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Effects of Facial Segments Features on Human Face Classification

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Abstract:

Pictures of human faces are difficult to analyze, recognize and identify by using computers. They are extremely complex objects that vary over times.The purpose of this paper is to detect the effects of the facial segments on classification of human face images. (25) Iraqi persons were studied. (7) Face images for each person were taken with different orientations and facial expressions. Therefore, each full face image was segmented into the three most important segments: eyes, nose and mouth segments. The clustering techniques were used to determine the effects of the facial segment features in this field by using the obtained data. The practical experiments gave interesting and useful results by using Pentium (4)–PC and MATLAB 6.5.

KeyWords:Classification,Face Recognition, Face Segmentation, Euclidean Distance .

1. Introduction:

There is no doubt that human beings can be recognized by looking at their faces. To identify any person, we look at his/her external face characteristics. In the social life, face recognition is our primary focus of attention. It plays a major role in conveying identity and emotion. We can recognize thousands of human faces learned throughout our lifetime to identify familiar faces at a glance even after several years of separation.

This skill is quite robust, despite large changes in visual stimuli due to viewing conditions, aging, expressions and distraction such as glasses, beards, moustaches, or changes in the hair style [1 , 2].The objective of this paper is to detect the effects of the facial segment features to automatically classify the human faces by using either the full face images or the features of the most important segments such as : eyes segment, nose segment, and mouth segment. To get this aim, (25) Iraqi persons were studied and for each one (7) full face images were taken. Each full face image was segmented to these three most important segments. We used the obtained data in the field of automatic classification.

Four experiments were applied to determine the class (cluster) of the face images for each person by using the full face images or its most important facial segments. For each experiment, the rate of the success percentage of classification was determined by updating the automatic clustering algorithm proposed in [3].

The obtained results asserted that there are robust effects of the facial segment features on human face classification.

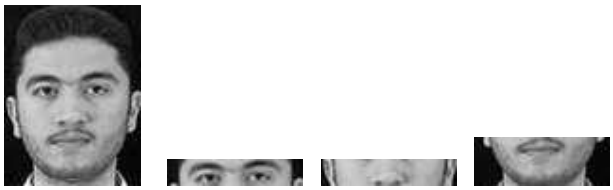
2. Human Face Segmentation:

Segmentation is the process that subdivides an image into its constituent parts or subjects. Segmentation is one of the most important elements in automated

image analysis. This is because it is at this step that objects or the other entities of the interest are extracted from an image for subsequence processing, such as description, classification and recognition.

S.A. Sirohey[4] in 1993 segmented the human face image from a moderately cluttered background using an approach that involves working with both intensity image of a face as well as the edge image. M. A. Turk and A. P. Pentland[5] used the eigenfaces to recognize the human faces. From the literature review, we found many researches which applied this technique in the image processing field [6,7,8,9,10]. In this paper, we used the segmentation technique to take the most important segments for each studied face image.

According to the real structure of human face, we can recognize many important segments such as: eyes, nose, mouth, cheeks, beard, chin and so on [5]. In this research, we segmented each full face image of the obtained images into its most important parts: eyes segment, nose segment, and mouth segments. The obtained facial segments images are (175) images for each of the eyes segments, the nose segments, and the mouth segments. Figure(1) Shows the full face image with its facial segments.



(a) (b) (c) (d)

Figure (1): A full face image with its most important facial segments.
(a) Full face image (b) Eyes segment image
(c) Nose segment image (d) Mouth segment image

3. Data Preparation:

The preparation of the studied images is an important phase of image processing. This phase influences on the obtained results.

3.1. Types of the Studied Face Images:

In this research, the following types of face images were used in the classification field.

Type(1) Full Human Face Images :

We applied (175) full face images with different rotation angles and different facial expressions concerning (25) Iraqi persons. For each one (7) different full face image were taken.

Type(2) Eyes Segment Images :

Eyes segment images were applied which were derived from type (1),such that one eye segment image for each full face image.

Type (3) Nose Segment Images:

(175) nose segment images were applied which were derived from type (1).

Type(4) Mouth Segment Images:

Mouth segment images were applied which were derived from type (1) such that one mouth segment image for each full face image.

3.2. Data Conditions :

In order to get optimal results, we attempted to put the entire studied face image under the same conditions. These conditions are as follows:

1- Using the same place and the same level of illuminations.

2- Taking (7) full face images for each studied person by using the same rotation angles (-15^o, -10^o, -5^o, 0^o, 5^o, 10^o, 15^o) in order to get one frontal face image and six profile face images during the moving of the used camera.

3- Using the same camera with the same resolution and zooming, the same fixed distance between the camera and the studied person, and the same fixed height for the camera with respect to the person face.

4- Using the same format. In this paper, we applied the JPEG format.

5- Converting each studied face image to the Gray- Scale-Level .

6- Normalizing each face image by using ACDSee program [11].

7- For each full face image, the same scale and size were used.

In this paper or work the size of each full face image was (96 x 72), whereas the size of the eyes segment images, nose segment images and mouth segment images were (14 x 72), (14 x 72) and (26 x 72) respectively.

4.Classification :

Classification is the clustering technique which partitions the input space (the studied population) into M regions on some similarity or dissimilarity metrics. From the literature review, there are many classification algorithms. The most public are the algorithms in which the number of clusters is given prior. Furthermore, the automatic classification algorithms in which the number of clusters is not given prior. In fact, in the automatic clustering algorithms the number of clusters is determined automatically through the implementation phase [12, 13, 14].

5. Neighbourhood and Classification:

The automatic classification methods often use the neighbourhood concepts such as :K-Neighbours, R- Neighbours, and the Adaptive-Neighbours [15, 16] . Using the adaptive neighbour's concepts in the automatic classification methods gives optimal results in this field, whereas using non adaptive neighbours may give no valuable results [3].

The following algorithm was used to determine the adaptive neighbours for each studied face image. These adaptive neighbours depended on the adaptive thresholds

.

5.1. Algorithm -1 (Adaptive – Neighbourhood Algorithm):

It is important to mention that if the adaptive neighbourhood concepts were used in the automatic classification techniques, then the results will depend directly on the mathematical formula with which the adaptive threshold is calculated. In this paper, the adaptive neighbours for each studied face image x was determined as follows :

1- Constructing a square matrix of degree N (N is the number of the studied face images) whose elements are the Euclidean difference distance between the studied face images.

2- Choosing a positive real number R as threshold.

3- Determining the neighbours for the face image x with respect to the chosen threshold R as follows :

$$\text{Neighbour}(x) = \{ y \in P / \ d(x, y) < R \} \quad \ldots \quad (1)$$

where P is the studied population, and d is the Euclidean difference distance.

4- Determining the number of neighbours for each x as follows :

Num(x) = Cardinal (Neighbour (x)) … (2)

5- Computing the adaptive threshold for each x as follows:

AdaptiveThreshold (x) = R/ Num(x) … (3)

6- Determining the adaptive Neighbours of each x as follows:

AdaptiveNeighbour(x) ={y Є P/ d(x, y) < AdaptiveThreshold(x)}… (4)

5.2. Algorithm -2 (Automatic Classification Algorithm) :

As previously mentioned, the final results of the automatic classification algorithms which used the neighbourhood concepts depend on the proposed method to compute the adaptive threshold. In this algorithm, the adaptive neighbours of algorithm-1 was applied.

Let ADN be an array of the number of the adaptive neighbours of the studied face images, where AND(x) is the number of adaptive neighbours of the face image x, and ADN(x) is defined as follows :

ADN(x) = Cardinal (AdaptiveNeighbour(x)).(5)

The main idea of the Automatic Classification Algorithm is the following:

The elements of the array ADN must be sorted in a descending order, and the corresponding face image must be swapped according to this descending order. The first face image which corresponds to the first element in ADN must construct (create) the first cluster (class) and all its adaptive neighbours must be located in the cluster. Therefore, the second face image whose position corresponds to the second element of the array ADN must be taken. We test if this new face image had been assigned to any existed cluster. Then all its adaptive neighbours must be located in this cluster. Otherwise this new tested face image will construct a new cluster and all its adaptive neighbours must be located in this new cluster. The process will continue until the final face image which corresponds to the final element in the array ADN has been classified in its corresponding cluster.

It is important to state that the obtained practical results by using alogorithm-1 and algorithm-2 gave good results.

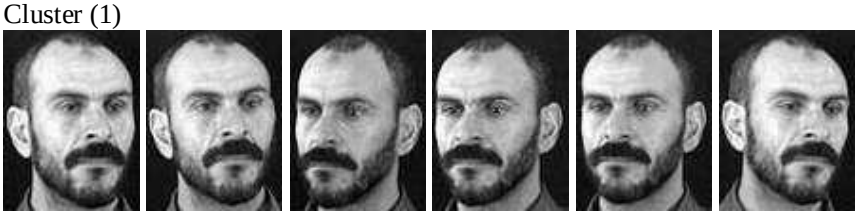
6. Practical Results :

Algorithm-1 and algorithm-2 were programmed in MATLAB version (6.5) using Pentium (4) PC. The used data concerned (25) Iraqi persons such that, (175) images for each type of the four types which they were been mentioned in Section (3) of this paper. The practical classification results of this research consists of the following experiments:

Experiment – 1 :

In this experiment, the proposed algorithms were applied to(175) face images of (25) Iraqi persons. For each studied person, (7) full face images was taken with different rotation angles (-15^o, -10^o, -5^o, 0^o, 5^o, 10^o, 15^o) and simple expressions. The studied population consists of males and females with different ages and some persons used glasses. Figure (2) shows a sample of the results of this experiment.

Cluster (1)



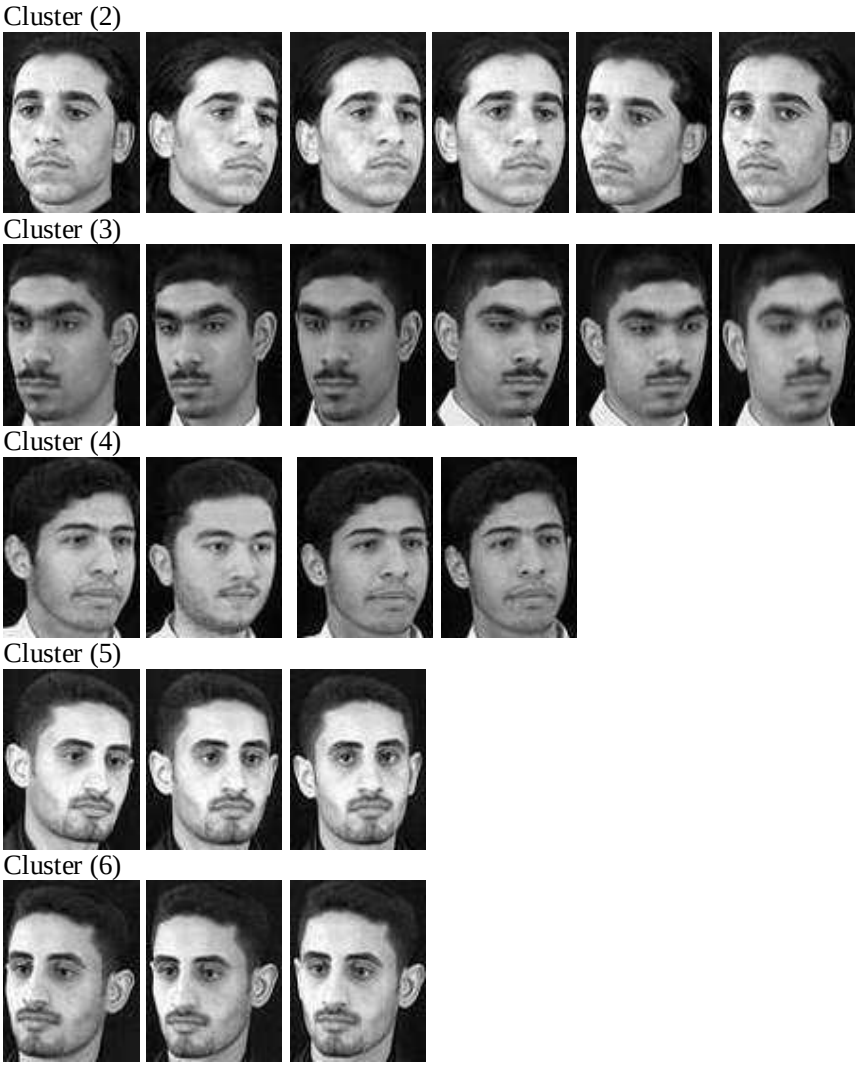


Figure (2): A sample of experiment – 1 results.

Experiment – 2 ***:***

In this experiment, (175) eyes segment images of (25) Iraqi persons were applied by using algorithm–1 and algorithm–2. The data of this experiment were derived form the data of experiment–1. Figure (3) shows a sample of the results of this experiment.

Cluster (4)

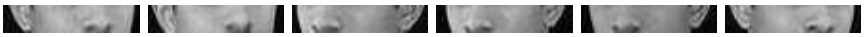
Figure (3): A sample of experiment – 2 results.

Experiment – 3 :

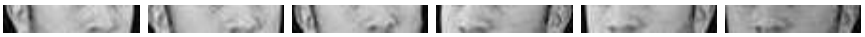
In this experiment, (175) nose segment images for (25) Iraqi persons were applied by using algorithm–1 and algorithm–2. The data of the experiment were derived form the data of experiment – 1. Figure (4) shows a sample of the results of the experiment.

Cluster (1)

Cluster (2)



Cluster (3)



Cluster (4)

Figure (4): A sample of experiment – 3 results.

Experiment – 4 :

Algorithm – 1 and algorithm – 2 were implemented in this experiment on (175) mouth segment images of (25) Iraqi persons. The data of this experiment were derived from the data of experiment – 1. Figure (5) shows a sample of the results of this experiment.

Cluster (1)

Cluster (2)

Cluster (3)

Cluster (4)

Figure (5): A sample of experiment – 4 results.

From the results of the classification algorithm on the four experiments, we get Table (1) which resumes the results of the four experiments when the population size is (175) images of the studied persons.

Table(1): Results of the four experiments when the population size is (175).

Experiment No.	Number of Clusters	Execution Time (in seconds)	Average of the Interval of Success Percentage (%)	Average of the Interval of Error Percentage (%)
Experiment – 1	25-31	168	91.58	8.42
Experiment – 2	26-39	104	79.83	20.17
Experiment – 3	29-43	97	66.46	33.54
Experiment – 4	27-47	112	73.4	26.6

Figure (6): Shows a histogram to the average of the interval success percentage of the four experiments when the population size is (175) images.

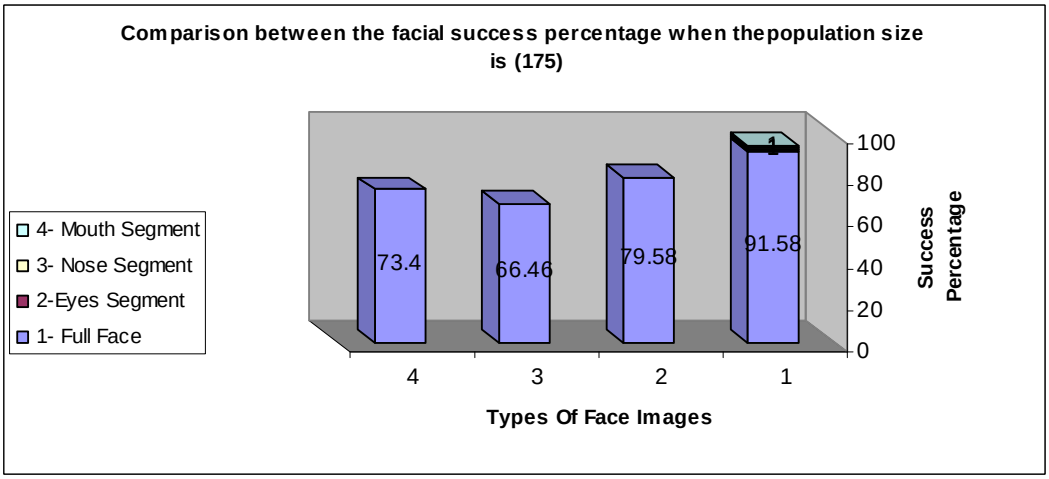


Figure (6): Comparisons between the success percentages of the four experiments when the population size is (175) images

7. Discussion of the Results :

1- In general, the initial value of the threshold R to get the results in the four experiments is approximately in the range $0.947 \leq R \leq 1.174$. There is no large difference in the initial value of R between any two pairs of our experiments.

2- From Table (1) and Figure (6), we noticed that the priority of best classification results were as follows : full Face Images, eyes segment images, mouth segment images and nose segment images.

3- It is normal that the full face images give optimal results in the field of classification because these images have more facial information than any facial segment image. The importance of the eyes segment images comes after the importance of the full face images, whereas the nose segment images have the least importance with respect to the other facial segment.

4- From the four experiments results, we can notice the importance of using the adaptive neighbours in the automatic classification algorithms. This is because the determination of the number of the adaptive neighbours for each face image depends on the real structure of the studied data.

5- In few cases, face images for more than one person lied in one cluster.

Cluster-4 of experiment-1 is an example of this error. We noticed also that the face image of the same person might be partitioned into two clusters. Cluster-5 and Cluster-6 are examples for these cases.

8. Conclusions:

1- From the experimental results, we confirm the importance effects of the facial segment features in the classification field.

2- Some of the facial segments have more information than the others. For example the eyes segment has more information than the mouth segment and the nose segment, whereas the mouth segment has more information than the nose segment.

3- The high priority of the eyes segment feature with respect to the other facial segments features is very useful for any person to hide his own identity. So for security reasons, some persons are shown on the media such as TV and newspapers put masks on their eyes segment in order to prevent the recognition of their identities.

4- The value of the adaptive threshold of any face image depends on the initial value of the constant threshold R, and the number of neighbours of that face image with respect to the initial value of R, whereas the number of the adaptive neighbours of the same face image depends on its computed adaptive threshold.

5- The results of the chosen automatic classification algorithms depend on the mathematical formula with which the adaptive threshold was computed.

6- From the experimental results, we noticed also that the increasing of the rotation angle values decreased the accuracy of automatic clustering algorithms results. This is especially when rotation angle value is greater than 10^{o}.

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تأثيرات سمات مقاطع وجه الإنسان في التصنيف

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المستخلص:

يصعب استخدام الحاسوب لتحليل الوجوه البشرية وتحديدها وتمييزها ، إذ أن الوجوه البشرية هي موضـــوعات معقدة التراكيب و تتغير مع مرور الزمن. هدف البحث الحالي هو اكتشاف تأثيرات مقاطع(أجزاء) الوجه البشري فـــي التصنيف (العنقدة) من خلال استخدام صور لوجوه (25) شخصا"عراقيا".أخذت (7) صور ذات اتجاهات و تعبيـــرات مختلفة لوجه كل شخص قيد الدراسة و قسمت صور الوجه الكلي لكل شخص إلى المقاطع (الأجزاء) الأكثـــر أهميـــة (بالنسبة لسمات الوجه البشري) ، وهذه المقاطع هي : صورة منطقة العيون ، صورة منطقة الأنف ، صورة منطقة الفم .استخدمت تقنيات التصنيف (العنقدة) لتحديد تأثيرات سمات المقاطع لوجوه الأشخاص قيد الدراســـة فـــي مجـــال التصنيف أو اكتشافها. أظهرت التجارب العملية التي نفذت على حاسوب شخصي من نوع بـــانتيوم (4) وباســـتخدام الحزمة البرمجية MATLAB 6.5 نتائج مشجعة ومفيدة .

الكلمات المفتاحية : التصنيف، تمييز الوجوه، تقطيع الوجه، مسافة إقليدس