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Multimodal biometric identification system based on face and fingerprint

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***Abstract*— A biometric system which is based only on a single biometric identifier in making a personal identification is often not able to meet the desired performance requirements. Multimodal biometrics is an emerging field of biometric technology, where more than one biometric trait to improve the combined performance. We introduce a bimodal biometric system which integrates face and fingerprint. This system takes advantage of the capabilities of each individual biometrics. It can be used to overcome some of the limitations of a single biometrics, increases the performance and robustness of identity authentication systems. In this context, a key matter is the fusion of a two different modality to obtain a final decision of classification. We propose to evaluate a binary classification schemes: support vector Machine to carry on the fusion. The experimental results show that merging multiple biometrics can help to reduce the error rate of the system.**

***Keywords*— Binary classifiers, biometrics, data fusion, face recognition, fingerprint recognition, support vector machine.**

I. INTRODUCTION

In the last years, biometric identification systems have been widely used in many applications which require reliable process of recognition. A biometric system is effectively a pattern-recognition system that recognizes a person based on a feature vector derived from a specific physiological or behavioural characteristic the person possesses [1]. It differs from classical user identification system which is based on something that one has (e.g., identification card, key) and/or something that one knows (e.g., password, PIN). Biometric-identification system is based on something that one is, such as fingerprints and face. All these biometric identifier have their advantages and disadvantages in terms of the precision and user acceptance. In order to perform this system, a multimodal biometric system which makes the identification of person based on multiple physiological or behavioural characteristics is suggested.

Some work on multimodal biometric systems has already been reported in the literature. Zhu Le-qing and Zhang San-yuan have proposed a fusing system combining finger geometry, knuckle print and palm print [2]. Lin Liu, Xiao-Feng Gu, Jian-Ping Li, Jie Lin and Jin-Xin Shi, Yuan-Yuan Huang have demonstrated the efficiency of an integration strategy which fuses three modalities face, iris and finger[3]. Wang and Han employed SVM which incorporated radial basis function as kernel for face-iris biometric system [4]. Zahid Akhtar, Giorgio Fumera, Gian Luca Marcialis and Fabio Roli have developed a multimodal identification system which integrates two different biometrics face and fingerprint that complement each other [5].

Multimodal biometric identification systems use various levels of fusion: (i) Fusion at the feature extraction level, where the features extracted using two or more sensors are concatenated; (ii) Fusion at the matching score level, where the matching scores obtained from multiple matchers are combined; (iii) Fusion at the decision level, where the accept/reject decisions of multiple systems are consolidated.

In this paper, based on our previous work on face recognition[6]. We propose a multimodal system based on fingerprint and face fused at decision level, so as to improve the matching efficiency as well as recognition accuracy.

This paper is organized as follows. Section 2 explains the face recognition with Gabor wavelet et PCA method. Section 3 presents fingerprint recognition method with Gabor filter. Section 4 introduces fusion method. Finally, experimental and results are discussed in section 5, and concluding remark in section 7.

II. FACE RECOGNITION

Face recognition is considered to be an important part of the biometrics technique, and meaningful in scientific research [7]. In general, a lot of methods are proposed to overcome the difficulty of face recognition. A good face recognition methodology should consider representation as well as classification issues, and a good representation method should require minimum manual annotations.

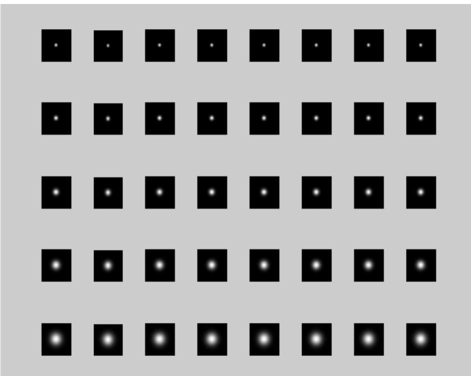
In our work of face recognition, we proposed a face recognition system that combines magnitude and the phase of Gabor filter, PCA and SVM as a classifier [6].

A. Gabor wavelet:

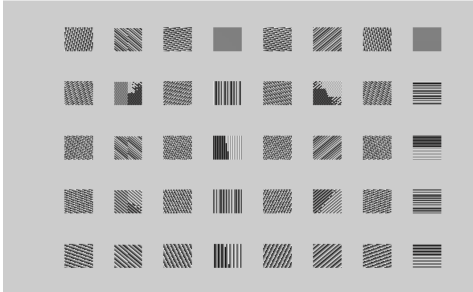
The Gabor wavelet, which captures the properties of orientation selectivity, spatial localization and optimally localized in the space and frequency domains, has been extensively and successfully used in face recognition [8]. Daugman pioneered the using of the 2D Gabor wavelet representation in computer vision in 1980’s [9]. The Gabor wavelet representation of a face image is obtained by doing a convolution between the image and a family of Gabor filters as described by Eq. (1). The convolution of image I(z) and a Gabor filter $\Psi_{\mu,v}(z)$ can be defined as follows:

$$F_{\mu,v}(z) = I(z) * \Psi_{\mu,v}(z) \quad (1)$$

Where z = (x, y), * denotes the convolution operator, and $F_{u,v}(z)$ is the Gabor filter response of the image with orientation u and scale v. The solutions suggested on each level of this chain resulted in a significant improvement of the performances compared to the traditional approaches. For the recognition algorithms, we proposed to fuse the phase and the magnitude of Gabor's representations of the face as a new representation, in the place of the raster image. Although the Gabor representations were largely used, particularly in the algorithms based on global approaches, the Gabor phase was never exploited.



(a)



(b)

Fig. 1 The magnitude part of the representation. (b) The phase part of the representation.

B. Principal component analysis "PCA":

Which is also known as Karhunen-Loeve expansion, is a classical feature extraction and data representation technique, and this technology is widely used in the areas of pattern recognition and computer vision [8]. Principal component analysis is proposed by Turk and Pentland in 1991, which is often used for extracting features and dimension reduction. In this paper, the PCA face recognition algorithm is used to extract the eigenvectors of the face images.

In mathematical terms, we wish to find the principal components of the distribution of faces, or the eigenvectors of the covariance matrix of the set of face images, treating an image as a vector in a very high dimensional space [10].

III. FINGERPRINT RECOGNITION

Among all the biometrics [11], fingerprint matching is one of the most popular, mature, and advanced technologies. In 1888 Sir Francis Galton found that fingerprints are rich in details in form of discontinuities in ridges.The uniqueness of an individual fingerprint is exclusively determined by the local ridge characteristics and their relationships. There are various types of local characteristics called minutiae in a fingerprint, but widely used fingerprint features are restricted to only two types of minutiae. The first is a ridge termination defined as the point where a ridge ends abruptly. The second is a bifurcation defined as the point where a ridge merges or splits into branch ridges. Galton also discovered that such features are permanent during lifespan [12].

A. *Filtering and binarization:*

This step is divided into two phases: filtering phase, in which we use Gabor filter and binarization phase, in which we involve the local threshold [13].

B. *Skeletonisation:*

The method used for skeletonisation is a 3 x 3 blocks neighbourhood. When this method is applied for the total of the image, the process costs too much time. To reduce the time of this phase, we consider that the process of thinning is applied only when the 3 x 3 bloc contains more than two black pixels. Experimental results show that the call of thinning function is reduced to third. Fig. 3.a shows the results of skeletonisation process. The major problem of skeletonisation is the occurrence of zigzag ridge that can influence the detection of the minutiae. This drawback is illustrated in Fig. 3.b and 3.d. The image issued from skeletonisation with smoothing filter Fig. 3.c is more adopted in the case of fingerprint because the changing of one pixel can modify the kind of minutiae. As an example, when a bifurcation minutiae is modified by one pixel we can view the block as transition or ending minutia [13].

(a) Thinning method without smoothing filter

(b) Presence of zigzag ridge

(c) Thinning method using smoothing filter

(d) Absence of zigzag ridge

Fig. 2 Skeletonisation method without (a,b) / with (c,d) Smoothing filter

C. *Minutiae Extraction:*

In this paper, a fingerprint recognition system based on a novel application of the classifier DECOC to the minutiae extraction and on an optimised matching algorithm will be presented. To identify the different shapes and types of minutiae, a Data-driven Error Correcting Output Coding (DECOC) has been adopted to work as a classifier. The proposed one has been applied throughout the fingerprint skeleton to locate various minutiae. Extracted minutiae have been used then as identification marks for an automatic fingerprint matching that is based on distance and direction between two minutiae and type of minutiae.

The data-driven ECOC (DECOC) is proposed to design the code matrix for ECOC by choosing the code words utilizing the intrinsic information from the training data. In a present decomposition mechanism for a K-class problem such as pair wise coupling, K*(K-1)/2 base learners are always needed, which can be a large number of base learners when K gets larger. The key idea of DECOC is to selectively include some of the binary learners into the code matrix based on a confidence score defined for a binary base learner.

This measure will help to determine how likely a learner will be included in the ensemble [13].

D. *The Matching Method*

There are many reasons for fingerprint template variations such as the fingers displacement, rotation, nonlinear distortion, pressure, skin condition and feature extraction errors, etc [12]. So it is hard to work with the coordinates of each minutia.

In this section a matching method that is performed by calculating the Normalized Euclidean Distance between every two minutiae by vertical scanning is proposed. This distance is calculated by squaring the difference between the corresponding elements of the feature vector.

This method is optimised by adding direction between the two minutiae and types (Ending, Bifurcation). So the signature of the two minutiae is: S= (Distance, Type, and Direction). So, the comparison is made by all the distances of input fingerprint and the distances of all fingerprints. When we find a distance that is inferior to $\varepsilon=0.01$ we verify the types between the corresponding minutiae. A minutia is accepted when the distance and types are accepted [13].

IV. FUSION

Having computed a match score between the claimed identity and the user, an identification decision is made whether to accept or reject the person.

Combining different modalities results in a system, which can outperform single modalities[14]. This is especially true if the different experts are not correlated. We expect from the fusion of face and fingerprint to achieve better results. In the next section, we will investigate the support vector machines as a binary classification approach.

Support vector machines are learning machines that classify data by shaping a set of support vectors [15]. SVMs provide a generic mechanism to robust the surface of the hyper plane to the data through. Another benefit of SVMs is the low expected probability of generalization errors [16]. Moreover, once the data is classified into two classes, an appropriate optimizing algorithm can be used if needed for feature identification, depending on the application [17]. SVM creates a hyper-plane between two sets of data for classification; in our work, we separate the data into two classes: feature extracted belongs to the train database or doesn't belong to the train database. Input data X that fall one region of the hyper-plane, (XT•W– b) > 0, are labeled as +1 and those that fall on the other area, (XT•W– b) < 0, are labeled as -1.

We seek the linear classifier that separates the data with the lowest generalization error. Intuitively, this classifier is a hyper plane that maximizes the margin error, which is the sum of the distances between the hyper plane and positive and negative examples closest to this hyper plane.

V. EXPERIMENT AND RESULTS

In identification mode, we talk about open problem since it is assumed that an individual has no model in the database (impostor) may seek to be recognized. So, you're doing a study on the database of learning for the appropriate threshold θ which allows us to identify whether that person is in our database or not he is an imposter.

To illustrate the efficiency of the system, we use two databases a grayscale database ORL face that have ten different images of each of 40 distinct subjects. For some subjects, the images were taken at different times, varying the lighting, facial expressions (open / closed eyes, smiling / not smiling) and facial details (glasses / no glasses) [9] and a grayscale database FVC2004 fingerprint that has been chosen randomly with different qualities.

TABLE I EQUAL ERROR RATE

	MULTIMODAL	FACE	FINGERPRINT
EER	0.02	0.09	0.04

This table show that the error rate has clearly decreased. It notes that fusing of the face and fingerprint has an important influence on the performance of the application and the improvement of the error rates.

VI. CONCLUSIONS

To conclude, we can say that the recognition of individuals remain a complex problem, in spite of current active research. There are many conditions real, difficult to model and envisage, which limit the performances of the current systems in terms of reliability and real time. So the multimodal person identification is a very promising approach. It combines the advantages of different techniques and may perform better than single modalities. We described a multimodal system using face information and finger for user identification. A critical question is how to combine the different modalities. We have evaluated the SVM as a binary classification for fusing the two biometrics information. Our experiments showed that these two fusion techniques do meet the requirements (accuracy and performance) of a multimodal system for identity identification.

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