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## ORIGINAL ARTICLE

# Novel feature extraction technique for the recognition of handwritten digits

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**Abstract** This paper presents an efficient handwritten digit recognition system based on support vector machines (SVM). A novel feature set based on transition information in the vertical and horizontal directions of a digit image combined with the famous Freeman chain code is proposed. The main advantage of this feature extraction algorithm is that it does not require any normalization of digits. These features are very simple to implement compared to other methods. We evaluated our scheme on 80,000 handwritten samples of Persian numerals and we have achieved very promising results.

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## 1. Introduction

The recognition of handwritten script is a difficult task due to the different handwriting qualities and styles that are subject to inter-writer and intra-writer variations. Many recognition systems in many applications have been proposed in recent years where higher recognition accuracy is always desired. Typically, the recognition systems are adapted to specific applications to achieve better performance. They can be divided into three main steps: preprocessing step, feature extraction and selection step, and classification and verification step. Handwritten digit recognition problem can be seen as a subtask of the optical character recognition (OCR) problem. Unconstrained handwritten digit recognition has been applied to recognize amounts written on checks for banks or zip codes on envelopes for postal services, etc.

This paper focuses on feature extraction and classification. The performance of a classifier can rely as much on the quality of the features as on the classifier itself. A good set of features should represent characteristics that are particular for one class and be as invariant as possible to changes within this class [1]. Commonly used features in character recognition are: invariant moments [2], projections [3], zoning feature [4], Fourier descriptors [5], and contour direction histogram [6]. A feature set made to feed a classifier can be a mixture of such features.

While handwritten Latin digits recognition has been extensively investigated [7–10] through various techniques, little work has been done for Arabic/Farsi digit recognition. Direction histograms using segmented characters from words in the CEDAR database [11] and transition information from the background to the foreground pixels in the vertical and horizontal directions of a character image [12] have been investigated. Later, feature extraction techniques generating local and global features were proposed [13] wherein local features were obtained from sub-images of the character including foreground pixel density information and directional information. The global features measured the fraction of the character appearing below the word baseline and the characters' width/height ratio. Furthermore, gradient features have been proposed for handwritten character recognition [14,15] where Awaidah and Mahmoud combined them with structural and concavity features for the recognition of Arabic (Indian) numerals using hidden Markov models (HMM) [16].

A probabilistic neural network (PNN) approach for the recognition of the handwritten Indian numerals [17] based on the center of gravity and a set of vectors to the boundary points of the digit has been presented however Montazer et al. [18] proposed a holistic approach using neuro-fuzzy inference engine to recognize the Farsi numeral characters. Finally, Impedovo et al. introduced a genetic algorithm based clustering approach using zoning features [19] whereas an adaptive zoning techniques for handwritten digit recognition are presented [20,21] where the features are extracted according to an optimal zoning distribution.

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