Multi-views Face Recognition System

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Résumé – Nous présentons des résultats de développement concernant un nouveau système de reconnaissance de visages multi vues. L'objectif est double, il s'agit d'augmenter les performances de reconnaissance et en même temps le niveau de sécurité informatique. Nous avons d'abord construit un système d'acquisition simple, bas coût et composé de 5 caméras standard. Il est capable de capter simultanément 5 vues d'un visage humain avec différents angles d'observation. Ensuite, une base de données de visages multi vues contenant 3600 images a été établie. Nous avons effectué des études préliminaires de la reconnaissance de visages sur cette base de données en utilisant deux méthodes d'analyse statistique : PCA et ICA. Les résultats expérimentaux montrent une augmentation de 5,5% des performances de reconnaissance avec notre système de multi vues.

Abstract – This paper presents some development results on a new multi-views face recognition system. Our objective is to study an efficient method in order to improve recognition performance and achieve more secure information. To do so, we built a simple and low-cost acquisition system composed of five standard cameras, which together can simultaneously take five views of a human face from different angles. Then, a multi-views face database of 3600 images was constructed. We also performed a preliminary study on multi-views face recognition based on two statistical methods: PCA and ICA. Experimental results show that an average improvement of 5.5% for face recognition performance has been obtained using our multi-views system.

1. Introduction

Face recognition has become a specialized area within the large field of computer vision. It has attracted much research efforts because of its potential applications. The interest into face recognition is mainly focused on the identification requirements for secure information systems, multimedia systems, and cognitive sciences. Recently, many research works on face recognition use 3-D system which allows more secure information and more robust recognition (less sensitive to pose and lighting conditions) compared with 2-D system.

Most 3-D acquisition systems use professional devices such as a traveling camera or a 3-D scanner. Typically, these systems require that the subject remain immobile during several seconds in order to obtain a 3-D scan, and therefore may not be appropriate for some applications such as human expression categorization using movement estimation or real time applications. Also, their cost can easily make these systems prohibitive for routine applications. In order to avoid using expensive and time intensive 3-D acquisition devices, some face recognition systems generate 3-D information from stereo-vision. Complex calculations, however, are necessary in order to perform the self-calibration and 2-D projective transformation. Another possible approach is to derive some 3-D information from a set of face images, but without trying to reconstitute the complete 3-D structure of the face [1].

Research in automatic face recognition dates back to at least the 1960s. Most current face recognition techniques, however, date back only to the appearance-based recognition work of the late 1980s and 1990s. A number of current face recognition algorithms use face representations found by unsupervised statistical methods. Typically these methods find a set of basis images and represent faces as a linear combination of those images. Principal Component Analysis (PCA) is a popular example of such methods. One characteristic of PCA is that it produces spatially global feature vectors. In other words, the basis vectors produced by PCA are non-zero for almost all dimensions, implying that a change to a single input pixel will alter every dimension of its subspace projection. There is also a lot of interest in techniques that create spatially localized feature vectors, in the hopes that they might be less susceptible to occlusion and would implement recognition by parts. The most common method for generating spatially localized features is to apply Independent Component Analysis (ICA) in order to produce basis vectors that are statistically independent.

The relative performance of the PCA and ICA techniques is an open question. Draper, Baek, Bartlette and Beveridge[2] compared PCA and ICA in the context of a baseline face recognition system, a comparison motivated by contradictory claims in the literature. They explored the space of possible PCA/ICA comparison and indicated that the relative performance of PCA and ICA depends on the task statement, the ICA algorithm, and (for PCA) the subspace distance metric. They also showed empirically that the choice of the subspace projection algorithm depends first and foremost on the nature of the task. Some tasks, such as facial identity recognition, are holistic and do best with global feature vectors. Other tasks, such as facial action recognition, are local and do better with localized feature vectors. So, exploring the relative performance of the PCA and ICA techniques based on different face databases is also a significant and challenge work.

In this paper, we present some development results on a new multi-views face recognition system. The face database of 3600 images has been constructed using an acquisition system composed of five standard cameras. We also implemented two currently used statistical analysis methods (PCA and ICA) in order to experiment multi-views face recognition. The rest of this paper is organized as follows. Section 2 describes the acquisition system and the multi-views face database. Experimental results are discussed in Section 3, and conclusions and perspectives are drawn in Section 4.

2. Acquisition system and multi-views face database presentation

The acquisition system is composed of five Logitech 4000 USB cameras with a maximal resolution of 640×480 pixels. The parameters of each camera can be adjusted independently. Each camera is fixed on a height-adjustable sliding support in order to adapt the camera position to each individual. The acquisition program grabs images from the 5 cameras simultaneously. These 5 images are stored in the PC with a frame data rate of 20×5 images per second. The human subject sits in front of the acquisition system, directly facing the central camera (see Figure 1). This acquisition system is simple, low-cost, and can also potentially process 3-D face pixels.

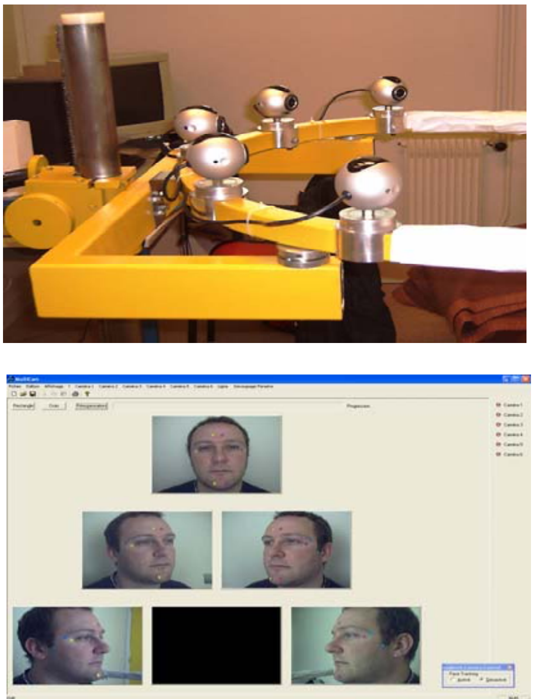

FIG.1: Acquisition system

We have constructed a multi-views face database which collected 3600 images taken in a period of 12 months for 10 human subjects (six males and four females). The rate of acquisition per month is 6 times per subject and 5 views for every subject at each occasion. The hairstyle and the facial expression of the subjects are different in every acquisition. The five views for one subject were simultaneously made but in different orientations. **Face**, **ProfR**, **ProfL**, **TQR** and **TQL** indicate respectively the frontal face, profile right, profile left, three-quarter profile right and three-quarter profile left images (see Figure 2).

ProfR **TFR** **Face** **TFL** **ProfL**

(a)

(b)

FIG.2: Examples of the database: five views simultaneously taken for one subject (a), and frontal views of one subject with different expressions (b).

3. Multi-views face recognition using statistical methods

Two statistical methods called Principal Component Analysis (PCA) and Independent Component Analysis (ICA) have been implemented in order to perform face recognition on our multi-views database. PCA and ICA are two wildly used subspace projection techniques for face processing. They are based on the idea that face recognition can be accomplished with a small set of features that best approximates the set of known facial images. Application of PCA/ICA for face recognition proceeds by first performing PCA/ICA on a well-defined set of images of known human faces. From this analysis, a set of principal (independent) components is obtained and the projection of the new faces on these components is used to compute distances between new faces and old faces. These distances in turn are used to make predictions about the new faces.

PCA approach consists of constructing an orthogonal basis from data set that yields the best compression. ICA is intimately related to the BBS (Blind Source Separation) problem, where the goal is to decompose an observed signal into a linear combination of unknown independent signals. There are a number of algorithms for performing ICA, we chose the InfoMax [3] and FastICA [4] algorithms. InfoMax algorithm was derived from the principle of optimal information transfer in neurons with sigmoidal transfer functions, whereas FastICA algorithm is based on a fixed-point iteration scheme for finding a maximum of the non-gaussianity, it can be also derived as an approximate Newton iteration [5].

For each individual in the multi-views face database, we chose 1, 2 or 3 images from 6 acquisitions per month to compose the training set; all the selected images (10 subjects) are aligned in row in the training matrix, one image per row. The remaining (5, 4 or 3) images from 6 acquisitions were used for testing purpose. The nearest neighbor algorithm and the cosine distance measure were used in order to predict identity of test face.

We performed a PCA algorithm and two ICA algorithms (InfoMax and FastICA) respectively on five views: **Face**, **ProfR**, **ProfL**, **TQR** and **TQL** (see Figure 2). Several executions of MATLAB program were run using randomly chosen training and testing sets, and we computed the mean recognition performance. The results are presented in Table.1.

TAB.1: Correct recognition rates for **ICA** and **PCA** using the multi-views face database

Algorithms	**InfoMax**			**FastICA**			**PCA**		
(train, test)	(1,5)	(2 ,4)	(3,3)	(1,5)	(2 ,4)	(3,3)	(1,5)	(2 ,4)	(3,3)
Face	0.8517	0.8980	0.9139	0.8284	0.8834	0.9111	0.8067	0.8375	0.8917
ProfR	0.9000	0.9313	0.9417	0.8450	0.8923	0.9222	0.8650	0.8958	0.9167
ProfL	0.9017	0.9334	0.9333	0.8683	0.9208	0.9278	0.8600	0.9125	0.9167
TQR	0.8484	0.8833	0.9361	0.8334	0.8480	0.9028	0.8250	0.8438	0.8750
TQL	0.8688	0.8915	0.9111	0.8483	0.8792	0.9000	0.8284	0.8500	0.8611
VOTE	0.9234	0.9479	0.9584	0.9084	0.9313	0.9500	0.8700	0.8875	0.9389

In order to fully explore our multi-views database, we also perform the majority-voting procedure among the five views (see Figure 3). Figure 4 gives results of multi-views face recognition performance comparison, using the FastICA algorithm as an example. Figure 5 illustrates "**VOTE**" and "**Face**" performances for three algorithms. The multi-views face recognition rates for PCA, InfoMax, and FastICA increase respectively by 5.35%, 5.56%, and 5.53% in comparison with frontal face recognition.

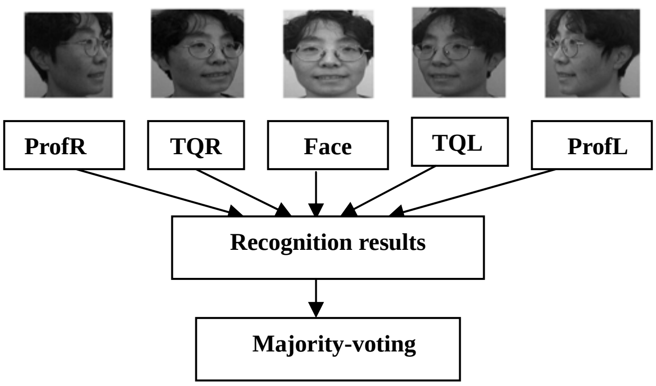

FIG.3: Majority-voting procedure using multi-views.

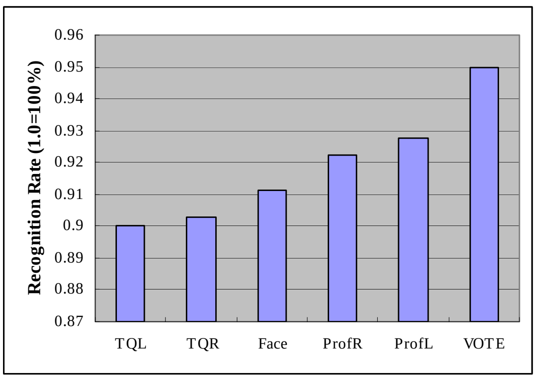

FIG.4: Multi-views recognition performance.

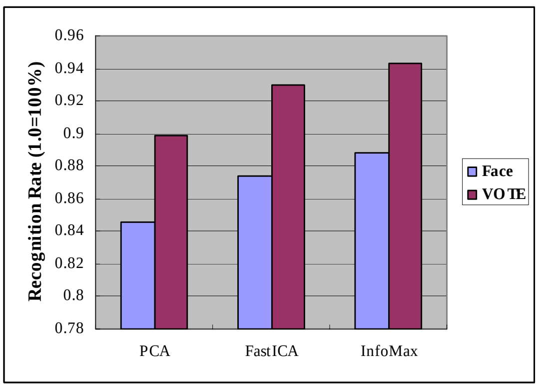

FIG.5: Face and VOTE performance comparison.

Our results are accordance with the Draper's on the FERET face data set [2] that the relative performance of PCA and ICA depends on the task statement, the ICA architecture, the ICA algorithm, and (for PCA) the subspace distance metric, and for the facial identity task, ICA performs well than PCA.

4. Conclusions and perspectives

In this paper, we proposed a new multi-views face recognition system and some development results. We built a simple and low-cost multi-views acquisition system. Then, a multi-views face database of 3600 images has been constructed. We evaluated the multi-views face recognition performances by three statistical analysis algorithms: PCA, InfoMax and FastICA. The nearest neighbor algorithm and the cosine distance measure were used in order to predict identity of test face.

Experiments show that an average improvement of 5.5% for face recognition performances has been obtained using our multi-views system in comparison with frontal face recognition, and according to our preliminary study, among five views of one subject, the highest recognition rate occurs in **ProfR** or **ProfL**, i.e the profile images, not in **Face**, i.e. the frontal face images, this is very interesting. Moreover, the multi-views system has potentially more secure information because we can identify a face according to five views other than only one frontal view.

Our future work will focus on the implementation of multi-views face recognition on embedded systems in order to realize real time application. We will also explore the new methods such as ensemble learning for independent component analysis using Random Independent Subspace (RIS) [6], Kernel ICA algorithm, and Common Face method by using Common Vector Approach (CVP) for face processing and later hardware implementations.

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