

Chapter 1

Introduction

1.1 Handwriting Recognition

Human eye can see and read what is written/displayed either in natural handwriting or in printed format. The same work in case the machine does is called handwriting recognition, which is the common definition. Handwriting recognition has been a popular area of research since few decades under the purview of pattern recognition and image processing. Handwriting recognition can be broken down into two categories: off-line and on-line.

- *Off-line:*

Off-line character recognition takes a raster image from a scanner (scanned images of the paper documents), digital camera or other digital input sources. The image is binarized through threshold technique based on the color pattern (color or gray scale), so that the image pixels are either 1 or 0.

- *On-line:*

In on-line, the current information is presented to the system and recognition (of character or word) is carried out at the same time. Basically, it accepts a string of (x,y) coordinate pairs from an electronic pen touching a pressure sensitive digital tablet.

Once the image is binarized in off-line case, the rest of the techniques for classification can be identical with only two basic differences. Firstly, off-line recognition happens after the writing completes and the scanned image is pre-processed. Secondly, it has no temporal information associated with the image due to which it is not known to the classifier about the way and order of writing. So, we can say, its knowledge about the character is limited. It means, off-line data only represents the final result after writing i.e an image.

Why do the global market demand follow the on-line recognition system? On-line handwriting recognition system, by contrast, captures the temporal or dynamic information of the writing, enhances the accuracy over off-line. Another advantage is interactivity, which means recognition errors can be corrected immediately with the series of test. Yet, adaptation of any drawings of character is also an advantage over off-line. when the user faces that some characters are not recognized accurately, user can alter his way of drawing until it recognizes. It means user can adapt to the machine. Conversely, recognizers are capable of adapting users' drawing, usually by storing a possible samples from a large number of users for subsequent recognition. Thus, there is adaptation of user to machine and of machine to user. Electronic pen input is the direct method to compare with the both off-line and keyboard entry to the system having recognition intelligence. In addition, on-line recognition

improves the work-flow, the information is immediately available. However, the natural and comfortable style in writing effectively reduces difficulty at the threshold of using computers for common users. Moreover, it is recently showed that handwriting input is the most acceptable and welcomed input style.

A handwriting recognition can further be broken down into two categories of writer independent and writer dependent.

- *Writer Independent and Writer Dependent:*

A writer independent recognition system recognizes a wide ranges of possible writing styles, while a writer dependent recognition system is trained to recognize only from specific users. Therefore, a writer dependent recognition system works on data with a smaller variability and therefore a chance of having higher reliability is achieved in contrast to writer independent recognition system. Writing one's style brings unevenness in writing units, which is the most difficult part. Variability in stroke numbers, their order, shape and size, tilting angle and similarity among characters from one another are found more often in writer independent recognition system. Broadly, there are two kinds of writing styles. They are hand printed and cursive handwriting. In cursive style, strokes are deliberately linked forming one from many to draw the character, while in hand printed style possible number of strokes are used, each stroke has significant role to complete the character. In cursive style, the important information such as intersections, loops, curves, straight lines and hooks etc. are missing. Some times, both writing styles are mixed. Natural handwriting contains all types of styles in writing from any of the users. Specifically, the writing is said to be natural as if user writes on a piece of paper.

With the introduction of portable hand held computers and computing devices such as PDAs (Personal Digital Assistant), non-keyboards and non-keypads based methods for inputting data are receiving more interest in both academic and commercial research communities, which are often writer independent. The most promising options are pen based and voice based inputs. Pen based method in inputting can be either off-line or on-line.

1.2 The Statement of Need

One can imagine how easy lives we have in this busy dynamic world in case the portable machine can understand what we write either in discrete or in natural handwriting mode. It would certainly be difficult that writing/typing addresses, memos, important information and communication as well for those who are non natives to English. In such a case, writing would be more cleared and easy to understand in their own local languages. In addition, it is helpful for those such as, computer novices, old people in using computer conveniently without the use of both keyboard and keypad. Therefore, the system having the intelligence in recognizing the natural handwriting for all possible scripts around the world is the global market demand.

Frequently, handwritten data is entered into IT solutions by human operators using keyboards. One can think of the processing of the forms, questionnaires and notes etc. not only

costlier but also time consuming. The easiest solution is the handwriting recognition system, which converts handwritten data into the format that can be used in further computing. Therefore, handwriting recognition is the connector between handwritten information and the IT world.

Despite many years of research in the field of handwriting recognition technology, IT has not reached the masses in local languages. Nepali is the one. According to the most recent official census, conducted by His Majesty's Government of Nepal (HMG) in 2001, Nepali is the mother tongue for 11 million people, which reflects the need of building a complete handwriting recognition system with maximum reliability.

A pencil and paper are often preferable for every one to use during the first draft preparation instead of using keyboard and other computer input interfaces like this. In such a case, handwriting recognition has gained the advantages. In addition, the languages having a large set of symbols, alphabets and numerals, designing a keyboard is bulky and cumbersome to use as well. For example, Nepali, Chinese and Japanese are under this category. Specifically, the basic set of symbols in Nepali consists of 31 pure consonants, 13 vowels, 16 modifiers and 10 numerals. In addition to these, consonants occur together in clusters, often called conjunct consonants. Modifiers appear on the top, at the bottom, on the left and to the right of the consonants and vowels, forming syllables. The script's rich of set of conjuncts make it complex to read and write. Altogether, more than 500 different symbols are used in Nepali. As, characters are derived from the mentioned basic sets, its input from the keyboard is cumbersome. However, new pen tablets offer the possibility of online handwriting when combined with handwriting recognition technology. The best way to solve the need is not to design the keyboard but to design the complete writer independent natural handwriting recognition system, such that one can write in one's writing style. In case the keyboard is designed, one needs to practice to use but no extra task is necessary for one to write one's style. To the best of my knowledge, the proposed recognition system will be one of the contributions for Nepali handwritten character recognition.

1.3 Goal

A novel approach on a template-based on-line writer independent Nepali natural handwritten character recognition by using both structural and spatial information is proposed.

1.4 Objectives

- To build a complete prototype classifier based on structural approach for natural handwritten characters.
- To design a stroke number and order free handwritten alphanumeric character recognition system.
- To determine the effects of pre-processing and feature selection in classification of natural handwritten characters.

- To handle spatial information about the strokes within a character for enhancing the reliability of the prototype classifiers.

1.5 Scope

The market of small hand-held Personal Computers (PCs) and pocket PCs is growing very fast in the recent years. With the advent of Personal Digital Assistant (PDA), smart phones and tablet PC's, rely on natural handwriting input, real-time handwriting has gained an immense importance. Writing short memos, ideas, editing simple texts, storing addresses, telephone numbers and so on are the today's natural input based users' demand. Not only this, many computationally intensive applications, like video editing and complicated mathematical calculations are also possible. As the electronic pen is turning to be more popular, the demand of handwriting input from intellectuals such as scholars, business managers, professors and doctors etc. is getting stronger. Within the scope of handwriting recognition, the focus of this research is on two problems, namely, the classification of natural Nepali handwritten alphabets and numerals.

Both from the commercial and academic fields have raised vital efforts and developments as well to make faster, easier, and more precise handwriting recognition system. However, the recent use of portable pen based computer has not reached the line of global demand. Recently, varieties in handwriting classifiers have very limited functions, because they were build with the assumption that people would use simply for writing short memos, storing addresses etc. This largely limits the things what the hand-held devices can do.

1.6 Thesis Overview

An overall thesis is outlined in the following chapters. The state of the art of off-line and on-line handwriting recognition during a period of renewed activity for Devanagari script is presented in chapter 2, which is based on extensive review of literature, including journal articles, conference proceedings and technical reports, major difficulties in on-line handwriting (especially in Nepali) with comprehensive ideas about the basic classification approaches (structural and statistical information), techniques and tools used in on-line handwriting character recognition. It provides reader a great chance to know about the varieties of works related to digitizer technologies, pre-processing strategies, feature selection techniques and model evaluation. Chapter 3 provides a complete proposed methodology in classifying a cursive characters along with the results from a series of experiments. Chapter 4 begins with novel idea in building a competitive classifier, which provides real solutions of some major difficulties. A constructed prototype classifier is template-based using structural properties of the on-line handwritten strokes. Some of the shortcomings, which are to be cleared are fixed with the addition of spatial information of the strokes with the introduction of newly proposed strategy in handling the spatial information of the characters. A discussion of the entire task is provided in every possible section for better understanding along with real time experimental results. Both global and local limitations of the on-line handwriting recognition system are critically analyzed in chapter 5. Chapter 6 concludes the thesis including recommendations.