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Luminance Pre-processing For Facial Composite System

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Abstract

The variation that arises in generated composite images affects the overall image when a feature from a very dark face is superimposed on a very light face or vice versa. The minimal edge smoothing is not always sufficient to blend this difference. So, the luminance pre-processing approach is utilized in a way that the resulted composite image seems realistic to most human observers. Face parts are transformed into correspondence background composite image before compositing process. This is achieved by employing the skin color information of the YIQ color space. The results obtained by applying luminance pre-processing approach show better improvement compared with minimal edge smoothing approach.

Keywords: Luminance Pre-processing, Facial Composite, edge smoothing, YIQ

المعالجة الأولية للإضاءة لأنظمة تركيب الوجوه

الخلاصة

إن التغير الناجم من الصور المركبة يؤثر على جميع أجزاء الصورة عند تركيب معالم وجه غامق جدا مع وجه شديد البياض والعكس بالعكس. إن طريقة تنعيم الحافات الدنيا ليست دائما كافية لتقليل هذا الاختلاف. لذا استخدمت طريقة المعالجة الأولية للإضاءة بحيث أن الصورة المركبة الناتجة تبدو طبيعية لمعظم ناظريها. قبل تركيب أجزاء الوجه، تم تحويل لون هذه الأجزاء إلى لون خلفية الصورة المركبة.أنجزت هذه العملية بتوظيف معلومات لون البشرة من خلال فضاء اللون YIQ. أوضحت النتائج المستحصل عليها بتطبيق طريقة المعالجة الأولية للإضاءة تحسينا أفضل مقارنة بطريقة تنعيم الحافات.

1. Introduction

The construction of facial composites by assembling individual facial features is common in criminal investigations. However, although humans have excellent facial recognition ability, it is widely recognized that they often have great difficulty recalling facial characteristics in sufficient detail to produce an accurate composite.

In recent years, most researchers of composite face systems depend on a recognition-based strategy, which allows a crime witness to create interactively a composite face without requiring isolated feature recall ability [1][2].

In recognition based facial composite system, composites are constructed out of face parts from images in the database. The feature annotations and eye-alignment made it possible to automatically recombine face parts from several different photographs and still get (most of the time) composites in which the pieces fit together fairly well. The variation that arises in generated composite images when a feature from a dark face is superimposed on a light face or vice versa affect on the overall image.

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In this paper, a luminance matching approach is used to overcome this problem. In the next section, besides an overview of facial composite systems is given. After that luminance pre-processing is described. Then experimental results are illustrated. Finally, conclusions are demonstrated.

2. Facial Composite Systems: An Overview

Modern police departments now use computerized systems for creating criminal composites. Many systems widely used for this purpose use interchangeable photographs of face parts, including forehead/hair, eyes, eyebrows, mouth, nose, and chin/cheeks, and includes accessory items such as beards and glasses [3][4]. Figure 1 gives an example of facial and accessory features. While figure 2 depicts steps toward constructing a facial face.

These systems require that a witness be able to recall isolated individual facial features. On the basis of psychological studies indicating that people find it difficult to apply single-feature recall, psychologists Johnston and Caldwell concluded that a different kind of system was needed. They state that while "humans have excellent facial recognition ability," they "have great difficulty recalling facial characteristics with sufficient detail to provide an accurate composite" [1]. To obtain advantage of the remarkable human ability to recognize faces, a recognition-based strategy is used, that allows a crime witness to create interactively a composite face without requiring isolated feature recall ability. In recognition-based facial composite system, faces are presented by a set of indices into a database of different face parts (such as those used by individual-based facial composite systems) together with a set of position coordinates for each part. Johnston and Caldwell claim that systems that are based on recognition strategy is better suited to the way people remember faces than systems that are based on individual feature recall strategy [1].

In general, for constructing a composite image, recognition-based composite systems permit the user to work with whole faces rather than individual features. Composites are constructed out of face parts from images in the database. Starting with a background image, which determines the cheeks and ears, the remaining face parts are superimposed on this background in rectangles of predefined size [1]. Figure 3 shows how the face-parts are structured into rectangles. Feature part rectangles may be resized slightly as necessary so that the rectangles fit tightly together. Rectangle edges are minimally blended with the background. The location annotation of a particular feature is inherited from its source image, so the process of annotating the composite is fully automated. Figure 4 shows composite construction example. The face in the upper is a composite made up of parts from the figures below it. The forehead from image A, the eyebrows and eyes from image B, the mouth and chin from image C and the cheeks and nose from image D.

3. Minimal Edge Smoothing

The composite image is constructed starting with the face supplying the cheeks and ears as a background. The remaining face parts (i.e., forehead, eyebrows, eyes, nose, and mouth/chin) are superimposed on top of this background face, with rectangle sizes for some parts adjusted as necessary to fit the pieces together tightly.

The resulted composite images generally good, but due to lighting, pose, and feature size variations, some problems do arise. One way to eliminate the variation that arise in generated composite images when a feature from dark face is superimposed on a light face is, 3×3 mean filter. Mean filter is convolved the boarder of each face part within the generated composite images. Mean filter is one of the simplest approaches to smooth and operates by replacing each pixel value by the average or mean of its immediate neighbors. The averaging process has the effect of ironing out significant gray-level differences between pixels in a neighborhood [5].

Figure 5 shows result from convolving mean filter on the boarder of each face part within the generated composite images [6]. The minimal edge smoothing is not always sufficient to blend the differences when a feature from a very dark face is superimposed on a very light face [1].

4. YIQ Color Model

Loosely speaking, luminance is a measure of brightness projected over some area. Luminance is a component found in several color models, including YIQ, YUV and YCrCb models (the Y component).

The NTSC defines Y, I, and Q as [7]:

$$Y=0.2290*R+0.5870*G+0.1140*B \quad (1)$$

$$I=0.5960*R-0.2750*G-0.3210*B \quad (2)$$

$$Q=0.2120*R-0.5280*G+0.3110*B \quad (3)$$

The RGB color space is linear (every color is a linear combination of R, G, and B) and a more appropriate value for Y in a linear color space is [8]:

$$Y=0.3086*R+0.6094*G+0.0820*B \quad (4)$$

The latter Y value is probably more correct. The crucial thing is that green is more important than red which is more important than blue. This is because of the way photoreceptors in our eyes respond to light.

Then to display the image in RGB color space the following equations are used [7]:

$$R=Y+0.9560*I+0.6210*Q \quad (5)$$

$$G=Y-0.2752*I-0.6470*Q \quad (6)$$

$$B=Y-1.1080*I+1.7050*Q \quad (7)$$

5. Luminance Pre-processing

This is achieved by matching skin-color components in the images using the YIQ color space. This approach is motivated by the fact that luminance is a notoriously fickle determinant of skin tones. The YIQ space describes an image in terms of its luminance (Y), hue (I), and saturation (Q).

The matching is performed by three steps. First, the color cues is explored by converting the RGB encoded color information to the YIQ color model. Second, a remapping is applied using Y component. Finally, converting the resulted YIQ encoded color information to the RGB color model.

The first step, converting the images to luminance, actually offers two advantages: matching one dimension histograms is easier than matching three dimension histograms, and fewer color channels means faster computations when search for best feature matches.

For the second step, matching the luminance distributions, we apply Hertzmann linear map that matches the means and variances of the luminance distributions [9]. More concretely, if $Y(p)$ is the luminance of a pixel in face part image A, then we remap it as:

$$Y(p) \leftarrow \frac{\sigma_B}{\sigma_A}(Y(p) - \mu_A) + \mu_B \qquad (8)$$

where μ_A and μ_B are the mean luminances, and σ_A and σ_B are the standard deviations of the luminances, both taken with respect to luminance distributions in face part A and background face image B, respectively.

Finally, the resulted luminance value is converted to RGB space. These processes continue to all face part images (*A's*) that superimposed on the background face image *B*.

6. Results

In this paper, database contains different face images with white background is used. Since luminance preprocessing approach uses skin color information, the database must contain the facial image and face parts information (i.e., feature annotations) represented as RGB color space, in addition to the luminance values of the facial image.

For each face image in the database, the mean and standard deviation luminance are calculated. When considering all the face image pixels to calculate the mean and standard deviation luminance the resulted remapped image shields with a light cover as shown in the figure 6. The white background in the face image is considered to be the trouble. This is confirmed by using luminance value from YIQ color space relatively similar to lighter value to separate the white background from the face region. For a candidate face region, convert input color face image into YIQ color to get skin color information, the high values of luminance represent the white background of a face image. This operation is applied to mask out the white background from a face image.

So, the mean and standard deviation luminance of each face image without its white background are stored also in the database.

Figures 7 to 9 show the results of applying the luminance pre-processing before composite face parts on the target image. Then minimal edge smoothing is applied. So the resulted composite image seems realistic to most human observers.

As it can be seen from figures 7 to 9 while all the resulted composite images that are utilize luminance pre-processing approach are more natural to human eyes, some differences have shown up as well. The different color of cloths appears in each face image effect also on the resulted composite image.

7. Conclusions

This paper utilizes luminance-pre processing approach to eliminate the variation that arises in generated composite images when a feature from a very dark face is superimposed on a very light face. The minimal edge smoothing alone is not sufficient to blend these variations. So before applying the minimal edge smoothing, luminance-pre processing approach is utilized to eliminates the variations that may appear.

The results showed the adequate of luminance pre-processing in reducing the variation between face parts and the background image that may arises.

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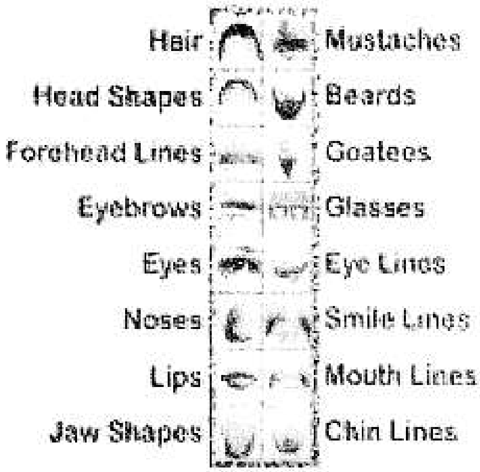


Figure 1 Facial and accessory features from (Aspley, 2004)

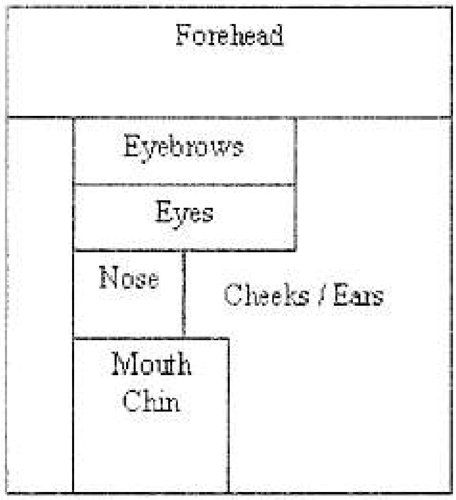


Figure 3 Face parts, from (Baker, 1999)

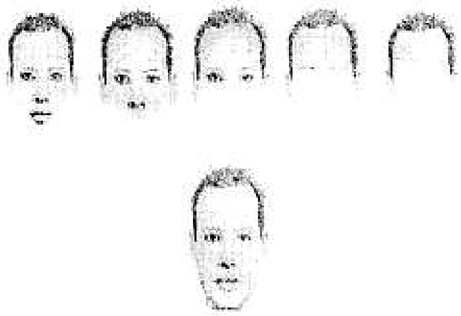


Figure 2 Steps toward constructing a facial face, from (Aspley 2004)

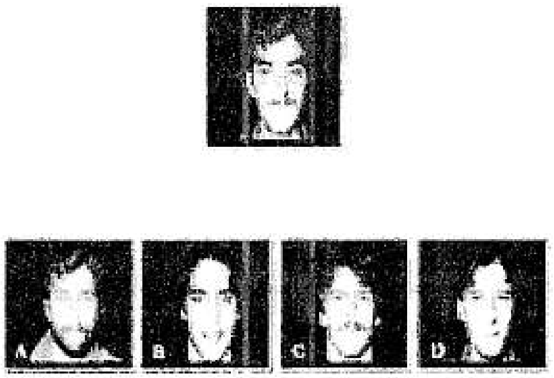


Figure 4 Composite Construction, from (Baker, 1999)

Figure 5 Facial Composite Image with smoothing, from (Al-Fiadh, 2004)

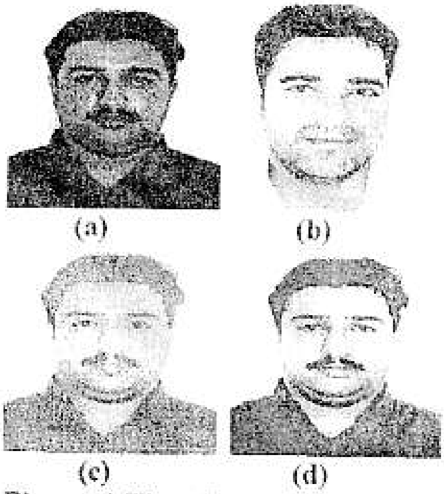


Figure 6 The effect of separate the white background from the luminance of the remapped image. (a) The source image (i.e., *A*). (b) Target image (i.e., *B*). (c) The resulted image after remapping including white background. (d) The resulted image after remapping excluding white background

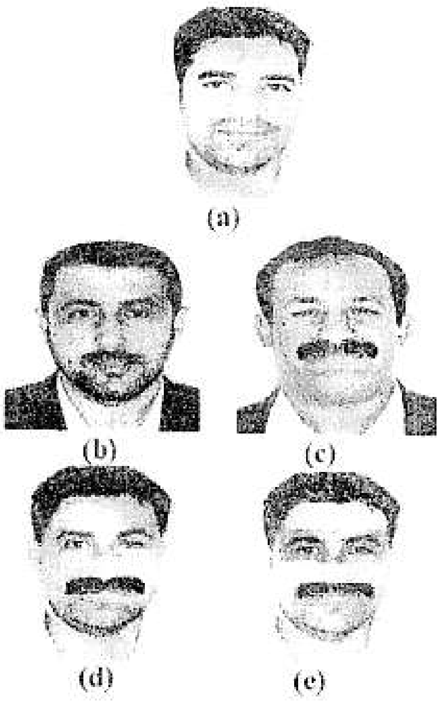


Figure 7 Composite Construction Results. The faces in (d) and (e) are composite made up of parts from the figures (b) and (c). The eyebrows and eyes came from image (b) and the mouth from image (c). The composite face in (d) with luminance pre-processing while the composite face in (e) is not.

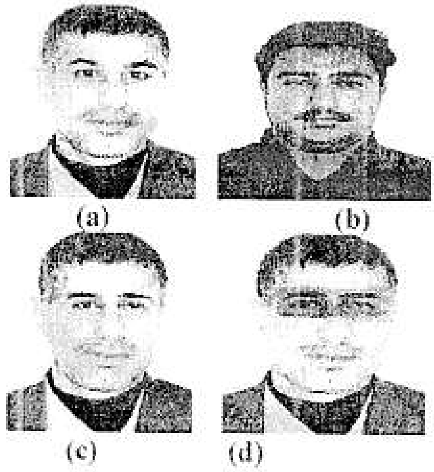
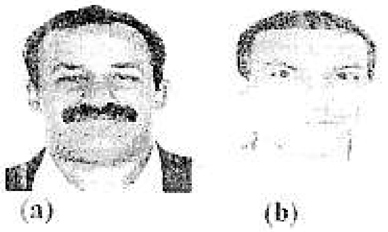


Figure 8 Composite Construction Results. The faces in (c) and (d) are composite made up of background image (a) and the eyebrows and eyes came from image (b). The composite face in (c) with luminance pre-processing while the composite face in (d) is not.



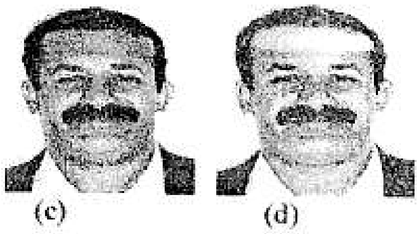


Figure 9 Composite Construction Results. The faces in (a) and (b) are constructed from the background image (a) and the forehead came from (b). The composite face in (c) with luminance pre-processing while the composite face in (d) is not.