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Recognition of Handwritten Farsi Digits Using DTW Algorithm

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Abstract

In this paper, variations of slope of handwritten Farsi digits have used in order to describe any digit. In this method, after several pre-processing steps, slope of each digit has calculated from bottom and left angle with equal interval, and continued along existent curvature. These feature have used as input of DTW algorithm and to compare similarity degree of each pattern with related references. Finally, designed system has implemented in Hoda data base that is used by researchers. Dataset used have included 1699 samples that recognition rate have been equal to 83.9 percent.

Key words: Slope, Handwritten Farsi Digit, Dynamic Time Warping, Hoda Dataset

1. Introduction

Researchers about recognition of English letter and digits have begun 50 years age and history researchers about Farsi and Arabic handwrites have return to 29 rears ago. Now, recognition of handwritten digits have much usages such as reading a value of bank check, reading cars' plates, reading a postal code and other information of forms. Many researches have done in field of recognition of handwritten Farsi digit that is based on methods of features extraction and trainable classifier. Regional feature (Takahashi. 1991), geometric moments (Jimenez. 1999), Zernike moments (Shirali et al. 1984), Fourier describers (Azmi et al. 1993), stable moments (Li. 1992), histograms and features of characteristics places (Glucksman. 1971) are proposed in order to recognize letter and digits. Selection of feature type depends on usage. More suitable feature id determined by empirical evaluation of involved data.

In this paper, variations of slope are applied to recognize digits. Farsi among various forms of digits some representative is selected. So that diversity of Farsi digits that is wide sp reading among common is presented. In following step, we attenuate each digit and select some black pixels with 5 white pixels between any two black dots. Then, we calculated black slope between any two black pixels. We do this foe all the sample and reference patterns. In section 2, how to select referenced id discussed. In section 3, two steps of preprocessing are done on samples and references that are much important. In section 4, we consider method of determining the slop of any two dots and creation of final dataset. In section 5, DTW method as used is described. In final section result of implementation is referred.

2. Selecting the reference patterns

Selecting the reference for handwritten Farsi digits should be done in form of their diversity. For example digit 4 has more diversity than digit 1. So, it needs more references. Therefore, selecting the suitable references for each digit, we can achieve higher recognition rate for that digit. Another problem existed is that although, with increasing the number of references for each digit, the probability that majority input forms related to the class is correctly indentified is increased, on the other hand, the probability that the references attract input forms related to other digits is increased as well, and consequently, reduce recognition rate (darvish et al. 2006). So, we should have optimum selection in the field. Examples of the references are shown in figure 1.

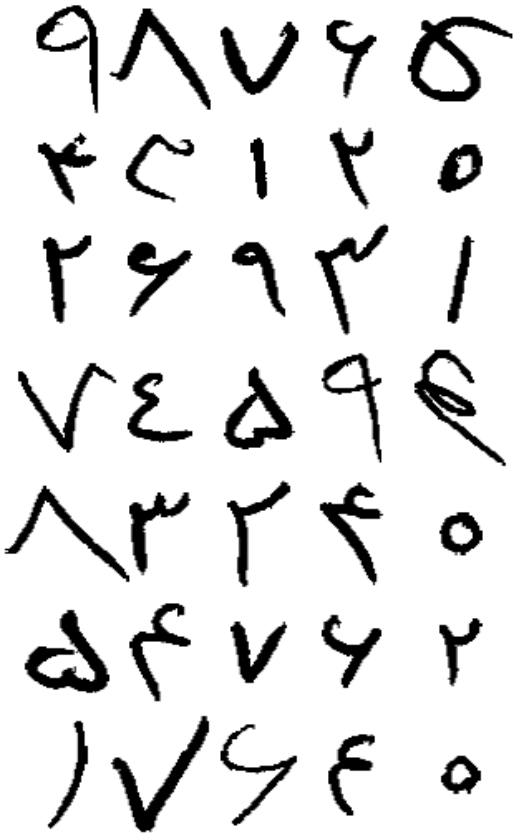

Fig 1: Examples of references of handwritten digit

3. Pre-processing

Pre-processing step include two steps. Extracting the digit skeleton (attenuating) and transform Attenuated image to dotted form.

3.1. Attenuating the digits

In this step Cranny's Quick algorithm is used to Attenuate and obtain skeleton of each digit, without erosion and rupture. This algorithm obtains suitable skeleton that preserves original from of the digit and don't create bogus data (kheir-khah and rahmanian 2007). Figure 2 is example of the step.

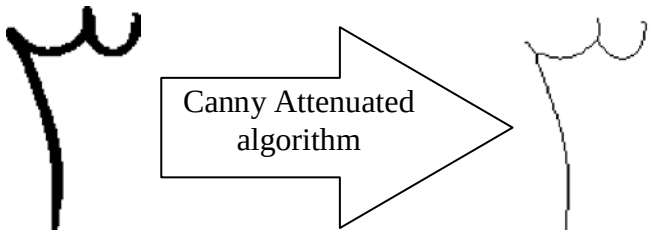

Fig 2: Attenuated sample

3.2. Converting the digit to dotted form

In the step of preprocessing, we transform the Attenuated digit to a image that is constituted from a number of brightened pixel with equal interval between brightened dots. Main advantage of the method is its resistance against small changes, simplicity of implementation and its high recognition rate. Thus, we are able to present more exact description of the Attenuated image.

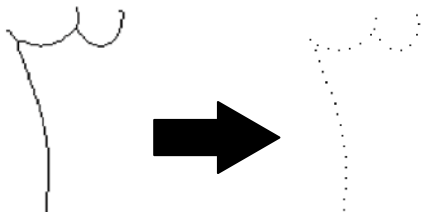

Fig 3: Converting the Attenuated image to dotted forms

4. Creating the dataset

In the step, we use the dots. We began from bottom and left the image and we continue to end of dotted forms. Any two sequential dots that we reach them are used to calculate their slopes. It is presumed that for digits with greater perimeter. We will have more number of slopes. Therefore, we will encounter a dataset whose number of feature of various samples will be different. Thus, we used DTW algorithm that is a technique of elastic pattern adaptation and its goal is finding a optimum justification between reference and sample entered.

5. Using adjusted DTW to recognition

DTW is used in recognition phase. DTW method is a technique based on dynamic programming for non linear time normalization (Amiri et al. 2007). DTW algorithm coincides two sequences is minimum. So, applying DTW as interval function, we are able to calculate interval of sequences of features of the two digits (sample and reference).

In DTW method, we encounter with two interval concepts: local interval and total interval. In first step, we consider reference pattern on axis Y and considered signal on axis X, and we break space in term of number of their frames. This is shown in figure 4.

In next step, we create local interval as value of each node. Now, we recessively search shortest path, regarding the issue that a path is short if it was short before.

We update total interval on basis of following equation:

$$G[i,j] = min\,(G[i-a\,,\,j-b] + d(x[i],y[j])w(a,b)) \qquad (1)$$

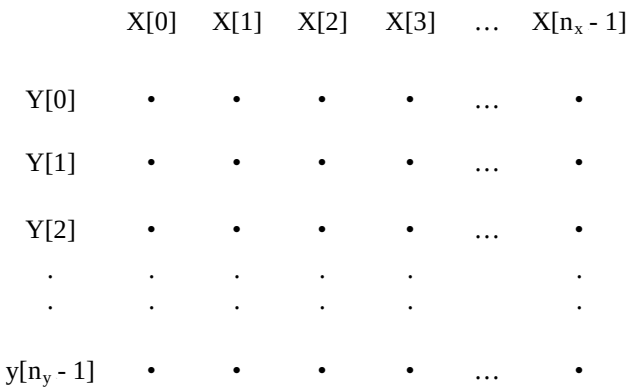

Fig 4: Space work for DTW

Where *d* is local interval and *G* is total interval. Argumant min shows optimum path and *w* is weighted coefficient of transmission from a node to another node. Two common from exist for the weighted coefficient that shown in fig 5.

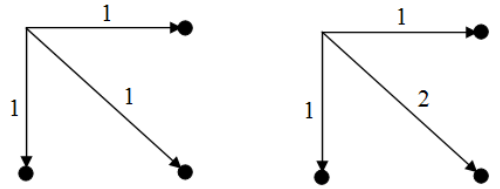

Fig 5: two forms for weighted coefficient of among nodes

6. Results of tests

Hoda Dataset is used in tests. In this paper, new idea to used slope of handwritten Farsi digits in dots with equal interval. For doing test, 26 samples in 10 classes were applied to create references. 1673 samples were used for testing set that correct recognition rate was equal to 83.9%.

It is noticeable that this recognition was obtained without any post-processing. Recognition rate for each digit is seen in table 1.

digit	number of reference	number of testing sample	number of correctly recognized samples	recognition rate (in percent)
0	2	174	142	81.6
1	3	167	161	96.4
2	2	161	129	80.1
3	3	168	131	77.9
4	4	169	137	81.1
5	4	168	133	79.2

6	4	170	133	78.2
7	1	171	151	88.3
8	1	168	149	88.7
9	2	157	138	87.9

Table 1. Recognition rate for each digit

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