ID Image Characterization by Entropic Biometric Decomposition

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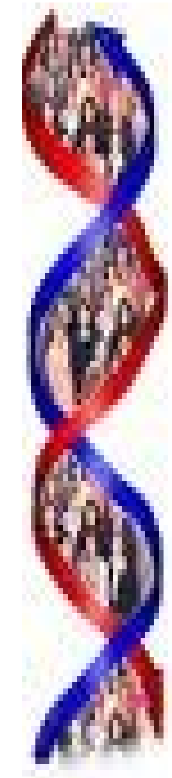
Introduction

Person's identity helpful in human behavior or required in biometry.



Identification technologies:

- non-invasive
- invasive

Face recognition remains of main interest.

Particular case: identity image recognition

- **robustness to print/scan**
- **simple & fast algorithm**

ID image recognition

Faces with neutral frontal expression.

Difficulties in recognition caused by

Print/scan process

Aging

Our goal: 100% recognition rate

Outlines

1 – Tools

2 – Methodology

3 – Subspace selection

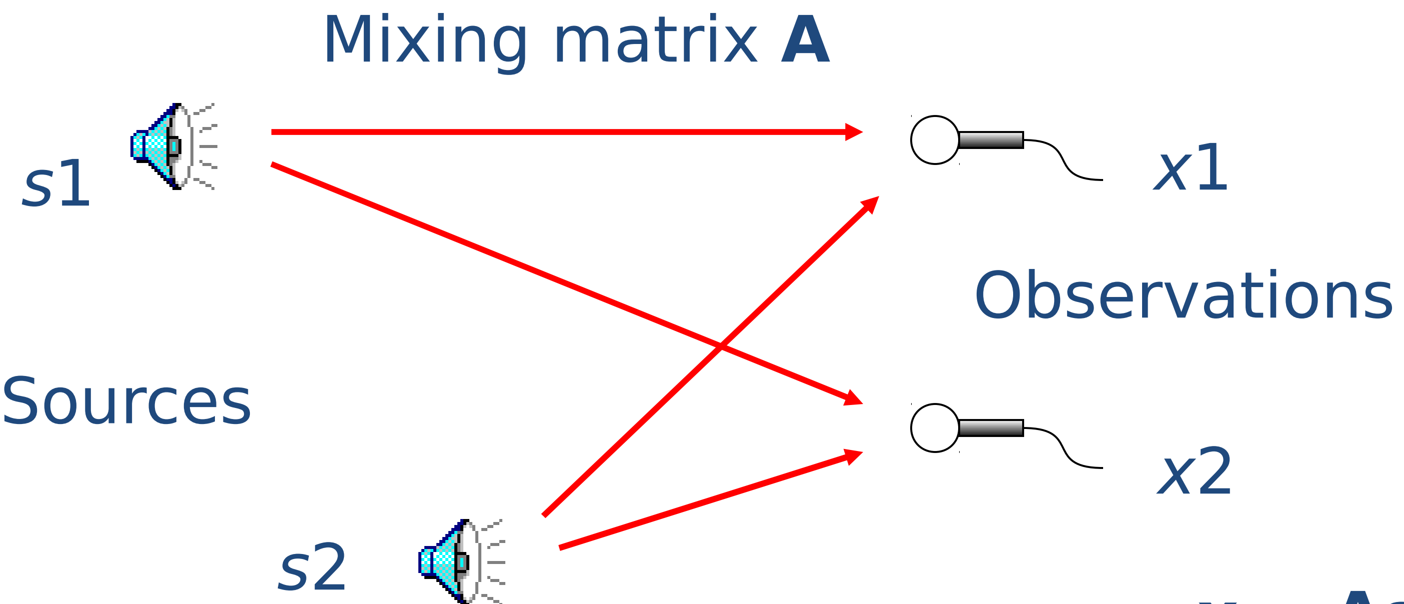
4 – Experimental results

5 – Conclusion

1.Tools for image recognition

Second order statics	**Principal Component Analysis (PCA)** – the subspace basis vectors are eigenfaces related to the spectrum of the covariance matrix.
Higher order statics	**Independent Component Analysis (ICA)** – the sources are independent.

The simple «Cocktail Party» Problem



$$\mathbf{x} = \mathbf{A}\mathbf{s}$$

n sources, m=*n* observations

Independent Component Analysis

Objective: maximize the statistical independence of the outputs.

Algorithm:

1. Preprocessing:
   a) centering
   b) whitening
2. X = A * s

$$\begin{pmatrix} x11 & x12 & x13 \\ x21 & x22 & x23 \\ \dots \end{pmatrix} = \begin{pmatrix} a11 & a12 \\ a21 & a22 \\ \vdots & \vdots \\ an1 & an2 \end{pmatrix} \begin{pmatrix} s11 & s12 & s13 \\ s21 & s22 & s23 \\ \dots \end{pmatrix}$$

The columns of A constitute the vector bases of ICA

The particular realizations are on the rows of x

The ICs are on the rows of s.

Algorithms

FastICA (Fast Independent Component Analysis)

- maximizes the non-Gaussianity by fixed-point iteration scheme.

InfoMax

- maximizes the entropy of the estimated independent vectors.

Independent Component Analysis

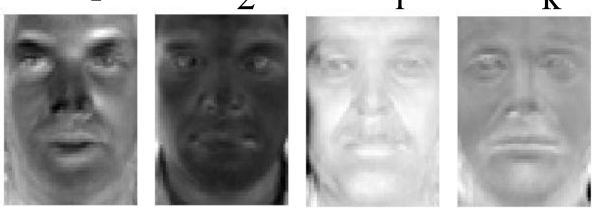
Two types of architectures.

x = [- - - - - - - -]

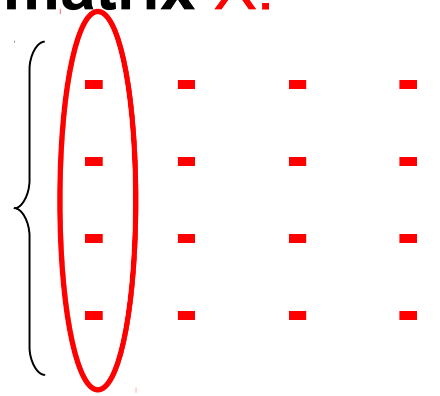
Architecture II – global features.

columns of matrix X.

A_1 A_2 A_i A_k



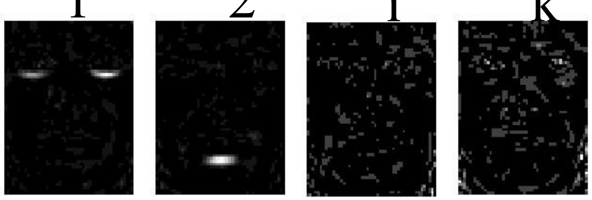
X =



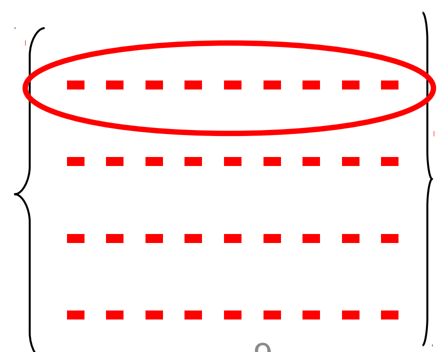
Architecture I – local features.

rows of matrix X.

S_1 S_2 S_i S_k



X =



ICA-Architecture I

Our approach for ID image characterization is based on biometric features.

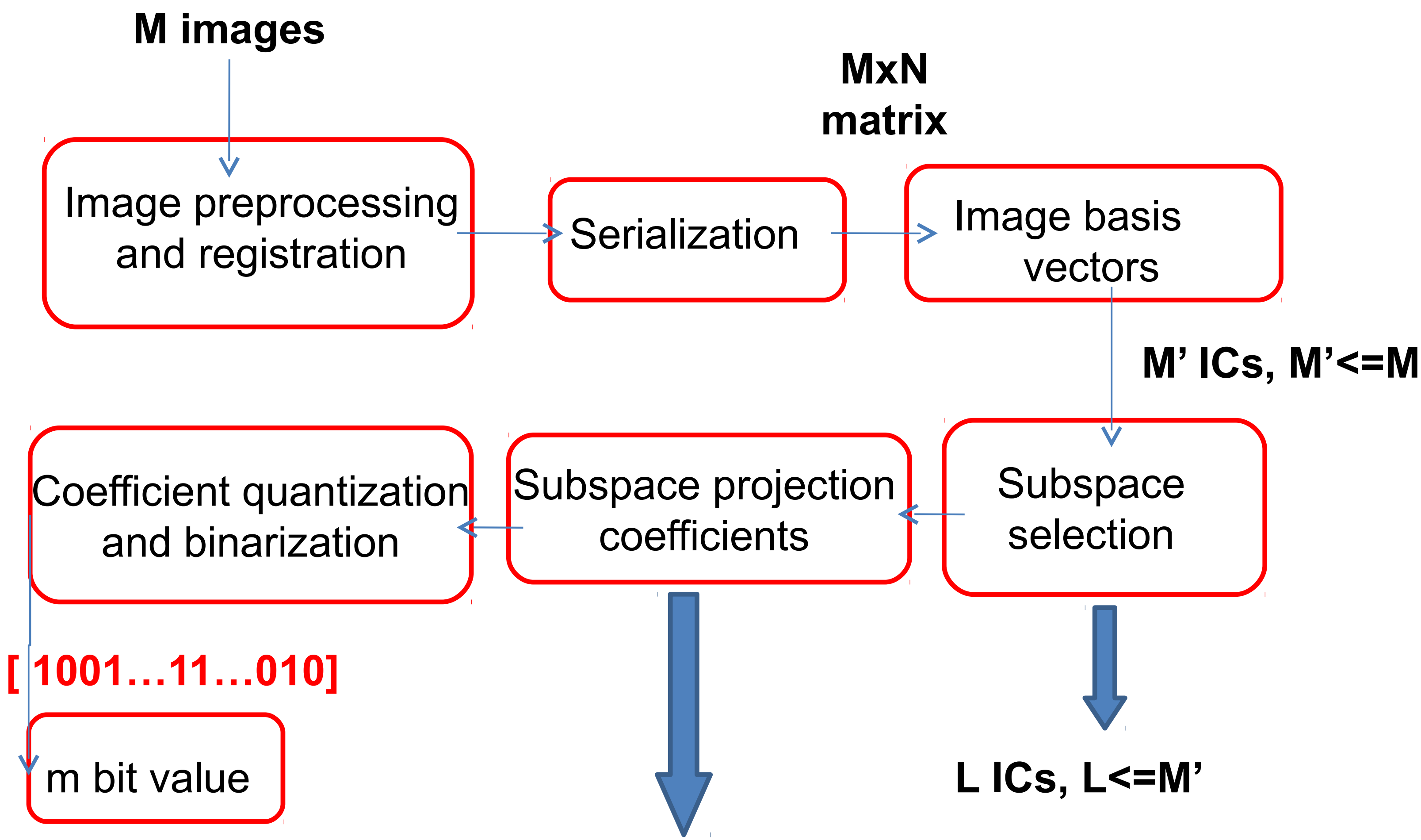
ICA – Architecture I

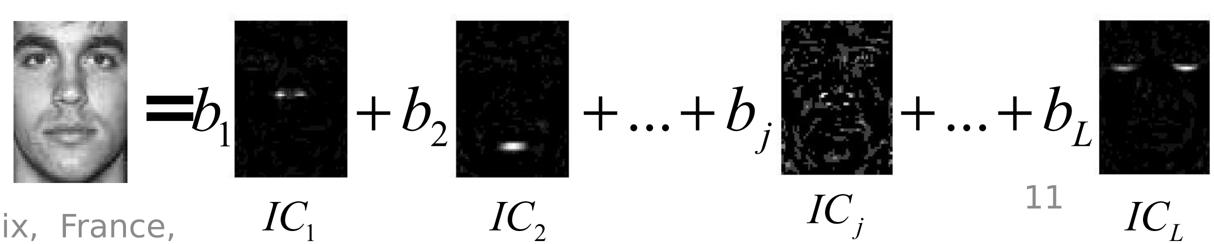
[1001…11…010]
m bit

Formalized goal:

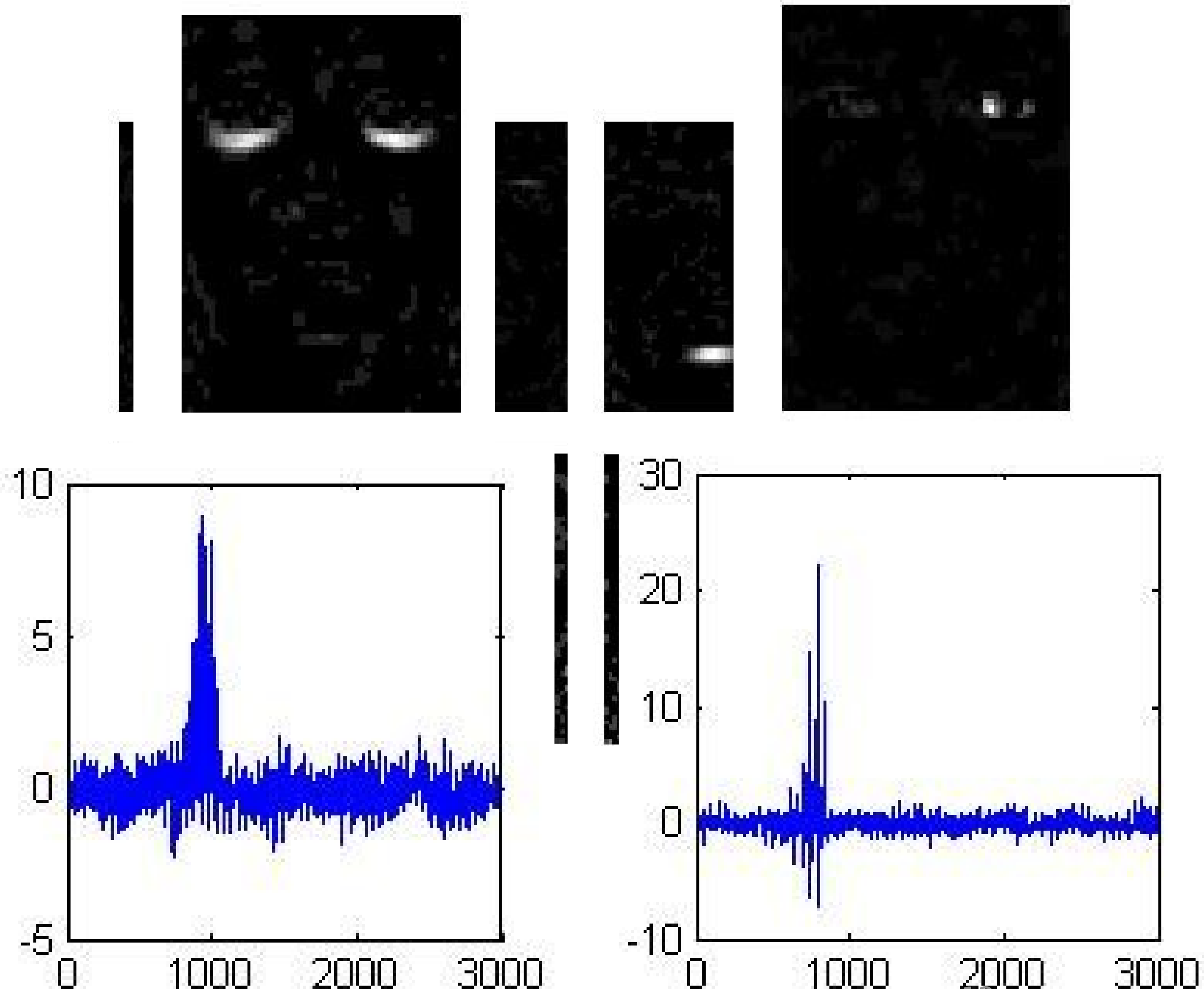
- **Each image represented as a m-bit value signature.**
- **Recognition rate 100%.**
- **High discrimination power.**

2. Methodology





3. Subspace selection



Subspace selection

Strategies for subspace selection:

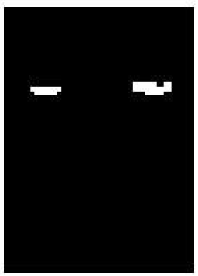
- **PCA by filtering the spectrum before ICA.**
- **ICA by using a global entropic criterion.**
- **ICA by using a local entropic criterion.**
- **Combination of the above two.**

Subspace selection

PCA selection to retain only the highest variance coefficients.

ICA selection by entropic criterion

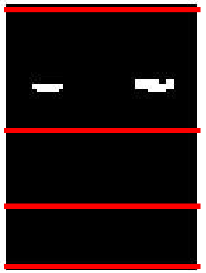
Global criterion (minimal entropy)



small area

high area

Local criterion (maximal/minimal entropy)



High area

Small area

4. Experimental results

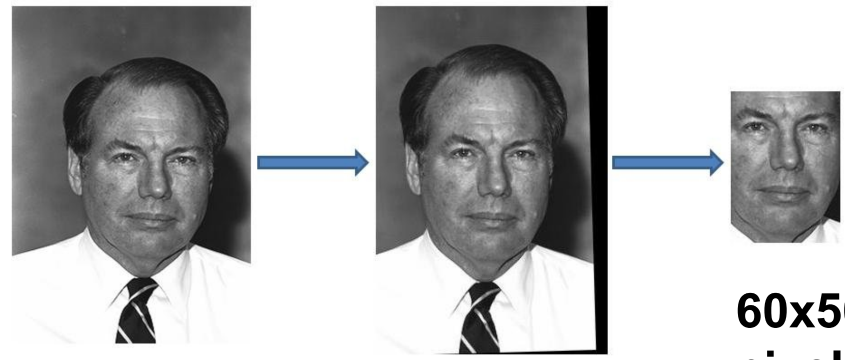
FERET Database

Experimental results

Gray level images of 384x256 pixels.

300 images for the training set.

210 images for the test set.



384x256 pixels

60x50 pixels

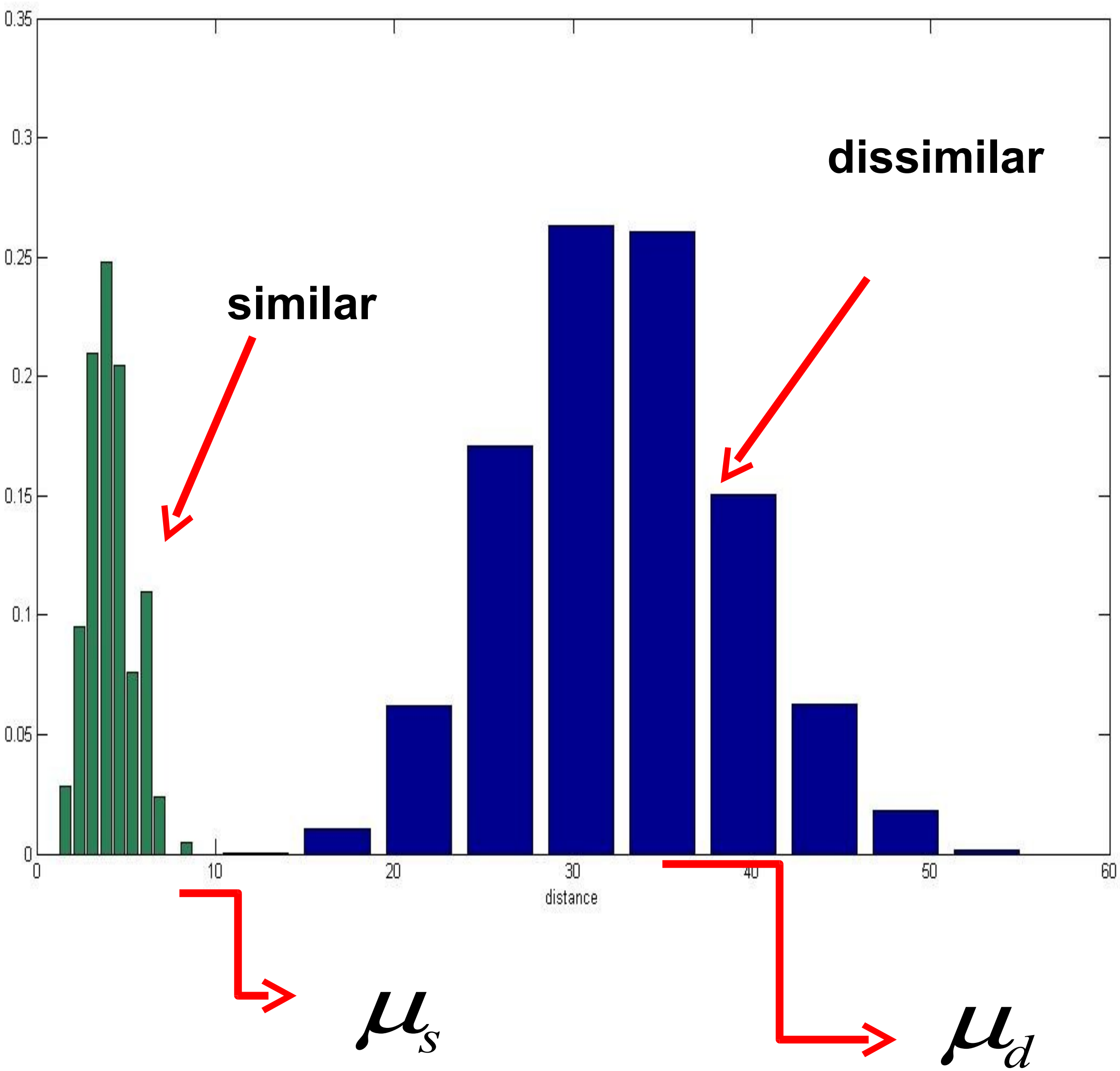
Affine transformation

Median filter

Noise addition

Experimental results

Discrimination power

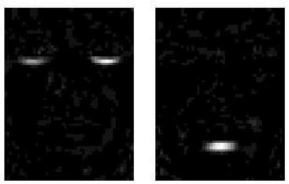


Discrimination measure

$$r = \frac{\left|\mu_s - \mu_d\right|}{\sigma_s + \sigma_d}$$

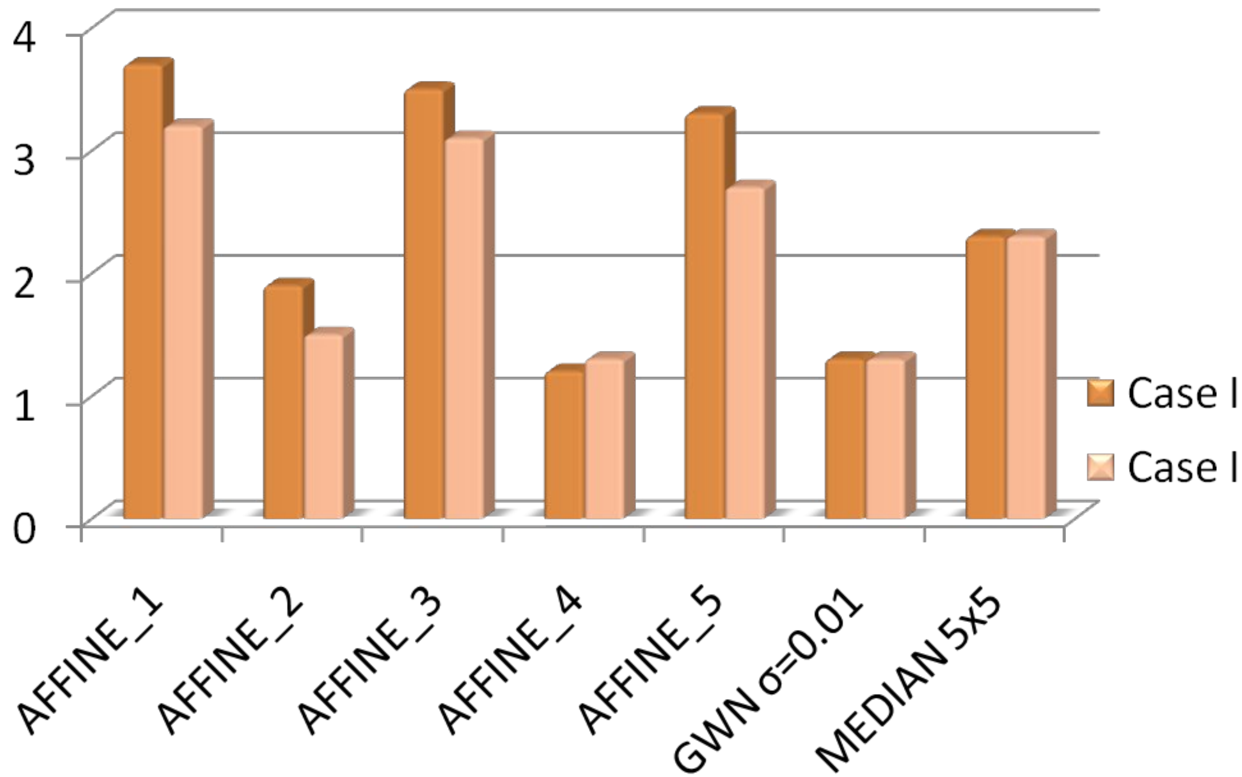
Experimental results **Importance of selection**

Case I



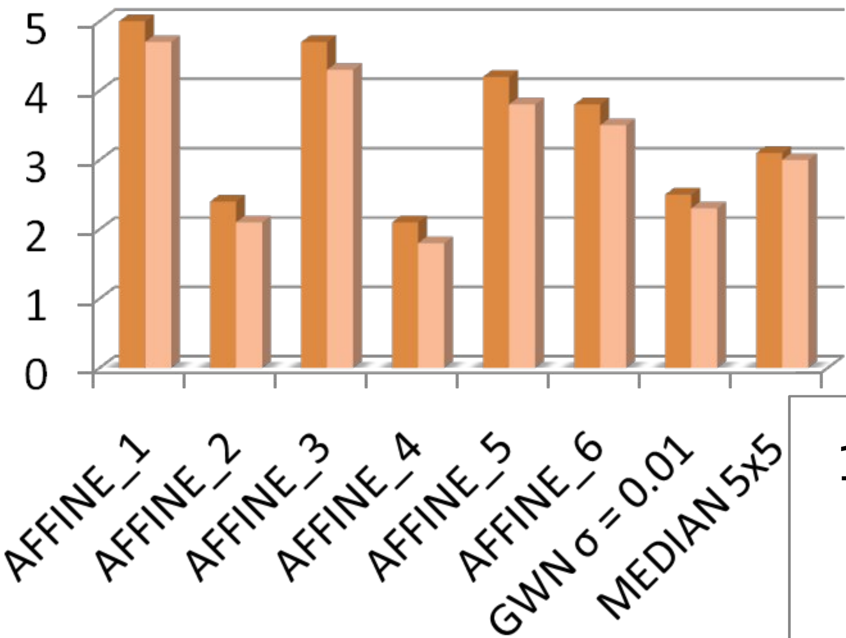
Case II

Discrimination measure



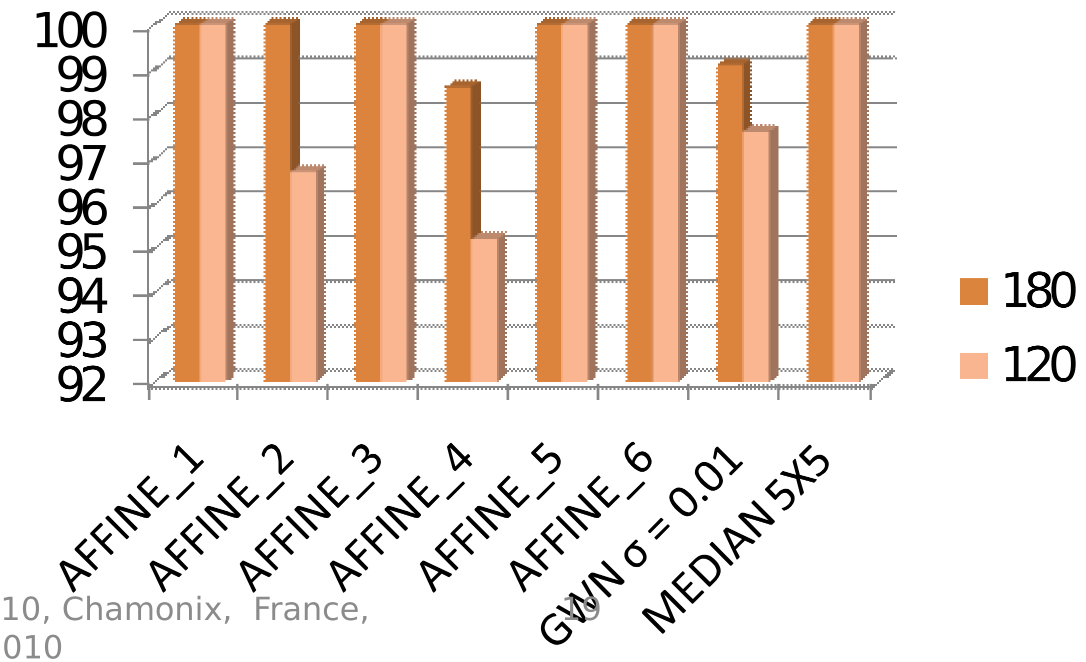
Experimental results

Tuning the number of ICs.



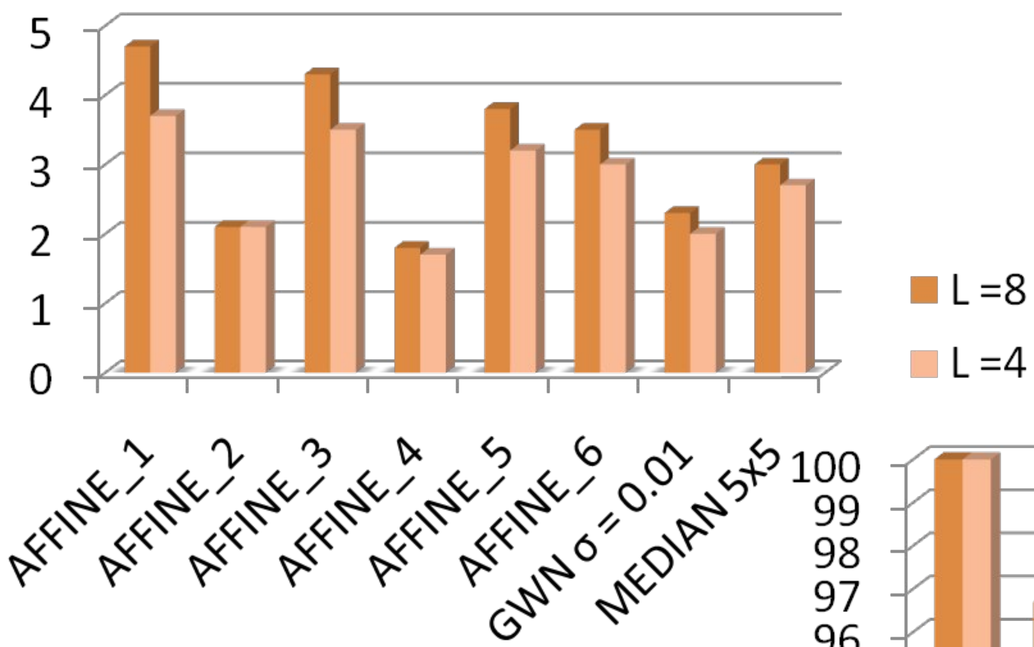
Discrimination measure

Recognition rate



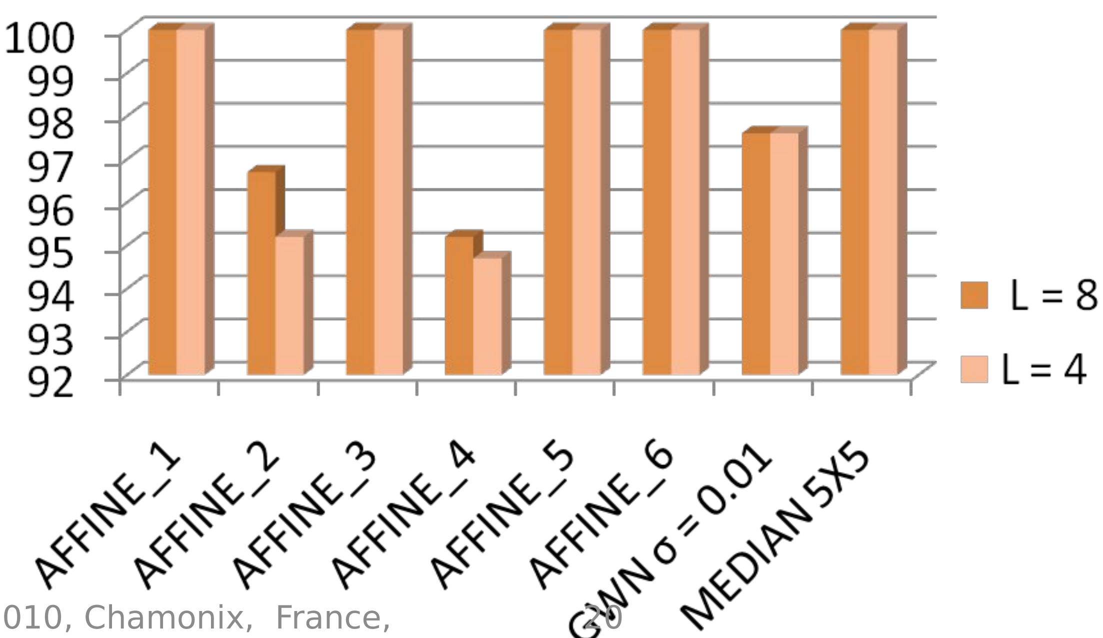
Experimental results

Tuning the number of quantization levels.



Discrimination measure

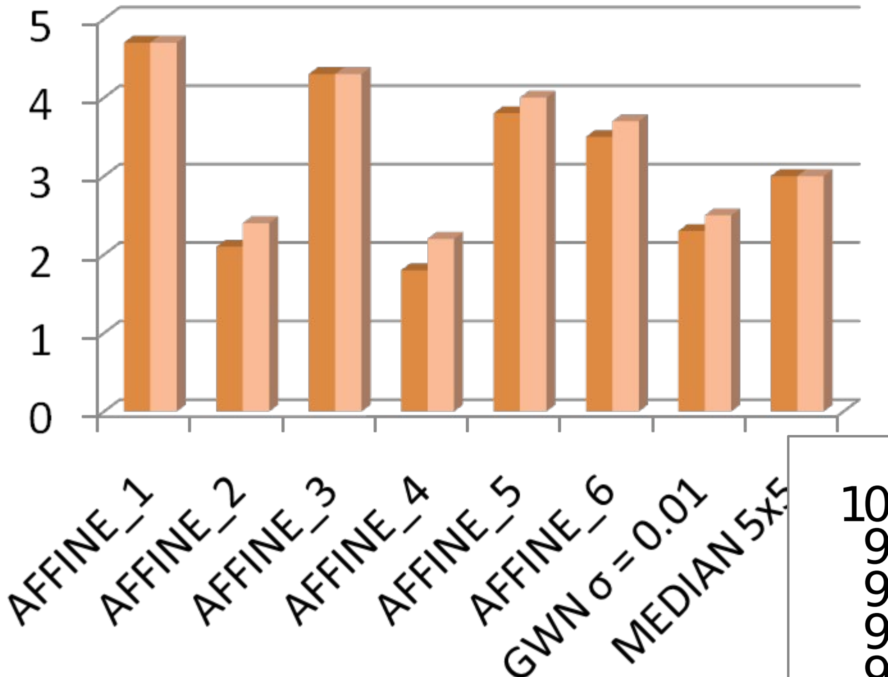
Recognition rate



Experimental results

Different strategies.

Number of ICs and quantization levels are constant.

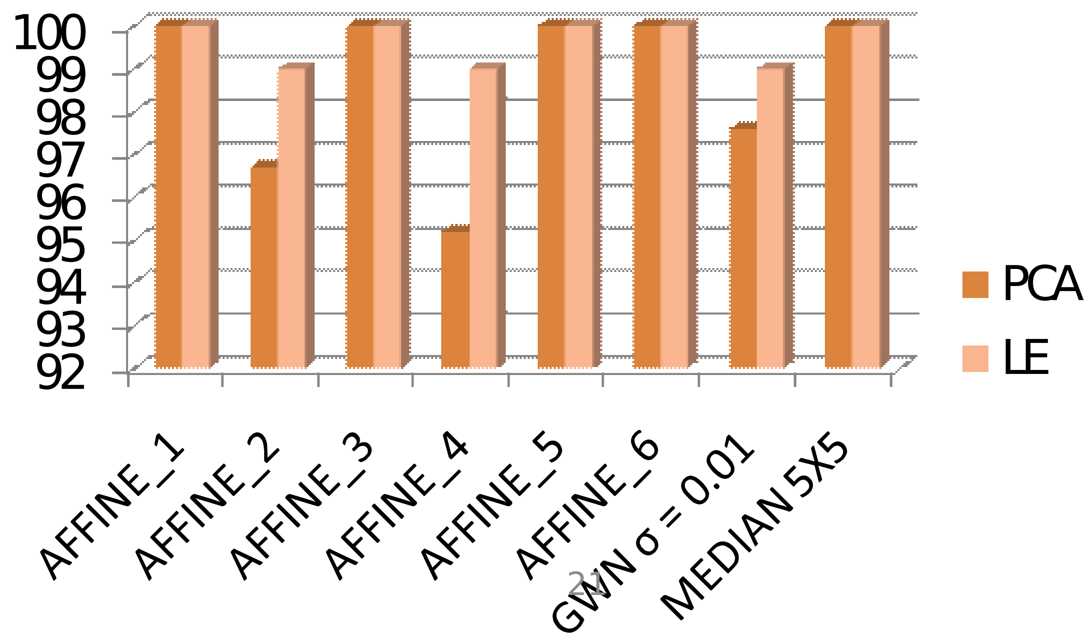


(PCA before ICA)

(ICA with LE)

Discrimination measure

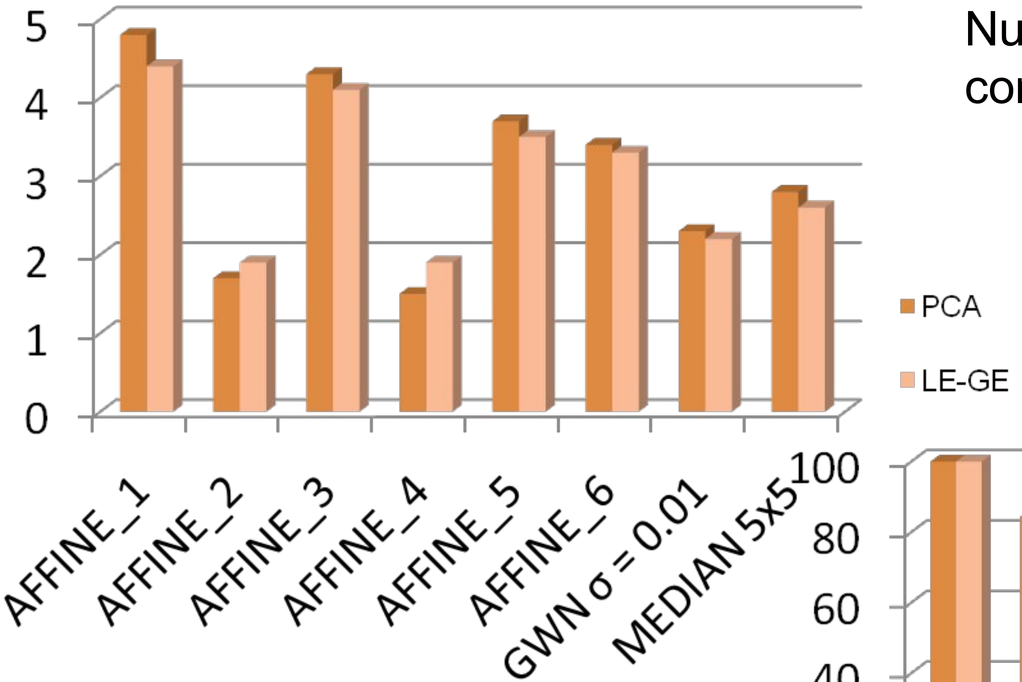
Recognition rate



Experimental results

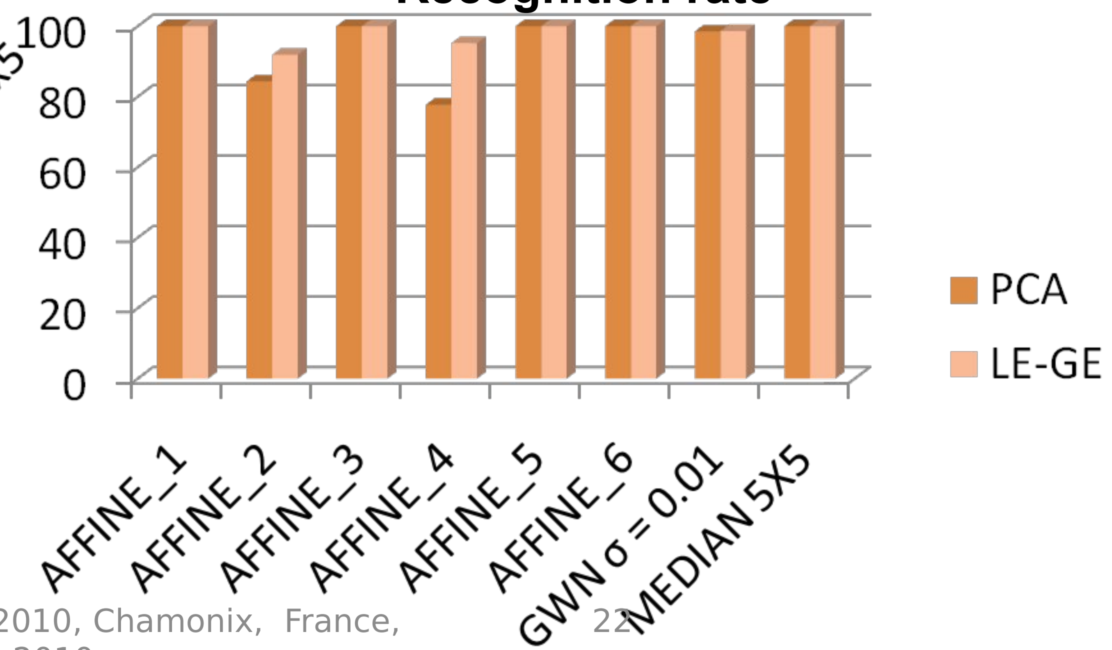
Strategies combination.

Number of ICs and quantization levels are constant.



Discrimination measure

Recognition rate



5. Conclusions

High recognition rate: 100% in almost all studied cases.

For a higher number of ICs and quantization levels the recognition rate and the gap between similar and dissimilar distributions is higher.

Local entropy maximization corresponds to the most suitable strategy for subspace selection.

Thank you!