

# Chapter 1

## Introduction

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An ancient belief of Egyptians was that writing is the gift of 'Thoth', the God of the moon and wisdom of learning. Those were the Egyptians who valued the invention of writing. It was written on an old piece of Egyptian papyrus (a thin paper like material) that writing is more useful than homes and better than monuments in a temple [214].

It is very difficult to say anything precise about the origin and emergence of handwriting but it can be assumed that writing skills of human beings which can be seen in a present form have emerged and developed through the ages. Handwriting has always been a very important medium of communication. The development of handwriting has led to the evolution of documentation. It is a vital tool used for knowledge assessment. Most of the historical documents are about laws, battles and rulers. Very few documents can be found which explains the life of the ordinary people [215].

Since last few centuries the evolution of documents can be seen in almost all the domains. Documents are mainly found in three forms like handwritten, printed and digitized. Information Technology has emerged so fast through last few decades that most of the document types found in workplaces either exists in printed or digitized form. To preserve the handwritten documents for centuries, it is very important to digitize the documents. Scanning of documents may be the answer. But two serious difficulties may arise so that ultimately it will be turned as useless. Firstly, sizes of the scanned files will be too large and secondly there will be no scope of document editing. Again, digitization of documents requires either hand typing through key boards or scanning of the same for further processing.

Hand typing is almost like climbing the peak of a rocky and snowy mountain as the existing handwritten documents to be digitized are huge. Scanning is the alternative way but the existing software can identify the handwritten documents from the scanned image with much limitations resulting further editing of the documents difficult. Scanning software scans the handwritten documents also with patches (noise).

Considering these facts it is evident that some efficient software is badly needed that can be able to identify the handwritten document characters instantaneously from the scanned files with much accuracy. That is why, in the recent years, handwritten character recognition has become a very significant field of research. It also puts forward a vast range of challenges for the researchers. Not only that, it opens up new fields of research. This will help human beings to develop such systems which can convert huge amount of human created manuscripts into electronic digitized data that can be accessed and processed fast. Handwritten and printed documents, containing valuable information, which may disappear with time, can even be preserved by digitization. The focus here is to develop user friendly models to recognize handwritten scripts taken from different individuals. Scripts may have huge variations in patterns, when taken from different individuals. The developed technology can be used in different organizations to digitize and identify their handwritten and printed documents electronically to meet their requirements in an economic way.

Though scanning devices can scan the documents with their limitations, it is not an easy task to develop software to identify the scanned handwritten scripts. To accomplish this work the first and most difficult task is to segment the scripts into individual characters because the handwriting styles vary from person to person. Some people write in such a complicated way that it becomes very difficult to identify joined characters because two or three characters appear as one character. Segmentation of complicated handwritten text into individual characters is itself a challenging field of research. After extracting out individual characters from handwritten paragraphs and sentences, development of methodologies is necessary to identify such extracted characters. This is another challenging field of research because an individual can not repeat the same pattern of handwritten characters even if he writes the same alphabet several times. So, it is very difficult to develop a computer program to accomplish this task.

A number of techniques, including Pattern Recognition and Artificial Intelligence (AI), have been used so far to recognize handwritten characters. Characters can be recognized to a greater extent of efficiency if an intelligent computer program is written using AI techniques. Of these, Artificial Neural Network (ANN) models are of ample

interest as it works like a human being. These models can even recognize printed scripts, if trained to do so.

## **1.1 Motivations**

Recognition of handwritten characters is an active and emerging area of research now-a-days. One can hardly find any handwritten recognition software. Some software which can recognize handwritten characters are having their own limitations. Human brain can recognize handwritten characters with ease and accuracy. If software is developed using Artificial Neural Network (ANN), the capabilities of human brain to recognize complex handwritten scripts can be implemented artificially, which will execute massive work instantaneously and efficiently. In this work emphasis has been given on the development of ANNs which can recognize handwritten scripts.

## **1.2 Main Objectives**

The goal of the work, presented here, is to develop different simple and generalized ANN models which can recognize the varied handwritten patterns with ease and accuracy. Improvement in the capability of recognition through development of new ANN models is of utmost importance.

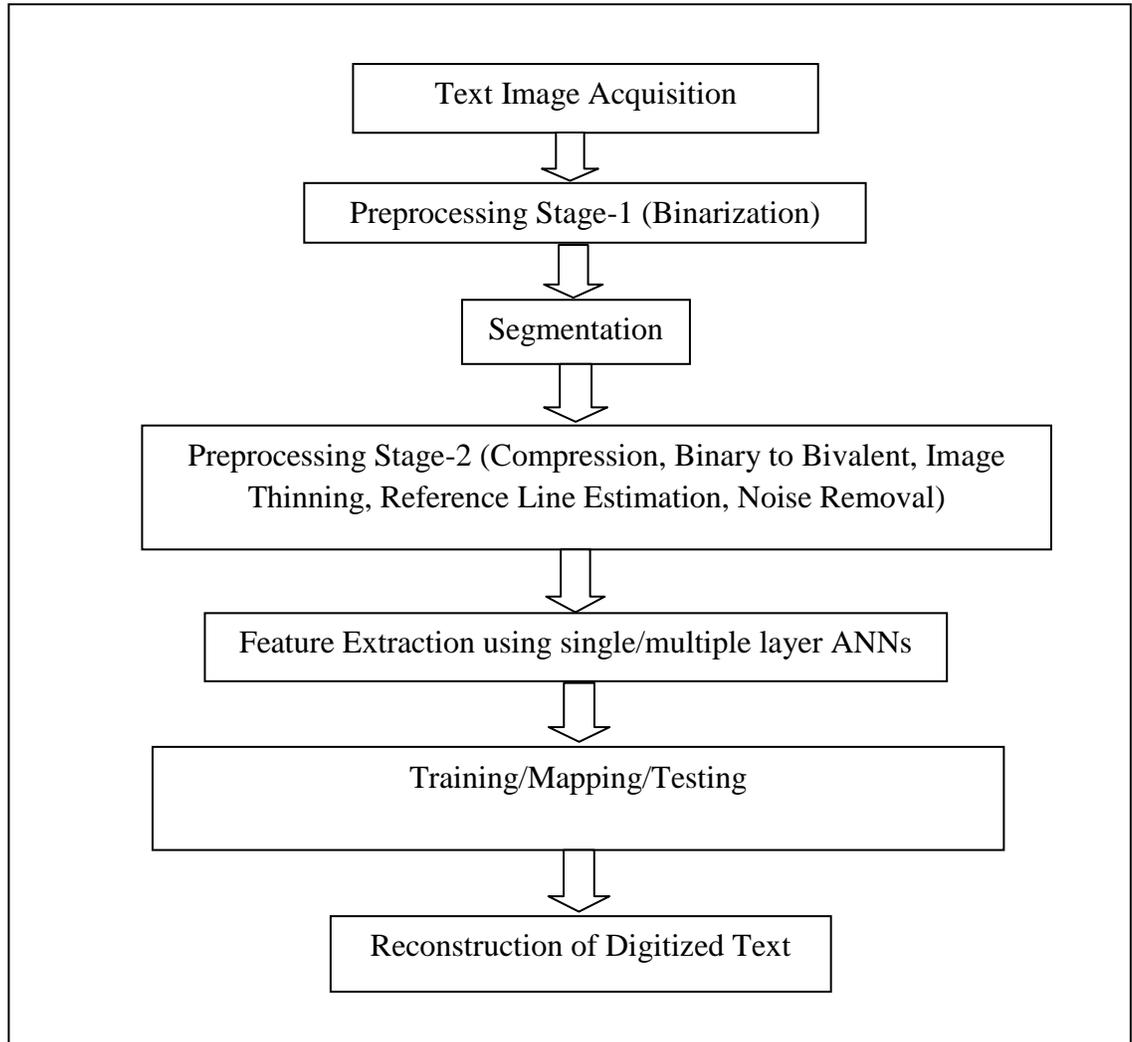
The main objectives of this work are summarized as follows:

- a.) To study the existing character segmentation methods
- b.) To study the existing and classical Artificial Neural Network (ANN) models.
- c.) To develop some character segmentation methods.
- d.) To develop single layer ANNs to recognize handwritten characters
- e.) To develop multiple layer ANNs by adding additional layers to single layer ANNs.
- f.) To perform a comparative study on different ANN models developed in this work as well as existing promising models.

Handwritten English script has been chosen, for this work, as it is a common language and used in huge scale in this country.

### 1.3 The System

A block diagram of the system to be developed is given in the following Figure 1.1. This consists of the processes like image acquisition, preprocessing, segmentation, single / multiple layer ANNs, training / testing and reconstruction.



**Figure 1.1: Conceptual Diagram of Overview of the Entire Work**

#### 1.3.1 Text Image Acquisition

The text paragraphs written on a piece of paper are acquired by scanning. A high definition scanner is used to scan the text paragraph images. These images are stored in computer in '.png' or '.bmp' format.

### **1.3.2 Preprocessing Stage-1**

The text images are binarized using MATLAB software. Binarization is a type of preprocessing where, using suitable software, the text image is converted into binary matrix. This is done in two steps, firstly the image is converted into grayscale by using 'rgb2gray()' function present in MATLAB. The grayscale image consists of white and black pixels. Another function 'dither()' present in MATLAB is used to convert grayscale image into binary form. The black pixels of the image are replaced by binary '1s' and white pixels of the image are replaced by binary '0s'. Presence of any noise i.e. black patches is also removed.

### **1.3.3 Segmentation**

The segmentation methods developed in this work are used to extract out individual characters from the handwritten text. In this work, two segmentation methods are developed. Slider Drifting Method (SDM) is used for the disjoint isolated type of handwriting and Baseline Pixel Burst Method (BPBM) works well for the joined and cursive type of handwriting as well as isolated type of handwritings.

### **1.3.4 Preprocessing Stage-2**

Some preprocessing methods are applied on the extracted out individual handwritten characters in this stage. The methods are compression, binary to bivalent conversion, image thinning, reference line estimation and noise removal.

### **1.3.5 Feature Extraction**

Different ANN models used feature extraction techniques for training/mapping purpose. Feature extraction is done by segmenting the input image matrix in different ways and training/mapping the segments individually. In single layer ANNs single layer of feature extraction has been applied. In case of multiple layer ANNs more than one layer of feature extraction has been applied.

### **1.3.6 Training/Mapping/Testing**

The supervised learning type of ANNs is subject to training for generating standard weights. The weights can be used to test the text samples in order to analyze the accuracy of the models. Mapping or clustering is used for unsupervised learning type of ANNs.

### **1.3.7 Reconstruction**

Reconstruction is the process of forming printed sentences using the recognized individual characters. Different interfaces are designed using MATLAB software which are linked to different codes used to program the segmentation and character recognition models.

## **1.4 Outline of the thesis**

The thesis has been organized with the following ten chapters. A brief summary of the chapters are presented:

**Chapter-1: Introduction.** A brief introduction to the work has been given in this chapter. The chapter begins with a little discussion on the significance of printed and handwritten scripts, need for documentation and digitization of documents. Little bit of discussion has also been done on choosing a suitable technology to digitize the scripts and logic behind selecting the type and language of the script for the work. In addition to that motivation, objectives and outline of the work has also been discussed.

**Chapter-2: Artificial Neural Network (ANN): An Overview.** This chapter starts with a brief discussion on the idea behind developing ANNs. Different types of ANNs and their applications are discussed. History of ANNs is also discussed and some examples demonstrating the working of ANNs are given.

**Chapter-3: Literature Review.** Here, various methods used to recognize handwritten characters, the related work and the pros and cons of the methods, till date, are discussed. The developments have been divided in two eras, early and recent and each era is discussed in decades. In this way this chapter discusses seven decades of the development

including the current decade in the neural network technology and emphasis has been given on the discussion on recognition of the handwritten characters using neural networks.

**Chapter-4: MATLAB Fundamentals.** This chapter is a short discussion on the MATLAB software which is used to design a demo system of interfaces in order to test the performances of different existing and newly developed models. Different functions of the MATLAB software have been discussed here.

**Chapter-5: Preprocessing of Handwritten Character Input Matrix.** This chapter is a discussion on the implementation of various preprocessing methods which are applied on the characters to standardize the input patterns, removing noise and also to make the ANNs simple. Different preprocessing techniques like binarization, matrix compression, thinning, reference line estimation and noise removal have been discussed and applied.

**Chapter-6: Development of Character Segmentation Techniques.** This chapter presents two handwritten character segmentation methods, Slider Drifting Method (SDM) and Baseline Pixel Burst Method (BPBM), developed for this work. SDM can easily segment out the isolated and disjoint characters and BPBM shows satisfactory performance in extracting out individual characters from the joined and cursive type of handwriting.

**Chapter-7: Development of Prototype Model.** Here, the development of a prototype model has been made. This model is used to test the performances of some traditional ANNs like Hebb and Perceptron. The handwritten text samples which are used to measure the performances of the newly developed models are presented to this prototype model in order to test the performances of the classical ANNs.

**Chapter-8: Development of Single Layer ANNs.** This chapter is on the development of various single layer ANNs which are developed by keeping minimum number of neurons. The single layer ANN models which are developed in this work are Row-wise

Segmentation Technique (RST), Column-wise Segmentation of Image Matrix (CSIM), Input Pattern Segmentation Technique (IPST) and Row-wise Segmentation using Adaptive Resonance Theory ART1 (RSA).

**Chapter-9: Development of Multiple Layer ANNs.** This chapter is on the development of various multiple layer ANNs where some additional layers are added to improve the performances of single layer ANNs. The multiple layer ANNs such as Arrow-Segmentation of Image Matrix (ASIM), Hoof Segmentation of Image Matrix (HSIM) and Pixel Density Gradient (PDG) Method are developed.

**Chapter-10: Results and discussion.** In this chapter a comparative analysis of the performances of the entire newly developed single layer and multiple layer ANNs has been made. Performances of the models are measured by developing software interfaces using MATLAB which can read different samples of handwritten texts and generates the printed sentences.

## **1.5 Conclusion**

It is realized that there is a need to develop software to recognize handwritten scripts. The broader range of challenges in this field makes the development of the handwritten character recognition techniques significant. The motivations and main objectives of the accomplished work are discussed. The conceptual system of the overall work has been illustrated. Chapter formations are also discussed depending on the contributions to the work. The outline of the overall work has been divided and covered in ten chapters.