International Journal of Electrical, Electronic and Communication Sciences
ISSN: 2517-9438
Vol:6, No:7, 2012

Skin Detection using Histogram depend on the Mean Shift Algorithm

Soo- Young Ye, Ki-Gon Nam, Ki-Won Byun

Abstract**—**In this paper, we were introduces a skin detection method using a histogram approximation based on the mean shift algorithm. The proposed method applies the mean shift procedure to a histogram of a skin map of the input image, generated by comparison with standard skin colors in the C_bC_r color space, and divides the background from the skin region by selecting the maximum value according to brightness level. The proposed method detects the skin region using the mean shift procedure to determine a maximum value that becomes the dividing point, rather than using a manually selected threshold value, as in existing techniques. Even when skin color is contaminated by illumination, the procedure can accurately segment the skin region and the background region. The proposed method may be useful in detecting facial regions as a pretreatment for face recognition in various types of illumination.

Keywords**—**Skin region detection, mean shift, histogram approximation.

I. Introduction

FACE detection plays an important role in various areas of human-computer interaction, such as face tracking, content-based image data search systems, and gesture analysis. Recently, skin detection methods based on skin color data have attracted considerable attention because of their computational efficiency in terms of rotation, size, and partial obstruction of the relevant region. Skin color is used to complement geometric data in designing accurate face detection systems[1]-[4]. Research on skin detection is generally conducted using visible spectrum images. However, skin detection in visible spectrum images is limited by ambient illumination, camera characteristics, ethnicity, and personal characteristics. Procedures using non-visual spectrum images, such as infrared images, have been considered as a means of resolving such issues, but these procedures require prohibitively expensive hardware devices or extremely limited environments [5]-[9]. When skin detection is conducted using predefined skin color data, the skin similarity threshold value that divides the background region from the skin region is determined from repeated experimentation. Such methods are limited in that the threshold values vary according to the experimental environment and skin color data. Also, these threshold values are not standardized objectively, and are partly based on subjective user concepts. In this paper, unlike the statistical approach, skin detection based on physical characteristics uses a physical model of inherent skin color.

Such physical models are often employed in research methods to detect skin regions because they neglect background-based changes in illumination, and use permanent skin color characteristics.

Soo-Young Ye is with Dept. of Radiological Science the Catholic University of Pusan, Korea (e-mail: syye@ cup.ac.kr).

Ki-Gon Nam is with Dept. of Electronics Engineering, Pusan National University, Korea.

Ki-Won Byun is with Dept. of Electronics Engineering Pusan National University, Korea.

II. Methods of Skin Detection

The proposed technique includes color transformation, skin map generation, histogram approximation to skin region detection, establishment of threshold value using mean shift algorithm.

A. Color transformation

It is to define the skin color region in skin color region detection. This definition is accomplished using existing skin color region images made from images of various people's faces in varying ambient illumination. The effects of illumination should be considered in detecting skin color regions. In this study, the lower-dimensional C_bC_r color space is used to minimize the effects of illumination [10]. The images used in this study, the C_b skin color values were distributed primarily between 102 and 118, while the C_r color values were between 137 and 152. A standard skin color table was constructed on the basis of 100 Korean male and female adults illuminated by fluorescent lights in ordinary buildings. According to the results of research on face detection, skin color distribution is similar in form to a Gaussian distribution. Thus, skin color distribution can be expressed as a 2D Gaussian function $G(\mu_{C_bC_r}, \sum_{C_bC_r})$.

$$x_i = \begin{bmatrix} C_b \\ C_r \end{bmatrix}, i = 1, 2, \ldots, N \quad (1)$$

$$\overline{C_b} = \frac{1}{N}\sum_{i=1}^{N} C_{b_i} \quad (2)$$

$$\overline{C_r} = \frac{1}{N}\sum_{i=1}^{N} C_{r_i} \quad (3)$$

$$\mu_{c_bc_r} = \begin{bmatrix} \overline{C_b} \\ \overline{C_r} \end{bmatrix} \quad (4)$$

$$\sum_{C_bC_r} = \frac{1}{N}\sum_{i=1}^{N}(x_i - \mu_{C_bC_r})(x_i - \mu_{c_bc_r})^t \quad (5)$$

Here, C_b and C_r denote pixel color values, $\overline{C_b}$ and $\overline{C_r}$ denote Gaussian mean color values, and $\sum_{C_bC_r}$ denotes a 3D Gaussian covariance matrix.

B. Skin map generation

The skin map used in this study is calculated from the skin region similarity between a standard skin color table and input images, and then normalized to brightness values between 0 and 255. The skin map is generated by applying the Mahalanobis distance to the Gaussian mean and covariance of predefined skin color images.

C. Histogram approximation

The proposed technique uses skin map histogram approximation to efficiently detect skin regions in environments with varying or complex illumination. The procedure is carried out in three steps.

First, the skin map histogram is regarded as a discontinuous function to be approximated by a continuous Gaussian function, using the Bezier curve theorem[11]. In the second step, the mean shift algorithm is used to find Gaussian local maxima in certain regions having similar brightness distributions, and the brightness values of pixels in the relevant regions are approximated at the local maxima. In the third step, the uniform brightness value of each region is investigated, and the region with the highest brightness value is detected via region growing.

D.Mean shift algorithm

In the mean shift algorithm, the mode of the probability density function is found by hill climbing. The probability density function indicates the brightness distribution of pixels in the intensity image. The algorithm is a procedure for converging on a local maximum point within the kernel via repetitive calculation of mean locations and mean brightness values of pixels having a similar brightness distribution in a neighborhood of the given pixel. That is, the pixel value at the current location is transformed to the brightness value at the local maximum, and thus the brightness values in the spatial region are made uniform. Thus, the optimal segmentation threshold value obtained by the mean shift algorithm is a point having a valley-point in the boundary line between uniform regions, or in Gaussian histogram approximation. Equ. (6) expresses the mean shift algorithm.

$$m = \frac{\sum_{x_i \in N(x)} P_s(x_i - x) \cdot x_i}{\sum_{x_i \in N(x)} P_s(x_i)} \quad (6)$$

Equ. (7) describes the transformation of the current pixel brightness value to the local maximum brightness value via the mean shift algorithm.

$$P_M(x') = x + m + k, 0 \le k \le 1 \quad (7)$$

Here, x denotes the current pixel brightness value and k denotes the weight variable. Thus, $P_M(x')$ transforms the current pixel brightness value to the local maximum brightness value in a given region via Equ.(7). Equ (8) gives the optimal threshold value for segmenting the background region and the skin region via Equations (9) and (10).

$$\mathrm{Th} = \max P_M(x_i') \quad (8)$$

The maximum is used because the skin region is the brightest region in the skin map.

Equation (16) is the equation for region growing.

$$I_R = \sum_{i=0}^{N} \max P_M(x_i') \quad (9)$$

Here, I_R indicates the skin region. The proposed technique is realized as follows.

Step 1. The RGB input image is transformed to be YCbCr image .

Step 2. From the analysis of standard skin color, skin color similarity is calculated using the following formula, and a skin map is generated.

$$I_S = (x - \mu_{C_bC_r})^t \Sigma_{C_bC_r}^{-1} (x - \mu_{C_bC_r}) \quad (10)$$

Here, $\mu_{C_bC_r}$ denotes the mean, $\Sigma_{C_bC_r}$ denotes the covariance, and $x = \begin{pmatrix} C_b \\ C_r \end{pmatrix}$ is expressed as a C_bC_r component of $I_{C_bC_r}$.

Step 3. After I_S is quantized, a skin-map histogram H_S is obtained, and is approximated by a Gaussian function using the Bezier curve of De Castelli's algorithm.

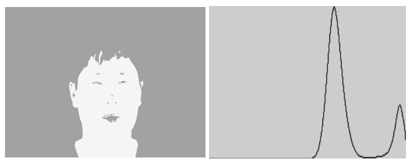
Step 4. The mean shift algorithm is used to find Gaussian local maxima in certain regions having similar brightness distributions, and the brightness values of pixels in the relevant region are made uniform with the local maximum.

Step 5. After the brightness values of the segmented regions are investigated, the regions having the maximum brightness value are detected as skin regions via region growing.

III. RESULTS

In the experiment, RGB color images 320×240 in size were captured with an ordinary digital camera. Figure 3 shows the process of skin region detection via the proposed method. Fig. 1(a) shows the input image, and Fig. 1(b) shows the normalization of skin similarity to brightness values of 0 to 255. Fig. 1(b) is brighter than the background because the face of the input image was accurately identified as the skin region by. Figure 1(c) shows the brightness data of Fig. 1(b) converted to a histogram, and Fig. 1(d) shows the continuous approximation of the histogram via De Castelli's algorithm. Fig. 1(e) illustrates the process of skin region detection via the proposed method.

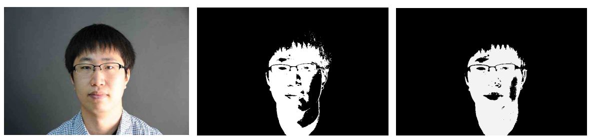
(a) (b) (c)



(d) (e)

Fig. 1 Skin detection process using the proposed method: (a) input image, (b) skin-map of (a), (c) histogram of (b), (d) histogram of (c) smoothed by De Castelli's algorithm, (e) skin region detection of (d) by mean shift algorithm

Fig. 2 compares the proposed method to the existing method [11] using the skin color model.



(a) (b) (c)

Fig. 2 Comparison of the existing and proposed methods: (a) input image, (b) result obtained by the existing method, (c) result obtained by the proposed method

Fig. 2 shows the results of skin region detection using the existing method, which establishes an appropriate threshold value based on ambient illumination, and the proposed method, in which segmentation points are determined via the mean shift algorithm.

Images used in skin detection experiments are generally captured in an internal environment under fluorescent light, where skin color contamination by illumination is insignificant. In this study, strong illumination was deliberately projected onto a certain part of the left side of the human face to investigate the performance of the proposed method. The same skin color model was used with both the existing and the proposed method for the sake of performance objectivity. Fig. 2(a) shows input images in which illumination was projected onto the faces from a certain direction. Fig. 2(b) shows skin detection results using the existing method, and Fig. 2(c) shows the results using the proposed method. In this experiment, the threshold values for the existing method were selected from optimum skin detection values determined by experiment. As Fig. 2 indicates, the proposed method detected skin regions more efficiently than the existing method, even though the skin color was changed by the illumination in certain directions.

The existing technique detected the region by calculating skin similarity and establishing a threshold value at each pixel, while the proposed method applies the mean shift algorithm to the skin map histogram to find Gaussian local maxima in certain regions having similar brightness distributions, and assigns uniform brightness values to pixels in the relevant regions.

IV. Conclusions

This study introduces a method of skin detection by applying the mean shift algorithm to histogram data. In existing methods using standard skin color models, skin similarity threshold values for segmenting the background region and the skin region are determined by repeated experimentation. A weakness of these techniques is that the threshold values vary according to illumination and environment. Also, established threshold values cannot be standardized objectively, and include subjective factors, determined by individual users. In the proposed method, a skin map histogram of an input image is created by using standard skin color characteristics of the C_bC_r color space, accumulated data at each brightness level are analyzed via the mean shift algorithm, and the skin region is detected by finding regional segmentation points. Even when skin color is contaminated by illumination, the procedure can accurately segment the skin region and the background region. The proposed method may be useful in detecting facial regions as a pretreatment for face recognition in various types of illumination.

Acknowledgment

This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education, Science and Technology(20120004409).

References

[1] Z. Jiang, Z. Wu and M. Yao. “Skin Detection on Images with Color Deviation”, *IEEE Trans Congress on Services*, Part Ⅱ, pp. 171-174, 2008.

[2] S. Kherchaoui and A. Houacine, “Face Detection Based on A Model of the Skin Color with Constranins and Template Matching”, *Int'l Conf. Machine and Web Intell*. pp. 469-472., 2010

[3] L. Zhengming, Z. Tong and Z. Jin,” Skin Detection in Color Images”, *Int'l Conf. ICCET*, pp. 156-159, 2010.

[4] T. Uongqiu, Y. Faling, C. Guohua and J. Shizhong.” Skin Color Detection by Illumination Estimation and Normalization in Shadow Regions”, *IEEE. Conf. ICIA*. pp. 1082-1085, 2010.

[5] D.A. Socolinsky, A. Selinger, and J.D. Neuheisel,” Face Recognition with Visible and Thermal Infrared Imagery”, *Computer Vision Image Understanding*, vol. 91, no.2, pp. 72-114, 2003.

[6] S.G. Kong, J. Heo, B.R. Abidi, J. Paik, and M.A. Abidi, “Recent Advances in Visual and Infrared Face Recognition: A Review”. *Computer Vision Image Understanding*, vol.97, no.1, pp.103-135, 2005.

[7] A.S. Nunez and M. J Mendenhall,” Detection of Human Skin in Near Infrared Hyperspectral Imagery”, *IEEE. Int'l IGARSS. 2*, pp. 621-624, 2008.

[8] C. Liensberger, J. Stottinger and M. Kampel, “Color-Based and Context-Aware Skin Detection for Online Video Annotation”, *IEEE. Trans. Intl'l MMSP*. pp. 1-6, 2009.

[9] Z. Pan, G. Healey, M. Prasad, and B. Tromberg, “Face Recognition in Hyperspectral Images”, *IEEE Trans. Pattern Anal. Mach. Intell*, vol.25, no.12, pp.1552-1559, 2003.

[10] W. Xinyu, X, Huosheng, W. Heng and L. Heng, “Robust Real-Time Face Detection with Skin Color Detection and The Modified Census Transform”. *Int'l Conf. ICIA*. pp. 590-595, 2008.

[11] R. L. Hsu, M. Abdel-Mottaleb, and A. K. Jain. “Face Detection in Color Images”, *IEEE Trans. on PAMI*, vol.24, no.5, pp.696-706, 2002.

Soo-young Ye was born in Pusan, Korea. She received the M.S. degree in electronic engineering from Pusan National University, in 1998. She received the Ph.D. degree in biomedical engineering in 2004 from the same institution. Her research interests include biomedical signal processing and measurement. She is currently a Professor at Dept. of Radiological Science in Catholic University of Pusan.

Ki-Gon Nam was born in Pusan, Korea. He received the M.S. degree in electronic engineering from Pusan National University, in 1977. He received the Ph.D. degree in biomedical engineering in 1981 from the same institution. His research interests include computer vision and pattern matching. He is currently a Professor at Dept. of Electronics Engineering, Pusan National University.

Ki-Won Byun was born in Pusan, Korea. He received the M.S. degree in electronic engineering from Pusan National University, in 2007. His research interests include computer vision and pattern matching. He is currently a course of ph. D in Pusan National University.