A Comparative Study on Arabic Handwritten Words Recognition Using Textures Descriptors

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***Abstract*— Nowadays, the recognition of Arabic handwritten become one of the most challenging issues because of the intrinsic characteristics of the Arabic language. In this work, we investigate the performance of several texture descriptors on the recognition of Arabic handwritten words. We propose to describe Arabic words using Local Binary Patterns (LBP) and Gray Level Co-occurrence Matrix (GLCM). In addition, we propose to use, for the first time, the Multi Level Local Phase Quantization (ML-LPQ) descriptor. To conduct classification, we use three supervised classifiers namely Support Vector Machine (SVM), Naïve Bayes (NB) and K-Nearest Neighbors (KNN). As a second contribution, we introduce a new database of Arabic handwritten that is made up of 1000 words from the computer science field. Experimental evaluation has shown promising results.**

***Keywords*— Arabic handwriting recognition;textures descriptors; LBP; GLCM; ML-LPQ.**

I. Introduction

Arabic is one of the most popular languages in the world, as it is ranked as the 4th spoken language in the world after Chinese, Spanish and English [1]. The number of Arabic speakers exceeds 300 million people and it is the official language of 26 countries. The recognition of Arabic handwritten is an active topic and it has received a growing interest by researchers in the last two decades. Despite the several proposed solutions, Arabic handwritten recognition remains a challenging task and a lot of efforts remain to be done. This is attributed to the nature of the Arabic language. Unlike to the other scripts, Arabic is written from right to left. In addition, Arabic language is characterized by the existence of some special signs called diacritics points. Some words can only be distinguished by diacritics, which confirm their high importance for word recognition. These signs could be above or below the character, but never up and down simultaneously.

In the literature, we distinguish two types of handwriting recognition systems according to the data acquisition process [2]: offline and online systems. In the offline systems, the system deals with already existing images (such as scanned images). This approach focus on the recognition of handwriting in the form of an image.

In the second approach (i.e., online systems), the system recognizes the symbols as they are drawn in real time [3]. This is usually done through pen-based interfaces where the writer writes with a special pen on a tactile screen. The system obtains the position of the pen as a function of time directly from the interface.

In this study, we focus our attention on offline recognition systems. The offline approach is considered to be more difficult than the online approach [4] because the system deals with an accomplished word, which makes difficult to distinguish the beginning of the word from its end. Particularly, to figure out the most discriminative descriptor, we conduct an experimental comparison between various texture descriptors. To confirm the capabilities of the tested descriptors, we opted for using three different classifiers instead of using a single one. As for the evaluation, finding a database that well represents the variety of handwriting styles and which assembles the most important classes in the target language is one of the most challenging aspects in the offline handwriting recognition. In the literature, a very few number of databases are freely available for research and academic use. For this reasons, we have introduced a new database, which is presented, in details, in the next sections.

The rest of the paper is organized as follows: In section II reviews certain relative works. Section III presents an overview of the proposed methods. The experimental evaluation and the details about our new database is given in section IV. Finally, we finalize the paper by outlining some conclusions.

II. Related work

In the handwritten recognition field, some researchers have limited themselves on recognizing characters only, whilst, certain others have interested by the recognition of handwriting text or documents.

The majority of works have intended for the recognition of isolated handwritten words. This category, in turn, can roughly be classified into two sub-categories. In the first one, word image is segmented into characters or sub-words. The second sub-category namely the holistic approach, as it considers the entire image i.e, without segmentation. Hereafter, we review some of the existing works which are close to ours.

Manal Abdullah et al [5] proposed a new system for Arabic handwritten words recognition. In their work, some enhancement techniques, including baseline estimation and correction, remove inter-words space, were firstly conducted. Afterwards, structural features were extracted from the entire image, and the Neural Network is used to perform classification.

A new approach based on the Dynamic Hierarchical Bayesian Network (DHBN) fis proposed by [6]. To describe the images, authors relied on both Zernike and HU moments.

Leila Chergui and M. Kef [7] proposed a new recognition system for offline Arabic handwritten words based on SIFT descriptor. At first, the whole image is partitioned vertically into five frames, then the similarity measure between each part from testing image and its corresponding part from the training images is calculated using the Euclidian distance. The testing image is assigned to the class of the closest training image.

A word-segmentation-based Arabic handwritten recognition system is presented in [8]. The authors introduced a new algorithm for word segmentation into sub-words. In order to improve the recognition yields, the number of sub-words is considered as a rejection criterion. It should be mentioned that words were described using the discrete cosine transform (DCT) descriptor, whereas SVM classifier with a reject option is utilized for classification ends.

An offline handwritten words recognition system based on classification combination is proposed by Rachid Zaghdoudi and Hamid Seridi [9]. In this work, Discrete Cosine Transform (DCT) and Histogram of Gradients (HoG) are used to describe images. Certain combination schemes were used to combine two classifiers namely SVM and fuzzy-KNN, where the Bayesian scheme has yielded the best result.

Mustapha AMROUCH et al [10] proposed a holistic method based on Hidden Markov Models (HMMs) using embedded training for Arabic handwriting recognition. In their system, various statistical and geometrical features were considered and extracted after the estimation of the baseline.

III. US METHODS (FEATURES& CLASSIFIERS)

The main objective of the handwritten recognition system is to translate the handwritten word images into a text in digital format. Therefore, the goal is to simulate human reading capacity. To achieve such a goal, generally five basic steps are required: 1) pre-processing, 2) representation, 3) segmentation, 4) feature extraction, and 5) classification. It worth noting that certain works consider only the last two phases.

Due to the nature of the handwriting with high degree of variability and imprecision, obtaining features that faithfully represent words is a quite difficult task. To tackle this issue, a large number of research papers and reports have already been published on Latin, Chinese and Japanese characters [11]. The textures descriptors are widely used for face recognition, and they attained encouraging results [12, 13, 14, 15 and 16]. In this paper, we examine the efficiency of some texture descriptors for the recognition of Arabic handwritten words.

In the following, we give details about the descriptors we have adopted for representing Arabic handwritten words and the methods we have pick out for recognition.

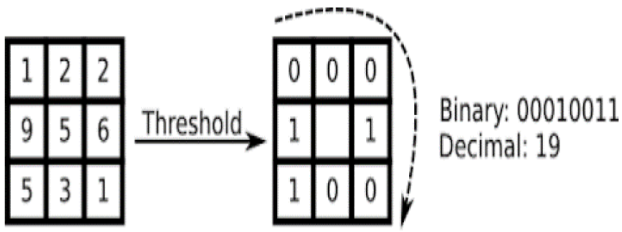
A. Feature extraction methods

1) Local Binary Patterns (LBP)

The LBP operator is a powerful description of texture [17]. It labels the pixels of an image with decimal numbers called Local Binary Patterns or LBP code, which encodes the local structure around each pixel [18].

The general principle is to compare the intensity level of each pixel with the levels of its neighbors by subtracting the central pixel value. The resulting values that are strictly negative are encoded with 0 and the remaining with 1.

A binary number is obtained by concatenating all these binary codes in a clockwise direction starting from the top-left. The corresponding decimal value is used for labeling. Figure 1 shows the principal of the LBP



descriptor:

2) Gray Level Co-occurrence Matrix (GLCM)

The GLCM is a matrix that describes the appearance frequency of different combinations of gray level values within the image according to a particular spatial relationship (i.e., offset and angle).

The matrix is sensitive to rotation By changing the offsets that define pixel relationships, such as varying directions rotation angle of an offset: (0°, 45°, 90°, 135°)

Figure 1: An example of the basic LBP operator

and displacement vectors (distance to the neighbor pixel: 1, 2, 3 …) [11], we can obtain different GLCM matrices (show Figure 2).

Haralick et al. [19] have proposed a number of textural features measures, which are derived from the GLCM matrix. Among these measures, we have selected the most commonly and the widely used ones, which are Contrast, Energy, Homogeneity and the Correlation.

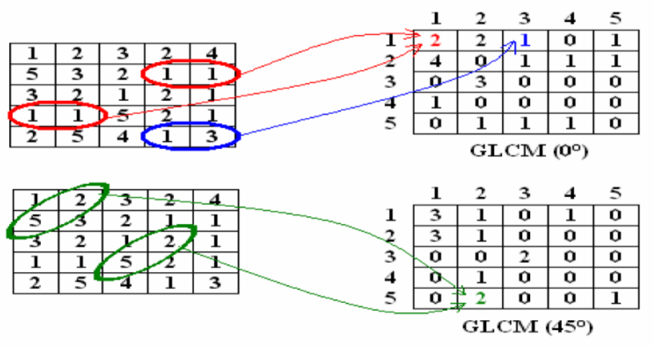


Figure 2: GLCM Matrix with two different angles

3) M ulti level Local Phase Quantization (ML-LPQ)

The local phase quantization (LPQ) descriptor is one of the most efficient and widely used features in writer identification and face recognition domain. LPQ is based on computing a Short-Term Fourier transform (STFT) that is calculated over a rectangular M×M neighborhood at each coordinate x within the image. It is given by the following equation [20]:

$$F(u,x) = \sum_{y \in N_x} f(x-y)e^{-j2\pi u^T y} = w_u^T f_x \qquad (1)$$

Where:

- w_u is the basis vector of the 2-D DFT at frequency u.
- $f_x$is a vector containing all M^2 neighborhoods.

In this study, the Multi-level term is used where the original image is divided into n sub-blocks ($n \in \{1,2,3,\ldots\}$). Then, extracting the LPQ feature from each sub-block. This operation is called multi block LPQ (MB-LPQ).

The main idea of Multi-Level [21] is to extract then combine features from different Multi-Block divisions. In other words, extract features from the whole image, then divide it into 2×2 sub-blocks and extract the features from each sub-block [22] and so on, until reaching the intended level.

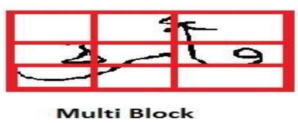


*Figure 3: Multi Block example 3*3*

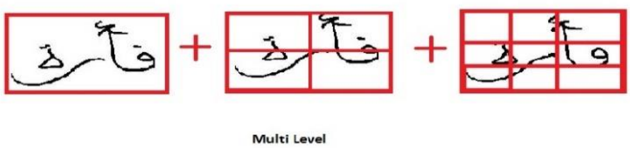


Figure 4: Example of ML-LPQ with 3 level

B. Classifiers

The main aim of the classification stage is to assign a label to each input text-image sample (decide which training word this input image belongs to).

several classifiers methods have been proposed some of them are supervised (the training data is already labled and just claculate its semilarity with the new input data) and others are unsupervised (the input data is unlabeled , there is no predefined dataset for training). in this paper, we adopted to use some classifiers of supervised approach namely:

- **Naïve Bayes (NB):** is a simple and effective probabilistic classifier based on Bayes theorem. The new simple will assigned to the class that has a high probability of belonging.
- **Support Vector Machine (SVM):** were first introduced to solve the pattern classification and regression problems. In this classifier, a data point is viewed as an n-dimensional vector, in n-dimensional space $Rn$and we want to know whether we can separate such points with an (n − 1) dimensional hyper plane. Many hyper planes might classify the data. One reasonable choice as the best hyperplane is the one that represents the largest separation, or margin, between the classes.
- **K-Nearest Neighbor (KNN):** is a simple supervised algorithm that stores all available data (training set), then classifies a new data (test set) by calculating the similarity between them then comparing, and assigned it to the closest sample in the training set.

Several reasons maked us to choose these classifiers; the major reason is their efficiency in solving different recent pattern recognition problems [23, 24 , 25, 26 and 27].

IV. Experimental Result & Discussion

In this study, we adopted the uses of the textures features in order to examine their efficiency on the recognition of isolated Arabic handwritten words. Moreover, for the best of our knowledge some of them are used for the first time.

In this section, we present and then discuss the experimental results that we have obtained using the proposed methods. The experimental results were conducted using our own-created database. The database assembles 1000 words, from the computer science field, representing 10 different concepts and written by more than 70 writers. Table 1 shows some typical from the database.

Table 1: Sample images from our database

الطابعة	خوارزمية	لوحة المفاتيح	ملف	الشاشة
التعليمات	مكبر الصوت	المعالج	فأرة	فيروس

As we have already stated, to accomplish the recognition task, we have used three supervised classifiers namely KNN, Naïve Bayes and SVM. The obtained results are presented in the table below.

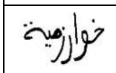
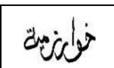
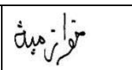
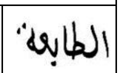
TABLE 2: EXPERIMENTS RESULTS FOR OUR DATABASE USING LBP,GLCM AND ML-LPQ DESCRIPTORS

Sub-groups	Descriptor	KNN	Naïve	SVM
1	***LBP***	28.34%	42.91%	30.31%
	GLCM	17.32%	25.59%	20.07%
	ML-LPQ	**95.66%**	**94.09%**	**95.27%**
2	***LBP***	28.22%	28.22%	16.85%
	GLCM	19.27%	18.78%	22.49%
	ML-LPQ	**95.56%**	**89.51%**	**95.96%**
3	***LBP***	26.19%	30.35%	14.28%
	GLCM	20.23%	26.19%	18.25%
	ML-LPQ	**96.82%**	**92.46%**	**97.22%**

Before examining the efficiency of descriptors each alone, we can clearly see that all the descriptors did not affected by changing the classifier where, the results were convergent with the three classifiers.

From table 2, we can observe also that the LBP and GLCM descriptors were relatively failed to extract the most relevant information from the handwritten word image, as comparatively low accuracies were scored by the two descriptors. This is may be attributed to the nature of the two descriptors that are based on the pixel intensity, which may be not enough to distinguish between the different classes. In order to prove this pretend, let us take a careful look on the GLCM features of certain words from distinct classes. The considered GLCM features are contrast, energy, homogeneity and the correlation. As shown by Table 3, we those features from 3 images representing the word "خوارزمية" and another one that represents the word "الطابعة".

TABLE 3: TABLE 3: THE FOUR GLCM MEASURES OF THE WORDS "خوارزمية" AND " الطابعة"

Measures	**Words**			
				
Contrast	0.0779	0.0966	0.0664	0.0811
Energy	0.7956	0.7285	0.8302	0.7495
Homogeneity	0.9611	0.9517	0.9668	0.9594
Correlation	0.4130	0.4754	0.3845	0.5392

Despite that the words "خوارزمية"and "الطابعة" belong to two different classes, they have roughly obtained the same values close to each other, which led to a low recognition rate.

The best recognition rate was scored by applying the ML-LPQ that well represents the handwritten words style and it successfully recognized the majority of words. The concept of multi level played a big role in well keeping information which lead to high accuracy for recognizing words.

V. CONCLUSION

This paper presents a comparative study for Arabic isolated handwritten words recognition based on texture descriptors. The aim of this work was to examine their capabilities in performing such an important task. Moreover, we utilize, for the first time, the ML-LPQ descriptor to describe the Arabic words. The descriptors was evaluted using the three well-known supervised classifiers namely KNN, Naive Bayes and SVM. Experiments were conducted on our new database of Arabic words, which groups 1000 words from 10 classes. The experimental results have proved the efficiency and the superiority of the ML-LPQ descriptor against the residual descriptors.

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