NON LINEAR FUSION OF COLORS TO FACE AUTHENTICATION USING LDA

M. Fedias, D. Saigaa, M. S. Mimoune, M. Boumehrez

Genie electric department, MSE Laboratory, University of Mohamed Khider, B.P 145 R.P Biskra (07000), Algeria

Corresponding author: M. Fedias, m_fedias@yahoo.fr

ABSTRACT: In this article, we propose the use of information color to authenticate face; several spaces of colors were used for the transformation of colorimetric components RGB of the original images. The results obtained in different spaces/or component colorimetric are combined by the use of a nonlinear fusion with a simple neuron network type MLP (Multi layer perceptron). We applied the method of linear discriminant analysis (LDA) to extract the characteristic vector of the face image. To validate this work we tested this approach on frontal images of the data base XM2VTS according to its associated protocol (protocol of Lausanne).
KEYWORDS: Linear discriminant analysis (LDA), face authentication, color spaces, neural network**.**

I. INTRODUCTION

Among the forms to be recognized, one finds the faces of the human which represent a complex stimulus and multidimensional and which deserves to be study has fine to carry out an automatic system of face recognition.
Indeed, the face constitutes a wide class of complex stimuli which is discriminated by mankind, with a very high level of expertise.
The recognition of face gained a considerable attention these last years, by the need growing with the systems of access control by using a biometric method which is simple and very well accepted by the users, because it is noninvasive (without direct contact with the sensors). The system of face recognition are employed for the identity check of a user on the Net, in the identification or monitoring systems by the police authorities or bodies, mainly public place, airport, border, automatic teller machine and laboratory.
The history counts tentative recognition of faces and several of this suffer from two principal disadvantages, first is that the execution time of the process of recognition is very large and the second it is high error rate of the more share of the methods and especially which work in the identification in real time.
We propose a method of *linear discriminant analysis* (LDA) [Yam00, MHK97, ZCK98, LW98]. The face is collected by a camera, and the system extracts characteristics of the face to make the comparison with the characteristics of the claimed person which are preserved in a data base.
The article is organized as follows: section 2 presents the problem of face authentication, section 3 explains the algorithm of LDA used for the extraction of characteristics, in section 4 we have the experimental results obtained, and finally we give the conclusions and the prospects.

II. FACE AUTHENTICATION

The purpose of authentication system is to check the identity of an individual. After this one was identified. Thus it is not about a system of identification in which is given to him the responsibility to discover the identity of an individual.
The principle of the system of face authentication of an individual is the extraction of a vector X of characteristics of this last, in order to compare it with a vector Y_i which contain the characteristics of this same individual extracted starting from his images which are stored in a data base ($1 \le i \le p$, where p is the number of images of face of this person in the whole of training).To estimate the difference between two vectors, it is necessary to introduce a measurement of similarity. Several metric can be used such as for example the Euclidean distances L1 and L2, the distance from Mahalanobis the correlation… etc. If the Euclidean distance enters the vectors X and Y_i is lower than a threshold, it is noted that the image of the face corresponds to the claimed person.
The problem which occupies us contains two classes, namely on the one hand the customers and other share impostors. A system extremely strict indicates a TFA (Rate of False Acceptance) weak and a FRR (Rate of False Rejection) high. On the other hand a system laxist will be characterized by a high FAR and a rather low FRR. The medium locates between the two, and if the error rates are equal, it will be at the rate of equal error or EER.
All these error rates were calculated in two sets initially

in the whole of the evaluation, which will make it possible to fix the EER, Then in the whole test by using the parameters fixed previously. Thus, one can check the robustness of the authentication system.

III. EXTRACTION OF CHARACTERISTIQUE BY LDA

The steps to follow to extract the discriminants for a set of images are [Yam00, BHK97, ZCK98, LW98]:

a) Calculate the within class scatter matrix

For the *ith* class, a scatter matrix (S_i) is calculated as the sum of the covariance matrices of the centered images in that class.

$$S_i = \sum_{x \in x_i} (x - m_i)(x - m_i)^T \qquad (1)$$

m_i is the mean of the images in the class. The within class scatter matrix (S_W) is the sum of all the scatter matrices.

$$S_w = \sum_{i=1}^{c} S_i \qquad (2)$$

C is the number of classes.

b) Calculate the between class scatter matrix

The between class scatter matrix (S_B) measures the amount of scatter between classes.

$$S_B = \sum_{i=1}^{c} n_i (m_i - m)(m_i - m)^T \qquad (3)$$

n_i is the number of images in the class, m is the mean of all the images.

c) Solve the generalized eigenvalue problem

Solve for the generalized eigenvectors (V) and eigenvalues (Λ) of the within class and between class scatter matrices.

$$S_B V = \Lambda S_W . V \qquad (4)$$

d) Keep first C-l eigenvectors

Sort the eigenvectors by their associated eigenvalues from high to low and keep the first $C - 1$ eigenvectors. These eigenvectors form the Fisher basis vectors.

e) Project images onto basis vectors

Project all the original images onto basis vectors by calculating the dot product of the image with each of the basis vectors.

IV. EXPERIMENTAL RESULTS

IV.1 DATA BASE

Our objective is to develop an application of face recognition thanks to a particular tool, and then test it on a data basis of faces, according to a quite precise protocol. So as to facilitate the comparison of the results who are indeed subjected to quality standards, we will present the data base XM2VTS.
The principal choice of this data base is its big size, with 295 people and 2360 images in total and its popularity, since it became a standard in the audio and visual biometric community of identity verification [M+99].
For each person eight catches were carried out in four sessions distributed for five months.
The protocol related to XM2VTS divides the base into two categories 200 customers and 95 impostors, the people are of the two sexes and various ages. The photographs are of high color quality and size (256x256).
The protocol of Lausanne shares the data base in three sets [LG98]:

1. The set of **training** (training): it contains information concerning the known people of the system (only customers)
2. The set of **evaluation** (validation): allows to fix the parameters of the face authentication system.
3. The set of **test** : allows to test the system by presenting images of people being completely unknown to him.

For the class of impostors, 95 impostors are divided in two sets: 25 for the set of evaluation and 75 for the set of test.
The sizes of the various sets are included in table 1.

Table 1. Distribution of the photographs in the various

set	customers	impostors
training	600 (3by subject)	0
Evaluation	600 (3by subject)	200 (8 by subject)
Test	400 (2 subject)	560 (8 by subject)

Figure 1. Examples of photographs of XM2VTS base [M+99]

IV.2 PRETREATMENT

The pretreatment is a significant phase in the total process of authentication. It is a simple method which increases the performances of the system in general. It often allows a first reduction of the data and it mitigates the effects of a difference in conditions at the time of the catches of sights.
By looking at the images one can realize directly what appears on the level of the neck as the collars of the chemise… etc in addition the hair is also a changing characteristic with the course time. This is why we have to decide to cut the images and from which the operation is to extract only the essential parameters for the identifier and who changes very little with time.
One uses low uniform filtering passes for the decimation.
When the images are filtered by a filter low passes, one can reduce quite wide the resolution of the images. Thus the images of dimension (NxN) after cutting are transformed into a dimension (N/2xN/2) after decimation (see figure 2 then we make the photonormalisation with the images, a photonormalisation has a double effect: on one hand it removes for any vector a possible shift compared to the origins and then it removes any effect of amplification (multiplication by a scalar). For each image one carries out the following operation:

$$photonormalisation(x) = \frac{x - mean(x)}{std(x)} \qquad (5)$$

Finally one applies the standardization which acts on a group of images (for each component, one withdraws the average of this component for all the images and one divided by the standard deviation).

(a) (b) (c)

Figure 2. a) image of entry, b) image after cutting and c) image after decimation.

IV.3 EXTRACTION OF CHARACTERISTICS

The extraction of the characteristics is done by the method of linear discriminant Analysis (LDA). The method proceeds as we already detailed with the section 3.

IV.4 CLASSIFICATION

In the problem of identity check, we seek to define, for each person, or in a total way, a threshold. This threshold will determine the minimum resemblance between two images to admit that it is about the same minimum the resemblance will be expressed like a maximum distance between the characteristics of the two images.
To fix threshold we will use the whole of evaluation to fix the weights of the neurons network.

IV.5 COMPARAISON

We carried out our experiments on several spaces colors [Har99, S+11]. To make a comparison of results, we presented the latter with a basic method LDA, which has these parameters:

- ✓ Pre treatment with photonormalisation
- ✓ Coefficients: following coefficients of sorted projection decreasing eigenvalues (100 clean vectors)
- ✓ Measure score (similarity): correlation.
- ✓ Thresholding: Total.

Without nonlinear fusion we obtained the results in table II.
We can see that the result obtained with the use of component color {Cr}of the space color YCrCb is the best with a EER of about **1.65%** by using only 100 principal components of the entry vector face and a rate of success RS of **96.10%** .
For the improvement of the performance of this system, we have applied a nonlinear fusion for classification with a simple network of neurons of type MLP (Multi layer perceptron). This network consists of three layers: sleep of entry, sleep hidden and sleep of exit. Each layer contains a finished number of the units which one calls the neurons that receive the signals of activation of the other neurons, by treating them then transmitted the output signal to all the units of the following layer. Each neuron of the layer (i-1) is connected to all neuron of layer (i). There is no connection between the units of the same layer [Tou92, St-A**]. Figure 3 shows the synoptic diagram of the network of neuron MLP to a hidden layer. In our work we used networks MLP like a binary classifier (customer where impostor).

Table 2. Error Rate of the colorimetric components with method LDA

Comp	Ensemble d'évaluation			Ensemble de Test		
	FRR	FAR	EER	FRR	FAR	RS
X	0,030	0,030	3,01%	0,030	0,031	93,91%
Y	0,032	0,033	3,22%	0,025	0,035	93,97%
Z	0,027	0,027	2,69%	0,018	0,030	95,23%
Y	0,030	0,030	2,99%	0,033	0,031	93,62%
Cr	**0,017**	**0,016**	**1,65%**	**0,023**	**0,017**	**96,10%**
Cb	0,032	0,032	3,20%	0,025	0,029	94,62%
R	0,037	0,036	3,65%	0,048	0,033	91,94%
G	0,030	0,031	3,04%	0,023	0,032	94,56%
B	0,027	0,026	2,65%	0,015	0,030	95,53%
Y	0,032	0,033	3,22%	0,030	0,032	93,78%
I	0,028	0,028	2,83%	0,028	0,022	95,03%
Q	0,020	0,020	1,99%	0,030	0,020	94,99%
Y	0,032	0,033	3,22%	0,030	0,032	93,78%
U	0,030	0,031	3,05%	0,020	0,027	95,33%
V	0,022	0,021	2,13%	0,025	0,022	95,27%
H	0,067	0,066	6,65%	0,055	0,083	86,22%
S	0,023	0,024	2,38%	0,030	0,026	94,38%
V	0,033	0,034	3,35%	0,040	0,031	92,89%
I1	0,030	0,031	3,03%	0,030	0,033	93,73%
I2	0,033	0,032	3,21%	0,038	0,032	93,06%
I3	0,017	0,017	1,67%	0,030	0,015	95,50%

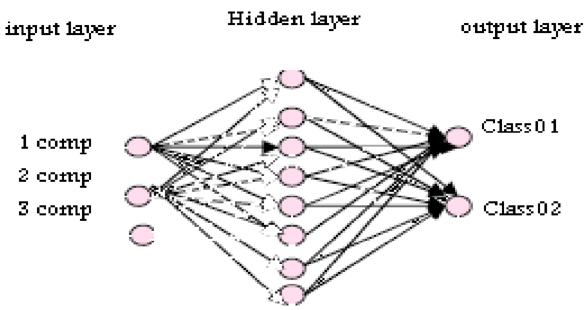

Figure 3. A network MLP with a hidden layer

We involved the MLP with pairs element (distances intra from Customers, distances extra from impostors) of the set of evaluation to fix the parameters of network MLP. To evaluate the performances of the authentication system by using a classifier MLP. Then we calculate the success rates of this classifier in the set of test.

The parameters chosen for our MLP are:

- A layer hidden with nine neurons .
- Three neurons in the layer of input.
- Two neurons in the layer of output .

The parameters of entry of network MLP are:

- The distance by using the first component color of LDA.
- The distance by using the second component color of LDA.
- The distance by using the third component color of LDA.

The various success and error rates in the test set by using a classifier MLP are shown in the table 3.

Table 3. Error Rates by nonlinear fusion

	Error rate in test set		
color	FRR	FAR	RS
YCrCb	**0,0175**	**0,008**	**97,45%**
RGB	0,0175	0,0271	95,54%
YIQ	0,02	0,0058	97,42%
YUV	0,0175	0,0132	96,93%
HSV	0,01	0,0272	96,28%
I1I2I3	0,02	0,0089	97,11%
XYZ	0,0175	0,0329	94,96%

It is observed that the nonlinear fusion of the results of the three components colors of space YCrCb color gives the best rate of success RS = **97.45 %**. That wants to say an improvement about 1.35**%** to the use of only one colorimetric component as characteristic of entry to the face authentication system. And we observe that the FRR is large compared to the FAR which is the very weak ;thus the system does not accept an impostor easily that wants to say that we can employ this kind of the strict system if high safety is required.

We can see easily that color information with all spaces colors used, improves the performance of the face authentication system compared to the use of the images in levels of gray with this system.

We found a rate of success RS of **93.03 %** with the use of the images in levels of gray. This means that the use of the color information especially the color space YCrCb, as a characteristic of entry with the method of linear discriminant analysis LDA and nonlinear fusion by networks of neuron of the type MLP to the face authentication system makes an improvement in the rate of success about **4.42 %** compared to the use of the images represented in level of gray.

CONCLUSION

We found that the use of nonlinear fusion by networks of neuron of type MLP as classifier on colorimetric components improves the performance of the face authentication system especially with the color space YCrCb which gives the best rate of success RS about **97.45 %**.

And if we compare this results with that obtained in levels of gray we find an improvement in the rate of success about **4.42 %.**

In future work we propose the fusion of the various methods with various colorimetric components.

REFERENCES

[BHK97] **Belhumeur P. N., Hespanha J. P., Kriegman D. J.** - *Eigenfaces vs. Fisherfaces: Recognition using class specific linear projection*. IEEE Trans. on Pattern Recognition and Machine Intelligence, 19(7):711– 720, 1997.

[Har99] **Hardeberg J. Y.** - *Acquisition et reproduction d'images couleur: approches colorimétrique et multispectrale*, thèse de doctorat de l'Ecole Nationale Supérieure des Télécommunications Specialité: Signal et Images, 1999.

[LG98] **Luettin J., Maitre G.** - *Evaluation protocol for the extended M2VTS database*. IDIAP, available at http://www.ee.surrey.ac.uk/Research/VSSP/xm2vtsdb/face-avbpa2001/protocol.ps, 1998.

[LW98] **Liu C., Wechsler H.** - *Enhanced fisher linear discriminant models for face recognition*. In Proceeding of the International Conference on Pattern Recognition (ICPR), 1998.

[M+99] **Messer K., Matas J., Kittler J., Luettin J., Maitre G.** - *XM2VTSDB: the extended M2VTS database*. In Proc. of Int. Conf. on Audio- and Video-based Person Authentication, pages 72–77, March 1999.

[S+11] **Saigaa D., Fedias M., Harrag A., Bouchelaghem A., Drif D.** - *Color space MS based feature extraction method for face verification*, the 11th International conference on hybrid intelligent systems HIS' 2011, 5 to 8 Dec 2011 Melaka, Malaysia. (IEEE proceeding).

[St-A**] **St-Amand N.** - *Réseaux neuronaux et classification (Fonctionnement, structure, initialisation et entraînement)* (cours).

[Tou92] **Touzet C.** - *Les réseaux de neurones artificiels, introduction au connexionnisme*, (cours) 1992.

[Yam00] **Yambor W. S.** - *Analysis of PCA-based and fisher discriminant based image recognition algorithms*, Technical Report CS-00-103, July 2000.

[ZCK98] **Zhao W., Chellappa R., Krishnaswamy A.** - *Discriminant analysis of principal components for face recognition*. In Proc. of Int. Conf. on Automatic Face and Gesture Recognition, pages 336– 341, 1998.