

Generation of Synthetic Irises

Jinyu Zuo and Natalia Schmid



Lane Department of Computer Science and Electrical Engineering
Natalia.Schmid@ mail.wvu.edu

Project is sponsored by
Center for Identification Technology Research

Motivation

- A large number of novel iris recognition methods are developed over the past 2-3 years.
- Need for extensive testing of existing and newly designed algorithms.
- There are a few publicly available datasets (of small size)
 - CASIA (108 classes, 7 images per class)
 - UBIRIS
 - WVU-G79
 - WVU off-angle (200 iris classes, 4 images per class)

Possible Solutions

- Collect a large dataset of irises. Make it publicly available.
 - Issues of privacy and security are not solved.
- Generate synthetic datasets.
 - Make public aware of possible bias. Hard to mimic the environmental variations (concerned with intra-class).
 - Idealized large scale dataset. May result in overoptimistic performance. Take it as achievable bounds.

J. Wayman, A. Jain, D. Maltoni, D. Maio (Eds): Biometric Systems: Technology, Design, and Performance Evaluation, Springer, New York, 2005.

Project Goals

- Create a tool to generate realistic iris images.
- Define measures of “realism” for synthetic iris.
 - Recognition performance of algorithms
 - Visual evaluation
 - Other measures

Existing Approaches

1. PCA based approach followed by superresolution

(J. Cui, Y. Wang, J. Zh. Huang, T. Tan, and Zh. Sun, “An Iris Image Synthesis Method Based on PCA and Super-Resolution,” ICPR 2004.)

2. Markov Random Field based method

(S. Makthal, A. Ross, “Synthesis of Iris Images using Markov Random Fields.” in Proc. of 13th European Signal Processing Conference (EUSIPCO), Antalya, Turkey, September 2005. To appear.)

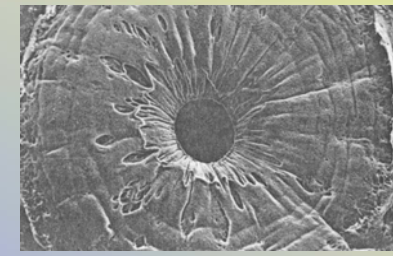
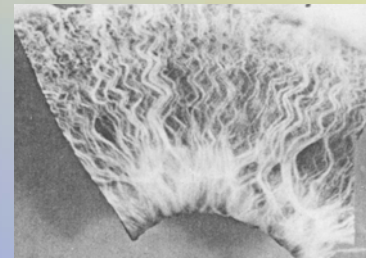
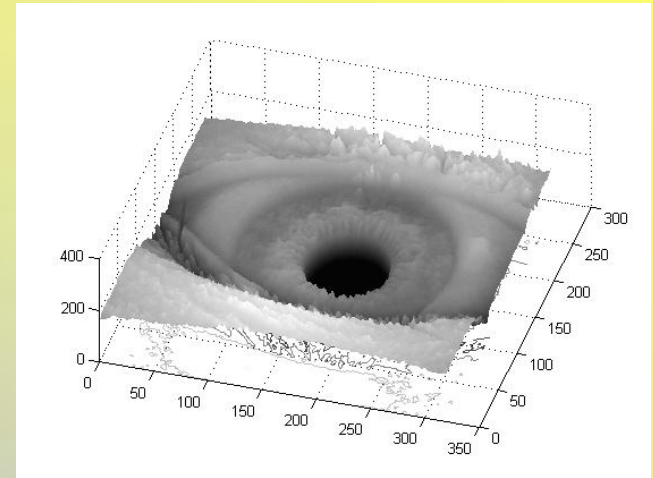
3. Model Based Anatomy/Iridology Based Method

(J. Zuo and N. A. Schmid, to be published in Proc. of ICBA 2006, Hong Kong, January 2006. To appear.)

Model Based Anatomy/Iridology Based

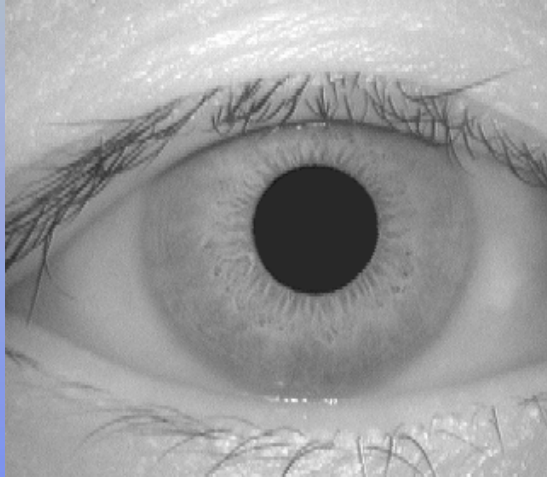
Outline:

- Research:
 - Observation of real iris image (CASIA, ultra-structure image, high-resolution image, WVU-G79, WVU off-angle)
 - Iridology (useful pseudoscience)
 - Iris modeling (anatomy)
- Movie, Procedure (5 steps), and Parameters (40 parameters with predefined statistics)
- Analysis and Results

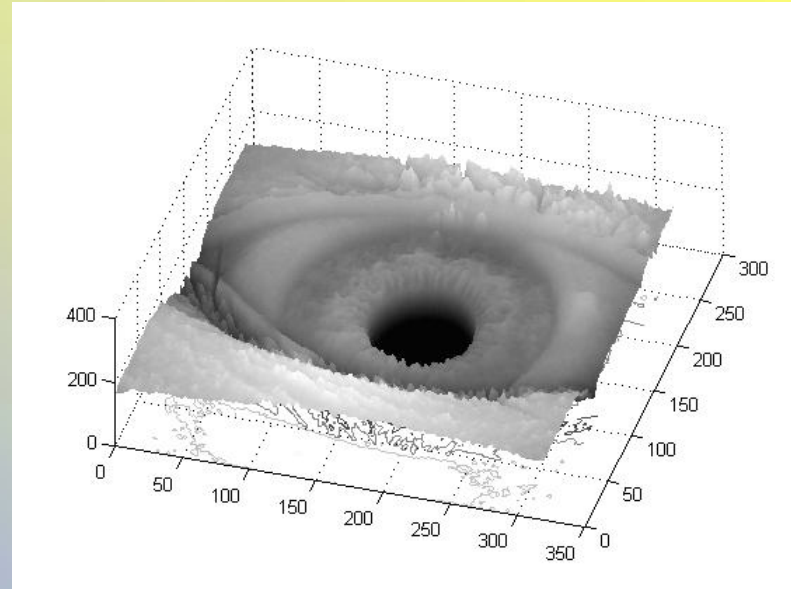


macro photos

Observations of Real Iris Images



(a) 001_1_1.bmp from CASIA

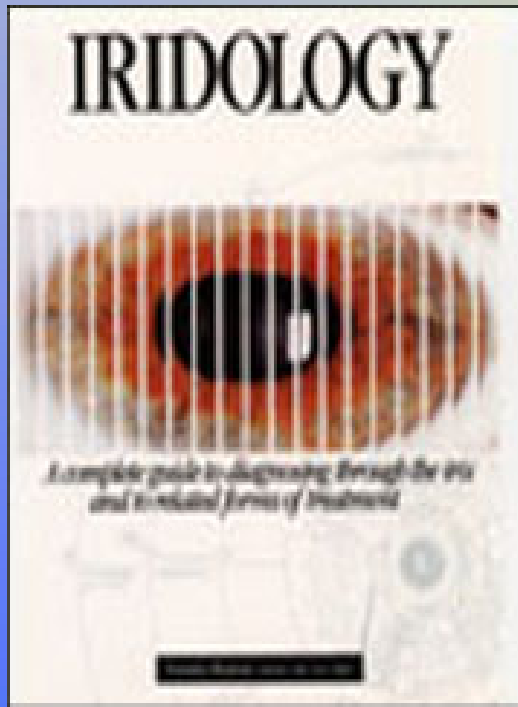


(b) its surfc(.) version in Matlab

- CASIA Iris Image Database (version 1.0); WVU G-79 data, and WVU off-angle data
- Ultra structure images (milesresearch.com)
- High-resolution images

Iridology

Iridology - Farida Sharan

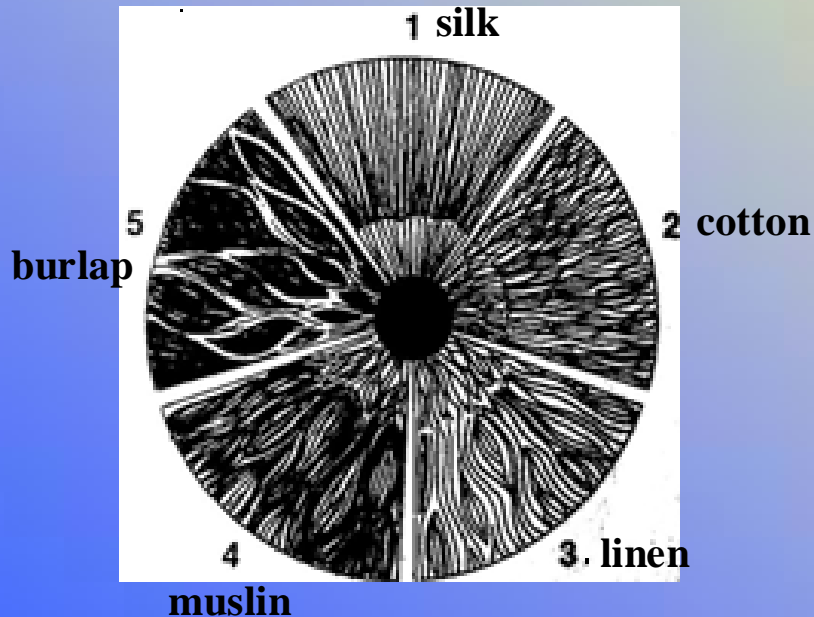


- *A complete guide to diagnosing through the iris and to related forms of treatment* by Farida Sharan.
- *Iridology* is a comprehensive reference to diagnosing disease through patterns in the iris. Eye patterns are described in detail as to their relation to physical disorders.
- (middlepath.com.au/eysite/)
- (iridology.gr/cases-index/casesenl.html)

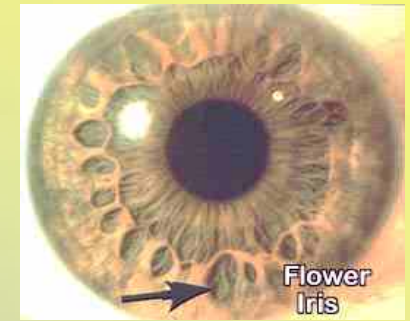
Iris Classes

Classifications in Iridology:

- Iris fiber density
- Patterns
- Other characteristics



Anatomical Studies (color images)



Reduces to 2 classes for IR.

<http://www.middlepath.com.au/eyesite>

Modeling the Iris

Iris Features:

- Spatial variation of both color and texture.
- The texture is inferred from the brightness variation.
- The iris geometry calls for a **cylindrical coordinate system** (Z, R, Θ) .
- The **collarete** is raised.

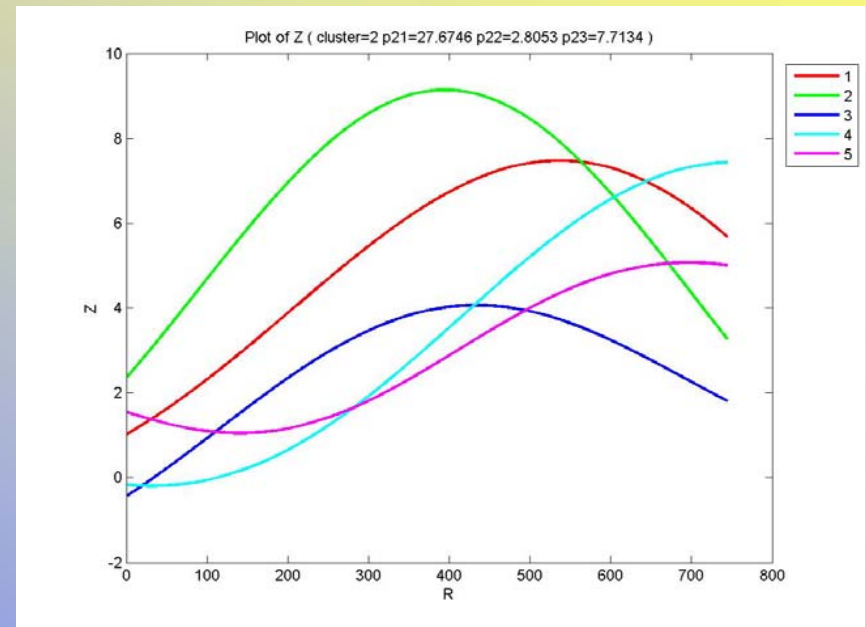
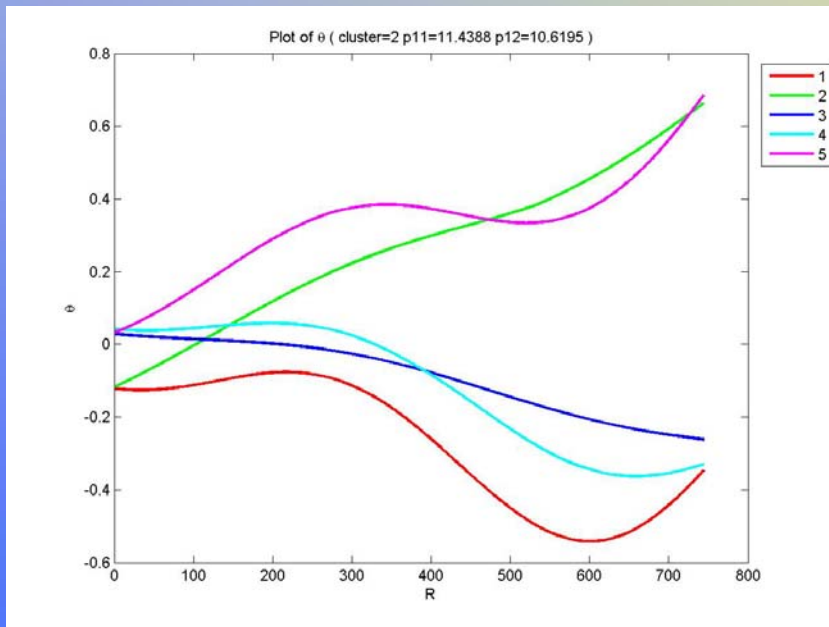
Common Iris Features:

- **Radial fibers** and **partial cover layer** build the main framework. Main texture is formed by the muscles, fibers and the cover layer.
- **Iris root** is typically blurred.

milesresearch.com/main/irismodeling.htm

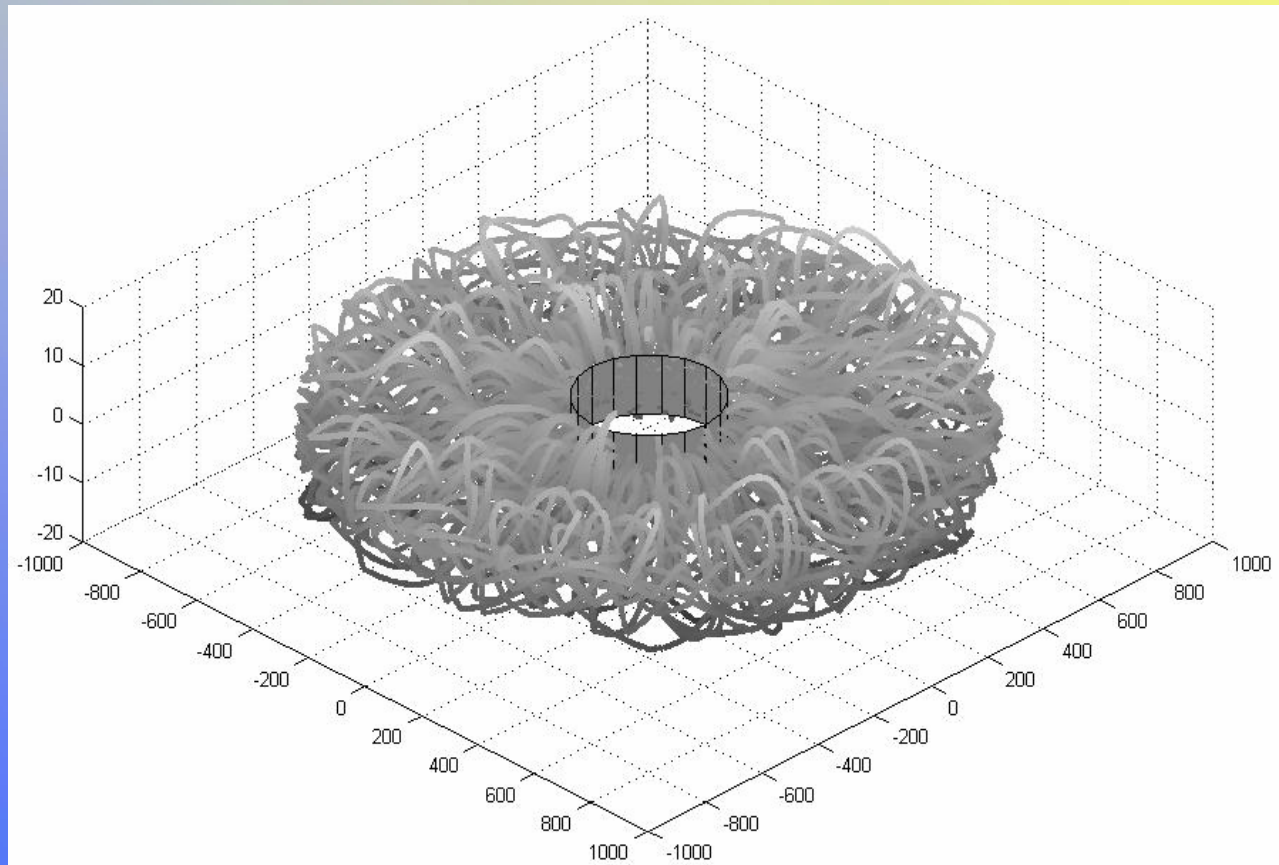
Example of Iris Generation

Step 1: Generate 3D fiber matrix (Θ, Z)



Example of Iris Generation

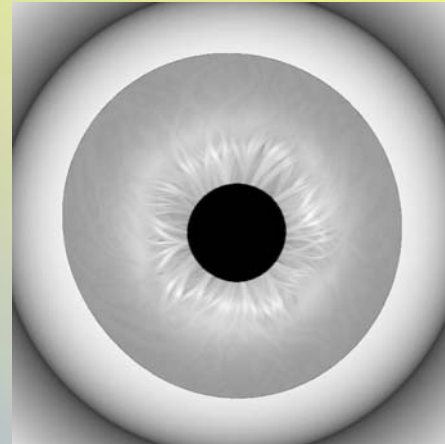
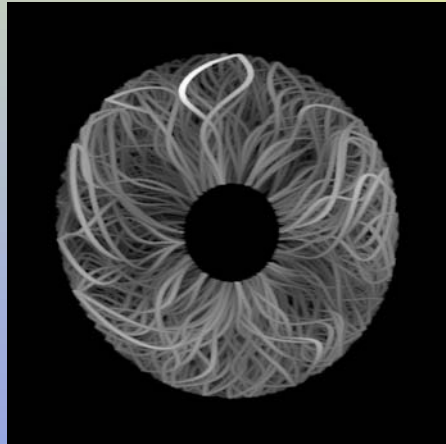
Three dimensional fiber structure.



Example of Iris Generation

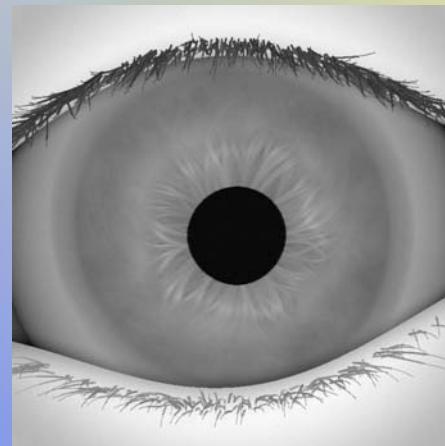
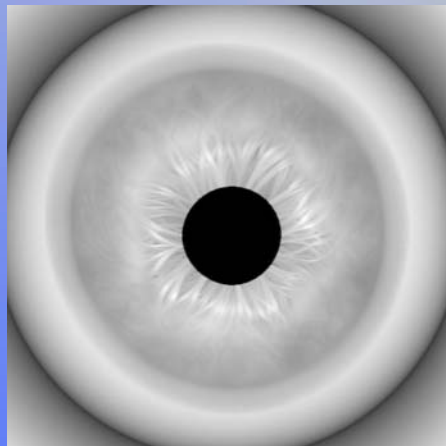
Step 2:

Generate base image from fiber matrix



Step 3: Generate ANW, Collarette and add the Top Layer.

Step 4: Blur edges and add layer pattern

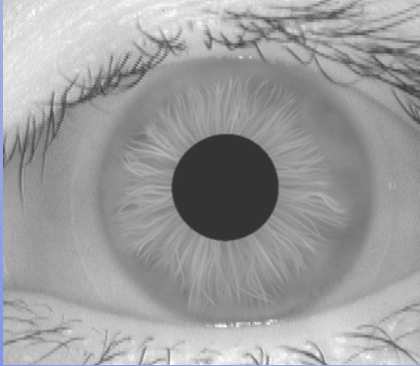


Step 5: Add eyelids and eyelashes, rotate, add noise, and add other effects.

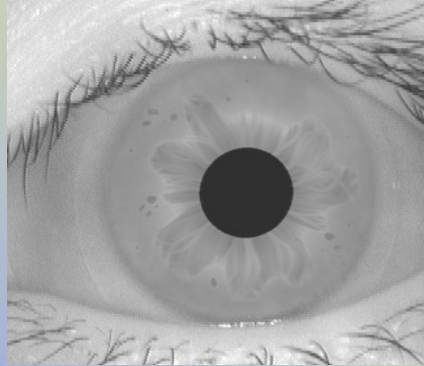
Parameters

- fibers resolution in R direction
- fibers number in Θ direction
- fiber size
- the size of the pupil
- iris thickness
- top layer thickness
- fiber cluster degree
- the image margin size
- the eye horizontal location
- the eye vertical location
- the eye angle
- average period along Θ
- average amplitude along Θ
- average period along Z
- average amplitude along Z
- the number of holes, if there are
- the hole distribution parameter
- the lowest value of the iris fiber
- the ANW corner number
- the ANW average radius
- the period of ANW cosine function
- the location of collarette
- the amplitude of the collarette
- the range of the collarette
- transparent parameter of the top layer
- blur range iris root
- transparent range of the ANW
- net structure of the iris
- parameter of the net structure
- eye size
- the number of eyelashes at the top
- the number of eyelashes at the bottom

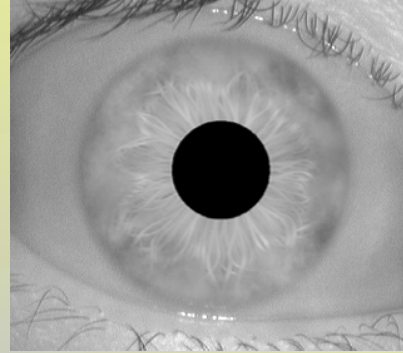
Results



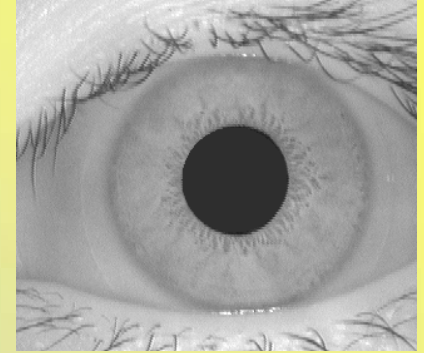
Iris 1



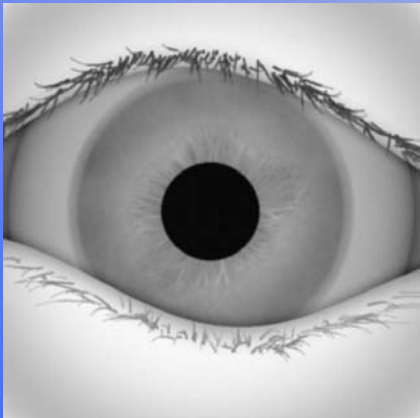
Iris 2



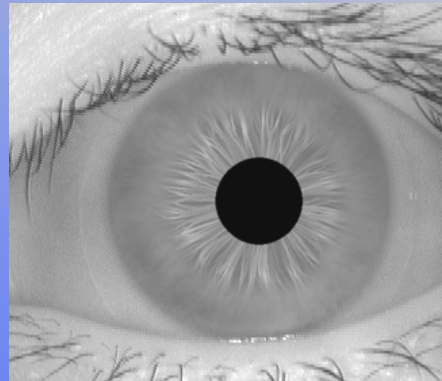
Iris 3



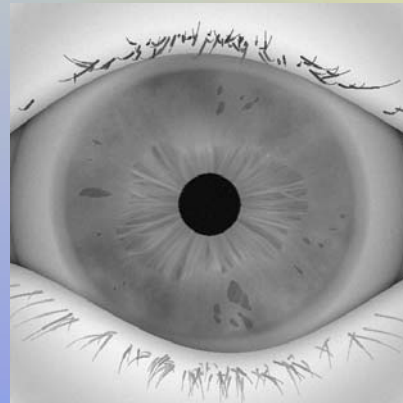
Iris 4



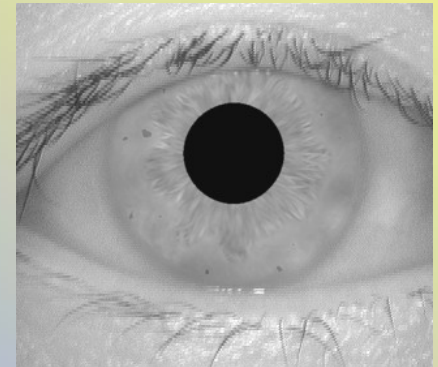
Iris 5



Iris 6

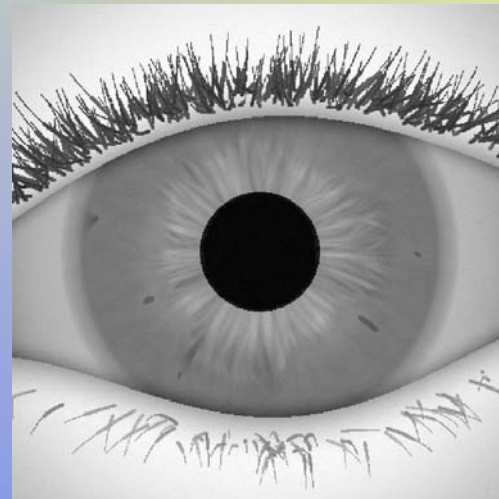
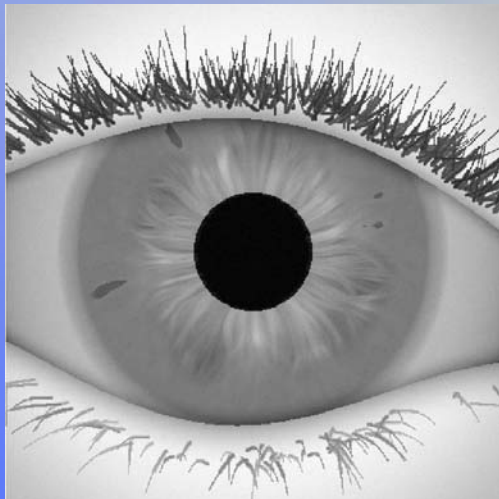
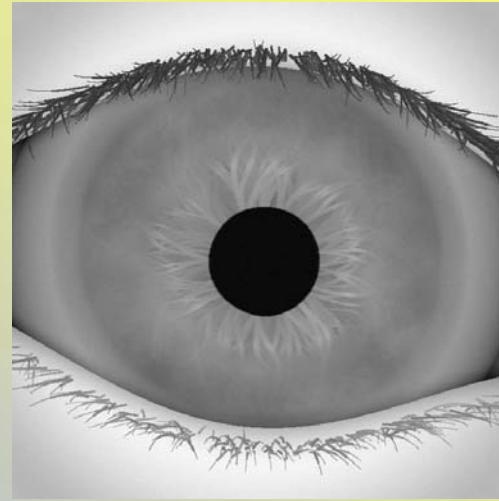
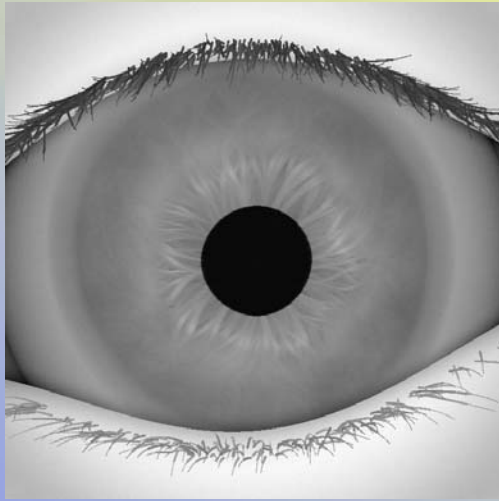


Iris 7



Iris 8

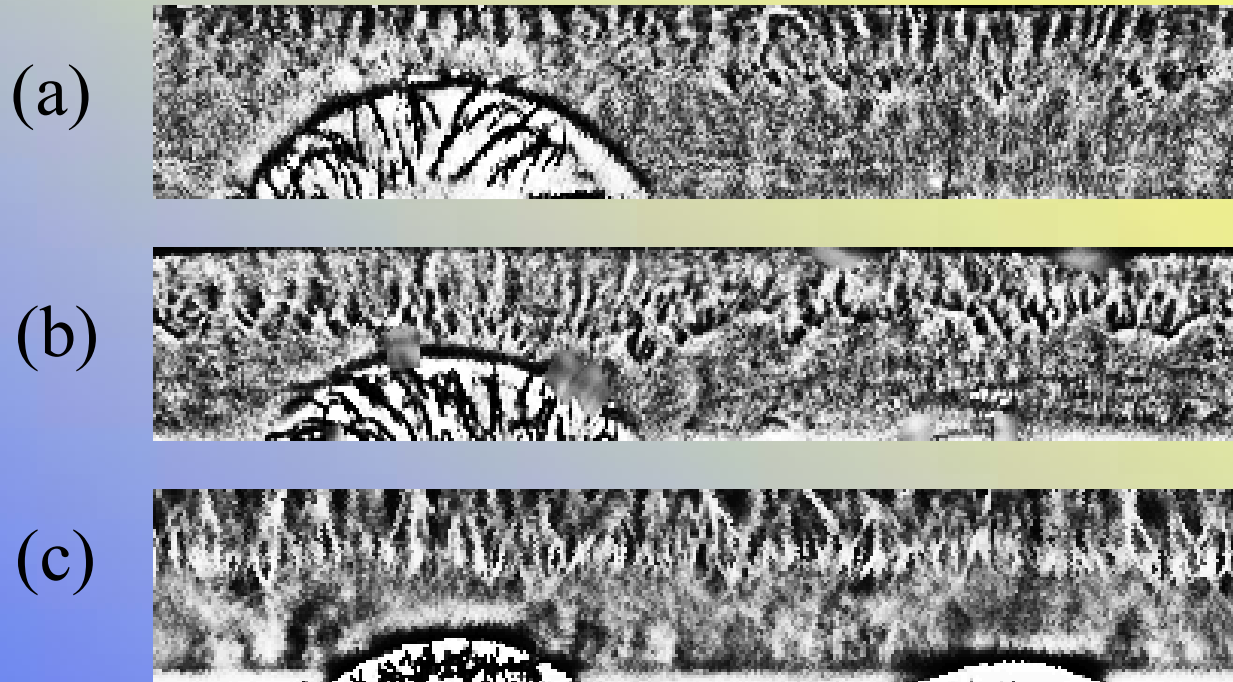
More Results



Left eye

Right eye

Analysis: Visual Evaluation



Shown are three segmented normalized and enhanced iris images. The three images are samples of (a) CASIA dataset, (b) WVU non-ideal iris dataset, and (c) dataset of synthetic irises generated using our model based approach

Analysis: Paring Local ICA



24 best matching pairs of local ICA functions extracted from CASIA and synthetic datasets



24 best matching pairs of local ICA functions extracted from CASIA and WVU datasets



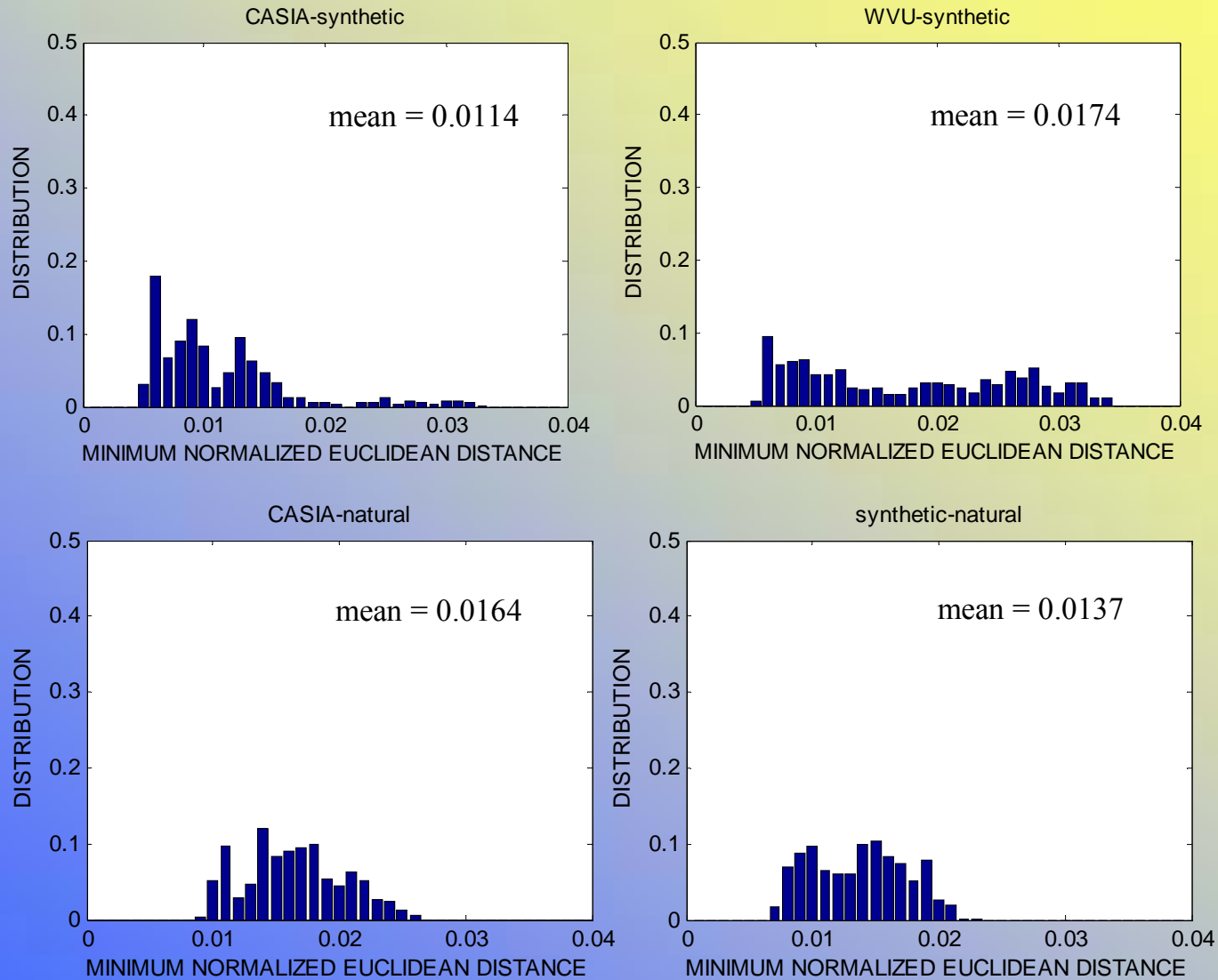
24 best matching pairs of local ICA functions extracted from WVU and synthetic datasets



24 best matching pairs of local ICA functions extracted from synthetic and natural datasets

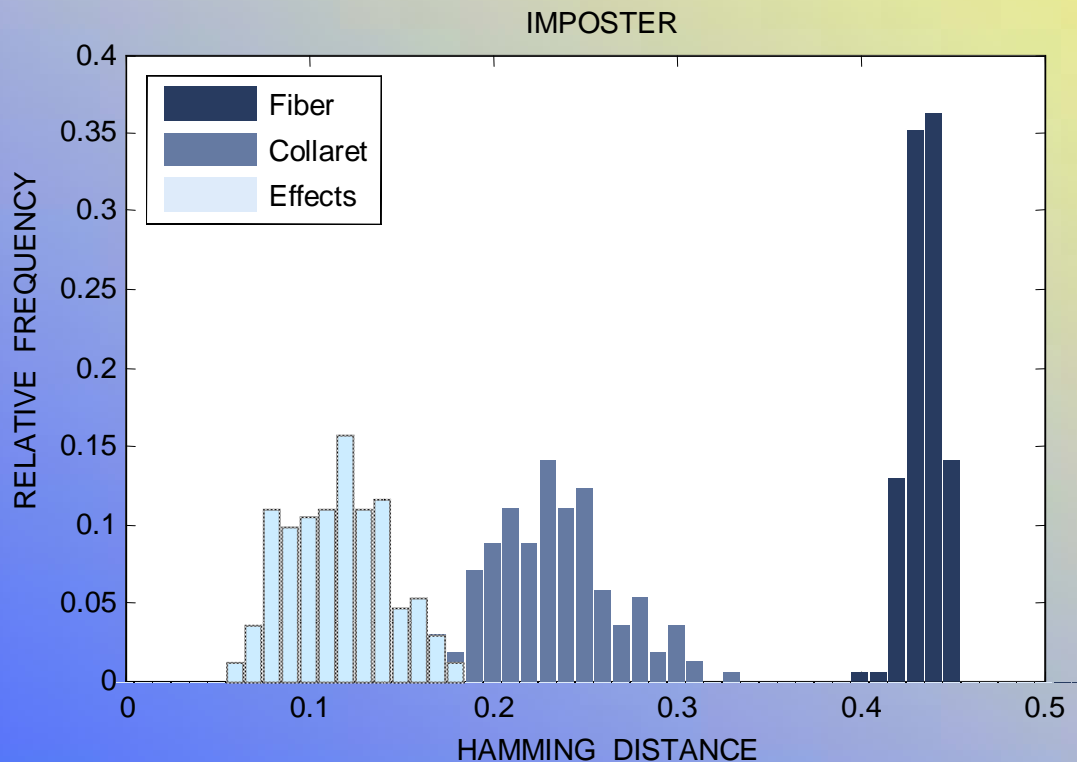
- Natural images. Available online at <http://www.cis.hut.fi/projects/ica/imageica/>

Distribution of ICA Pairs

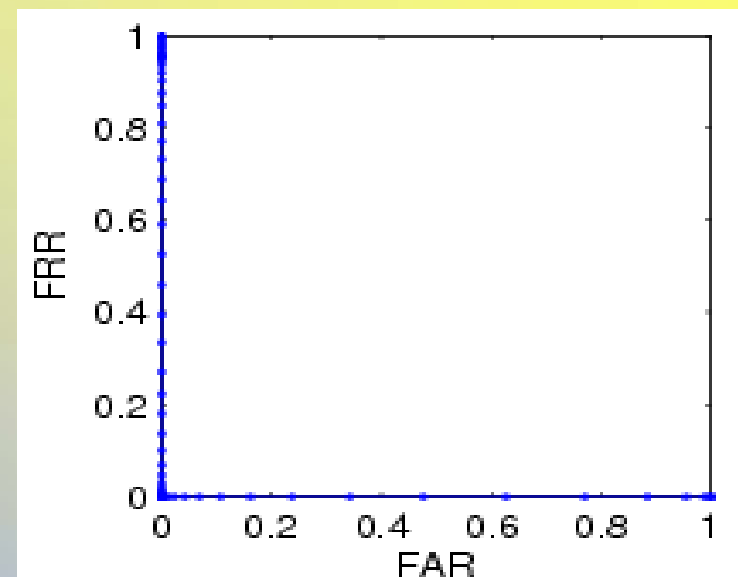
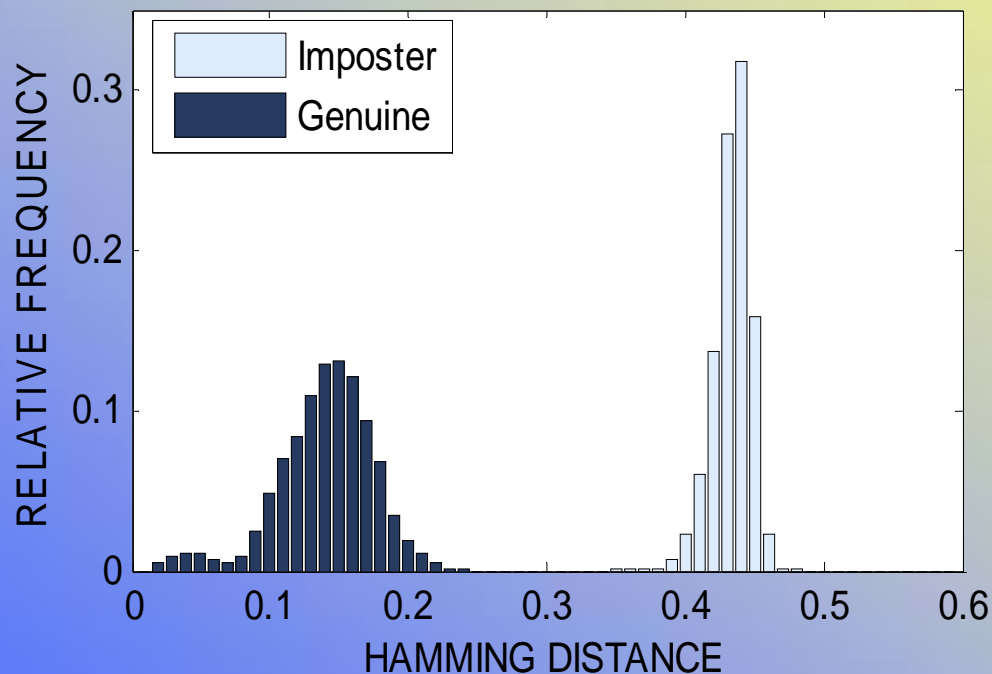


Important Parameters

- All parameters are subdivided into 3 broad groups: (i) fiber parameters, (ii) ANW and related parameters, and (iii) parameters responsible for effects (transparency, top level thickness, holes, blur, etc.)
- Keep two sets fixed and vary randomly parameters in the other set.



Verification Performance



- 204 iris classes, 6 images per class
- rotated, blurred, rotated-blurred, perfect segmentation
- d-prime is approximately 11.

Present State and Future Plans

- 1000 iris classes (6 images per class) are generated
- Working on refinement of fibers and effects
- Extrapolation of performance (based on extremes)
- Plan to make available for the public through CITEr web page (November 2005)
 - Data are free of charge
 - Have to be requested (e-mail)
 - Rules have to be followed (an agreement has to be signed)
 - Variable size datasets up to 10,000 generated iris classes may be requested.