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Face and Facial Component Detection by Using Image Characteristic

JIN-TAE KIM*, DONG-WOOK KIM**, JIEKWAN KIM***, HANKYU LIM****, HO-KEUN SONG*

* Department of Computer & Information Science, Hanseo University, Korea

** Department of Information & Communication Engineering, Jeonju University, Korea

*** Department of Industrial and Systems Engineering, Changwon National University, Korea

**** Department of Multimedia Engineering, Andong National University, Korea

Abstract: - This paper proposes an algorithm of a face and facial component detection for face recognition. For efficient extraction using image processing, we analyze and improve detecting facial components that are the basis of an image characteristic. The proposed algorithm includes face region detection without the effect of skin color hairs, eye region detection with weighted template matching, eyebrow region detection using a modified histogram, and mouth region detection using skin characteristics.

Key-Words: - face recognition, characteristic, template matching, skin color, modified histogram

1 Introduction

Facial expression, together with speech, hand or body gesture, plays an important role in intention communication. It is applied to the research that recognizes and expresses the intended meaning of the communication [1-2]. These research processes require facial component extraction in preprocessing. Since a face is complex in structure and its shape and color vary according to viewpoint and lighting, it is difficult to extract the facial component from the face alone. The hardware systems are expensive devices, pose an inconvenience or psychological load to experimenters due to the markers, which are attached to the face, and it cannot detect variations of the face in local, but important regions. However, face extraction, through the use of image processing, can solve the problems in the hardware systems.

This paper proposes face and facial component detection by using image processing of image characteristic. The proposed algorithm analyzes and improves the conventional algorithm. It removes the effects of skin color hairs in face region detection, it detects a more accurate eye region using weighted template matching, and it more easily detects the eyebrow and mouth regions using a modified histogram and skin characteristics, respectively. To evaluate performance of the proposed algorithm, the facial components are detected in various images. The simulation result shows that the proposed algorithm properly detects the facial components.

2 Problems of the existing methods

Methods of obtaining only the face regions from an image include those using information on the contour lines or those applying statistical probability distribution in the projection data of the contour lines. The most effective, however, is the one using skin colors. If brightness is included in the skin color extraction, a problem occurs in designation of a condition formula for skin colors. Correct skin colors can be extracted only if the extraction is carried out under a certain degree of brightness. It creates skin color images regardless of a change in brightness [3].

Also, the existing method of locating a face based on the contour lines failed in the extraction when there are two or more faces involved. It also showed a problem of an increase in errors with complex background. Its problems lay in an attempt to locate a face based on the entire size of the input image. In actuality, a face is not a rectangle, but an oval shape and thus background noises are inserted in the outmost regions. The more slanted a face is, the more background noises contained are [4]. In this paper, the regions of skin color images are divided and processed as objects, and thus all the regions of skin colors can be making object. Thus, the face regions are designated as their inherent regions, not as rectangles, and multiple faces can be processed independently at the same time.

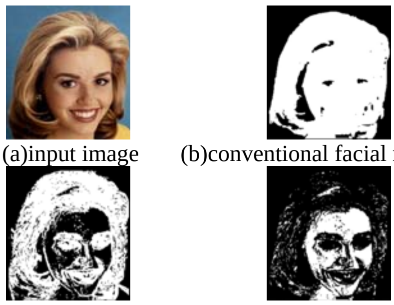
3 Facial component detection

3.1 Facial region detection

In this paper, the facial components to be greatly affected by facial expression are defined as the eye, eyebrow, and mouth. Facial region detection is important in preprocessing for facial expression recognition and is largely classified into two groups using facial template and color information. In the former, due to the various sizes and shapes of a face, which are dependant on viewpoint and distance, it is difficult to make an appropriate facial template. In the latter, the face region can be easily extracted by the comparison of color information, although it is affected both by skin color differences between races and variations in lightings [5]. We adopt the latter for the facial region detection, since the facial skin color is distributed in the restricted color range and the color in an input image is easily acquired and compared with the standard facial skin color. Additionally, we use the YC_bC_r color space to compute the skin color, since it is separated by the chrominance components (C_b and C_r) and the luminance component (Y) and that can reduce the lighting effect. Fig. 1 shows the facial region detected by skin color. The facial region is well detected.

Fig. 1 Detected facial region object

We solve the problem of the conventional facial region detection by detecting the hair region using its characteristics that the hair region has a larger luminance variation among pixels than the facial region. Fig. 2 shows the facial region detected by the proposed algorithm. Fig. 2(a) is the input image with the golden hair. Fig. 2(b) is the facial region detected by the conventional algorithm: it shows that the hair region is detected as the facial region. Fig. 2(c) is the hair region, which is detected by means of the luminance variation. Fig. 2(d) shows the facial region image without the skin color hair effect. The final facial region is detected by the post-processing, the largest cluster is extracted as the facial region in Fig. 2(d) and then the holes in the facial region are changed into the facial region.



(a)input image (b)conventional facial region

(c)hair region (d)result image

Fig. 2 Removal of the skin color hair effect

3.2 Eye region detection

Template matching is used to detect the eyes in the detected facial region and many eye candidate regions appear in its result. The real eye regions can be detected by the following facts. The eyes are located symmetrically in the upper facial region and under the eyebrow if the eyes and the eyebrows are detected simultaneously.

To get a more accurate eye shape, we complement the eye region detected by the conventional algorithm with a weighted template. First, we assign new eye search region: one half of width and height of the detected eye region is added to its right and left sides and it's up and down sides, respectively. To provide a comparison against a much smaller search region, we also specify one fifth of the facial region width and two-thirds of the facial region height for its minimum width and height, respectively. Then we detect the edges in the eye search region with the Canny edge operator and apply the weighted template to the edge image. Fig. 3 show processing of the eye regions detected by the proposed algorithm.

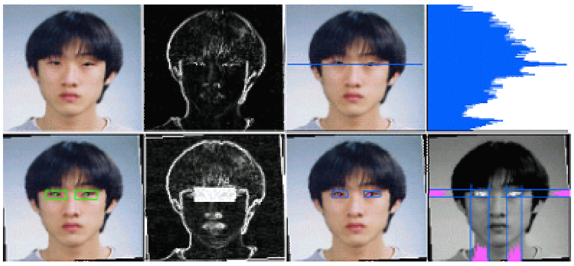


Fig. 3 Eye regions detection processing

3.3 Eyebrow region detection

Since their shapes change according to feeling and emotion, the eyebrows play an important role in the analysis of facial expression. We specify the eyebrow search region on the basis of the detected eye region. It is located just above the eye region and its width and height are twice and one half of the width of the detected eye region, respectively. In the eyebrow search region, the eyebrow region is detected by the threshold technique using a luminance histogram. In general, the histogram has many peaks and valleys formed with one bin and they make it difficult to select the threshold fixing the eyebrow region.

We adopt a modified histogram to solve the problem of the conventional algorithm. In the modified histogram, the peaks and valleys formed with one bin are changed into the larger bin and the smaller bin between both side bins, respectively. Fig. 4 shows the detected eyebrow region. A wrong detection can occur in the shade region and the hair that is included in the eyebrow search region. It is revised by using the shape information of the eyebrow.

(a)input image (b)eyebrow region

Fig. 4 Eyebrow region detection

3.4 Mouth region detection

A mouth search region is specified by the positions of the detected eyes and the statistical data regarding the geometric information of a face.

As with the hair, the mouth region also has a large luminance variance, which is in this case due to the wrinkles on lips. We can therefore detect the mouth region using the luminance variance computed in the mouth search region. Fig. 5 shows the detected mouth region.

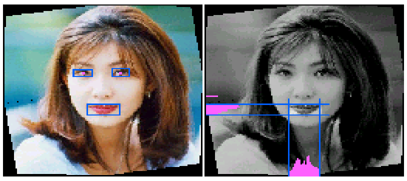


Fig. 5 Mouth region detection

4 Computer simulation and result

As a result of applying the proposed algorithm, it showed more successful results of extraction than that of locating a single face or that of extracting a face region. It also showed satisfactory results in locating each component of each face even when multiple faces are close to background. The following is a result of an experiment conducted using 250 photos.

Table 1 Analysis of experimental images

Experiment Image	Small sized photos	Complex background photos	
		Normal	Inclusion of Skin Color Background
Total Image	**37**	**63**	**150**
Success	**37**	**61**	**124**
Failure	0	2	26
(Skin color background)	0	1	12
(long hair)	0	0	2
(viewpoint)	0	1	7
(skin color range)	0	0	5
Rate of Success (%)	**100.0**	**96.8**	**82.7**

In our experiments, samples are mostly photos taken with a digital or PC camera, some with changed shapes. The extraction was 100% successful with small-sized photos. It also showed excellent results even in those with complex background, which showed that complex background are all filtered in the process of skin color extraction. Exceptions were those in which faces were in the outermost regions or covered by other shapes in their input images, or whose colors in the input image were changed to show blue or red tones, or faces wearing sunglasses or masks.

It extracts a valid in 222 images, but an invalid in the remaining 28 images. The images with the wrong are classified into four cases as depicted in Table 1. The first case was due to background effects. When the background with skin color is detected as the facial region, the algorithm cannot detect the facial components. The second case was because of long hair. Long hair covering the eyes and eyebrows causes the wrong eye region detection and makes it impossible to detect the remaining facial components. The third case was affected by viewpoint. The input image is limited to a bust shot, including a front view of the face, but the limited images are already included in the image database for the experiment. Basically, they disagree with the geometric information of a face and as a result, the facial components cannot be normally detected in them. The fourth case regards a problem with skin color range. The skin color of several non-Caucasian people was out of the assumed Caucasian skin color range and the facial region could not be detected in them. The front three cases were solved by cautious images acquisition, and the last case solved by adjusting a skin color range to a race.

5 Conclusion

This paper proposes the improved facial component detection algorithm, important information for facial expression and recognition. The proposed algorithm analyzes and solves the problem of the conventional algorithm. It adopts the luminance variance, the geometric information of the facial components, the weighted template, and the modified histogram. They make it possible to detect the facial components more easily and more accurately, and that is shown in the facial component detection experiment.

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