AUTOMATIC CLOSED EYE CORRECTION

Jean-Charles Bazin, Dang-Quang Pham, Inso Kweon

RCV Lab, KAIST
South Korea

Kuk-Jin Yoon

Computer Vision Lab, GIST
South Korea

ABSTRACT

On a large group picture, having all people open their eyes can turn out to be a difficult task for photographers. Therefore, in this paper, we describe an original method to automatically correct closed eyes on everyday pictures. For this aim, we explore the combination possibilities of (1) Active Shape Model (ASM) to detect facial features, such as eyes, nose and head shape, and (2) Poisson editing to clone open eyes seamlessly. To improve the performance of seamless cloning, we suggest a pre-processing method that adjusts skin luminosity between two pictures. A nearest neighbor-based search to find the best suited pair of eyes among a set of donor candidates is also presented.

We applied the proposed algorithm on several pictures and obtained very natural results, which demonstrates the validity of our approach.

***Index Terms*—** closed eyes correction, Poisson editing, facial features

1. INTRODUCTION

Capturing group portraits without having someone with closed eyes can be a difficult task. Moreover, people wish to look perfect on pictures of important events, such as weddings, graduation or award ceremony, but due to closed eyes, the picture would not correctly reflect the joy and atmosphere of the event. Therefore, in this paper, we propose a method to automatically perform closed eye correction (cf Fig 1).

To the best of our knowledge, only [1] explicitly faced this problem and is composed of 2 steps. First, eye state (open/closed) is automatically detected by using adaboosted cascade detectors at different scales [2]. In the second step, the authors correct closed eyes by a Principal Component Analysis (PCA) generative model of concatenated closed and open eyes. Whereas the first step permits to obtain interesting results, the approach of the correction step suffers from some limitations. First, it requires not only several normalized frontal images of the person, but also corresponding open and closed eyes, which is inconvenient and complicated to obtain in practice. And second, the correction is essentially based on heuristics (transparency, average skin color, etc.) to adjust the colors.

To overcome these limitations, this paper presents a new method for closed eye correction. Our algorithm is composed of three main tools. First, we apply an ASM-based search to detect a set of facial features and detect eye state, similarly to [1]. Second, open eyes from a donor image are cloned to the receiver seamlessly thanks to Poisson editing. Compared to [1], the main advantage of this technique is to automatically obtain natural results even with different illuminations and color casts. Moreover, it avoids the difficult part of building a training set (time consuming and inconvenient in practice) for PCA and can work with a single correct donor image. To enhance the performance of seamless cloning, we suggest an efficient pre-processing method that adjusts skin luminosity between two pictures. Finally, in the case where several donor pictures are available for correction, we propose an automatic method to find the most suitable donor picture, by a nearest neighbor-based search on facial feature distances.

(a) (b) (c)

Fig. 1. (a): original picture with one person having closed eyes (red box), (b): detailed view of the closed-eyed person, (c): result of our automatic closed eye correction method.

2. ASM FOR FACIAL FEATURE DETECTION

Active Shape Model (ASM), described by Cootes et al. [3], is a general algorithm to extract features on an object. It consists of a profile model and a shape model that has to be trained. The profile model describes the local texture around feature points. It is used to locate the approximate position of each feature by template matching. Given an image, the features are moved towards the position that matches best with the profile model. This suggested shape is then adjusted by a shape model that defines possible relative positions of all landmarks to exclude abnormal shapes. This process is iterated until convergence of the landmark locations.

Several ASM methods dedicated to facial feature detection exist in the literature [4][5][6]. Before ASM search is started, Viola and Jone's face detection [7] algorithm is usually applied to crop the picture and center the face. In our implementation we selected [6] and typical results obtained by this method are shown in Fig 2. Then the open/closed eyes can be automatically detected (e.g. [1]) and for more interaction, we have let the user the possibility to select other faces and eyes manually.

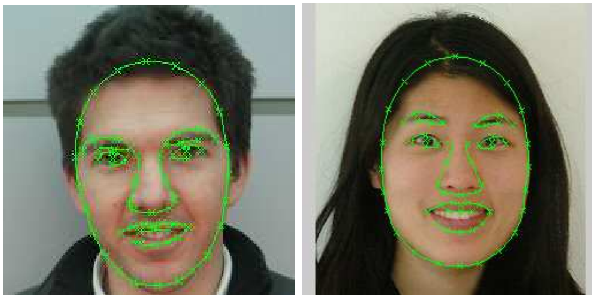

Fig. 2. Typical results of automatic facial features extraction by [6].

3. POISSON EDITING AND SEAMLESS CLONING

Once feature detection has been done, we would like to clone the donor's open eyes into the receiver face. As pictures may have different illumination and color casts, classical "copy and paste" produces unwanted discontinuities (cf Fig 4(d)). To solve this problem, [8] proposes a seamless cloning technique with Poisson editing and permits to obtain very natural images. This approach provides a nice mathematical formulation and reduces to a sparse linear system which can be solved easily (due to space constraint, readers are invited to refer to [8] for more details).

As a result, we can insert donor's eyes into receiver's face without discontinuities (cf Fig 4(e)). However, during experiments, we noticed that when the skin color is strongly different between donor and receiver images, the eye color seems to fade away (bluring/whitening effect). To solve this problem, we suggest a simple but efficient method that automatically adjusts the skin luminosity. Inspired from color balancing [9], we computed the intensity distribution of pixels located inside the head shape for each RGB channel in the donor picture, and then scaled the distribution means so that it matches the RGB distribution means of the receiver picture. Fig 3 presents typical examples of the suggested color balancing. Fig 4 and 5 compare the cloning results obtained with and without pre-processing. It shows that this pre-processing method significantly improves the performance of the Poisson editing.

4. AUTOMATIC ALIGNMENT OF FACIAL FEATURES

Once the facial features have been extracted, it is not possible to directly clone the donor's open eyes into the receiver face because the donor's and receiver's faces might have different rotation, scale and position in the pictures (cf Fig 6). Thus the 2 sets of facial features must be aligned. The end-user could manually align the eye areas by adjusting rotation, scale and rotation but it would be a time consuming task. Therefore we developed an automatic alignment

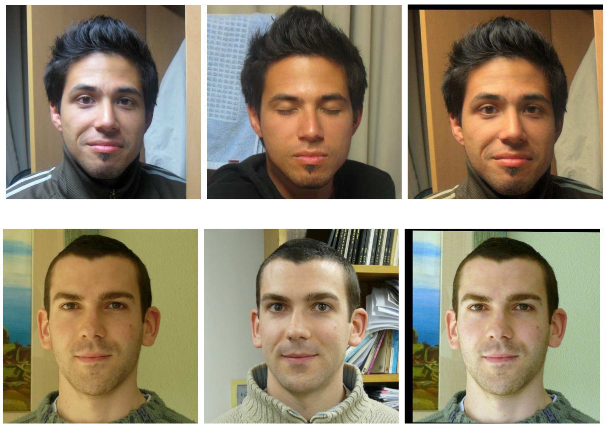

Fig. 3. From left to right: reference image, target image, color balancing of the reference image towards the target image.

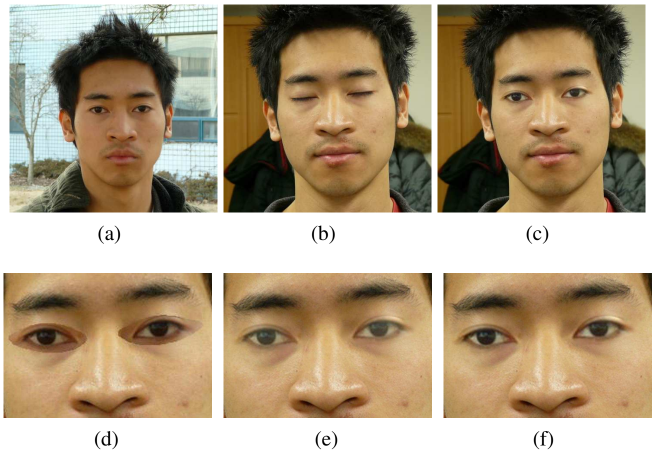

Fig. 4. Input pictures: donor (a) and receiver (b). Output result using Poisson editing and the suggested pre-processing method: (c). Detailed views of basic copy and paste (d), traditional Poisson editing (e) and Poisson editing with the suggested pre-processing method (f).

method inspired from the behavior of users of image manipulation softwares (Photoshop or Gimp) (due to space limitation, details are not included in this paper). We distinguished 2 main procedures and implemented one of them. For translation, we align the exterior corner of the left eye (another fixed facial feature could be used instead). Then, rotation is adjusted by defining a horizontal line passing through the 4 corners of the extracted eye features (using line fitting by least-square method). The rotation of a donor picture is set by forcing this line to be parallel to the receiver's. The scale is adjusted by measuring the length between the 2 extreme eye corners on the donor and the receiver's images. The scale factor to be applied on the donor image is the ratio between these 2 lengths. Finally, in order to obtain a precise alignment, we perform a refinement on the scale and translation. Formally speaking, the refinement is obtained by minimizing the following cost function:

$$\min_{s,d_x,d_y} \sum_{i=1}^{n} \left(x_r^i - s\left(x_d^i + d_x\right)\right)^2 + \left(y_r^i - s\left(y_d^i + d_y\right)\right)^2 \quad (1)$$

(a) (b) (c)

(d) (e) (f)

Fig. 5. Same legend than Fig 4.

where n is the number of facial landmarks, s and (d_x, d_y) are the unknown scale factor and translation vector, (x_r^i, y_r^i) are the coordinates of the i^{th} landmark on the receiver image, (x_d^i, y_d^i) are the coordinates of the i^{th} landmark on the donor image. The solution is obtained by non-linear minimization and the result of the above procedure is used as initial solution. Experimental results of alignment are presented in figure 6 and show the effectiveness of the method.

(a) (b) (c) (d)

Fig. 6. Results of facial features alignment. (a): donor, (b): receiver, (c): donor aligned with receiver (scale, rotation and translation), and (d): layered picture to depict the alignment accuracy.

5. FINDING THE BEST DONOR PICTURE

In the case several donor pictures of one person are available, an automatic suggestion of the most suitable donor picture could save precious time during correction process and enhance final results. Candidate faces can be automatically extracted by state-of-the-art algorithms of face detection/recognition and we can also give the user the freedom to manually select faces. To compare the candidate faces, the alignment procedure, described in section 4, is first applied to all the facial landmarks. Then, our cost function is defined as the sum of distances between all the corresponding landmarks on the donor and receiver pictures:

$$cost = \sum_{i=1}^{n} \left(x_r^i - \widehat{x_d^i}\right)^2 + \left(y_r^i - \widehat{y_d^i}\right)^2 \quad (2)$$

where $(\widehat{x_d^i}, \widehat{y_d^i})$ are the coordinates of the i^{th} landmark on the donor picture after being aligned on the receiver picture. To pick

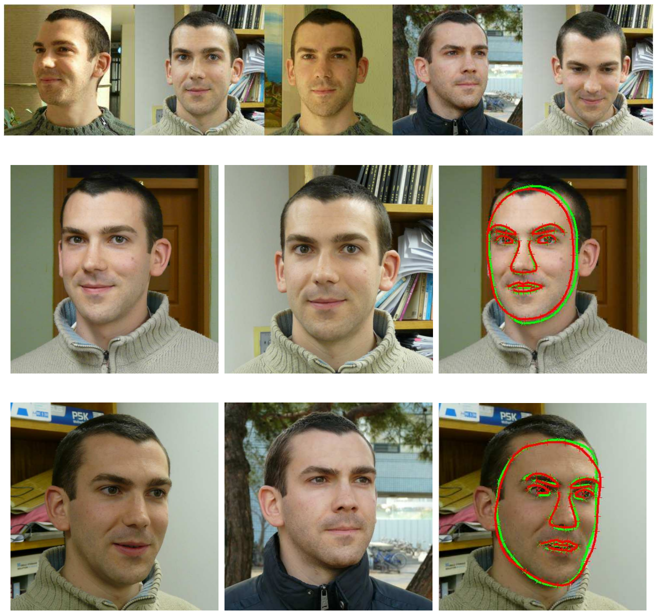

Fig. 7. Top row: database of donor candidates (5 out of 12). Middle and bottom rows: input receiver (left), automatically suggested donor using proposed nearest-neighbor search (middle) and associated facial feature alignment (right) of receiver (in green) and donor (in red).

up the best donor, we perform a nearest-neighbor search and select the face that gives the smallest cost among all donor candidates. Figures 7 and 8 depict experimental results obtained by this method. Moreover qualitative experiments have shown that the suggested best donor corresponds to the candidate picked up by a set of human users.

6. RESULTS

To study the validity of our algorithm, we performed extensive experiments on different sets of pictures: illumination, skin color (caucasian, asian and middle-east), environment (indoor/outdoor), resolution (7 mega-pixel camera, webcam), gender (male/female), etc. Some results have been shown in Fig 4 and Fig 5. Extra typical results are shown in Fig 9. It demonstrates that our method efficiently corrects closed eyes and provides natural results when a suitable donor picture is given. For completeness, we would like to add that the proposed algorithm might lead to unrealistic images in some situations like strong illumination differences or different head orientations (examples not included in this paper because of space limitation).

7. CONCLUSION

In this paper, we have proposed an original method for automatic closed eye correction. The challenge was to use general pictures and obtain results that look very natural in an automatic procedure. For this aim, facial features are detected using ASM-based algorithm and applied Poisson editing technique to seamlessly clone donor's open eyes into the receiver face. In order to enhance the performance of seamless cloning, we suggested a simple but efficient method to

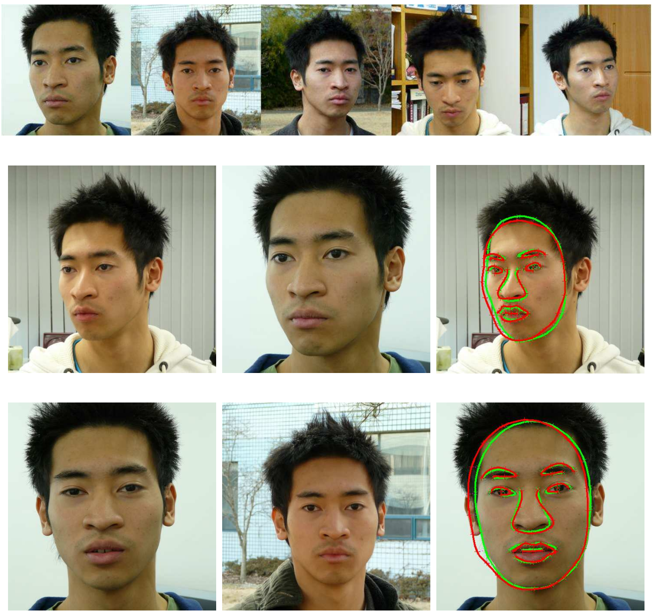

Fig. 8. Top row: database of donor candidates (5 out of 10). Middle and bottom rows: input receiver (left), automatically suggested donor using proposed nearest-neighbor search (middle) and associated facial feature alignment (right) of receiver (in green) and donor (in red).

adjust the skin color between 2 images. We also proposed an automatic method to find the most suitable donor picture, by a nearest neighbor-based search on facial features distances. Extensive experiments have demonstrated the validity and the generality of our approach.

In future work, we will focus on improving algorithms of facial feature extraction for extreme head orientations such as profile pictures. We also plan to expand our approach for the situations where the faces in a donor and a receiver pictures have a different orientation. Finally we plan to develop photogenic enhancement of human faces by correcting non-smiling faces with a similar approach.

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Fig. 9. From left to right: original receiver, donor, receiver with closed eye correction.

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