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Off Line Handwriting Digit Recognition by Using Direction and Accumulation of Pixels

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Abstract. In this paper, a new method is proposed to extract the features of a one-number Persian image in which for the final verification of the extracted features, a three-layer neural network of Perceptron has been utilized. The method is capable of extracting some ideal features from a one-number image that are stable against rotation, movement, size change and noise. The method is examined on a database of 10000 discredited numbers, from which 7000 numbers were used in the training stage and 3000 ones were used for the experiment. The recognition percentage of 94.3% shows the great efficiency of the proposed method.

Keywords: Features Extraction; Recognition of Persian Numbers; Perceptron Neural Network; Direction, Accumulation.

1. Introduction

Recognition of Persian handwritten numbers has many applications such as the recognition of a zip code on an envelope, the amount of money written on a check, the numbers written in examination forms [1], etc. The main problems are dependence on the style of handwriting, image quality and handwriting size. After lots of investigations in the field, various methods were proposed to solve these problems [1-10]. Most of these methods were proposed for English, Japanese and Chinese numbers, and only few of them were for Persian numbers such as Markov hidden model [3], Neural Networks [4], Constitutional Features [3-10] and Momentums [2]. The proposed method in this paper is based on the Extraction of new features of a number-narrowed image, and the final recognition is done through neural network.

The selection of features for proper classification is of great importance, because wrong selection of features leads to incorrect recognition of the classifier. Direction and Accumulation, which are used to extract the features of image, is capable of extracting some new and appropriate features.

In this paper, image of each digit will be dividing in 24 frames. After that two features will extract from each part of digit's picture. As result, we obtain 48 features for final recognition via neural network.

2. The Proposed Method

After pre-processing stage, it is time to describe proposed method.

Proposed method divides to 3 parts:

A) Frame finding
B) Classification
C) Feature extraction
D) Recognition Using Neural Network

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2.1 Frame finding

After narrowing the digits, the frame of narrowed digits is required in order of extracting features and executing classification algorithms. This frame includes just the important data of the input digit and some parts of the image that have unnecessary data is eliminated.

For finding narrowed digit frame, the coordinates of pixels with the quantity of one(black) in the farthest left, right, up and down side are found.

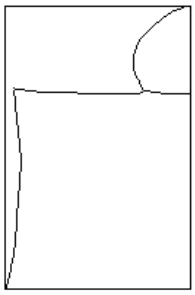


Fig. 1: Digit's Frame

2.2. Classification

After the end of pre-processing and having the result of that, it is time to classify the narrowed digits to two category that are digits 1,2,3,4,6 and 9 that have a 1-like base and the other digits that are 0,5,7and 8. To classify the narrowed digits to this two category first we need to have the height(H) of input digit. This could be achieved by having the coordinates of farthest pixels with the quantity of one in the up and down side from the previous step. Then, a line parallel to the horizontal edges of the frame in the proposed coordination system of formula 5 is drawn.

$$H = X_{\max} - X_{\min}$$
$$\begin{cases} X_S = X_E = X_{\min+} \dfrac{30}{100} \times H \\ Y_S = Y_{\min} \\ Y_E = Y_{\max} \end{cases} \quad (1)$$

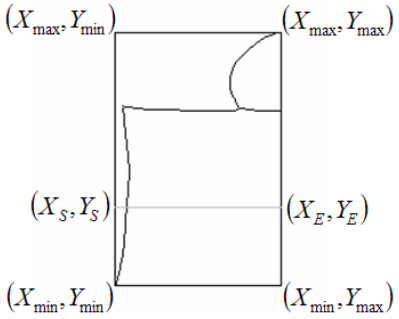


Fig.2: Picture Of number 2

After drawing the mentioned line, the digits are categorized due to their intersection with this line. If the line intersects with the digit in just one point it implies that the digit is of the category one. Otherwise the digit belongs to the category two. Since a new section was added to the narrowing algorithm, categorizing algorithm is working properly.

The framing algorithm divides the frame obtained from previous steps to 6 rows and 4 columns. In fact a 6*4 table is set for the frame according to its dimension.

Fig.3: Framing of narrowing digit in 6*4 frame

Since in this work the image of input digit is not normalized there is a possibility that in the framing process the last row (column) of frame is not the same as the others. In the nest section it would be noted that this would not affect the accuracy of the algorithm.

3. Feature extraction

We have 24 frames from image after dividing image that we extract 2 features from each frame called accumulation and direction.

3.1. Pixels accumulation

For calculation pixels accumulation in each frame, we have some variables as shown below:

1) (N_B) : Numbers black pixels in each frame
2) (N_W): Numbers white pixels in each frame
3) (N_{PB}) : Numbers black pixels in image
4) (N_P) : Numbers of all image's pixel
5) (PN_B) : Pixels accumulation percentage

According to above variables, pixels accumulation percentage is calculated with following equation:

$$PN_B = \frac{N_B}{N_B + N_W} \times \frac{N_{PB}}{N_P} \tag{2}$$

Base on equation 6, we conclude 2 results:

1: change in size of input image is not effective in pixels accumulation percentage.

2: be similar size of frames is not important for calculating of pixels accumulation percentage.

3.2. Direction

For calculate direction feature, emphasis on white pixels. All while pixels of each frame effect by figures 4. Vectors as shown in figure 4 are continued for each white pixel until crash with black pixel. Then we calculate numbers of crash, thus value of each pixel is determined.

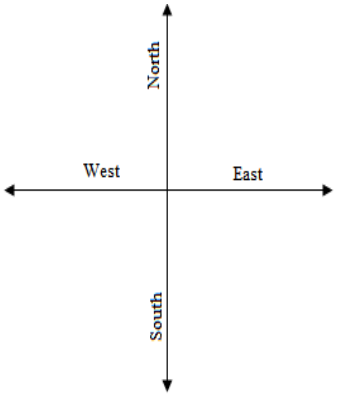


Fig.4: Direction for white pixels

4. Recognition Using Neural Network

After extracting the features introduced in section 2.4 from the figure, using a multi-layer Perceptron neural network and a feed-forward algorithm, the final recognition of the number is performed. To determine the number of medial neurons, the network is simulation according to the number of different neurons in the medial layer; the results are shown in table 1. As seen in this table, as the number of neurons in the middle layer increases, not only does the recognition percentage increase, but also the recognition times increases. The irregular increase of neurons in the middle layer leads to a progressive increase in the recognition time; this happens while there is no considerable change in the recognition quality. The number of the neurons is pleasant as long as the recognition time does not increase progressively and the recognition percentage is not constant. According to the numbers recorded in table 1, it is concluded that 16 neurons in the hidden layer provides appropriate conditions for recognition process.

Table 1: The rate and the time of recognition based on the number of neurons in the middle layer.

The number neurons in the hidden layer	*5*	*20*	*40*	*50*
The rate of recognition (%)	*67.12*	*74.87*	*83.09*	*94.30*
The recognition time (seconds)	*0.009*	*0.01*	*0.12*	*0.21*

5. Stability Rate of Feature Arrow

In this section, the stability of the method is studied against noise, rotation, image size and movement.

5.1 Stability Against Noise

The type of the extracted features in this work does not show any dependency on noise. To study the sensitivity of this method to noise, Gaussian and Pepper-Salt noises were exerted on the image, and the recognition results are shown in table 2.

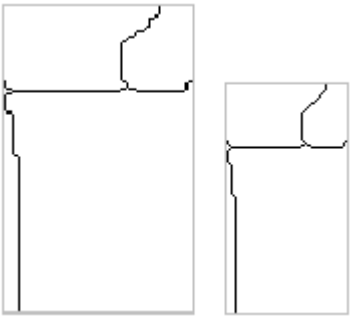
The recognition percentages presented in table 2 show the strong resistance of the proposed method against noise conditions.

Table 2. the sensitivity of this method to noise

Noise Type	Noise Rate	Recognition Percentage
Gaussian	2%	88.13
	5%	86.11
	8%	79.91
	10%	74.86
Pepper-Salt	2%	92.12
	5%	91.58
	8%	87.38
	10%	85.78

5.2. Change in Input Image Size

On the contrary, of the some of the propsed algorithms [7] one of the advantages of the extraction algorithm is the high stability of it against resizing the input image. Since two features of direction and accumulation are extracted taking into account the black pixels of the frame, all pixels of the frame(black&white), all black pixels of the image and all pixels of the image(image size), changing the size of the input image results in change in all these features so that the percentage extracted for these features in every frame stands the same. The image of digit 4 in two different positions (figue 5-a and 5-b) that are similar in shape but different in size are shown. These images are used to evaluate the stability of the algorithm against resizing for one of the extracting algorithms.



5. a) Picture number4 in size(66*39), b) Picture number4 in size(116*64)

Table 3. Percentage of accumulation for 5.a

0	0	40.38	21.42
43.09	12.43	36.54	8.39
93.81	0	0	0
91.22	0	0	0
90.36	0	0	0
90.36	0	0	0

Table 5. Percentage of accumulation for 4.b

0	0	40.38	21.42
43.09	12.43	36.54	8.39
93.81	0	0	0
91.22	0	0	0
90.36	0	0	0
90.36	0	0	0

According to the table 3 and table 4, Average angle have stability against change size.

6. Conclusions

In this paper, a new method has been proposed to extract image features through water filling algorithm. The number-narrowed image is the input of water filling method. And the extracted features are given to a Perceptron neural network for the final recognition. The relatively high stability of the extracted features against noise, rotation, image size changes and movement is the most important advantage of the proposed.

In this work, a database[11] of 60000 Persian numbers was used, out of which 40000 were used for education purposes, and 20000 were used for the experiment. Recognition percentage of the experiment was found to be 92.7%.

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