생체 인식을 위한 치아 영상 인식에 대한 연구

김태우*
*한양사이버대학교 정보통신공학과
e-mail: twkim2@hycu.ac.kr

A Study on Teeth Image Recognition for Biomerics

Tae-Woo Kim*
*Dept of Information and Communication Engineering,
Hanyang Cyber University

요 약

본 논문은 치아의 전치 교합과 후치 교합 상태에서 획득된 영상들에 대해 BMME와 LDA에 기반한 개인 인증 방법을 제안한다. 이 방법은 두 치아 교합 상태의 영상들로부터 치아 영역 추출, BMME, 패턴인식 과정으로 구성된다. 두 상태의 치아 교합을 사용하면 영상에서 일정한 치아 모양이 유지되며, BMME는 패턴인식에서 정합 오차를 줄일 수 있도록 해 준다. 강체인 치아는 영상 획득시 왜곡되지 않으므로 치아 영상을 이용하는 방법은 생체 인식에 장점으로 작용한다. 실험에서, 제안한 방법은 20명에 대해 개인 인증을 위한 인식에 성공하여 다중 인증 시스템에 사용될 수 있음을 보였다.

1. Introduction

Biometrics[1] can be used for personal identification for securities such as gate entrance, bank ATM, mobile equipment, computer system, etc. Biometrics is categorized into two methods: one is using physical feature such as finger print, hand vein, iris, face, etc. and the other is by behavioral feature such as signature, voice, foot step, etc. Biometric systems can be used for two applications of verification and identification. Identification is to search an object on the predefined database, while verification is to decide whether a user is oneself or not.

Currently, the biometric measurements that are useful for personal authentication are images for face, fingerprint, iris, hand vein, etc[1]. Iris recognition requires an image acquisition equipment with high resolution. Fingerprint can be easily contaminated with other materials such as sweat, dust, etc. Face and hand vein can be often deformed due to inconsistent poses of a user.

This paper proposes a personal identification method using teeth images. The method is based on BMME and LDA technique for images acquired at anterior and posterior occlusion expression of teeth. Teeth have played an important role in identifying a person under special situations like accidents because of having unique characteristics for each person such as geometric feature and constitutional material.

2. Teeth Recognition

In general, human being has 32 permanent teeth, which are embedded to the upper (maxillary) and lower (mandibular) gingival body as shown in Fig. 1. Teeth images can be acquired with the digital camera, although without high resolution, of a dedicated personal identification system, a personal computer, or other devices.

Our teeth recognition is using an appearance-based method[3]. The recognition procedure consists of teeth region extraction, Block Matching Motion Estimation (BMME)[2], and pattern recognition in sequential steps. An input teeth pattern is projected by LDA[3] and matched with each pattern of the database containing teeth feature vectors of people.

Teeth region in the image is the rectangle bounding frontal view of the anterior teeth as shown in Fig. 2. The region can be extracted by thresholding[5] in the image because the teeth region and their both sides are usually bright and dark, respectively. The thresholding gives both sides of teeth as shown in Fig. 3 (b). The centers of mass[5], C_L and C_R, of the side areas of the teeth are obtained as shown Fig. 3 (c). The image is rotated to make the line connecting the centers horizontal, resulting in as shown in figure 3 (d).

The bounding rectangle is extracted by

drawing a box between both sides of teeth in the rotated image as shown in Fig. 3 (e). The rectangle is composed of horizontal lines along the line interconnecting the centers of mass and vertical lines defined as $L_H = RL_V$, where R is ratio between the horizontal and vertical length. The teeth region is extracted and normalized in size according to the rectangle as shown in Fig. 3 (f).

This paper uses PMVFAST(Predictive Vector Field Adaptive Search Technique)[2] to reduce matching error in pattern recognition step. In our case, BMME is the matching between an input teeth image and each teeth image of the database.

The block $M \times N$ is typically smaller than normalized teeth region $L_H \times L_V$. In our case, the block size is represented as $M = ROUND(L_H \cdot R_H)$ and $N = ROUND(L_V \cdot R_V)$, where $0 < R_H, R_V \leq 1$ and determined by experiments in specific application. The block location is determined by $x = ROUND(L_H(1-R_H)/2)$ and $y = ROUND(L_V(1-R_V)/2)$ where $ROUND(\cdot)$ is a function to convert a floating point value to corresponding integer value by rounding.

The normalized and motion-estimated teeth region in the previous step is projected to LDA space[3]. And the projected image is matched to each pattern of the database. Each person has different characteristics in appearance of the anterior and posterior occlusion as well as of the teeth themselves.

For classification of the projected feature vectors, we uses a nearest neighbor(NN) algorithm[4] which is one of the popular minimum-distance classifiers in pattern recognition.

3. Experimental Results

For the experiments, teeth images for 20 people, ten images for each person, were acquired by a digital camera embedded to a mobile phone under constraints such as illumination and teeth expression. The camera has image resolution of 352×288 in pixels.

Ten images for each teeth occlusion of a person were acquired and stored to teeth image database for pattern recognition, as shown in Fig. 4. For all the samples, the matching procedure was performed with the feature vectors on the database. The results for 20 people were successful in teeth recognition for personal identification. From this result, it was found that our method can be another modality for biometrics.

4. Conclusion

This paper presented a personal identification method based on BMME and LDA for images acquired at anterior and posterior occlusion expression of teeth. In the experiments, personal identification for 20 people was successful. It was shown that the method using teeth images can contribute to multi-modal authentication systems.

Teeth images give merits in recognition because teeth, rigid objects, cannot be deformed at the moment of image acquisition.

References

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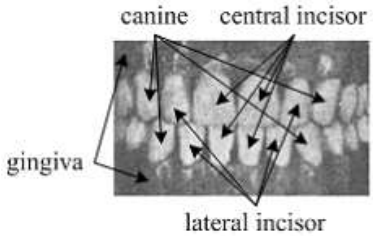
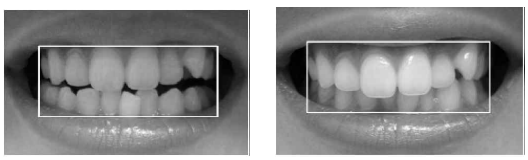
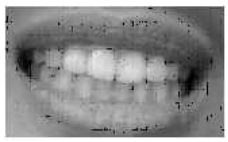


Fig. 1. Frontal view and names of typical foremost anterior teeth.



(a) (b)

Fig. 2. Teeth region, depicted as a white rectangle, in the frontal view of the anterior teeth in the image: (a) anterior teeth occlusion and (b) posterior teeth occlusion.



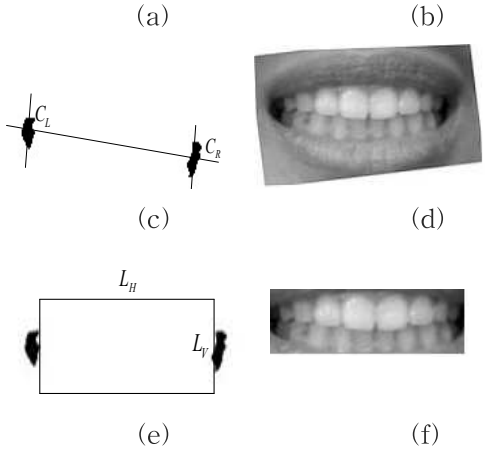


Fig. 3. Teeth region extraction procedure: (a) acquired teeth image,(b) thresholded image, (c) the centers of mass, (d) the image rotated to make the line connecting the centers horizontal, (e) the bounding box of the teeth region, and (f) extracted teeth region.

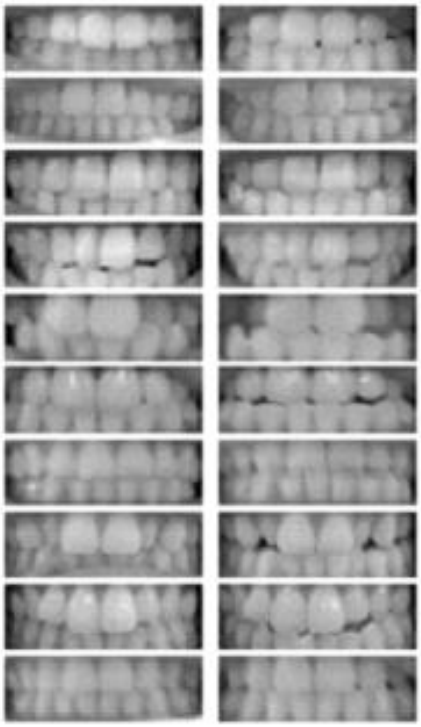


Fig. 4. Example of size-normalized teeth regions for 10 people at the anterior (right) and posterior (left) occlusion teeth expression.