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Segmentation of Persian Cursive Words Using Basic Shapes

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ABSTRACT
Segmentation is a process of dividing cursive words into smaller parts in order to decrease complexity and increase accuracy of handwriting recognition process. However it is a complicated and time-consuming task. In this paper, we introduce the concepts of basic shapes and explore its application for segmentation of Persian words. Considering a set of pre-defined shapes include line and open or closed curve extracted from Persian alphabets, our approach will employ those shapes with decision tree technique to divide a cursive word into segments in a less complicated process. Experimental results showed 98.83% accuracy in segmenting Persian words.

Keywords – **Handwriting Recognition**, **Basic Shapes, Segmentation**, **Persian Cursive Words**, **Decision Tree**

1. INTRODUCTION

In recent two decades, the problem of on-line handwriting recognition has been of great importance and a lot of studies and researches have been conducted to address it [1-3]. Due to new trends in natural user interfaces and general acceptance of touch-based devices, requests for more convenient way of inputting data, especially in those devices have been greatly increased. Therefore, recently, there are more works focused on recognition of languages that are based on Arabic script such as Persian [4-11].

In comparison with other scripts, Arabic has some distinctive characteristics, such as direction of writing, number and position of diacritic marks, various writing forms of alphabets in cursive script, and so on. These different characteristics make recognition of cursive words somehow difficult. As a solution to reduce the complexity in the process of recognition, segmentation is normally applied to divide whole cursive word into smaller parts, usually letters, that are easier to identify [1, 2, 5, 12]. Then the written words will be recognized simply by its forming letters. Although, Segmentation plays an important role during recognition process, however, it's a complicated and time-consuming process [1, 2, 11].

In this paper, we propose an approach that segments Persian cursive words using less complicated process. The rest of it is organized as follows: Section 2 will introduce basic concepts. In Section 3, we present our approach to apply basic shape matching on Persian cursive words to segment them and section 4 will show experimental results. Finally, Section 5 will end the paper with some conclusions.

2. BASIC CONCEPTS

This section will introduce Persian words structure, the concept of segmentation, the idea of basic shapes, and how it can help us to segment cursive words.

2.1. Persian Handwriting and Segmentation

As we mentioned previously, Persian language is used by many people around the world. It contains 32 alphabets, which are written in four forms: At the beginning, in the middle, at the end and in a standalone form (Fig. 1). Another generic feature of the language's alphabet is that some letters have extra parts such as dot, stroke, etc. called Diacritic. Since the language script is based on Arabic and due to its nature, Persian words are written in right-to-left direction and cursive format. Albeit the recognition of Persian letters is not difficult as much, however combination of letters in different forms with different diacritics in words makes the recognition process a complicated task. Therefore, segmentation process is applied to reduce the complexity and increase the accuracy of recognition process.

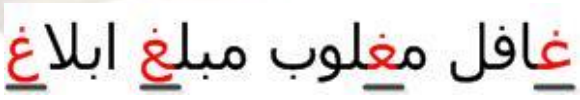

Figure 1. Letter "Ghain" ("غ") in different placements in words.

In handwriting recognition, segmentation is defined as the process of dividing a cursive word into smaller parts, usually letters, which form the written word.

However, with respect to shape of the word, it can also be smaller or bigger than a letter.

2.2. Basic Shapes Idea

The idea of basic shapes is somehow based on how the segmentation process works. While segmentation divides cursive words into letters, the idea here is to reform the shape of the written word in terms of pre-defined basic shapes that are generic in nature of writing style of letters.

After examining various writing styles of letters, 3 generic shapes have been considered in different positions as shown in Fig. 2:

Figure 2. Generic shapes that all letters can be formed by them.

"Semicircle" and "line" shapes usually appear in different positions in words. For example, line may be a horizontal, vertical or even oblique (Fig. 3) and semicircle may come in 4 positions, in which every position has 90 degree rotation in clockwise order respectively (Fig. 3).

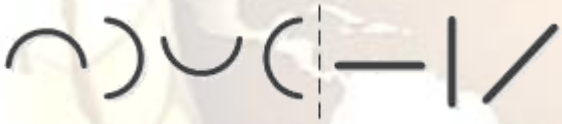

Figure 3. Semicircle and line in different positions

One advantage of applying basic shapes is that it reduces the complexity of segmentation process. Our examination of transforming each letter into basic shapes showed that not only every letter can be written in terms of basic shapes, but the combination of letters together can also be written using them. Therefore, the complex form of a written word contains a series of abundant points with no semantic meaning and possibly lot of noises is simply converted to a sequence of pre-defined shapes that not only have less noises, but making them into segments are much simpler task. Since a generic shape can be simply produced by series of points appeared in specific sequence independent of the number of points, writing style of the person or the pressure of input device during writing time, another advantage of using the idea is independency of the conversion process from size of the written word, the person who writes it, and pressure of input device.

3. OUR APPROACH

Previously, we introduced the concepts of the segmentation and the basic shapes. In this section we will use those concepts along with decision tree technique to segment Persian cursive words in three steps including *Data Preparation*, *Shape Formation*, and *segmentation*, which will be explained as follows:

3.1. Data Preparation

Each person has their own writing style that can be different in their writing speed, size of written words, placement of dots or other diacritics and many other parameters that result in different styles for various people. Therefore, the input word might be written in different sizes and since the input data for written word is captured in discreet points, it's highly possible that some noises being produced during the process of writing. Thus prior to producing basic shapes, we need to apply normalization process on input data to increase the accuracy of next steps.

Although producing basic shapes is independent of mentioned parameters, however in order to treat different writings uniformly and have more accurate results in next step, we use the nearest neighbor interpolation technique to normalize the input data (as used in [13]). The output will be normalized input that is ready to be used in the next step for producing basic shapes.

3.2. Shape Formation

After normalizing input data, we need to convert them to pre-defined basic shapes that introduced previously. In order to form the basic shapes we use a simple pattern matching technique, in which we examine each point with next point in neighbor until a generic shape can be formed. Whenever a basic shape has been matched (formed using series of points in normalized data) in examining process, it will be added to a list and the process will be continued with next point in the input data (Fig. 4).

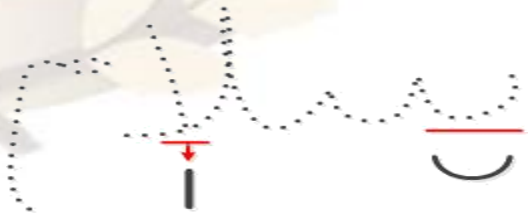

Figure 4. Forming generic shape from input points.

However, in our approach, some noises may be generated in process of writing words, which include points that either result in malformation of basic shapes or augment the computations of shape formation in later

stage. In order to reduce noises we use a threshold, which is defined as an interval to remove auxiliary or unrelated points. This threshold is usually used to remove unnecessary paths during shape formation process. An example of reducing noise was shown in Fig. 5.

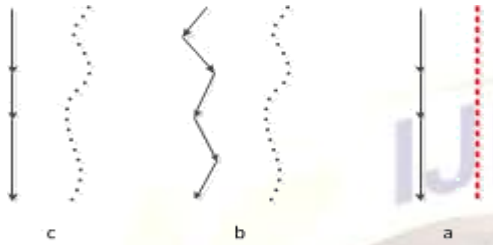

Figure 5. Using threshold to remove noise. An original letter "Alef" ("ا") and its generic shape (a). A written letter "Alef" by a user and its generic shapes without using threshold (b). A written letter "Alef" by a user and its generic shapes using threshold (c).

3.3. Segmentation

After reforming the written word in terms of basic shapes, in this step, we form the shapes into segments. For identifying segments we use an approach introduced in [12], in which segments are produced using building block concept and decision tree technique.

Building blocks specified as a set of pre-defined shapes that can form body of all alphabets' letters; they can be as big as a letter or as small as an edge of it. The goal here is to compose generic shapes and produce building blocks. Decision Tree technique is used to accomplish this task.

Decision Tree is a classification technique that classifies patterns using a tree like graph. The tree contains internal nodes, which may branch to other internal node or leaf (an ending node). A primary condition is put on the root and moves down along a path on the tree until reaches a decision on a leaf node (Fig. 6).

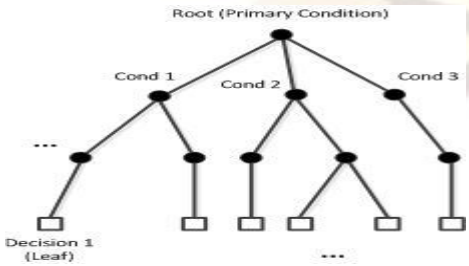

Figure 6. A decision tree scheme

A list containing sequences of generic shapes produced in last step is given to a decision tree to form building blocks. The decision tree begins with a first shape in the list and continues until reach a building block on a leaf. If the tree reaches a "null" leaf, which means there is a noise in the sequence, it will employ a back tracking technique to remove a noisy part.

4. Experimental Results

To evaluate the efficiency and accuracy of our approach, we developed a program to segment Persian cursive word in online mode. C# language and Visual Studio 2010 were used as developing language and environment respectively. Input data was captured using digital pen and mouse as input devices and 100 people participated in the experiment by writing 50 different words. Table 1 presents outcomes of applying our approach for segmenting Persian cursive words:

Table 1. Accuracy of identifying right building blocks and correct segmentation.

Words	No. of correct	No. of incorrect	Accuracy
ساربان	8	0	100%
صادرات	6	0	100%
مهرام	4	1	80%
خورشید	7	0	100%
محبوب	6	0	100%
عاشق	6	0	100%
گودرزی	6	0	100%
لامپ	4	0	100%
امیرطهماسبی	13	1	86.5%
کلاغ	4	0	100%
Other 40 words	360	3	99.2%
Total words	386	5	98.83%

Our experiment showed 98.83% accuracy in identifying right segments. However, there were some complications in forming generic shapes and detecting building blocks for some letter such as "he" ("ه") when it came in middle form due to its complex form of writing.

5. Conclusion

In this paper, we proposed an approach to segment online Persian words using basic shapes. We described the concept of basic shapes and presented an approach

to use the concept alongside decision tree to segment the written word into fundamental building blocks introduced in [12]. At first, we captured input data as series of ordered discrete points. Then we normalized the input data and applied a pattern matching technique to produce generic shapes from input points. Later, we employed decision tree technique to identify segments.

The experimental results from implementation of our approach have shown total accuracy of 98.83% for segmentation of online Persian cursive words, which is better than [12] in comparison, which was 98.625%. The decrease in accuracy came from letters such as "ه" that have complex form of writing when they come in middle.

For future works, our approach can be modified to resolve the issue of words with complex writing style of middle forms. It can also be used alongside other approaches to help recognizing Persian cursive words.

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