Personal Recognition Based on Facial Information

Research (in biometrics) at Halmstad University, Sweden

Josef Bigun,
Professor, PhD

Fernando
Alonso-Fernandez
Postdoctoral
Researcher, PhD

Stefan Karlsson
Postdoctoral
Researcher, PhD

Kenneth Nilsson
Associate
Professor, PhD

Anna Mikaelyan
PhD student, MSc

Fernando Alonso-Fernandez (feralo@hh.se)

Content

- About Halmstad University
- Biometrics Research at Halmstad University
- Fingerprints, lip-motion
- Iris Analysis
- Periocular Analysis
- Face Analysis

Fernando Alonso-Fernandez (feralo@hh.se)

About Halmstad University

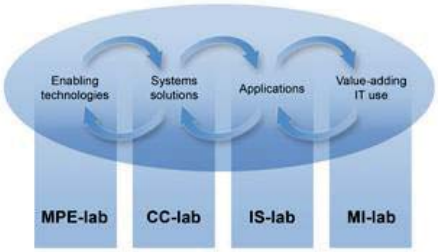
School of Information Science Computer and Electrical Engineering

Largest research environment at Halmstad University

85 people from 20 nationalities

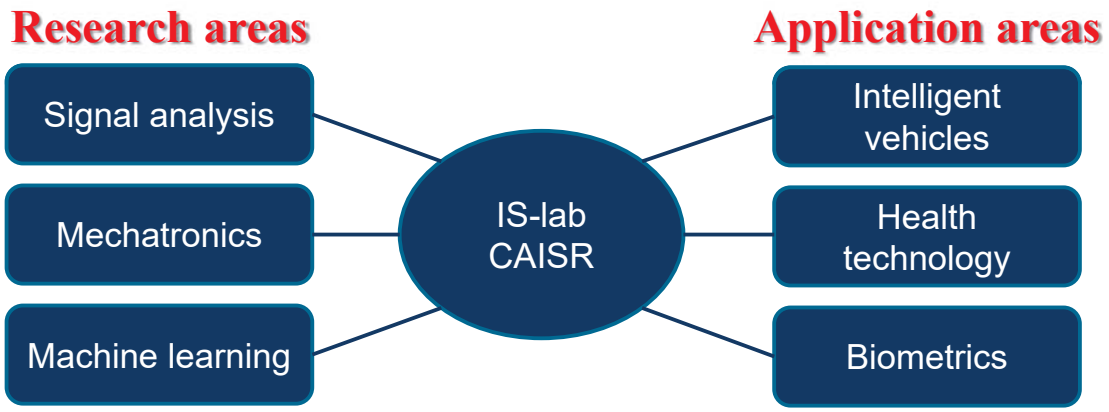
Organized in 4 different laboratories:

- **Computing and Communication** (CC-lab)
- **Man and Information technology** (MI-lab)
- **Mathematics, Physics and Electrical engineering** (MPE-lab)
- **Intelligent Systems / Centre for Applied Intelligent Systems Research** (IS-lab/CAISR)



About Halmstad University

Intelligent Systems laboratory (IS-lab/CAISR)



Biometrics Research

Well-recognized group in Sweden, with international impact

With funding from:

- **Swedish Research Council** (postdoctoral grant, project grants)
- **EU FP6/FP7**
  - Marie Curie Intra-European Fellowship (2011-2013)
  - BIOSECURE Network of Excellence (2004-2007)
  - BBfor2 Marie Curie Initial Training Network (2010-2014)
- **EU COST Actions** IC1106 and 275

Vetenskapsrådet

SEVENTH FRAMEWORK PROGRAMME

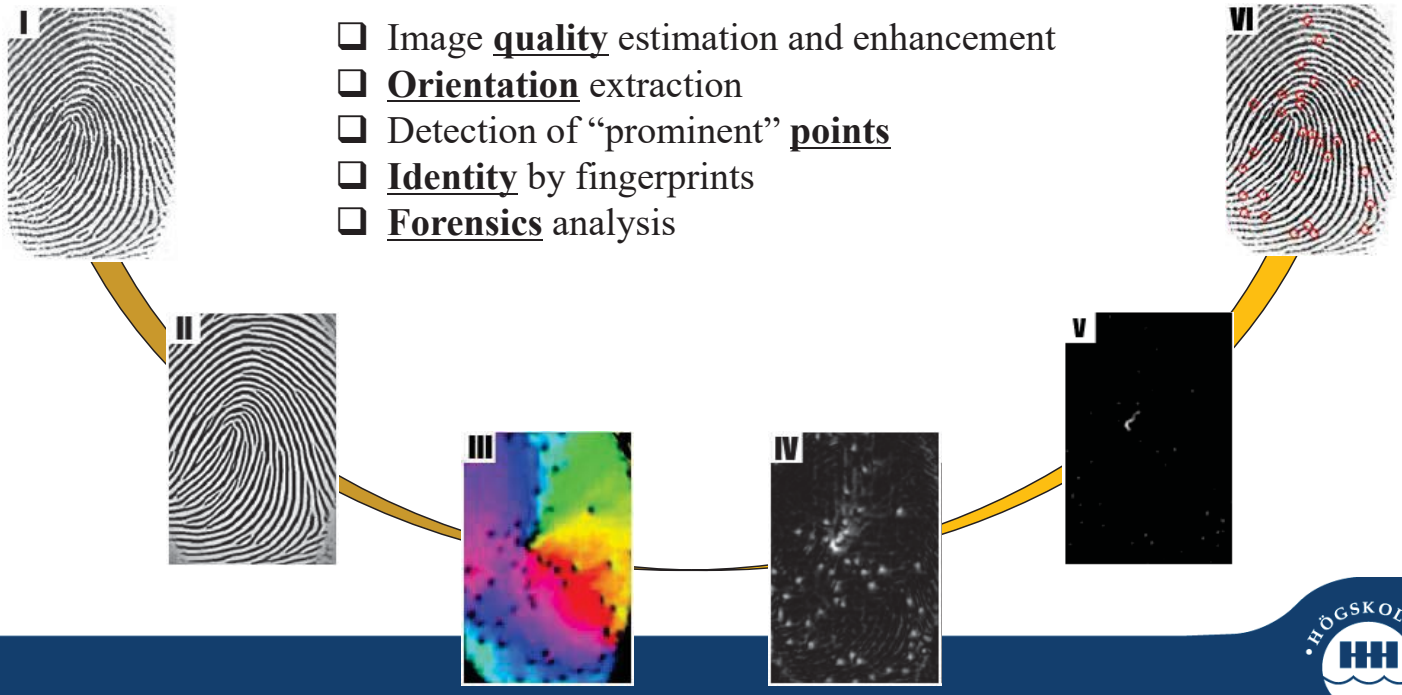
MARIE CURIE ACTIONS

cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

And research in topics including:

- Fingerprints, iris, face, lip-motion
- Quality analysis
- Multibiometrics
- Liveness detection

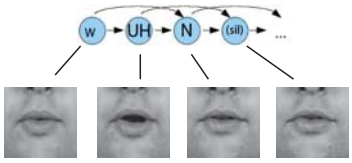
Fingerprints

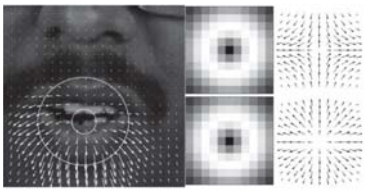


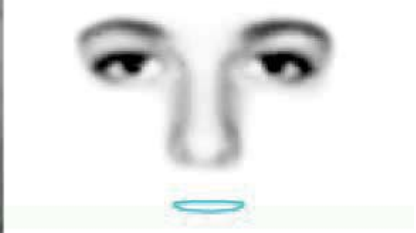
- ❑ Image **quality** estimation and enhancement
- ❑ **Orientation** extraction
- ❑ Detection of "prominent" **points**
- ❑ **Identity** by fingerprints
- ❑ **Forensics** analysis

Lip Motion Analysis

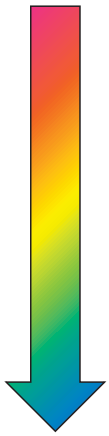
- Lip-motion dynamics
- **Use:**
  - Person recognition
  - Liveness assessment
  - Lip-reading, speech analysis
  - Avatar emulation (face synthesis)



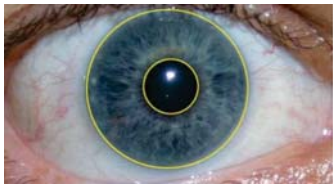




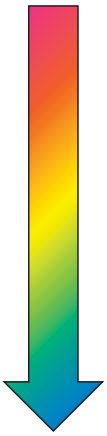
Personal Recognition based on Facial Information



- **Iris Analysis**
- **Periocular Analysis**
- **Face Analysis**



Personal Recognition based on Facial Information



- **Iris Analysis**
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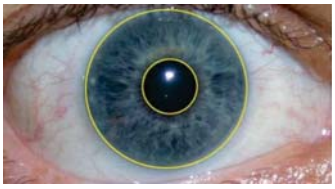
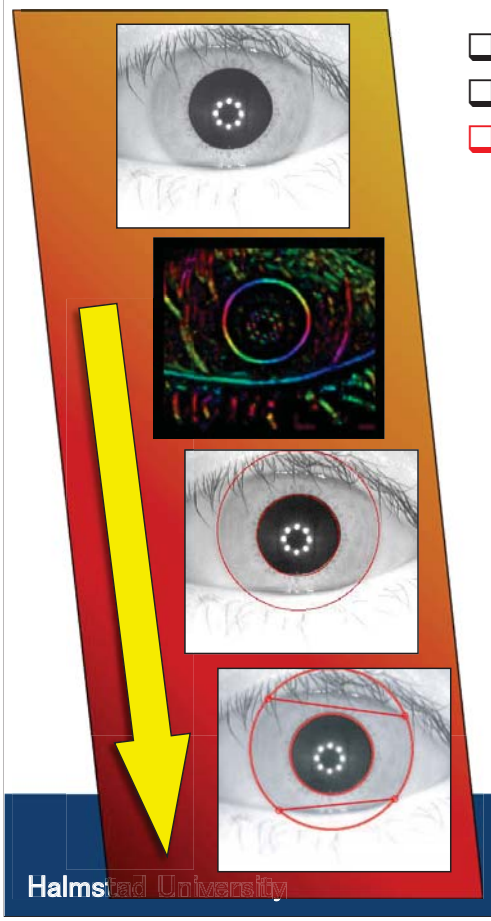
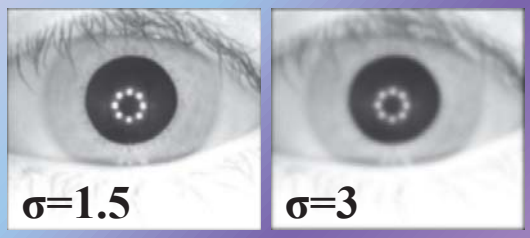


Iris Analysis

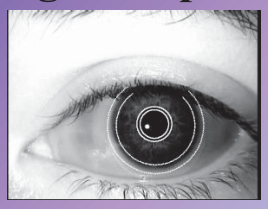


- ❑ Iris **detection** and **segmentation**
- ❑ Image **quality** analysis
- ❑ **Identity** by iris

defocus blur



Edge sharpness



Pupil: 40.17
Sclera: 99.77

Gray level variability

high (0.78) **low (0.29)**

Iris Segmentation using Symmetry Filters (GST)

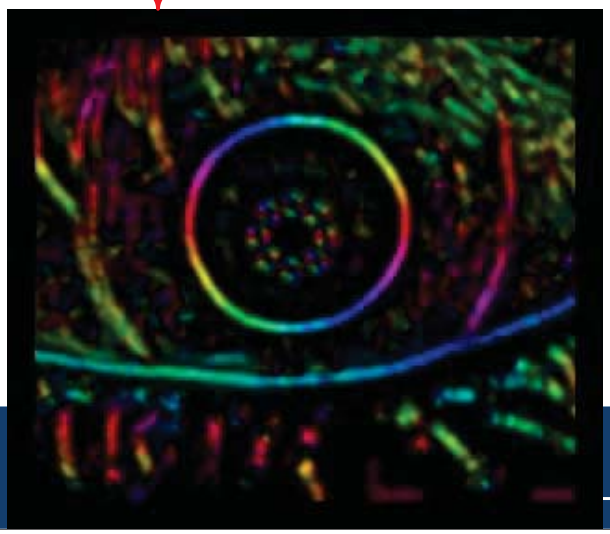
Hue: direction
Saturation: magnitude

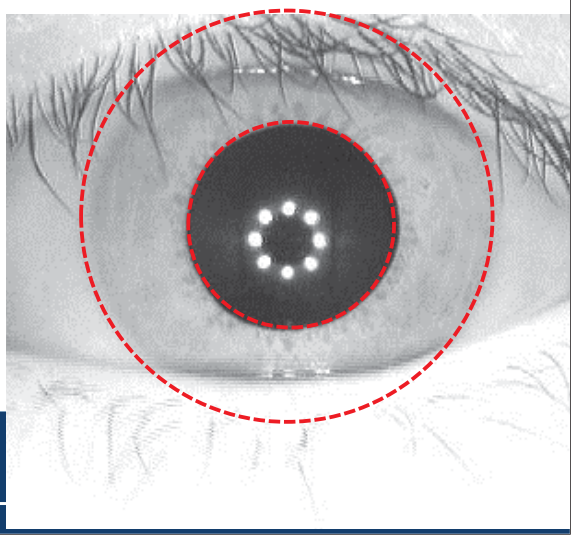
The Generalized Structure Tensor (GST)

- GST is a feature matrix/vector that can be represented by one complex, I_{20}, and one real valued, I_{11}, measurement:

$$I_{20} = \sum_p c[p]\left(f_x[p] + if_y[p]\right)^2 \qquad I_{11} = \sum_p \left|c[p]\right|\left|\left(f_x[p] + if_y[p]\right)^2\right|$$

(complex) circular filter





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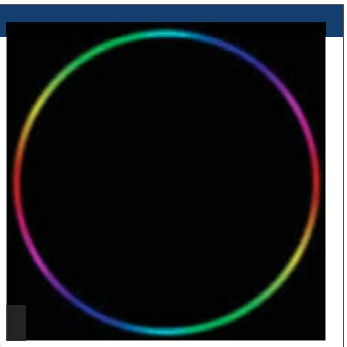
Iris Segmentation using the GST



The Generalized Structure Tensor (GST)

- The circular filter is an example of **symmetry filters**, designed to detect points with certain symmetry (circular, parabolic, linear…)
  - Magnitudes I_{20} and I_{11} encode the evidence of the sought symmetry
  - Apart from **correlation of edge magnitudes**, the filter takes into account the **direction of edges** (by encoding its expected orientation), so any disagreement in the direction will be penalized
    - Not exploited by other edge-based methods (Daugman, Wildes)

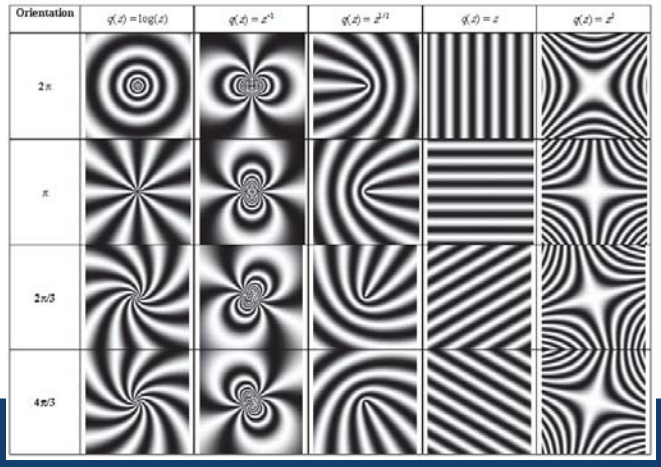
      → All boundary pixels contribute equally (**do not penalize**) the detection of circles

Fernando Alonso-Fernandez (feralo@hh.se)

Detection Tasks Using Symmetry Filters

Symmetry filters: family of filters (computed from symmetry derivatives of Gaussians) to detect **position and orientation of symmetric patterns** such as lines, circles, parabolas, stars…

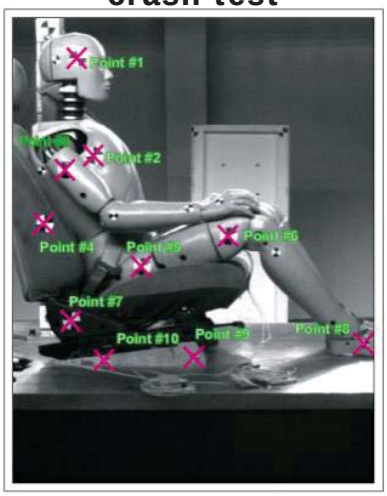
- For each family of symmetric patterns, there is an **appropriate symmetry filter** suitable to detect the **whole family**
- The maximum in the filter response (magnitude of I_{20}) gives **evidence** of the sought symmetry pattern, and the argument of I_{20} at maxima locations gives the **orientation** of the pattern



Detection Tasks Using Symmetry Filters

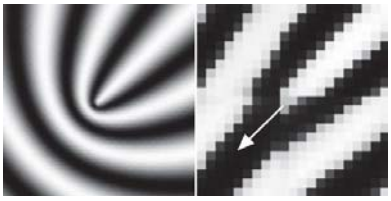
Symmetry filters have been successfully applied to a wide range of detection tasks

crash test



robot tracking

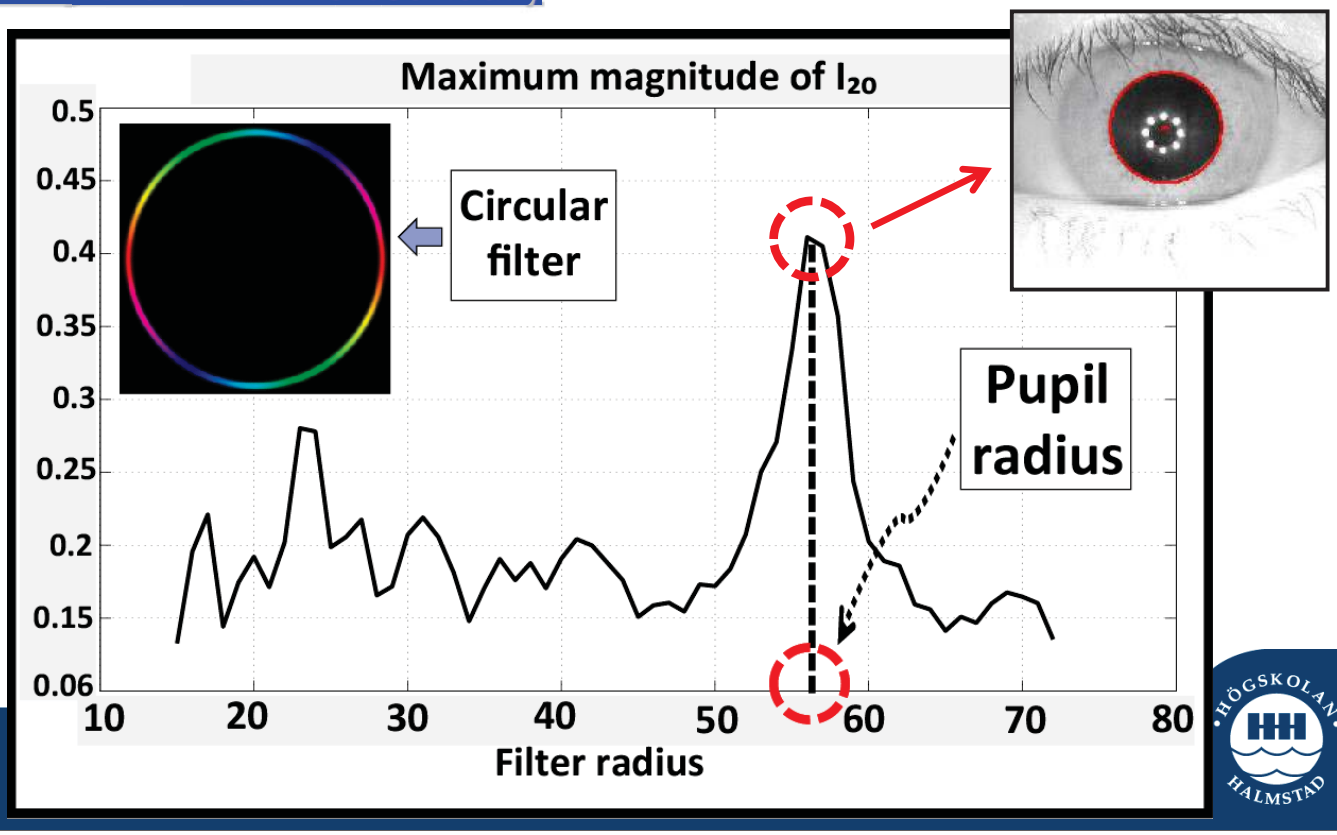
Fingerprint minutiae



Iris Segmentation using the GST

$$I_{20} = cf * \left(\frac{\partial I}{\partial x} + i \frac{\partial I}{\partial y} \right)^2$$

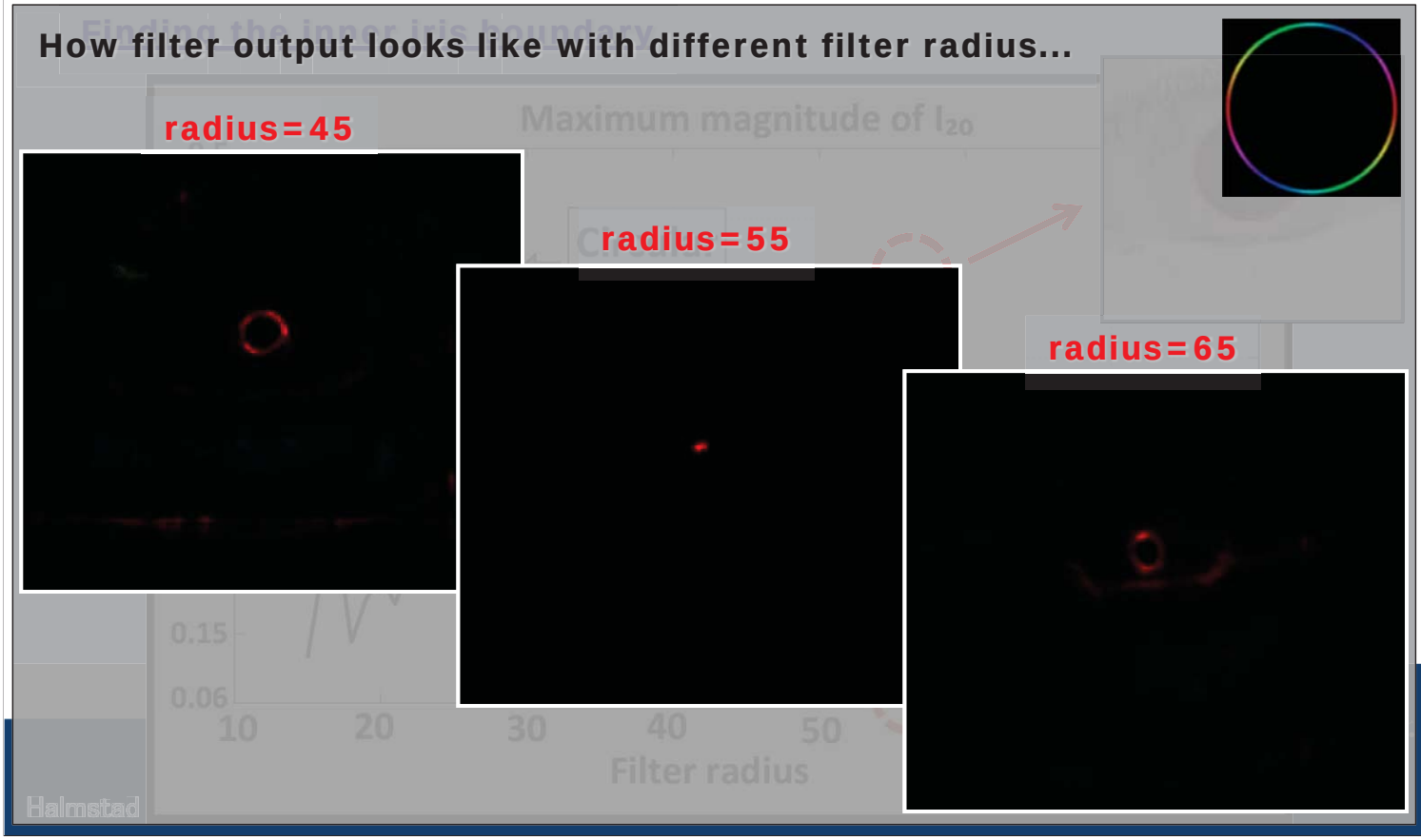
Finding the inner iris boundary



Iris Segmentation using the GST

$$I_{20} = cf * \left(\frac{\partial I}{\partial x} + i \frac{\partial I}{\partial y} \right)^2$$

How filter output looks like with different filter radius...



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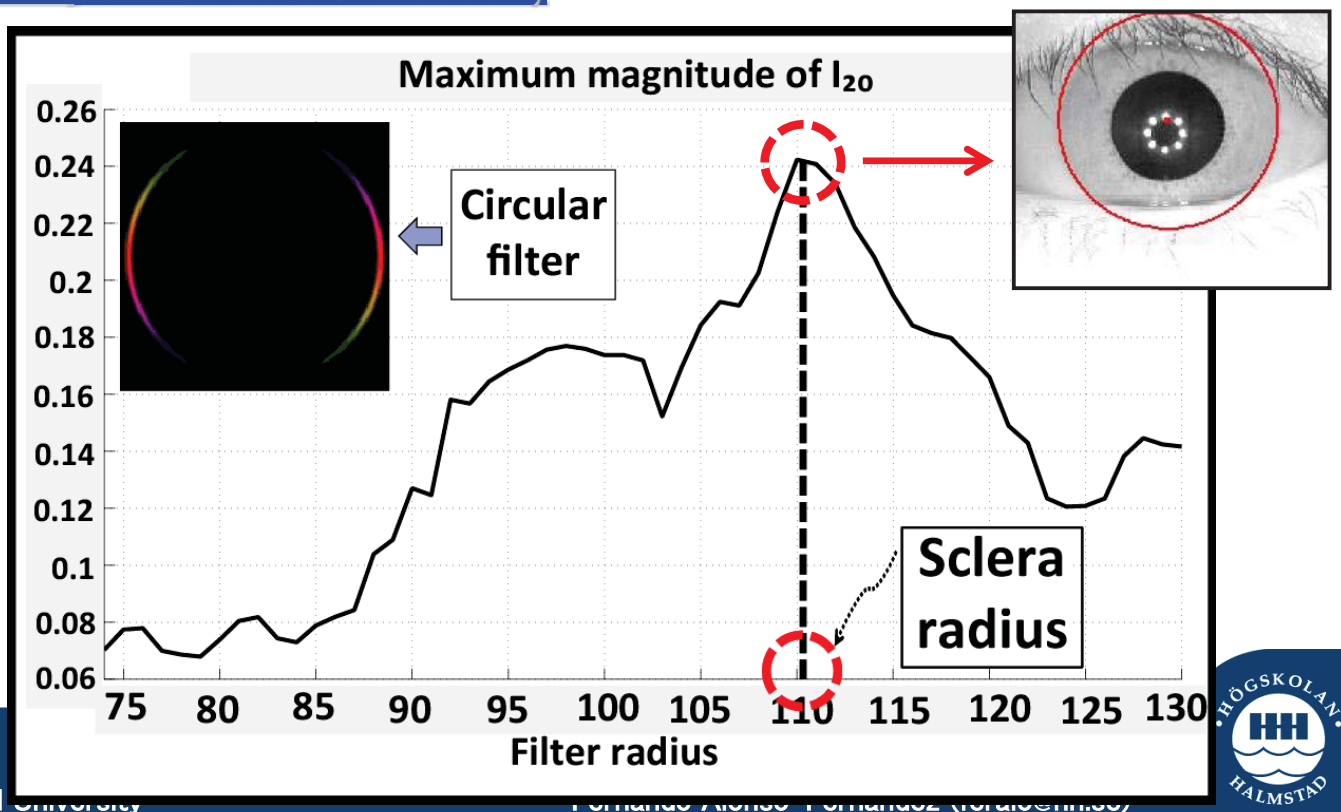
Iris Segmentation using the GST

$$I_{20} = cf * \left(\frac{\partial I}{\partial x} + i \frac{\partial I}{\partial y} \right)^2$$

Finding the outer iris boundary

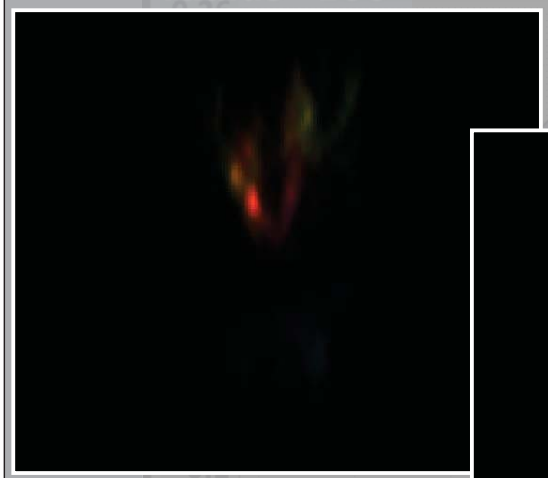


Iris Segmentation using the GST

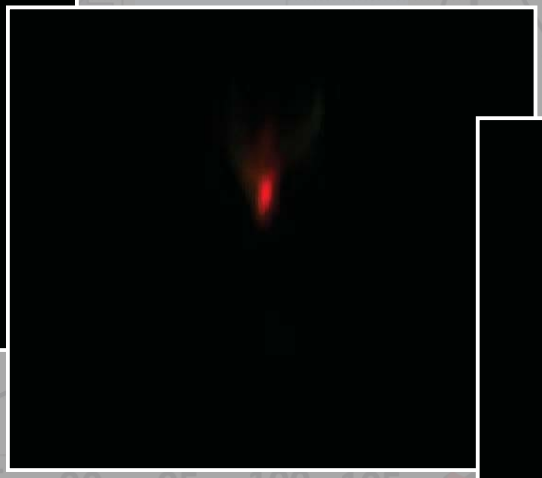
$$I_{20} = cf * \left(\frac{\partial I}{\partial x} + i \frac{\partial I}{\partial y} \right)^2$$

How filter output looks like with different filter radius...

radius=100

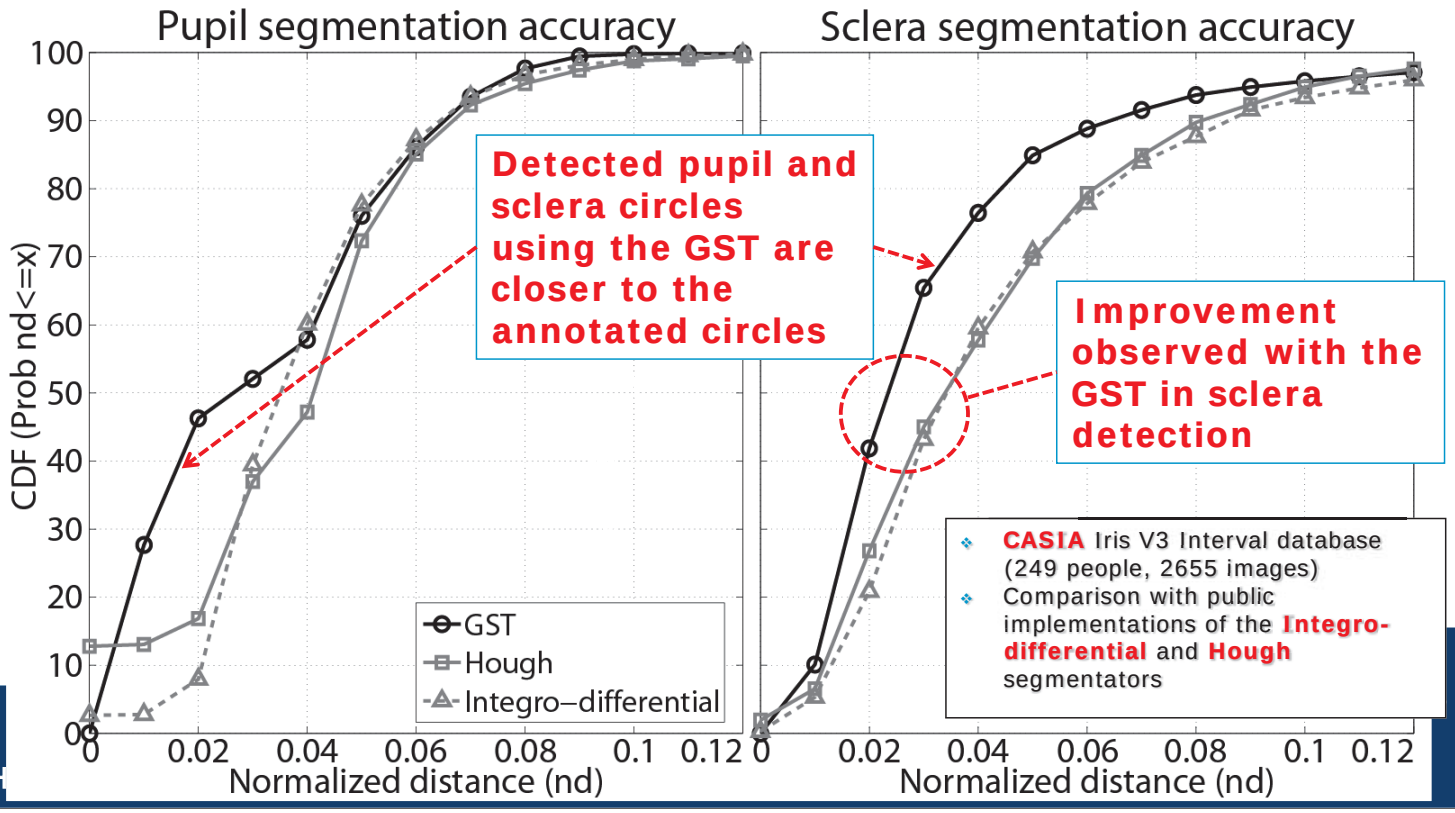


radius=110

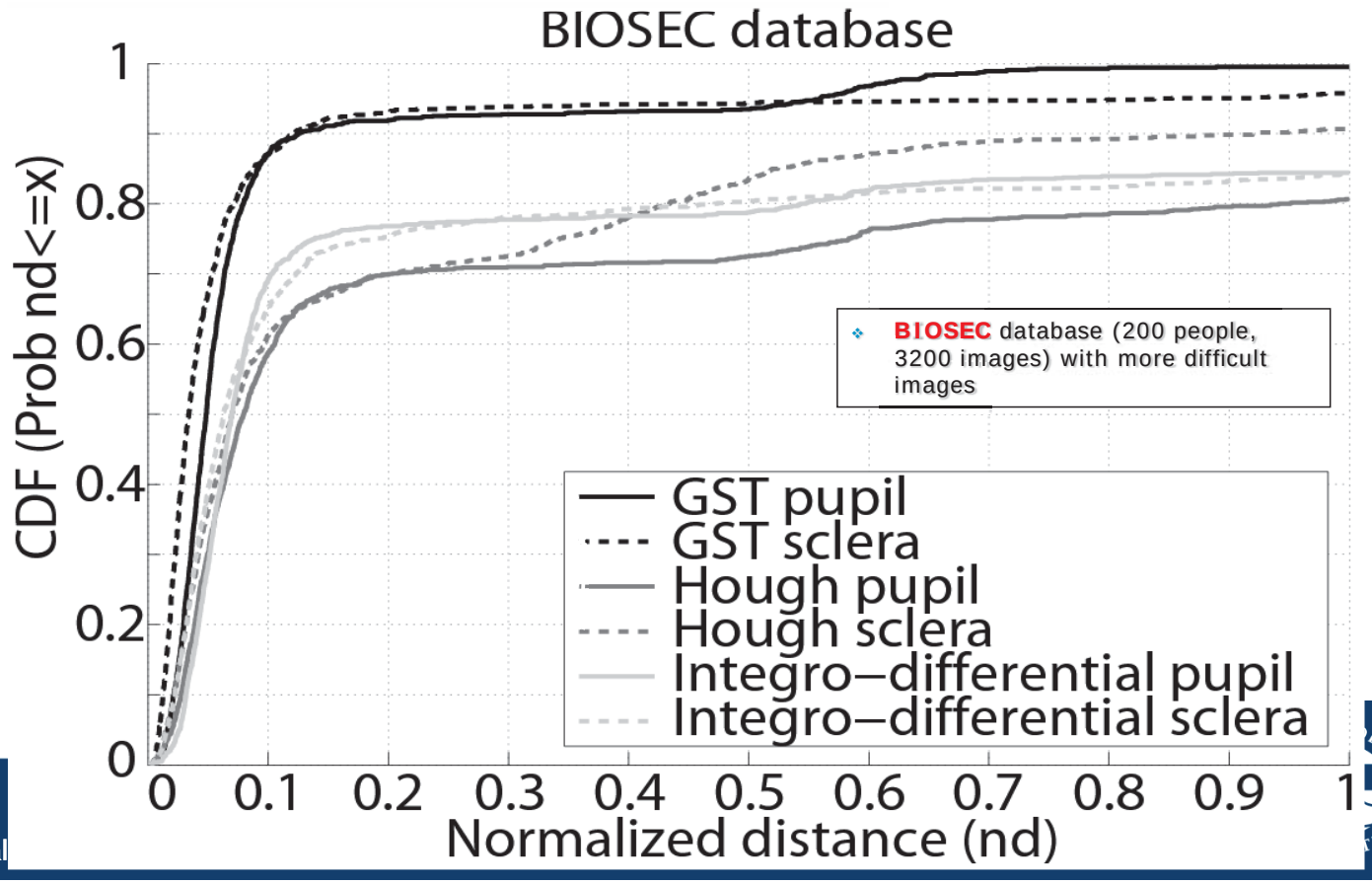


radius=120

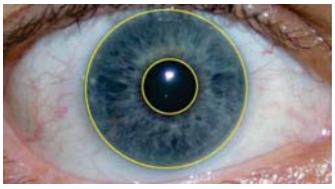
Iris Segmentation using the GST



Iris Segmentation using the GST



Personal Recognition based on Facial Information



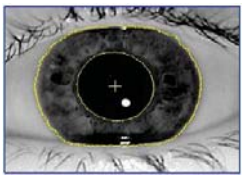
- Iris Analysis
- **Periocular Analysis**
- Face Analysis

Periocular Analysis

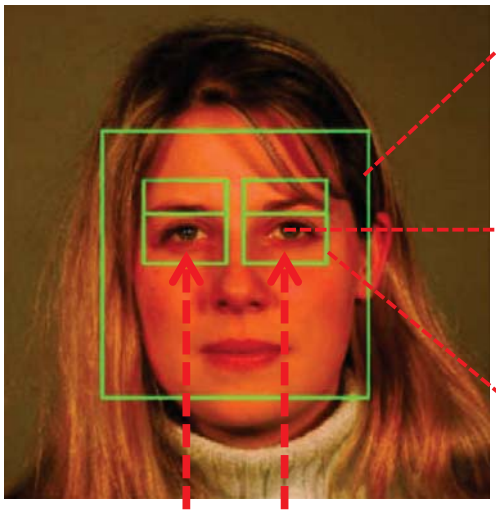
Levels of facial analysis:

"Far": whole face
- Occlusion, lightning, background…
- Unavoidable in some applications (forensics, mobile devices…)

"Close": iris texture
- Reliable acquisition (resolution, off-angle…)
- Works better in NIR range



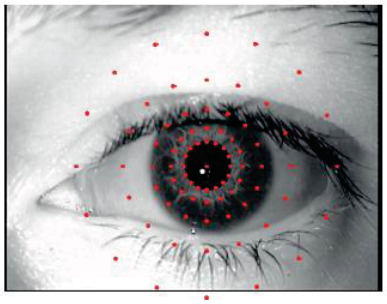
"Medium": periocular
- Available over a wide range of distances, even when the iris texture cannot be reliably obtained or under partial facial occlusion
- …and with existing face/iris acquisition setups
- Relaxation of user cooperation
- Revived attention (mobile devices, distant acquisition, surveillance…)



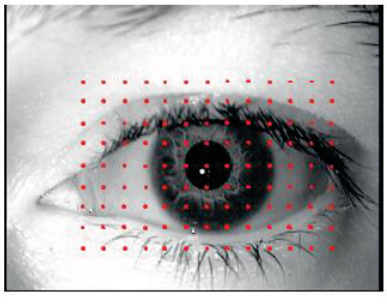
PERIOCULAR REGION
face region in the immediate vicinity of the eye
(including eyes, eyelids, eyelashes and eyebrows)

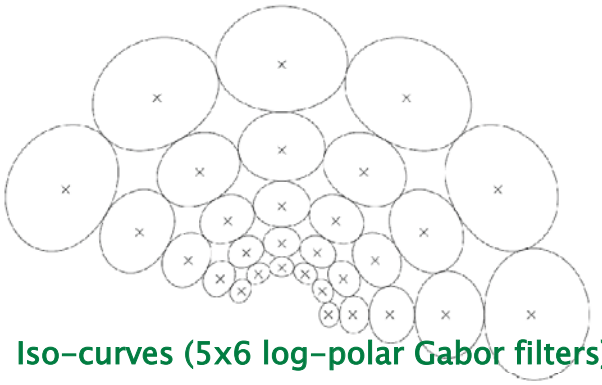
Periocular recognition using retinotopic sampling and Gabor decomposition of the spectrum

Circular sampling



Rectangular sampling





Iso-curves (5x6 log-polar Gabor filters)

- **Databases**: CASIA (249 people, 2655 images), BioSec (200 people /3200 images)
- **Sampling grid:**
  - Circular vs. square
  - Fixed vs. variable dimensions
- **Matching using Gabor decomposition**:
  - Magnitude vs. phase information from complex responses
  - Rotation compensation between test and query images

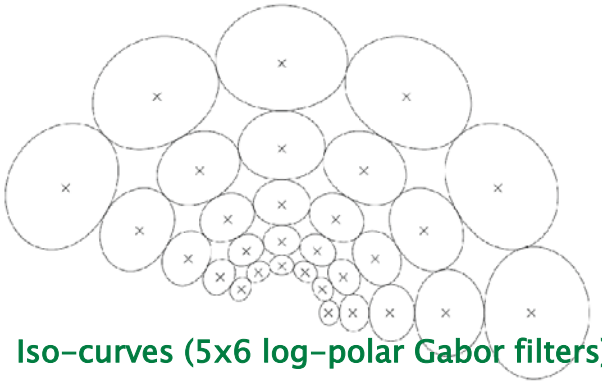
What's in a Face? ECCV 2012 Workshop

ECCV 2012

Periocular recognition using retinotopic sampling and Gabor decomposition of the spectrum

Circular sampling

Rectangular sampling



Iso-curves (5x6 log-polar Gabor filters)

- **Best figures**: EER = 5.7% (CASIA) and 13.9% (BioSec, intersession)
- **Competitive** in comparison with results reported in the literature for other approaches:
  - LBPs: 19%
  - GO: 22%
  - SIFT: 7%

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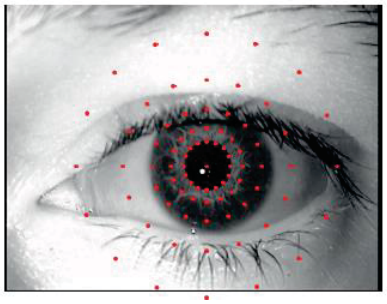
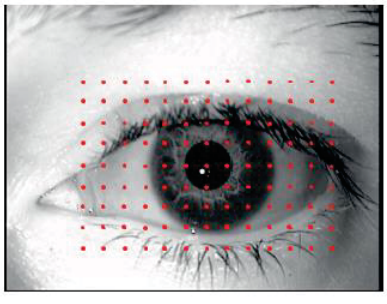
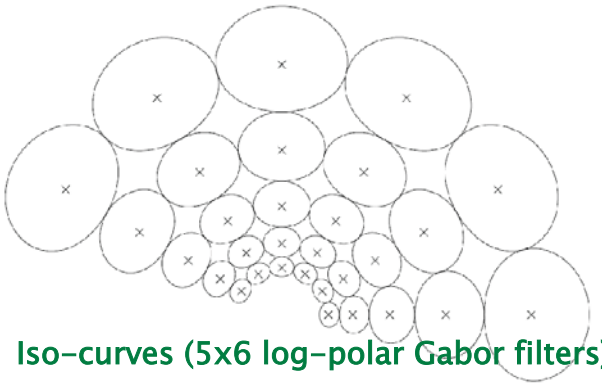
Periocular recognition using retinotopic sampling and Gabor decomposition of the spectrum

Circular sampling



Rectangular sampling





Iso-curves (5x6 log-polar Gabor filters)

- **Other interesting outcomes**:
  - **Rotation compensation** during matching can be suppressed without sacrificing recognition accuracy
  - Performance is not substantially affected with grids of **fixed dimensions** -> no accurate iris segmentation needed, only the center of the eye

What's in a Face? ECCV 2012 Workshop

ECCV 2012

Periocular recognition using retinotopic sampling and Gabor decomposition of the spectrum

Circular sampling

Rectangular sampling

Iso-curves (5x6 log-polar Gabor filters)

- **Current directions**:
  - **Detection** of the periocular region
  - Applicability to less-constrained conditions, where **accurate detection** of the iris and/or its position is not guaranteed

What's in a Face? ECCV 2012 Workshop

ECCV 2012

Halmstad University Fernando Alonso-Fernandez (feralo@hh.se)

First ICB Competition on Iris Recognition

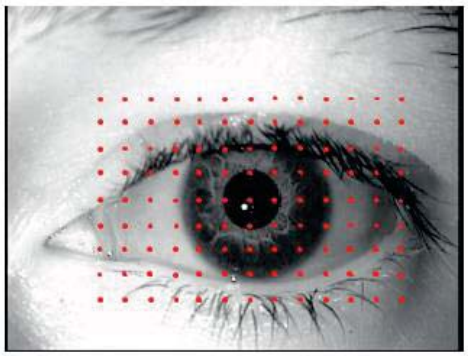
Submission based on:

- Pupil boundary detection (only) using the presented GST segmentation system
- Recognition by fusion of:
  - Periocular system described and
  - SIFT keypoints

Fig. 1. Example of iris images from the ICIR2013 training database (CASIA-Iris-Thousand).

Fig. 2. Example of iris images from the ICIR2013 testing database (IR-TestV1).

Rectangular sampling



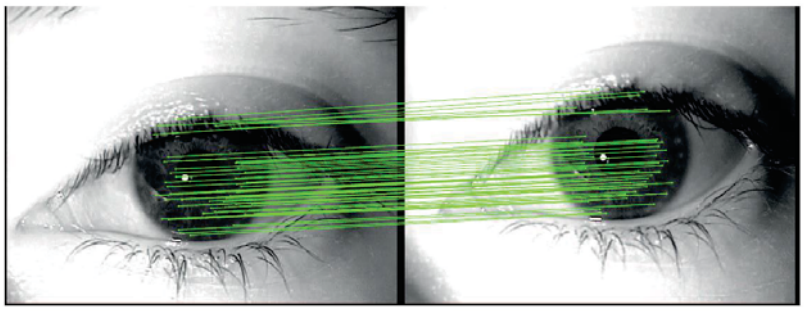


Fig. 7. Matching of two iris images using the SIFT operator.

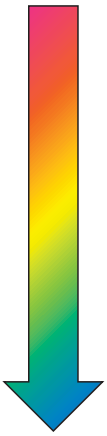
First ICB Competition on Iris Recognition

Testing Results of The First ICB Competition on Iris Recognition (ICIR2013)

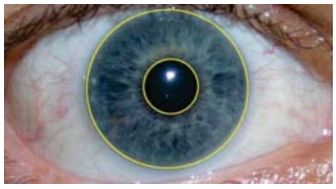
Rank	Developers	Organization	Country	FNMR@ FMR=0.0001	EER
1	Wu Su	Zhuhai YiSheng Electronics Technology Co. Ltd	China	7.09%	2.75%
2	Fernando Alonso-Fernandez Josef Bigun	University of Halmstad	Sweden	9.24%	3.19%
3	Stephane Derrode	Institut Fresnel (CNRS UMR 7149)	France	42.16%	9.33%

Number of participants: 8 developers from 6 countries **Number of algorithms: 13**

Personal Recognition based on Facial Information

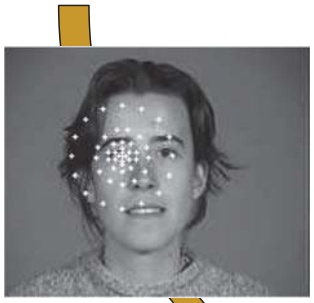


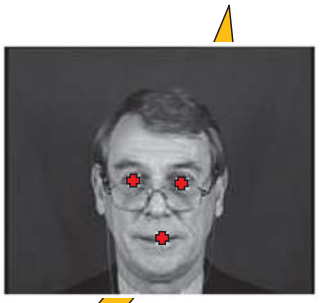
- Iris Analysis
- Periocular Analysis
- **Face Analysis**

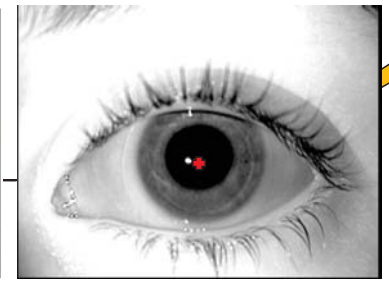


Facial Analysis

- Face and eye **detection**
- **Identity** by face



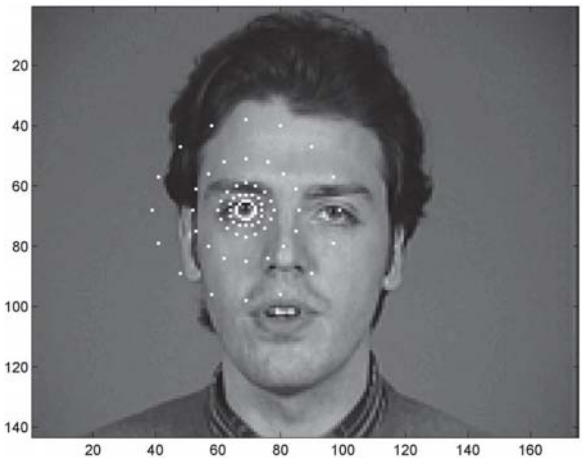


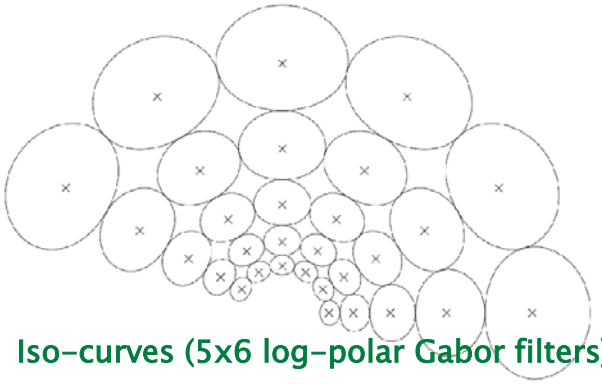


Face detection with retinotopic sampling

Local descriptors by averaging the Gabor responses from the **center** of the **eyes** and the **mouth** of a training dataset

- Vectors with orientation-selective responses for each frequency channel
- **Separate models** for each eye and the mouth



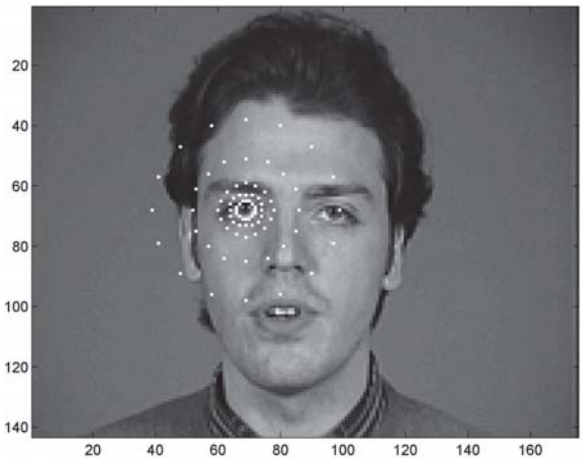


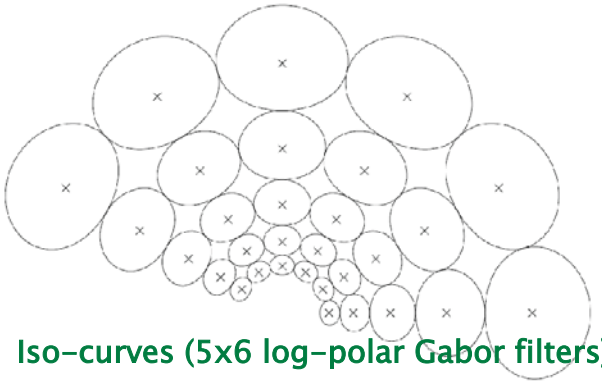
Iso-curves (5x6 log-polar Gabor filters)

Face detection with retinotopic sampling

Biological analogy of this model

- Eyes and mouth are the main regions of interest for the brain
- Photoreceptors in the retina are arranged exponentially, with more focus of attention (~photoreceptors) in the center
- The Gabor decomposition mimic the simple cells of the primary visual cortex having the same receptive field but different spatial directions and frequencies



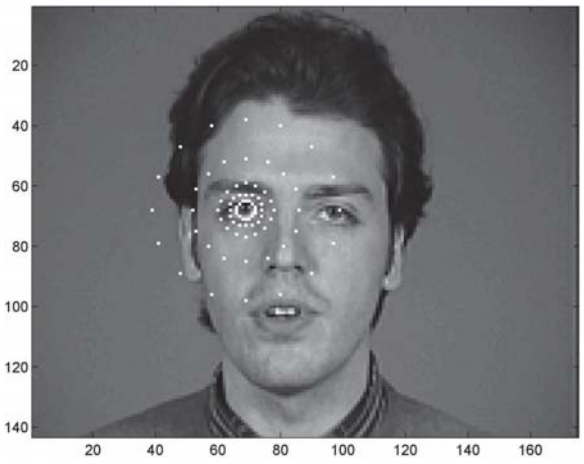


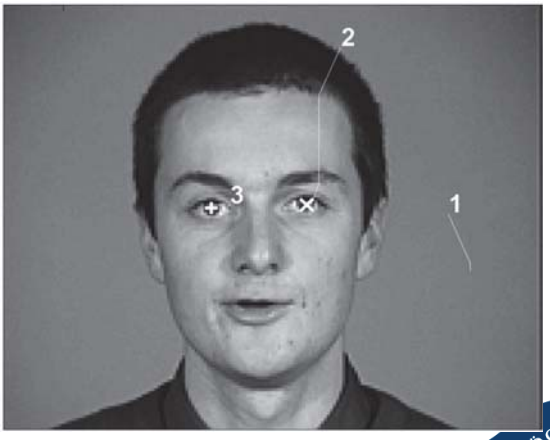
Iso-curves (5x6 log-polar Gabor filters)

Face detection with retinotopic sampling

Saccadic search

- Humans do not explore the image in a raster-like fashion, instead, they perform rapid jumps (saccades) between regions of interest
- Search until convergence (maximum SVM response), which is finer as the maximum is approaching since the grid is denser at the center





Face detection with retinotopic sampling

Results with M2VTS (349 images) and XM2VTS (2388 images)

Frontal images, four sessions separated by a significant time interval

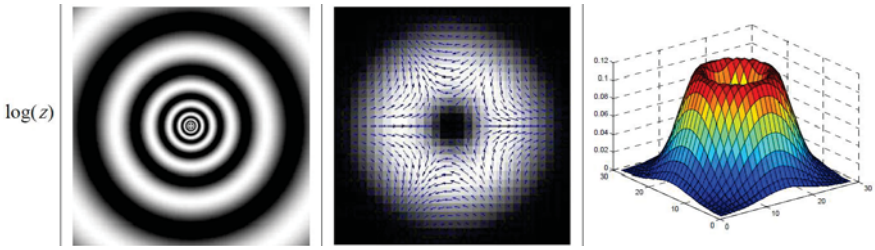
M2VTS:

- 1.4% images: misdetection of one eye
- 98.6%: all features detected

XM2VTS:

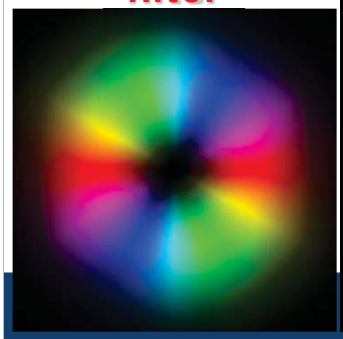
- 0.3% images: complete erroneous detection (no landmarks detected)
- 99.5% : at least two features detected
- 97.4%: all features detected

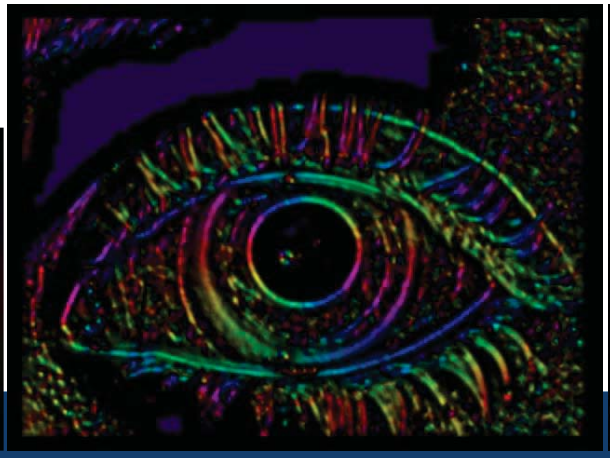
Eye detection using symmetry filters (GST)

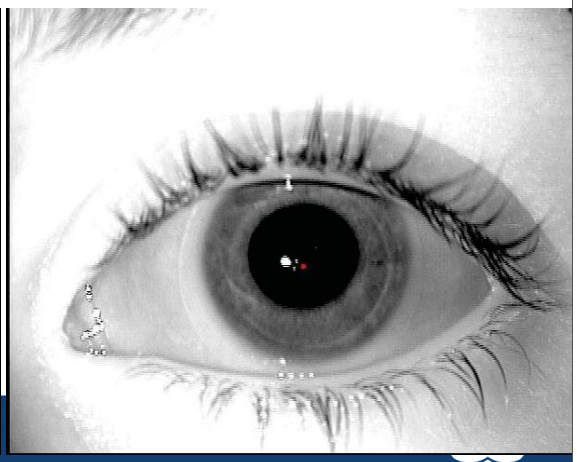


$$I_{20} = \sum_{p} c[p]\left(f_x[p] + if_y[p]\right)^2$$

(complex) filter

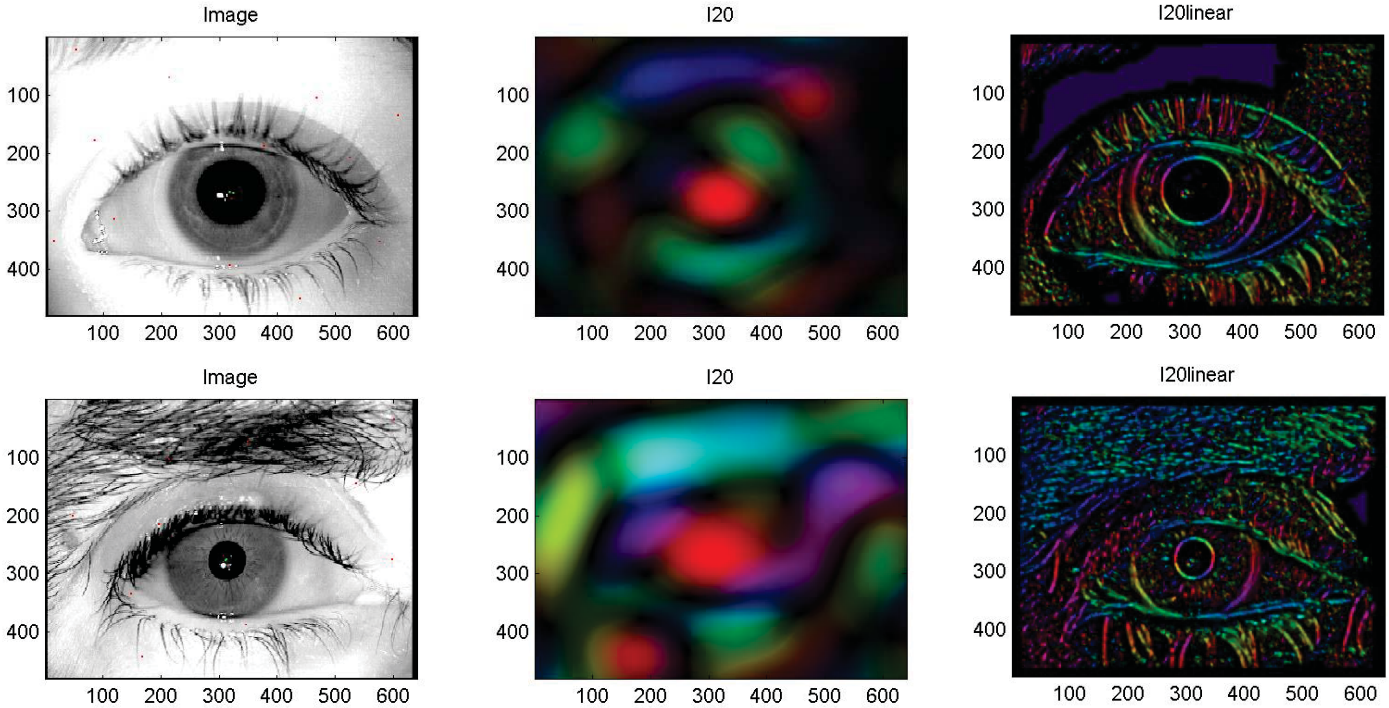






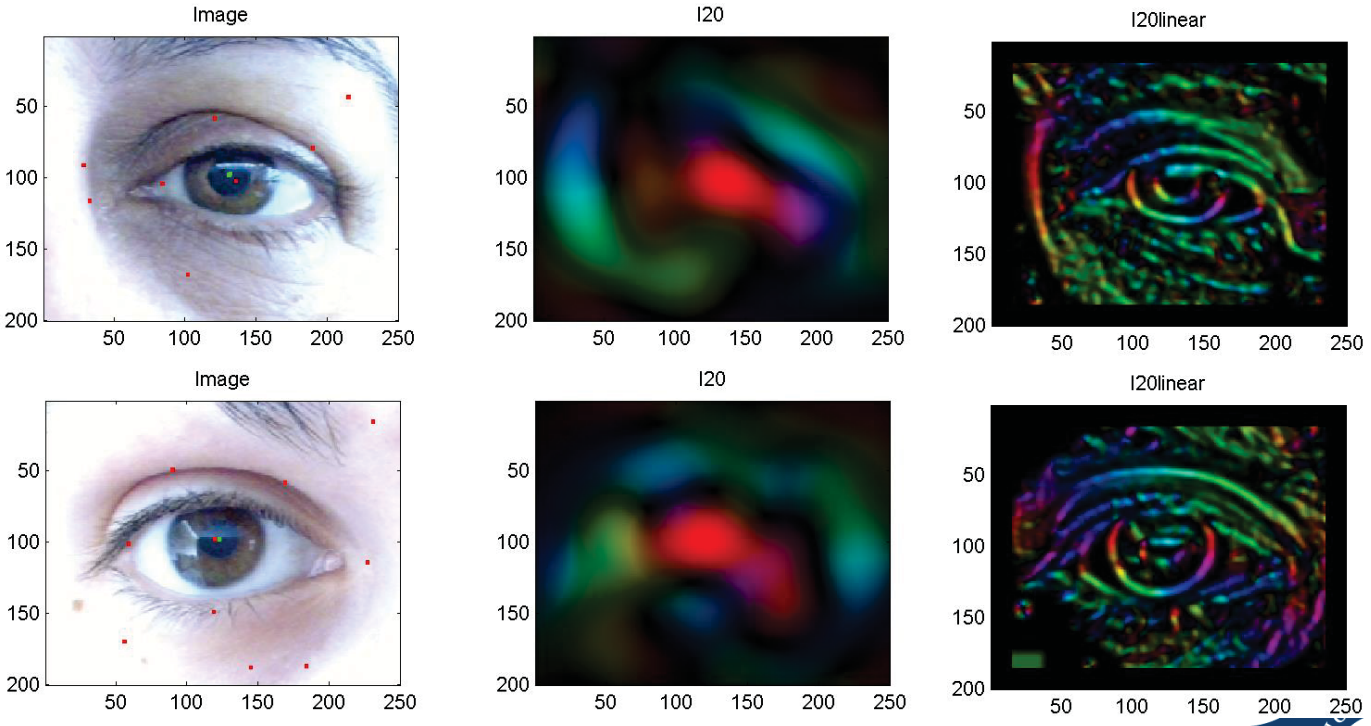
Eye detection using symmetry filters (GST)

Examples with BioSec: close-up NIR iris sensor



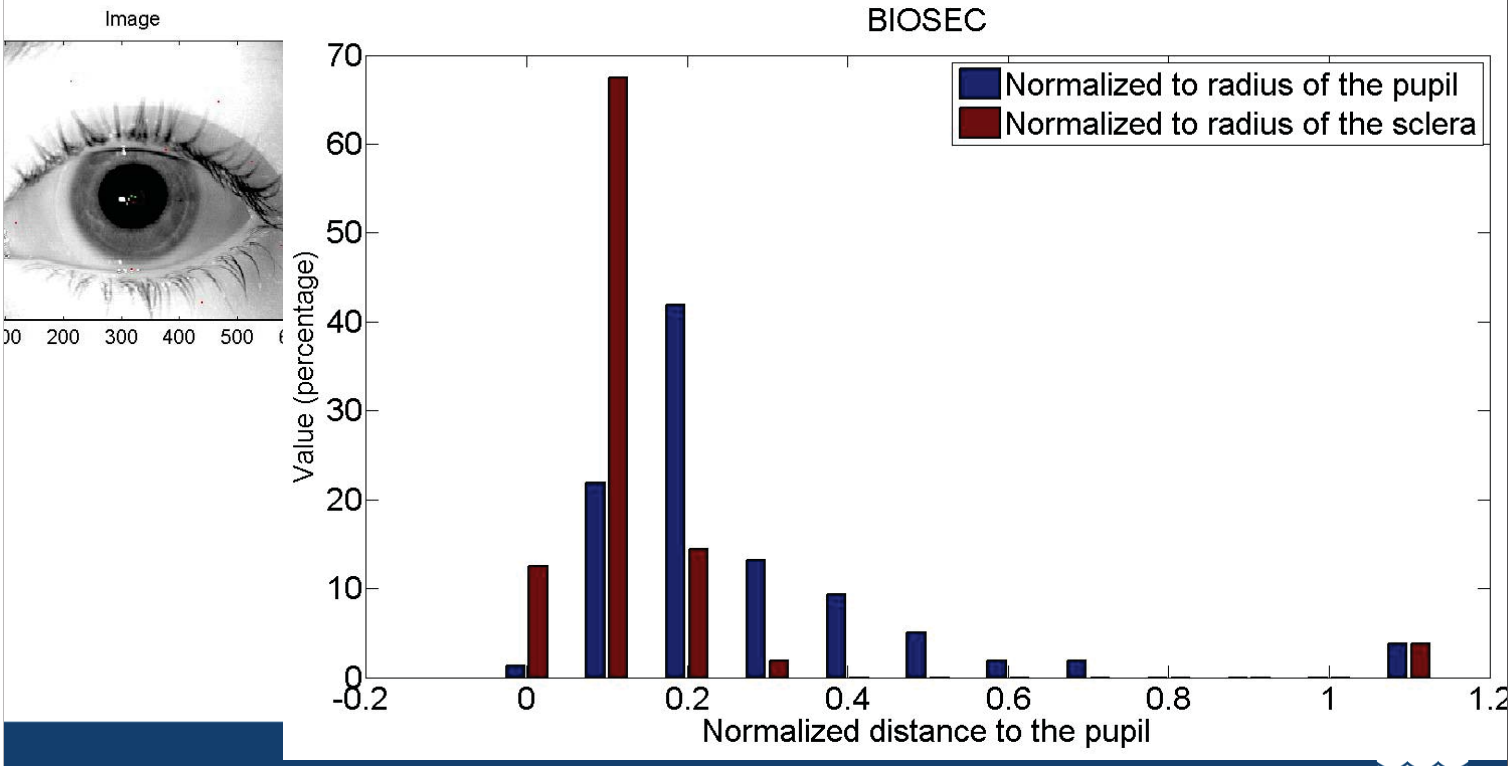
Eye detection using symmetry filters (GST)

Results with MobBIO: tablet PC webcam (visible range)



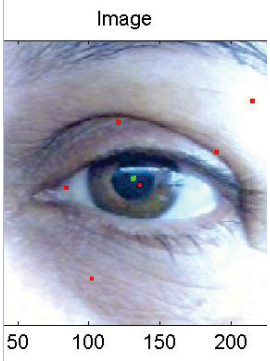
Eye detection using symmetry filters (GST)

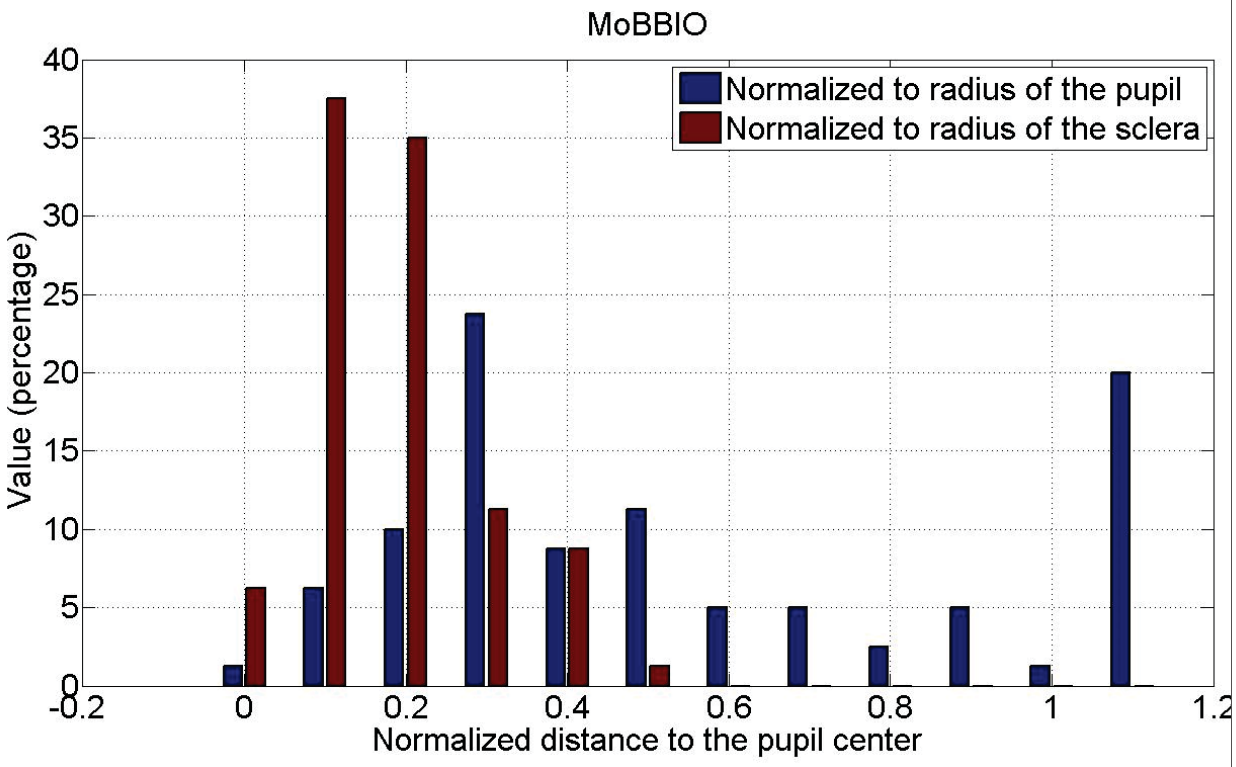
Results with BioSec (160 images): close-up NIR iris sensor



Eye detection using symmetry filters (GST)

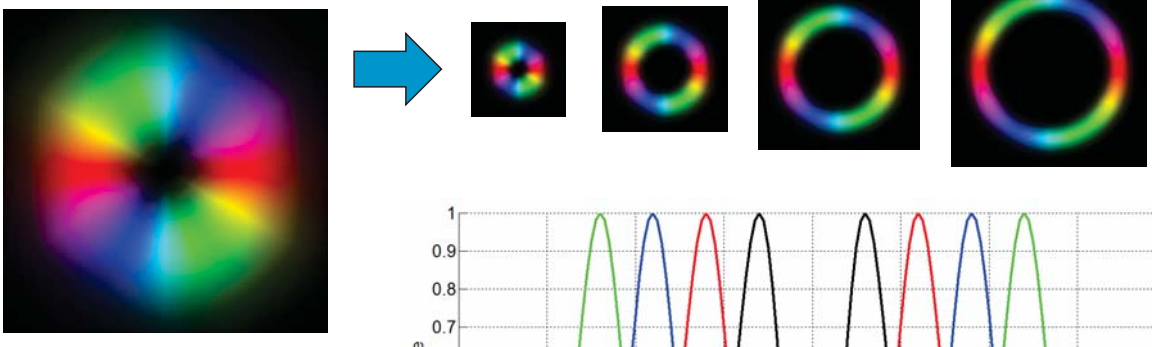
Results with MobBIO (80 images): tablet PC webcam (visible range)

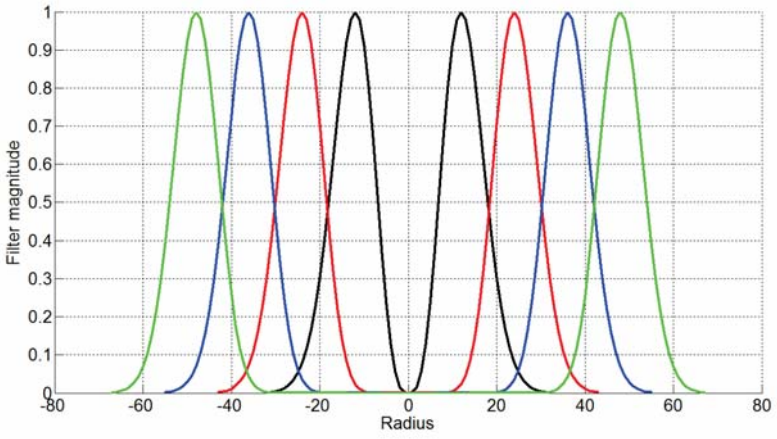




Eye detection using symmetry filters (GST)

On-going work: improving the selectivity of the filter with sub-bands

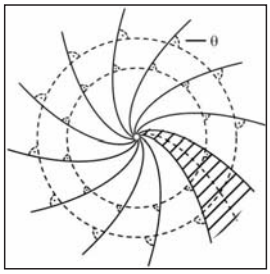


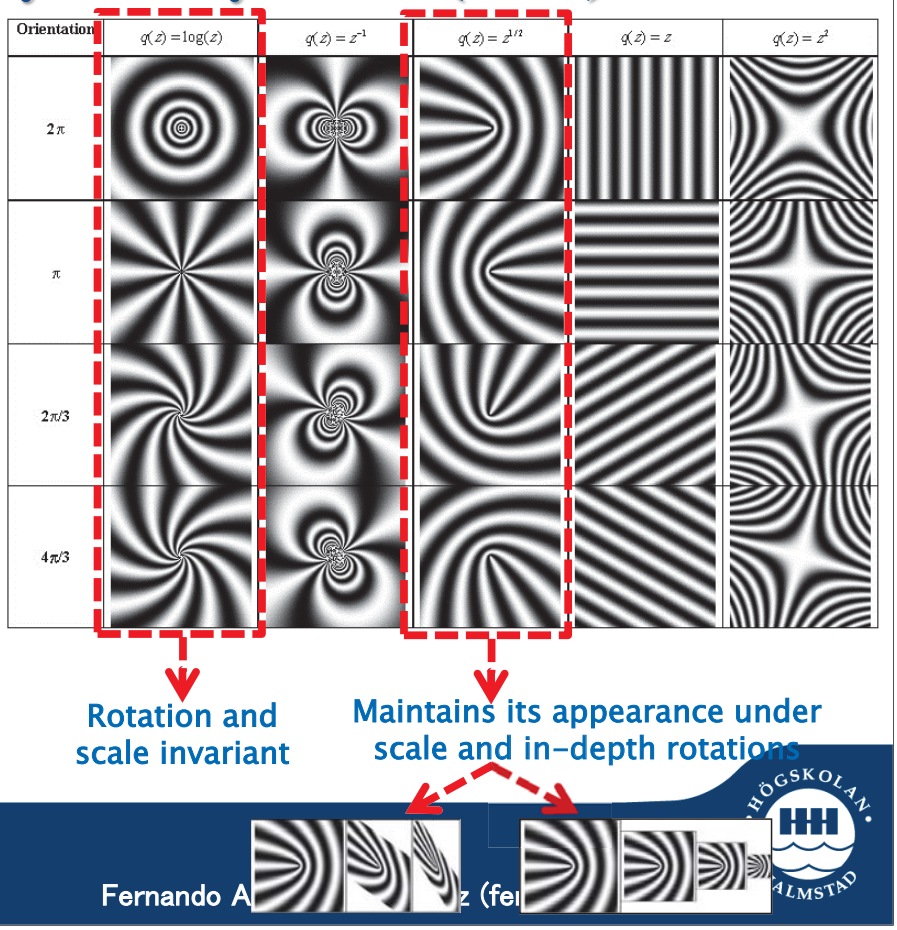


Face detection using symmetry filters (GST)

On-going work:

- use other families of symmetry filters resilient to different perturbations
- use full face images and detect other landmarks (nose, mouth)… separately
- use less-constrained images (low cost devices, difficult environment)

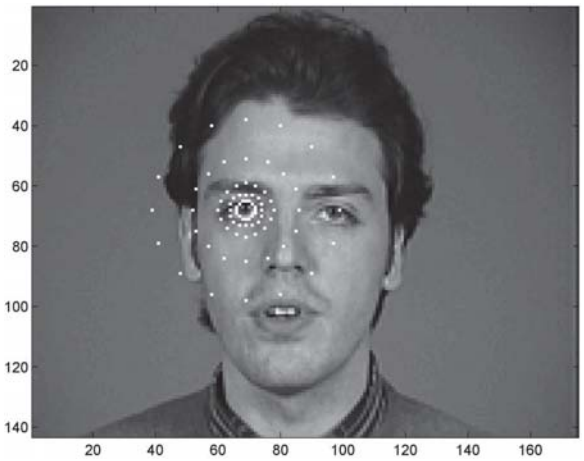


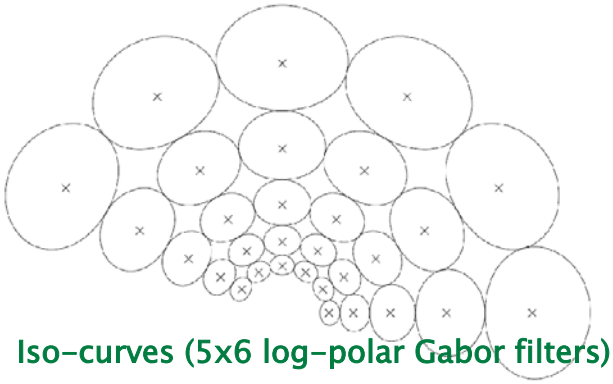


Face recognition using retinotopic sampling and Gabor decomposition of the spectrum

Same framework as presented for periocular recognition

- Three classifiers based on Gabor responses with the grid on the eyes and the mouth (tested NN, KNN and SVM)
- Expert fusion of the three classifiers



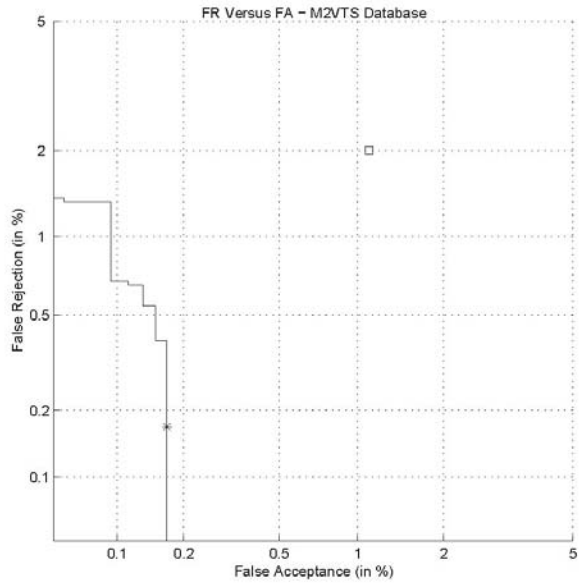


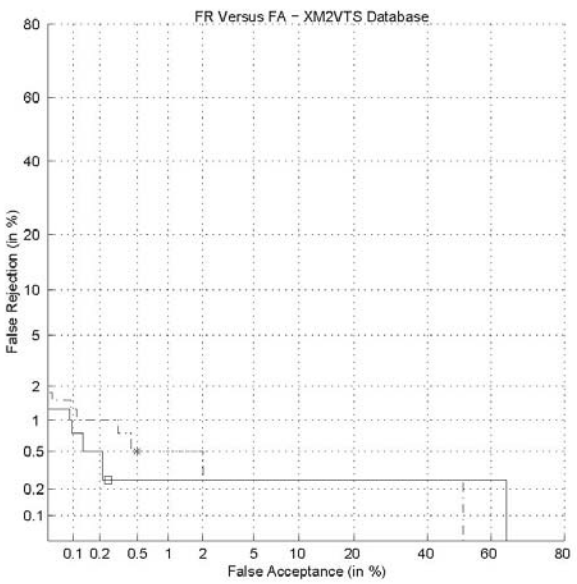
Iso-curves (5x6 log-polar Gabor filters)

Face recognition using retinotopic sampling and Gabor decomposition of the spectrum

Results with M2VTS (349 images) and XM2VTS (2388 images)

- **M2VTS:** EER=0.15% (three images per person for training)
- **XM2VTS**: EER=0.50%/0.25% (four/six images per person for training)





Halmstad University

Fernando Alonso-Fernandez (feralo@hh.se)

Personal Recognition Based on Facial Information

Research at Halmstad University, Sweden

Josef Bigun,
Professor, PhD

Fernando
Alonso-Fernandez
Postdoctoral
Researcher, PhD

Stefan Karlsson
Postdoctoral
Researcher, PhD

Kenneth Nilsson
Associate
Professor, PhD

Anna Mikaelyan
PhD student, MSc

Fernando Alonso-Fernandez (feralo@hh.se)