Topographic-based facial skin color transfer

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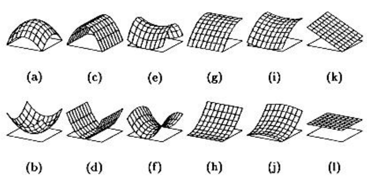
1 Introduction

The psychological finding – so-called "other-race" effect, has attracted research interests for many years [Goldstein 1979]. "Other-race" effect refers to the phenomenon that other-race faces are perceived to be more alike (i.e., more homogeneous) and therefore are less discriminable than own-race faces. For example, white subjects remember white faces better than they remember black and Asian faces. Psychophysical explanations emphasize such factors as "loss of facial details with decreased reflectance from dark skin" or "race- related differences in variability of facial features". People of different races have different skin colors. Is skin color among one of the factors that affect race or race- related recognition? From intuition, the answer seems to be yes, since the most noticeable characteristics of a human's appearance is skin color. This research attempts to provide a tool to answer this question. We developed a novel method to transfer skin color from one race to the other in an attempt to scientifically verify the importance of skin color for race-related face identification.



(a) peak; (b) pit; (c) ridge; (d) ravine; (e) ridge saddle; (f) ravine saddle;
Hills: (g)convex; (h) concave; (i) convex saddle; (j) concave saddle; (k) slope; (l) flat.
(a)-(l): The center pixel in each example carries the indicated label.

Figure 1: Topographic labels for facial details representation.

2 Skin Color Transfer

Inspired by recent advances of color transfer between images [Welsh et al. 2002], we developed a novel method specifically for facial skin color transfer between different races. Other than matching local image statistics [Welsh et al. 2002], transferring facial skin colors requires more accurate region correspondence. We propose to match pixel intensities in the corresponding sub-regions which have same topographic structures. Then we transfer the entire color mood (i.e., RGB components) simultaneously from the source image to the target image.

For computational efficiency, both source image and target image are first converted to HSI color space (other than the *lab* space as used in [Welsh et al. 2002]). In order to find the corresponding regions for skin color transfer, we need to make an explicit representation for the fundamental structure of facial surface details. Here we propose to use the topographic primal sketch (labeling) [Haralick et al. 1983] to find the regions with similar structures between two face images, where the face image is treated as a topographic terrain surface. We distinguish the topographic features of a face by twelve labels, as shown in Figure 1. Each pixel is assigned one of the topographic label peak, ridge, saddle, hill, flat, ravine, pit or hills. These topographic categories can reveal the light intensity variations caused by the facial surface reflections. We expect to transfer skin colors between the same topographic category of two facial images.

The topographic label classification is determined by the estimation of the *Hessian matrix*, which is formed by the first-order and second-order directional derivatives of the surface. We use Chebyshev polynomials to approximate the terrain surface. The eigenvalues (λ_1 and λ_2) of the *Hessian matrix* are the values of the extrema of the second directional derivative, and their associated eigenvectors (ω_1 and ω_2) are the directions in which the second directional derivatives have greatest magnitude. The pixel labeling (Figure 1) is based on the values of λ_1, λ_2, ω_1, ω_2 and ∇f. For example, a pixel is labeled as a peak if the following condition is satisfied: $\lambda_1 < 0$, $\lambda_2 < 0$ and $\nabla f = 0$. After the topographic region labeling, we can search the most similar pixel in the source image by finding the minimum intensity difference between the source pixel and the target pixel restricted in the same topographic regions. Note that the level of details of topographic regions (from coarse to fine) is adjustable by the order of Chebyshev polynomials. In this work, coarse level is sufficient for the optimal matching.

3 Result

Seventy-two frontal face images are collected for our test, which include male, female, white, black and Asian people. Figure 2 shows one example of the results. A psychological test was conducted by 12 volunteers from different races. 50% people can correctly recognize the other-race face images. After the colors are transfered to their own race color, the percentage increases to 67%. The results show that the other-race effect is affected by skin colors to a certain degree. Facial skin color is one of the aspects to influence race-related face identification and memorization. Future improvements will be the combination of color, texture and 3D topographic structures to synthesize race-related features under variable lighting conditions.

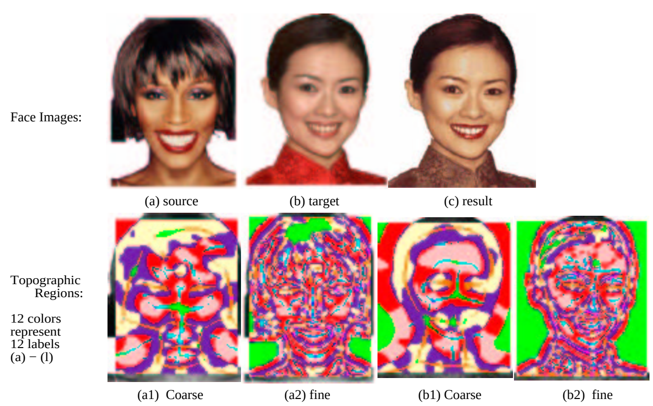


Figure 2: Example of color transfer.

References

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