A PERSONAL AUTHENTICATION FROM VIDEO USING HANDHELD CAMERA BY PARAMETRIC EIGENSPACE METHOD

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ABSTRACT

In this paper, we proposed a new authentication method using video that was taken during moving a hand-held camera in front of the face. The proposed method extracted individuality from the obtained image sequences using the parametric eigenspace scheme. Changes of facial appearance through authentication trials draw continuous tracks in the low dimensional eigenspace. The similarity between their continuous tracks are calculated by DP-matching to verify their identities. Experimental results confirmed that different motions and persons change the shapes of continuous tracks, so the proposed method could identify the person.

Keywords: biometrics, video-based authentication, parametric eigenspace, DP-matching

1. INTRODUCTION

In recent years it has been required to ensure higher security on the high performance mobile devices. Although such devices are currently mounted with a PIN code authentication system which can achieve a sufficient security level, it may often be annoying for users to enter or/and have a risk of forgetting[1]. Therefore some biometrics authentication systems have been normally in the devises to avoid that risk. Especially, face recognition is natural for users not requiring touching devices. However 2D image-based recognition systems tend to be affected by clutter, variability of the background, noise, and occlusion[2].

Nowadays much research has been concentrated on video-based face recognition[3, 4, 5, 6, 7]. But recognizing a nonrigid 3D face from its 2D images poses many problems. The illuminations and pose problems are two prominent issues for appearance-or image-based approaches. To solve these problems, Fukui et al. have proposed multi-frame and multi-viewpoint authentication system by using multi-camera[8]. Since recognizing the face from variable viewpoint is equal to treating the face in 3D, we could easily to figure it out that the video-based authentication is much better than using a single still image[9].

In this paper, we present a novel video-based authentification that treats not only the nonrigid 3D face, but also the motion features. In other words, we treat the appearance changes of face image sequences as his/her unique feature.

The proposed method extracts both individuality and motion features from the obtained image sequences by using parametric eigenspace method[10]. parametric eigenspace method method is general algorithm for recognizing moving objects from appearances of 3D object. Murase et al. adopted this method to human gait analysis and lip readings[11] and showed that using eigenspace can reduce calculations and provide more robustness to noise. We extend this idea to identifying person's motion from the video data captured with the camera that users arbitrarily moves in front of their face.

The proposed method shows that a temporal sequence of track drawn in the low dimensional eigenspace impresses the unique motion and appearance-based features. We adopt DP-Matching to compare the similarity of each track. The experimental results show that the unique temporal sequence of track will be able to identify the difference of individuality.

2. THE PROPOSED METHOD

2.1 Overview

We use a hand-held camera to take a video while moving it. Figure 1 shows the flow of the proposed method. The image of the way of authentication is illustrated in the top of the figure. After registering motion, we extract the face-region from each obtained frame by using the face detection technique supported on OpenCV [12, 13]. Figure 2 shows example of the obtained image sequence after the face-region extraction.

2.2 Parametric Eigenspace Method

Let the $x'(i)$ be ith image of the obtained video data. The intensity of the image is normalized by

$$x(i) = x'(i)/||x'(i)||. \quad (1)$$

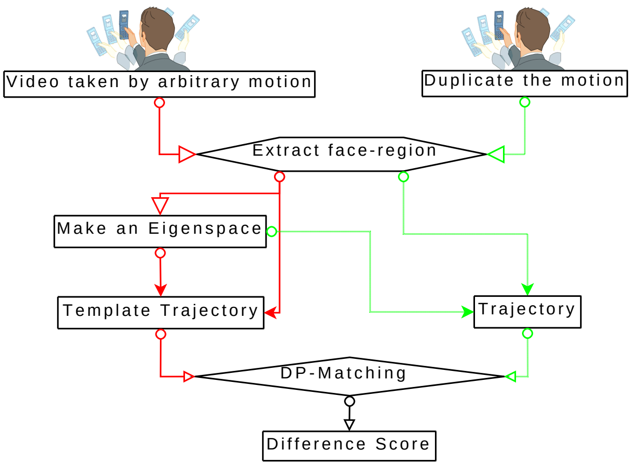

Fig. 1: Flow of the Proposed Method

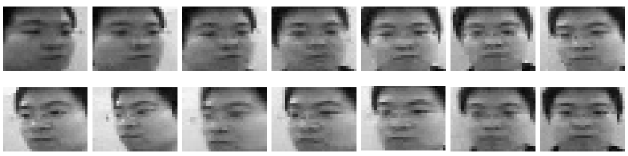

Fig. 2: An example of image sequence

The covariance matrix of the image set $x(i)$ is calculated by

$$\boldsymbol{Q} = \sum_{i=1}^{I}(x(i) - \bar{x})(x(i) - \bar{x})^T, \qquad (2)$$

where I is the number of obtained frame, $\bar{x}$ is the mean vector of $x(i)$ and T is transpose operator. Then, k eigenvectors $\boldsymbol{e_1}$, $\boldsymbol{e_2}$, $\cdots$, $\boldsymbol{e_k}$ of the covariance matrix Q are calculated in order of magnitude of the eigen values. The k-dimensional subspace spanned by these eigenvectors is called eigenspace. Generally, the first few eigenvectors correspond to large changes of the image sequence, while higher-order of eigenvectors correspond to smaller changes.

Each image can be mapped to a point in this eigenspace; thus the obtained image sequence can be represented as a trajectory in the eigenspace. The 3D eigenspace representation are shown in Figure 6,7,9. The registered trajectory is represented by a vector function $\boldsymbol{u(i)}$= $[\boldsymbol{e_1}, \boldsymbol{e_2}, \cdots, \boldsymbol{e_k}]^T$ $x_R(i)$, and input trajectory is represented by a vector function $\boldsymbol{v(i)}$= $[\boldsymbol{e_1}, \boldsymbol{e_2}, \cdots, \boldsymbol{e_k}]^T$ $x_A(i)$,which are expanded by eigenvectors in a k-dimensional eigenspace.

2.3 Difference measured by DP-Matching

The number of the obtained frame changes through authentication trials; so we adopt DP-Matching to calculate the difference Score $S(\boldsymbol{u}, \boldsymbol{v})$ between template trajectory $\boldsymbol{u}$ and input trajectory $\boldsymbol{v}$. The difference Score $S(\boldsymbol{u}, \boldsymbol{v})$ is an accumulation of the error distance and calculated by the following recursive equations:

$$S(\boldsymbol{u}, \boldsymbol{v}) = \frac{D[M, N]}{M + N} \qquad (3)$$

$$D[i, j] = max \begin{cases} D[i-1, j-1] + D[i, j] \\ D[i, j-1] + D[i, j] - P \\ D[i-1, j] + D[i, j] - P \end{cases} \qquad (4)$$

$$D[i, j] = \|\boldsymbol{u_i} - \boldsymbol{v_j}\|^2 \qquad (5)$$

Where M and N represents the total frame numbers of the registered template $\boldsymbol{u}$ and the input $\boldsymbol{v}$ respectively. The algorithm is equivalent to searching for a maximum route.The larger the measured difference $S(\boldsymbol{u}, \boldsymbol{v})$ is, the more $\boldsymbol{u}$ and $\boldsymbol{v}$ resemble each other.

3. EXPERIMENT

3.1 Experimental Condition

We take a video by using a digital camera with pixel resolution of 640 $\times$ 320. To eliminate the influence of some obstacle or background, we conducted all experiments in the same place where the background textures is a white board. Next we normalized the size of the extracted face-region to 32$\times$24 pixels.

3.2 The Difference by Motion

To see how the way of the motion reflects the trajectory, we conducted the following experiment. Figure 3 shows the registeration motion and Figure4 shows authentication trail motions. All of these motion are done two times in a row. The difference of each trial motion to the registered motion in the 10-dimensional eigenspace is shown in Figure 5. The result shows that the difference obtained by the same motion as registered one scored the highest score of -0.11. The difference scores of the other motions become much lower than that of the same motion.

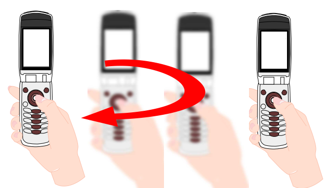

Fig. 3: Registration Motion

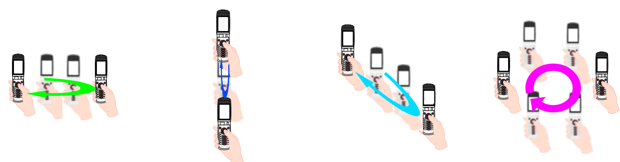

Fig. 4: Trial Authentication Motions. The left one is the same as registration motion

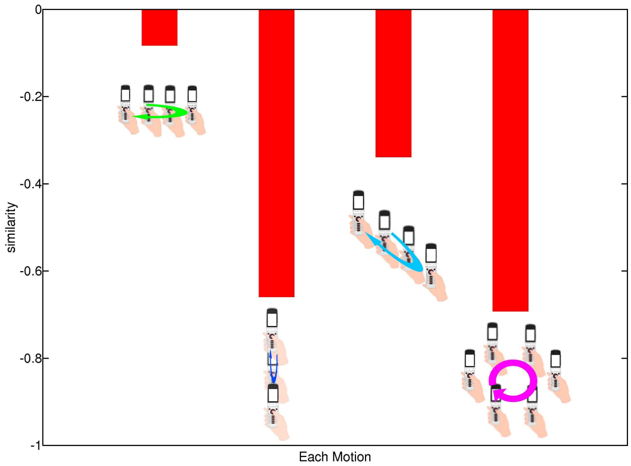

Fig. 5: Difference of Each Motion Calculated by DP-Matching

3.3 The Difference by Person

Now, let we consider the situation that both the registration and the authentication motion are the same as Figure 3, but the users are different persons. Figure 6 shows the trajectories authenticated by another person in the 3-dimensional eigenspace and Figure 7 shows the trajectories authenticated by the identical person with the registered trajectory.

From Figure 6, the shape of the trajectory obtained by another person is different from the registered trajectory. On the other hand, the trajectory by the identical person is similar to the registered trajectory. Moreover, the difference scores calculated by DP-Matching in 10-dimension are -0.56 and -0.11 respectively. This is because the appearance-based features in the obtained frame are different, so the trajectory projected in the eigenspace is different as a result.

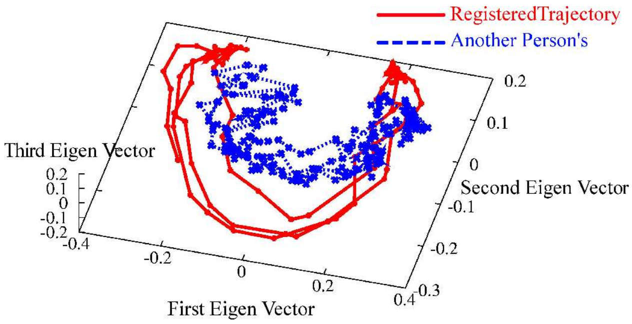

Fig. 6: Trajectory by another person

3.4 Changes with Passage of Time

To verify the influence of the slight changes of motion by the passage of time, we performed the authentication with

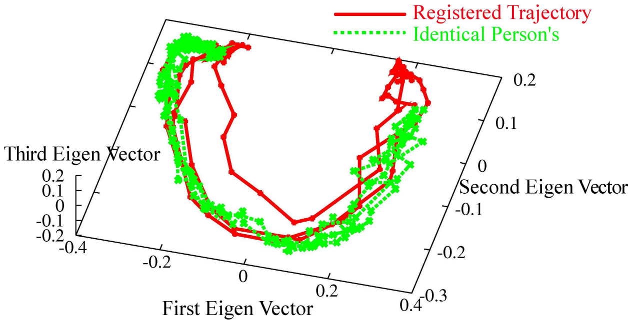

Fig. 7: Trajectory by identical person

the same motion over a month. Figure8 shows the difference score against the passage days.

This result shows that the difference score fell down after a week but held up after three weeks. Comparing the trajectories in the 3-dimensional eigenspace, we can find that these shapes of trajectories are almost similar to the registered trajectory. In other words, even if the motion is slightly changed, our method extracts the unique features and has a possibility to recognize the identical person.

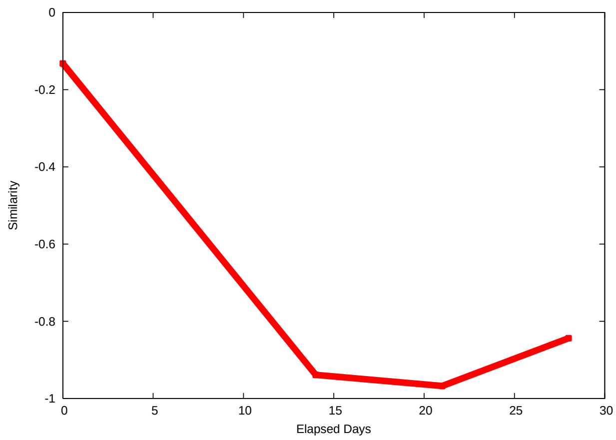

Fig. 8: Changes of Similarity by Elapsed Days

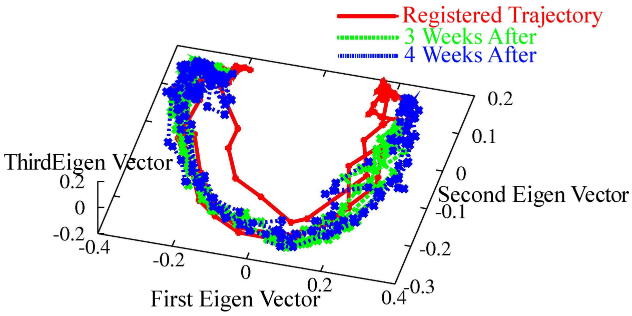

Fig. 9: Trajectory With Elapsed Days in 3-dimension

3.5 Conclusion

We proposed a new authentication method which uses video taken during moving hand-held camera in front of the face. By adopting the parametric eigenspace method, we extract the unique features as the trajectory projected in the low dimensional eigenspace generated from the video data. From the experimental results, the shape of trajectory changes by the motion and appearance-based images.

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