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Handwriting recognition of digits, signs, and numerical strings in Persian☆

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ABSTRACT

This paper presents an important step towards the standardization of research works on Optical Character Recognition in Persian language. It describes the formations of a standard handwritten database, including isolated digits, isolated signs, multi-digit numbers, numerical strings, courtesy amounts, and postal codes. In this regard, binary images of 72,180 samples were extracted from the designed forms. These forms were filled by 180 writers selected from different ages, genders, and jobs. Then these forms were scanned at 300 dpi with a high-speed scanner. Finally, forms are segmented into samples and are stored in bitmap format. This database is named PHOND, Persian Handwritten Optical Numbers & Digits, and it is available to the research community. Comparisons with the previous related databases illustrate the advantages of PHOND against other databases. Different experiments are done using PHOND database and the results are compared with other research works in handwritten recognition.

1. Introduction

Nowadays, recognition systems are used in many fields that have different natures. Optical Character Recognition (OCR) was started from the recognition of machine printed digits and characters. Afterward, it was developed for the recognition of machine printed words. Gradually, handwritten digit, character and word recognition were introduced into this domain. Several research works have been focusing towards evolving the newer techniques that would reduce the preprocessing time and provide higher recognition accuracy [1].

A handwritten character recognition system may be classified as on-line or off-line system. In offline character recognition system, the document is first generated, digitized, stored in the computer and then it is processed. In case of online character recognition system, character is processed during the creation. External factors like pressure, speed of writing, stroke making and etc. do not have any influences in case of offline system, but they have great impact on the online system.

Recognition of handwritten characters is one of the most interesting topics in pattern recognition. Applications of OCR are in different areas, especially digit recognition, which deals with postal mail sorting, bank check processing, form data entry, vehicle plate recognition, postal address block detection and recognition, camera OCR etc. [1].

English, Chinese, and Kanji handwritten number recognition have been a focus of study for a long time and high recognition rates are reported. Persian language is spoken by more than 110 million people, mainly in Iran, Afghanistan, Tajikistan, and partly in some other countries [2]. There are also other languages, which use the same alphabets and digits or subsets of them such as Arabic, Urdu, and Pashto.

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Digit	English	0	1	2	3	4		5	6		7	8	9
	Persian	0	1	2	3	۴	٤	5	۶	٦	7	8	9

Fig. 1. Digits in Persian and English.

In Persian language, words, sentences, and dates are written from right to left, but numbers are written from left to right, which match the style of writing numbers in English language. Ten digits in Persian language are shown in Fig. 1. Digits 4 and 6 can be written in two different shapes. Considering these facts, it is crucial to have a standard database in order to improve research on Persian handwritten digit and number recognition.

Standard databases play vital roles in pattern recognition tasks. To compare the different algorithms and select the best one, they must be examined using a same database. Only the results obtained from the standard databases can be reliable and useful for evaluating the performance of various approaches. Consequently, standard databases can strongly provide advancement in OCR research works.

In the last few decades, numerous methods have been proposed for machine recognition of handwritten characters, especially for the more popular languages such as English [3,4], Japanese [5,6], and Chinese [6,7]. The number of countries with the English language is not small. However, some of the researchers in other countries also are working on the English handwritten datasets. Therefore, after a on face searching, it seems that the recognition of Latin numeral characters has attracted much attention [7,8,9]. Because it is a handy case for testing various techniques (preprocessing, feature extraction, and classification) and it has many applications (postal mail sorting, check reading, form processing, etc.). So far, many effective recognition methods have been proposed and high accuracies up to 99% on some handwritten digit databases have been reported [4,10].

For the recognition of Persian (Arabic) handwritten digits, several works have been reported and few ones like [11,12] have investigated the handwritten number recognition. A lot of data such as addresses are written on envelopes; amount are written on checks; names, addresses, identity numbers, and Rial (Currency of Iran) values are written on invoices and forms by hand and these had to be entered into the computer for processing.

This paper introduces a database that named PHOND, Persian Handwritten Optical Numbers & Digits. PHOND is a new standard database for offline handwritten Persian (Arabic) digits, signs, numerical strings, courtesy amounts, and postal codes. It is suitable for using in optical number recognition research works. Furthermore, PHOND can be employed in recognition of numbers in other languages such as Urdu, Kurd, and Arabic. These languages use the same digits and signs in writing.

In addition, in this paper, toward the number recognition, numeral images are segmented to digits and then our modified framing feature is extracted from the digits. For extracting the modified framing feature, a digit image is divided into some frames and for each frame, average distance, average angle and outer profiles are calculated. Experimental results illustrate that our proposed modified framing feature results higher recognition rate up to $\approx$ 99% compared to the previous methods.

Different experiments are done using PHOND and previous handwritten databases and the results are compared with other research works about handwritten recognition.

The organization of this paper is as follows: Related work in Handwritten Recognition is described in Section 2. Section 3 covers the related databases to this paper. In Section 4, PHOND is introduced and the way of data collection to provide it is described. In Section 5, comparison between our new database, PHOND and other databases is provided. Section 6 describes our method for handwritten number recognition. Some experiments have been done on PHOND and previous databases and the results have been shown in Section 7. Finally, conclusions and future work are presented in Section 8.

2. Related work

Soltanzadeh et al. [13] developed a technique that uses four views based on the structural features of the digits. It transforms the Arabic/Persian digits into four one-dimensional features based on top, bottom, left, and right views. These views represented the number of white pixels from the side of the view to the boundary of the digit. In this research, Support Vector Machines (SVM) and Multilayer Perceptron (MLP) neural network were used for classification and Arabic check database of CENPARMI was used to report the results. Digits were normalized to 64 $\times$ 64 pixels before the feature extraction stage and recognition rates of 94.14% and 91.25% were reported using SVM and MLP, respectively. For handwritten Farsi numeral recognition, Soltanzadeh et al. [14] extract features from the outer profiles, crossing counts and projection histograms [14]. The resulted 64-dimentional feature vector is classified using one-versus-all SVM classifiers, with polynomial and radial basis function (RBF) kernels, respectively. Using 4974 samples for training and 3939 samples for testing, they obtained accuracies of 99.44% (polynomial kernel) and 99.57% (RBF kernel).

Solimanpour et al. in [15] tested the method of [14] on the Farsi handwriting database of CENPARMI. The database has 11,000 Farsi numeral samples for training, 2000 samples for verifying, and 5000 samples for testing. Using the verifying data for selecting kernel parameters for SVM classifier, they obtained a test accuracy of 97.32%. This lower accuracy indicates that the samples in CENPARMI database are more challenging than those, which are presented in [14].

Javidi et al. [7] presented a method to combine multiple classifiers based on a static structure. This method established based on decision templates (DT). They do not only rely on the similarity between a test sample x and c decision template matrices. Moreover, to make a decision about pattern x they construct q wrong decision templates, and compute likeness between pattern