Extract of Facial Feature Point

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Summary
Extract of facial feature points has become an important issue in many applications, such as face recognition, expression recognition, and face detection. A method of facial feature extraction-based and corner detection is presented in this paper. In this method we develop a technique for extracting the facial features from a color image captured by the online webcam, under normal lighting condition; And saving the time during the feature extracting by the goal of detecting the features in different expression and orientations.

Key words:
Facial feature extraction, Face recognition, Corner detection, Image processing.

1. Introduction

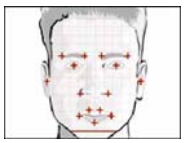
Human facial features play a significant role for face recognition. Neurophysiologic research and studies have determined that eyes, mouth, and nose are amongst the most important features for recognition [1]. Recognizing someone from facial features makes human recognition a more automated process.
Basically the extraction of facial feature points, (eyes, nose, mouth) plays an important role in many applications, such as face recognition [2], face detection [3], model based image coding [4], expression recognition [5], facial animation [6] and head pose determination [7].
It is important to note that because the systems use spatial geometry of distinguishing facial features, they do not use hairstyle, facial hair, or other similar factors.
Facial recognition can be used generally for police work purposes. For example, public safety, suspected terrorists, and missing children.
Facial feature extraction has some problems which must be thought and be solved. Some problems of facial feature extraction are given as follow:
Small variations of face size and orientation can be effected the result. As the input image comes from the webcam in the rooms condition the captured image has different brightness, shadows and clearness which can be failed the process. Sometimes facial features may be covered by other things, such as a hat, a glasses, hand or hairs. Human faces have a variety of emotions by many different expressions, but this system can detect the corner of the features in the case of neutral, sad, happy and surprise.
Most facial feature extraction methods are sensitive to various non-idealities such as variations in illumination, noise, orientation, time-consuming and color space used. In the next secession we briefly describe the related work also comparing the techniques together, while in the third secession the research methodology will be explain. Finally the testing result and the average rate can be realized in the fourth secession.

2. Related Work

In Facial feature extraction, local features on face such as nose, and then eyes are extracted and then used as input data. And it has been the central step for several applications. Various approaches have been proposed in this chapter to extract these facial points from images or video sequences of faces.
The basically of approaches are come as follow:

2-1-Geometry-based

Generally geometry-based approaches extracted features using geometric information such as relative positions and sizes of the face components. Technique proposed by Kanade [8], localized eyes, mouth and the nose using vertical edge map. Nevertheless these techniques require threshold, which, given the prevailing sensitivity, may adversely affect the achieved performance.



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2-2- Template-based

This approach, matched facial components to previously designed templates using appropriate energy functional. The best match of a template in the facial image will yield the minimum energy. Proposed by Yuille et al [9] these algorithms require a priori template modeling, in addition to their computational costs, which clearly affect their performance. Genetic algorithms can be proposed for more efficient searching times in template matching.

2-3-Colour segmentation techniques

This approach makes use of skin color to isolate the face. Any non-skin color region within the face is viewed as a candidate for eyes and/or mouth. The performance of such techniques on facial image databases is rather limited, due to the diversity of ethnical backgrounds [10].

2-4-Appearance-based approaches

The concept of "feature" in these approaches differs from simple facial features such as eyes and mouth. Any extracted characteristic from the image is referred to a feature. Methods such as principal component analysis (PCA), independent component analysis, and Gabor-wavelets [11] are used to extract the feature vector. These approaches are commonly used for face recognition rather than person identification.

Table 1, shows all techniques in finding the facial features and compare them by the number of features extracted. As we can see there, most of techniques except of the hybrid one which are not included here, are using still images as an input and the user's images are frontal so we don't use the template-based. As mentioned in introduction, it is so time consuming to using the appearance-based approaches cause of training part which is take the long time.

Also we couldn't use the color-based approaches, because just working when the eyes are visible; it means that it doesn't give good results in different expression.

The geometry-based technique works on the frontal one but we used that plus the corner detection which will be introduced in methodology.

Table 1: techniques of facial feature

author	technique	no. of feature	video/still-frontal/rotated
T. Kanade, 1997	geometry-based	eyes, the mouth and the nose	still-frontal
A. Yuille, D. Cohen, and P. Hallinan, 1989	template-based	eyes, the mouth, the nose and eyebrow	still-frontal
C. Chang, T.S. Huang, and C. Novak,1994	color-based	eyes and/or mouth	still and video-frontal initially in a near frontal position and therefore both eyes are visible
Y. Tian, T. Kanade, and J.F. Cohn,2002	appearance-based approaches	eyes and mouth	still-frontal and near frontal with different expression

3. Methodology

As mentioned previously, eyes, nose, and mouth are the most significant facial features on a human face. In order to detect facial feature candidates properly, the unnecessary information in a face image must be removed in advance. The first stage is cropping the face area as soon as the picture is taken from the webcam; the second part of preprocessing is prepared by resizing that cropped image.

To adjust the contrast and brightness of the image in order to remove noises built-in MATLAB function are used then it is converted to the gray scale image, because the corner detector can only be applied on gray level.

Facial features in the face model are corresponded to the dark portion on a more light for face region, that is, eyes, nose, and mouth is darker for- skin region. A Gaussian derivatives filter is an effective filter that is the good response to such patterns of intensity variation. This filter is composed of a second derivative of a Gaussian in a direction, and the other filter is a Gaussian in the orthogonal direction for

finding the corner point applying the corner detection algorithm which is started by Auto-correlation:
Step1. Constructing the auto-correlation matrix, also called (weighted)
Step2. Strength assignment
Step3. Non-maximum suppression
Auto-correlation matrix captures the structure of the local neighborhood and measure based on eigenvalues of this matrix. If finding two strong eigenvalues, it means that point is the interest point, if finding one strong eigenvalue it means, the selected part is the contour and if no eigenvalue it means, that is a uniform region. Interest point detection find after Threshold on the eigenvalues and Local maximum for localization.

Step 1: Auto-correlation matrix:
Auto-correlation function for a point (x, y) and a Shift $(\Delta x, \Delta y)$ .Here is the Auto-correlation matrix:

$$A(p) = \begin{bmatrix} \sum_{q \in W_p} w_q (I_x(q))^2 & \sum_{q \in W_p} w_q I_x(q) I_y(q) \\ \sum_{q \in W_p} w_q I_x(q) I_y(q) & \sum_{q \in W_p} w_q (I_y(q))^2 \end{bmatrix}$$

And the auto-correlation function is:

$$f(p;\Delta p) = \sum_{q \in W_p} (I(q) - I(q + \Delta p))^2$$

The auto-correlation function at an interest point has high value for all shift directions

$$f(x, y; \Delta x, \Delta y) = \sum_{(x_k, y_k) \in W} (I(x_k, y_k) - I(x_k + \Delta x, y_k + \Delta y))^2$$

$$I(x_k + \Delta x, y_k + \Delta y) \approx I(x_k, y_k) + \begin{pmatrix} I_x(x_k, y_k) & I_y(x_k, y_k) \end{pmatrix} \begin{pmatrix} \Delta x \\ \Delta y \end{pmatrix}$$

$$f(x, y; \Delta x, \Delta y)$$

$$= \sum_{(x_k, y_k) \in W} \left(\begin{pmatrix} I_x(x_k, y_k) & I_y(x_k, y_k) \end{pmatrix} \begin{pmatrix} \Delta x \\ \Delta y \end{pmatrix} \right)^2$$

$$= (\Delta x, \Delta y) \begin{bmatrix} \sum_{(x_k, y_k) \in W} (I_x(x_k, y_k))^2 & \sum_{(x_k, y_k) \in W} I_x(x_k, y_k) I_y(x_k, y_k) \\ \sum_{(x_k, y_k) \in W} I_x(x_k, y_k) I_y(x_k, y_k) & \sum_{(x_k, y_k) \in W} (I_y(x_k, y_k))^2 \end{bmatrix} \begin{pmatrix} \Delta x \\ \Delta y \end{pmatrix}$$

$$= (\Delta x, \Delta y) A(x, y) \begin{pmatrix} \Delta x \\ \Delta y \end{pmatrix}$$

Step 2: Strength assignment:
Strength is determined by eigen-structure of auto-correlation matrix or the min of eigenvalues.
Size of the ellipse is given by eigenvalues λ1, λ2 of Q(x, y):

$$R = \det M - k (\operatorname{trace} M)^2$$

$$\det M = \lambda_1 \lambda_2$$
$$\operatorname{trace} M = \lambda_1 + \lambda_2$$
(k – Empirical constant, k = 0.04-0.06)

R depends only on eigenvalues of M, and the value of R is large for a corner also it is negative with large magnitude for an edge, and |R| is small for a flat region.
Figure1, illustrate the image when it segmented to parts of edge, corner and flat region. Then choose the best candidates (non-max suppression and threshold) as the facial feature's corners.

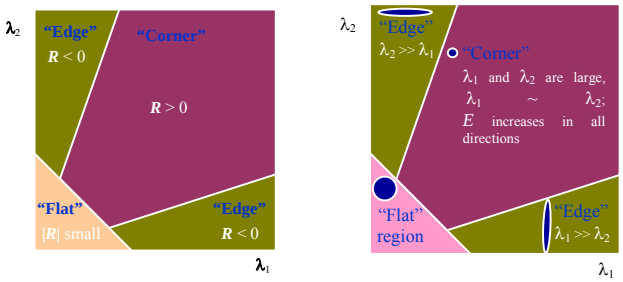

Figure1: image's parts

Table 2: frame work

Pre-process	Video → Stop → Capture the last frame		
	Manually Crop the image for finding the → Resiz		
	Adjust for removing the noise → The color image converts to gray-scale		
Facial Feature points	Smooth/Blur the gray image with guassian kernel (by conv2 in MATLAB)		
	Threshold=0.05 the → Compute cornerness as size of smallest eigenvalue		
	Compute local maxima of		
	Corner= both eigenvalues		

Table2 shows the diagram of the system's process in two parts; preprocessing stage and facial feature point stage. As mentioned earlier, the user's face is captured from the real-time webcam, then manually crop the face area by the MATLAB's function and also resize and adjusting the picture for removing

the noises, the final image is converted to the gray-scale in the pre-processing stage.
The second stage describe that gray image is smoothed by the guassian kernel, after three stages of the corner detection which were described earlier in auto corilation matrix, Strength assignment and Non-maximum suppression steps.

4. Result

The Facial feature extraction method was implemented in MATLAB and examines in four different expressions are Sad, Happy, Surprise, Neutral, also in five orientations as follow; Left side, Frontal, right side, Up and Down.
Table3, illustrate the experiment result, for each user checked for each orientation and expression, repeated five times. The experimental result is presented in Table3.

For example capture the user's face from the left side in the sadness expression, so the corners is marked and the value is calculated by the average of four more pictures results in the same position, moreover this testing continued for other expressions and orientations, we do not have any result for the left eye in the right side face picture, because the left eye doesn't appear in the right side picture also for the right eye in the case of left side photo.
Finally the average detection rate for all of the expression and orientation is 89.15, as we can see in Table3. We got the highest result for nose, and the least result for the left eye, the factors that affected the result are brightness and shadows.
Some test results are shown in figure2.

Table3: experiment result

	left eye		***nose***		***lip***		***right eye***	
	expression	value	expression	value	expression	value	expression	value
left side	sad	100	sad	100	sad	100	sad	-----
	happy	100	happy	100	happy	60	happy	-----
	surprise	80	surprise	100	surprise	60	surprise	-----
	neutral	80	neutral	100	neutral	100	neutral	-----
frontal	sad	80	sad	100	sad	100	sad	100
	happy	60	happy	100	happy	80	happy	100
	surprise	80	surprise	100	surprise	60	surprise	80
	neutral	80	neutral	100	neutral	100	neutral	100
up	sad	100	sad	100	sad	100	sad	100
	happy	80	happy	100	happy	100	happy	100
	surprise	100	surprise	100	surprise	100	surprise	80
	neutral	80	neutral	100	neutral	100	neutral	100
right side	sad	-----	sad	60	sad	100	sad	100
	happy	-----	happy	100	happy	80	happy	80
	surprise	-----	surprise	80	surprise	60	surprise	60
	neutral	-----	neutral	100	neutral	60	neutral	80
down	sad	60	sad	80	sad	80	sad	100
	happy	80	happy	80	happy	80	happy	80
	surprise	100	surprise	60	surprise	100	surprise	100
	neutral	100	neutral	100	neutral	100	neutral	60
		85		93		86		88.75
		89.15						

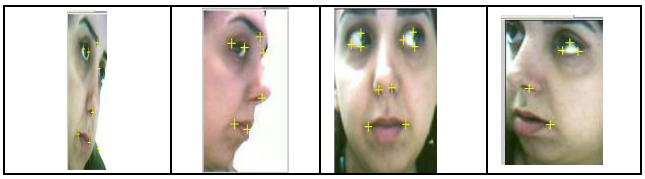

Figure2: test results

5. Conclusion and future works

In this paper, it's been tried to review the works done in facial feature extraction, and proposed the geometry-based technique by the corner detection for extracting the facial feature points and also present the preprocessing approach. The experiment result shows the system can works in the different orientation and expression.

In the future we will improve the detection by the higher accuracy and also it will be work in the real-time video.

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