The Combinational Use Of Knowledge-Based Methods and Morphological Image Processing in Color Image Face Detection

Sima Emami[1] Ramin Meshkabadi[2]
[1]Department of Mechatronics ,Ahar Branch, Islamic Azad University, Ahar, Iran
Email: s_emami@iau-ahar.ac.ir(Corresponding author)
[2]Department of Mechatronics ,Ahar Branch, Islamic Azad University ,Ahar ,Iran
Email: r-meshkabadi@iau-ahar.ac.ir

Abstract

The human facial recognition is the base for all facial processing systems. In this work a basic method is presented for the reduction of detection time in fixed image with different color levels. The proposed method is the simplest approach in face spatial localization, since it doesn't require the dynamics of images and information of the color of skin in image background. In addition, to do face recognition, there is no need for the existence of image. For the extraction of facial features, the combination of knowledge-based and morphological image processing methods is utilized, which has a high accuracy, compared to other methods. The proposed method is analyzed by MATLAB software and tested on different images which demonstrated high accuracy and efficiency of the method.

Keywords: Face detection, Morphological operation, Knowledge-based method, Color image

1- Introduction

The recognition and verification of identity according to facial image is one of a few methods that don't generate a lot of troubles, and it has a high accuracy. It requires a close contact with individual and should ask the participant to give some of his time or stand in the specific position to provide the respected image [2]. Meanwhile with the installation of a camera, without any disturbance for the subject, the facial image can be provided from a long distance. So this image can be used for recognition or checking the identity. The facial texture is a unique feature of human. Even twins have minor differences regarding face, too. Hence, face can be used as one of important and suitable factors in identification and recognition of human beings. The researches in the field of face recognition and face detection have been the focus of researcher's interest for years. So that, nowadays, the subject of face recognition has many applications in various areas, such as, public security, identification, protection of important and sensitive locations, access control, video monitoring and so on. Additionally, face recognition systems in new fields like Human-Computer Interrelation, Internet services, like online shopping and so on are further used.

In recent years, the researchers have investigated the facial recognition methods. Face detection is the primary step in the recognition of face. In the input image to machine (computer or robots), at first, machine should be aware of input image, then, it should proceed to recognize the face among thousands of images in the faces' bank [3].

The main application of face recognition includes topics such as: face identification and the analysis of human emotions. The main deviation factors in recognition processes are as follow: light intensity, the angle of head, the state of head, face latency (by beard, mustache and glasses), and head rotation, and so on. For this reason the engineers endeavor to overcome this problem. Sushi Kumar Paul proposed a comparative algorithm for specifying points of face [4].

Wong.k.W. suggested a new algorithm for the extraction of face features[5]. Tanmay Raj pathak introduced a unique approach for face recognition by using morphological and color image processing[7]. Two main important problems in facial recognition applications include the speed and accuracy in recognition. During the past decade, effective efforts have been dedicated to improve speed performance and identification accuracy [11].

The problem of diagnosis speed, still, is a serious problem and is an obstacle for extension of simultaneous applications of face recognition. In this work a simple method has been introduced for face recognition in which the features of each face are extracted by a combination of knowledge-based methods and morphological image processing and by using pre-processing methods such as the reduction of the effects of brightness and darkness of image, considering the different postures of a face image, in faces' bank, would improve the face recognition in terms of optimal accuracy and speed of detection.

2- Suggested method

In the presented system, at first, eye areas, due to having the most valued parameters, are detected by using the morphological operators and once again by a rule-based method. The likely candidate areas are found for eye obtained by combining two results and by applying geometric relations between pairs of eyes. Then the area of face is located and the face characteristics are extracted.

At last, given that the extracted features of discriminated face histogram is different for the face of any person; it is used for the recognition of individuals' face. The general scheme of suggested method is presented in figure 1.

2.1- Determination of face region:

At this stage the regions related to right and left eye are obtained. For this purpose, obtained facial area is divided into two left and right parts. Then these two parts are divided to up and down sections, through which the top segment contains eye positions. Thus, by reduction of search space, running time of algorithm is decreased. In figure 2, findings of face area are presented.

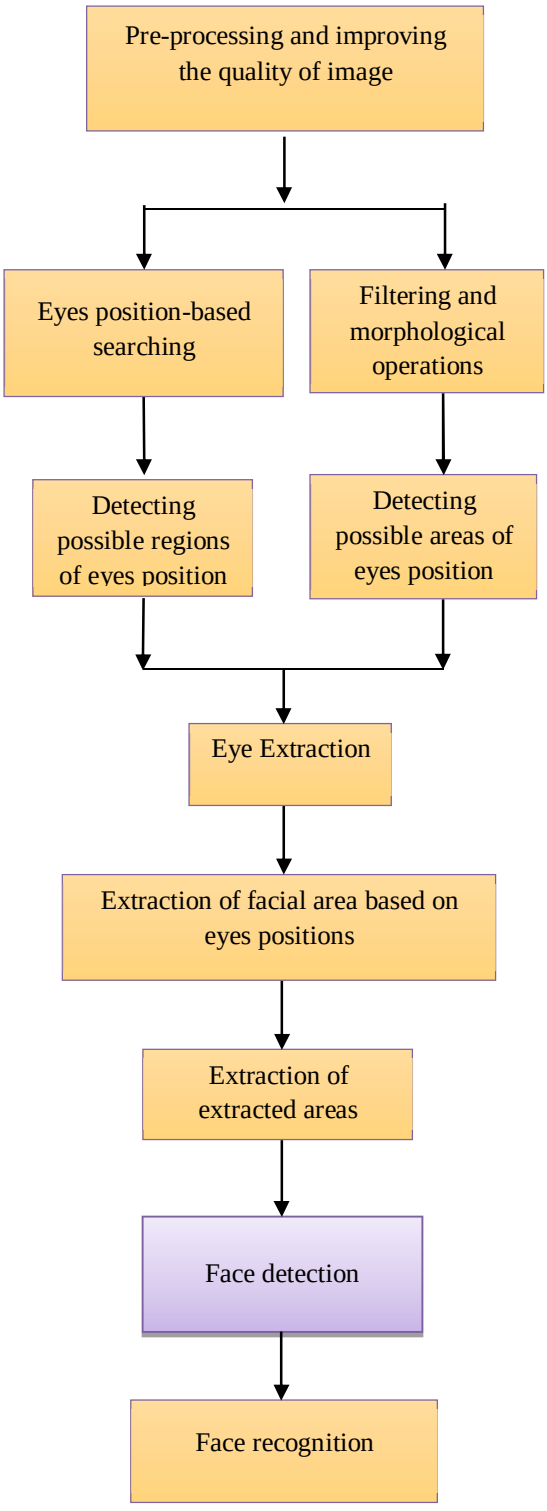


Fig.1. Diagram of proposed methods

Fig.2. Obtaining the facial area

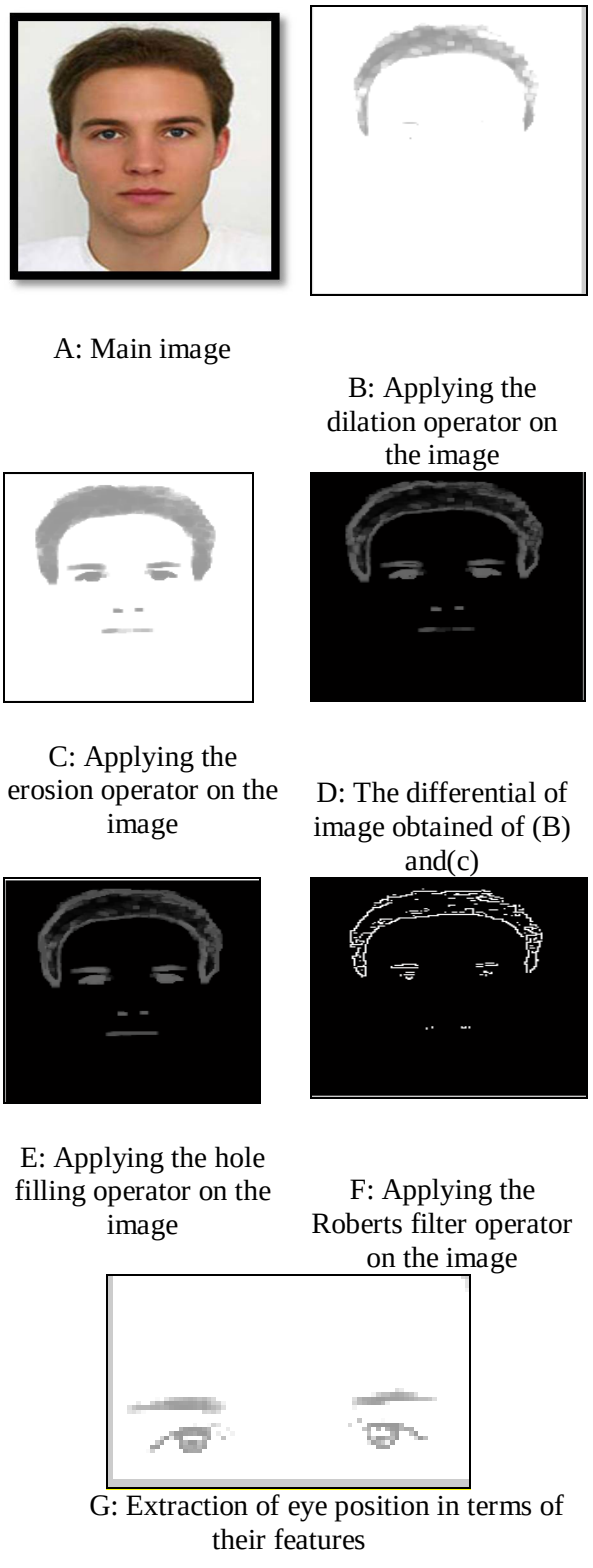
2.2- Detection of eyes by applying morphological operation and filtering:

After pre-processing, and finding the areas related to eyes with respect to main feature of the eye, using morphological approach, the possible areas of the eye are cleared and specified. Including the basic operations of morphological image processing are the dilatation and erosion operations. Dilatation is an action that causes amplitude or enlargement of the objects of binary image. Erosion causes the shrinkage or thinning of the elements in the binary image. In the proposed method, the morphologic technique is used for border face detection. The image borders are obtained by calculating the differences between dilation and erosion of an image. In dilation and erosion process, there is no need to choose a suitable structure. The structure which has been chosen in this work is suitable for dilation of spherical structure and its radius depends on different face images, and for erosion the structure is straight line. Since it is required that eye area should be a continuous area, in this step, the hole filling process is performed to obtain the possible areas of eye zones as a continuous region in the image. It should be noted that some of the obtained areas in the

image are much larger or smaller and both of them can't be considered as the eye candidates. After applying the morphologic operations on the image, the sharpening filter is applied on the output image. In the area of location, filters are classified into two categories: 1) calming filters 2) sharpening filters. The calming filters causes the generation of calmer images by applying a change in the light intensity of sharp pixels of images. In spite of the calming filters, the sharpening filters cause the extraction of further details of image by changing on the quiet pixels of image. In some cases it has been observed that image has crystalline state (details aren't visible). In such cases, to remove the crystal property, sharpening filters are used. In figure3, the stages of the detection of eye areas by morphological operators and filtering are presented.

2.3- Eyes Detection and finding five areas of eye by using knowledge based method:

Firstly, the eyes in the facial images are circular. And secondly, they are darker than other areas of face- using the Hough Transformation rule, the coordinates of eyes found and in the meantime, you may run a process to find the eyes. But, due to this fact that in most images, the eyes are the darkest points, the first areas of circular and dark forms are eyes. Therefore, if the above mentioned conditions are met, the found area is chosen as the center of the eye. After finding the eyes area in images, these areas which are specified by mathematical relations are transformed to main image. The eyes detection by knowledge-based method is presented in figure 4.



A: Main image

B: Applying the dilation operator on the image

C: Applying the erosion operator on the image

D: The differential of image obtained of (B) and(c)

E: Applying the hole filling operator on the image

F: Applying the Roberts filter operator on the image

G: Extraction of eye position in terms of their features

Fig.3. The stages of the detection of eye areas by morphological operators and filtering

Fig.4. Eyes detection using a Knowledge based method

By using knowledge-based method, the eye and surrounding areas are found. And by the use of knowledge based method, the position of pupil and exact position of eye are obtained. Now, the results of rule based method with morphological method sand based on pupil considered as the center of eyes, can be found in five areas of the eye. Accordingly, the focus on five areas of eye guided us to identification of other areas of face. In figure5, the quintet areas are shown.

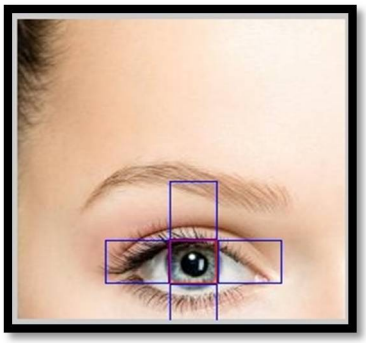


Fig.5. Obtainingfive areas of eye

$R_1 < R_2$; and $R_1 < R_3$; and $R_1 < R_4$; and $R_1 < R5$

According to figure5, it is clear that R_2, R_3, R_4, R_5 are equal, and these values are more than R_1 value of previous section which is obtained to find eyes.

2.4- Face detection and the extraction of areas features:

The face areas are localized and detected by using geometry relations between the different features of face and the distance between extracted eyes. After the detection of the areas of face, they are divided into several different sections which are the face characters. As shown in figure 5, the points of face are obtained by searching in these areas and the searching space is limited to these areas. Each of the areas contributed to one feature of the face. The right and left eye are located on top of these two areas, the nasal holes are located in the center and mouth in the down area. If we assume that the distance between two eyes is D, so, W=2D (image width) and H=3D (image length) and the areas of interest on the face have the size of W×H.

1- The areas related to right and left eye which only contain eye areas of the size of(D×D).
2- The area related to nose, only included nasal areas with the order of (D×D).
3- The area related to mouth only including the mouth area with the size of (D×D).

In figure 6, the area determination is shown.

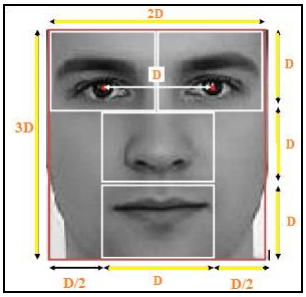


Fig.6. Area determination method for the feature extraction

2.5- Face detection and separation of face image:

After separation of eye, mouth and nose, the identifying action and separation of the face image will be discussed, this is the last stage. With the help of facial detection as illustrated above, the face frame can be obtained. In figure7, the separated image is shown. For testing the database program, images were inserted in the database testing program. At first, the extraction matrix program which contains listed information is loaded, and then face of subject is detected by the use of proposed method and extracting the features of the image. If the intended image be available in the database, it's revealed in the database and is shown the face detected message on the image. In the absence of image in the database, no face detection message is shown.

Fig.7. The Extraction of the points of eye, mouth, and nose feature

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3- Evaluation of proposed facile detection Method

Our intended method was tested by using Matlab 2014 program windows 7 professional operating system, by a system of core i3, MHz 2/13 equipped with RAM4GB. The most important part of suggested algorithm is the eye detection component since if the accuracy of eye for the detection of position isn't acceptable; the whole process of face detection won't be done well and with acceptable accuracy. Eye detection in color images, achieved by using a method of eye plots, is about 78.9% precisely. The proposed method for eye detection in this thesis responded 93%.

4- Results and discussion

The obtained results of the evaluation of suggested algorithm are shown below. Then detection of exact face position was tested on 120 images. The accuracy of proposed method for exact detection of face position frontally is about 95%, the proposed method in frontal facial images having high accuracy. The main reason for this high accuracy is the use of features which are in the detected face tissue structure and in which the majority of adverse and unwanted information, such as hair, have been removed. The results of this experiment are shown in Table 1.

Table.1.Results of proposed algorithm for front al face detection

Pictures Collection	TP	FP	DR
120 face image of front	114	6	95%

Also the proposed facial detection method on the database containing 120 image of face with glasses is investigated. The results of evaluation have been presented in table 2.

Table.2.Results of proposed algorithm for detection of face with glasses

Pictures Collection	TP	FP	DR
120 face image of front	89	31	74.16%

As the result indicates, when both eyes are closed, the accuracy of proposed method is about 74.16% which isn't an acceptable result. The main reason of decreasing the accuracy is that the whole detection process and extraction of face features depends on the proper detection of eye position and in the absence of property detection of eye areas, this method will not work properly. For this reason, this method won't act upon images with glasses and the presence of glasses in the image results in that position of eyes can't be recognized correctly .For indicating the performance and capability of proposed method against the light intensity changes, the proposed algorithm, evaluated on the images, were chosen with different light intensity. For this aim, the results of 120 tests on the chosen photos are indicated in Table 3. According to resulted conclusions, it is clear that the proposed method has a good stability and resistance to light intensity changes. The detection accuracy is % 91.66 which is the main reason for that it is the use of histogram adjustment and adjusting the light intensity to overcome on the available changes of light intensity in the images.

Table.3.The performance of proposed algorithm to light intensity changes

Pictures Collection	TP	FP	DR
120 face image of front	110	10	91.66%

In table 4, the results of proposed method compared with some other methods and the practical results indicate the high rate of face detection results indicating the high rate of face detection in the proposed method.

Table.4. The performance of proposed algorithm compared with previous suggested methods

Algorithm	Face Detection rate%	(S)
Method[8]	86.3	18
Method[9]	91.5	9
Method[10]	92.91	15-18
Method[11]	86.2	5
Suggested method	92.95	4-6

As seen, the proposed algorithm compared with previous existing algorithms has a good performance in terms of speed and accuracy. Although the proposed method in [10]is more accurate than our suggested algorithm, the difference of accuracy is to the extent that the short time necessary for operation (11sec) is negligible

5- Conclusion

In the proposed method since morphological process lessens the searching time, the proposed method is fast because

the whole system depends on detected center of eye. Since the proposed algorithm has no need to any training phase, we achieved a high accuracy along with high speed in face detection.

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