REVIEW OF FEATURE EXTRACTION TECHNIQUES FOR OFFLINE HANDWRITING ARABIC TEXT RECOGNITION

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ABSTRACT
Offline recognition of Arabic handwritten texts has been an ongoing research problem for many years. Generally, offline text recognition field has been gaining more interest lately due to an essential role in many human computer interaction applications including cheque verification, mail sorting or office automation. Most of the offline text recognition systems can be broken down into the following stages: pre-processing, feature extraction and also classification. This paper compares between different techniques that have been used to extract the features of Arabic handwriting scripts in offline recognition systems. Those methods attempt to extract the feature vector of Arabic handwritten characters, words, numbers or strokes. This vector then will be used in the recognition engine to recognize the pattern using the feature vector. The strategy and structure of those reviewed techniques are explained in this article. We will also discuss the weaknesses and strengths of using these techniques.

KEYWORDS: *Offline recognition, Features Extraction, Arabic handwriting.*

I. INTRODUCTION

A handwriting recognition system can be either online or offline. The offline handwriting is based on Optical Character Recognition (OCR) and is usually applied on scanned documents. On the other hand, in online handwriting, the pressure is applied on digital instruments and sequence of points traced out by the pen. Offline handwriting recognition involves the automatic conversion of text in an image into letter codes which are usable within computer and text processing applications, and it is generally observed to be harder than online handwriting recognition.
In recent years, some research has been done on the problem of offline Arabic handwriting recognition [1], [2], [3]. Despite this fact, offline Arabic handwriting recognition is still very challenging because of the varying writing style from person to person, difficulty of segmentation because of the cursive nature of the Arabic writing.
Recognition of Arabic handwriting is a difficult task due to the similar appearance of some different characters. This system is broken into four main stages: image acquisition, pre-processing, feature extraction and also classification. However, the selection of the method for feature extraction remains the most important step for achieving high recognition accuracy.
In this paper, we discuss the characteristics of a handwritten Arabic script and a brief overview of the features extraction techniques proposed in the past works in the area of offline Arabic handwriting recognition will be described and compared.
This paper is organized as follows: Section II gives a brief description of Arabic script characteristics. Feature extraction methods are explained in section III. Section IV deals with past works on offline Arabic handwriting. Section V presents the conclusion of the study. Finally, future work will be referred to in section VI.

II. BRIEF DESCRIPTION OF ARABIC SCRIPT CHARACTERISTICS

Arabic language is the main language of all Arabic countries with more than 280 million people speaking this language as a first language and 250 million as a second language. Arabic language comes as the fifth rank of most commonly used languages in the world. However, there are some other languages related to Arabic language. These languages have some similarities with Arabic language as regards the characters shapes or the pronunciation. These languages are Jawi, Persian, Urdu, Pashto, Bengali, and others. These languages are spoken by millions of people in many Islamic countries such as Iran, Afghanistan, Pakistan, parts of India, Bangladesh, Sri Lanka, Malaysia, Indonesia, and other countries [4].

Several reasons make Arabic language different from other languages from the shape and the writing style [5]. Here are some of these reasons:

- Arabic script is written from right to left in a cursive way.
- The Arabic alphabet consists of 28 characters.
- Arabic script is inherently cursive.
- Arabic characters differ in position and/or the number of dots (Fig.1).
- Each character can have one to four different forms: isolated, connected from the left, connected from the right and connected from right and left (Fig.2).
- Arabic words can be written using different writing styles that make the letters and words have different shapes which cause ambiguity any recognition system. Figure 3 shows example of different styles of writing the word Valley (وادي).
- Arabic writing may be classified into three different styles [6], [7]:
  - ✓ **Typewritten:** This style is generated by computer. It is the simplest one because the characters are written without overlaps or ligature (Fig.4).
  - ✓ **Typeset:** This style is more difficult than the typewritten because it has many ligatures and overlaps. It is used to write newspapers and books. Nowadays, this style may also be generated using computers.
  - ✓ **Handwritten:** This style is the most difficult because of the variation of writing the Arabic alphabets from one writer to another.

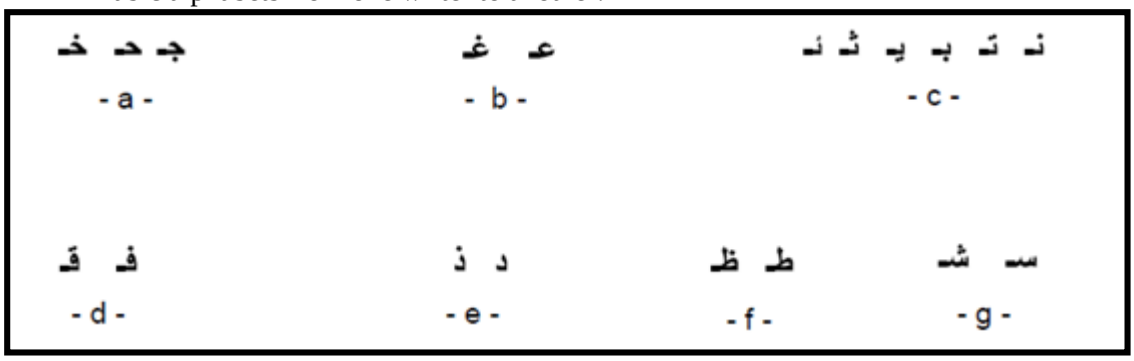

Fig. 1: Arabic characters differ by the position and/or the number of dots

Letter	Single	Beginning	Middle	Terminate
Alif	أ	أ	ـا	ـا
Baa	ب	بـ	ـبـ	ـب
Taa	ت	تـ	ـتـ	ـت
Thaa	ث	ثـ	ـثـ	ـث
Jeem	ج	جـ	ـجـ	ـج
Haa	ح	حـ	ـحـ	ـح
Khaa	خ	خـ	ـخـ	ـخ
Dal	د	د	ـد	ـد
Dhal	ذ	ذ	ـذ	ـذ
Raa	ر	ر	ـر	ـر
Zai	ز	ز	ـز	ـز
Seen	س	سـ	ـسـ	ـس
Sheen	ش	شـ	ـشـ	ـش
Sad	ص	صـ	ـصـ	ـص
Dad	ض	ضـ	ـضـ	ـض
Taa	ط	طـ	ـطـ	ـط
Dhad	ظ	ظـ	ـظـ	ـظ
Ain	ع	عـ	ـعـ	ـع
Ghain	غ	غـ	ـغـ	ـغ
Faa	ف	فـ	ـفـ	ـف
Qaf	ق	قـ	ـقـ	ـق
Kaf	ك	كـ	ـكـ	ـك
Lam	ل	لـ	ـلـ	ـل
Meem	م	مـ	ـمـ	ـم
Noon	ن	نـ	ـنـ	ـن
Haa	ه	هـ	ـهـ	ـه
Waw	و	و	ـو	ـو
Yaa	ي	يـ	ـيـ	ـي

Fig. 2: Arabic language alphabets

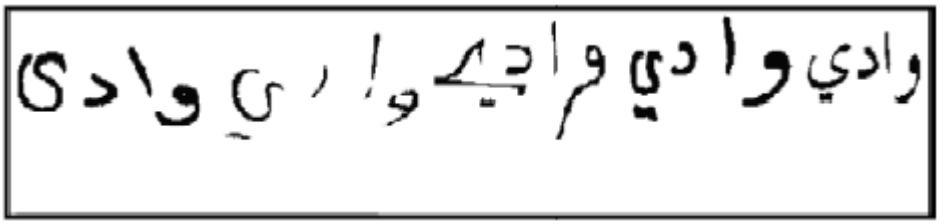

Fig. 3: Different writing styles of the word Valley (وادي)

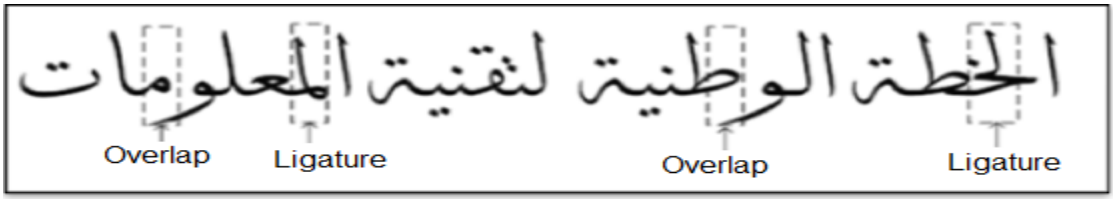

Fig.4: An Arabic writing shows the “ligatures” and “overlaps”

III. FEATURE EXTRACTION METHODS

Feature extraction is very problem dependent. Good features are those in which values are similar for objects belonging to the same category and distinct for objects in different categories. Choosing the proper type of features depends on the nature of the text, the type of the system processing which may be offline or online, and the scripts types that can be handwritten or printed.
For selecting good features, the following criteria should be considered: features should preferably be independent of rotation and size, features should be easily computed and features should be chosen so that they do not replicate each other.
According to [8], features used in off-line recognition are classified into high level features which are extracted from the whole word image, medium level features which are extracted from the letters, and low level features which are extracted from sub-letters. However, feature types can be categorized into three main groups: statistical features, structural features and global transformation [9]. The description of each type is explained as follows.

3.1. Structural Features

Structural features describe the geometrical and topological characteristics of a pattern by describing its global and local properties. The structural features depend on the kind of pattern to be classified.
For Arabic characters, the features consist of zigzag, dots, loops, end points, intersection points and strokes in many directions. The number of dots and their positions with respect to the baseline can also be used as a structural feature [10], [11]. The length of contour segment and the distance between the start and end points of the contour projection of the x–axis and y–axis are structural features that can be extracted from the text image.
In general, structural features are challenging to extract from the Arabic text image and many errors occur because of the small difference between Arabic characters.

3.2. Statistical Features

Statistical features are numerical measures computed over images or regions of images. They include, but are not limited to, histograms of chain code directions, pixel densities, moments, and Fourier descriptors [12].
Statistical features are easy to compute and text independent. An example of such features are zoning of pixels which are used by dividing the text image into zones and using the density of pixels in those zones as a feature (Fig.5). This type of features is used in offline systems and used in few online systems by combining them with structural type.

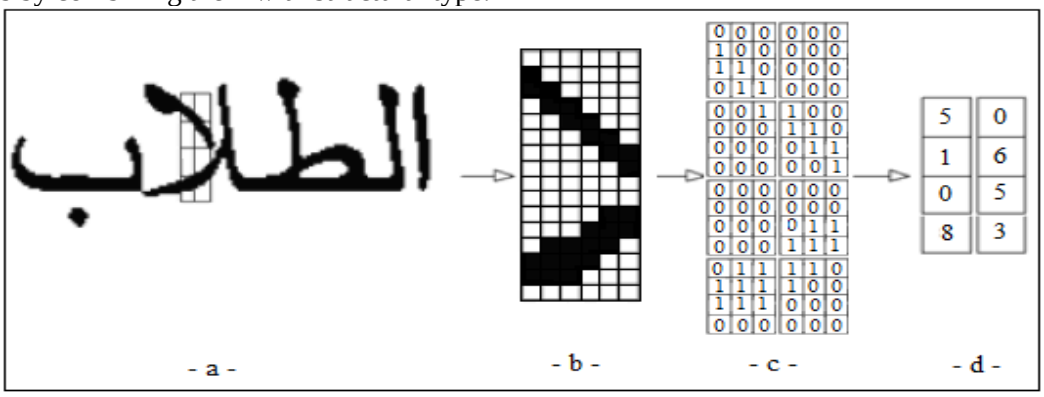

Fig.5 : feature vector using intensity method

3.3. Global Transformation

The transformation schemes convert the pixels transformation of the pattern to a more compact form which reduces the dimensionality of features. One of the transformations is the projection transform [13], [14] to represent the character image as a string of primitives.
Fourier descriptors method is also applied by using the coordinates of the contour pixels. The character may then be represented by a periodic function [15], [16].

Hough transform [17] can also be used to represent the skeleton of a character as a set of line segments and then use the length, slope and location of the line as a feature.

IV. PAST WORKS ON OFFLINE ARABIC HANDWRITING

Early research on offline Arabic handwriting recognition was done by G.H. GRANLUND [18]. They proposed a recognition method for print and cursive Arabic character. The method was based on features extracted by Fourier transformations, from these Fourier coefficients, a distinction can be made between genuine shape constants and constants representing size, location, and orientation. The utility of the method has been tested with a computer program that was used to classify 175 samples of hand printed letters, 7 sets of the 25 letters A to Z. In this test, 98 % were correctly recognized.

In 1987, Almuallim and Yamaguchi proposed one of the first methods for Arabic handwriting recognition [19]. It used the skeleton representation and structural features for word recognition. Words were segmented into "strokes" which were classified and combined into characters according to the features. The feature vector is calculated by considering the 7 features (questions f1-f7) for example, f2: is the end point a line end? 1: yes, 0: no. The calculated vector is then compared to the identification vectors of this group. The method achieved a recognition rate of 91% on 400 words by two writers.

In 1992, Al-Yousefi and Udpa introduced a statistical approach for the recognition of isolated Arabic characters [20]. It included the segmentation of each character into primary and secondary parts (such as dots and small markings) and normalization by moments of horizontal and vertical projections. The features were nine dimensions of kurtosis, skew, relationships of instants and the recognizer was a quadratic Bayesian classifier. A set of 10 handwritten samples was chosen from a database of 50 samples containing a fair mixture of good, moderate, and low quality samples. The results of classification for this set varied between 81% and 98.79% according to selected characteristics.

In 1996, Sano and al. [21] introduced a structural approach using fuzzy relations for recognizing handwritten isolated Arabic characters. Each input pattern is divided into sub-patterns (strokes) by feature points; end points, branch points, intersections and maximum curvatures point, etc. The number of sub-patterns varies from one to six depending on the input character. The sub-pattern is then characterized in terms of similarity to primitive elements (straight line, circle and diacritical point). The algorithm has been tested on a small number of handwritten samples.

In 1997, another study was done by Abuhaiba and al. [22] here; Thinned images of strokes are converted to straight-line approximations. A straight-line approximation of an off-line stroke is converted to a one-dimensional representation by a novel algorithm which aims to recover the original sequence of writing. The system was tested against the handwritings of 20 subjects yielding overall subword and character recognition rates of 55.4 % and 51.1% respectively.

In 2001, A. Dehghani and al.[23] proposed a new method for off-line recognition of isolated handwritten Persian characters based on hidden Markov models (HMMs). The features used in this process based on regional projection contour transformation (RPCT). In this stage, two types of feature vectors FH and FV are extracted. The performance of V_HMM, H_HMM and Combination method classifier for test sets is 47.75%, 53.69% and 71.82% respectively.

The following year, Snoussi Maddouri and al. [24] proposed a recognition system of Arabic hand-written words issued from literal amounts of Arabic checks. This system is a specific NN, named Transparent Neural Network (TNN), combining a global and a local vision modeling (GVM - LVM) of the word. It proceeds by GVM of structural features of the word in order to do a first classification. A second step of classification is done after a LVM of zones without structural features by the use of invariant Fourier descriptors (FD).

2100 images are used as 30 samples for each of the 70 words. The evaluation is done in four steps. Experimentation results are presented in table 1:

Table 1: Recognition rate for all words of literal Arabic amount

Combination Possibilities	Words Recognition rate
TNN + manual GVM	98%
TNN + GVM	90%
TNN + manual GVM + LVM	100%
TNN + GVM + LVM	97%

In 2003, Mario Pechwitz and Volker Maergner [25] presented an offline recognition system for Arabic handwritten words. The recognition system is based on a semi-continuous 1-dimensional HMM. The feature extraction is directly based on an image representation of the script using pixel values as rudimentary features. A rectangular window is moved in respect to the Arabic writing direction from right to left across the normalized gray level script image and generates a feature vector (frame). Performance of this system achieved maximal recognition rates of about 89% on a word level.

In 2005, El-Hajj and al.[26] demonstrated the benefit of features based on lower and upper baselines, within the framework of frame-based features with an HMM recognizer. They included features measuring densities, transitions and concavities in areas defined by the detected baselines. The system was tried on the IFN/ENIT database minus those names that have fewer than eight images, assigning 21,500 images for analysis. For each of four experimentations, the system was trained on three of the four image sets and tested on the remaining set. Recognition rates ranged from 85.45% to 87.20%. In their tests, the adding of the baseline-dependent features to similar measurements that do not use those zones significantly improved recognition.

Also in 2005, Mozaffari and al. [27] proposed a method for the recognition of Arabic numeric characters which is structural and also uses statistical features. Endpoints and intersection points were detected on a skeleton then used to partition it into primitives. Eight statistical features were processed on each primitive, the attributes for all primitives were concatenated, and the outcome was normalized for length. Nearest-neighbor was utilized for classification. Eight digits were tried and tested, and 280 image of each were used for training and 200 for the tests. The digits were written down by over 200 writers collectively. The recognition level was 94.44%.

In 2007, H. El Abed and V. Margner [28] proposed an approach using Semi Continuous HMMs (SC-HMM) recognizer and compared different pre-processing and feature extraction methods. Three different feature extraction methods are discussed in this work. The Sliding Window with Pixel feature extraction method needs normalized gray level images with the top- and base- lines information. The skeleton direction-based feature extraction method is based on the different main zones, which requires normalized skeleton graphs with only baseline information. The Sliding Window with Local feature extraction method uses only the original image and the baseline information, without any others pre-processing. They achieved recognition rates of up to 89% on word level using the skeleton based method for baseline estimation and skeleton direction features.

In 2009, M. Hamdani and al. [29] proposed a new technique by using three off-line methods of feature extraction andone on-line method for Off-line Arabic Handwriting Recognition. The first method is pixel values (OFF-1), these features are computed from a window with a size of 5 pixels and 3 pixels as overlap between consecutive windows. The second method is densities and Moment Invariants (OFF-2), the density of black pixels is calculated by a re-sampling procedure, the window is divided into cells and the value of the density of black pixels of each cell is used, the Moment Invariants are calculated for each window and concatenated with the density values. The third method is pixel distribution and Concavities (OFF-3), they use 16 features related to the pixels distribution and 8 features representing the different possibilities of concavities extracted from a sliding window with a size of 8 pixels and without overlap. The latter method is on-line features (ON-1), after the transformation of the input image into a sequence of coordinates; each part of word (PAW) is segmented into a sequence of graphemes. And 21 features related to the beta-elliptic modelling are extracted from the grapheme. The system is evaluated using the IFN/ENIT database. The recognition level is in maximum 63.90% for the individual systems. The grouping of the on-line and off-line systems allows improving the system accuracy by 81.93%.

In 2010, Jin Chen and al. [30] discussed the effectiveness of the method for extracting Gabor features vectors compared to other methods such as GSC features (a set of gradient, structure, and concavity

features) and Graph features. In this work, the Gabor filtering is used for extraction of features; they use the magnitude response of the Gabor filter: the square root of the sum of the squares of real response and imaginary response. To assess the efficacy of the Gabor filter based features, they perform Arabic subword recognition using support vector machines (SVM) for classification. The rate of recognition by proposed Gabor features, GSC features and Graph features was 82.7%, 81.6% and 68.2% respectively. On the other hand, the rate of recognition by{Combination of proposed Gabor and GSC}, {Combination of Graph and GSC}, and {Combination of proposed Gabor and Graph} was84.3%, 79.7% and 82.8% respectively.

In 2011, A. Lawgali and al. [31] compared the effectiveness of Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT), the purpose is to capture discriminative features of Arabic handwritten characters. In this work they used the technique DCT for convert data of the image into its elementary frequency components, the higher value DCT coefficients are extracted in a zigzag fashion and stored in a vector sequence. DWT is another technique used to extract the features of the characters in which, at each decomposition level, a low-pass filter (LPF) and a high-pass filter (HPF) are applied to each row/column of the image to decompose into one low-frequency sub-band (LL) and three high frequency sub-bands (LH, HL, HH). The coefficients of both techniques have been used for classification based on an Artificial Neural Network implementation. The rate of recognition by technique DCT amounted to value 96.56%, whereas the rate of recognition by technique DWT was just 59.81% in the best cases.

In 2012, H. M. Eraqi and S. Abdelazeem [32] proposed novel techniques of diacritics detection and feature extraction. The Douglas-Peucker algorithm is applied on the skeletonized parts of the offline images to convert it into piecewise linear curves that are used for efficient detection of diacritics, noise segments, and the baseline. The strategy used in the proposed feature extraction technique lies in combining efficient baseline-dependent and baseline independent features that are extracted from the image before and after removing the diacritics segments, in an HMM-based system which has proven to achieve promising recognition rates indicating the effectiveness of the proposed techniques. The rate of recognition by Proposed System (Without Lexicon Ranking and Reduction) and Proposed System (With Lexicon Ranking and Reduction) amounted to value 96.01% and 96.78% respectively in the best cases.

V. CONCLUSION

Feature extraction is an important phase in text recognition systems and for many pattern recognition problems. It aims to remove the redundancy from the data and gain a more effective representation of the text image by a set of numerical characteristics. The combination of features can give a more general description of the character, word, digit, or stroke.

In this article we have presented a brief description of the different techniques of feature extraction and the success rate of each technique in past work. We noticed that the success rate of any recognition system depends not only on the features extraction but it depends on several reasons such as the recognizer technique, the pre-processing stage, or the segmentation step.

VI. FUTURE WORK

After studying the various techniques of feature extraction and the recorded recognition rates, we will work in the same way on the study of different classifiers, with the purpose of contributing to the amelioration of the recognition systems of handwritten Arabic texts. Moreover, with the technique of the sliding window and HMM classifier (Hidden Markov Models), we will work on a system to recognize the handwritten texts.

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