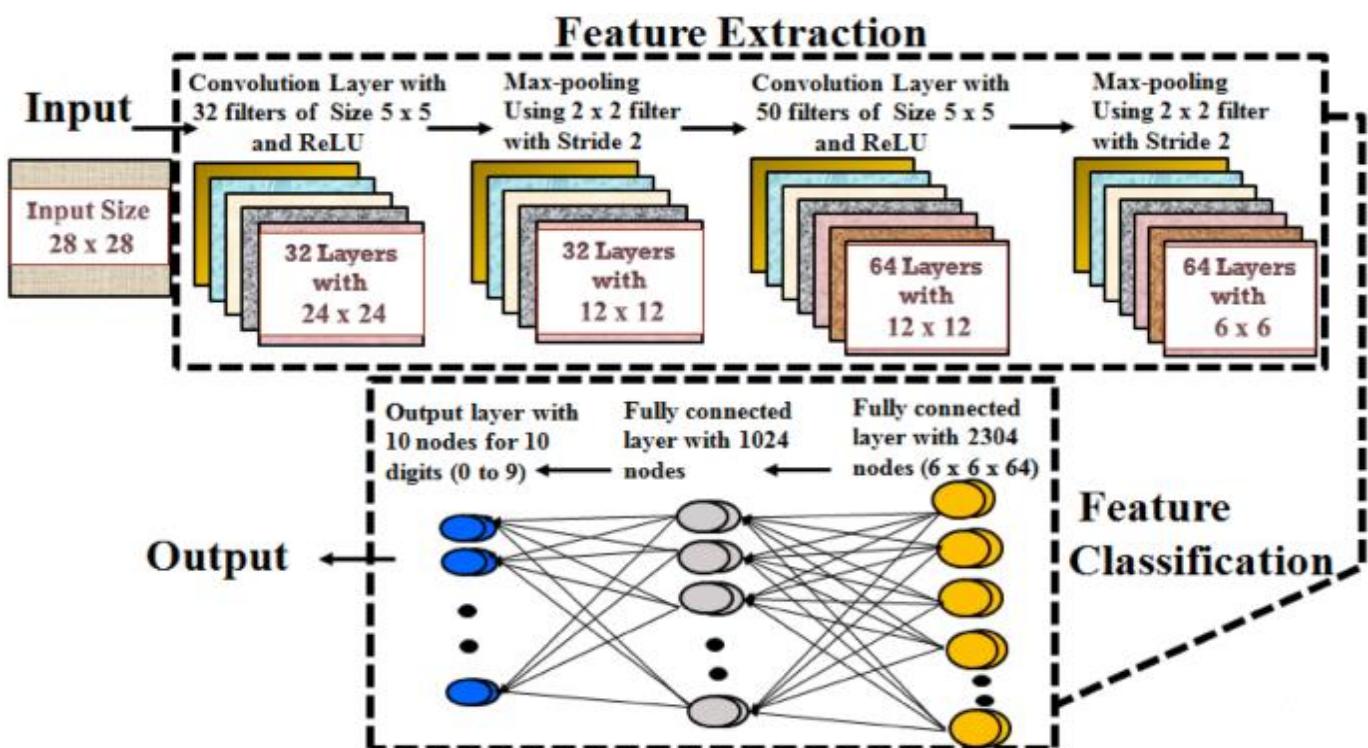


Fig 1.4 Feature Extraction

- ❖ **Input Image:** The input to a CNN is a 2D array of pixels representing an image.
- ❖ **Convolutional Layers:** The input image is convolved with a set of filters to produce a set of feature maps. Each filter slides over the input image, computing the dot product between its weights and a small patch of the image at a time, producing a single value in the output feature map. The number of filters and their size are hyperparameters that are determined during the design of the CNN.
- ❖ **Activation Function:** The output of the convolutional layers is passed through an activation function,

such as ReLU, which applies a non-linear transformation to the output of each neuron in the layer. This introduces non-linearity into the model and enables it to learn more complex patterns in the data.

- ❖ Pooling Layers: The output of the activation function is typically passed through a pooling layer, which downsamples the output of the convolutional layers by aggregating nearby values. The most common pooling operation is max pooling, which selects the maximum value in each pooling region.
- ❖ Fully Connected Layers: The output of the pooling layers is flattened into a 1D vector and passed through one or more fully connected layers. These layers apply a linear transformation to the input, followed by an activation function.
- ❖ Output: The final layer of the CNN is a fully connected layer with a softmax activation function, which outputs a probability distribution over the classes in the dataset. The class with the highest probability is chosen as the predicted class for the input image.
- ❖ Training: During training, the weights of the CNN are updated using backpropagation and gradient descent. The objective is to minimize a loss function that measures the difference between the predicted output of the CNN and the true label of the input image.
- ❖ Prediction: During prediction, the input image is fed forward through the CNN, and the predicted class is output based on the probabilities computed by the final softmax layer.

Literature Survey

A. Neural networks for the recognition of the handwritten English alphabet

Neural Networks are used by the journal to acknowledge the handwritten alphabets in English. The alphabets are shown as

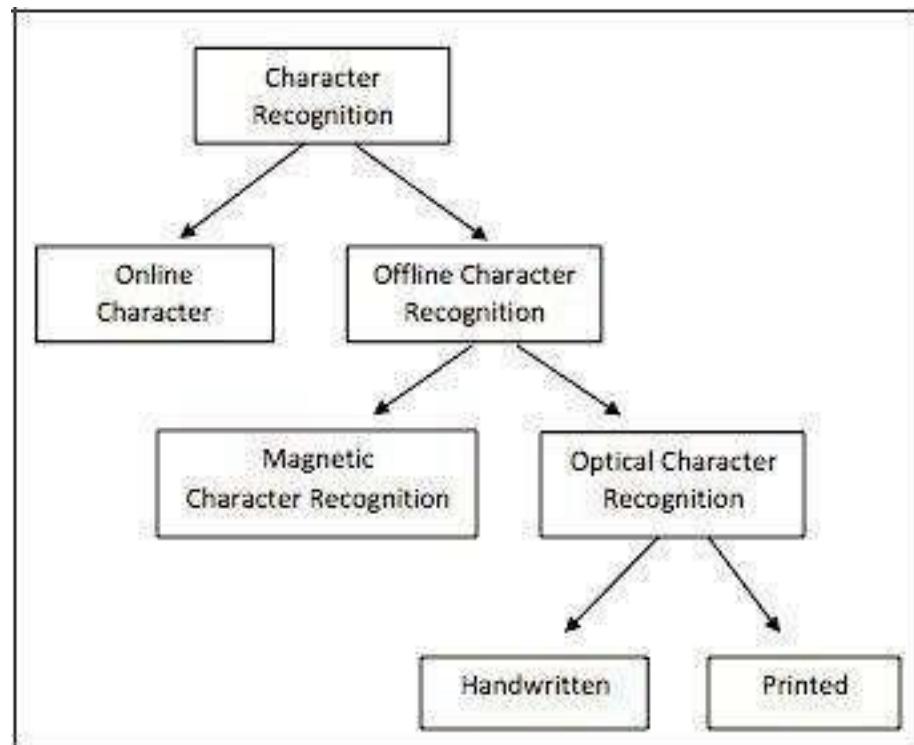


Fig 1.5 Types

binary values in the form of 0 and 1. These binary images are then used as an input to the extraction stage of the function, and this phase's output is supplied as an input in the scheme of Neural Network. In the experiments conducted, similar alphabets appeared to be misclassified as the data set on which the tests were conducted was small. The bigger the information set, the more precise outcomes would be generated by the scheme.

A. Direction Based Extraction of Feature

Paper introduces a feature extraction technique to acknowledge handwritten characters, which is referred to as the direction feature.

The method of extracting the characteristics of the segmented characters has shown better outcomes compared to the extraction method for the transition function and other methods. The identification rate has been shown to be above eighty percent experimentally. The characters are automatically segmented from the benchmark CEDAR (Cursive Digit and Character Recognition).

B. Diagonal-based system for extraction of neural net- works

Using a fresh method called the diagonal function extraction technique, the characters in this document are acknowledged. Two methods were used, first with 54 characteristics and second with 69 characteristics that formed the character recognition scheme of the Neural Network. The diagonal extraction method was compared to traditional horizontal and vertical extraction methods by the practice

of the neural network using both methods. Six neural detection networks have been developed in the process. The findings disclosed experimentally that 69 characteristics provided a higher precision rate than 54 characteristics. The scheme described in the journal seems ideal for conversion into structural format of handwritten text files.

A. Handwritten recognition of English character using neural networks

The article shows the use with the Back Propagation Algorithm of Feed Forward Algorithm. We document uses a multilayer perceptron with 1 hidden layer to effectively recognize characters. When the quantity of hidden nodes to be used is efficiently determined, a greater effectiveness can be achieved in back propagation. The recognition of character proves better and provides a precision of seventy percent or more for hand-written digits and English alphabets.

B. Techniques for digital image processing in recognition of character

The paper outlines the various steps of picture processing in character recognition, such as restoration of images, improvement of images, segmentation, characteristic extraction, and classification of recognition. Because of its elevated tolerance to noise, these methods are used together with Neural Network. This helps remove all undesirable signals in distorted pictures over the years. Successful identification of characters is also feasible for such papers and ideal outcomes are generated by the systems.

C. Recognition of character using a neural network

Neural networks are used in this article to identify alphabets and digits. As the scheme is created for English characters in isolation i.e (A to Z), it increases recognition rate. The document uses technique of feeding forward propagation and the NN is trained for classifying and acknowledging characters using Back Propagation. The English alphabets and digits are depicted in the binary form as they are then supplied for further processing to the Neural Network. Cursive handwriting is not recognized by this paper.

A. Handwritten recognition of digits

The paper compares the characteristics vectors, it is proven that The extraction techniques of features are better than their baseline counterparts. The technique of gradient extraction works best for gray scale images, which produce a very precise character rate and also outcomes in an outstanding result from normalization-cooperated feature extraction. The gradient extraction method is applied to the grey pictures and the extraction methods of other features are applied on the binary image. The combination of extraction of feature along with normalization has been shown to produce greater precision rates of recognizing personality.

II. Phases of recognition of character

Handwritten recognition is usually split into six stages: picture acquisition, pre - processing, segmentation, extraction of features, classification, and post-processing.

A. Acquisition of Image

The first stage of HCR is the acquisition of images. Acquiring a picture from a camera or scanner is a technique. The picture is in a defined file format, say JPEG, PNG. The picture input may be cultured, grey, or binary. The acquisition stage comprises input image-processing, compression, depot and display. The user submitted picture will have certain limitations to adhere to. The limitations may differ to improve the precision rate of character recognition for distinct algorithms.

B. Pre-Processing

With vision to improve a picture for further processing, the pre-processing stage includes distinct operation phases. Preprocessing involves reducing noise, binarizing, detecting edges and thresholding

You can remove unwanted noise signals from an image by using suitable filters. This filter may be a medium filter, a max filter or a Gaussian filter, etc. for removing noise from an image.

C. Reducing Noise

Noise is the haphazard variation in a picture's brightness or color intensity that is not present in the picture's initial object. The scanned input picture includes noise and may even be of reduced quality which might not result in a required consequence being adequate. The preprocessing stage involves the removal undesirable noise signals and enhancing image quality for the next following processing stages.

If noise signals between sections of the lines are not removed, great gaps will arise; these noises should be removed to obtain all the significant data. In a bunch of pictures, one of them might have many noises.

D. Binarisation

Binarisation is a process in which the alphabet/digit image is converted into 0 and 1 form. Performing on grays Cal pictures is an significant phase. The stage of character segmentation and pattern recognition becomes simpler once the binarisation method is performed in a fruitful way.

A. Edge Detection

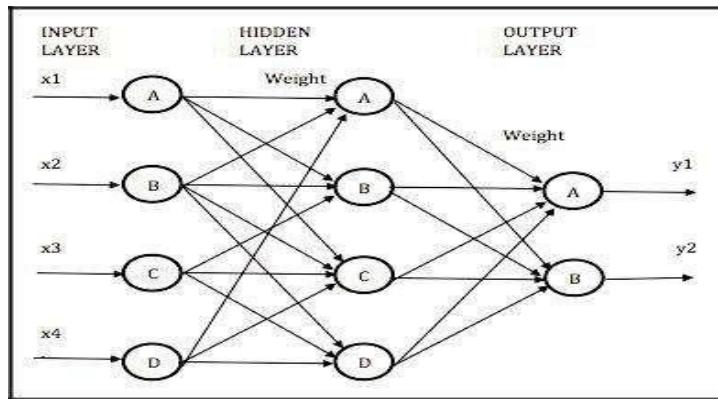
Edges is defined as an object's limit; so, in stages such as detection and segmentation, these object limits are helpful. Edge detection enables filter all aberrations cut unnecessary amount of data-information, while maintaining all of significant picture characteristics. There are multiple ways in which detection of edge can frequently be done in either Gradient or Laplacian classification. In the first derivative of a picture, analyzing the maximum and minimum detects the corners in the gradient method. Searching for the zero crossings in the second derivative is to identify edges in a picture

B. Thresholding

The coloured or grey pictures are in binary form to enhance the processing speed and decrease storage requirements ; that is, as a binary image representing 1 for each value above a selected threshold and 0 represents everything below.

C. Segmentation

The precision of the effective identification of personality depends on the precision of the segmentation carried out. The words are divided into single letters. A character is segmented from



the beginning to the end of the character. It is possible to further classify segmentation into external-internal segmentation. External segmentation is described as the de-composition into logical units of the page layout. A significant aspect of document analysis is external segmentation. Internal Segmentation is described as the decomposition of a picture into sub-image sequence of characters.

D. Feature Extraction

The technique of collecting significant materialistic information from the content of raw information. Important materialistic information is the accurate and effective depiction of characters. The set of characteristics obtained from raw information is referred to as feature extraction to maximize the character recognition rate including the least quantity of components.

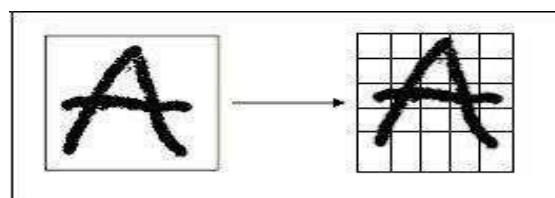
Extraction of features is not only a significant stage in the recognition of characters but also in any application for pattern recognition. Techniques such as Scale Invariant Feature Extraction (SIFT), Linear Discriminant Analysis (**LDA**), Histogram, Principle Component Analysis (PCA), Chain Code (CC), Extraction-based Gradient are used to obtain needed and helpful information characteristics. To train a system for executing pattern recognition jobs, these characteristics are essential.

E. Zoning

In the zoning phase, the character picture is split into $L \times B$ areas. Every feature is obtained from the feature vector in each area. Zoning is referred to as the technique of gaining local features leaving out worldwide features.

F. Diagonal Feature Extraction

Extraction of diagonal-oriented characteristics is a fresh technique introduced to extract handwritten alphabet characteristics.



It primarily operates to acknowledge handwritten characters offline. For example, consider a size 80x50 pixel character picture that is further split into 54 areas, each area having a size of 10x10 pixels. The characteristics are obtained in each area by shifting across the area diagonal. Each area has D amount of diagonal rows and to extract a single function, the foreground pixels on the diagonal are added up. Extracting D amount of sub-functions from every area.

E. Classifications and Recognition

When feeding an input picture into the character recognition scheme, every-important characteristic is obtained and input as an artificial neural network into a trained classifier. To locate the suitable match class for the input picture, a comparison of the input characteristics with stored patterns is made. With the assistance of classifiers, this is achieved. Classification of test samples requires correctly labeled training data.

F. Matching Template

Matching of templates is said to be a prototype scheme. This scheme is used by comparing two or more pictures to effectively identify alphabets, numbers and characters. It is recognized as a model of that picture for finding a sub-image in a picture. This method is called matching template. Their centers assist to determine the registration parameters after discovering a amount of templates. The template matching method is to determine the similarities of the same size picture in a template (sub-image) and window.

G. Parametric Recognition

As the previous information of characters about data collection is already accessible, a parametric model can be obtained for each individual personality. The classification of characters is made on the grounds of decision rules based on the probabilities acquired.

H. Neural Network

To conduct duties of recognition and classification, an Artificial Neural Network (ANN) is used. The Artificial Neural Networks is now counted among the finest instruments for classification and strong character recognition in offline systems. Neural networks are split into two designs that are primarily feed-forward and feed-back networks. Depending on the algorithm used, the feed-forward network has one or more concealed layers. Multiple neuron layers with transfer features allow the network to understand and recognize various linear and nonlinear vector interactions.

To obtain pattern recognition of handwritten characters, the NN architecture is used here. The classifier includes several smaller sub-networks, a 3-layer sub-network.

2.0 ANALYSIS

PHASE 2

ANALYSIS

2.1.0 PROJECT PLAN:

2.1.1 PROJECT ESTIMATE:

The estimation of project can be carried out depending upon the feasibility study of all the service (i.e. modules) which is included in our project. The numbers of lines of code, Function points are used for calculations of estimate. Since with the feasibility study for our project, it can be designed and developed within 5 - 6 months. The different stages like communication, planning, modeling, construction and deployment of waterfall model are used at every stage.

Reconciled Estimates

- Requirement collection and analysis – 2 months.
- Feasibility study - 2 month.
- Design - 2 month.
- Coding and testing - 3 months.
- Deployment - 1 month.

2.1.2 COST ESTIMATE:

Cost of a project is estimated using current estimation models such as Line of Code, Number of classes which allows us to estimate cost as a function of size. Thus, it also allows us to estimate and analysis the feasibility of the system in given time frame. As this project is developed completely using Python Language, the expenditure during development are only the efforts made by the developer for the successful completion of the project

2.1.3 TIME ESTIMATES:

SR.NO	DURATION	TASKS
1.	18- August -2022 To 30 August 2022	Selection of domain
2.	5 -September -2022 To 15-September-2022	Topic selection
3.	16-September-2022 To 22 –September-2022	Base paper selection.
4.	21-September-2022 To 30-September-2022	Literature Survey.
5.	3-October-2022 To 7-October-2022	Requirement collection
6.	1-November-2022 To 25-November -2022	Project proposal plan.
7.	First week of December 2022	Presentation on project Plan.
8.	Fourth Week of December 2022	Module design.
9	06-February-2023 To 21- February -2023	GUI
10	22- February -2023 To 03-March-2023	Implementation.
11	04- March -2023 To 31- March -2023	Testing.
12	03-April-2023 To 17-April-2023	Installation of application
13	17-April-2023	Final Project presentation

Gantt chart

Activity	W3	W4	W5	W2	W3	W4	W5	W2	W1	W2	W3	W4
Selection of domain												
Topic selection												
Base paper selection												
Existing system												
Requirement collection from Industry												
Project proposal plan.												
	August			September				Oct	November			

Figure : Gantt chart of Action Plan

Activity	W1	W4	W2	W3	W4	W5	W1	W2	W3	W4	W5
Presentation on project Plan											
MSBTE W-2022 Exam for CPP											
Module design.											
GUI.											
Implementation											
	December			February				March			

Figure : Gantt chart of Action Plan

2.2.0 SOFTWARE REQUIREMENT SPECIFICATION:

Software Used	Version of Software
Python	3.8.10
Cv2	4.7.0
Numpy	1.23.5
Keras	2.11.0
TensorFlow	2.11.0
Pandas	1.4.4
Matplotlib	3.5.2

2.2.1 PURPOSE AND SCOPE OF DOCUMENT:

The purpose of this documentation part in SQA is to describe each of the work products produced as part of the software processes.

Overview of Responsibilities of Developer

The team comprises of 4 members for development of the project. We all have different sets of knowledge; experience regarding the material used for the projects i.e. Knowledge of python programming language, Knowledge of testing and etc.

Member 1 - Documentation and most of the non-technical work.

Member 2 - Non-technical planning and coding.

Member 3 - Technical planning and coding, Documentation.

Member 4 - Technical planning and coding, Documentation

2.3.0 PROBLEM DEFINITION AND SCOPE:

2.3.1 PROBLEM STATEMENT:

To develop an accurate and reliable system that can identify handwritten characters with high precision and speed.

Goals and Objectives

The objective is to create a system that can automatically recognize the handwritten characters on bank cheques and other documents, thereby reducing the need for manual processing and increasing efficiency

Statement of Scope

- User have to install our app in his/her device.
- User have to upload image of text which he/she have to predict or recognize.
- Application will provide accurate prediction of text.
- This application is able to predict Handwritten English/Hindi/Marathi number, Handwritten English/Marathi/Hindi character.

2.3.2 METHODOLOGIES OF PROBLEM SOLVING AND EFFIENCY ISSUES:

Many numbers of handwritten papers, forms and controls are held up by organisations over the years. These handwritten paper papers may also be distorted over the years and may no longer be useful. To maintain such handwritten paper files, it would decrease the recovery process if transformed to a digital format and also make it simpler and safe to handle such files. The recognition of optical character sometimes does not recognize the written text because the style of writing differs from one person to another. An OCR's primary job is to effectively distinguish and acknowledge printed text. OCR covers the following stages: pre-processing, segmentation, extraction of features and recognition classification. The one- phase output acts as an input for the next phase.

2.3.3 OUTCOME:

- High Accuracy of prediction
- Less human efforts
- More Efficiency
- User friendly
- No internet required (offline)

2.3.4 APPLICATIONS:

Banking and finance: Handwritten character recognition systems can be used to process checks and other financial documents quickly and accurately, reducing the need for manual processing and improving efficiency.

- **Education:** Handwritten character recognition systems can be used to automatically grade exams and assessments, saving teachers time and reducing the risk of errors.
- **Healthcare:** Handwritten character recognition systems can be used to digitize patient records and prescriptions, making it easier to store, access, and share medical information.
- **Logistics and shipping:** Handwritten character recognition systems can be used to automatically process shipping labels and other documents, improving the speed and accuracy of package delivery.
- **Legal:** Handwritten character recognition systems can be used to process legal documents, such as contracts and court records, making it easier to search and analyze large volumes of text.
- **Postal services:** Handwritten character recognition systems can be used to sort and process mail, improving the speed and accuracy of delivery.

Overall, the application of handwritten character recognition systems can help automate tasks that involve handwritten text, improving efficiency, accuracy, and productivity across a wide range of industries and fields.

2.3.5 HARDWARE RESOURCES REQUIRED:

The minimum hardware configuration required is :

Hardware resources Used	Specifications
Processor	Intel (any version)
RAM	4 GB or above
Hard Disk	50 GB or above
Machine	Laptop or Computer

2.3.6 SOFTWARE RESOURCES REQUIRED:

The minimum software configuration required is :

Software Used	Version of Software
Python	3.8.10
Cv2	4.7.0
Numpy	1.23.5
Keras	2.11.0
TensorFlow	2.11.0
Pandas	1.4.4
Matplotlib	3.5.2

3.0 DETAILS OF DESIGN, WORKING AND PROCESSES

PHASE 3

DETAILS OF DESIGN, WORKING AND PROCESSES

3.1 PROPOSED MODEL FOR HANDWRITTEN CHARACTER RECOGNITION SYSTEM :

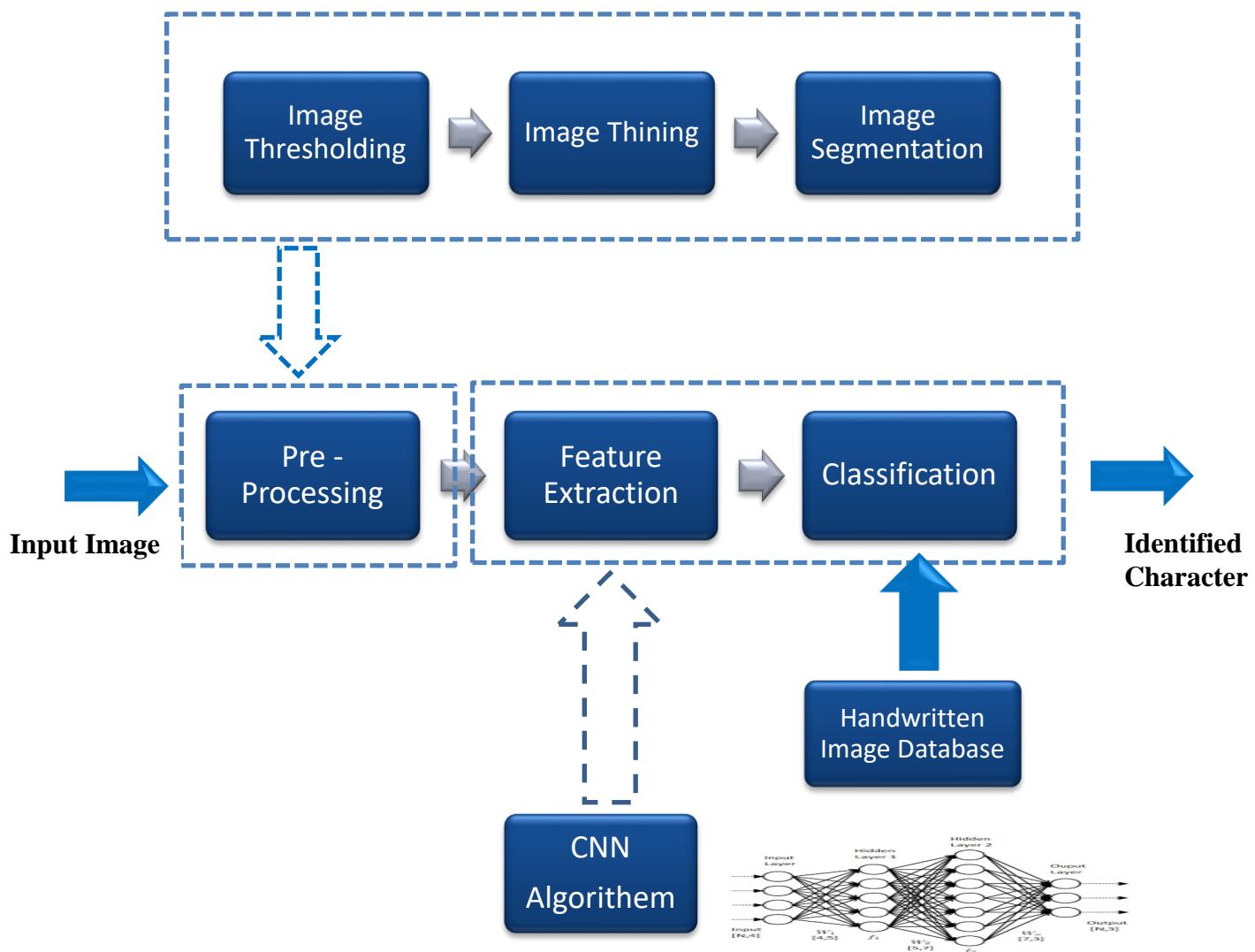


Fig : Proposed Model of Handwritten Character Recognition System

Data preprocessing: This involves preparing the input data, such as scanned images of handwritten text, for further analysis. This may include tasks such as image enhancement, noise reduction, and segmentation of individual characters.

Feature extraction: This involves identifying relevant features from the preprocessed input data that can be used to classify the characters. Common features include stroke width, curvature, and aspect ratio.

Classification: This involves using machine learning algorithms or other methods to classify the input characters based on the extracted features. Common classification methods include conventional neural networks (CNNs).

Post-processing: This involves refining the output of the classification stage to improve the overall accuracy and consistency of the system. This may include tasks such as error correction and character grouping.

3.2 USE CASE DIAGRAM :

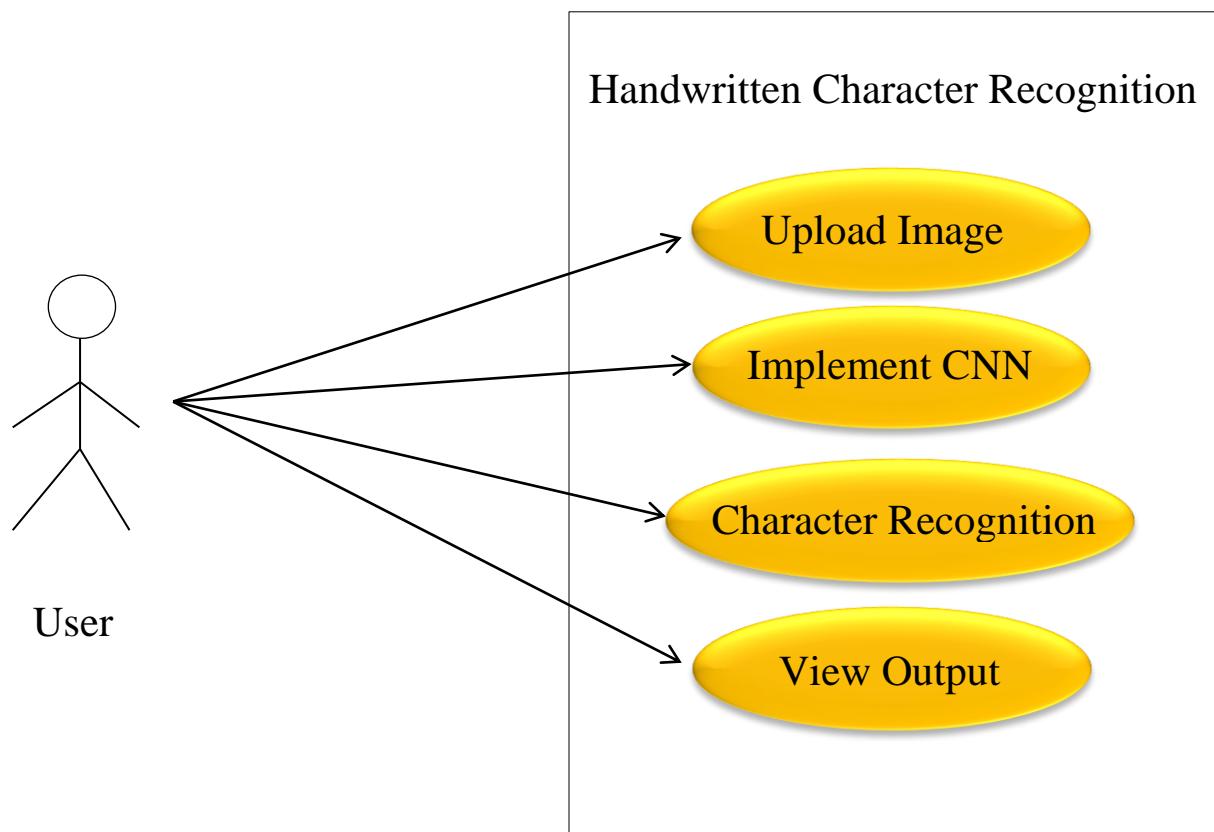


Fig : Use Case Diagram

3.3 DATA DESCRIPTION:

IAM Handwriting Database : We have used IAM Handwriting Database to train model our project not required internet

3.4 DATA OBJECTS AND RELATIONSHIPS:

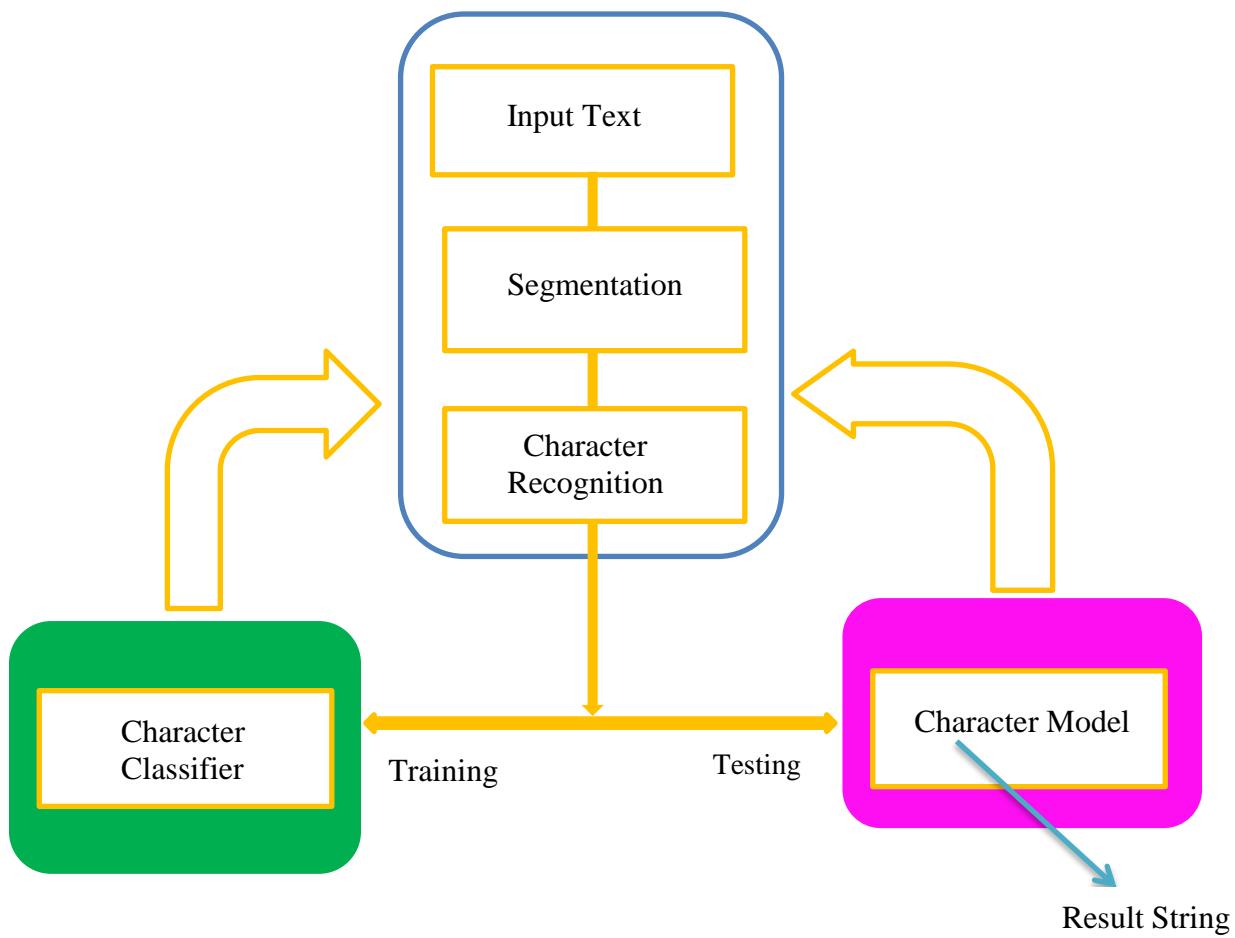
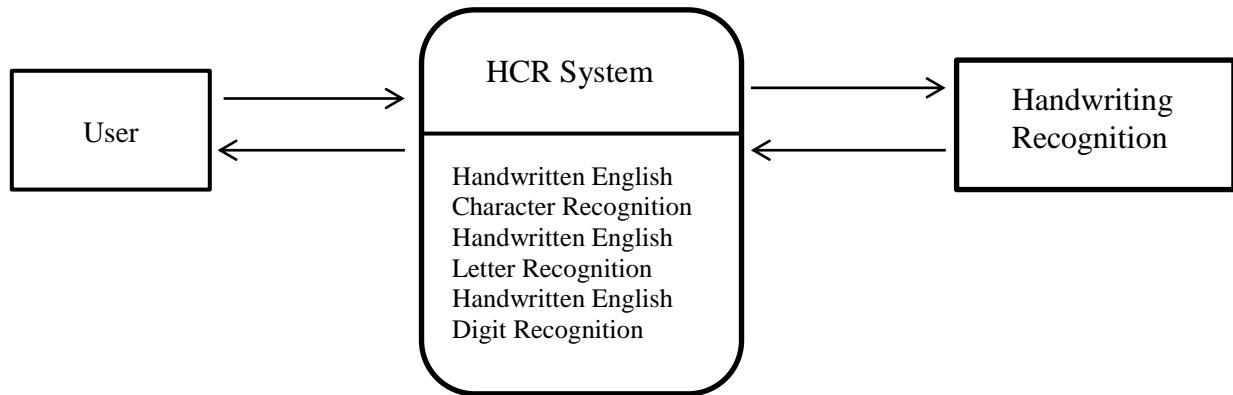


Fig : Relationship Diagram

3.5 DATA FLOW DIAGRAM:**Fig : Level 0 DFD**

The user gives the input in the form of image this image is recognized by the HCR application.

3.6 FLOW CHART:

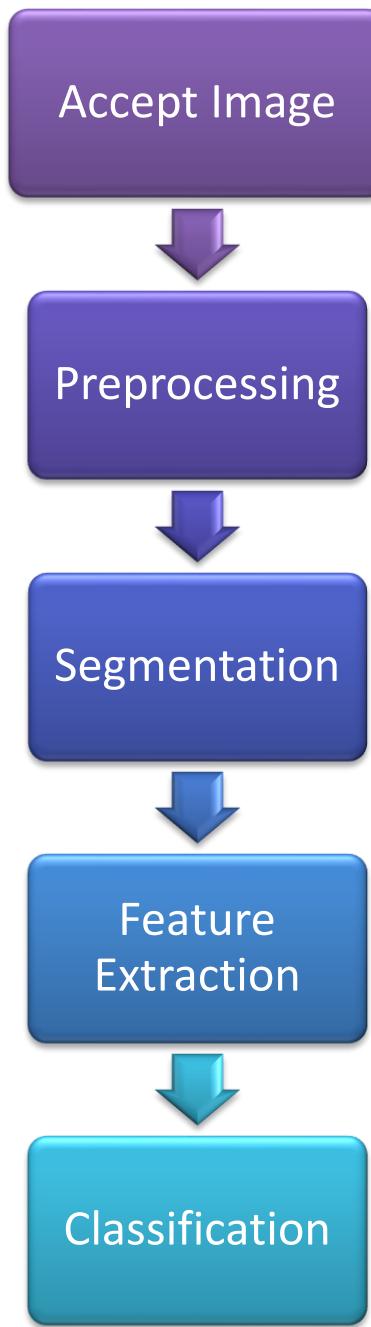


Fig : Flow Chart

3.7 SYSTEM ARCHITECTURE:

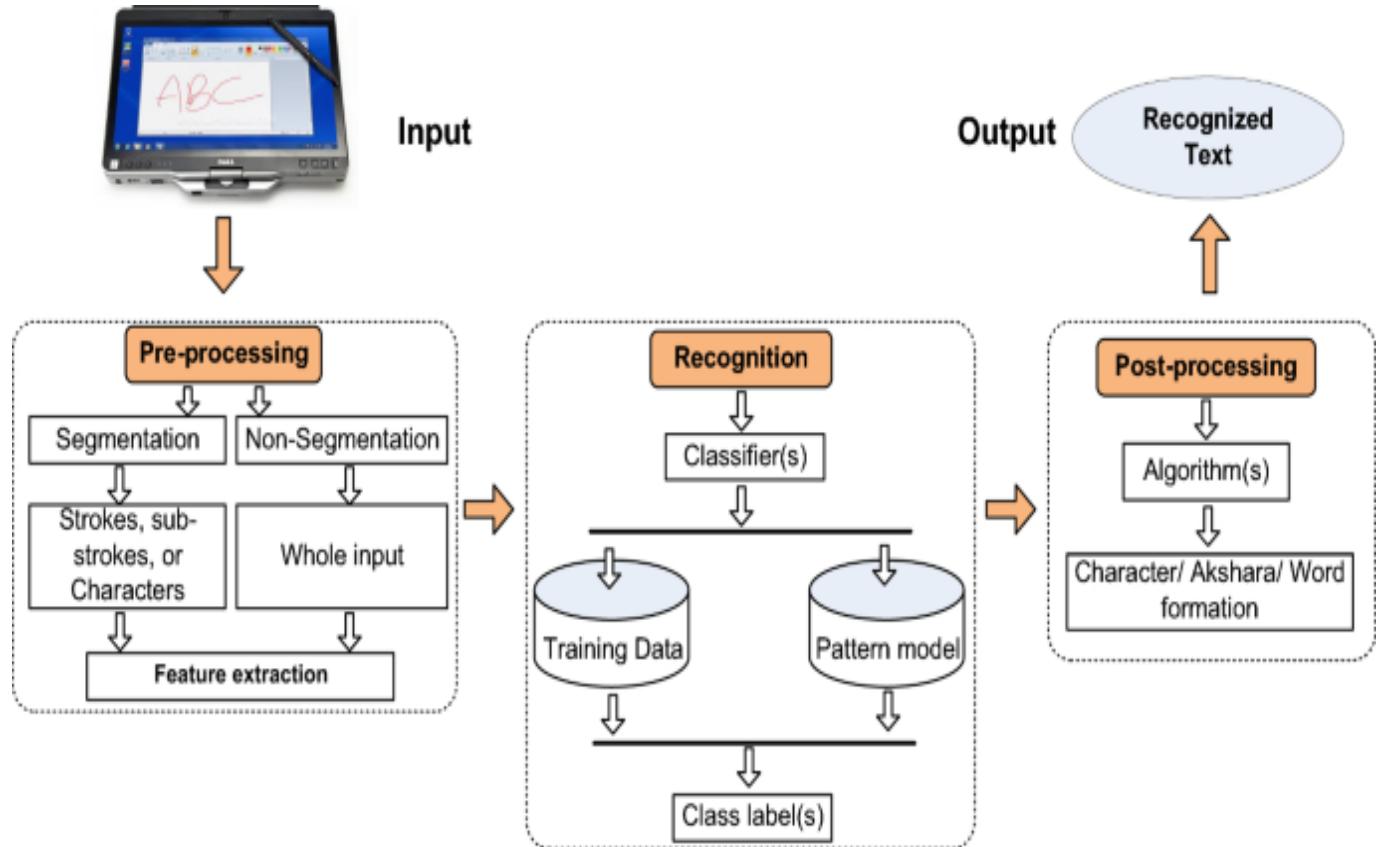


Fig : System Architecture

3.8 SOFTWARE IMPLEMENTATION:

Python

Python is an interpreter, high-level, general-purpose programming language. Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object-oriented, imperative, functional and procedural, and has a large and comprehensive standard library. Rather than having all of its functionality built into its core, Python was designed to be highly extensible.

Jupyter notebook

Jupyter Notebook is an open-source web application that allows you to create and share documents that contain live code, equations, visualizations, and narrative text. It is used for data cleaning and transformation, numerical simulation, statistical modeling, data visualization, machine learning, and much more.

To use Jupyter Notebook, you need to install it on your computer or use a cloud-based service such as Google Colaboratory, Microsoft Azure Notebooks, or IBM Watson Studio. Once installed, you can create a new notebook and start working by creating code cells and adding text and visualizations using markdown language. You can also save and share your notebooks with others, allowing for collaboration and reproducibility.

Functions()

Following are the operations performed on the input in the system: Recognize ():

- pd.read_csv() = use to read path of csv file
- data.head() = use to display rows
- drop() = use to drop coloums
- split(X, y, test_size)= use to split x,y coordinate
- reshape() = use to custom image
- shuffle() = use to shuffle image.
- Subplots() = use to creates a new figure and returns a tuple containing a figure object and an array of subplots.
- flatten() = use to returns a copy of the array with all of its elements flattened into a single dimension.
- Threshold() = It is used to create a binary image from a grayscale or color image by setting all

pixels above or below a certain threshold value to either 0 (black) or 1 (white).

- Imshow() = use to display image.
- Zeros() = used to create an array filled with zeros.
- values() = used to return a NumPy representation of a pandas object.
- Barh() = used to create a horizontal bar chart.
- Grid() = used to display grid lines on a plot.
- show() = used to display a plot on the screen.
- to_categorical() = used to convert a class vector (integers) to binary class matrix.
- Sequential() = used to create a linear stack of layers in a neural network.
- Conv2D() = used to add a 2D convolutional layer to a neural network.
- MaxPool2D() = used to add a 2D max pooling layer to a neural network.
- Flatten() = used to flatten the output of a convolutional layer or a max pooling layer into a one-dimensional vector.
- Fit() = used to train a neural network model.
- summary() = used to print a summary of a neural network model.
- Save() = used to save a trained neural network model to a file.

Features

Following is the list of some implemented features,

1. Text recognition: The primary function of offline OCR is to recognize text in images and scanned documents. The OCR software identifies and extracts text from the image, and then converts it into machine-readable text that can be used for further analysis or processing.
2. Image preprocessing: Offline OCR often includes image preprocessing features, such as noise reduction, deskewing, and contrast enhancement, which can help improve the accuracy of text recognition.
3. Batch processing: Offline OCR can process multiple images or documents in a batch, which can save time and improve efficiency.
4. Customization: Some offline OCR software allows users to train the software on specific fonts, characters, or handwriting styles, which can improve the accuracy of text recognition for specific use cases.
5. Export formats: Offline OCR software can export the recognized text in a variety of formats, such as plain text, formatted text, or searchable PDF, which can be used for further analysis or processing.
6. Integration: Some offline OCR software can be integrated with other software applications or workflows, which can automate the process of text recognition and streamline workflows.

4.0 RESULTS AND APPLICATION

PHASE 4
RESULTS AND APPLICATION

RESULTS :

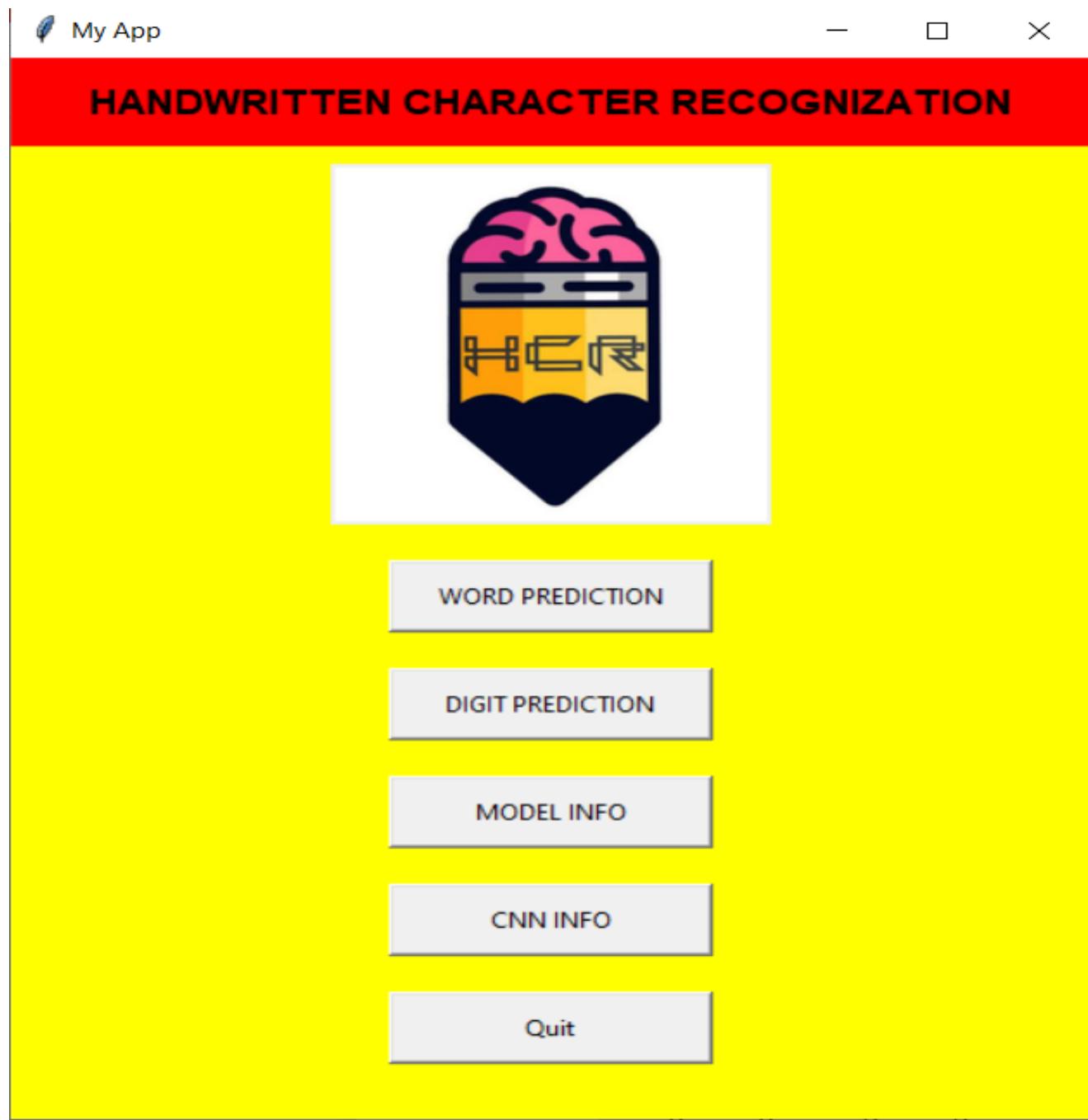


Fig : Home Page

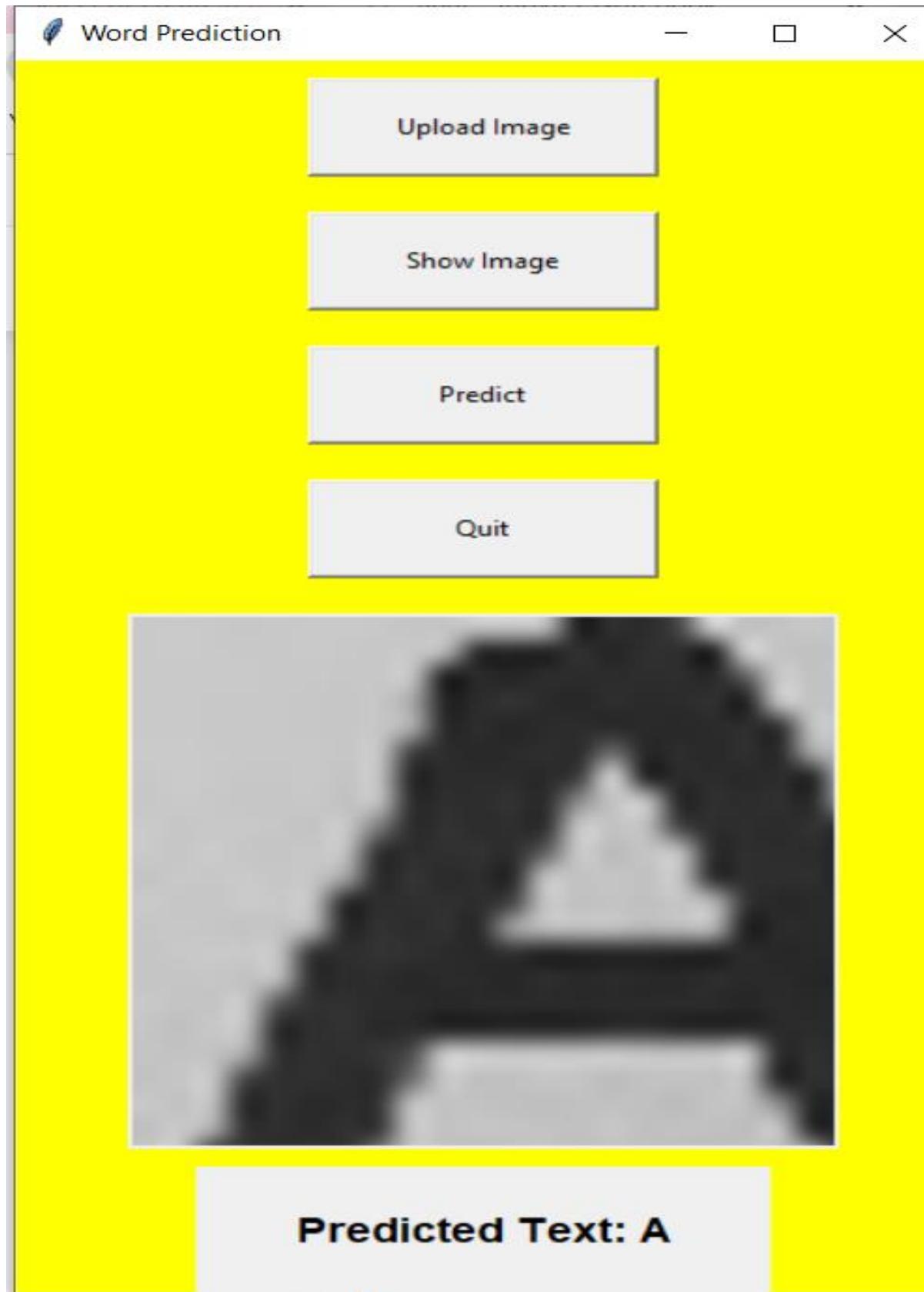


Fig : Recognition of Character

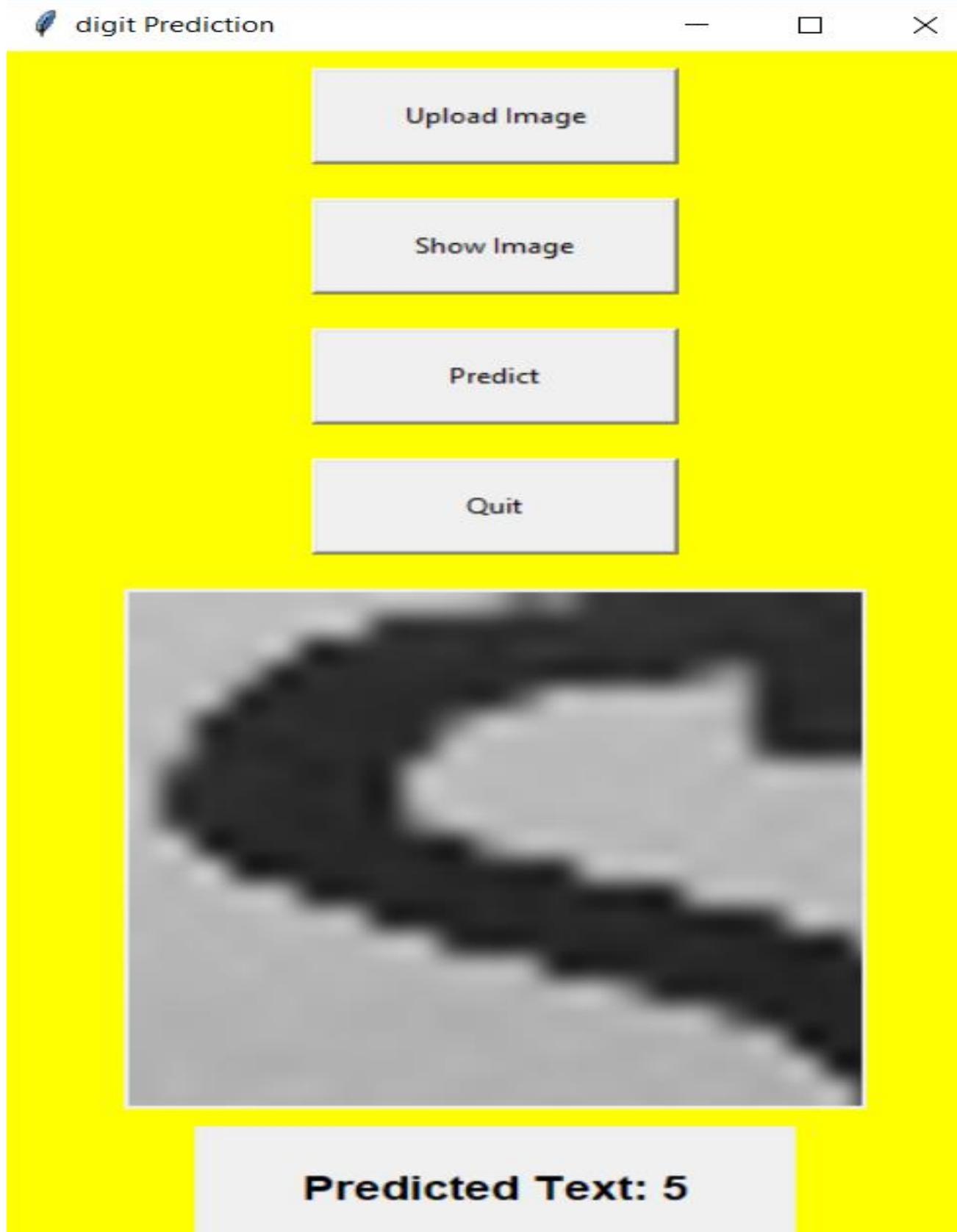


Fig : Recognition of Digit

APPLICATIONS

An offline handwritten character recognition system has many potential applications in the financial industry, including in the operations of the Central Bank of India. Here are some possible use cases:

Cheque processing: The Central Bank of India handles millions of cheques every day. By using an offline handwritten character recognition system, the bank could automate the process of reading and processing cheques, reducing errors and increasing efficiency.

Signature verification: Another common task in the financial industry is verifying signatures on documents such as loan applications or bank statements. An offline handwritten character recognition system could be used to automate this process, ensuring that signatures are genuine and reducing the risk of fraud.

Customer identification: The Central Bank of India may also use an offline handwritten character recognition system to identify customers based on their handwriting. This could be useful in situations where a customer has forgotten their ID or password, or in situations where a customer needs to verify their identity quickly and securely.

Document processing: The Central Bank of India processes a large number of documents every day, such as loan agreements, account opening forms, and KYC documents. An offline handwritten character recognition system could be used to automate the process of reading and extracting information from these documents, reducing errors and increasing efficiency.

Overall, an offline handwritten character recognition system has the potential to revolutionize the way the Central Bank of India and other financial institutions handle handwritten documents, improving accuracy, efficiency, and security.

Banking and finance: Handwritten character recognition systems can be used to process checks and other financial documents quickly and accurately, reducing the need for manual processing and improving efficiency.

Some other Applications :

- **Education:** Handwritten character recognition systems can be used to automatically grade exams and assessments, saving teachers time and reducing the risk of errors.
- **Healthcare:** Handwritten character recognition systems can be used to digitize patient records and prescriptions, making it easier to store, access, and share medical information.
- **Logistics and shipping:** Handwritten character recognition systems can be used to automatically process shipping labels and other documents, improving the speed and accuracy of package delivery.
- **Legal:** Handwritten character recognition systems can be used to process legal documents, such as contracts and court records, making it easier to search and analyze large volumes of text.
- **Postal services:** Handwritten character recognition systems can be used to sort and process mail, improving the speed and accuracy of delivery.

Overall, the application of handwritten character recognition systems can help automate tasks that involve handwritten text, improving efficiency, accuracy, and productivity across a wide range of industries and fields.

5.0 TESTING

PHASE 5

TESTING

5.1.0 SOFTWARE TESTING TYPES:

PURPOSE OF TESTING

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, sub-assemblies, assemblies and/or a finished product. It is the process of exercising software with the intent of ensuring that the Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of test. Each test type addresses a specific testing requirement.

1. System Testing

System testing is a level of testing that validates the complete and fully integrated software product. The purpose of a system test is to evaluate the end-to-end system specifications. Usually, the software is only one element of a larger computer-based system.

2. Unit Testing

Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application .it is done after the completion of an individual unit before integration. This is a structural testing, that relies on knowledge of its construction and is invasive. Unit tests perform basic tests at component level and test a specific business process, application, and/or system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

3. Integration Testing

Integration tests are designed to test integrated software components to determine if they, actually run as one program. Testing is event driven and is more concerned with the basic outcome of screens or fields. Integration tests demonstrate that although the components were individually satisfaction, as shown by successfully unit testing, the combination of components is correct and consistent. Integration testing is specifically aimed at exposing the problems that arise from the combination of components.

4. Functional Testing

Functional testing is a type of software testing that validates the software system against the functional requirements/specifications. The purpose of Functional tests is to test each function of the software application, by providing appropriate input, verifying the output against the Functional requirements.

5. System Testing

System testing ensures that the entire integrated software system meets requirements. It tests a configuration to ensure known and predictable results. An example of system testing is the configuration oriented system integration test. System testing is based on process descriptions and flows, emphasizing pre-driven process links and integration points.

6. White Box Testing

White Box Testing is a testing in which in which the software tester has knowledge of the inner workings, structure and language of the software, or at least its purpose. It is purpose. It is used to test areas that cannot be reached from a black box level.

7. Black Box Testing

Black Box Testing is testing the software without any knowledge of the inner workings, structure or language of the module being tested. Black box tests, as most other kinds of tests, must be written from a definitive source document, such as specification or requirements document, such as specification or requirements document. It is a testing in which the software under test is treated, as a black box .you cannot “see” into it. The test provides inputs and responds to outputs without considering how the software works

8. Unit Testing

Unit testing is usually conducted as part of a combined code and unit test phase of the software lifecycle, although it is not uncommon for coding and unit testing to be conducted as two distinct phases.

9. GUI Testing

GUI means graphical user interface to test the friendliness of that system. Here we testing for the images, object properties, weather the screens are user under stable or not.

Test Objectives

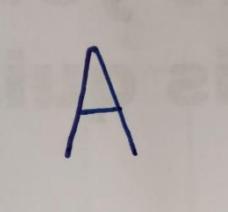
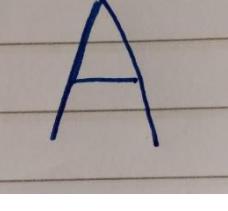
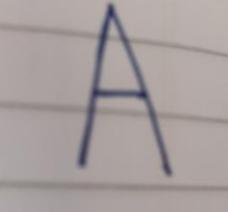
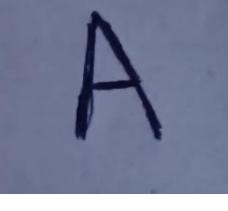
- All field entries must work properly.
- Pages must be activated from the identified link.
- The entry screen, messages and responses must not be delayed.
- Features To Be Tested
- Verify that the entries are of the correct format
- No duplicate entries should be allowed
- All links should take the user to the correct page.

5.2.0 INTEGRATION TESTING:

Software integration testing is the incremental integration testing of two or more integrated software components on a single platform to produce failures caused by interface defects. The task of the integration test is to check that components or software applications, e.g. components in a software system or – one step up – software applications at the company level – interact without error.

- **Test Results:** All the test cases mentioned above passed successfully. No defects encountered.
- **Test Results:** All the test cases mentioned above passed successfully. No defects encountered.
- **Test Cases:** Set of inputs, execution conditions and expected results carried out for some objectives

5.3.0 TEST CASE:

Sr. No.	Test Objective	Input Data	Expected Result	Actual Result	Status
1	Clear image of character		A	A	Pass
2	Capture image of character with line background		A	A	Pass
3	Capture blur image		A	A	Pass
4	Capture image in dark		A	A	Pass

6.0 CONCLUSION

PHASE 6

CONCLUSION

In conclusion, an offline handwritten character recognition system has the potential to bring significant benefits to various industries, including finance, healthcare, education, and more. By automating the process of reading and analyzing handwritten text, these systems can reduce errors, increase efficiency, and improve accuracy, thereby saving time and resources.

The system architecture of an offline handwritten character recognition system typically involves various components, including data preprocessing, feature extraction, classification, and post-processing. The accuracy and performance of the system depend on the quality of the dataset used for training and testing, the complexity of the model, and the optimization techniques employed.

In the financial industry, an offline handwritten character recognition system can be particularly useful for tasks such as cheque processing, signature verification, customer identification, and document processing, among others. These use cases have the potential to revolutionize the way financial institutions handle handwritten documents, making the process faster, more secure, and more accurate. Overall, the development and application of an offline handwritten character recognition system can bring significant benefits to various industries, and its potential for further innovation and improvement is vast.

7.0 FUTURE SCOPE

PHASE 7

FUTURE SCOPE

There are many developments possible in this system in the future. As of now the system can't recognize cursive handwritten text. But in future we can add support for recognition of cursive text. Currently our system can only recognize text in English languages. We can add support for more languages in the future. Presently the system can only recognize letters and digits. We can add support for recognition of Special symbols in the future. Currently our system can only recognize letters. We can add support for whole page or paragraph in the future There are many applications of this system possible. Some of the applications are Processing of reading addresses on letter in Post office. Helping hand in Desktop publishing. Recognition of text from business cards. Helping. the blind in recognizing handwritten text on letters. And we can add support for recognize text written in exam paper by students.

8.0 Sponsorship

PHASE 8

Sponsorship



AISSMS
POLYTECHNIC
CENTER OF ACADEMIC EXCELLENCE



Approved by AICTE New Delhi, Recognized by the
Government of Maharashtra and Affiliated to MSBTE, Mumbai

To,

**The HR Manager,
Central Bank of India MG Road,
Pune, Maharashtra.**

Subject: Request for providing project sponsorship to the Final Year Computer Engineering
Diploma students of Academic Year 2022-23

Respected Sir/Madam,

With reference to above subject, I would like to inform you our final year diploma
students have to submit a major project as part of the curriculum hence I would like to request
you to avail sponsorship for the project to Computer Engineering Department students

- | | |
|----------------------|---------------|
| 1. Darshan Kakad | Roll No. 2435 |
| 2. Pranjali Kulkarni | Roll No. 2436 |
| 3. Aditya Mangade | Roll No. 2443 |
| 4. Harshal Mali , | Roll No. 2444 |

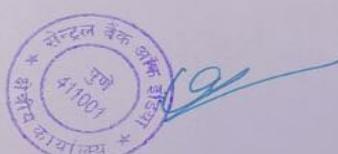
As per survey done by our students, your team is interested for sponsoring project title
“Handwriting recognition System”.

Looking forward for your favorable reply.

Thanking you,

Regards,

Mr. V.N.Kukre



HOD
DEPTT. OF COMPUTER ENGG.
AISSM'S POLYTECHNIC, PUNE - 1

Certificate of Completion by Company

The student has shown the demo of the project. The backend activity is completed but GUI front end yet to complete. kindly complete GUI for completion of project.

S. Shingare
(Suhel Shingare)
CM - 25



9.0 Publication And Participation

PHASE 9

Publication and Participation

Handwritten Character Reognization System - A Review.



e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science

(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:02/February-2023 Impact Factor- 6.752
www.irjmets.com

HANDWRITTEN CHARACTER RECOGNITION SYSTEM – A REVIEW

Ms. A. A. Shirode¹, Harshal Mali², Pranjali Kulkarni³, Darshan Kakad⁴,
Aditya Mangade⁵

¹ Professor, Dept. of computer Engineering, AISSMS polytechnic
Pune ,Maharashtra ,India

^{2,3,4,5} UG Student, Dept. of computer Engineering, AISSMS polytechnic
Pune ,Maharashtra ,India

ABSTRACT

In this paper we present an innovative method for offline handwritten character detection using deep neural networks. In today world it has become easier to train deep neural networks because of availability of huge amount of data and various Algorithmic innovations which are taking place. Now-a-days the amount of computational power needed to train a neural network has increased due to the availability of GPU's and other cloud based services like Google Cloud platform and Amazon Web Services which provide resources to train a Neural network on the cloud. We have designed a image segmentation based Handwritten character recognition system. In our system we have made use of OpenCV for performing Image processing and have used Jupyter, Tensorflowlite and Keras for training a the neural Network with the. We have developed this system using python programming language.

Keywords: Handwritten Character Recognition, Neural Network, OpenCV, Android, Jupyter, Tensorflowlite, Keras, Python, OCR, Image Processing, Feature Extraction

I.

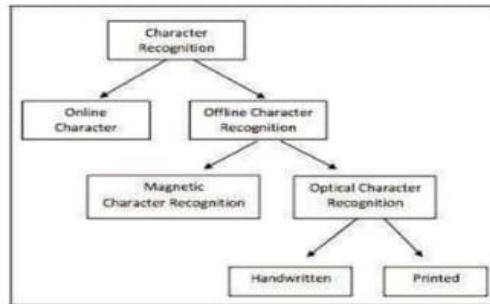
INTRODUCTION

Handwriting Recognition is one of the active areas of research where deep neural networks are being utilized. Recognizing handwriting is an easy task for humans but a daunting task for computers. Handwriting recognition systems are of two types: Online and Offline.



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In an online handwriting recognition system the handwriting of the user is recognized as the user is writing. The information like the order in which the user has made the strokes is also available. But in offline handwriting recognition system, the handwriting of user is available as an image. Handwriting recognition is a challenging task because of many reasons. The primary reason is that different people have different styles of writing. The secondary reason is there are lot of characters like Capital letters, Small letters, Digits and Special symbols. Thus a large dataset is required to train a near-accurate neural network model. To develop a good system an accuracy of at least 98% is required. However even the most modern and commercially available systems have not been able to achieve such a high accuracy. Our system comprises of two parts:

1)An Android application:

This is the frontend of our system. The android application helps the user to click a picture of text which is to be recognized, using their smartphone camera. This picture is passed on to a python script running on a server which further processes this image to extract the relevant information

2)A server:

This is the backend of our system. This server is a computer which is capable of executing a python script. It is needed because an android smart phone does not have the computation power required for running neural networks and performing image processing operations. Also the use of server for performing computationally intensive tasks enables users of older smart phones to make use of our system.

II.

PHASES OF RECOGNITION OF CHARACTER



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Handwritten recognition is usually split into six stages: picture acquisition, pre-processing, segmentation, extraction of features, classification, and post-processing.

A. Acquisition of Image : The first stage of HCR is the acquisition of images. Acquiring a picture from a camera or scanner is a technique. The picture is in a defined file format, say JPEG, PNG. The picture input may be coloured, grey, or binary. The acquisition stage comprises input image-processing, compression, storage and display. The user submitted picture will have certain limitations to adhere to. The limitations may differ to improve the precision rate of character recognition for distinct algorithms.

B. Pre-Processing : With vision to improve a picture for further processing, the pre-processing stage includes distinct operation phases. Preprocessing involves reducing noise, binarizing, detecting edges and thresholding.

You can remove unwanted noise signals from an image by using suitable filters. This filter may be a median filter, a max filter or a Gaussian filter, etc. for removing noise from an image.

C. Reducing Noise : Noise is the haphazard variation in a picture's brightness or colour intensity that is not present in the picture's initial object. The scanned input picture includes noise and may even be of reduced quality which might not result in a required consequence being adequate. The preprocessing stage involves the removal of undesirable noise signals and enhancing image quality for the next following processing stages. If noise signals between sections of the lines are not removed, great gaps will arise; these noises should be removed to obtain all the significant data. In a bunch of pictures, one of them might have many noises.

D. Segmentation : The precision of the effective identification of personality depends on the precision of the segmentation carried out. The words are divided into single letters. A character is segmented from the beginning to the end of the character. It is possible to further classify segmentation into external-internal segmentation.

External segmentation is described as the decomposition into logical units of the page layout. A significant aspect of document analysis is external segmentation. Internal Segmentation is described as the decomposition of a picture into sub-image sequence of characters.

Certificates Provided By Paper Publications:



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Date: 24/02/2023

Certificate of Publication

This is to certify that author "Ms. A.A. Shirode" with paper ID "**IRJMETS502000039122**" has published a paper entitled "**HANDWRITTEN CHARACTER RECOGNITION SYSTEM – A REVIEW**" in **International Research Journal Of Modernization In Engineering Technology And Science (IRJMETS), Volume 05, Issue 02, February 2023**

A. Deval

Editor in Chief



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*This is to certify that author “**Pranjali Kulkarni**” with paper ID “**IRJMETS502000039122**” has published a paper entitled “**HANDWRITTEN CHARACTER RECOGNITION SYSTEM – A REVIEW**” in **International Research Journal Of Modernization In Engineering Technology And Science (IRJMETS)**, Volume 05, Issue 02, February 2023*

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Editor in Chief



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Participations in Events

We participated in “ INNOVISION ” which was organized by MIT Polytechnic & MIT-WPU School of Polytechnic and Skill Development, Pune at INNOVISION project competition held on 5th of April 2023. In this , we participated in Project Presentation Competition on topic “Handwritten character Recognition system”.

We are pleased to inform you that we have got **SECOND PRIZE** in this presentation competition







Handwritten Character Recognition System

We also participated in “State level Paper Presentation competition” which was organized by AISSMS Polytechnic, Pune In this, we participated in Paper Presentation Competition on topic “Handwritten character Recognition system”



Handwritten Character Recognition System

We also participated in “State level Paper Presentation competition” which was organized by Sou. Venutai Chavan Polytechnic, Pune In this, we participated in Paper Presentation Competition on topic “Handwritten character Recognition system”



Handwritten Character Recognition System

We also participated in “Idea Presentation competition” which was organized by Sou. Venutai Chavan Polytechnic, Pune In this, we participated in Paper Presentation Competition on topic “Handwritten character Recognition system”





Dr. Vishwanath Karad
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IDEA
GO



"Idea Presentation Competition 2023"

CERTIFICATE

Pranjali kulkarni

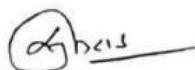
From

Aisssms polytechnic pune

**has participated and performed excellent during the Idea Go
presentation competition held on 3rd April 2023**



Prof. Mrunal Fatangare
HOD IT Department



Dr. S. S Karad
Head of School



Dr. R. S. Kale
Associate Dean



Dr. Vishwanath Karad

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IDEA GO



"Idea Presentation Competition 2023"

**CERTIFICATE
Aditya Mangade**

From

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IDEA
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"Idea Presentation Competition 2023"

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Darshan kakad**

From

Aissms polytechnic pune

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10.0 REFERENCES & BIBLIOGRAPHY

PHASE 10

REFERENCES & BIBLIOGRAPHY

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