Recognition of Handwritten Arabic (Indian) Numerals Using Freeman's Chain Codes and Abductive Network Classifiers

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Abstract—Accurate automatic recognition of handwritten Arabic numerals has several important applications, e.g. in banking transactions, automation of postal services, and other data entry related applications. A number of modelling and machine learning techniques have been used for handwritten Arabic numerals recognition, including Neural Network, Support Vector Machine, and Hidden Markov Models. This paper proposes the use of abductive networks to the problem. We studied the performance of abductive network architecture on a dataset of 21120 samples of handwritten 0-9 digits produced by 44 writers. We developed a new feature set using histograms of contour points chain codes. Recognition rates as high as 99.03% were achieved, which surpass the performance reported in the literature for other recognition techniques on the same data set. Moreover, the technique achieves a significant reduction in the number of features required.

Keywords- Abductive network, Arabic digit recognition

I. INTRODUCTION

Handwritten numeral recognition systems have contributed significantly to progress in the automation process and have improved the interaction between man and machine in many applications, including cheque verification and a large variety of banking transactions, business and data entry applications. Over the past few decades, several approaches have been proposed for pre processing, feature extraction, classification, post-processing of handwritten text, and standard image databases were developed for evaluating the performance of such system [1]. However, most of such research activities have been limited to Latin, Japanese and Chinese text, with little work done on Arabic text including Arabic (Indian) numerals. This may be partially due to the fact that no generally accepted databases existed for Arabic text/numeral recognition that was freely available to researchers [1]. Therefore, various research groups working in the field had to develop their own datasets, which is tedious work. Moreover, performance of various techniques on different datasets may not be directly comparable.

This paper explores the use of an abductive network approach for recognizing handwritten Arabic (Indian) numerals zero to nine (0-9) used in Arabic writing as shown in Figure 1. Following a review of related earlier work in Section 2, Section 3 introduces abductive network modelling. Section 4 describes the handwritten Arabic (Indian) numerals dataset used and the proposed feature extraction techniques. Section 5 summarises the experimental work using abductive machine learning and the results obtained. Finally, section 6 concludes the paper.
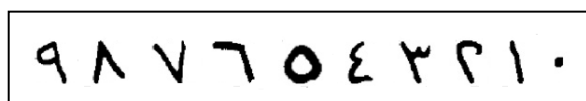

Figure 1: Handwritten Arabic (Indian) digits 0 to 9

II. RELATED WORK

In recent years some researchers have developed computational intelligence models for the accurate recognition of Arabic text. Al-Omari [2] used an average template-matching approach for recognizing Arabic (Indian) numerals. Feature vectors representing significant boundary point distances from the digit centre of gravity (COG) were extracted and used to derive a model for each numeric digit. Classification was performed using the Euclidean distance between the feature vector of the test samples and the generated models. Similarly, Sadri et al. [3] proposed the use of support vector machine for the recognition of isolated handwritten Arabic/Persian numerals. The method views each digit from four different directions, extracting 64 features used to train SVM classifiers to separate the various digit classes. An average recognition rate of 94.14%, was obtained. A new method for recognition of isolated handwritten Arabic (Indian) numerals using Hidden Markov Models (HMM) was presented by Mahmoud [4]. In his method, four sets of features, i.e. angle, circle, horizontal and vertical (ACHV), were generated based on the segmentation of digit pixel image, and for each segment the ratio of black pixels to segment size was computed. These features were used for training and evaluating the HMM models. Average recognition rate of 97.99% was achieved.

Recently, abductive networks have emerged as a powerful tool in pattern recognition, decision support, classification and forecasting in many areas [5], [6], [7]. Inspired by promising results obtained in other fields, we explore the use of this approach for the recognition of handwritten Arabic (Indian) numerals.