BIDS 2009

Iris Recognition Based on SIFT Features

Fernando Alonso-Fernandez, Pedro Tome-Gonzalez
Virginia Ruiz-Albacete, Javier Ortega-Garcia

Fernando Alonso-Fernandez
Biometric Recognition Group – ATVS
Escuela Politécnica Superior
Universidad Autónoma de Madrid, Spain
September 2009

Escuela Politécnica Superior

UNIVERSIDAD AUTONOMA DE MADRID

Introduction

- **Biometrics** provide a convenient way of user recognition:
  - no tokens or keys to carry (which can be lost)
  - no passwords to remember (which can be forgotten)







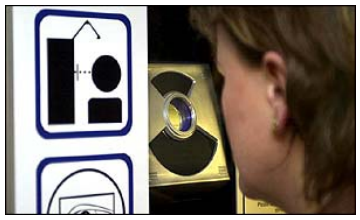

Introduction

- Iris recognition is regarded as one of the most **reliable** and **accurate** biometric recognition system available
- Additionally, the iris is
  - highly **stable** over a person's lifetime
  - **non-invasive** (externally visible organ)
- Explosion of interest in iris biometrics in recent years, with many applications developed



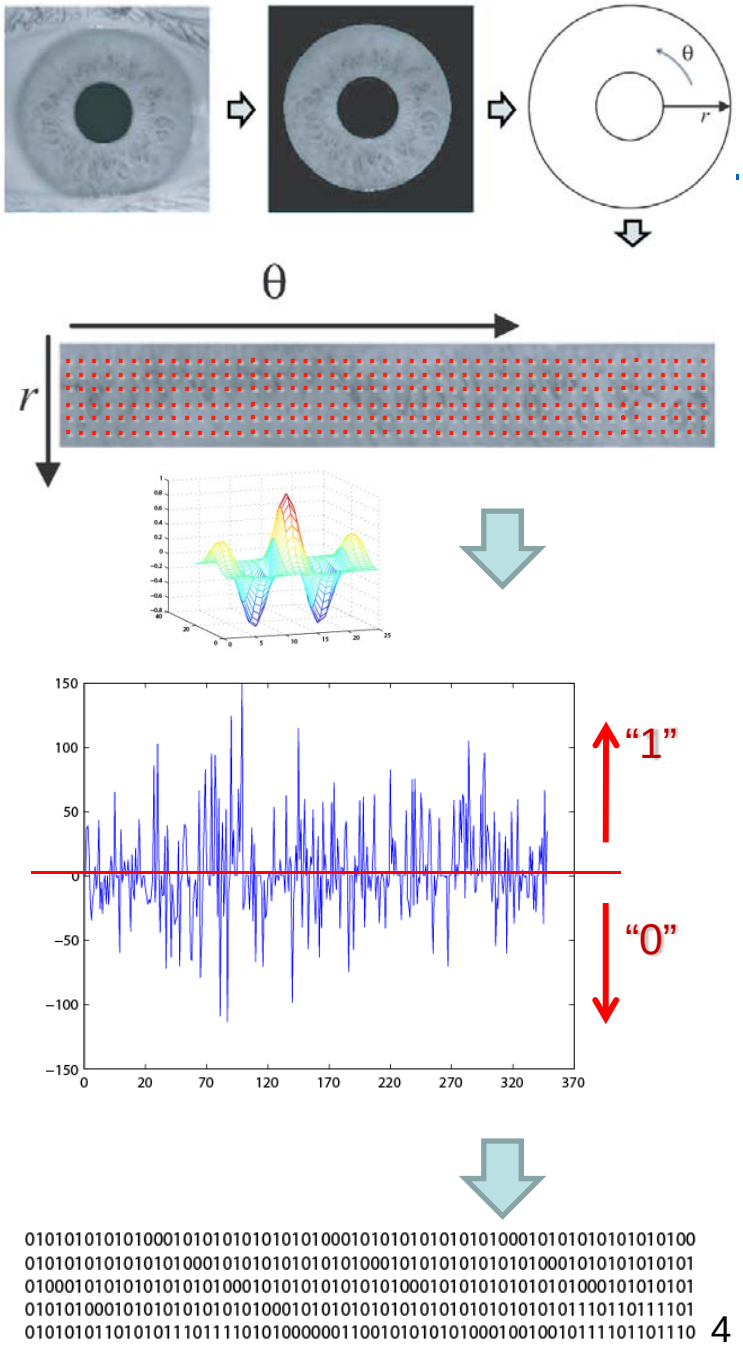







Introduction

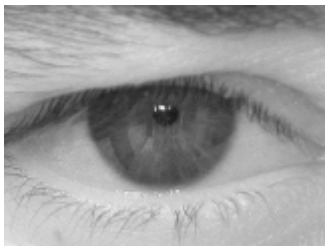
- Traditional iris recognition approaches approximates **iris boundaries as circles**.
  - Transformation of the ring-shaped region of the iris to a **rectangular** image
  - Features are then extracted from the **rectangular normalized iris pattern** (Gabor filters, log-Gabor filters, Gaussian filters, Laplacian-of-Gaussian filters, wavelet transforms, etc.)



Introduction

- **Reliable transformation** to polar coordinates is **crucial**:
  - Highly accurate **segmentation** needed
  - Problems with **non-cooperative or low quality data** (changes in the eye gaze, non-uniform llumination, eyelashes/eyelids occlusion, etc.)

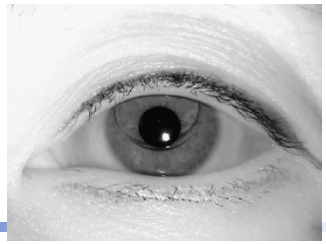
Occlusion



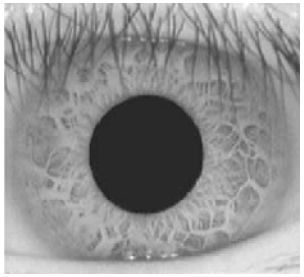
Glasses

Gaze

Contact lens



Occlusion



Incomplete iris

Index

- This work is structured as follows:

Scale Invariant Feature Transformation (SIFT)

Database and protocol

Experimental results

Conclusions and Future Work

Scale Invariant Feature Transformation (SIFT)

Scale Invariant Feature Transformation (SIFT)

- Algorithm developed for **general purpose object recognition***
- SIFT detects **stable feature points** of an object such that the same object can be recognized with **invariance to illumination, scale, rotation and affine transformations**
- **Advantages** for iris recognition
  - Transformation to polar coordinates or highly accurate segmentation is **not needed**
  - Due to its invariance to illumination, scale and rotation, it is expected to be feasible its use with **unconstrained image acquisition conditions ->**
    - increased user **convenience**
    - applicability to **non-cooperative** environments

*** D. Lowe, "Distinctive image features from scale-invariant key points," Intl Journal of Computer Vision, vol. 60(2), 2004**

Scale Invariant Feature Transformation (SIFT)

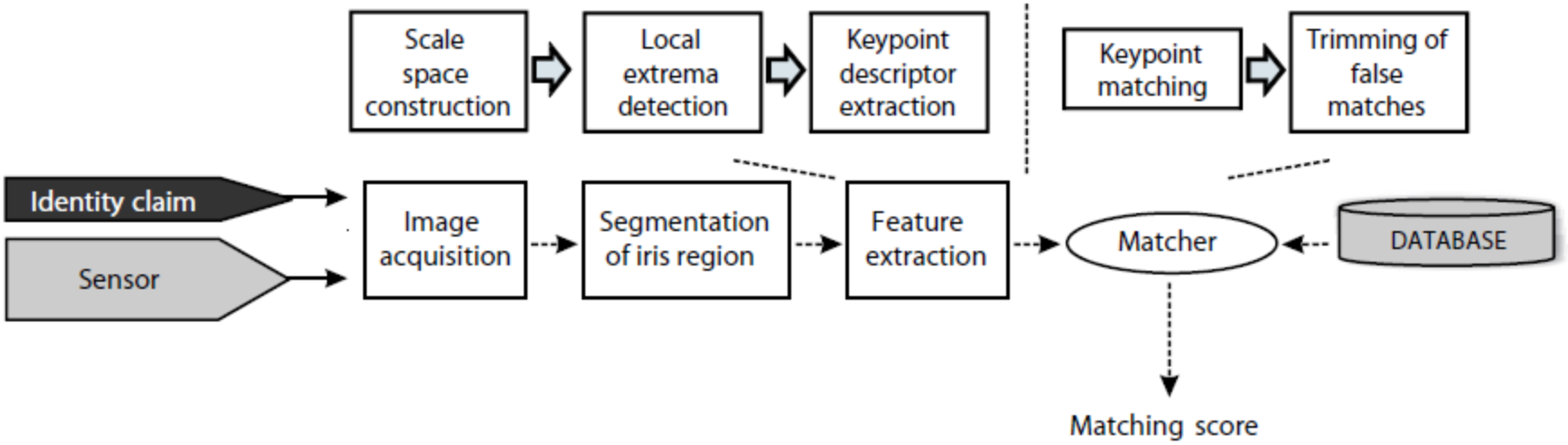
- **SIFT operation** for iris verification

FEATURE EXTRACTION

1. Scale space construction
2. Local extrema detection
3. Keypoint descriptor extraction

FEATURE MATCHING

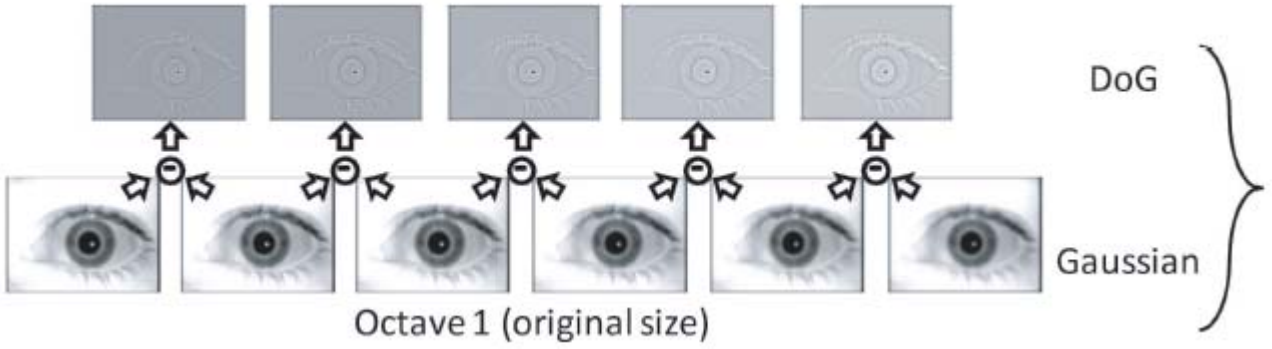
4. Keypoint matching
5. Trimming of false matches



FEATURE EXTRACTION

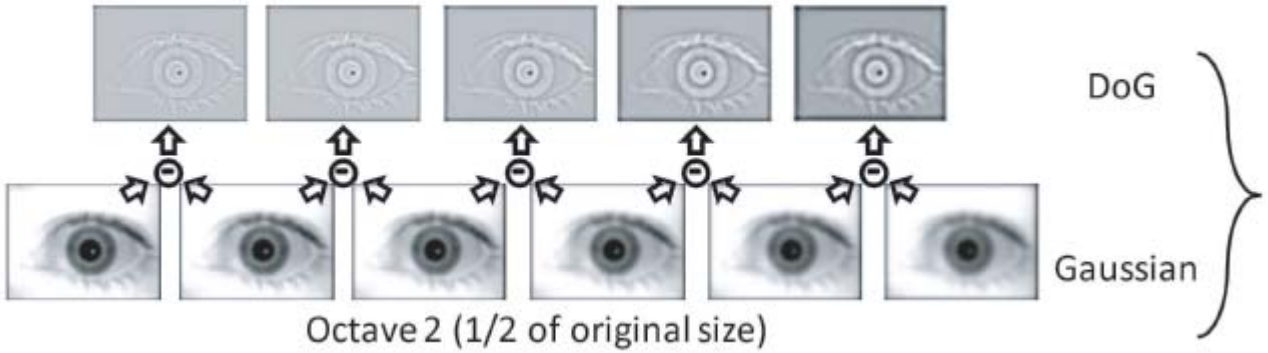
1. Scale space construction

Substraction of consecutive images (DoG images)



Convolution with 2D **gaussian operator** of increasing σ

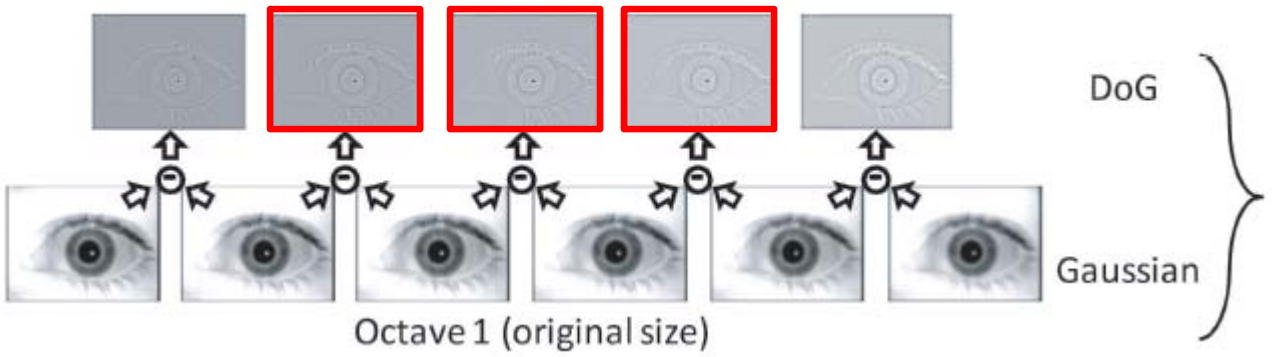
Image **downsampling** (scale invariance)



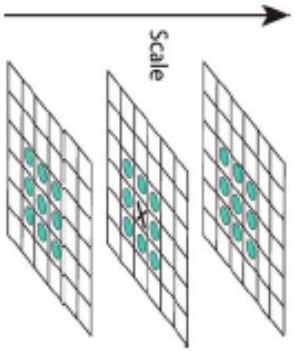
.....

FEATURE EXTRACTION

2. Local extrema detection (I)



- Detection of **local minimum or maximum** in the DoG images
- Comparison with its 8 neighbors in the current image and 9 neighbors in the two adjacent DoG images

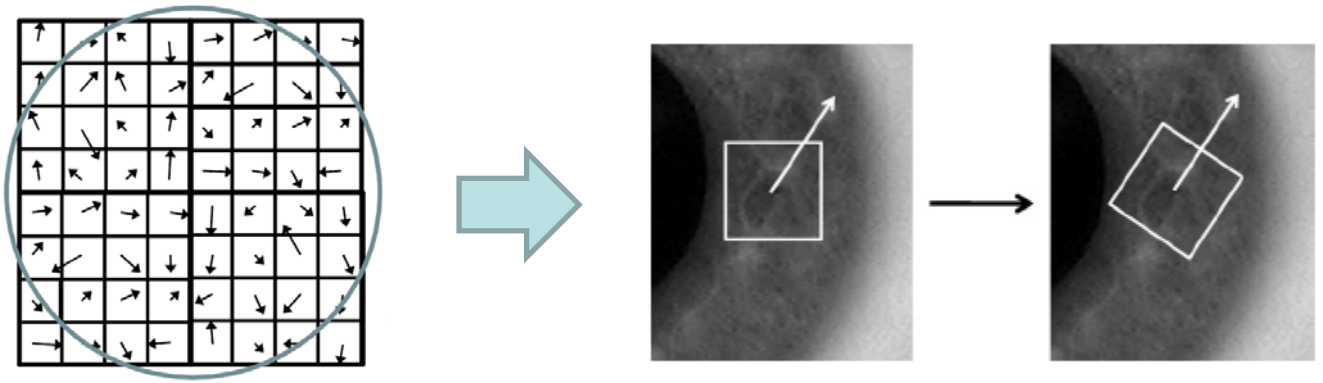


FEATURE EXTRACTION

2. Local extrema detection (II)

- Removal of **unstable points** (two thresholds)
  - Points with **low contrast** (sensitive to noise)
  - Points **along an edge** (sensitive to viewpoint or lightning variation)

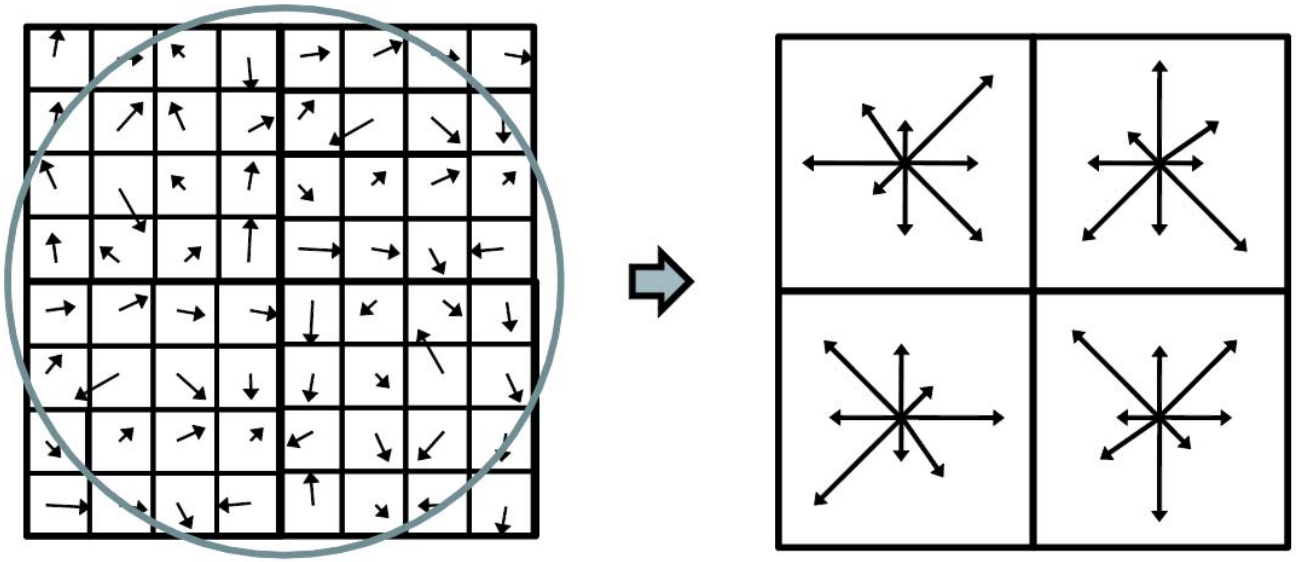
- **Orientation assignment** to each point (rotational invariance)
  - Histogram of **gradient orientations** around the point (36 orientation bins covering 360 degrees)
  - Detection of the histogram peak



FEATURE EXTRACTION

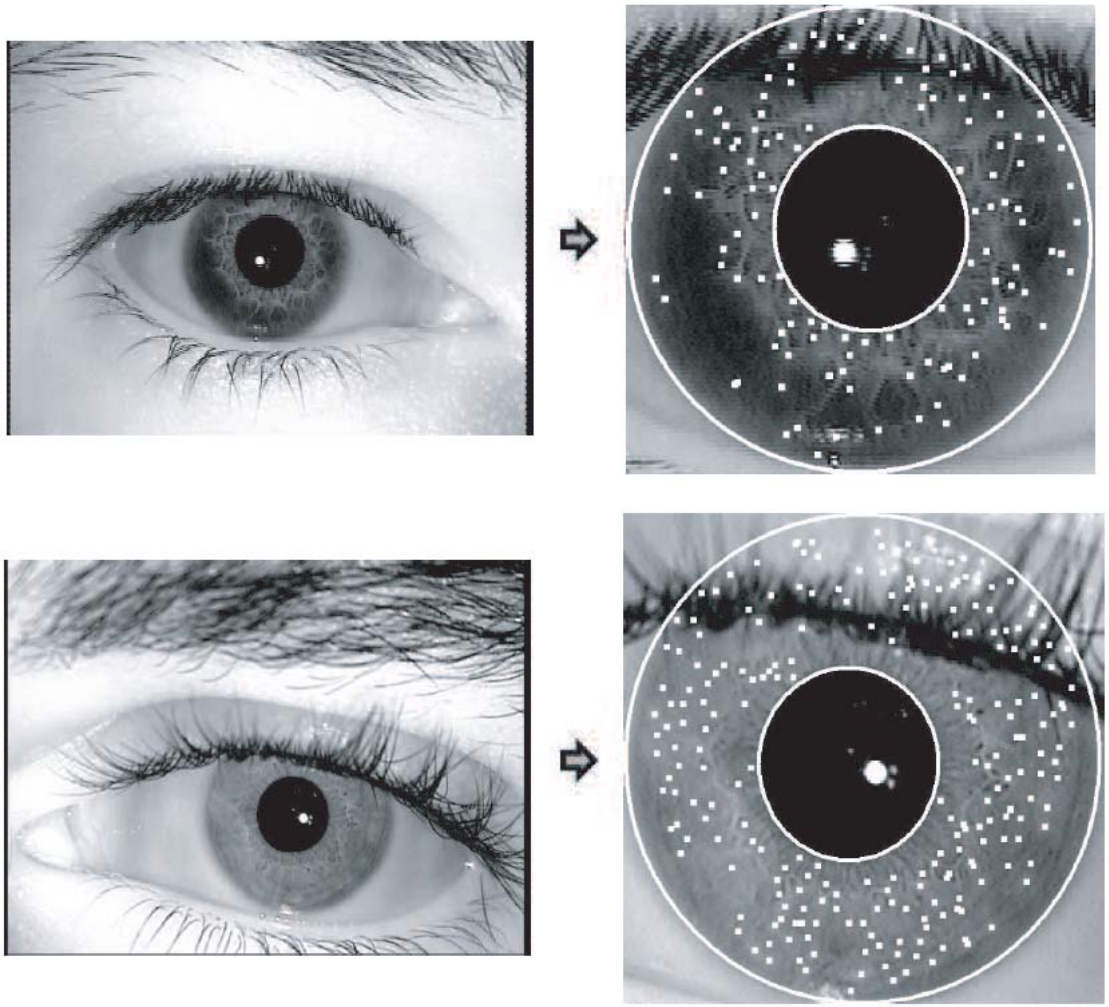
3. Keypoint descriptor extraction

- Histogram of **gradient orientations**, relative to the major orientation of the point (8 orientation bins covering 360 degrees)
- Computation in 4x4 sub-regions around the point
- **Vector** with all the histogram entries (4x4x8=128 elements)



Scale Invariant Feature Transformation (SIFT)

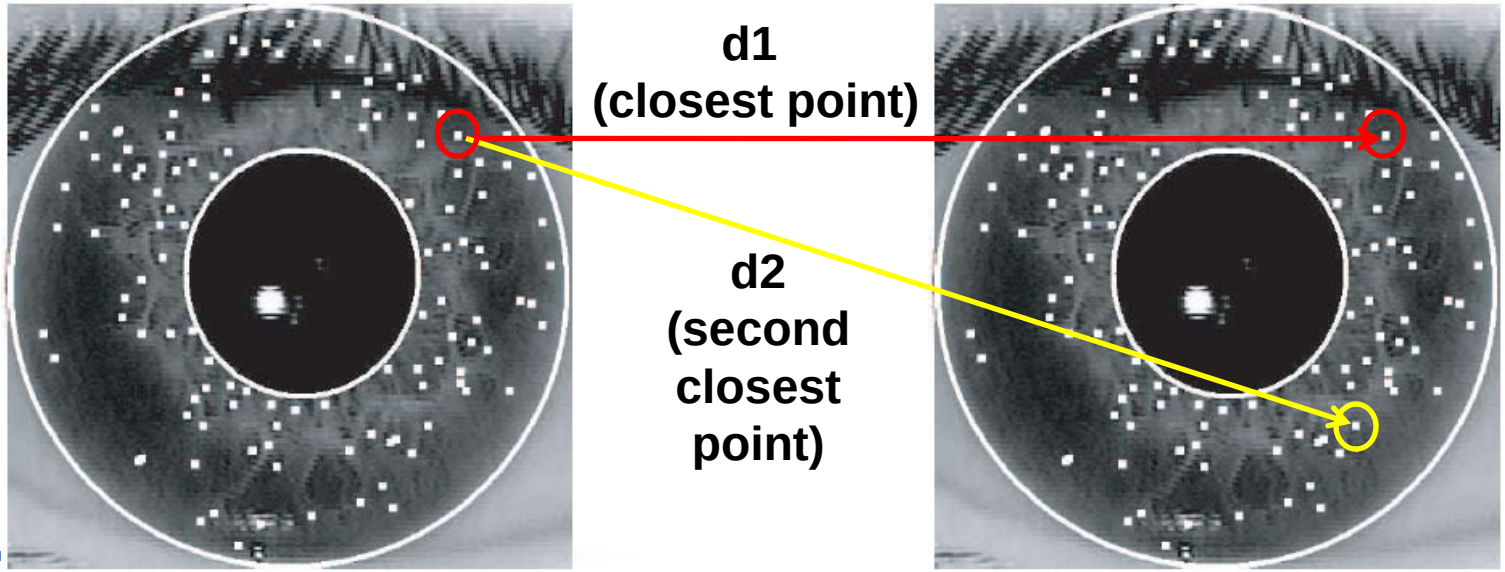
FEATURE EXTRACTION



FEATURE MATCHING

4. Keypoint matching

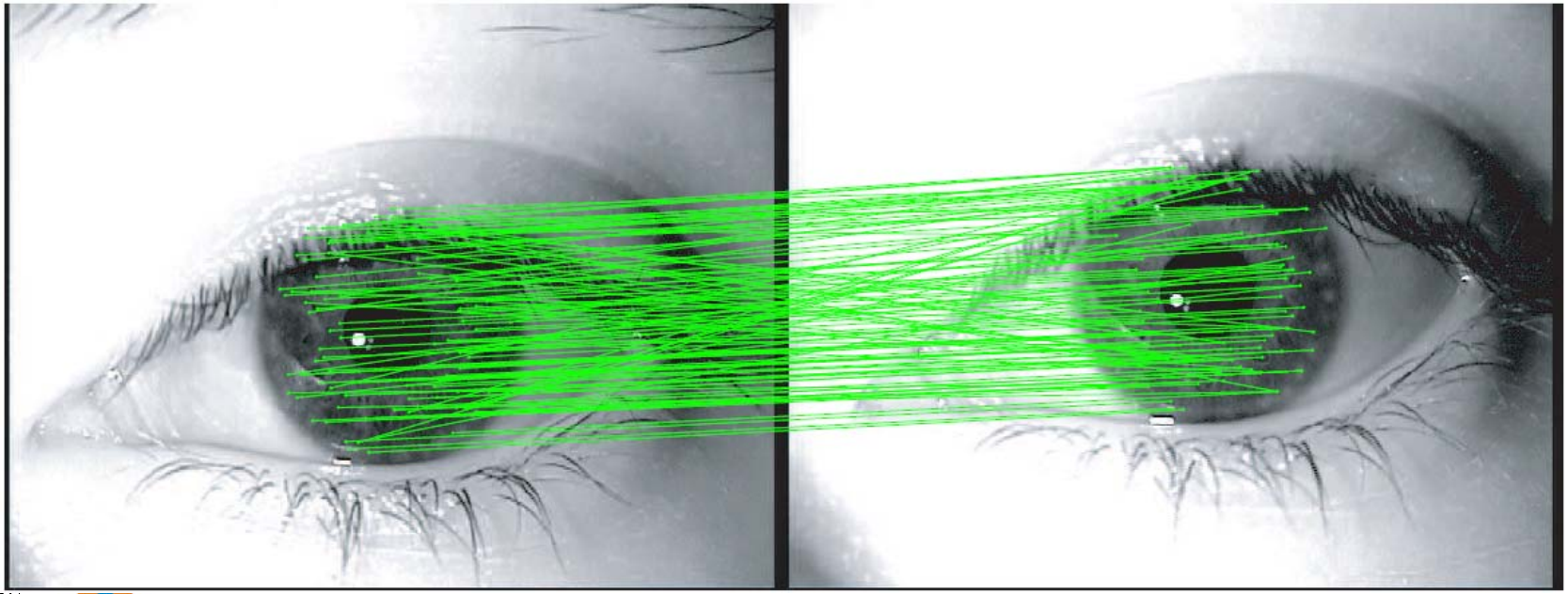
- Pairing of keypoints of two images based on the **Euclidean distance**
- **Matching of two points** if d1/d2 is sufficiently small



FEATURE MATCHING

4. Keypoint matching

- Pairing of keypoints of two images based on the **Euclidean distance**
- **Matching of two points** if d1/d2 is sufficiently small
- **Matching score** between two images=number of matched points



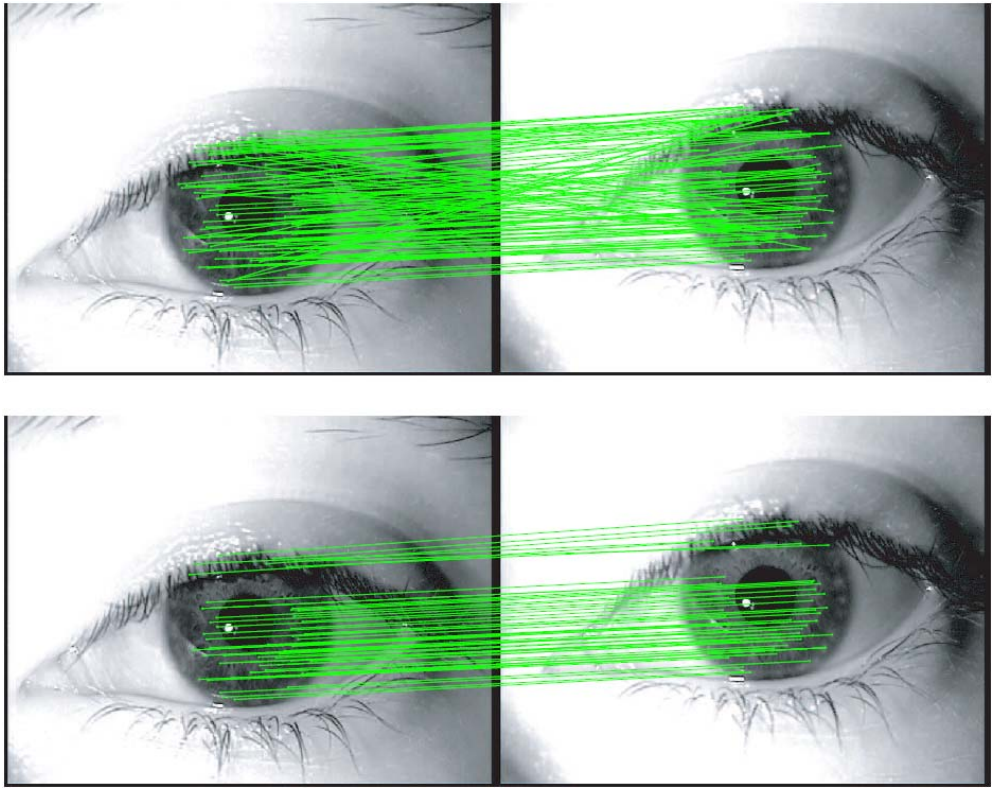
Scale Invariant Feature Transformation (SIFT)

FEATURE MATCHING

5. Trimming of false matches

- Removing erroneous matching points using **geometric constraints** by limiting typical geometric variations to **small rotations and displacements**

- Not proposed in the original algorithm, adapted from *

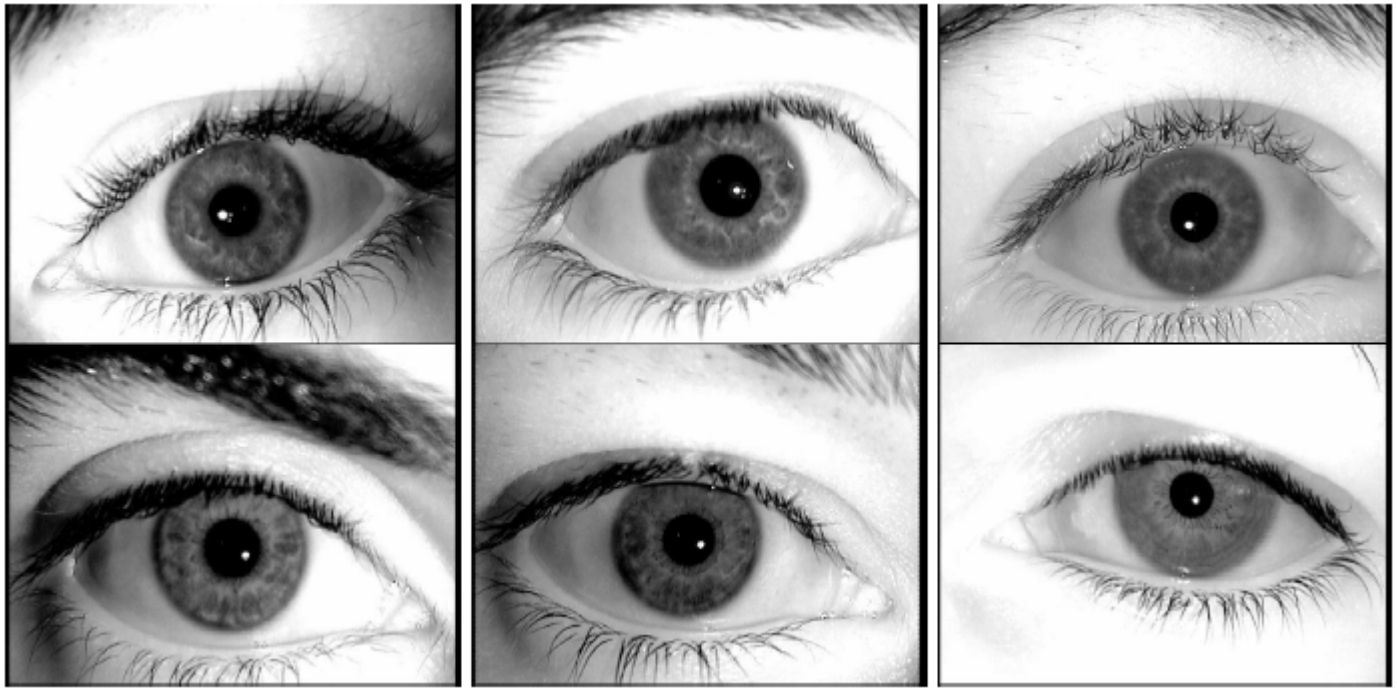


* U. Park, S. Pankanti, and A. K. Jain, "Fingerprint verification using SIFT features," Defense and Security Symposium, Biometric Technologies for Human Identification, BTHI, Proc. SPIE, 2008.

Database and protocol

Database and protocol

- **200 subjects from the BioSec Multimodal Database (*)**
  - 2 acquisition sessions, office environment
  - Iris data with LG Iris Access 3000 sensor, image of 640x480 pixels
  - 200 individuals X 2 eyes X 4 images/eye x 2 sessions = 3200 images



* J. Fierrez, J. Ortega-Garcia, D. Torre-Toledano, J. Gonzalez-Rodriguez, "BioSec baseline corpus: A multimodal biometric database," Pattern Recognition, vol. 40(4), 2007.

Database and protocol

- **Protocol**
  - 50 individuals for training, 150 for testing
  - Each eye considered as a different user (total 400 users)

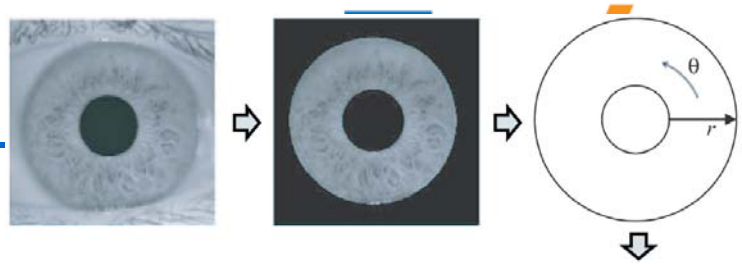
  - **Genuine matchings**= the 4 samples of the first session against the 4 samples of the second session
  - **Impostor matchings**= the 4 samples of the first session against 1 sample of the second session of the remaining individuals

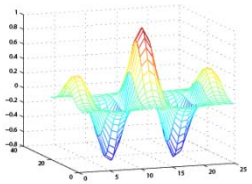
  - **Images segmented automatically** using circular Hough transform + **manual correction** of incorrect images (to avoid bias in the performance due to incorrectly segmented images)

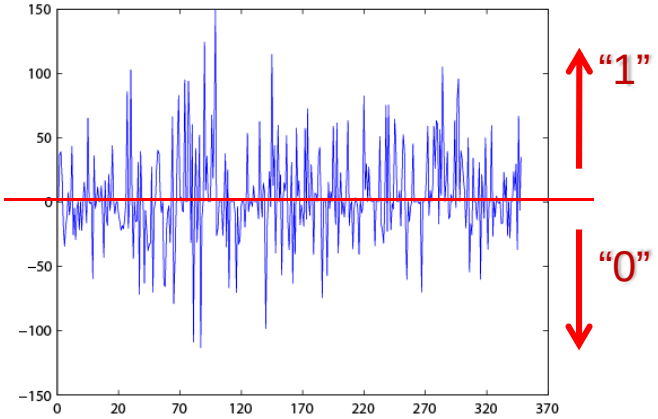
* J. Fierrez, J. Ortega-Garcia, D. Torre-Toledano, J. Gonzalez-Rodriguez, "BioSec baseline corpus: A multimodal biometric database," Pattern Recognition, vol. 40(4), 2007.

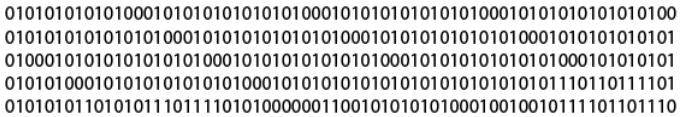
Database and protocol

- **Baseline iris matcher (*)**
  - For comparison with the proposed SIFT matcher
  - 1D implementation of the Daugman algorithm
  - Based on transformation to polar coordinates and Log-Gabor wavelets
  - Output of filtering is phase quantizied to binary level
  - Matching using the Hamming distance





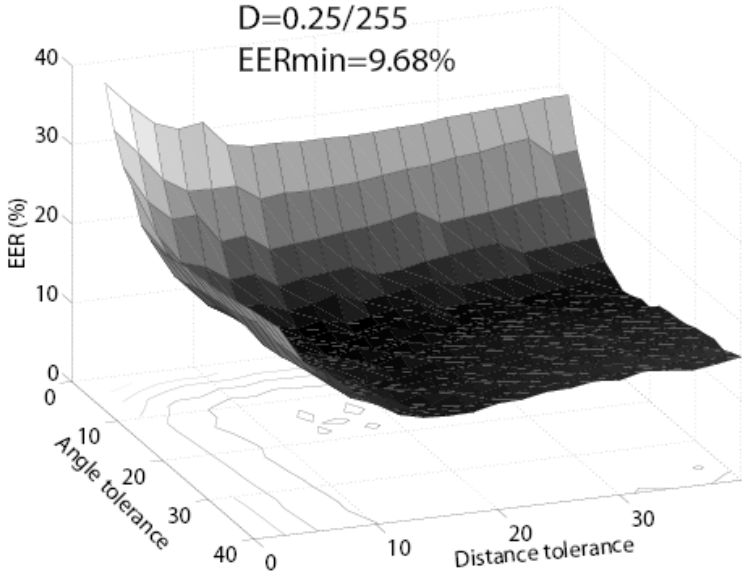




* L. Masek and P. Kovesi, "Matlab source code for a biometric identification system based on iris patterns," The School of Computer Science and Software Engineering, The University of Western Australia, 2003.

Experimental Results

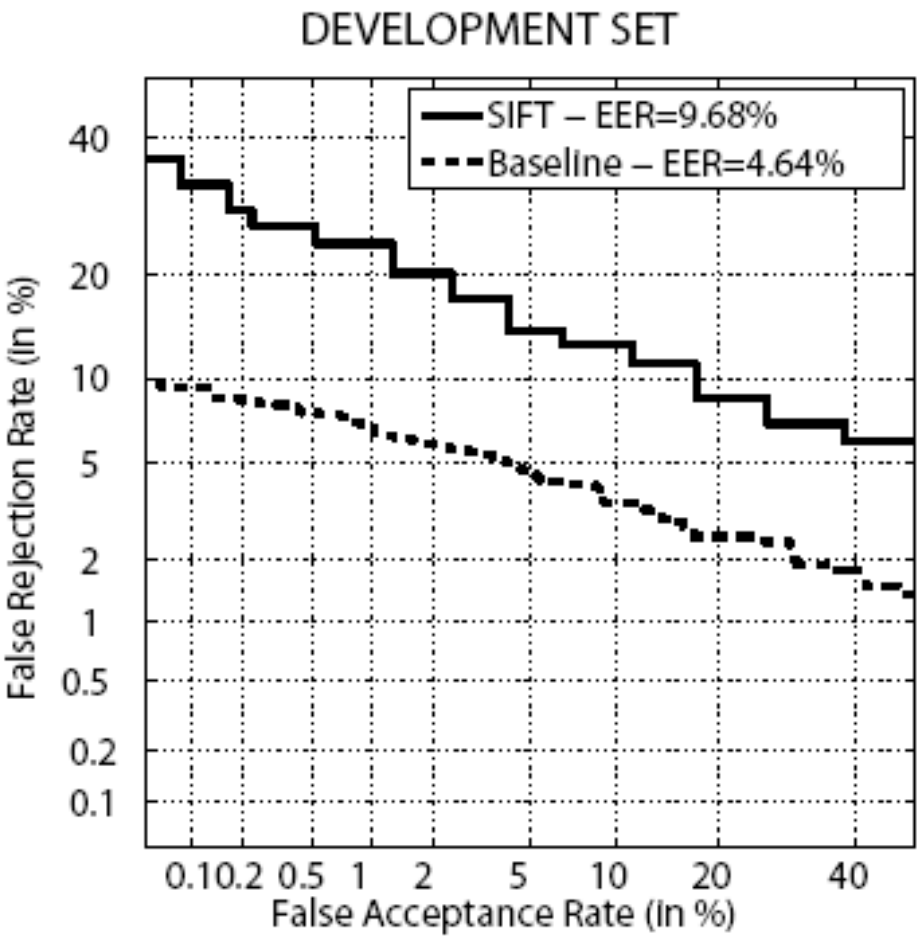
- **Optimization of SIFT parameters (training set)**
  - **Threshold D** for **discarding low contrast points** (the one proposed in the original paper discards most of the useful points in the iris region)
  - **Rotation and displacement tolerances** for **trimming of false matches**
  - Finding out the optimal combination of parameters (minimization of the EER in the training set):

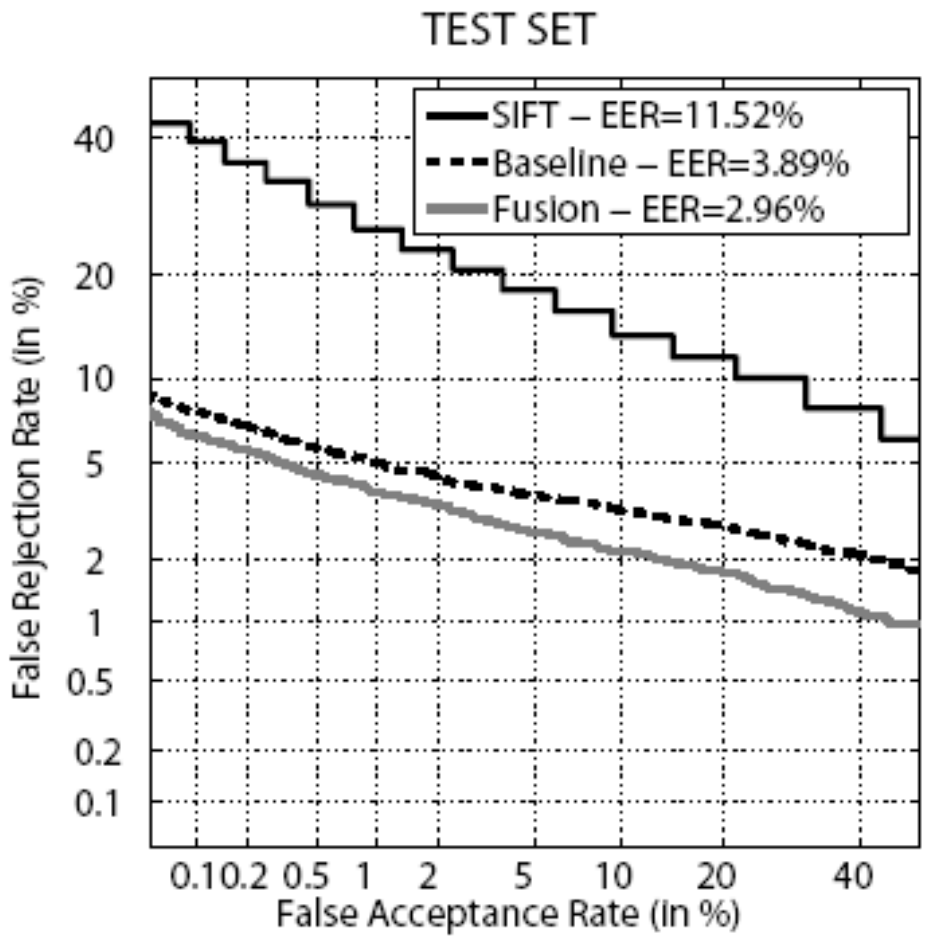


D	ε_θ	ε_ℓ	EER
0.25	-	-	36.85%
0.25	**18**	**14**	**9.68%**
0.5	14	16	9.92%
0.75	18	14	10.96%
1	16	14	14.03%

Results

- **RESULTS**





Conclusions & Future Work

Conclusions

- **Proposal of the SIFT operator for iris feature extraction and matching**
  - Analysis of the influence of different SIFT parameters
  - Inclusion of an step for trimming of false matches

- Although the performance is (still) below popular approaches, we demonstrate its **feasibility** for iris recognition, as well as its **complementarity in the fusion**

- The SIFT operator:
  - Does not need transformation to **polar coordinates** or highly **accurate segmentation**
  - Due to its invariance to illumination, scale and rotation, it is expected to be feasible its use with **unconstrained image acquisition conditions**

Future Work

- Inclusion of **eyelids / eyelashes** detection
- Inclusion of **local quality measures** (*) to weight the contribution of each point to the matching score
- Applicability to datasets acquired in **unconstrained conditions** (**)

*** Y. Chen, S. Dass, and A. Jain, "Localized iris image quality using 2-D wavelets," Proc. International Conference on Biometrics, ICB, Springer LNCS-3832, 2006.**

**** NIST MBGC, NIST Multiple Biometric Grand Challenge http://face.nist.gov/mbgc, 2007.**

Iris Recognition Based on SIFT Features

Fernando Alonso-Fernandez, Pedro Tome-Gonzalez
Virginia Ruiz-Albacete, Javier Ortega-Garcia

Fernando Alonso-Fernandez
Biometric Recognition Group – ATVS
Escuela Politécnica Superior
Universidad Autónoma de Madrid, Spain
September 2009