

A Novel Fractal Approach for Persian/Arabic Identification based on Handwriting Recognition

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Abstract: Problem statement: In recent years, fractal and multi-fractal analysis have been widely applied in many domains, especially in the field of image processing. In this study we presented a novel method for Persian and Arabic text-dependent writer identification based on fractal and multi-fractal features. **Approach:** From the images of Persian or Arabic words, we calculated their fractal dimensions by using the “Box-counting” method and then we calculated their multi-fractal dimensions by using the method of Diffusion Limited Aggregates (DLA). **Results:** To evaluate our method, we used 50 writers of the PERSIANDB database, each writer wrote 288 words (24 words repeated 12 times) with 2/3 of words are used for the learning phase and the rest is used for the identification. **Conclusion:** The results obtained by using k nearest neighbor classifier, demonstrated the effectiveness of our proposed method.

Key words: Multi fractal, writer identification, persian writer recognition, image processing

INTRODUCTION

Writer identification still remains an active area in the field of handwritten documents analysis. It can be useful in several domains such as, check of signatures, legal world where it is necessary to authenticate the author of a document or a bill of sale, to help in the handwriting recognition. Recently, different approaches for writer identification have been proposed. These approaches are generally categorized as off-line, where only a scanned image of the handwriting is available and Online (Al-Omari *et al.*, 2009; Hashim and Abdl, 2010), where temporal and spatial information about the writing is available. In this context, (Al-Omari *et al.* (2009), presents a method for identification of writer, who describes an off-line approach based on texture analysis. The step of feature extraction, two different methods are used, a multi-channel Gabor filter and a calculation of co-occurrence matrix. For identification, two classifiers are used, the k-nearest neighbors and the Euclidean distance. (Chabaa and Zeroual, 2009) evaluated the performance of edge-based directional probability distributions as characteristic for the identification of the writer (Jampour *et al.*, 2010) introduced the concept of invariants of the writer, exploited by (Athanasios *et al.* 2010), who presents a system of writer identification based on the comparison

of documents by their respective graphemes, by a measure of similarity. Andreas Al-Omari *et al.* (2009) present a system for online writer identification based on Gaussian documents, to validate their system that based on text-independent approach. (Kherallah *et al.*, 2009) presents a system of writer identification for Persian/Arabic documents, based on multi-channel Gabor filtering and co-occurrence matrix features.

In this study, we have proposed a text-dependent method for off-line writer identification. Our method is based on Persian and Arabic words and we have used the fractal and multi-fractal features. We have used PERSIANDB database (El Abed *et al.*, 2009) in our experiments. The tests are performed on images of words from 50 writers.

At first, we present the fractal and multi-fractal approach, then we present the application of the approach that we adopted for the writer identification, afterward we show the experiments and the obtained results and finally the conclusion.

Fractal and multi-fractal analysis:

Fractal analysis: The fractal theory was discovered by Al-Saidi and Said (2009). With this theory which studies the complex objects; a new description of these objects has been established. Fractal geometry has

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shown the limitations of Euclidean geometry in describing complex objects. It has offered new opportunities for science and many applications. Today, the ideas resulting from this notion of fractal geometry are used in several scientific domains, such as, the Earth sciences, Medicine, Geography, Computer Science, in particular in the analysis of texture in images. The fractal geometry can be seen as a generalization of the Euclidean geometry. We shall see it through the definition of the fractal dimension which is a generalization of the Euclidean dimension. Over the past decade, several studies in the field of handwriting analysis and font recognition (Moussaa *et al.*, 2009) have used the fractal analysis by calculating fractal dimension.

Fractal dimension: Several methods allowed estimating the fractal dimension of an object. We can cite, the Box Counting Method, the Differential Box Counting Method, the Box Counting Density. The box-counting is the most widely used for the calculation of fractal dimensions because it is easier to implement in practice, contrary to the other methods indicated previously.

Box-counting method: This method is applied to binary images and can determine the fractal dimension for self-similar objects. The image can be divided into a number of boxes of size ϵ . The boxes containing the information will be counted. The process is repeated for the other boxes of different size so that sequences of scales ϵ_i and of the number of boxes $N(\epsilon_i)$ can be obtained. The basic fractal equation may be given by Eq. 1:

$$N(\epsilon) = \frac{1}{\epsilon^D} \tag{1}$$

Where:

$N(\epsilon)$ = The number of boxes with size ϵ
 D = The fractal dimension which can be expressed by the following Eq. 2:

$$D = \lim_{\epsilon \rightarrow 0} \frac{\log(N(\epsilon))}{\log(\frac{1}{\epsilon})} \tag{2}$$

where, D is obtained by a least squares regression method.

Multi-fractal analysis: Mathematically, fractal objects have an infinite number of scales. For these objects, the fractal dimension is the same on all scales. Indeed, the

properties of self-similarity of a set of points can be characterized by the fractal dimension. This characterization is complete only for simple cases. In fact, most fractals are not homogeneous. There is rarely an identical pattern repeated on all scales and self-similarity properties can change from point to point. In this case, the object may have different dimensions at different scales. Thus, fractal analysis can be generalized by introducing the multi-Fractal concept.

Multi-fractal dimensions or generalized fractal dimensions (D_q):

Given the structure with the mass (number of Pixel) M_0 with the size L , covered grid boxes of size l , the generalized fractal dimension D_q for the mass distribution is defined as follows (Abed, 2009):

$$\sum_i \left(\frac{M_i}{M_0} \right)^q \approx \left(\frac{1}{L} \right)^{(q-1)D_q} \tag{3}$$

Where:

M_i = The number of pixels in the i^{th} box
 q = A variable which allows to distinguish fractals properties at different scales

A large difference between the fractal objects (mono-fractals) and the multi-fractal objects (multi fractals) is that for the mono-fractals, D_q is the same for all q varies between $-\infty$ and $+\infty$, by cons for the multi-fractals, different generalized fractal dimensions are not equal. For $q = 0$, D_0 correspond to Box-counting dimension; it is equal to the fractal dimension, for $q = 1$, D_1 correspond to the information or entropy dimension and for $q = 2$, D_2 correspond to the correlation dimension. It turns out that the direct application of (3) in practice is hindered by the fact that for $q < 0$, the boxes that contain a small number of pixels give anomalously large contribution to the sum on the left hand side of (3) (Al-Saidi and Said, 2009). To solve this problem, a solution has been proposed in (Abed, 2009). This solution is based on the application of generalized sand box method that is used to demonstrate the multi-fractality of the DLA.

This procedure consists in choosing randomly N pixels belonging to the structure and counting for every pixel i the number of pixels M_i , inside boxes of linear dimension R , centered on the selected pixel. The left-hand side of the Eq. 3 can be interpreted as the average of the quantity $\left(\frac{M_i}{M_0} \right)^{(q-1)}$ According to the probability

distribution $\left(\frac{M_i}{M_0}\right)$, when the centers of the boxes are chosen randomly, the averaging is made during this distribution and consequently, the Eq. 3 becomes:

$$\left\langle \left(\frac{M(R)}{M_0}\right)^{(q-1)} \right\rangle \approx \left(\frac{R}{L}\right)^{(q-1)D_q} \quad (4)$$

where the $\langle \dots \rangle$ denotes the average over the centers.

Fractal and multi-fractal for writer identification:
Our work is based on the calculation of the fractal dimension D and generalized fractal dimensions D_q for the image of each word. Initially, we proceed by the method of counting of the box to calculate the fractal dimension, in a second time, using the DLA method to calculate the generalized fractal dimensions.

Let us remember that 50 writers wrote 24 words repeated 12 times, including 2/3 words are used in the learning stage and 1/3 for identification. For each image of the word, the fractal dimension is calculated using the Box-counting method, described above, to see if a single fractal dimension is sufficient to characterize a textured image and obviously able to identify the writer of the word in question. Then, for the multi-fractal dimensions, for each of these images of words, we select randomly, 100 pixels, from those containing information (M_0 is about 400 pixels) and counting the number of pixels $M(R)$ contained in box centered at each pixel selected randomly for different values of R . Afterward, we calculate the average number of pixels in all boxes of the same radius R_i . This procedure is repeated 50 times. The calculation of multi-fractal dimension D_q is made for $-20 < q < 20$. For the case where $q = 1$, Eq. 4 is non-analytical, hence the choice of $q = c$, with $c = 0.0001$. The equation becomes: $D_1 \approx (D_{1-c} + D_{1+c})/2$.

The main steps of the algorithm of calculation of the generalized fractal dimensions D_q by the method of DLA, is presented as follows:

- Reading the image and calculating the number of pixels containing information
- Selection of 100 pixels from the pixels containing information and creating a box of radius R_i centered on randomly selected pixels
- Calculation of the number of pixels containing information in every box of radius $R_i = 2, 4, 6, 8, \dots, 16$
- While $R_i < R_{max}$, calculation of the average of the number of pixels containing information in all the boxes of the same radius R_i

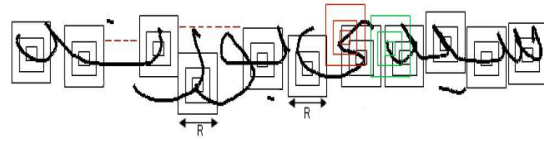


Fig. 1: DLA method for one Arabic and one Persian word (بودند and سیدی)

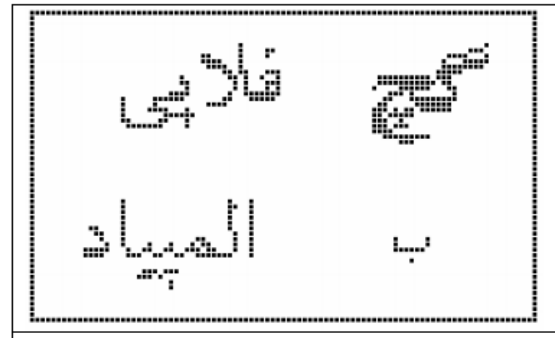


Fig. 2: Some written words

- Calculation of the average of the number of pixels containing information in all boxes of all radiuses. If $q = 1$ then $D_1 = (D_{1-c} + D_{1+c})/2$:

$$\text{Else } D_q = \frac{1}{q-1} \frac{\log \left[\left(\frac{M(R)}{M_0}\right)^{q-1} \right]}{\log \left[\frac{R}{L} \right]}$$

- If number of simulation equals to 50 goes at 2, Else calculate the average for these 50 simulations to obtain the multi-fractal dimensions D_q . End of program.

The Fig. 1 shows the boxes centered on pixels chosen randomly, as well as the growth of their sizes R .

One word is written by different faces. This is shown in Fig.2

MATERIALS AND METHOD

Our method is based on a text-dependent approach, where a writer has to write the same fixed text to perform identification. In this direction, each one of 50 writers wrote 14 Persian and 10 Arabic words. The writing samples of these 50 writers are obtained by a selection from the Persian and Arabic PERSIANDB database. This selection is based on a query which considers that the writers which wrote in common the 24 words, with 12 repetitions.

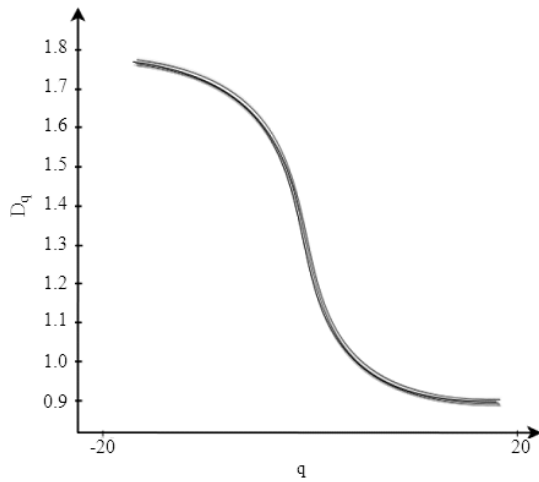


Fig. 3: D_q according to q for 50 times

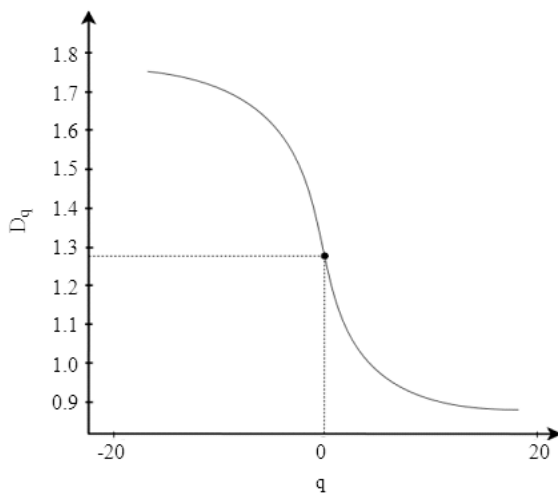


Fig. 4: Multi-fractal spectrum.

The 2/3 of words is used for the training and the rest is used for the identification. We present some images of words of this database. For each binary image of word, we applied the Box-counting method, to calculate the fractal dimension D and it, to verify, if it is possible, from this fractal dimension if we can identify the writer of the word in question. Then we applied on the same images of words, the DLA method to obtain the generalized fractal dimensions; in this case 41 features are extracted ($-20 \leq q \leq 20$).

We demonstrate in what follows the simulation of the image of the Fig. 3 presented above, the objective is the evaluation of the generalized dimensions D_q . The spectral of generalized dimensions by D_q according to q is represented by the Fig. 4.

Table 1: Some values of D_q

| D-20 | D_0 | D_1 | D_2 | D_{20} |
|--------|--------|--------|--------|----------|
| 1.7450 | 1.2786 | 1.2167 | 1.1823 | 0.8769 |

Table 2: Representation of some results

| Words | Box-counting (%) | DLA (%) |
|--------|------------------|---------|
| سید | 85.2 | 92.6 |
| بودند | 83.8 | 91.3 |
| فارسی | 82.2 | 88.8 |
| فرکتال | 81.3 | 87.2 |

RESULTS AND DISCUSSION

This Fig. 3 shows the shape of the curve of D_q according to q and this for 50 repeated times of chosen randomly pixels. By averaging these 50 repetitions, we obtain the multi-fractal spectrum presented by the following Fig. 3.

We notice according to Fig. 3 that there is a hierarchy of exponents of multi-fractal dimensions D_q with a capacity dimension always smaller than the information dimension, which is in his turn is always smaller than the correlation dimension. The following Table 1 gives some values of D_q according to q .

We present in what follows some result for the Words سید، بودند، فارسی and فرکتال on Table 2.

CONCLUSION

We presented a new method for the writer identification, based on the extraction of fractal and multi-fractal features from the images of Persian and Arabic words. We demonstrated through our writer identification method, that although the fractal dimension D would identify the writer in several cases, it is still insufficient to characterize a textured image; it is that two images can have the same fractal dimension although they have a completely different aspect. In this case the generalized fractal dimensions are the right answer, in the places to have a single dimension; we shall have a vector of dimensions which characterizes the image of word in several levels.

The rate of correct identification for some words is more than 90% in Top-4 as described in Table 2, what demonstrate the effectiveness of our proposed method.

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