Iris Recognition III

CSE 40537/60537 Biometrics
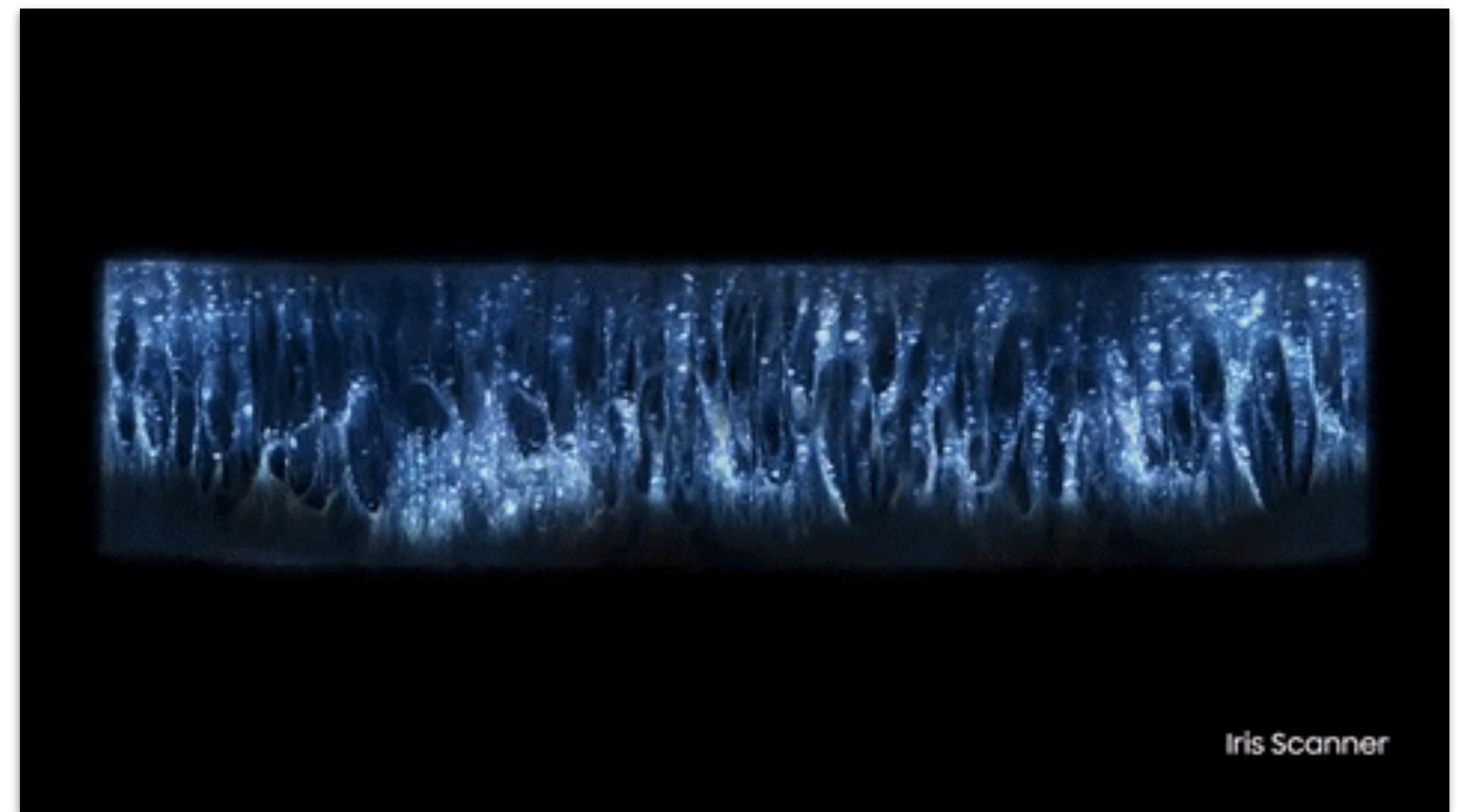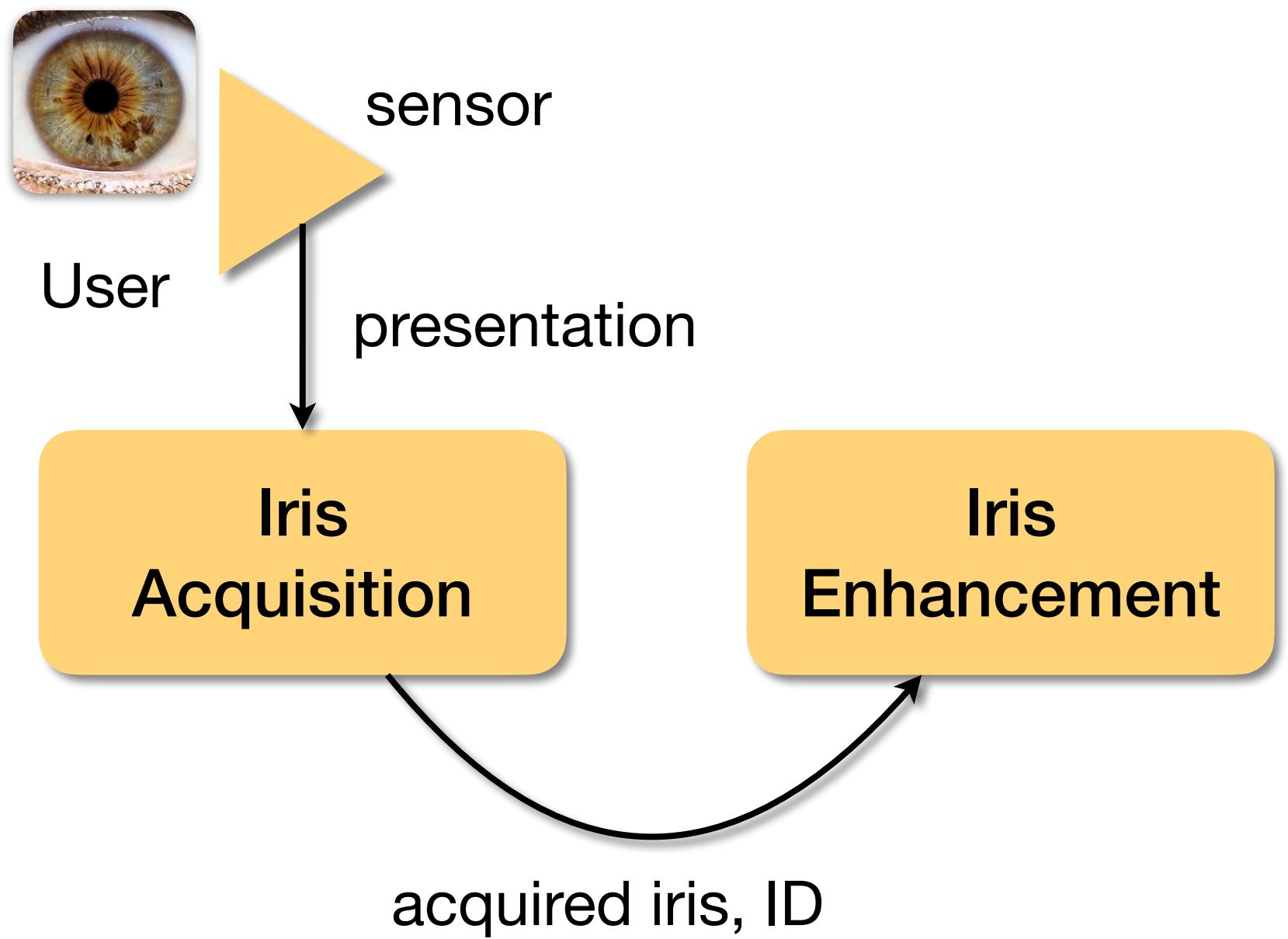
Daniel Moreira

Spring 2022

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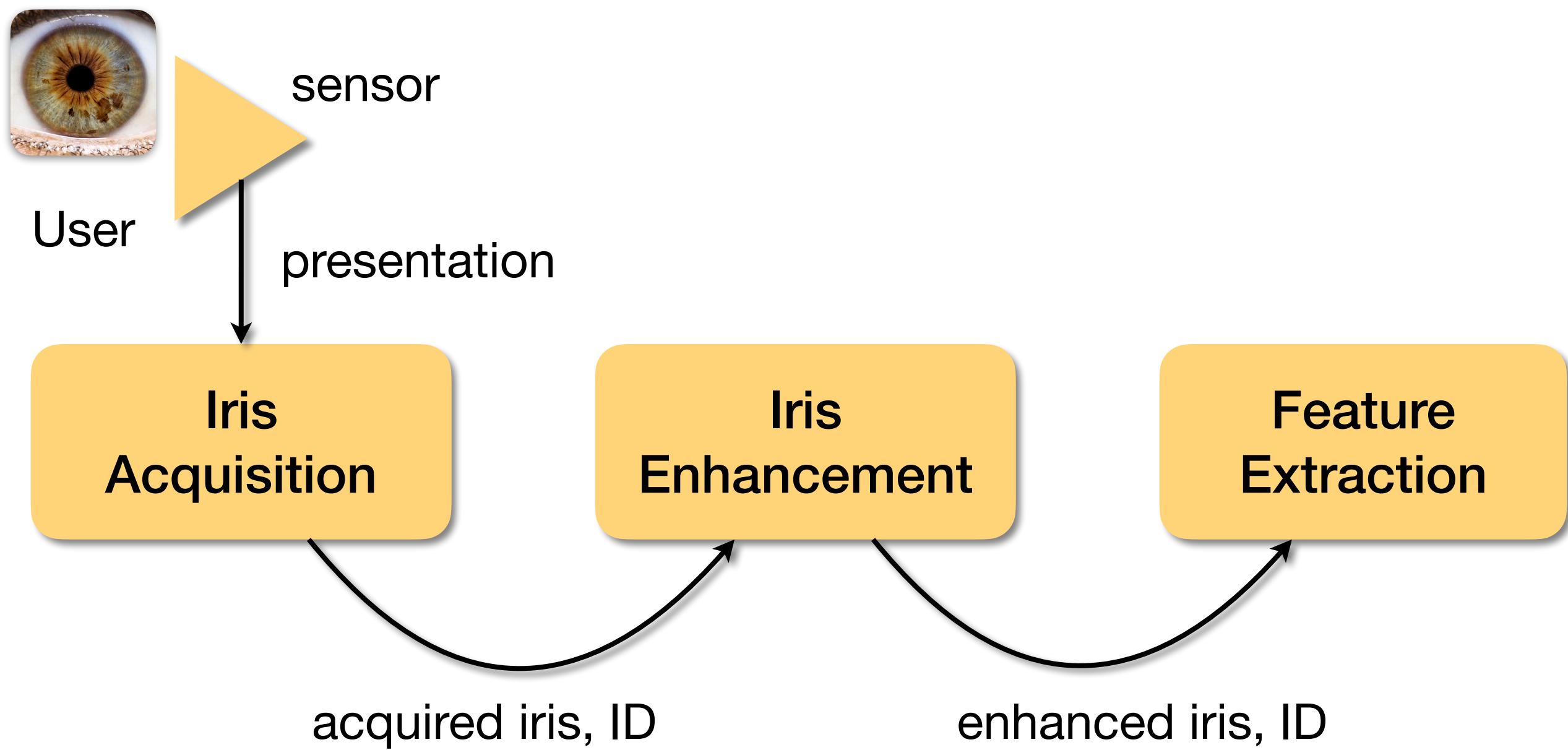
Today you will...

Get to know
Iris description and matching.

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Iris Recognition

sensor

User

presentation

Iris Acquisition

Iris Enhancement

acquired iris, ID

Iris Scanner

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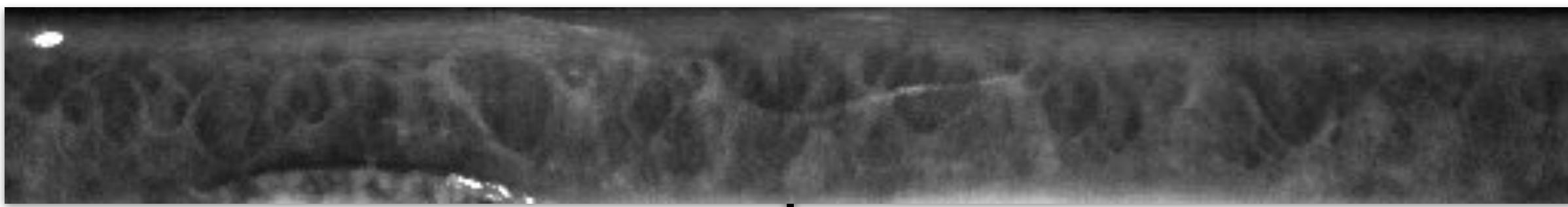
Iris Recognition
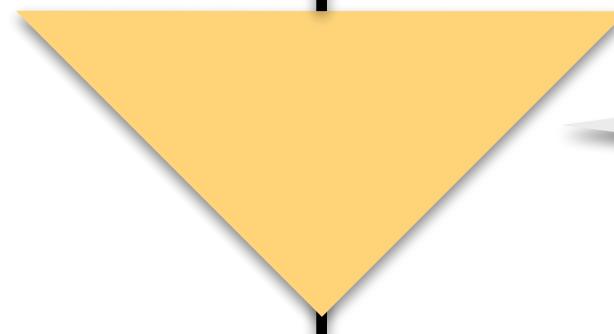
Feature Extraction

Typical Description Framework

normalized iris
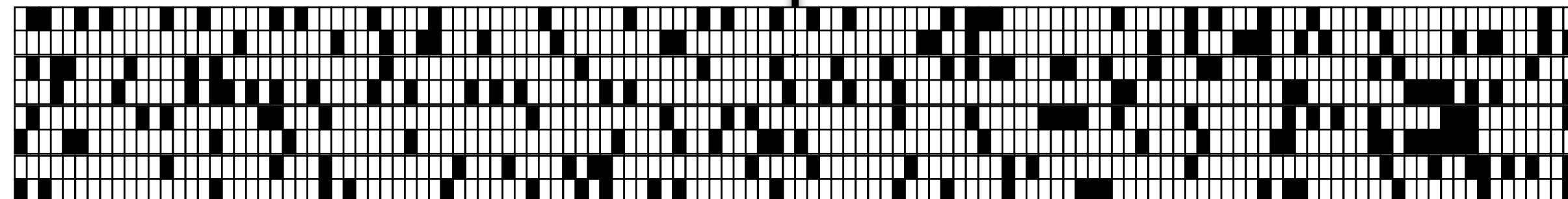
signal processing / image filters

Let's see 3 methods!

binary iris code
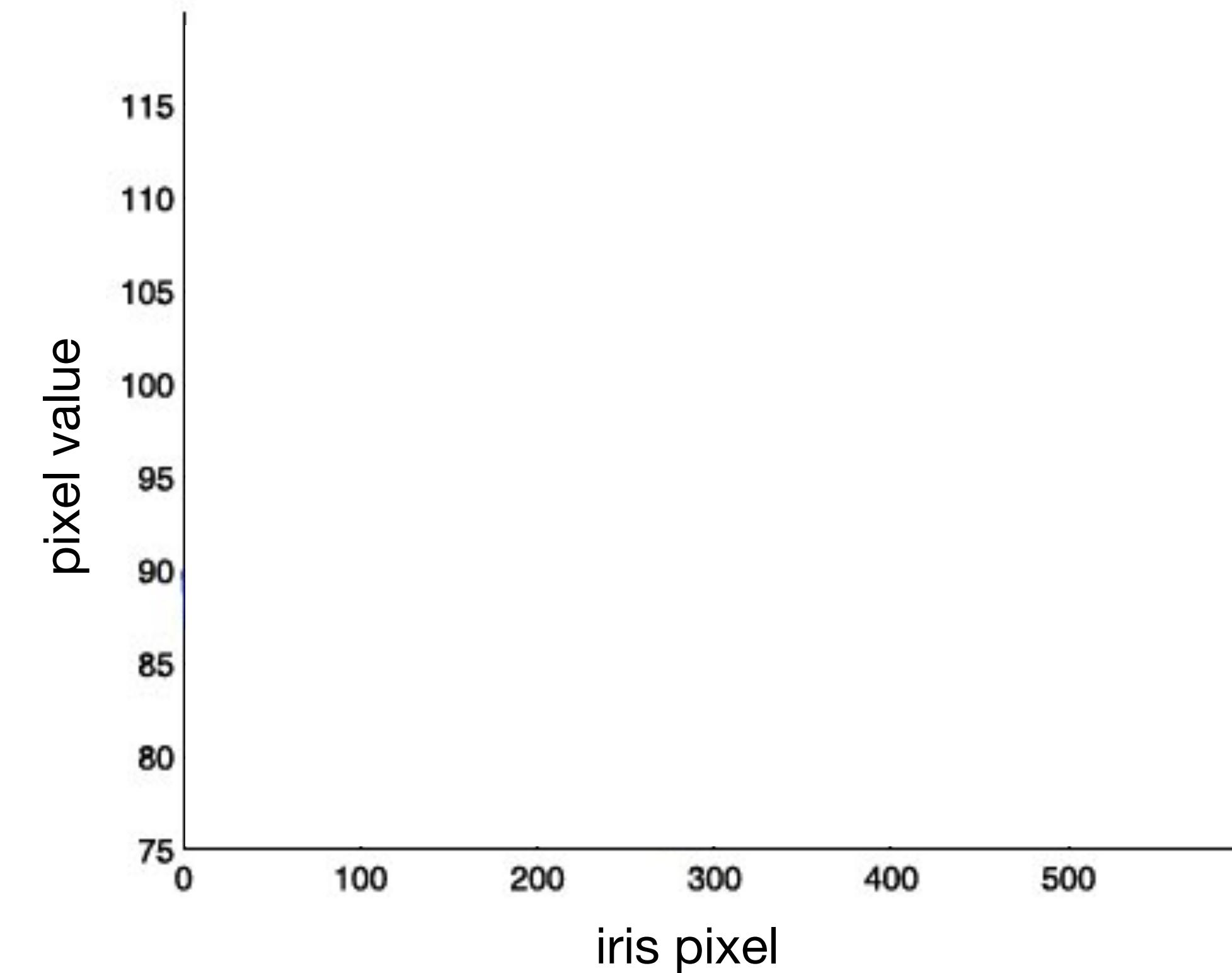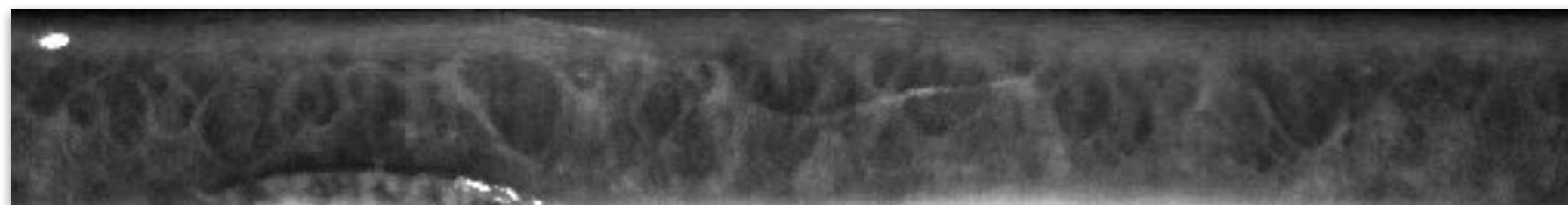
Feature Extraction

Zero-Crossing Approach (1/3)

Proposed by W. W. Boles.

Iris image is treated as a 1D signal (iris signature).
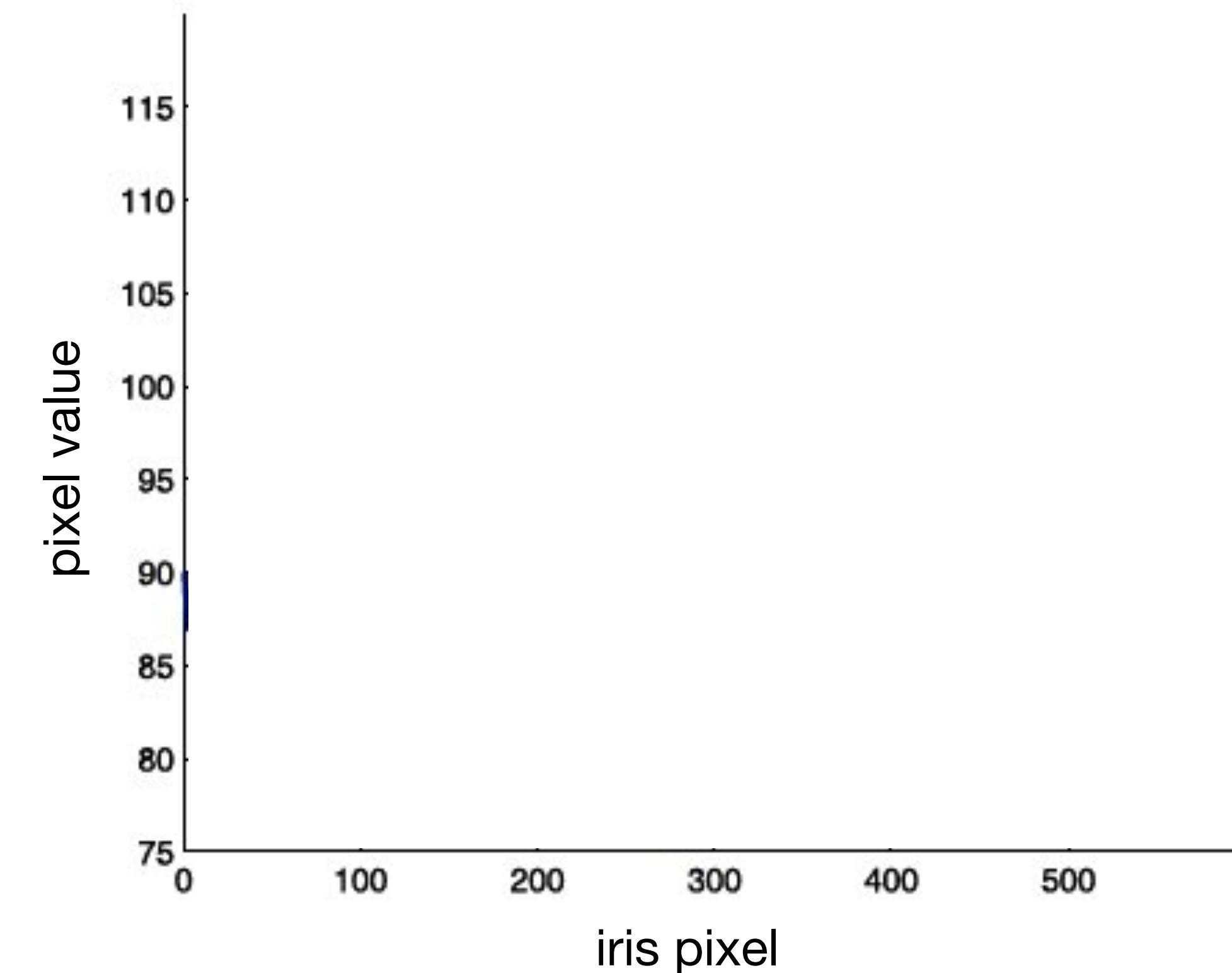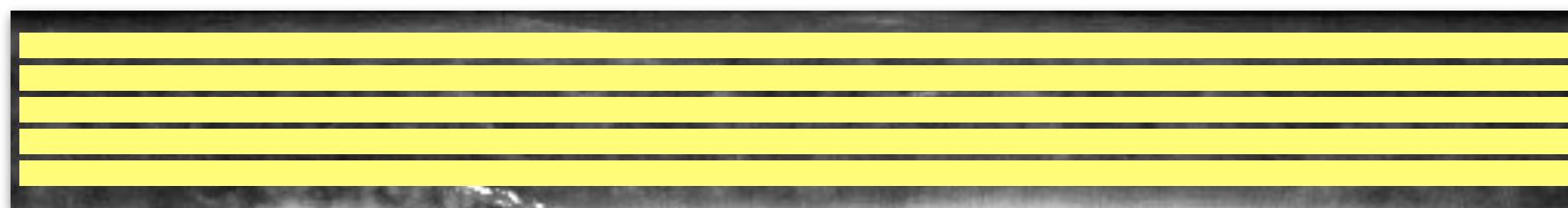
Feature Extraction

Zero-Crossing Approach (1/3)

Proposed by W. W. Boles.

Dr. Adam Czajka
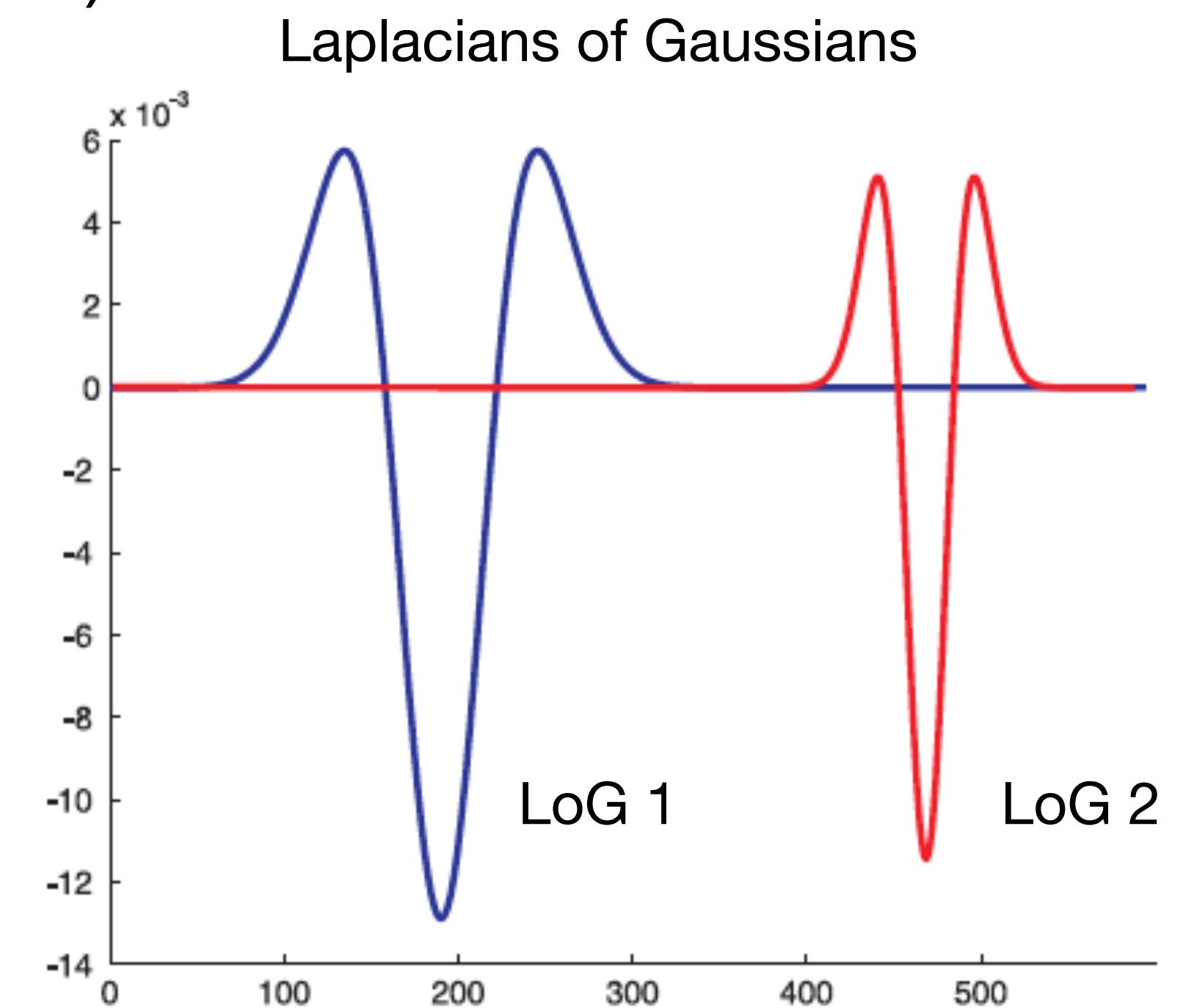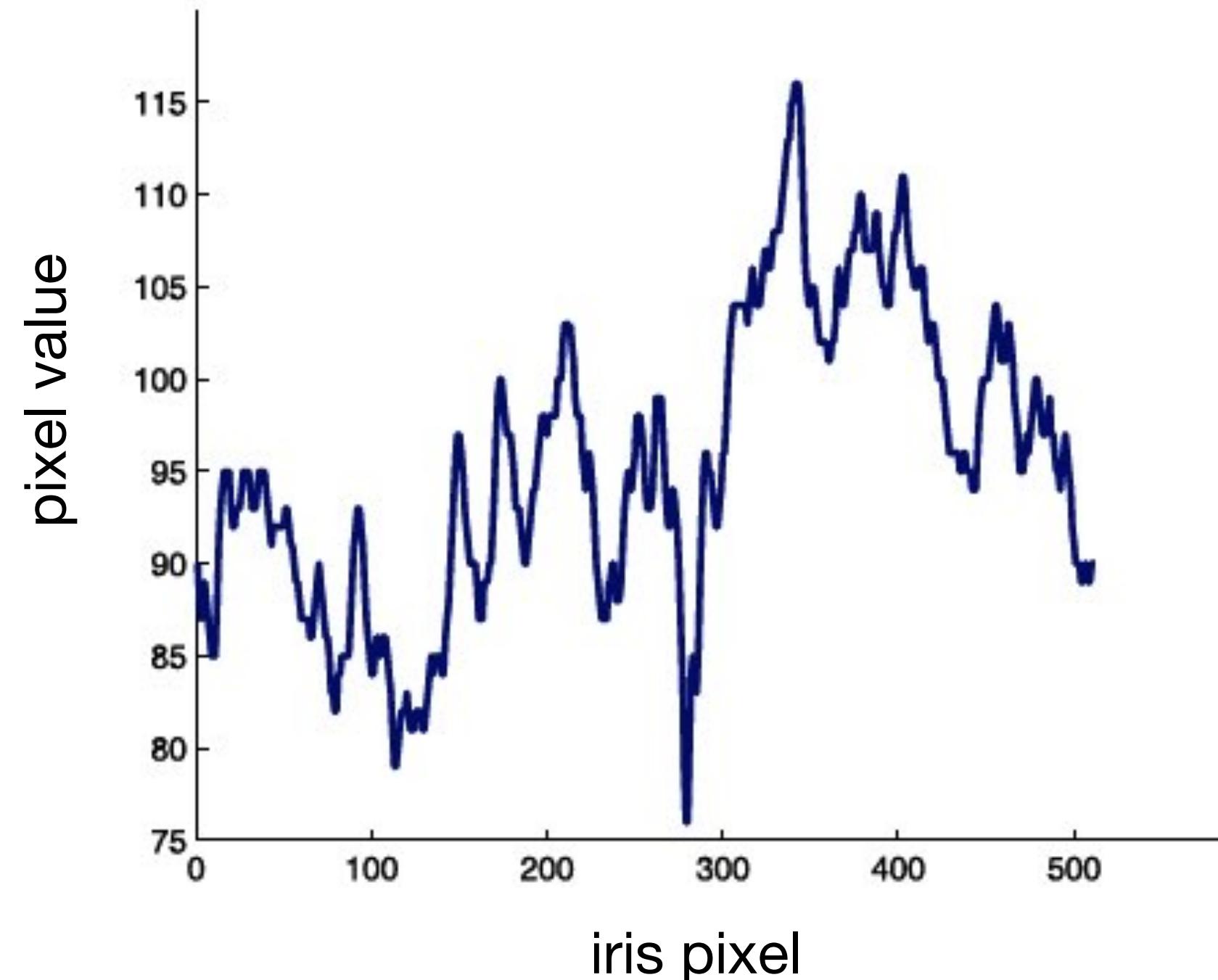
Iris image is treated as a 1D signal (iris signature).

Feature Extraction

Zero-Crossing Approach (1/3)

Proposed by W. W. Boles.

Iris image is treated as a 1D signal (iris signature).

Dr. Adam Czajka

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Feature Extraction

Zero-Crossing Approach (1/3)

1. Iris signature is filtered by Laplacians of Gaussians (LoG)
(second derivative of Gaussian).

iris pixel

Laplacians of Gaussians

LoG 1   LoG 2

Dr. Adam Czajka

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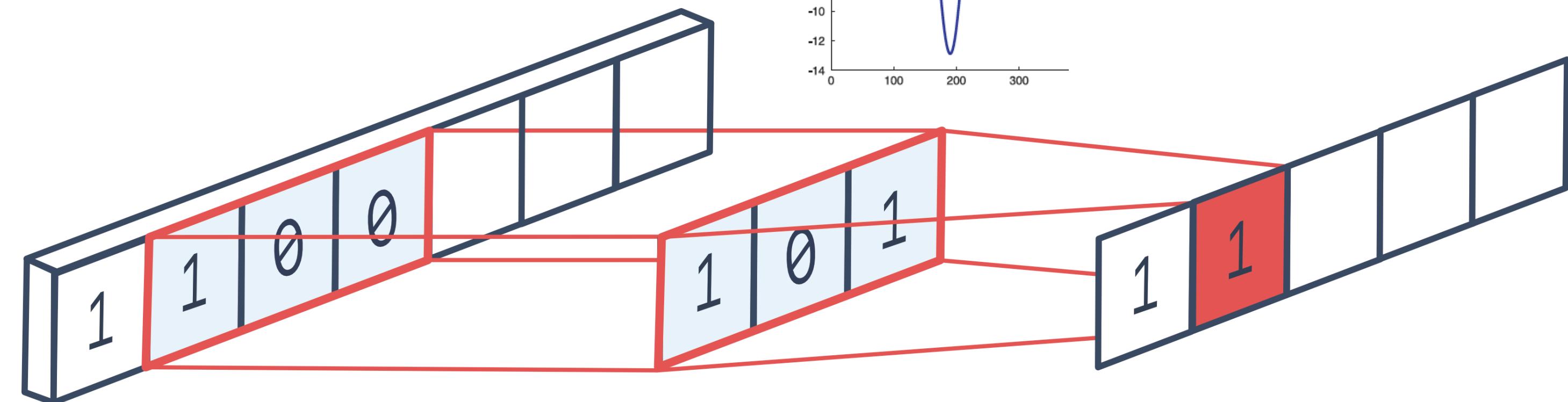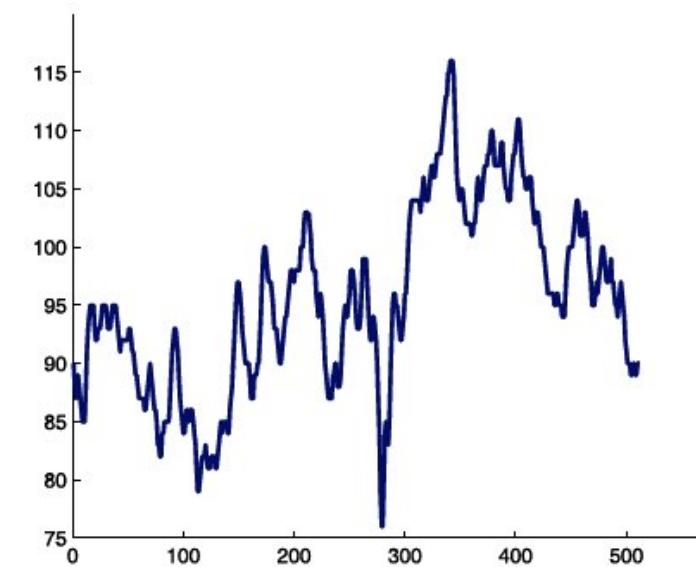
Feature Extraction

Zero-Crossing Approach (1/3)

1. Iris signature is filtered by Laplacians of Gaussians (LoG)
(second derivative of Gaussian).

1D Convolution

https://peltarion.com/knowledge-center/documentation/modeling-view/build-an-ai-model/blocks/1d-convolution
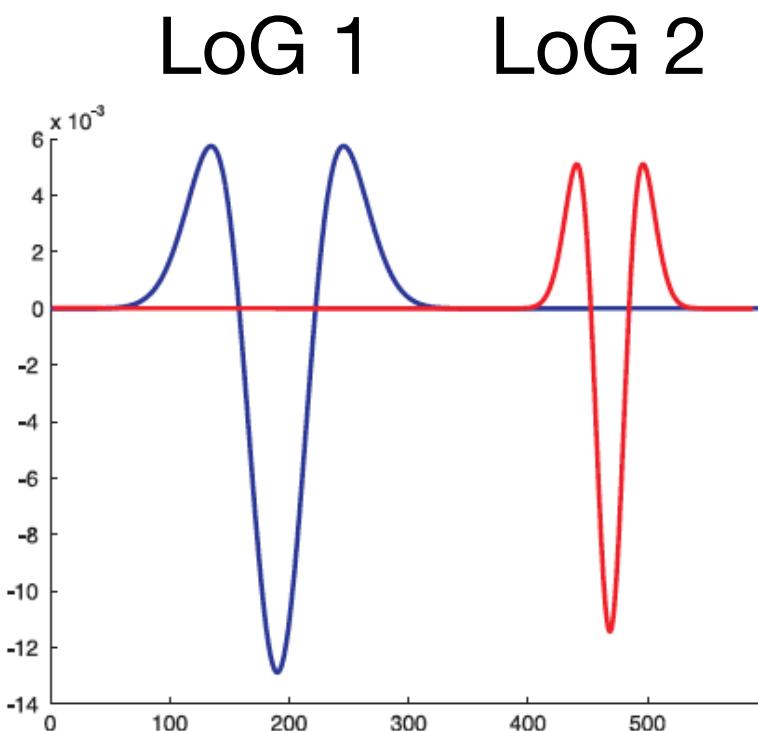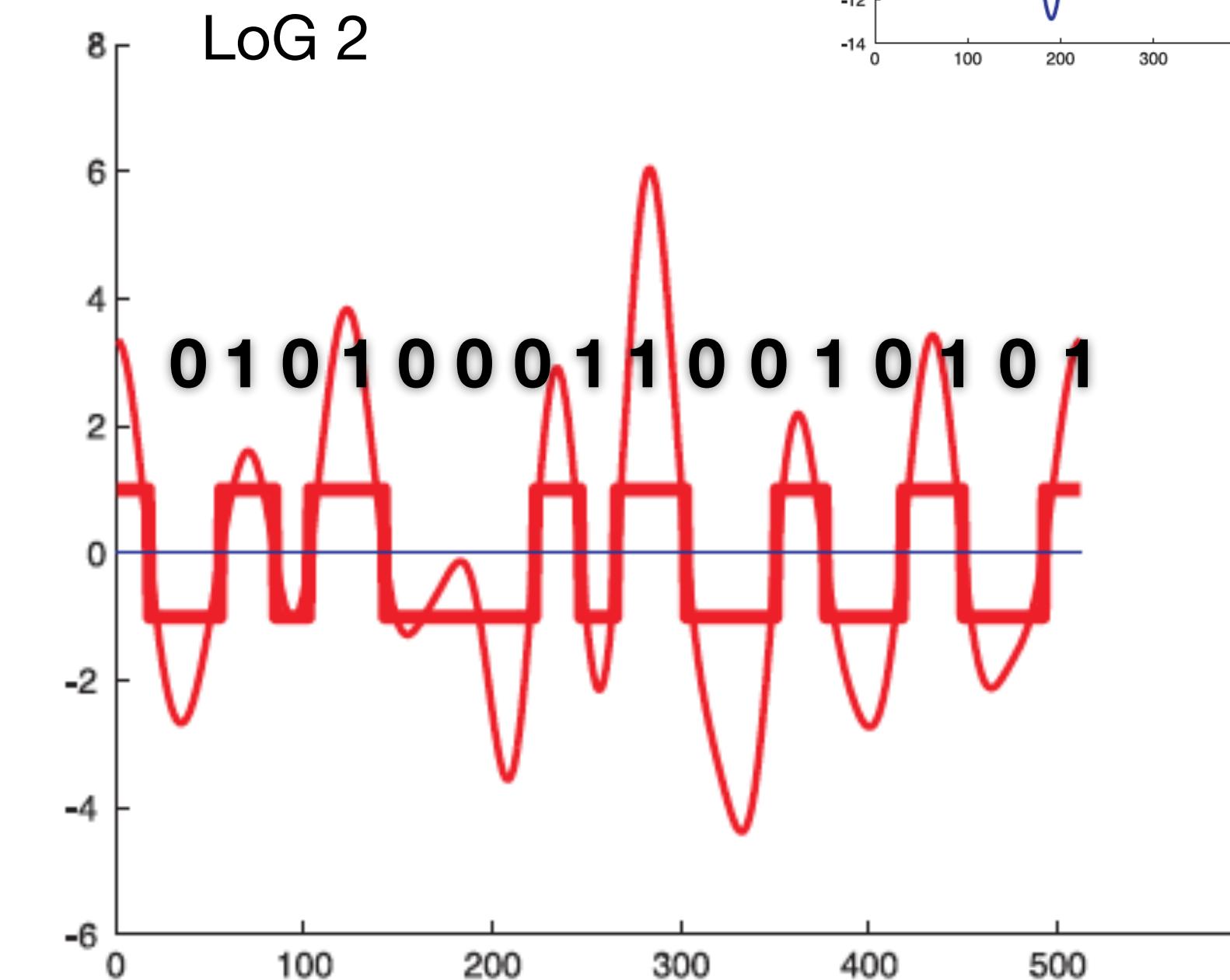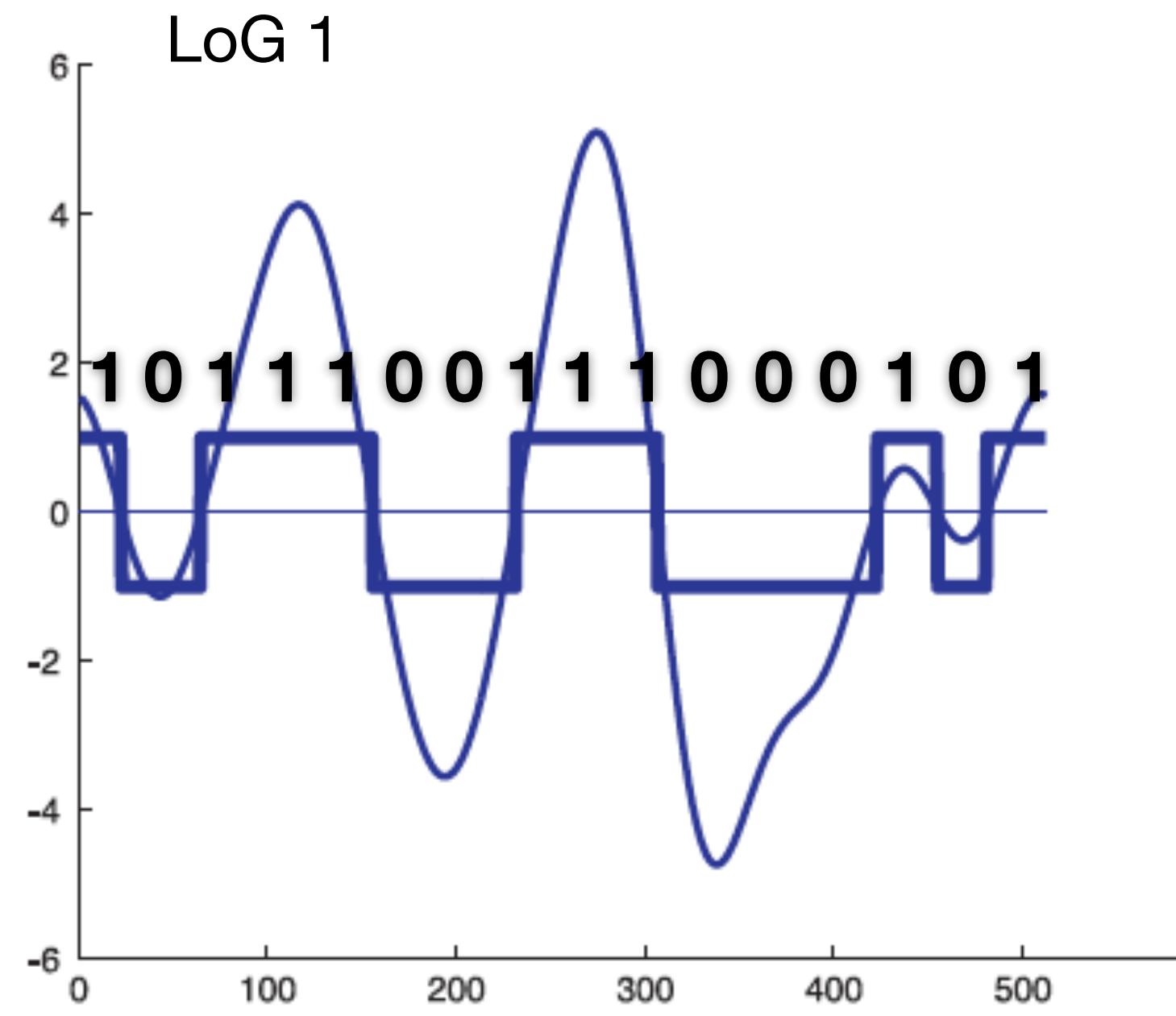
Feature Extraction
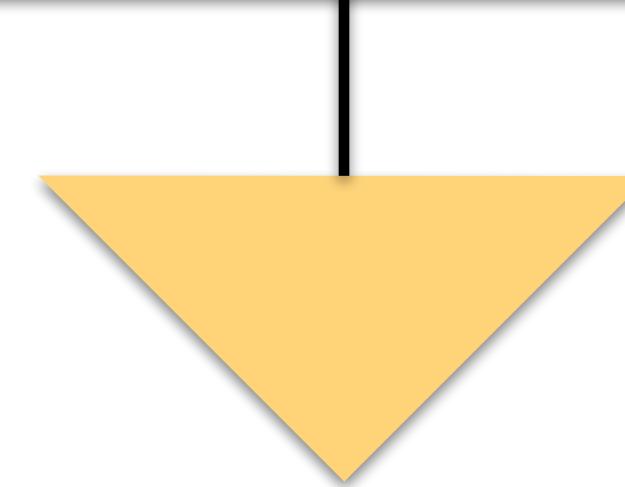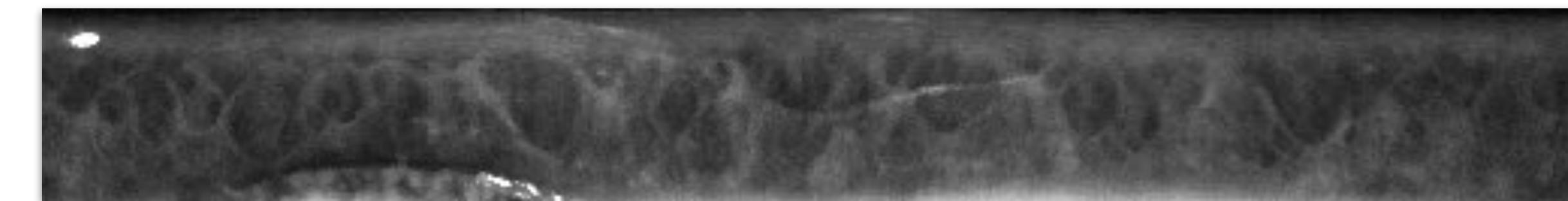
Zero-Crossing Approach (1/3)

2. Zero-crossings lead to bits up; everything else is zero.

LoG 1

1 0 1 1 1 0 0 1 1 1 0 0 0 1 0 1

LoG 2

0 1 0 1 0 0 0 1 1 0 0 1 0 1 0 1

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Feature Extraction

Zero-Crossing Approach (1/3)

LoG 1   LoG 2

1 0 1 1 1 0 0 1 1 1 0 0 0 1 0 1   0 1 0 1 0 0 0 1 1 0 0 1 0 1 0 1   concatenation
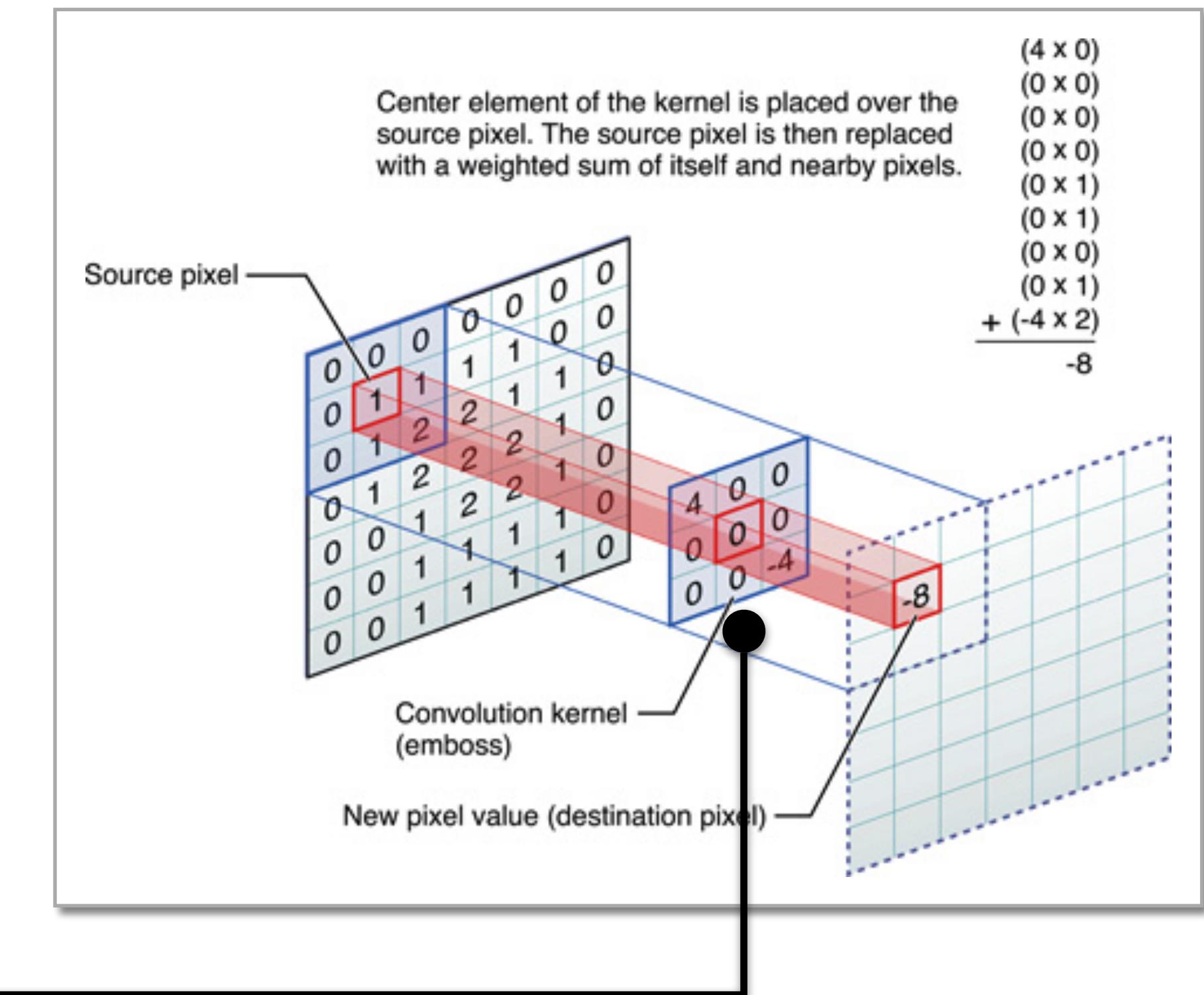
Feature Extraction

2D-Gabor Filtering Approach (2/3)

Proposed by John Daugman.

De facto iris description solution. More complete and robust than zero-crossing.

2D Gabor filters are convolved with the normalized iris image.

Feature Extraction

2D-Gabor Filtering Approach (2/3)

Proposed by John Daugman.

Empirical selection of a proper Gabor wavelet (adequate to encode iris texture).
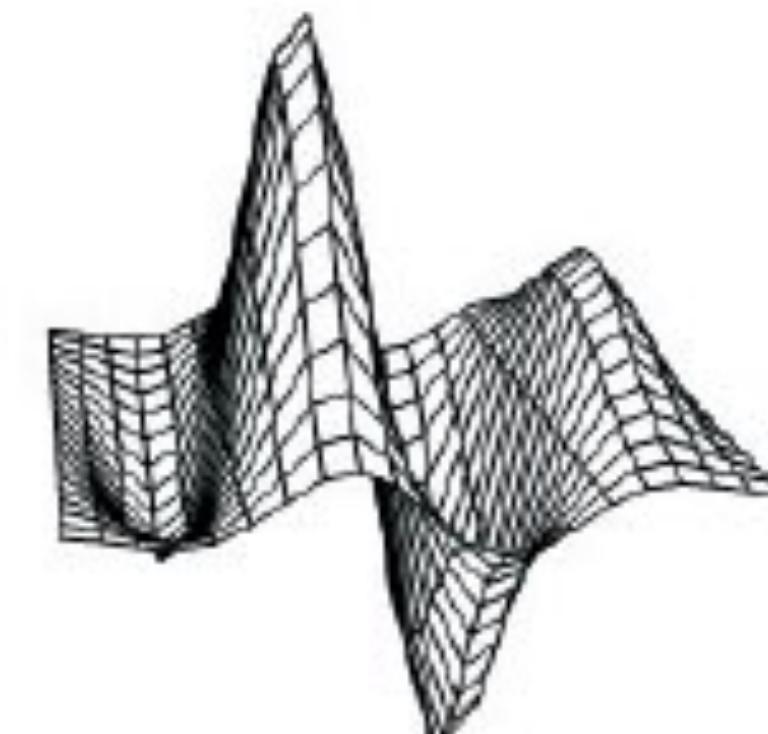
Gabor wavelets are a good model of neural receptive fields found in the visual cortex.

Filter 1

Filter 2

wavelet real component

wavelet imaginary component

J. Daugman
Probing the Uniqueness and Randomness of IrisCodes: Results from 200 Billion Iris Pair Comparisons.
IEEE Proceedings, 2006

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Feature Extraction

2D-Gabor Filtering Approach (2/3)

Jain, Ross, and Nadakumar
Introduction to Biometrics
Springer Books, 2011

Filter 1

wavelet real component

Filter 2

wavelet imaginary component

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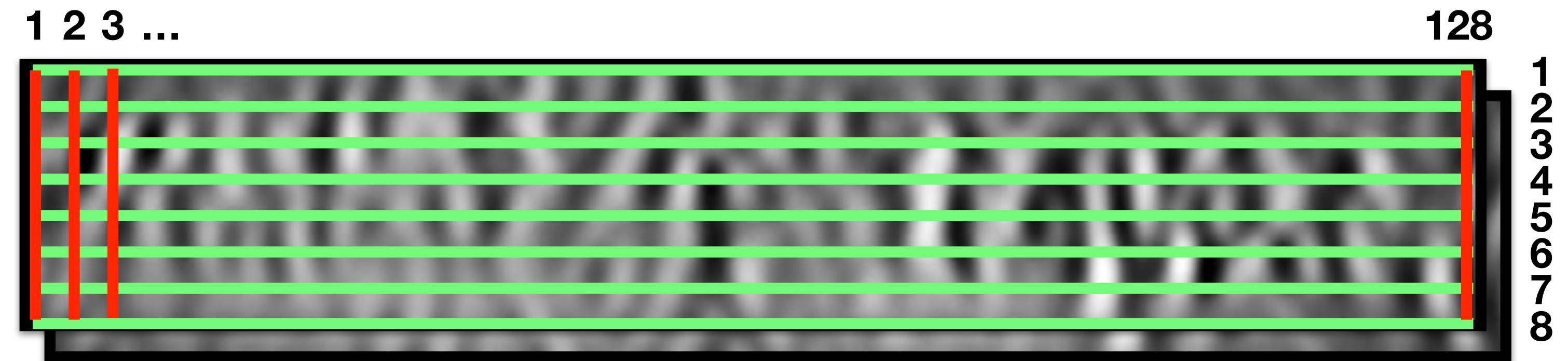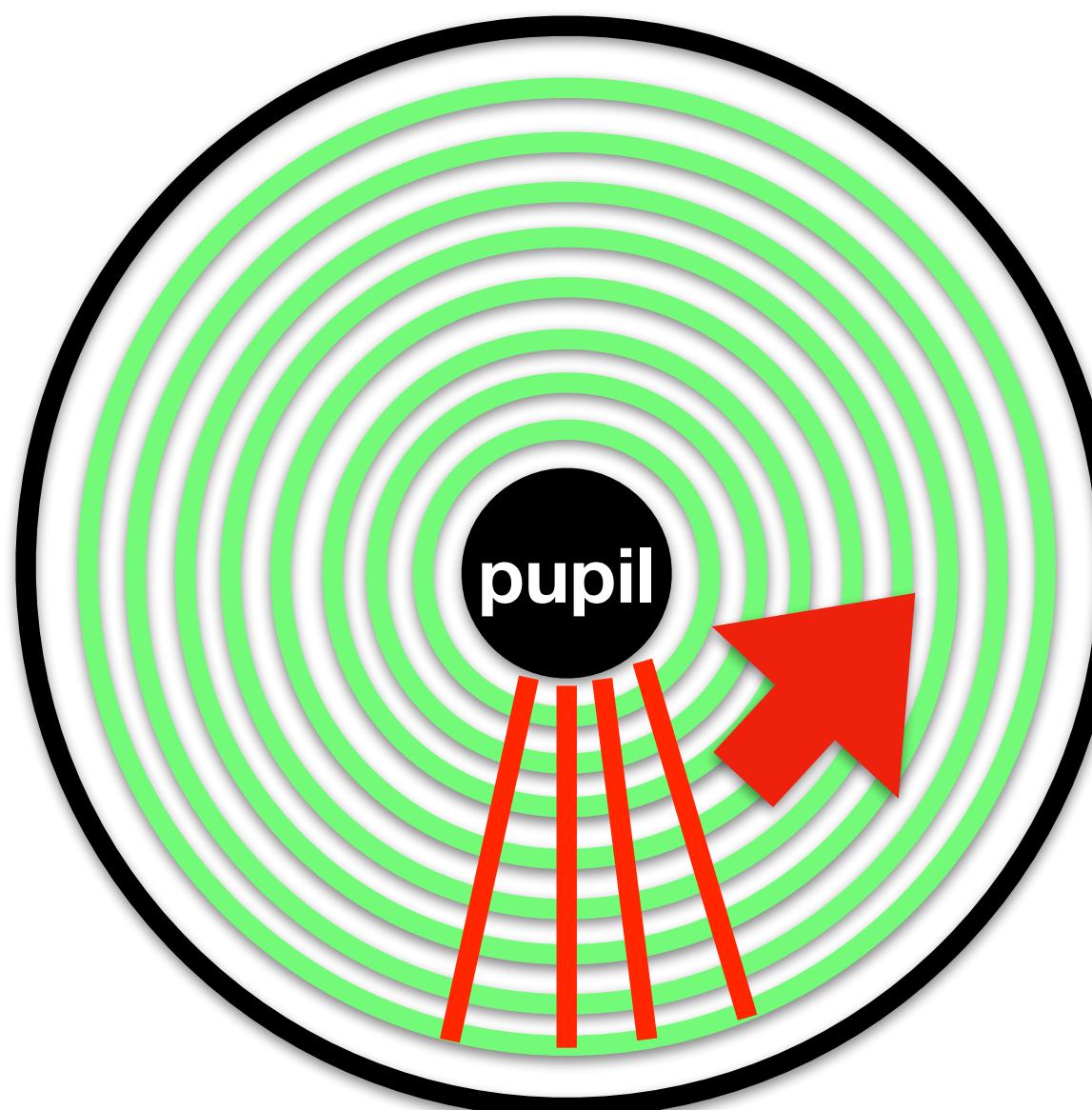
Feature Extraction

2D-Gabor Filtering Approach (2/3)

Feature Extraction
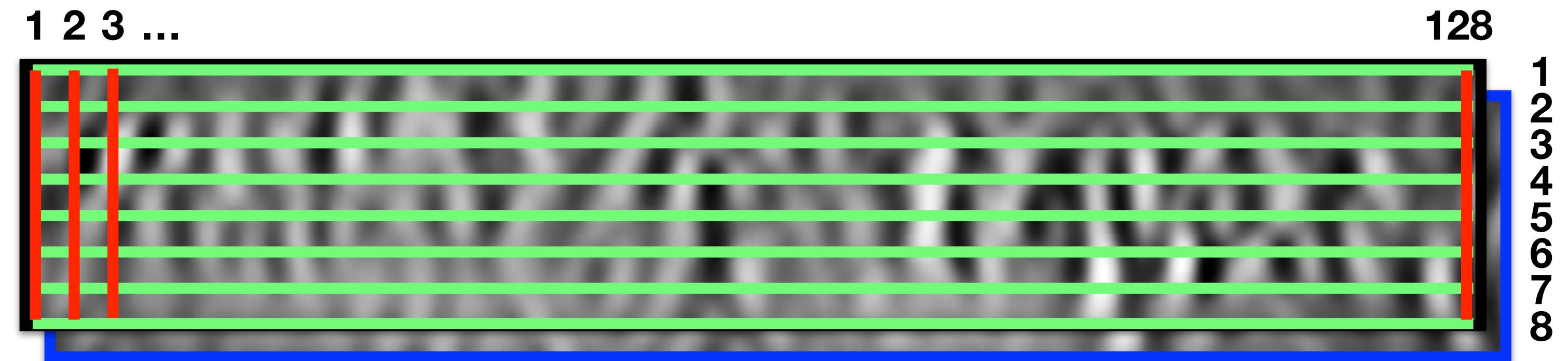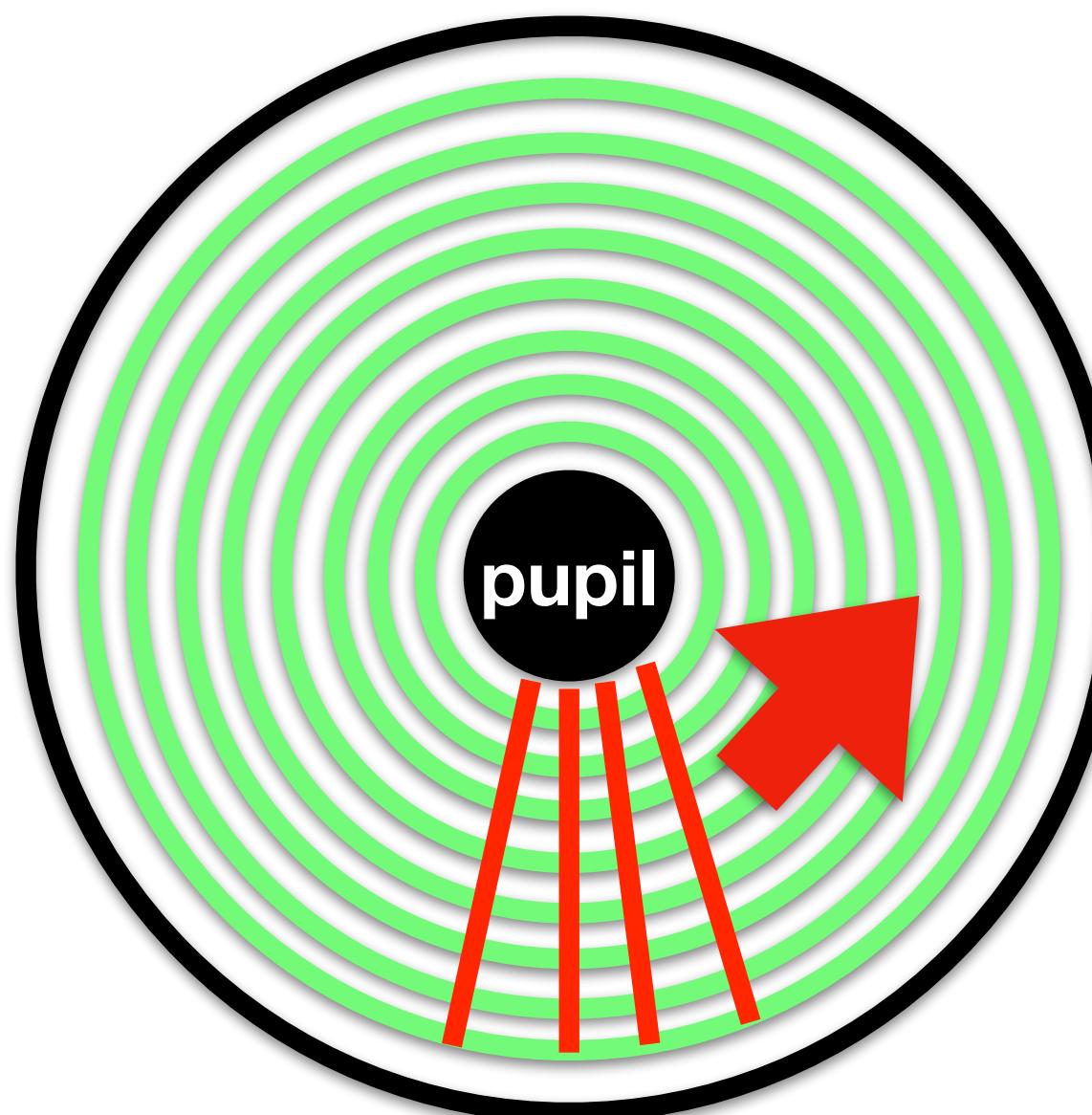
2D-Gabor Filtering Approach (2/3)

Number of cells: 8 x 128 = 1024

Feature Extraction

2D-Gabor Filtering Approach (2/3)

Number of cells: 8 x 128 = 1024 **x 2 = 2048**

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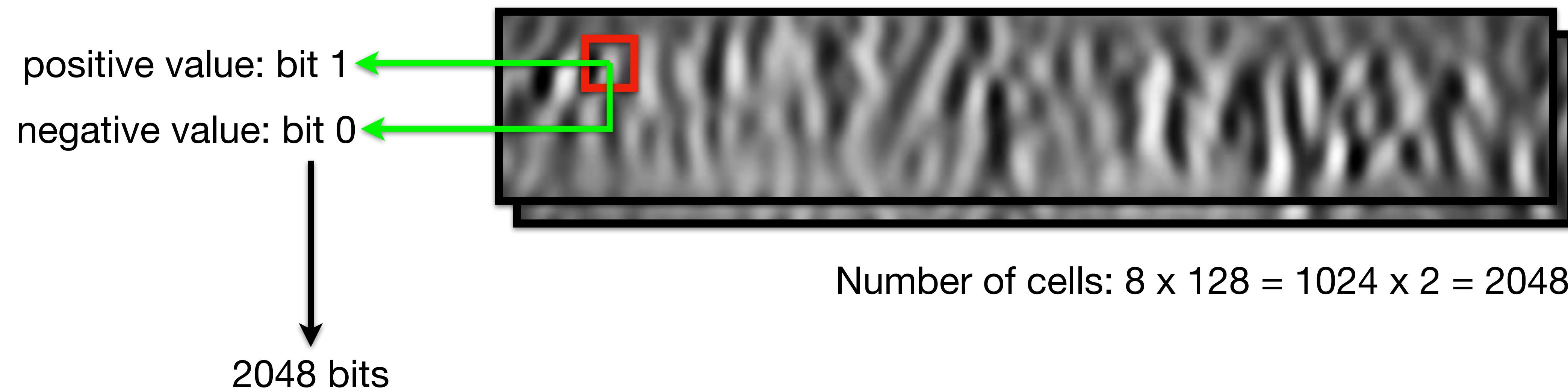
Feature Extraction
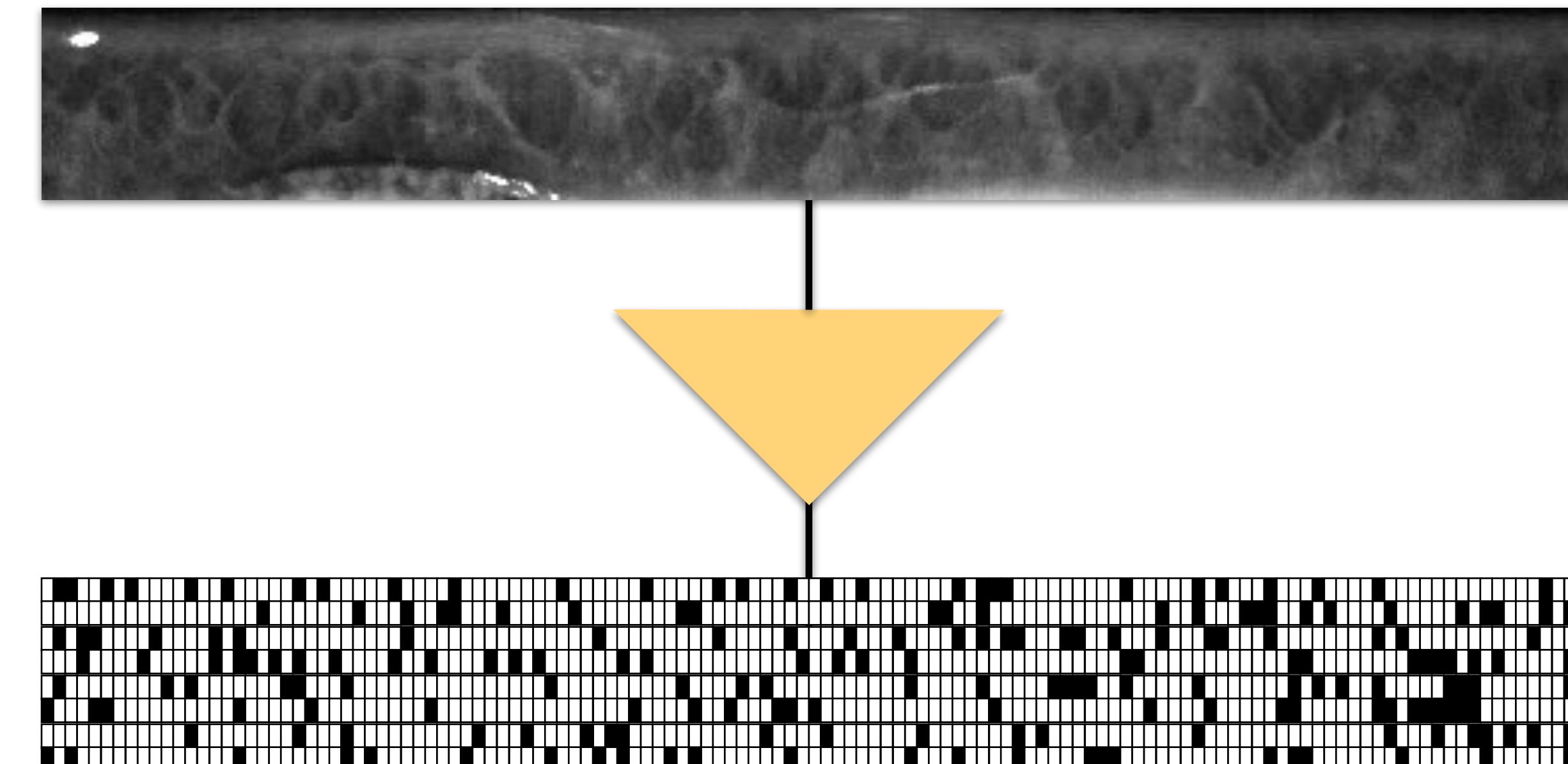
2D-Gabor Filtering Approach (2/3)

Take one cell…

positive value: bit 1

negative value: bit 0

2048 bits

Number of cells: 8 x 128 = 1024 x 2 = 2048

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Feature Extraction

2D-Gabor Filtering Approach (2/3)

2048 bits
IrisCode

Feature Extraction

BSIF Approach (3/3)
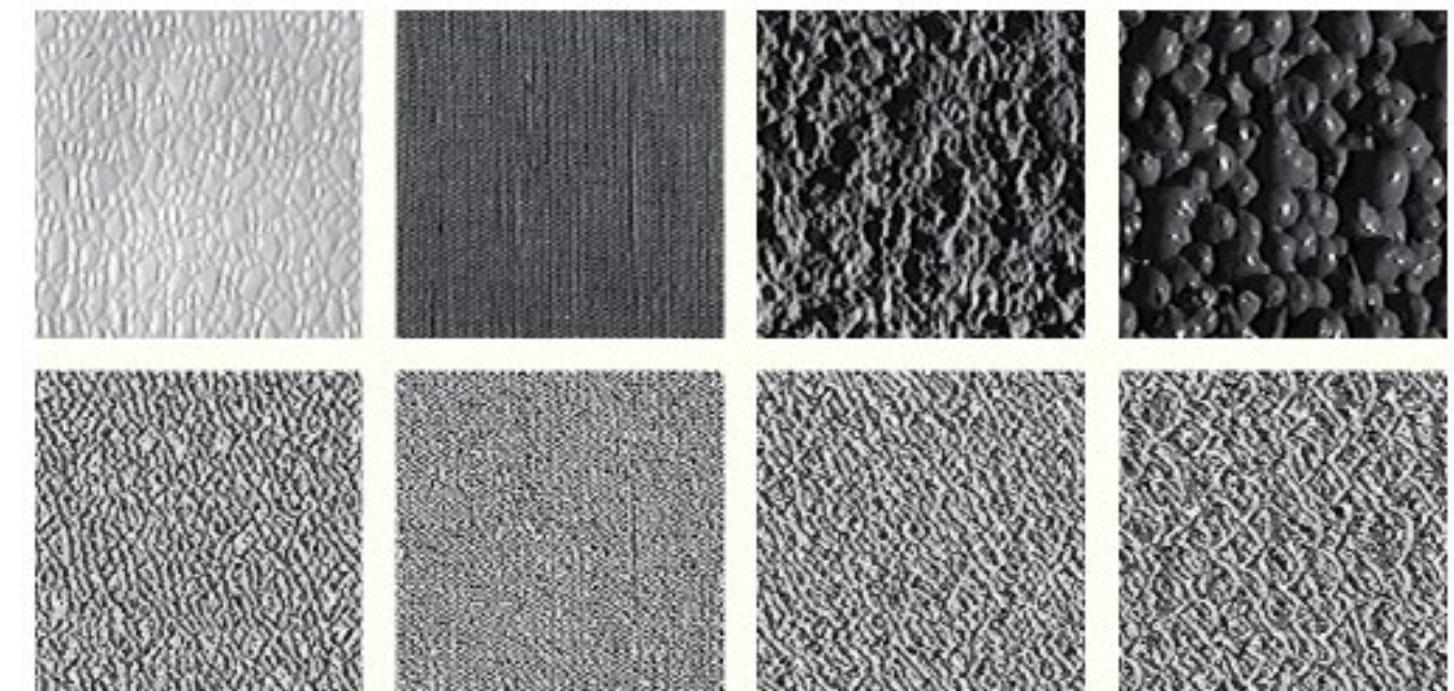
Binarized Statistical Image Features (BSIF)
General-purpose local image descriptors designed for texture encoding.

Kannala and Rahtu
BSIF: Binarized Statistical Image Features
ICPR 2012

Examples of textures that one might one to describe.

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Feature Extraction

BSIF Approach (3/3)

Binarized Statistical Image Features (BSIF)
Subspaces of representative image patches (further used as filters) are learned from a set of example patches through *Independent Component Analysis* (ICA).

ICA: *N* filters of size *l x l* are estimated from examples by maximizing their mutual statistical independence.

Kannala and Rahtu
BSIF: Binarized Statistical Image Features
ICPR 2012

Eight filters of size 9x9 pixels that better represent patches of size 9x9. Computed with ICA.
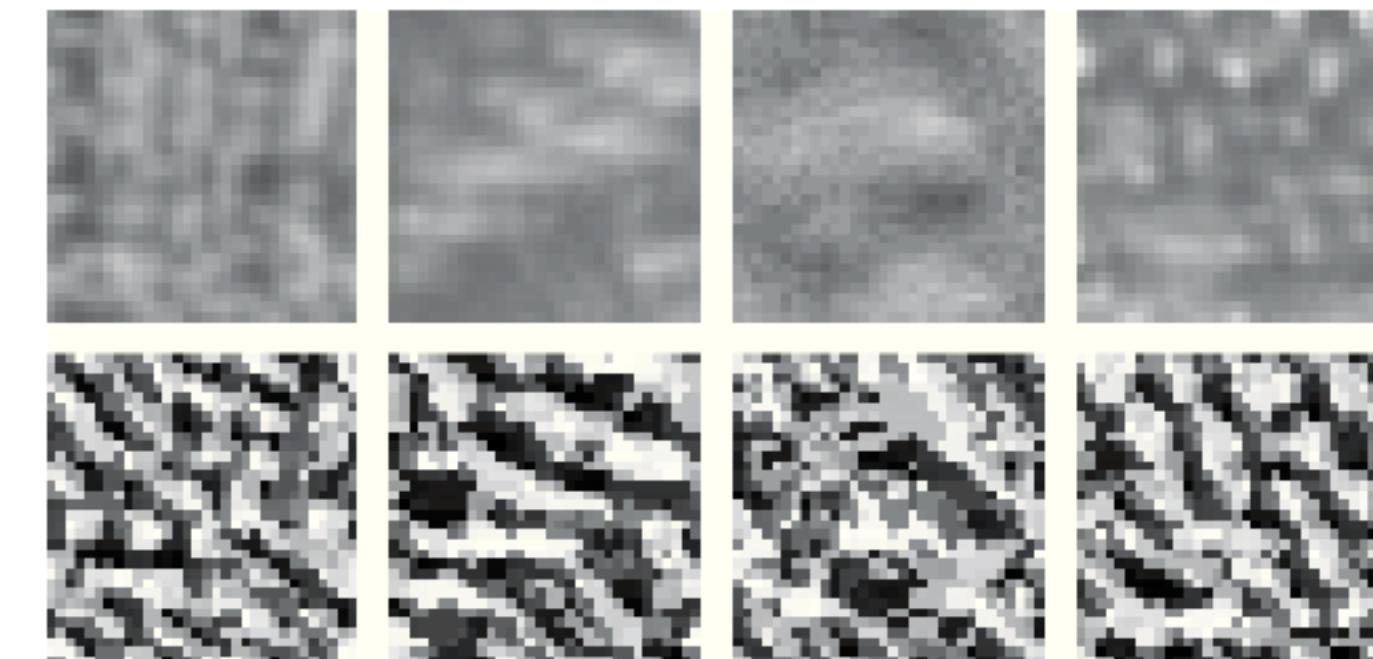
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Feature Extraction

BSIF Approach (3/3)

Binarized Statistical Image Features (BSIF)
Images are convolved with each BSIF filter leading to various projections in the target subspace.

BSIF code: a threshold is used to make the image projections binary; anything above zero is ONE, everything else is ZERO.

Kannala and Rahtu
BSIF: Binarized Statistical Image Features
ICPR 2012

BSIF code examples

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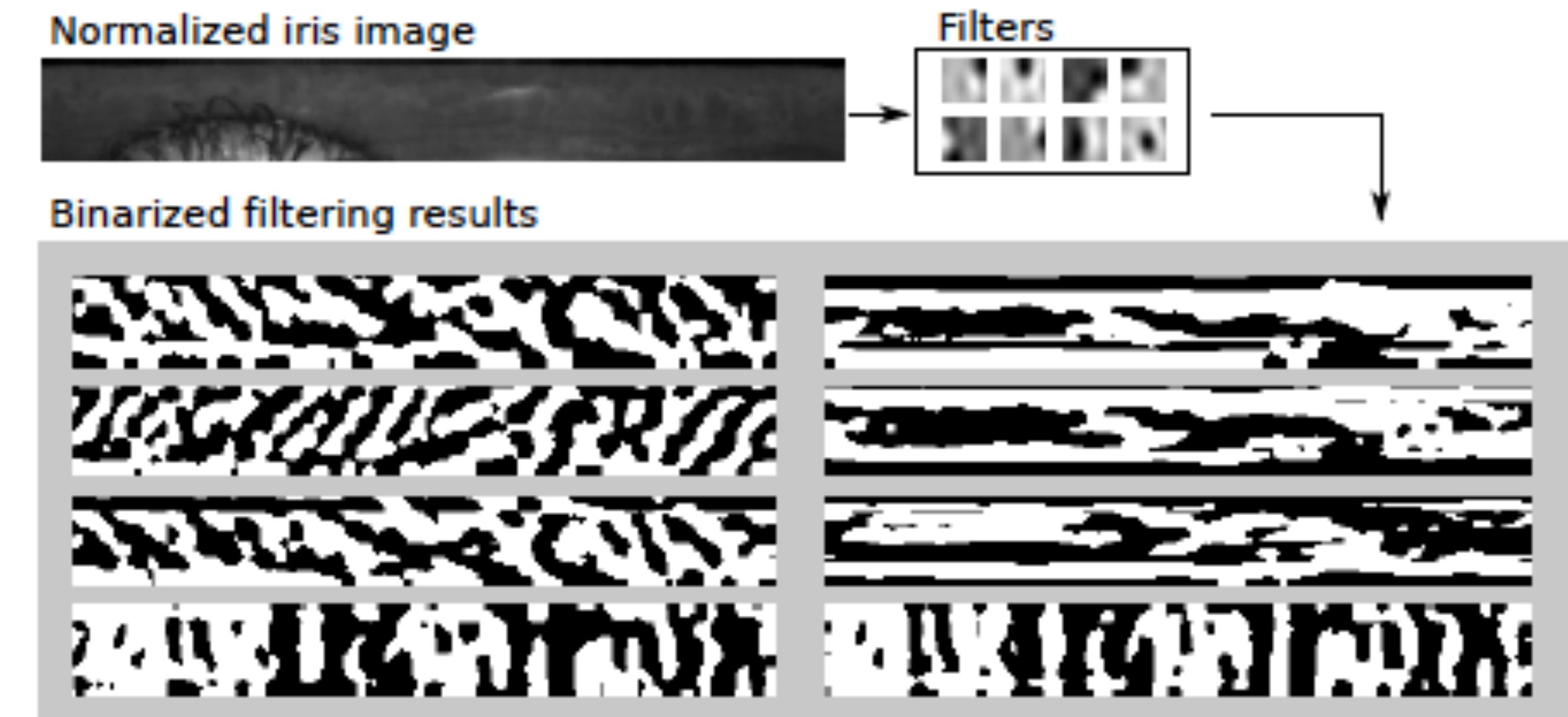
Feature Extraction

BSIF Approach (3/3)
In the case of irises…

Solution's performance is on par with the Gabor-based one.
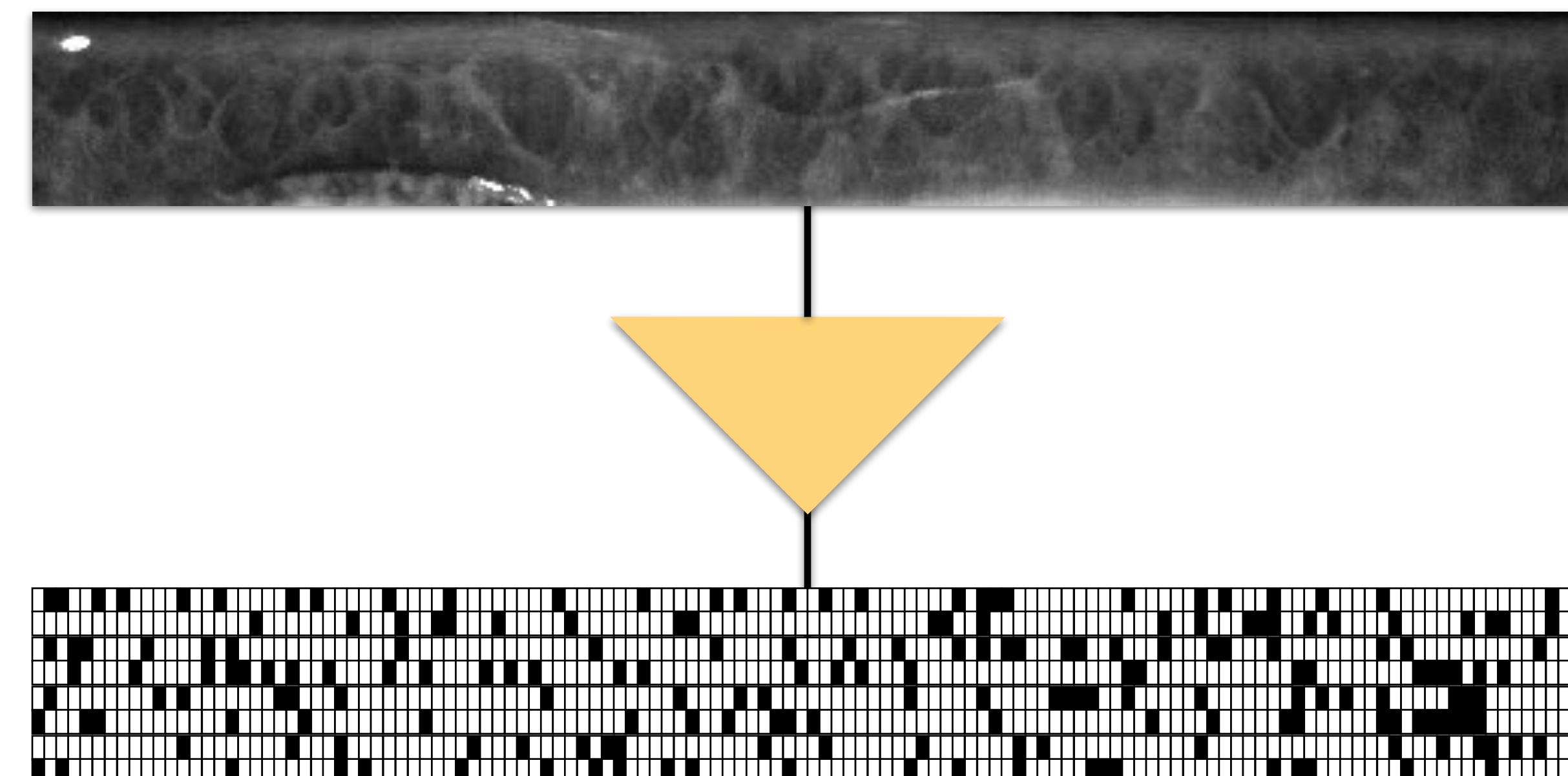
Normalized iris image

Filters

Binarized filtering results

Feature Extraction
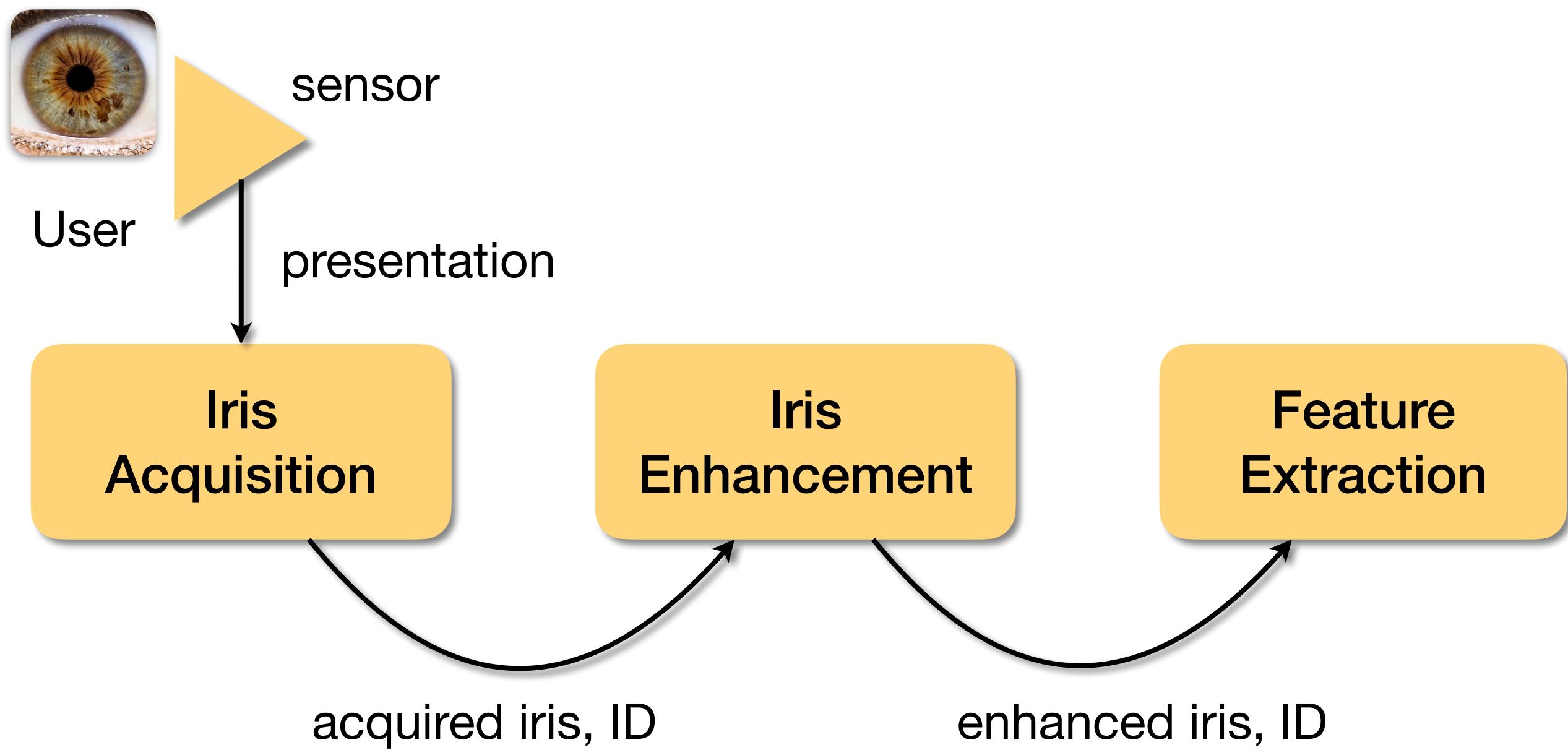
BSIF Approach (3/3)

In the case of irises…
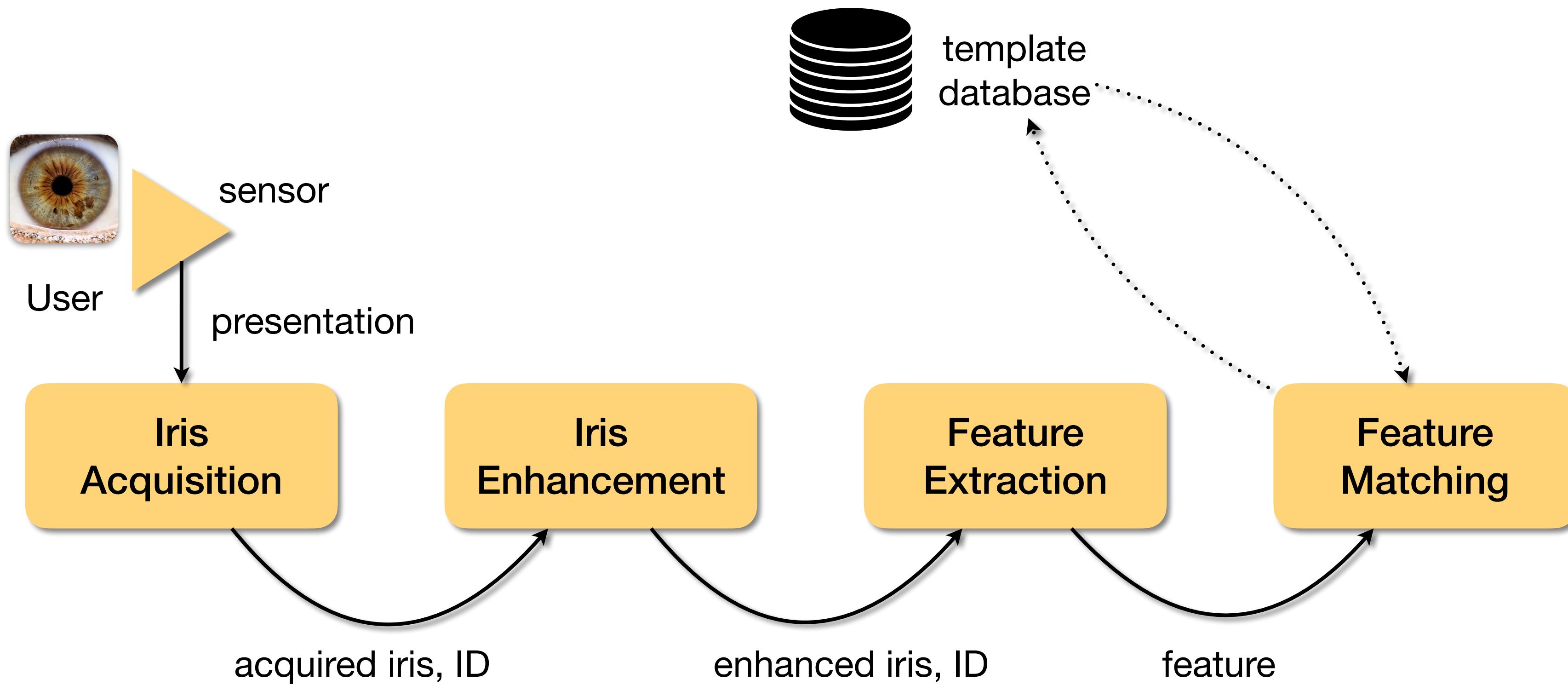
BSIF Code

Iris Recognition

User → sensor → presentation → **Iris Acquisition** —acquired iris, ID→ **Iris Enhancement** —enhanced iris, ID→ **Feature Extraction**

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Iris Recognition

template
database

sensor

User

presentation

Iris Acquisition

Iris Enhancement

Feature Extraction

Feature Matching

acquired iris, ID

enhanced iris, ID

feature

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Feature Matching

How to Compare Binary Codes?

Use Hamming distance.

iris 1   **1 0 1 1 1 0 1 0 1 1 0 0 0 1 0 1**

iris 2   **0 0 1 1 0 0 1 0 0 1 0 1 1 1 0 0**

XOR   ——————————————————————

Distance = sum(**1 0 0 0 1 0 0 0 1 0 0 1 1 0 0 1**) = 6
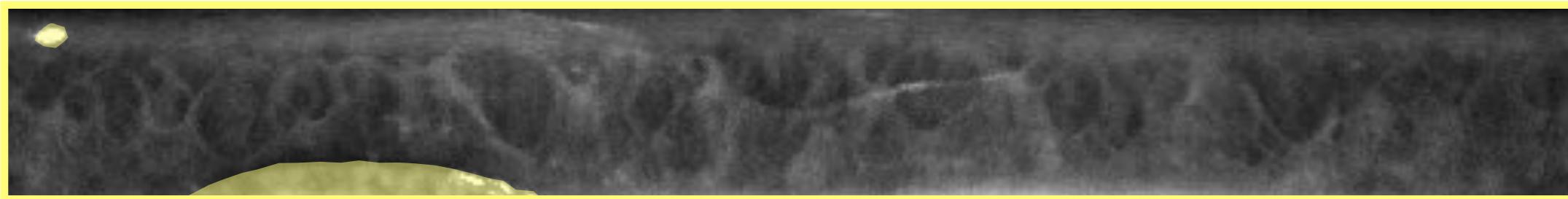
Feature Matching

How to Compare Binary Codes?

Problems (1/2)
How to consider iris masks?

Iris 1

Iris 2

Mask 1

Mask 2

Feature Matching

How to Compare Binary Codes?

Problems (1/2)
How to consider iris masks?
Solution: Normalized Hamming Distance

I_1: cells from iris 1
I_2: cells from iris 2
M_1: cells from mask 1
M_2: cells from mask 2

$$dist = \frac{bitwise\_sum(I_1 \ XOR \ I_2 \ AND \ M_1 \ AND \ M_2)}{bitwise\_sum(M_1 \ AND \ M_2)}$$

Only cells considered by both masks are used.

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Feature Matching

How to Compare Binary Codes?
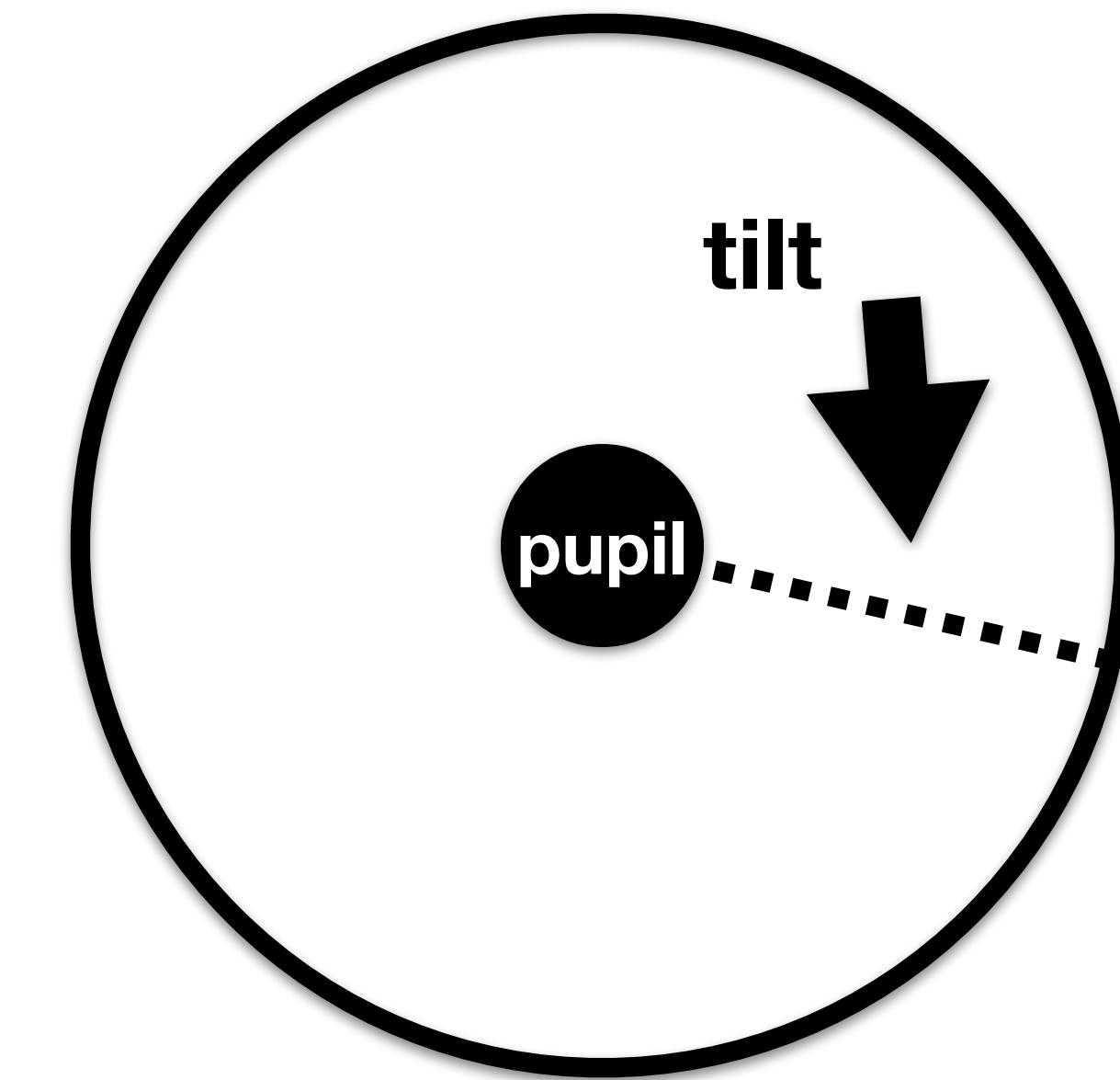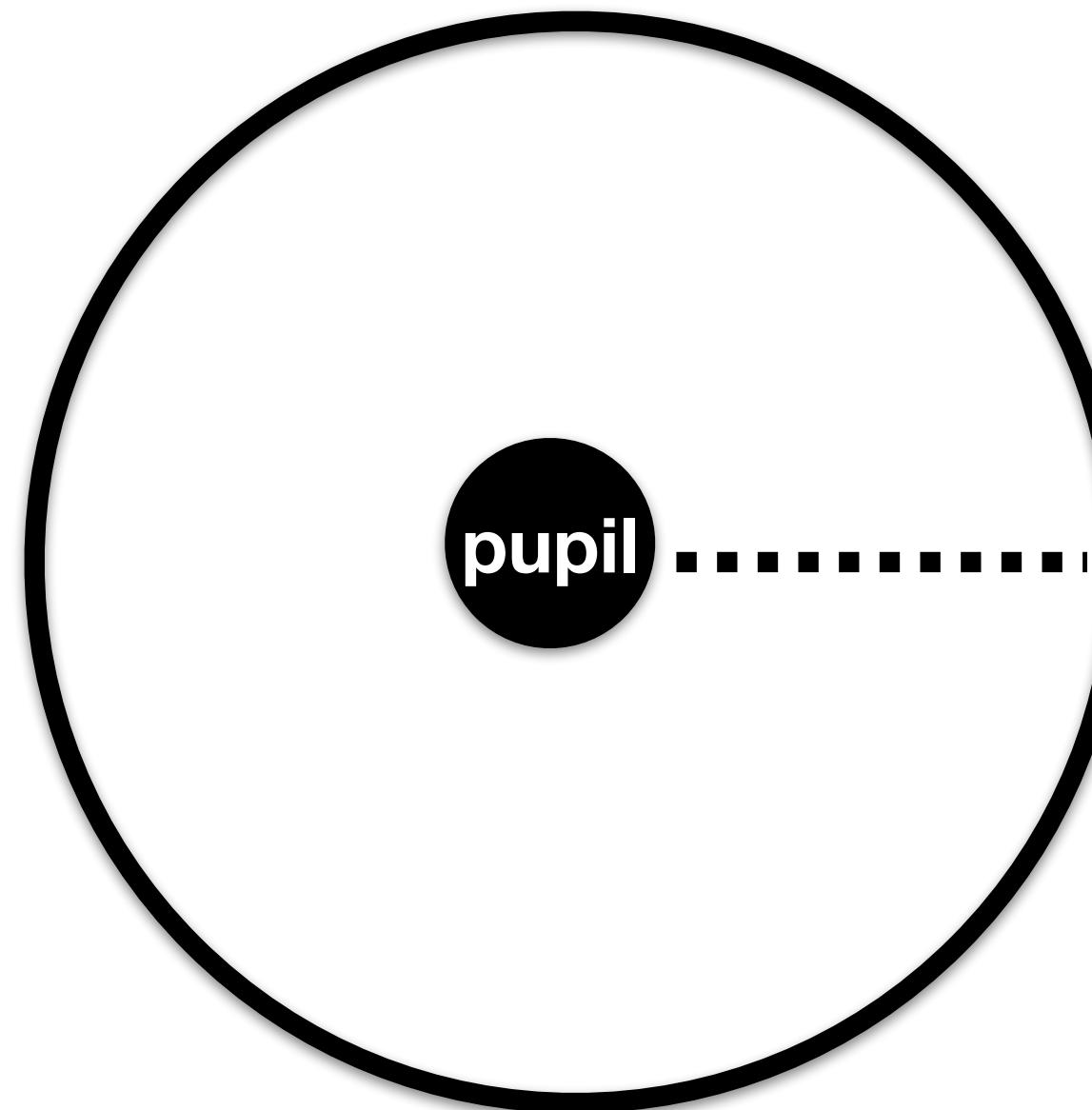
Problems (2/2)
How to deal with iris rotations?
They happen when heads are tilted…
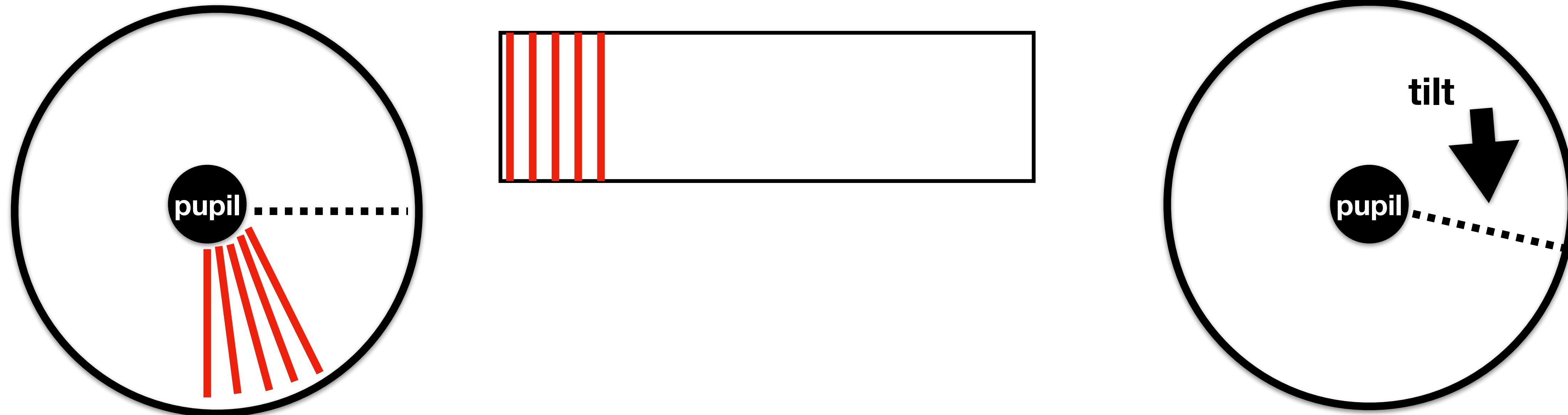
Feature Matching
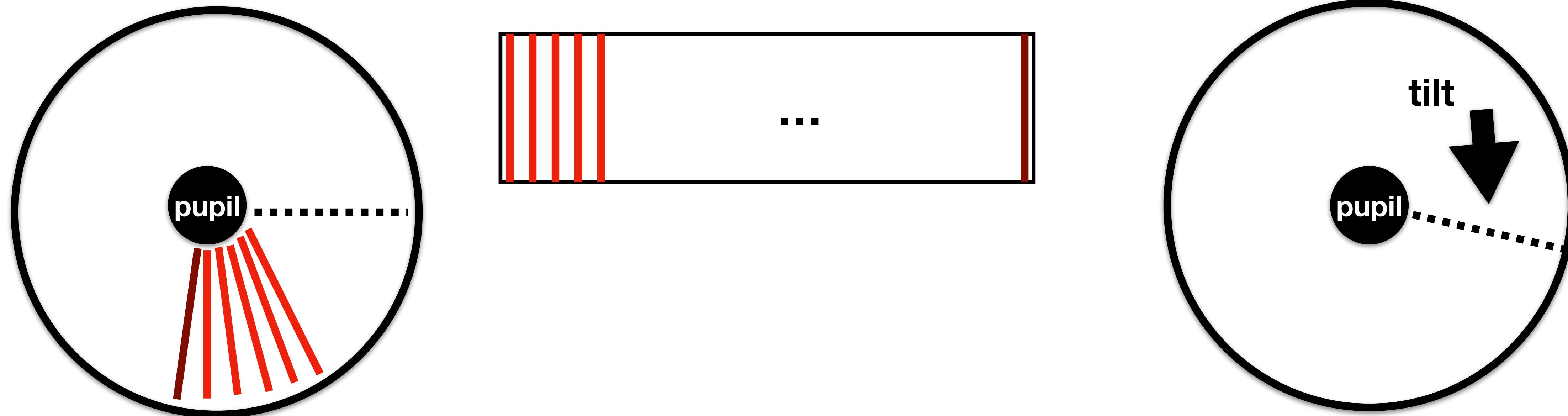
How to match with iris rotations?

Feature Matching

How to match with iris rotations?

Feature Matching

**How to match with iris rotations?**

Feature Matching

How to match with iris rotations?

Feature Matching

How to match with iris rotations?

misalignment

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Feature Matching

How to match with iris rotations?

misalignment
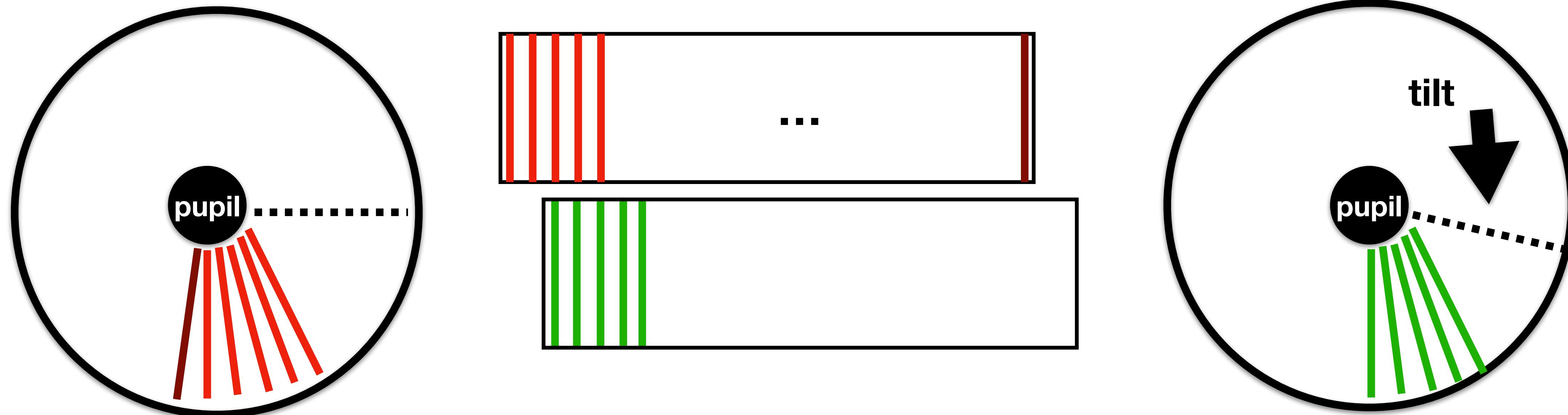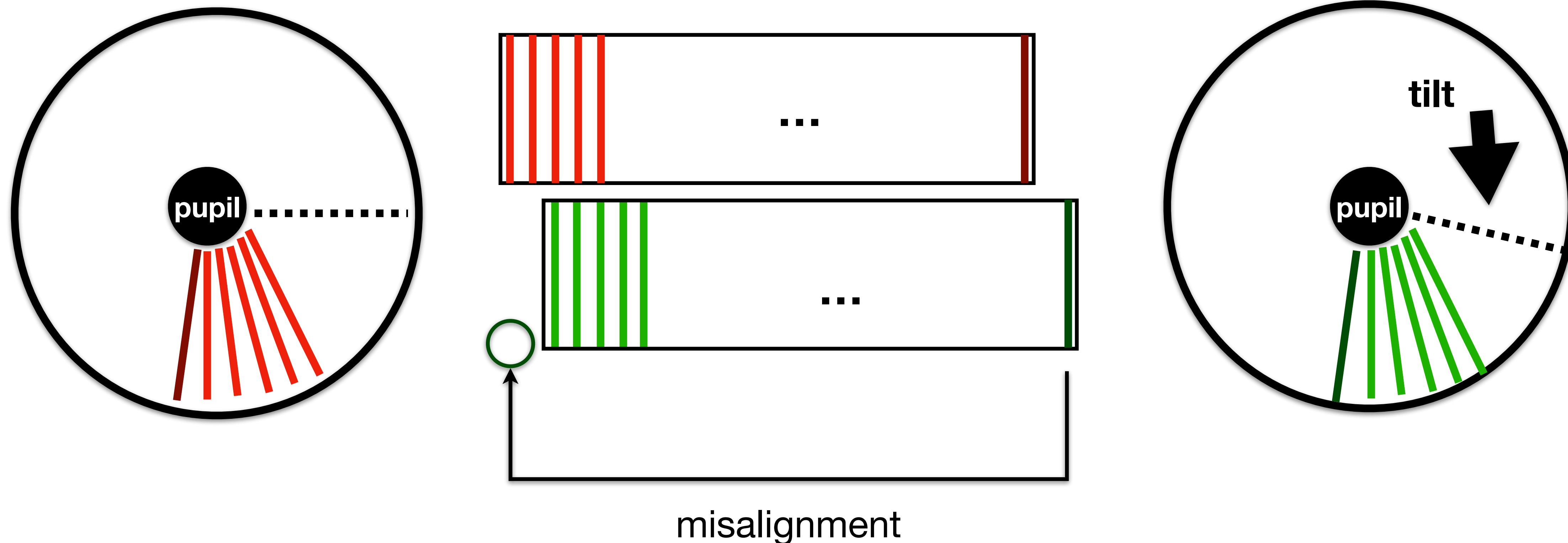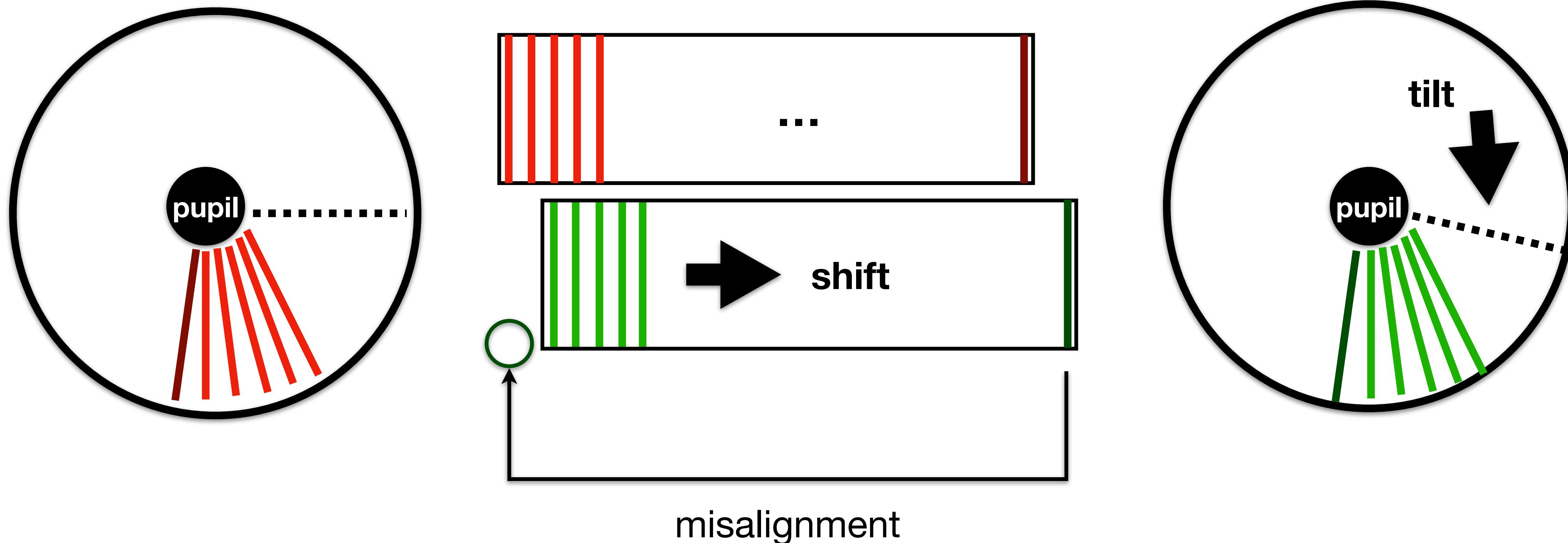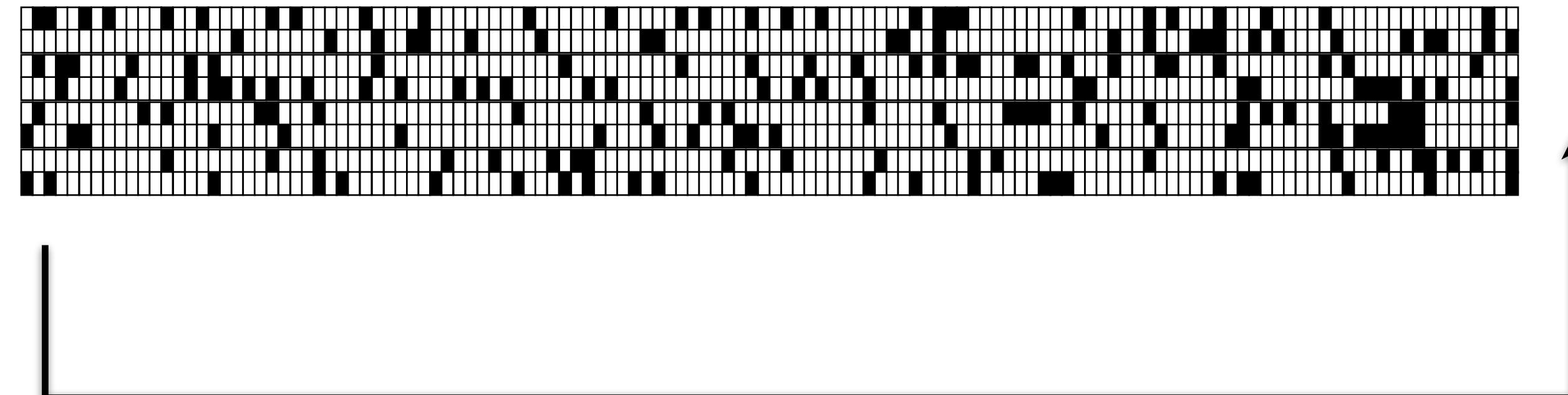
Feature Matching

How to Compare Binary Codes?

Problems (2/2)
How to deal with iris rotations?
Solution: provide different shifts for one of the iris codes.

Feature Matching

How to Compare Binary Codes?
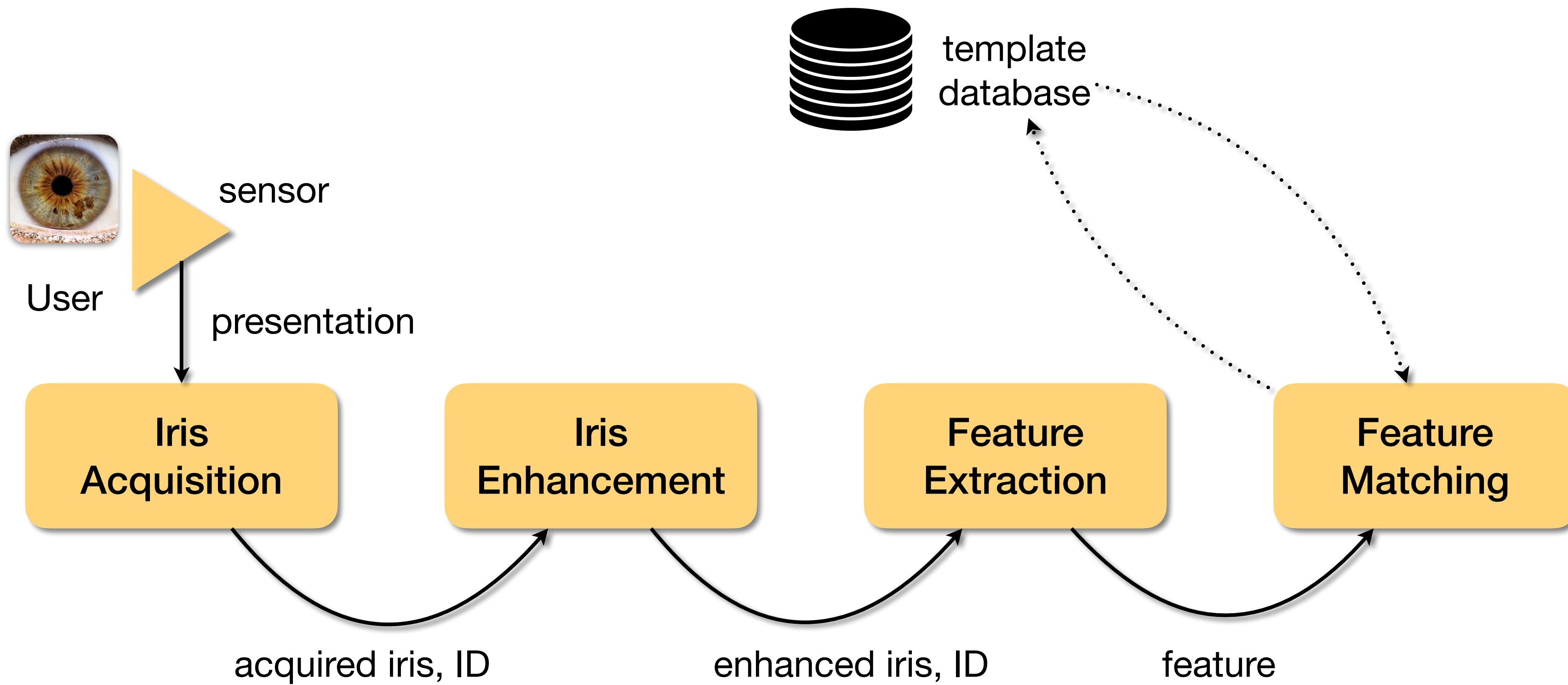
Problems (2/2)
How to deal with iris rotations?
Solution: provide different shifts
for one of the iris codes.
Compute various normalized
Hamming distances (one for each shift).
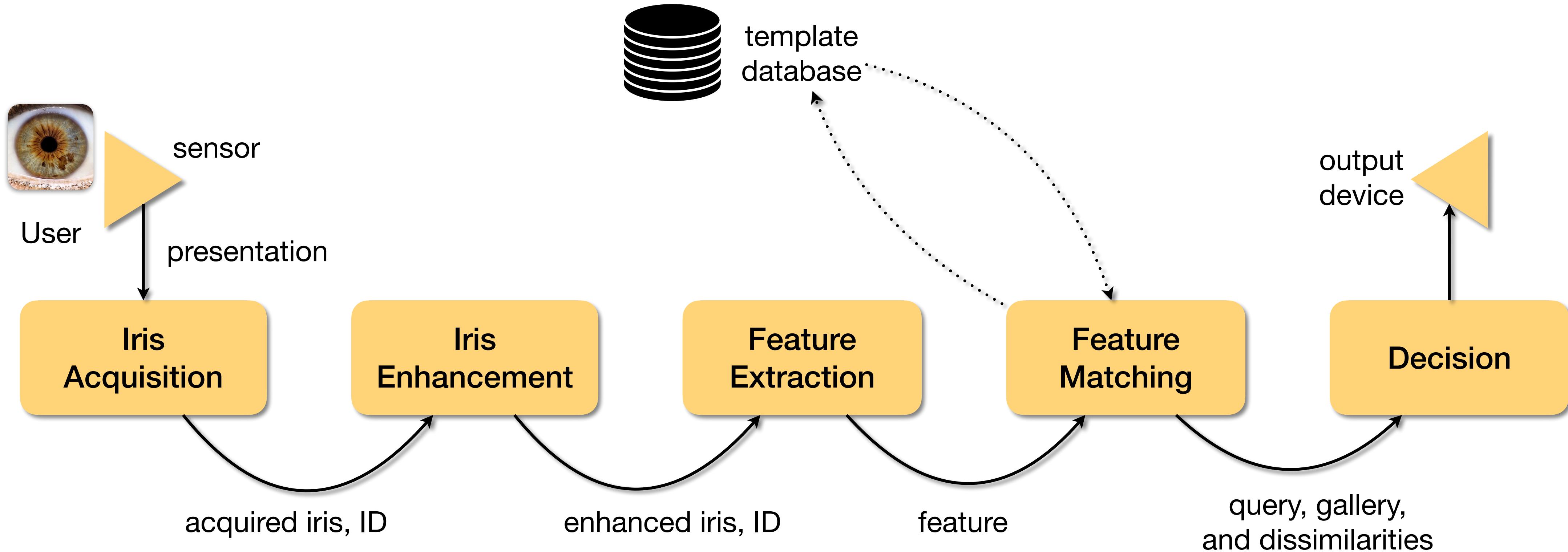
Take the smallest distance as the score.

Iris Recognition

template
database

sensor

User

presentation

Iris
Acquisition

Iris
Enhancement

Feature
Extraction

Feature
Matching

acquired iris, ID

enhanced iris, ID

feature

UNIVERSITY OF
NOTRE DAME

Iris Recognition

sensor

User

presentation

template
database

output
device

Iris Acquisition

Iris Enhancement

Feature Extraction

Feature Matching

Decision

acquired iris, ID

enhanced iris, ID

feature

query, gallery,
and dissimilarities

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Iris Recognition

template database

sensor

User

presentation

Iris Acquisition

acquired iris, ID

Iris Enhancement

enhanced iris, ID

Feature Extraction

feature

Feature Matching

Decision

output device

Use distance threshold.

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Domain-Specific BSIF Codes

Original BSIF:
Natural images to learn filters.
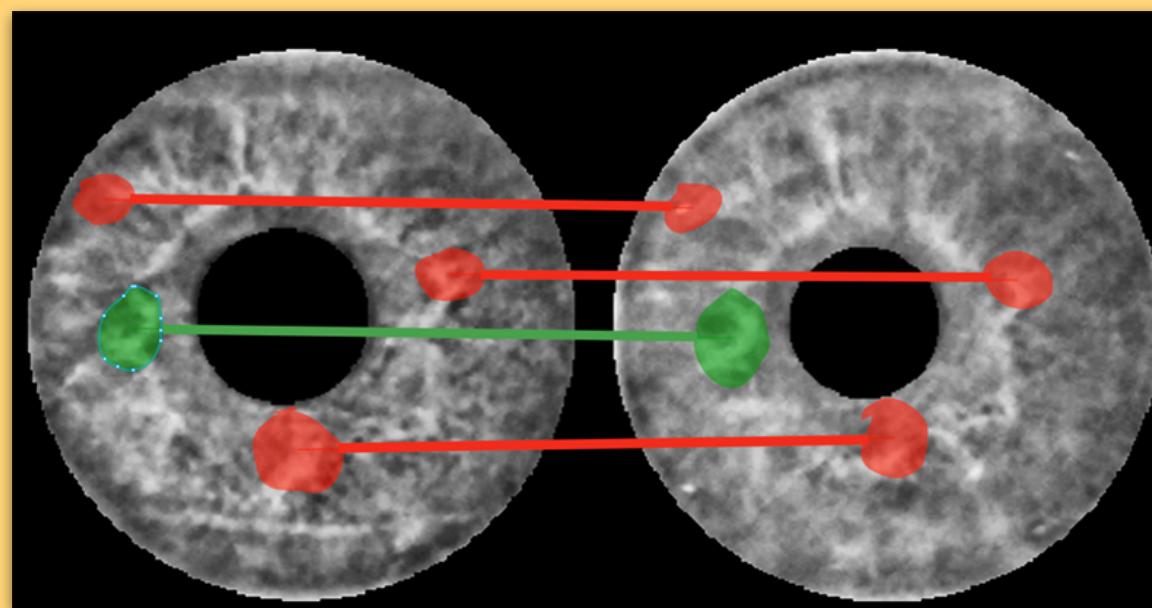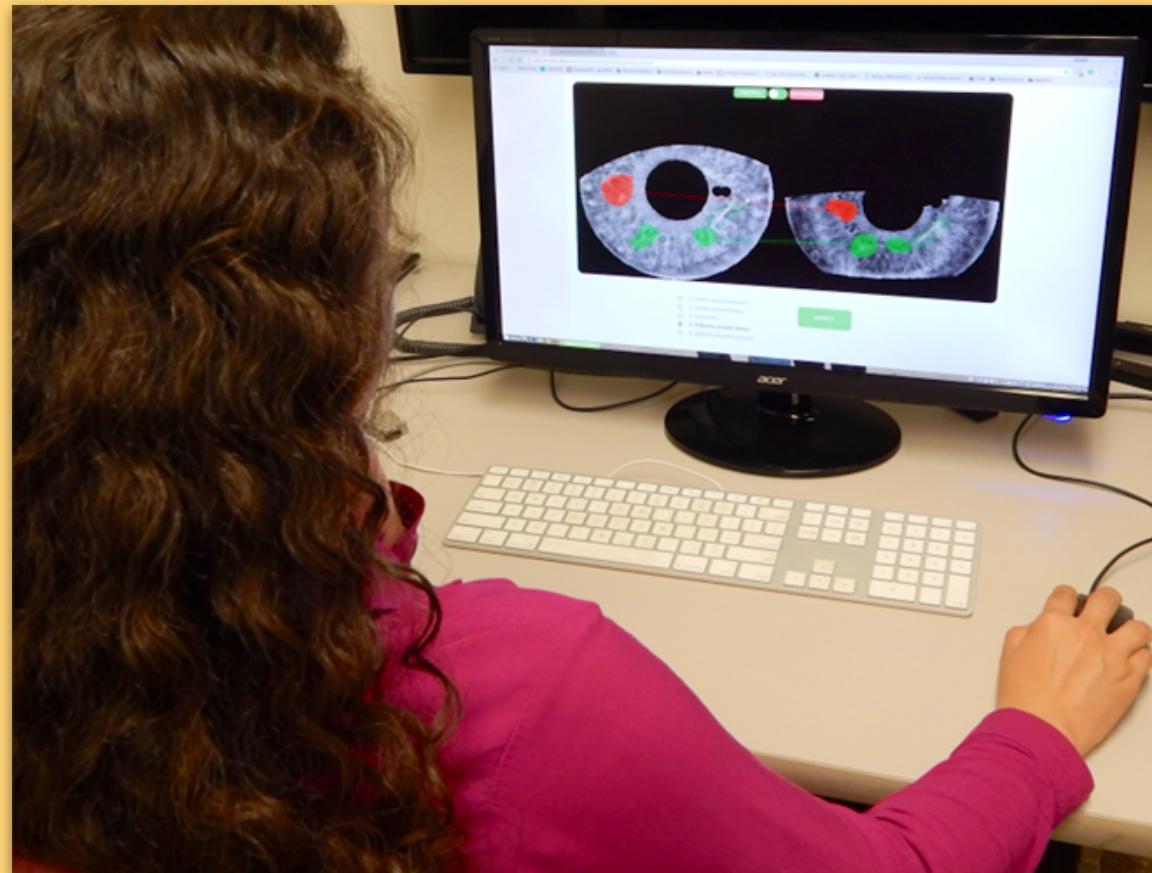
What is the gain of learning from irises?

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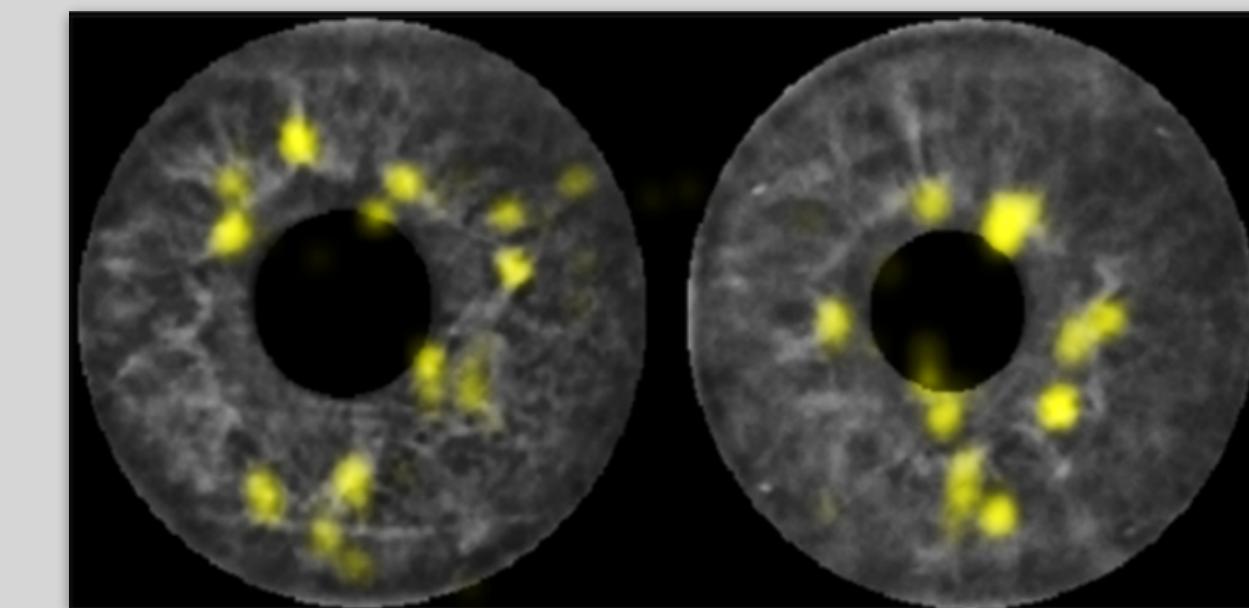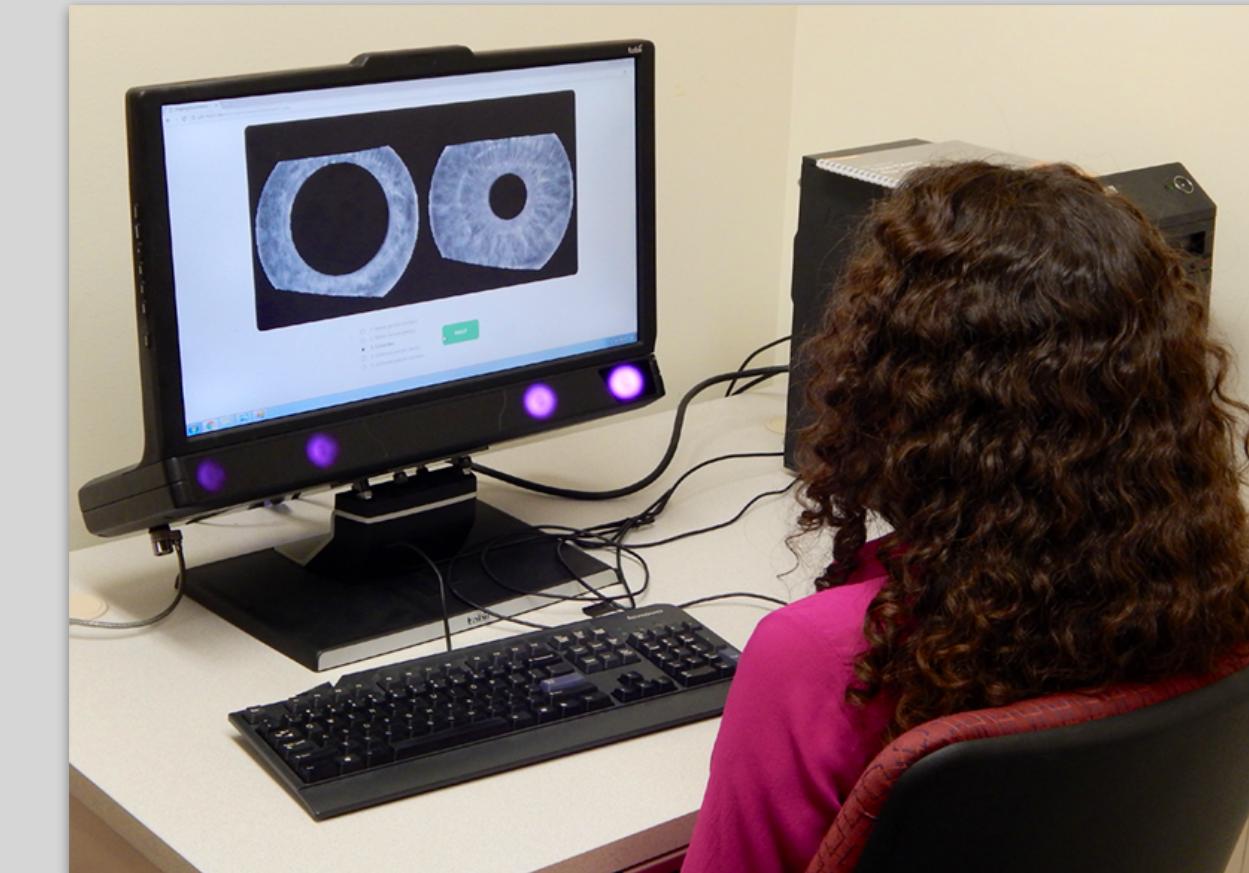
Domain-Specific BSIF Codes

How to Select Iris Patches?

Manual Annotation
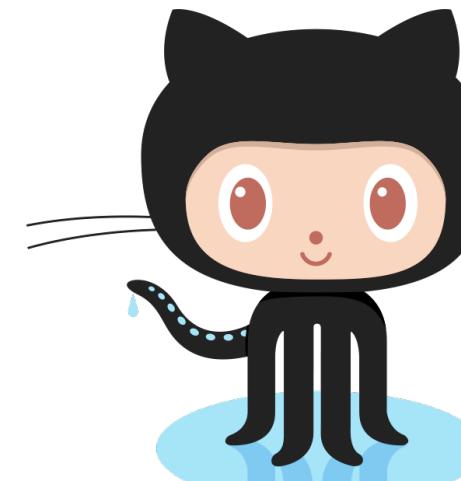
Eye-Tracker Data
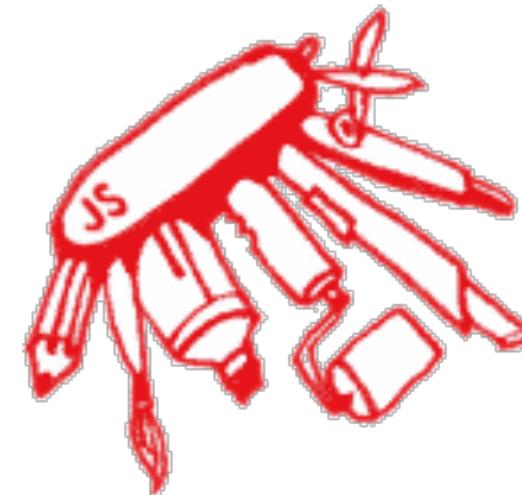
Domain-Specific BSIF Codes

Annotation Tool

Available at
https://github.com/
danielmoreira/iris-examination
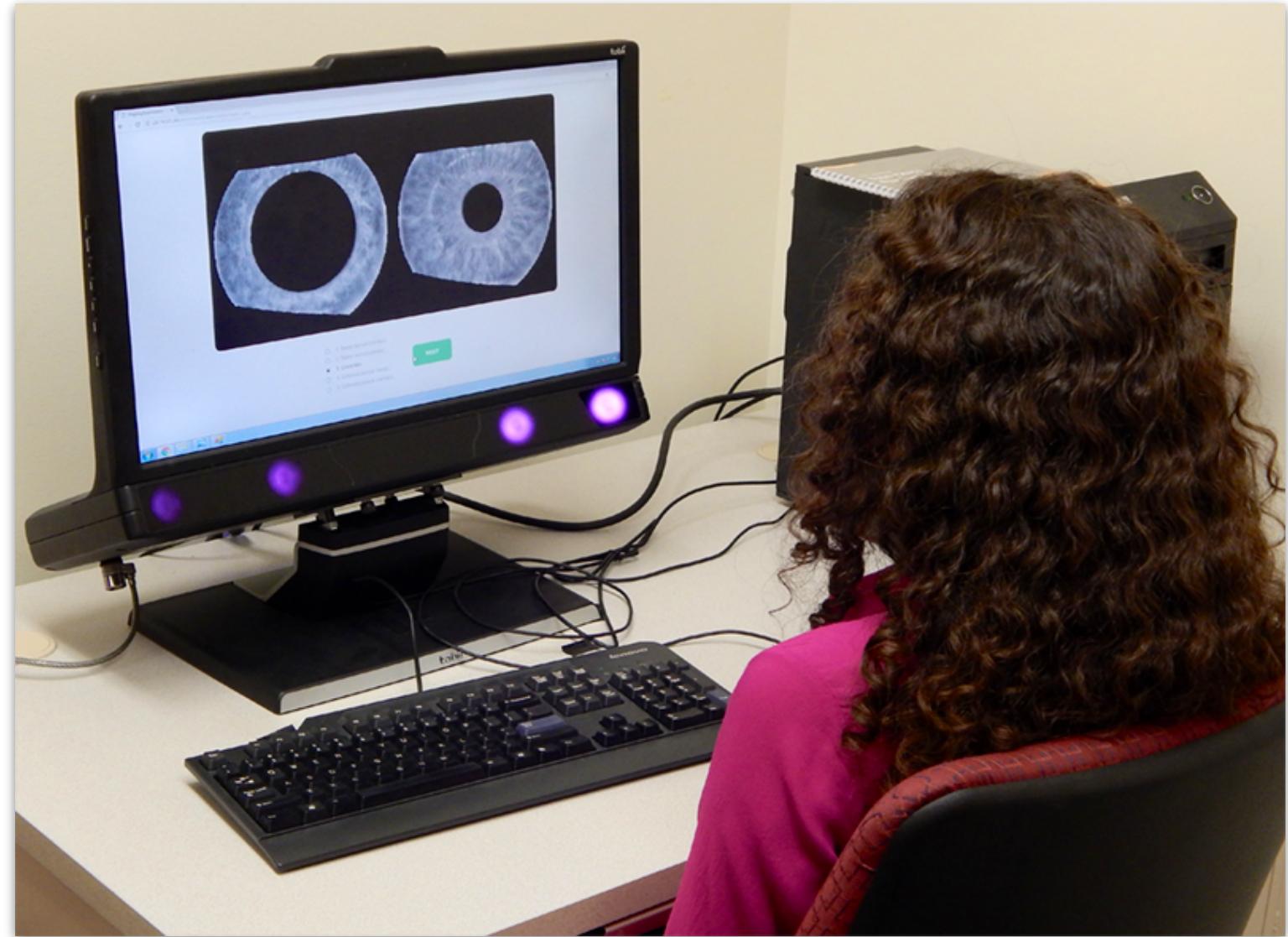
Paper.js
Web-browser drawing library.

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45
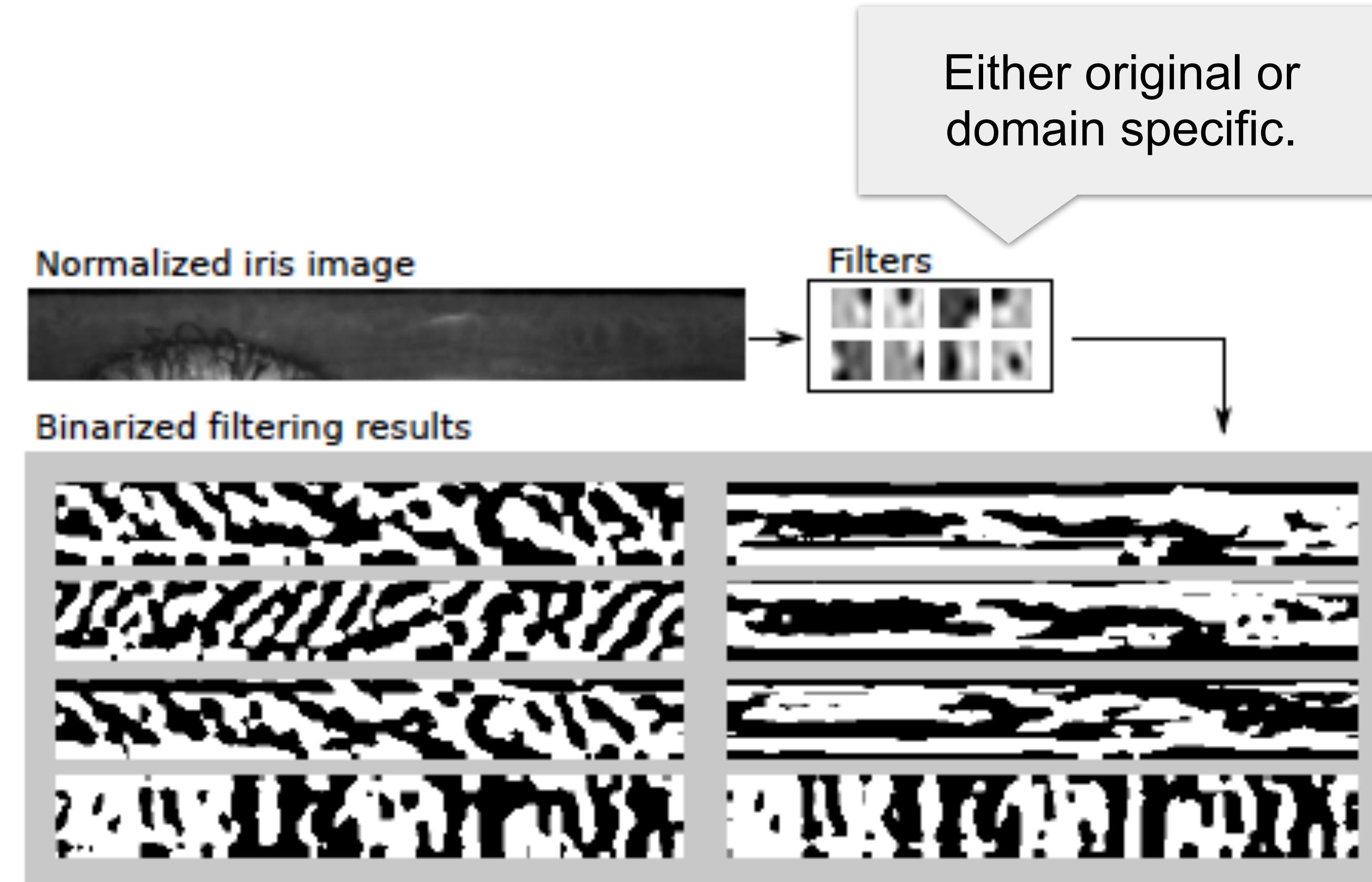
Domain-Specific BSIF Codes

Eye Tracker

Domain-Specific BSIF Codes
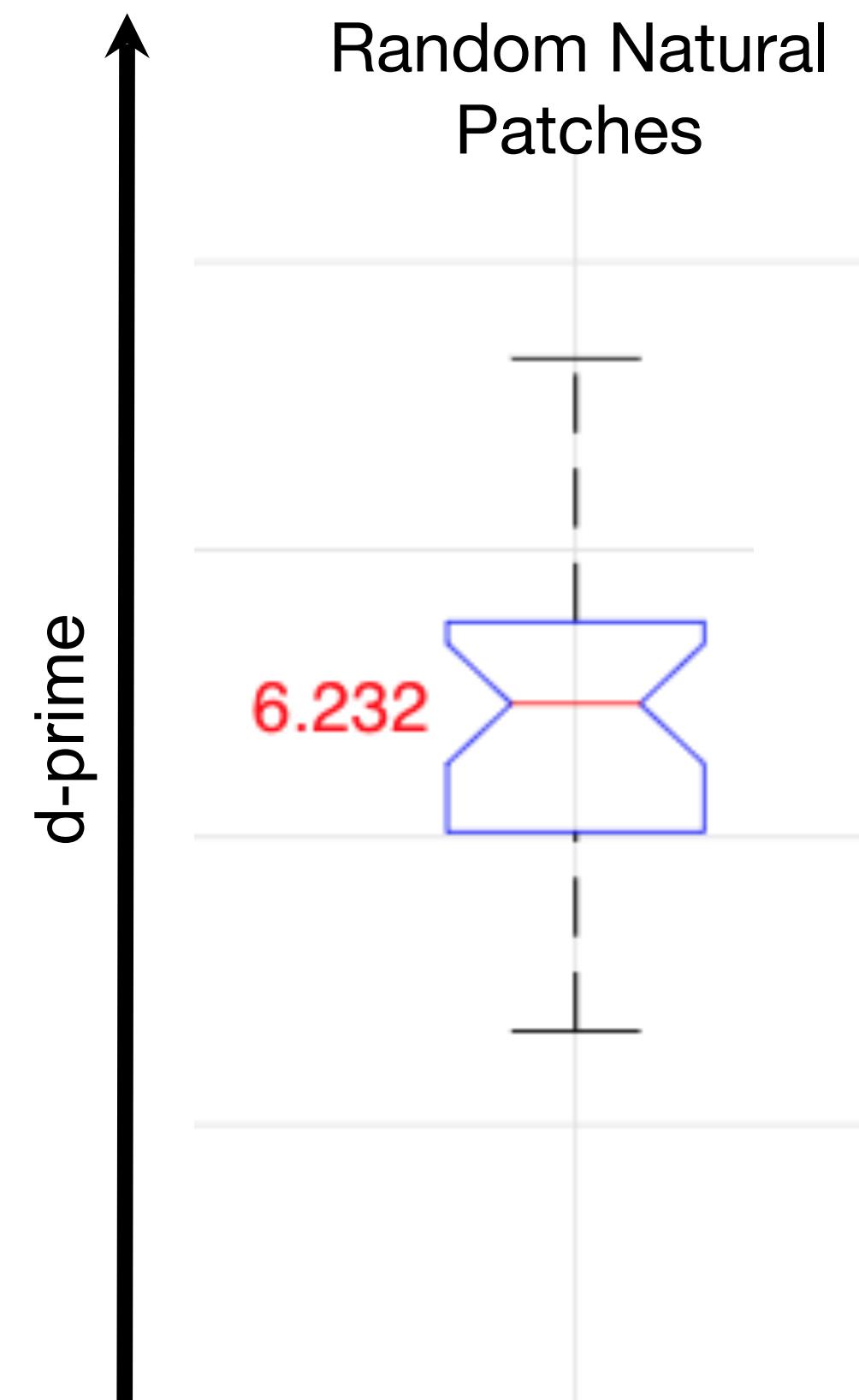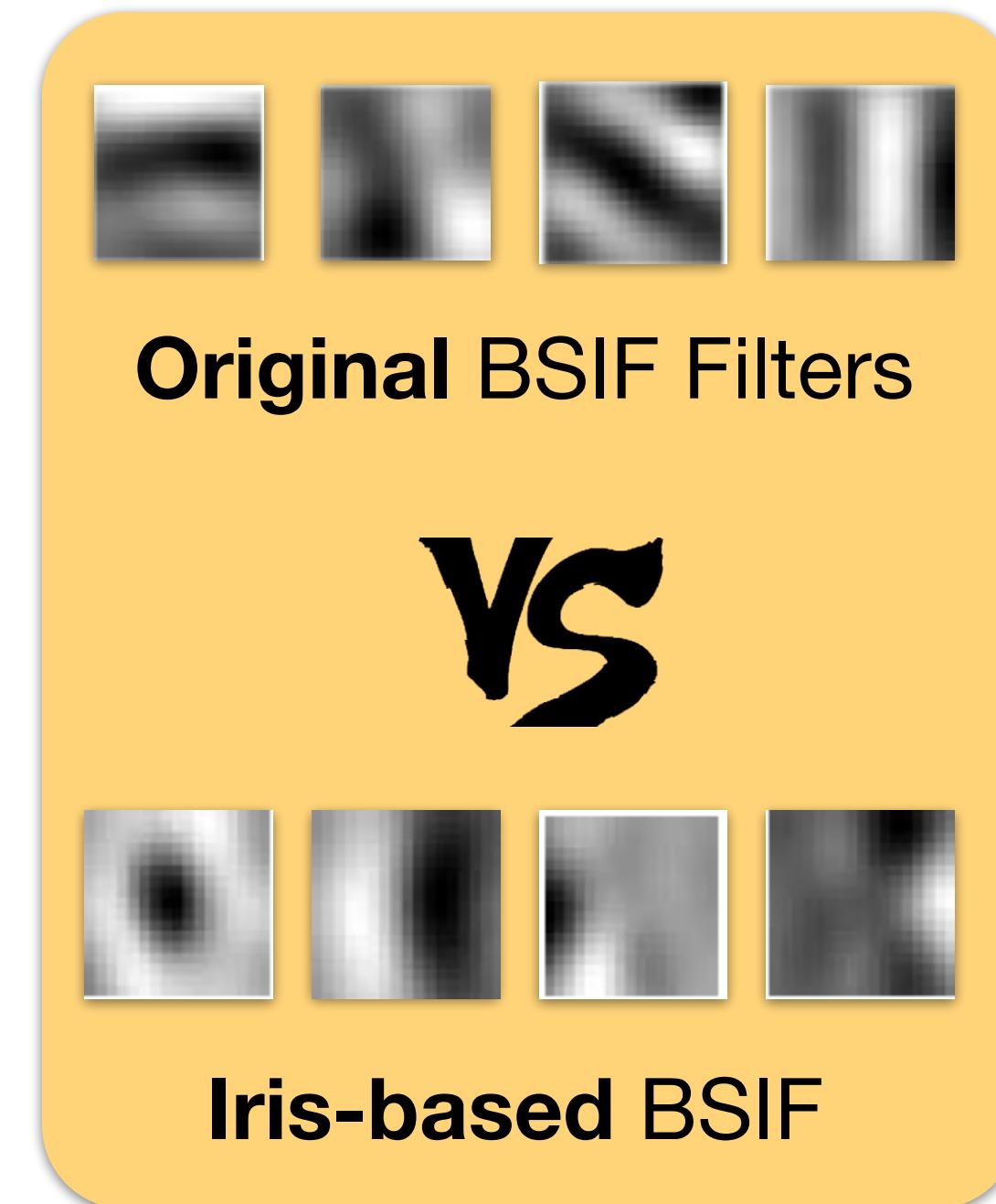
Application

Either original or domain specific.

Normalized iris image

Filters
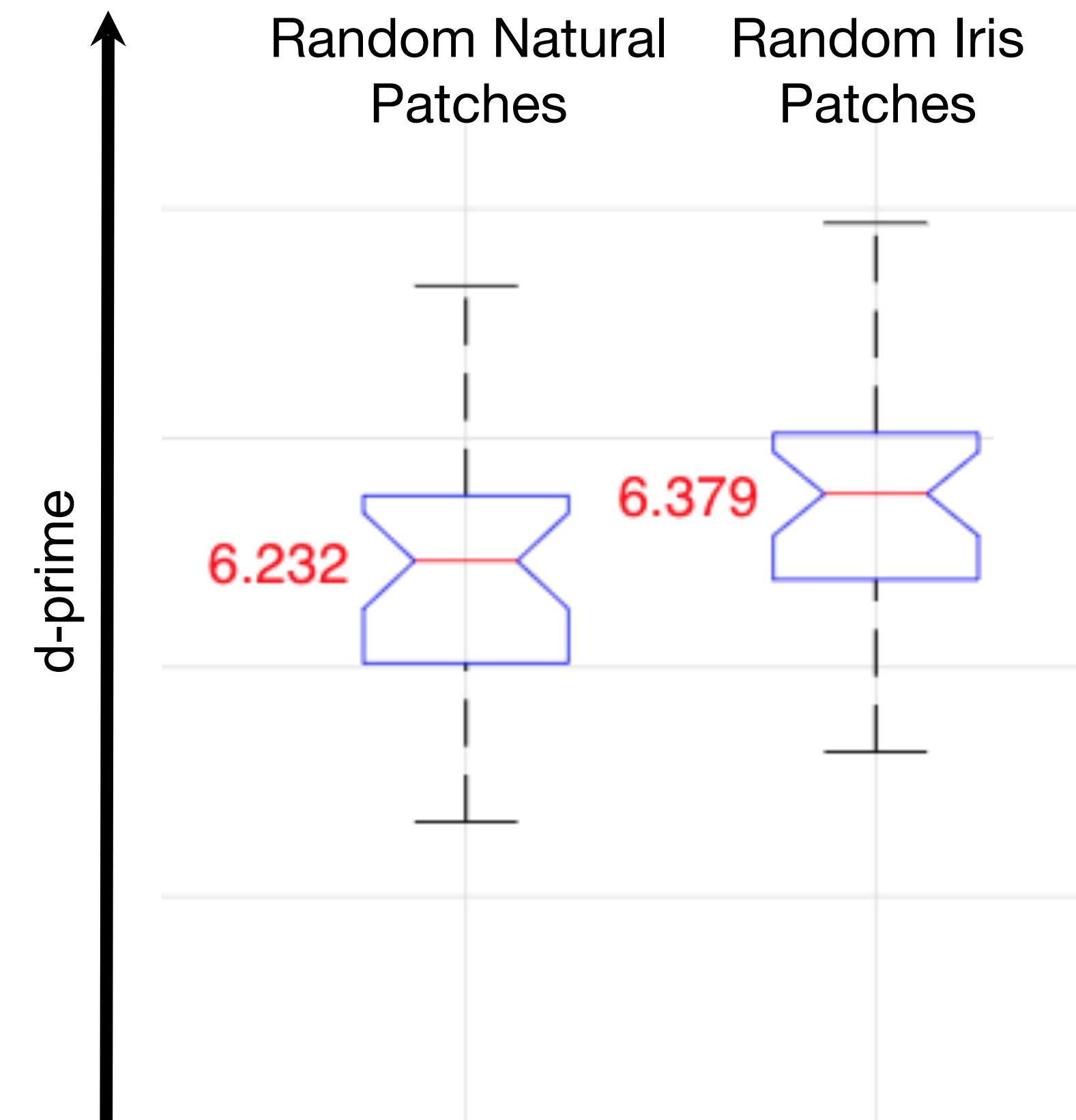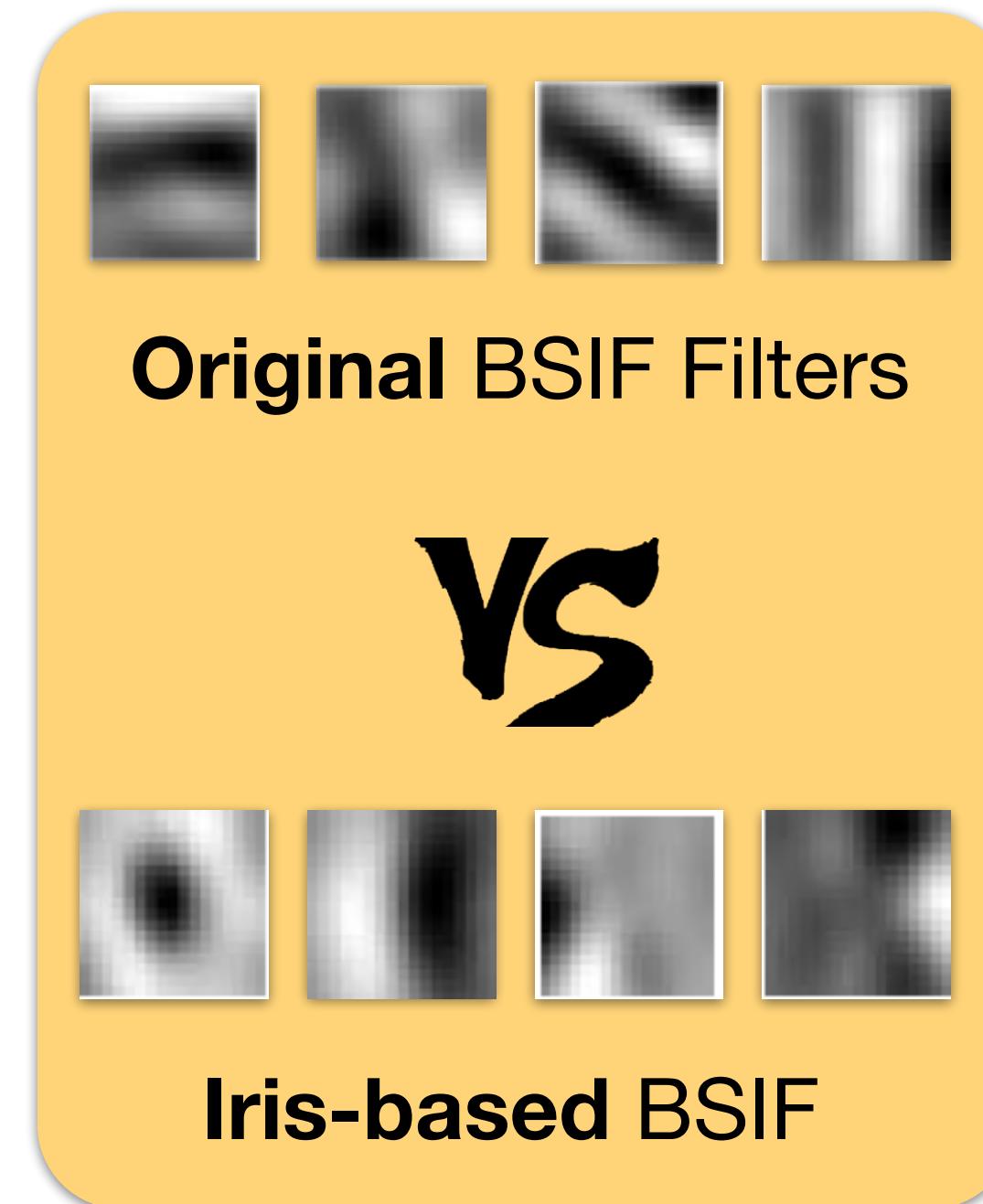
Binarized filtering results

Czajka et al.
*Domain-Specific Human-Inspired
Binarized Statistical Image Features
for Iris Recognition*
WACV 2019

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Domain-Specific BSIF Codes

Results

Original BSIF Filters

VS

Iris-based BSIF

Random Natural Patches

d-prime

6.232

Czajka et al.
*Domain-Specific Human-Inspired
Binarized Statistical Image Features
for Iris Recognition*
WACV 2019

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48

Domain-Specific BSIF Codes

Results

Original BSIF Filters

VS

Iris-based BSIF

d-prime

Random Natural Patches

Random Iris Patches

6.232

6.379

Czajka et al.
Domain-Specific Human-Inspired Binarized Statistical Image Features for Iris Recognition
WACV 2019

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Domain-Specific BSIF Codes

Results

Original BSIF Filters VS Iris-based BSIF

d-prime

Random Natural Patches — 6.232

Random Iris Patches — 6.379

Manual Iris Patches — 6.559

Czajka et al.
Domain-Specific Human-Inspired Binarized Statistical Image Features for Iris Recognition
WACV 2019

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Domain-Specific BSIF Codes

Results

Original BSIF Filters

VS

Iris-based BSIF

d-prime

Random Natural Patches

Random Iris Patches

Manual Iris Patches

Eye-tracked Iris Patches

6.232

6.379

6.559

6.716

Czajka et al.
Domain-Specific Human-Inspired Binarized Statistical Image Features for Iris Recognition
WACV 2019

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S'up Next?

**Fingerprint Recognition
Coding Class**

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