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Pattern Recognition Letters 26 (2005) 2215–2220
Pattern Recognition Letters
www.elsevier.com/locate/patrec

Eyeglasses removal from facial images

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Received 3 July 2004; received in revised form 1 April 2005
Available online 31 May 2005

Communicated by T.K. Ho

Abstract

A novel approach of removing eyeglasses from frontal facial images is proposed. The region occluded by eyeglasses is firstly detected; a natural looking eyeglassless facial image is then synthesized by recursive error compensation of PCA reconstruction. The synthesized images have neither trace of the eyeglasses, nor the reflection and shade caused by the eyeglasses. Experimental results show that our method can effectively synthesize eyeglassless facial images.

Keywords: Eyeglasses removal; Face recognition; Face synthesis; Eyeglasses detection

1. Introduction

Face recognition has been one of the most active research areas in pattern recognition and computer vision for its wide potential applications. Many methods have been proposed in the past decades, and some of them have been successfully applied to the task of face recognition. However, a recent test report FRVT2002 (Phillips et al., 2003) has shown that there are still some problems which are not solved very well until now, including different lighting conditions, facial expressions, poses, and occlusion by other objects. Among the last category, eyeglasses are the most common occluding objects, which have a significant effect on the performance of face recognition systems.

Some approaches have been proposed to extract and remove eyeglasses from facial images. Saito et al. (1999) synthesized eyeglassless facial images using principle component analysis (PCA). However, their method left some traces of eyeglasses on the reconstructed facial images. In (Wu et al., 2004), Chenyu studied the statistical mapping between facial images with eyeglasses and their counterparts without eyeglasses; they modeled their joint distribution in an eigenspace spanned by all

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doi:10.1016/j.patrec.2005.04.002

training pairs and used that to synthesize eyeglassless facial images. In their method, 15 points are selected to describe the shape of eyeglasses, and a maximum a posteriori (MAP) solution is designed to locate the points. However, for some eyeglasses with no frame, the location result is not good enough. Jiang et al. (1998) designed six measures of edge information around eyes to determine the presence of eyeglasses, which are then combined to improve the performance. Their method appears too sensitive to the result of iris location. Jing and Mariani (2000) developed an eyeglasses detection algorithm with a deformable contour method based on both the edge features such as strength, orientation and the geometrical features including convexity, symmetry, smoothness and continuity. Wu et al. (2002) used a 3D Hough transform to detect the eyeglasses frame. 3D Hough transform is applied to trinocular stereo facial images to determine the 3D plane passing through the rims of eyeglasses. Their method does not require any prior knowledge about the face pose, the eyes position and the shape of eyeglasses, at a cost of more cameras and computational time than other 2D image based methods. Saito et al. (2000) used Active Contour Model to extract frame of eyeglasses, they applied Genetic Algorithm to optimize parameters of snake. But their method used the symmetric property of eyeglasses which may fail when the input face image has rotation in plane, their algorithm is computational expensive.

In this paper, we proposed a new approach to synthesize eyeglassless facial images. First, the region occluded by eyeglasses frame and reflection of eyeglasses are extracted by an adaptive binarization approach. Then a recursive error compensation approach based on PCA reconstruction is applied to synthesize eyeglassless facial images.

This paper is organized as follows: Next section introduces the simple PCA method proposed by Saito et al. Section 3 describes our eyeglasses removal procedure. First, the occluded regions caused by eyeglasses are extracted. A recursive process of PCA reconstruction and error compensation is then applied to synthesize eyeglassless facial images. Section 4 demonstrates the experiment results, and finally conclusions are given in the last section.

2. Simple PCA reconstruction method

In (Saito et al., 1999), Saito developed an eyeglassless facial image reconstruction method based on PCA. Facial images with eyeglasses are projected into the eigenspace trained by eyeglassless facial images, from which corresponding eyeglassless facial images are reconstructed. The upper half of the facial region in the PCA reconstructed image and the lower half of input image are then combined to generate eyeglassless facial image.

The representational power of PCA depends on the training set. Since the training images have no eyeglasses, the reconstructed images will not have eyeglasses no matter the input facial images have eyeglasses or not. Therefore, reconstruction errors caused by eyeglasses are spread out over the entire reconstructed image. This results in some degradation of quality and some traces of the eyeglasses frame remained. The simple PCA method has some limitations in synthesizing natural looking glassless facial images.

3. Eyeglasses removal procedure

Our eyeglasses removal procedure consists of two parts: the first is extraction of occluded region caused by eyeglasses, and the second is error compensation according to the reconstructed image and the extracted occluded region. The whole procedure is depicted in Fig. 1. The input facial image is first reconstructed by PCA. The occluded region is then extracted combining the input image and the reconstructed image. After that, a compensated facial image is calculated according to the reconstructed image and the extracted occluded region. Finally the compensated image is fed back to PCA to obtain the second reconstructed image. The whole procedure stops when there is no big difference between current compensated image and previous compensated image.

3.1. Extraction of occluded regions caused by eyeglasses

The extraction of regions occluded by eyeglasses is crucial for our eyeglasses removal system.