Iris Recognition III

CSE 40537/60537 Biometrics
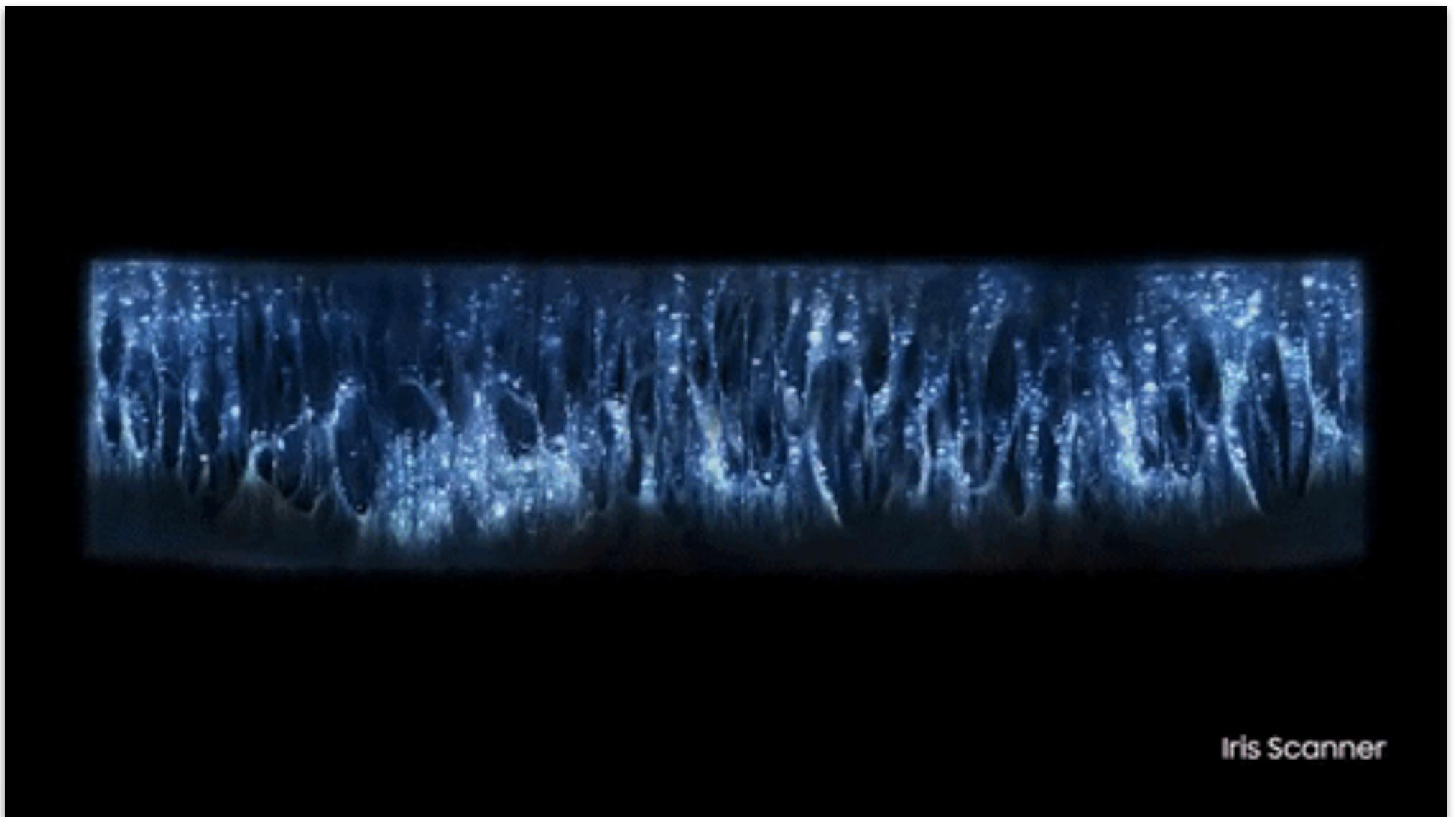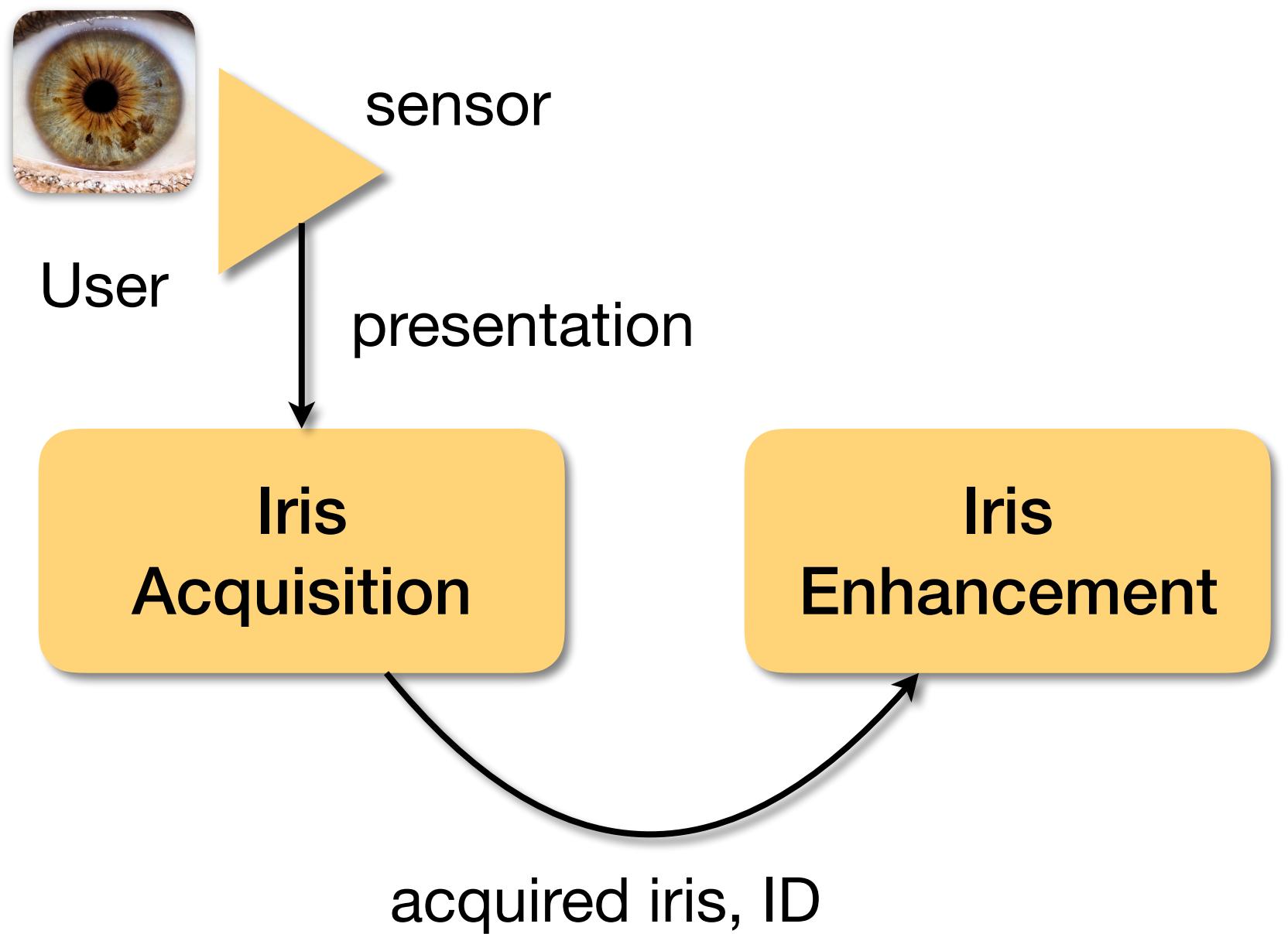
Daniel Moreira

Spring 2020

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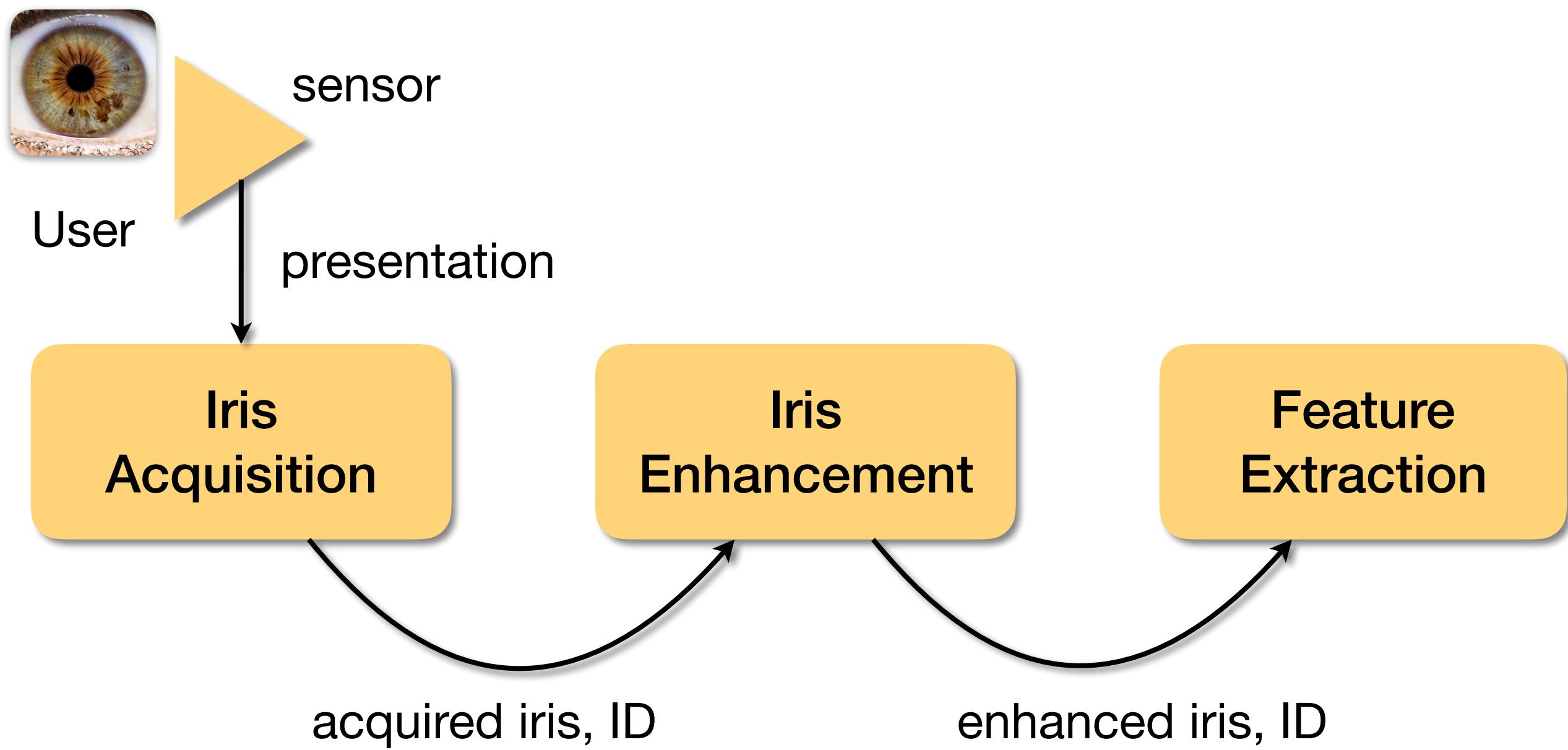
Today you will...

Get to know
Iris description and matching.

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Iris Recognition

User

sensor

presentation

Iris Acquisition

Iris Enhancement

acquired iris, ID

Iris Scanner

Iris Recognition

sensor

User

presentation

Iris Acquisition

Iris Enhancement

Feature Extraction

acquired iris, ID

enhanced iris, ID

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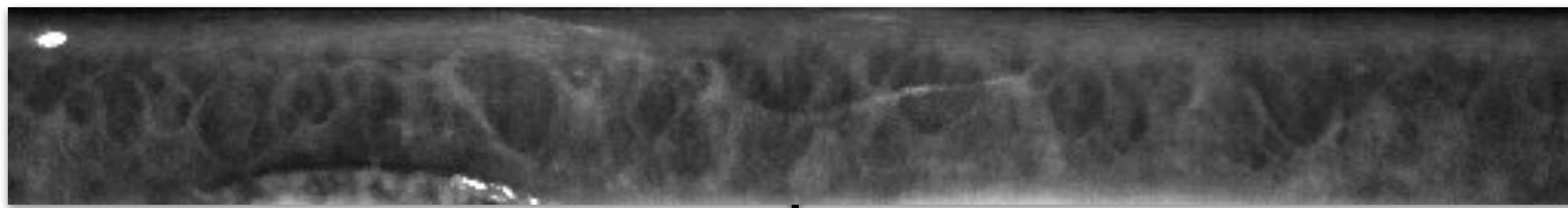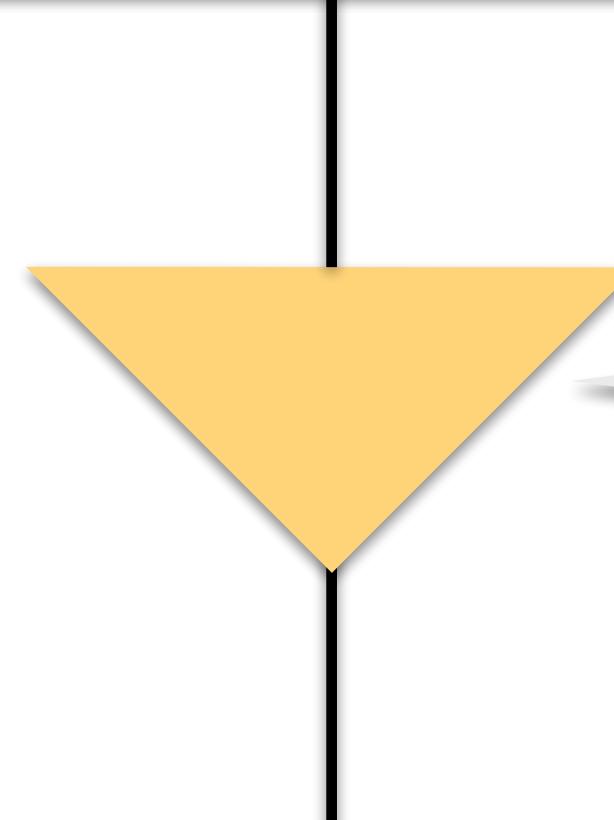
Feature Extraction

Typical Description Framework

normalized iris
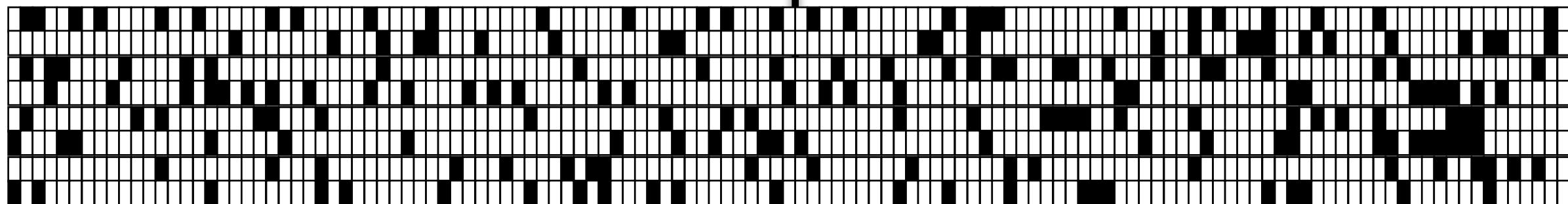
signal processing / image filters

Let's see 3 methods!

binary iris code
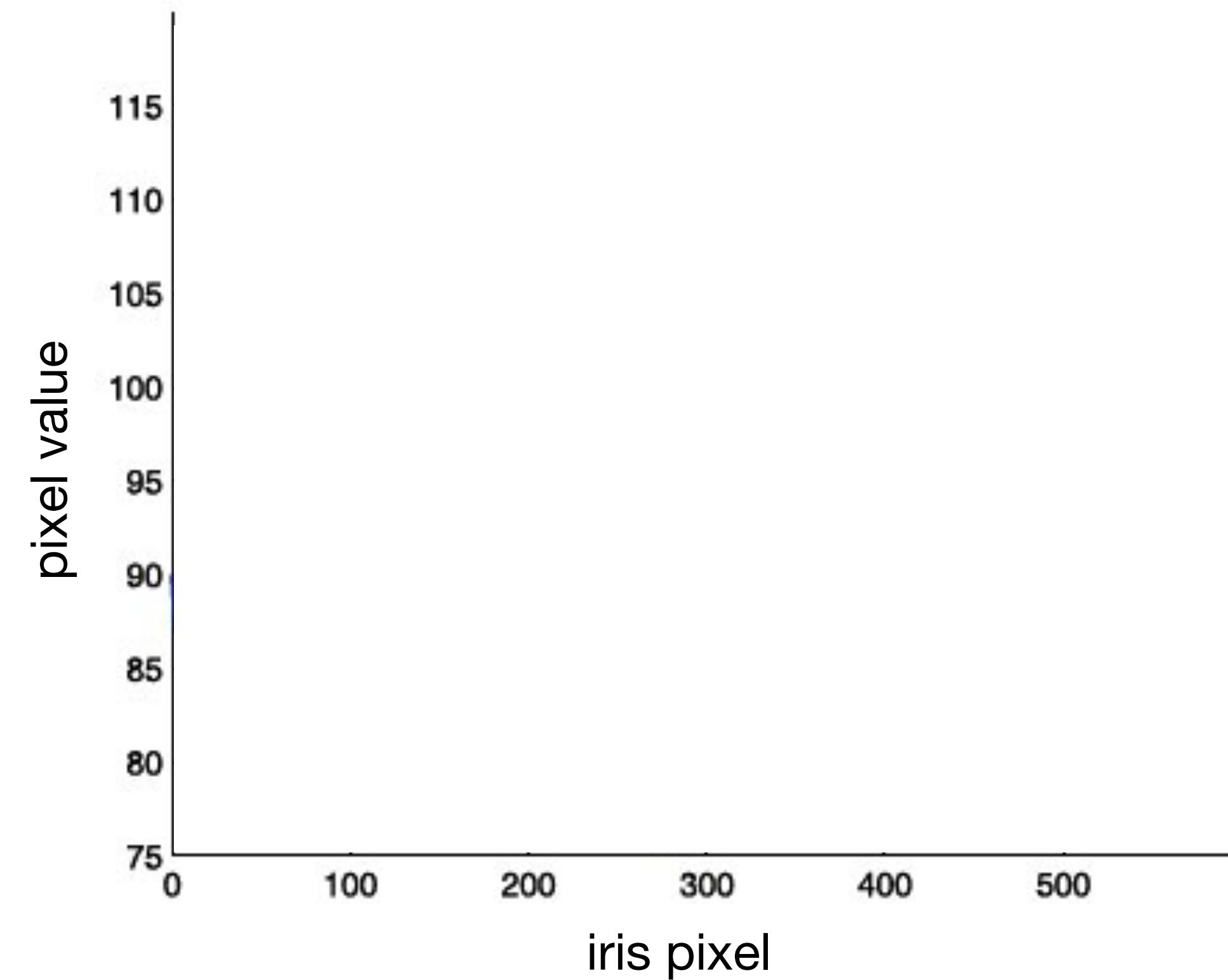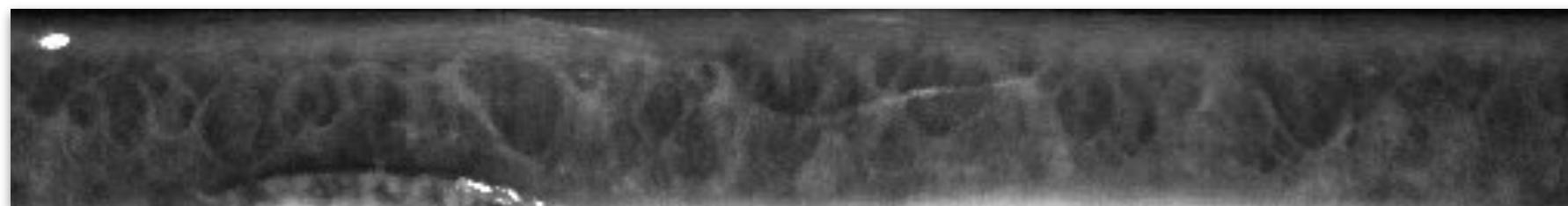
Feature Extraction
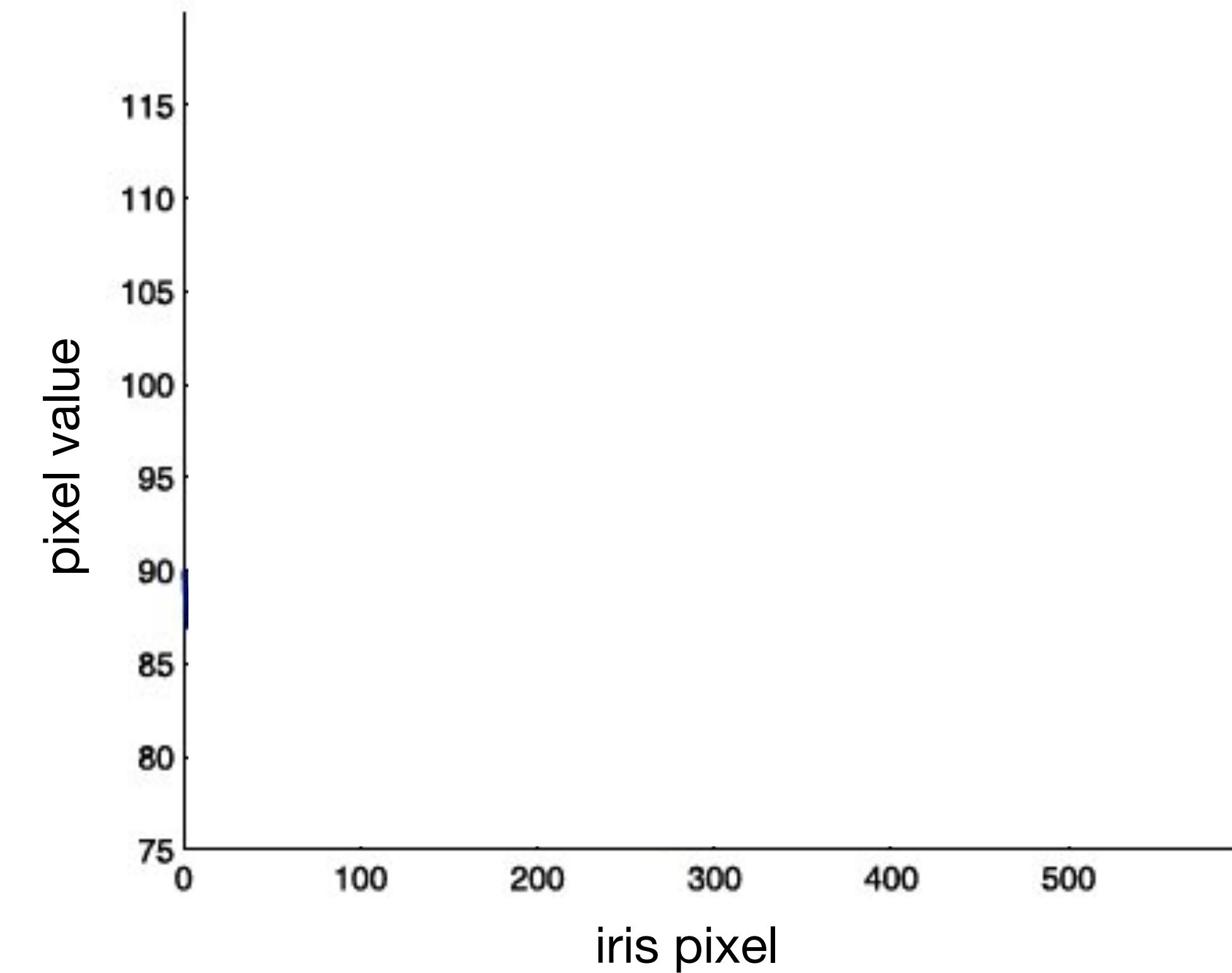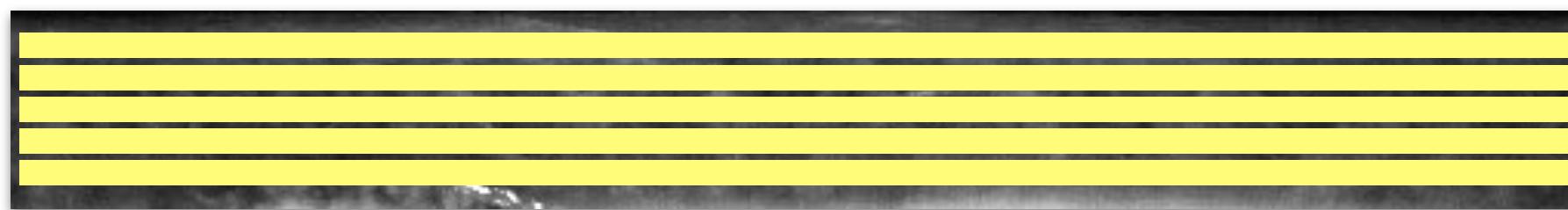
Zero-Crossing Approach (1/3)

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.

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

Dr. Adam Czajka

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

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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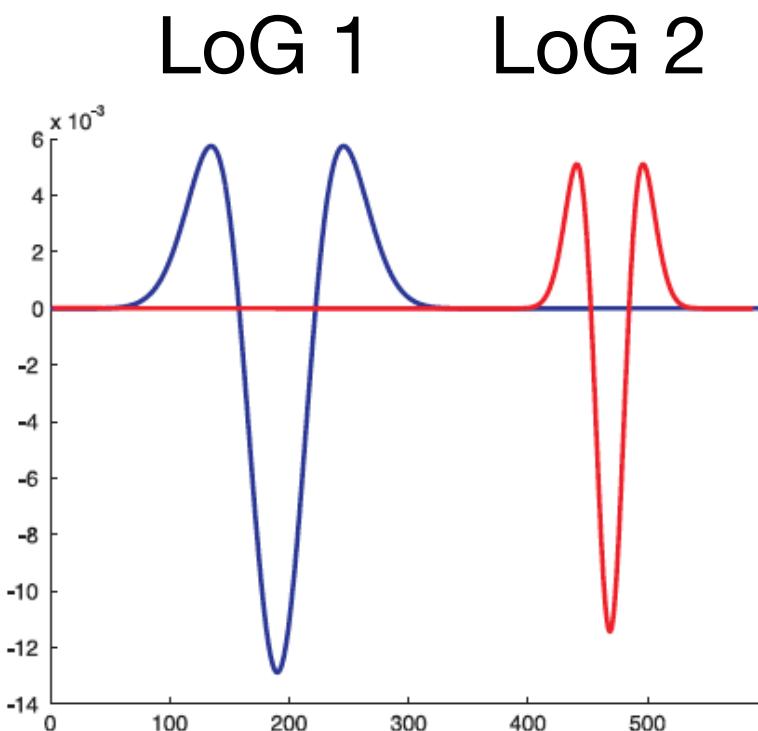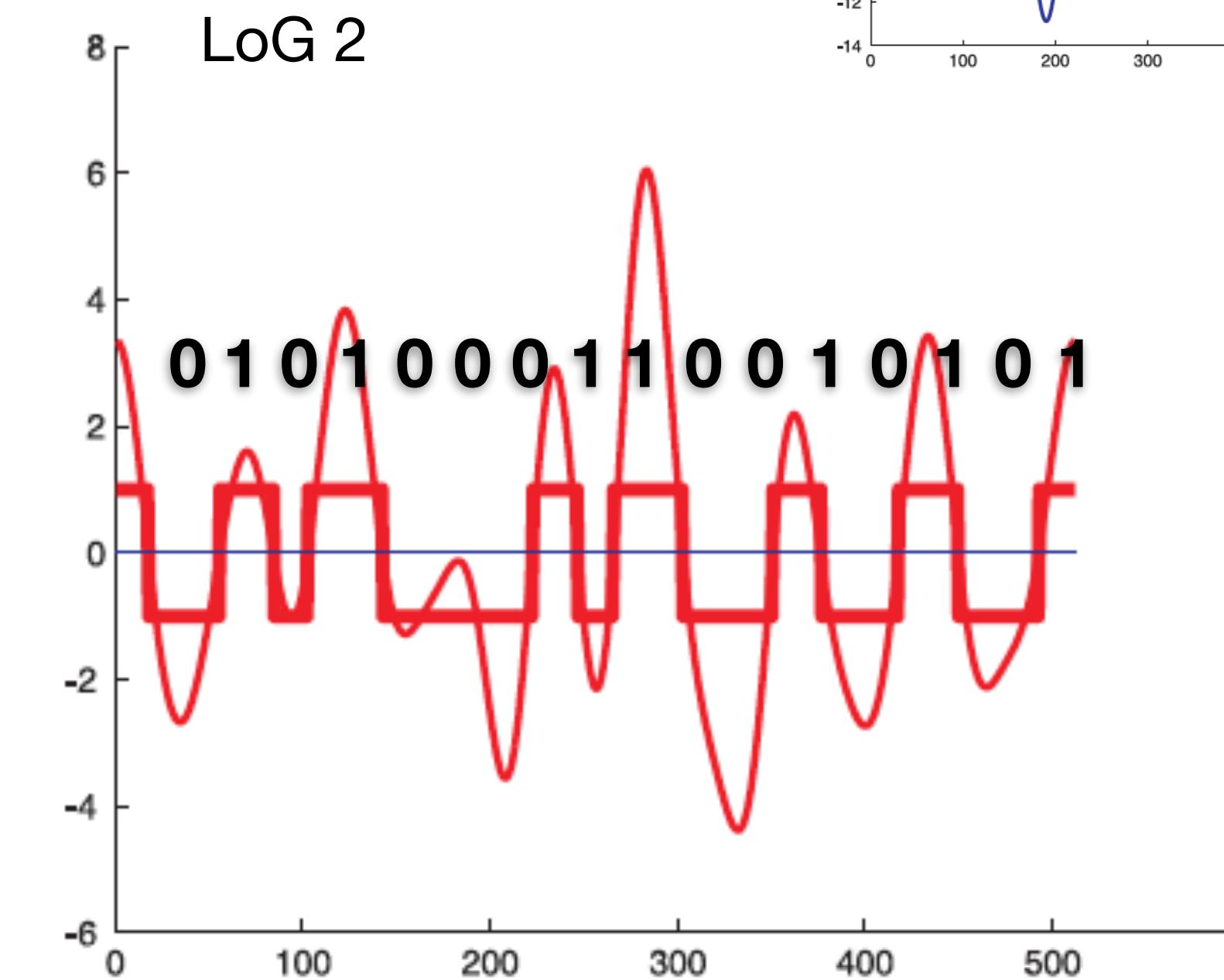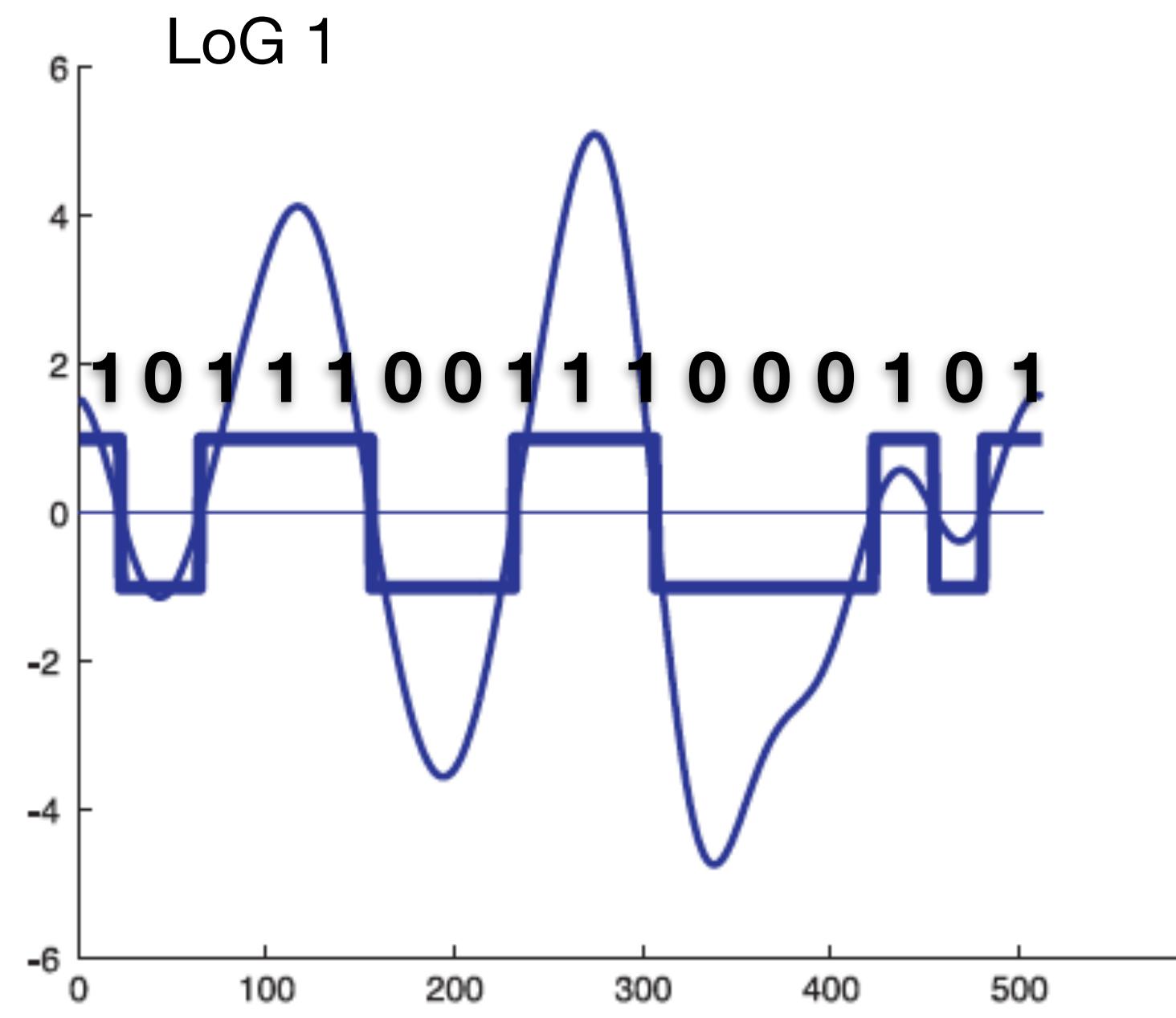
Feature Extraction
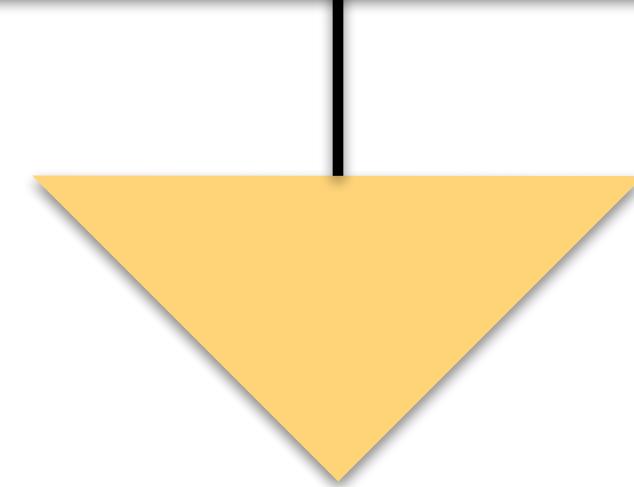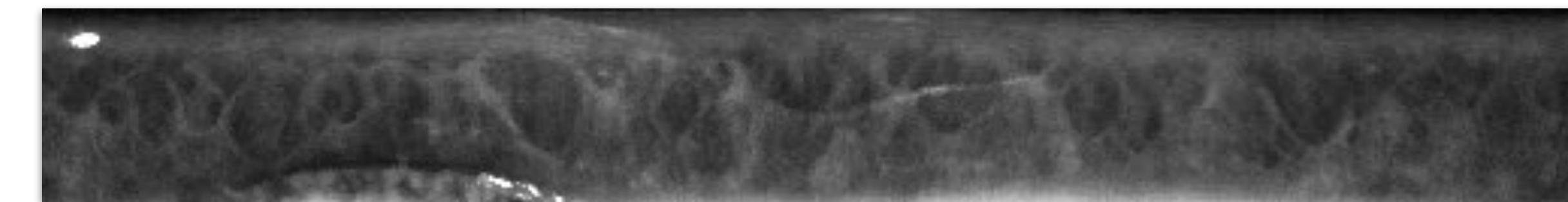
Zero-Crossing Approach (1/3)

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

LoG 1   LoG 2

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

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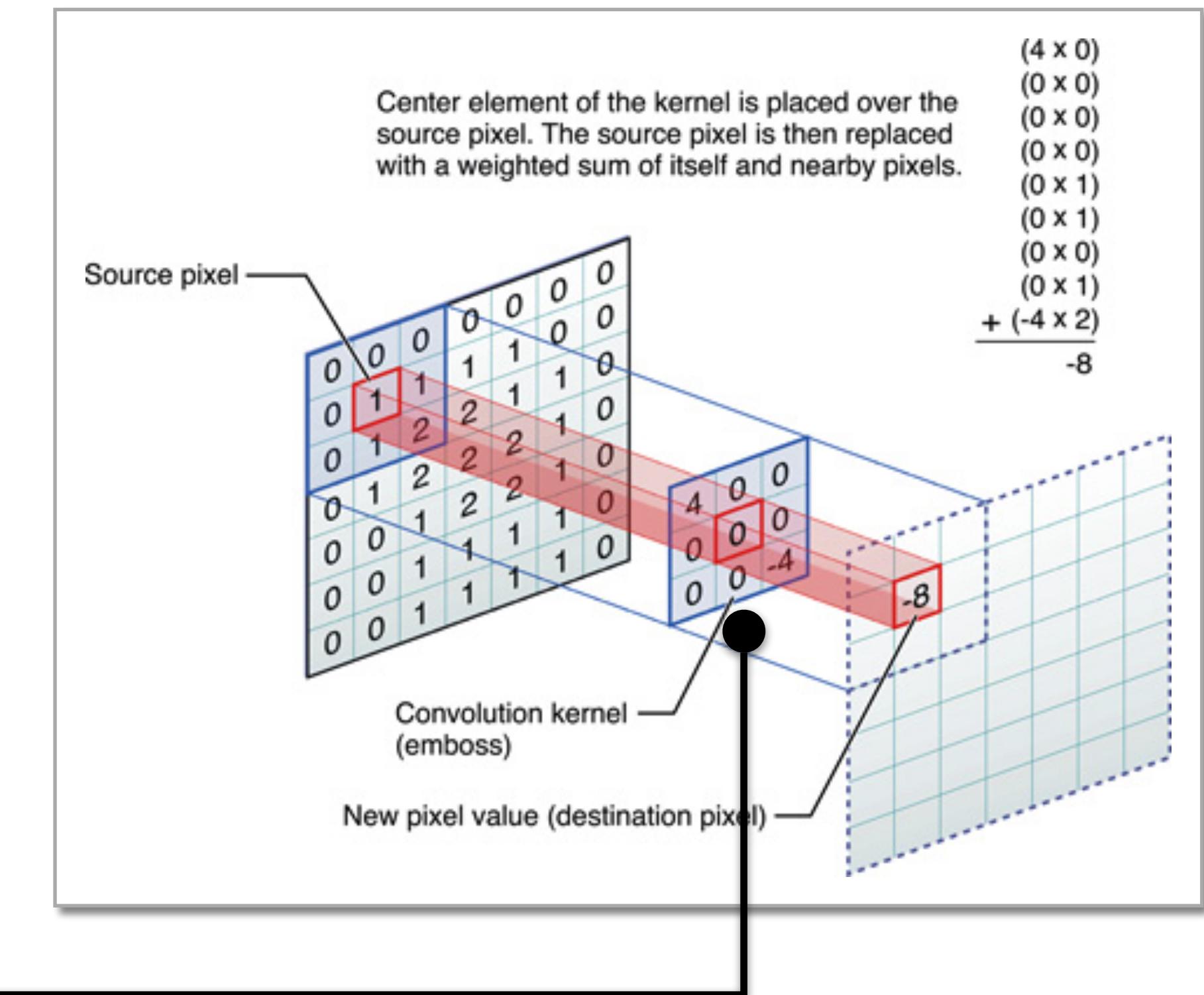
Feature Extraction

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.

Center element of the kernel is placed over the source pixel. The source pixel is then replaced with a weighted sum of itself and nearby pixels.

Source pixel

Convolution kernel (emboss)

New pixel value (destination pixel)

(4 x 0)
(0 x 0)
(0 x 0)
(0 x 0)
(0 x 1)
(0 x 1)
(0 x 0)
(0 x 1)
+ (-4 x 2)
-8

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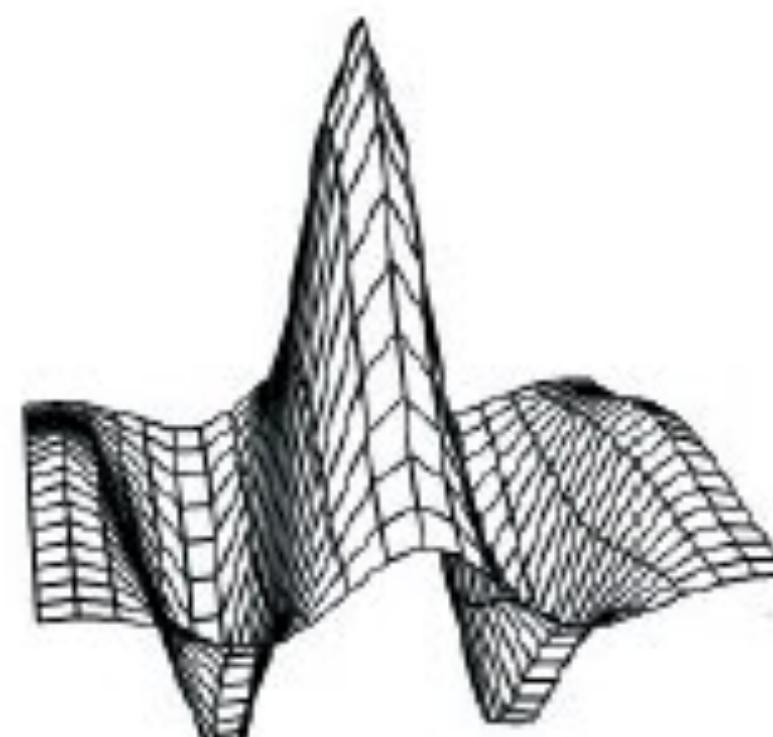
2D-Gabor Filtering Approach (2/3)

Proposed by John Daugman.

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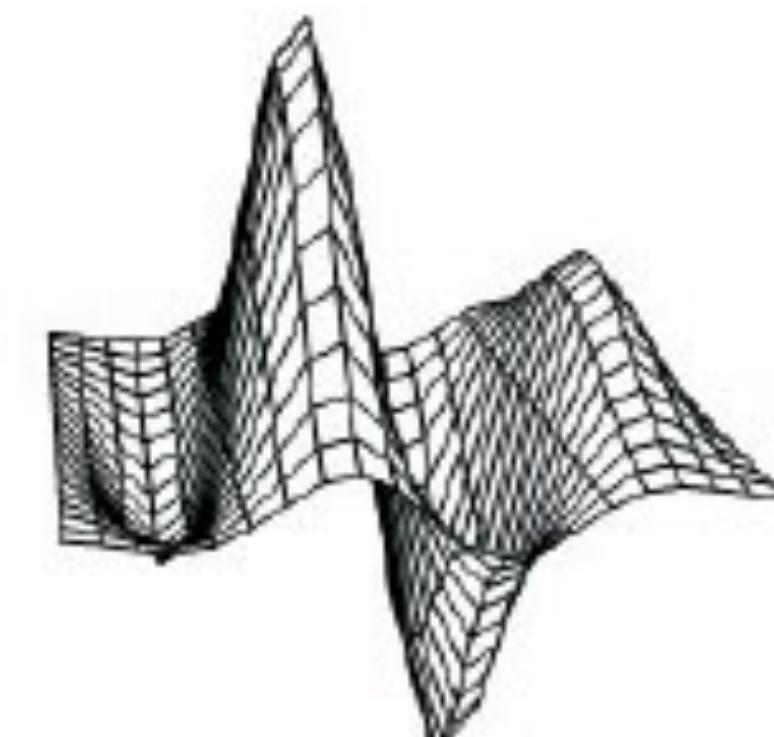
Gabor wavelets are a good model of neural receptive fields found in the visual cortex.

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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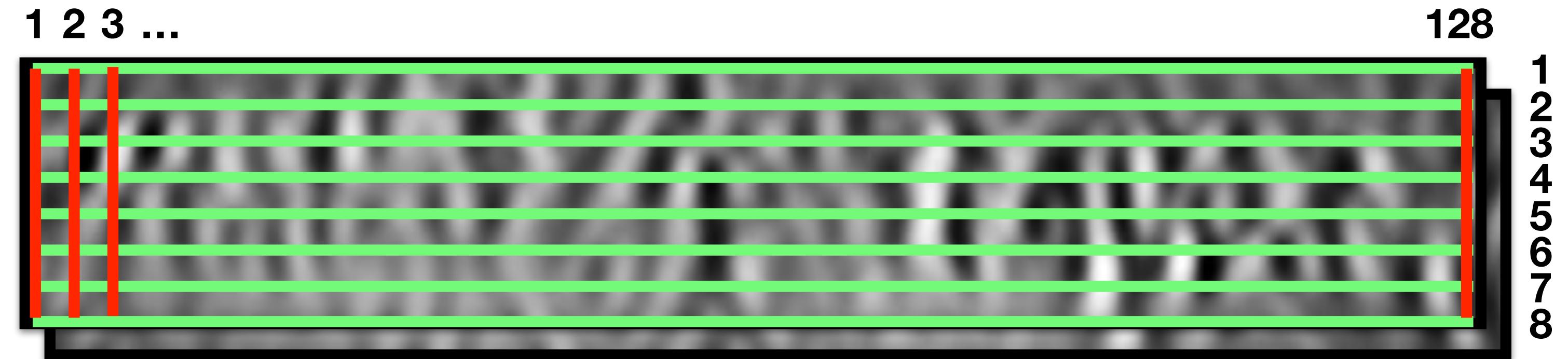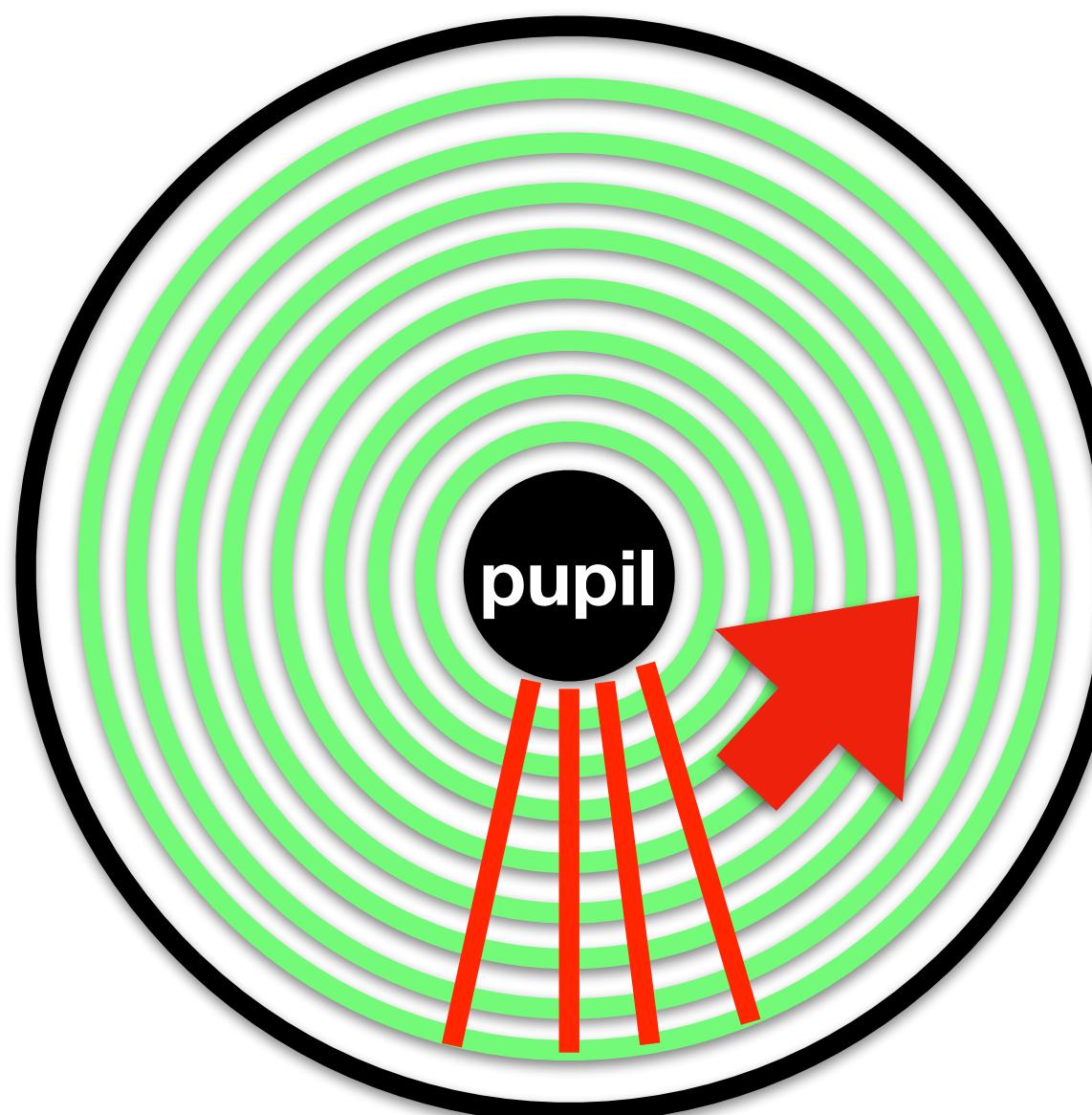
Feature Extraction

2D-Gabor Filtering Approach (2/3)

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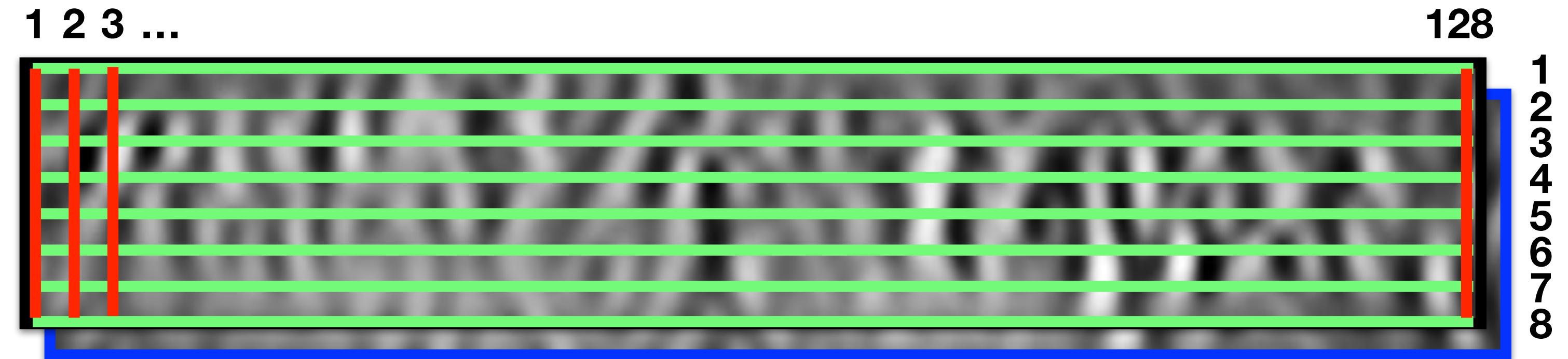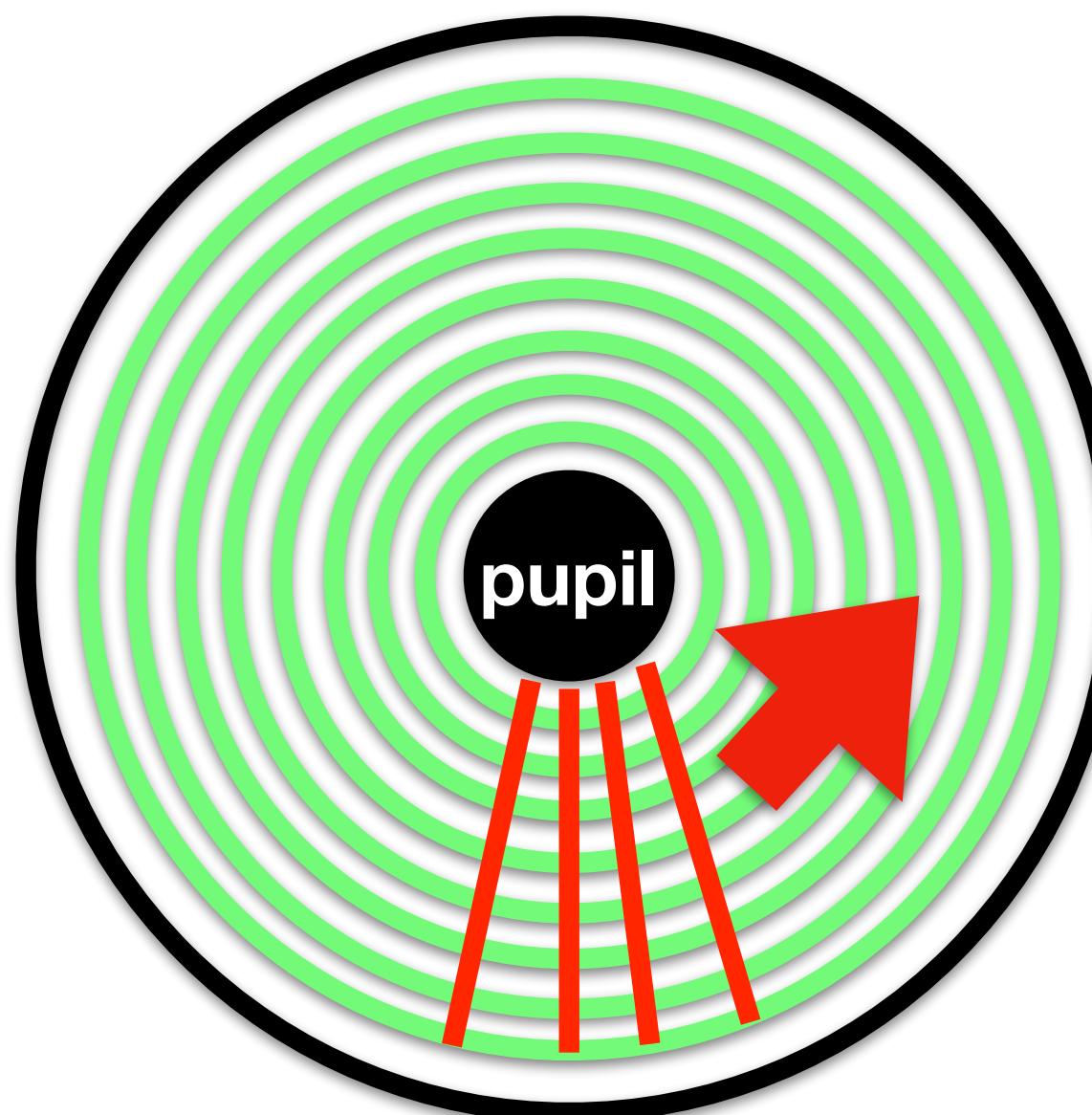
2D-Gabor Filtering Approach (2/3)

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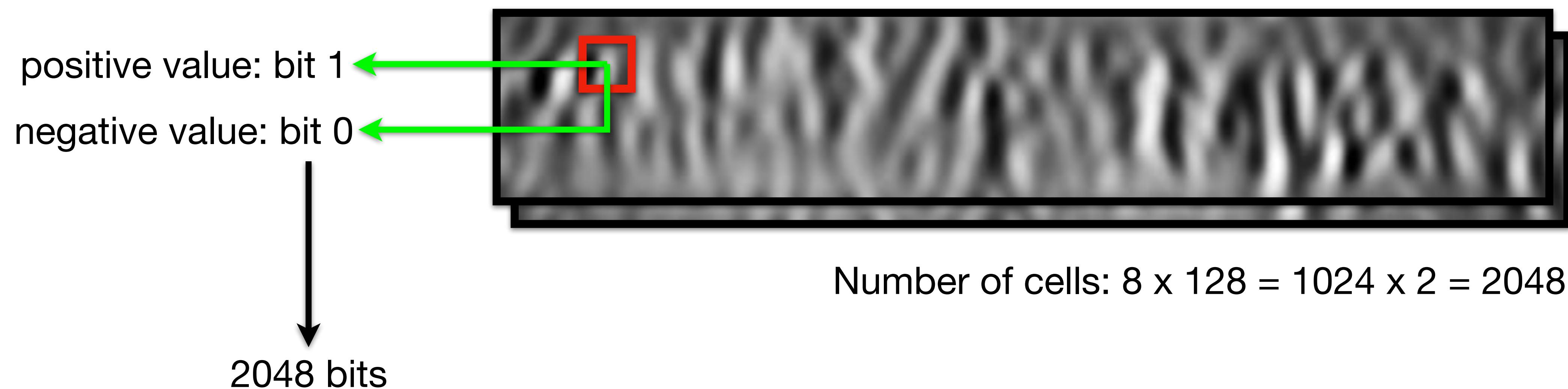
Feature Extraction
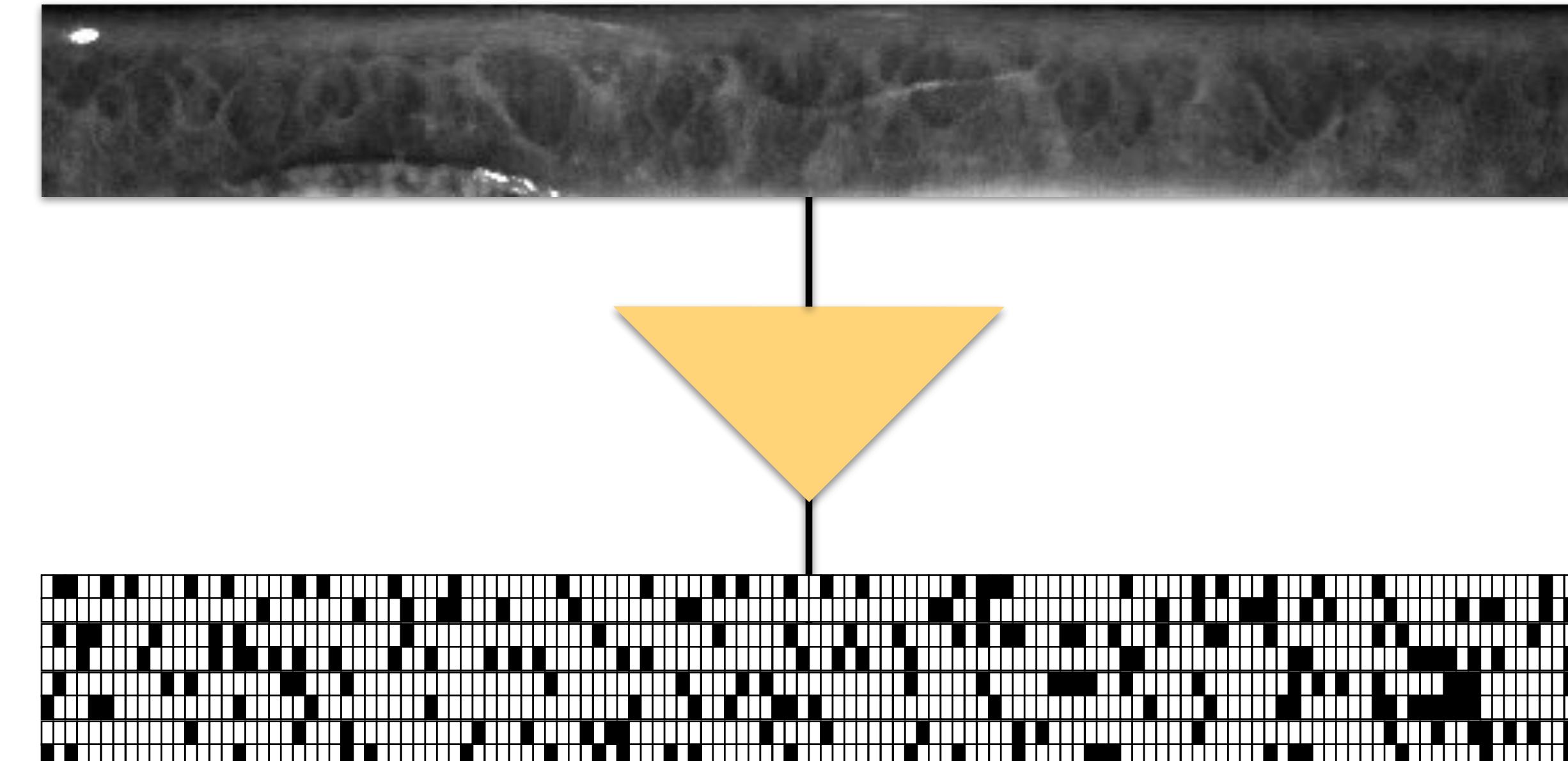
2D-Gabor Filtering Approach (2/3)

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
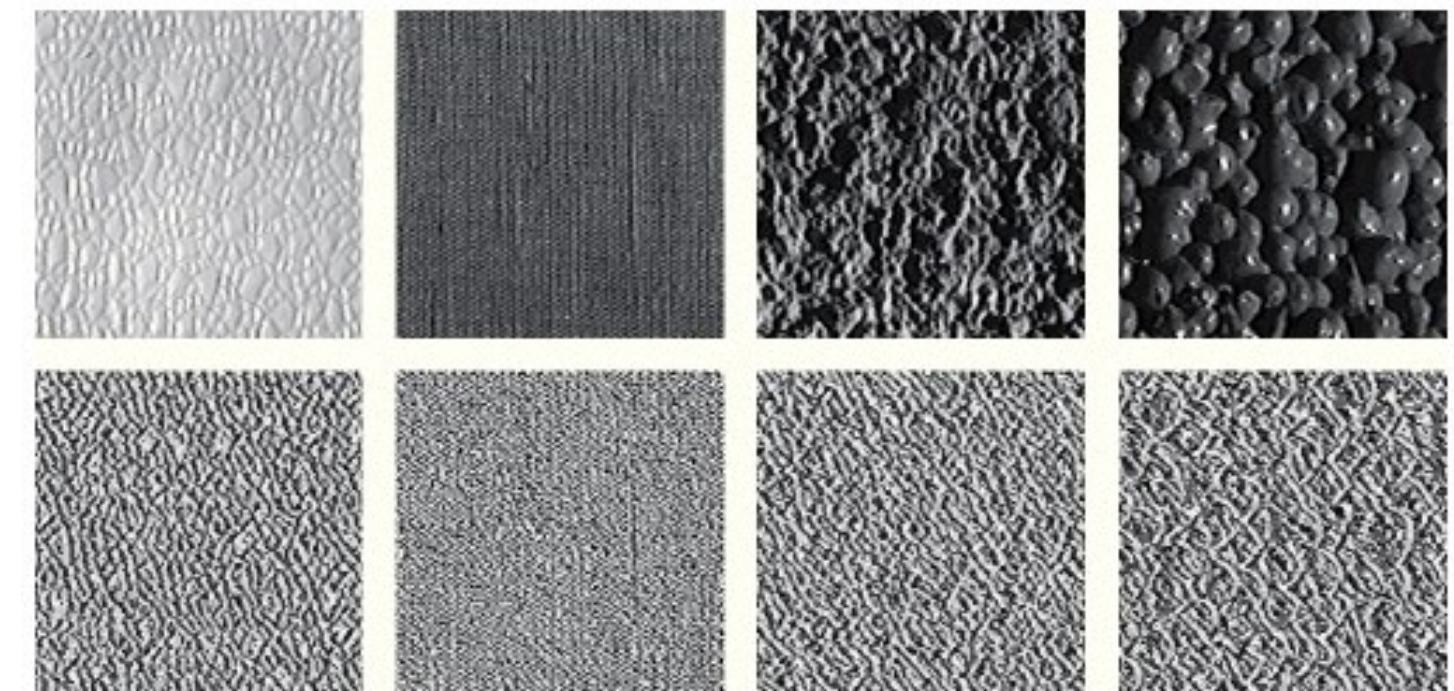
Feature Extraction

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.
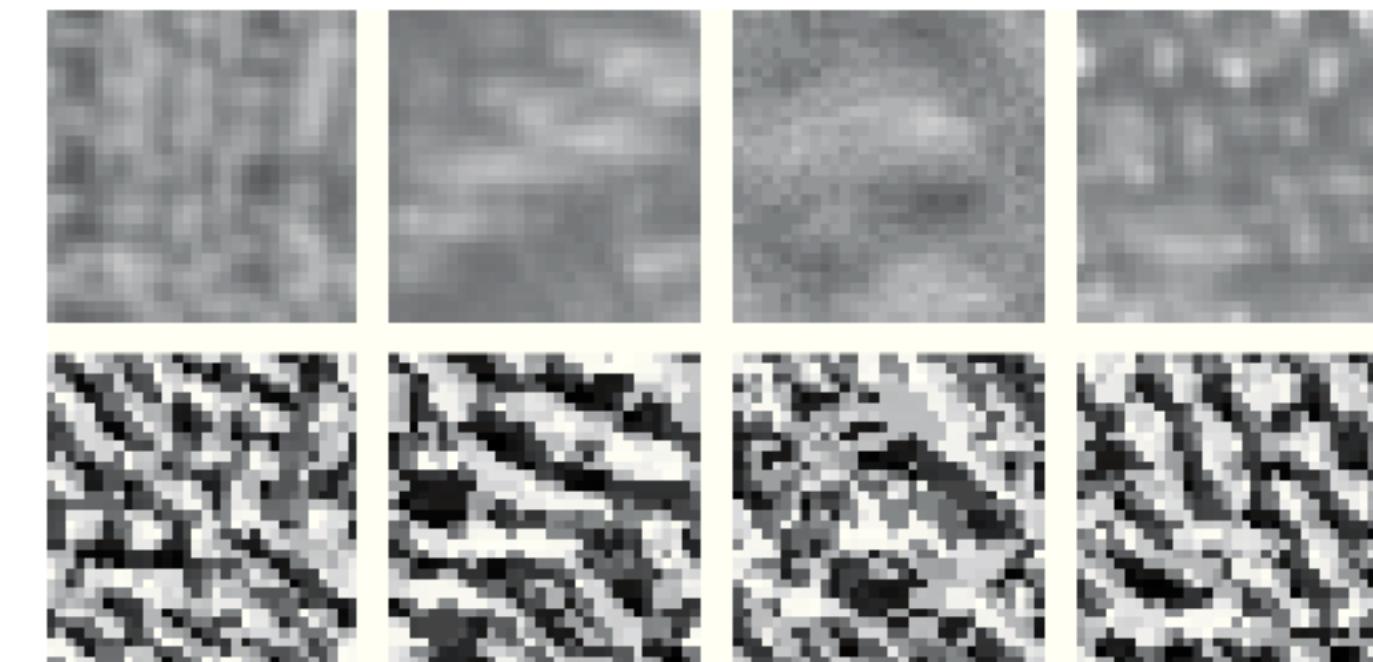
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Feature Extraction

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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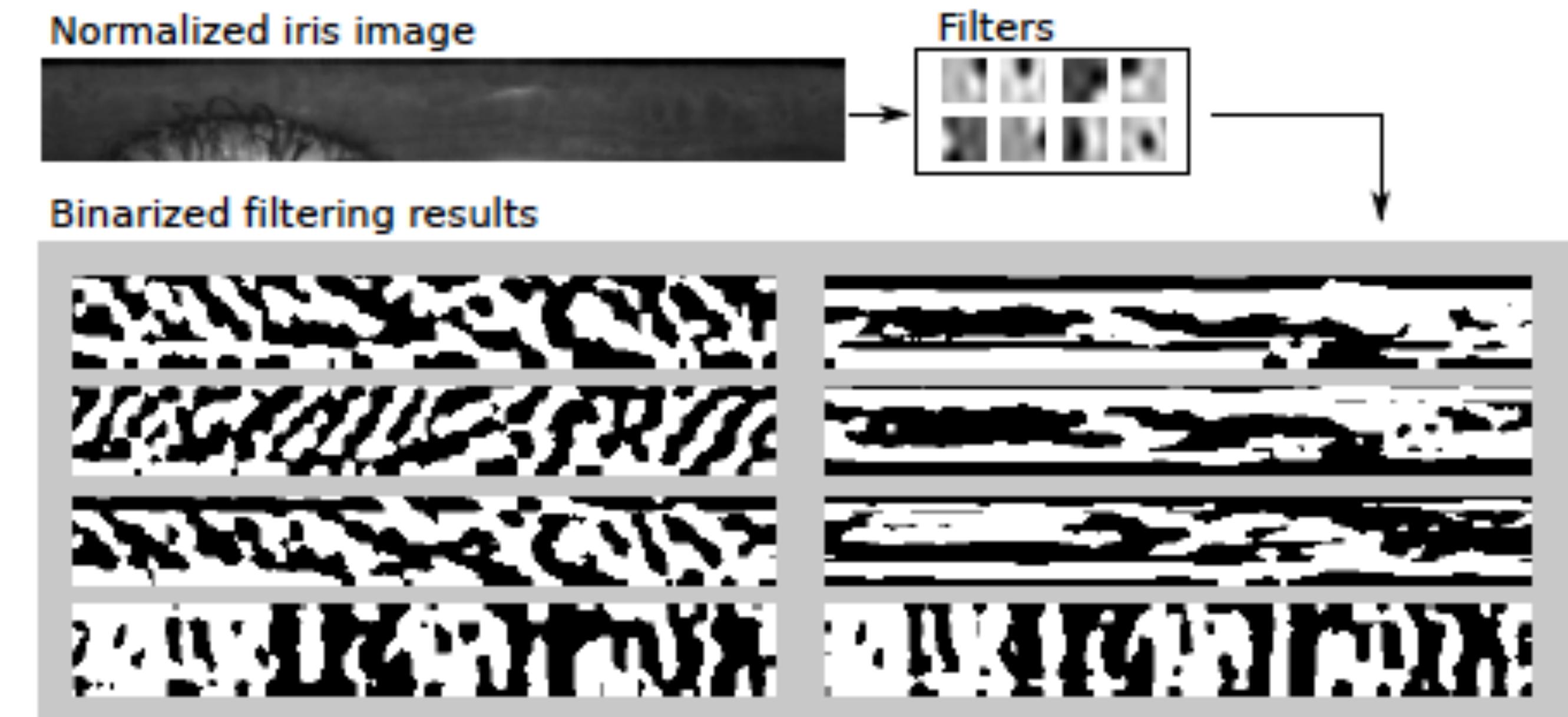
Feature Extraction

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

Solution's performance
is on par with the
Gabor-based one.
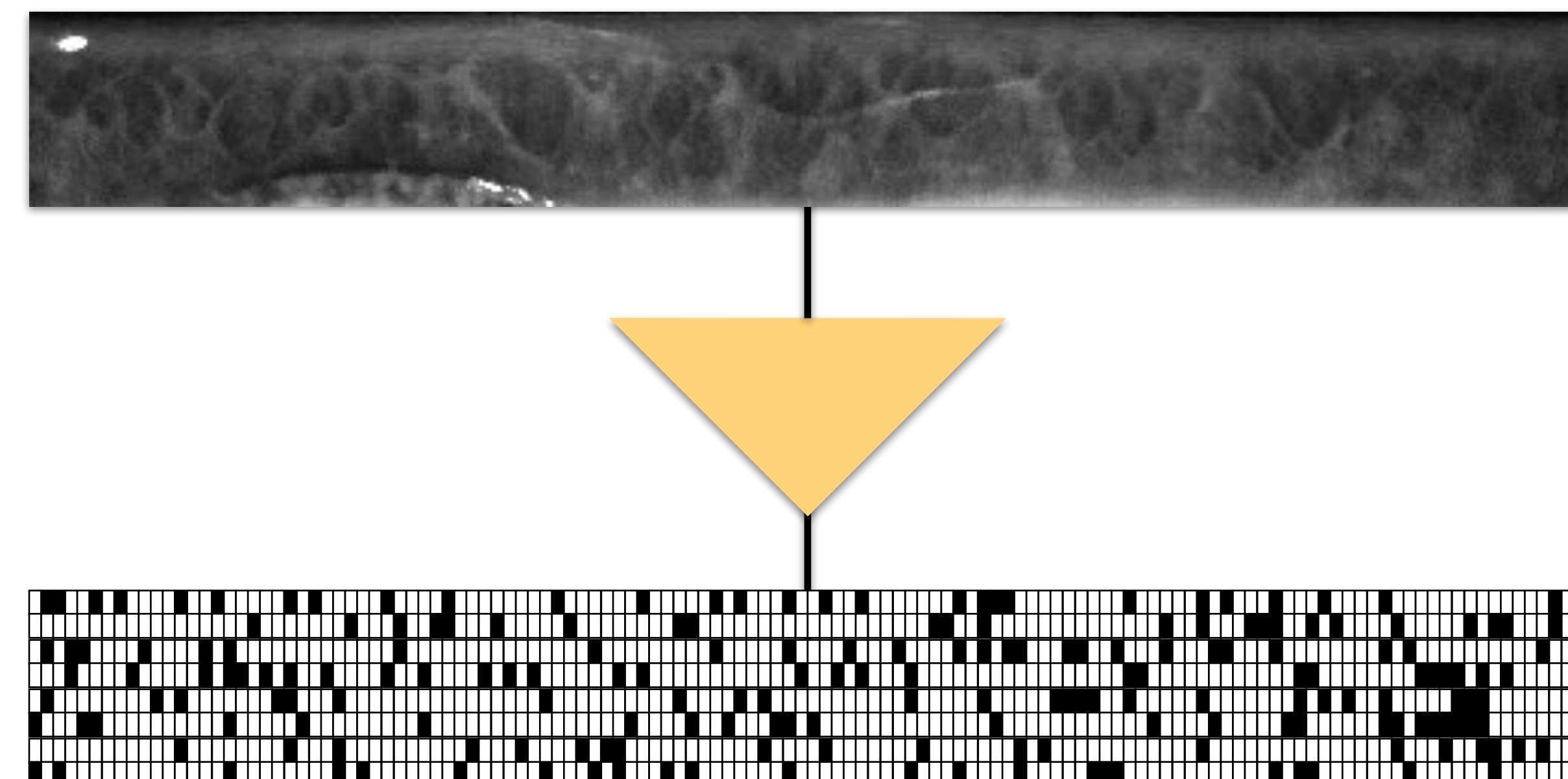
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Feature Extraction
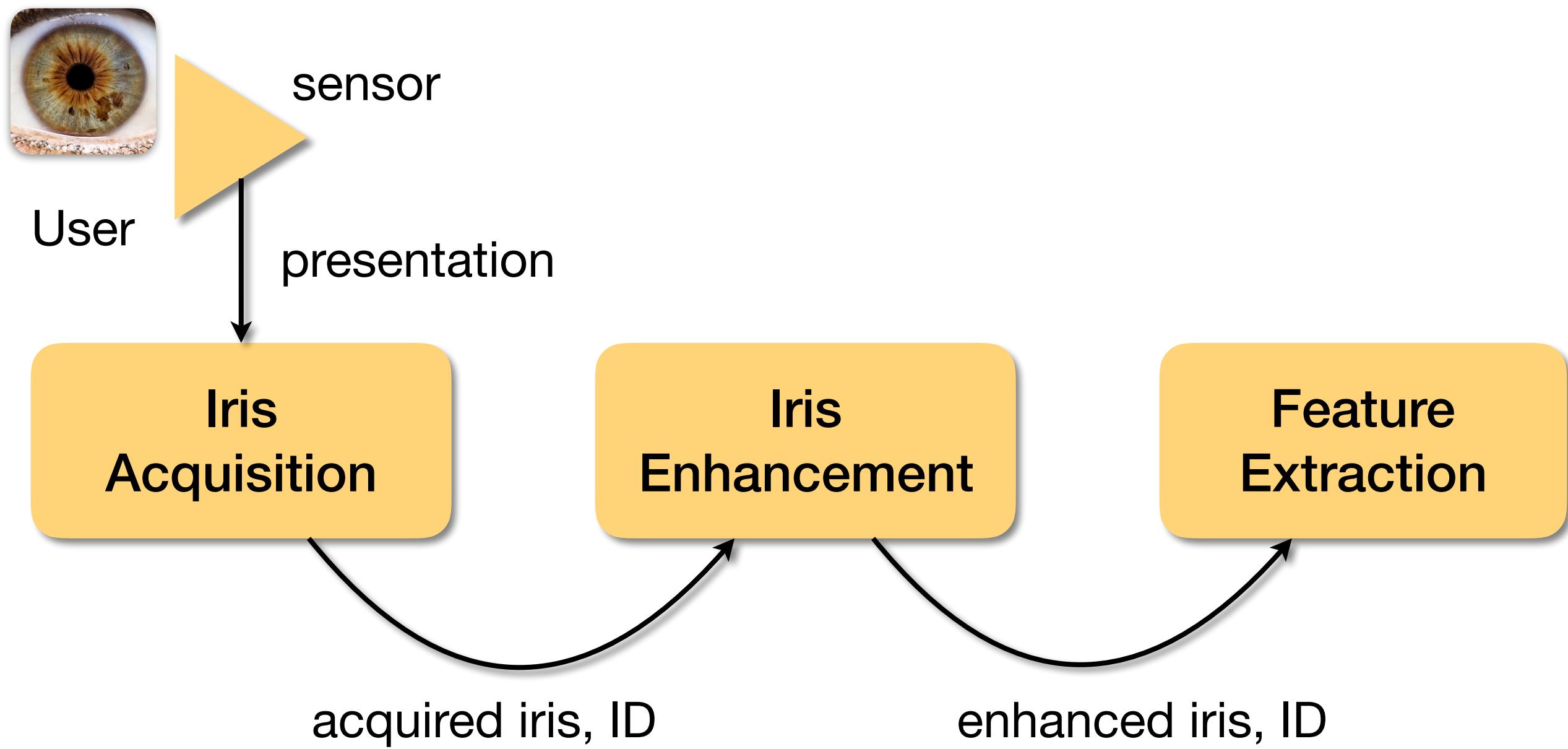
BSIF Approach (3/3)

In the case of irises…
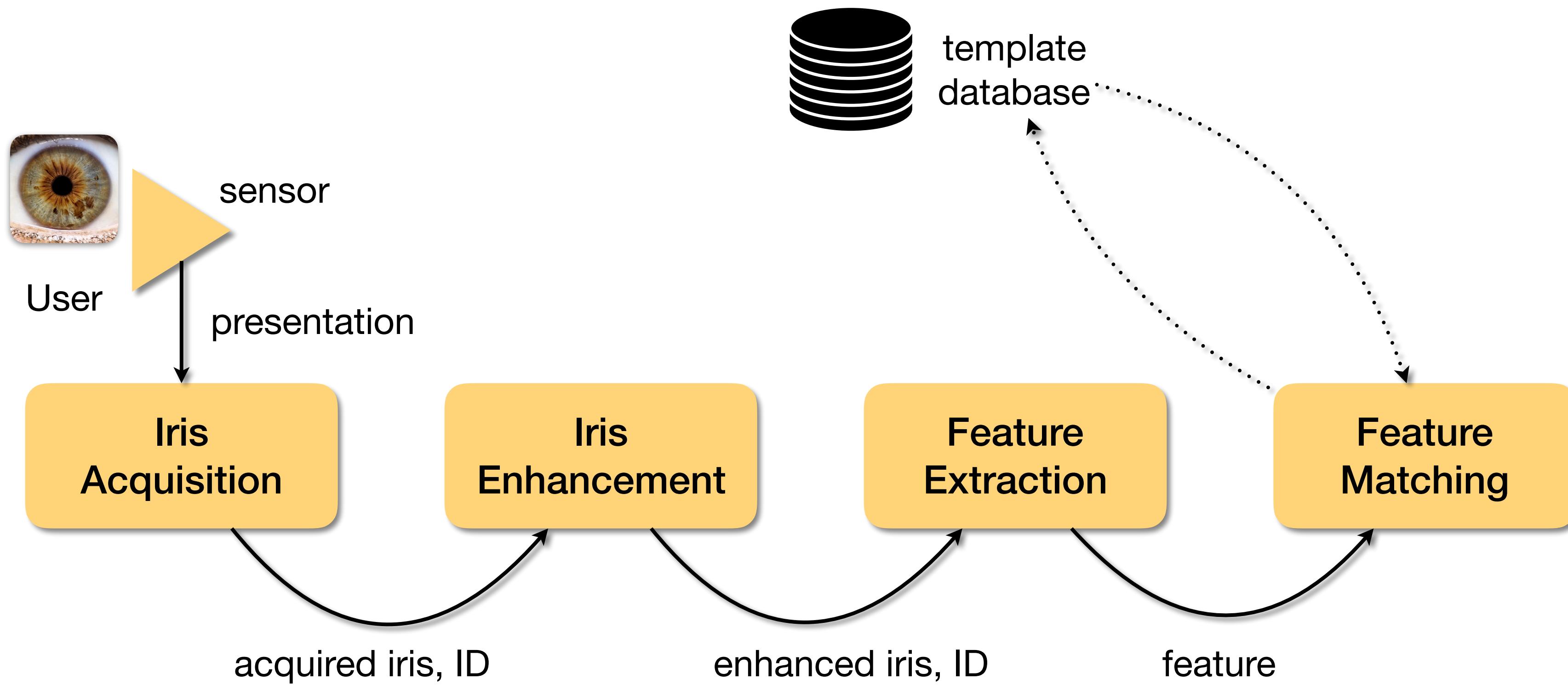
BSIF Code

Iris Recognition

User
sensor

presentation

| Iris Acquisition | | Iris Enhancement | | Feature Extraction |

acquired iris, ID   enhanced iris, ID

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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
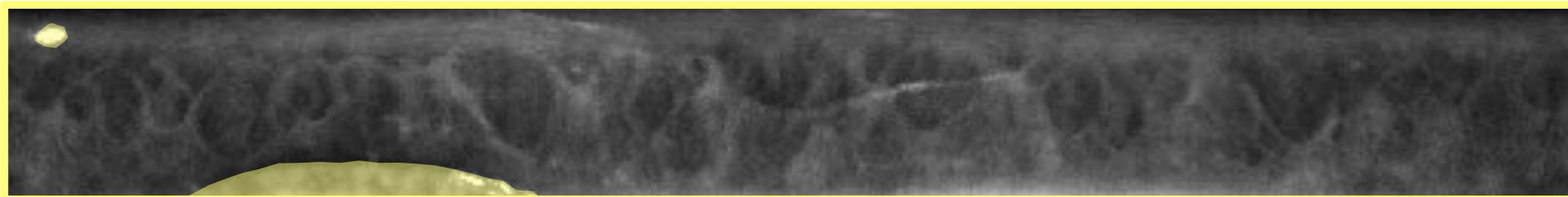
Feature Matching

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?
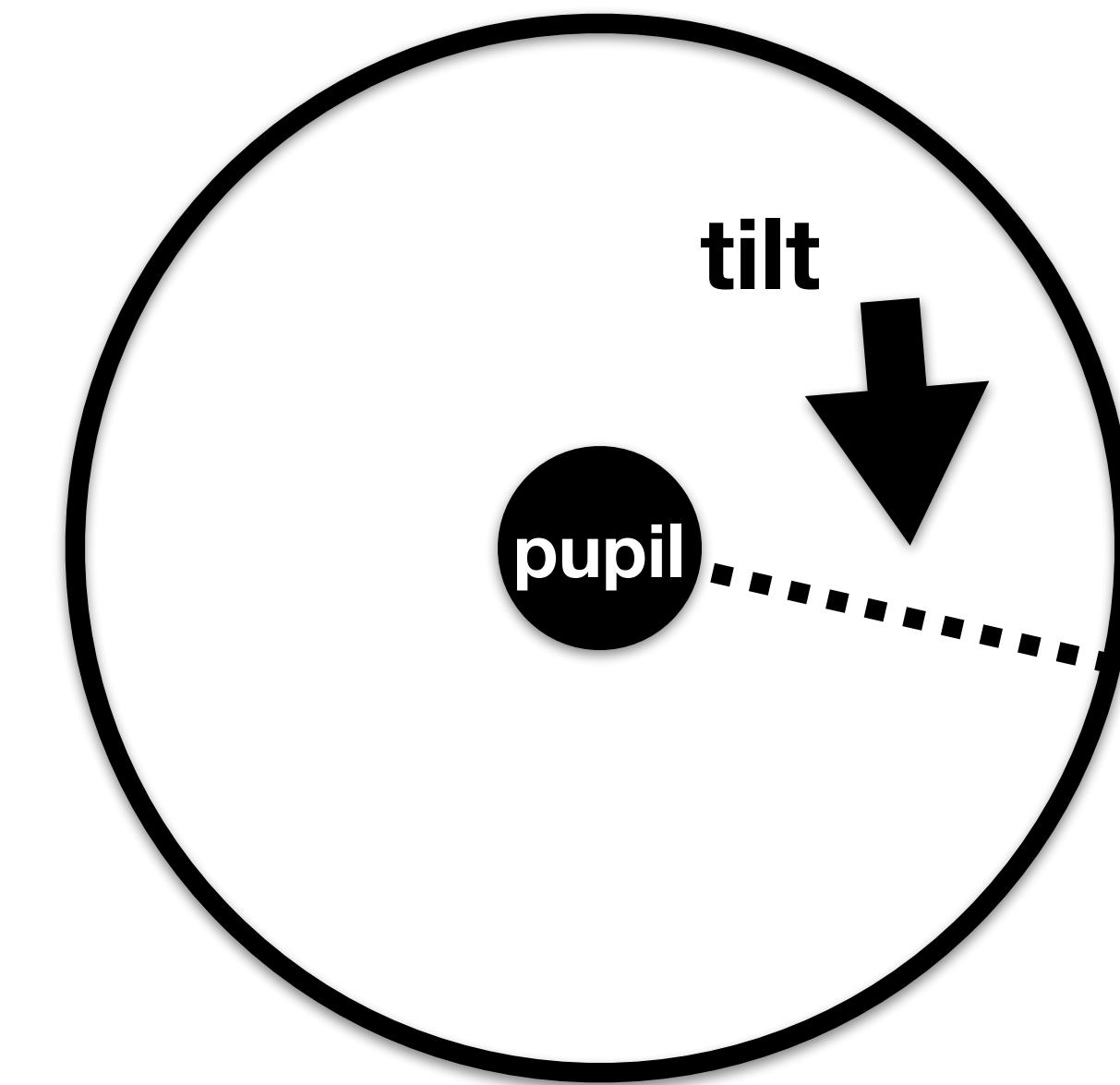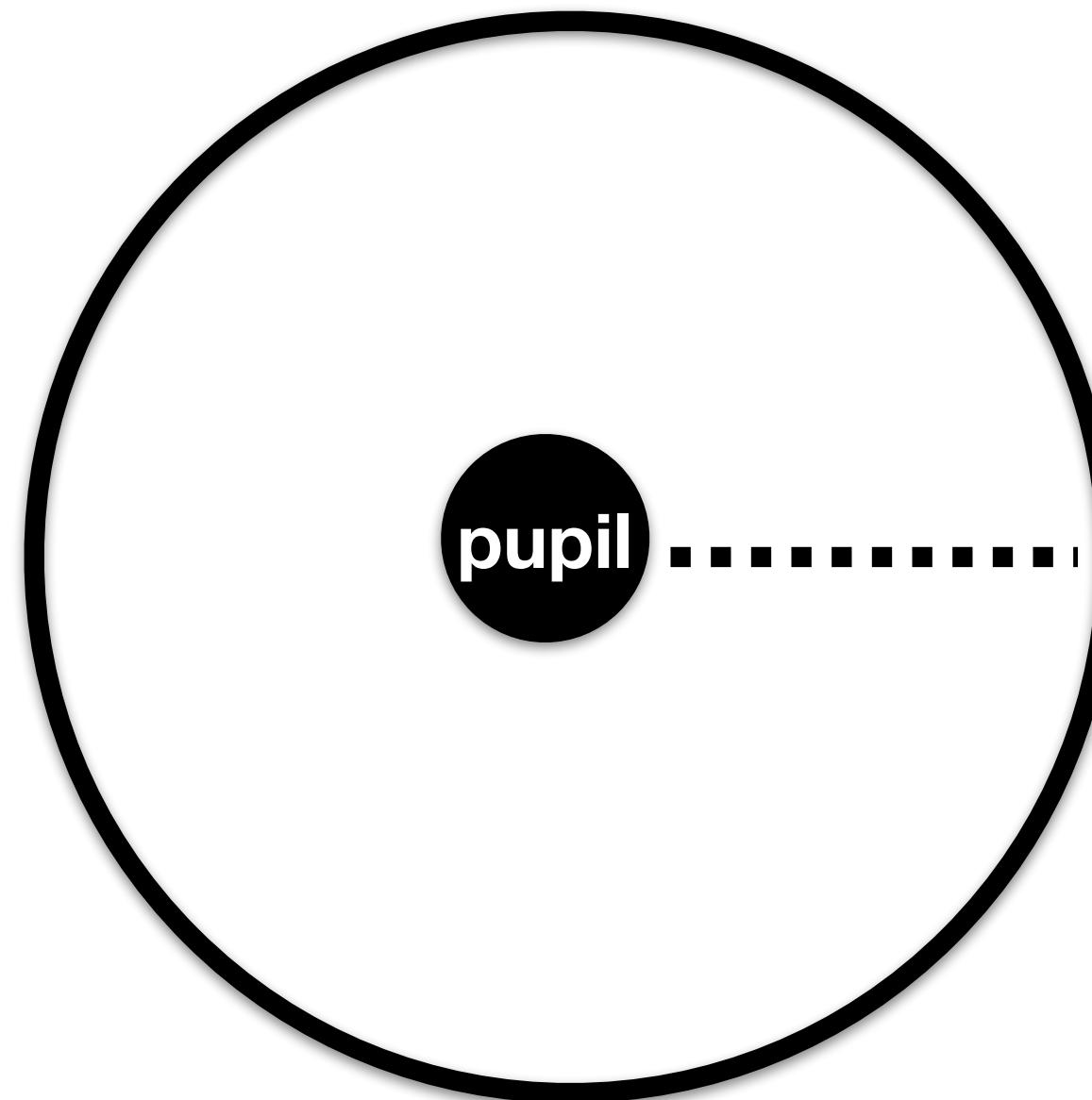
Problems (2/2)
How to deal with iris rotations?
They happen when heads are tilted…
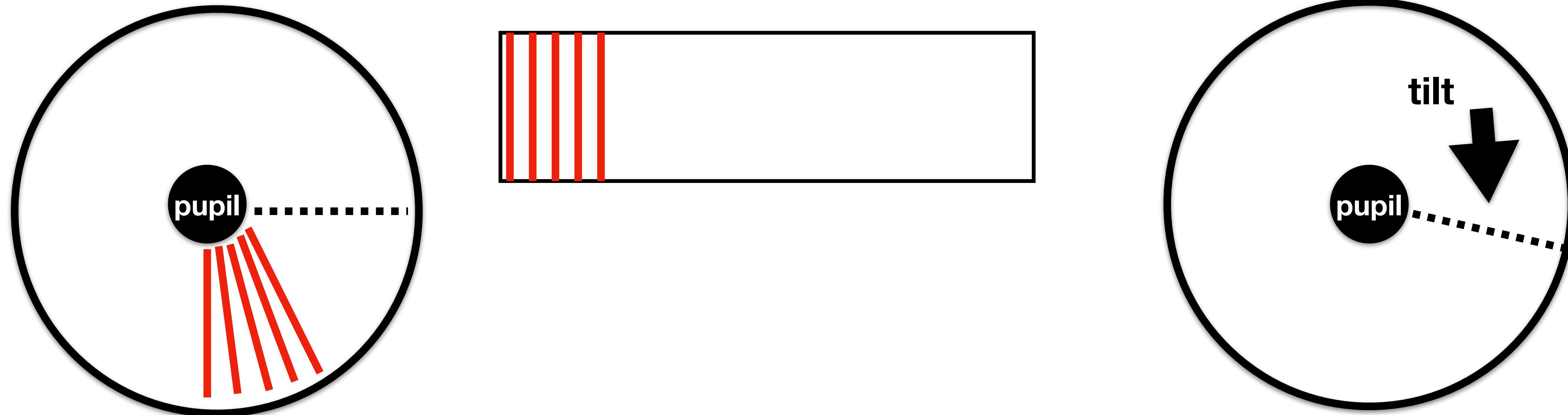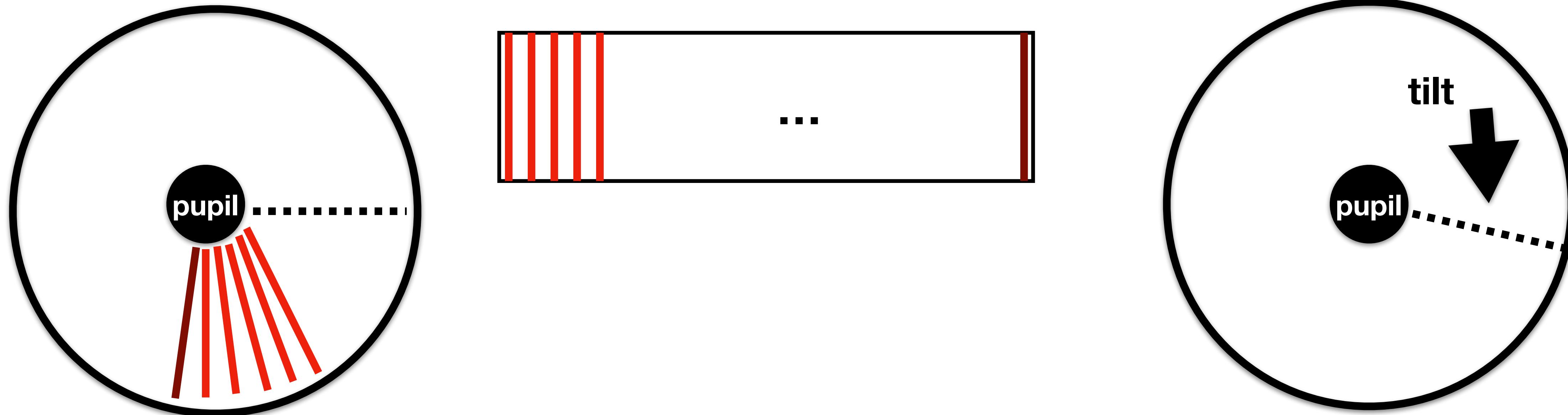

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Feature Matching

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

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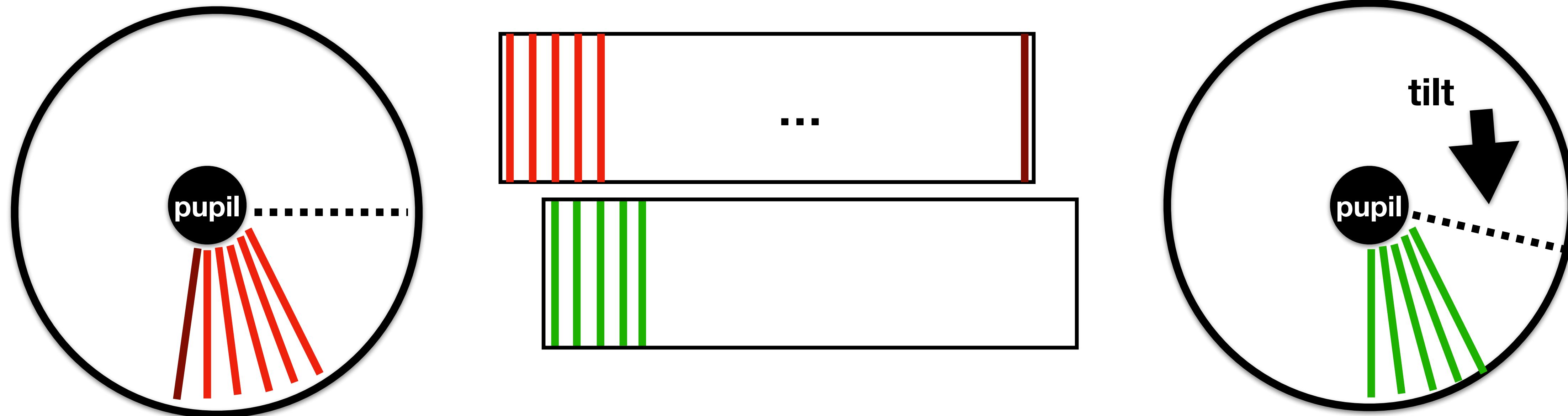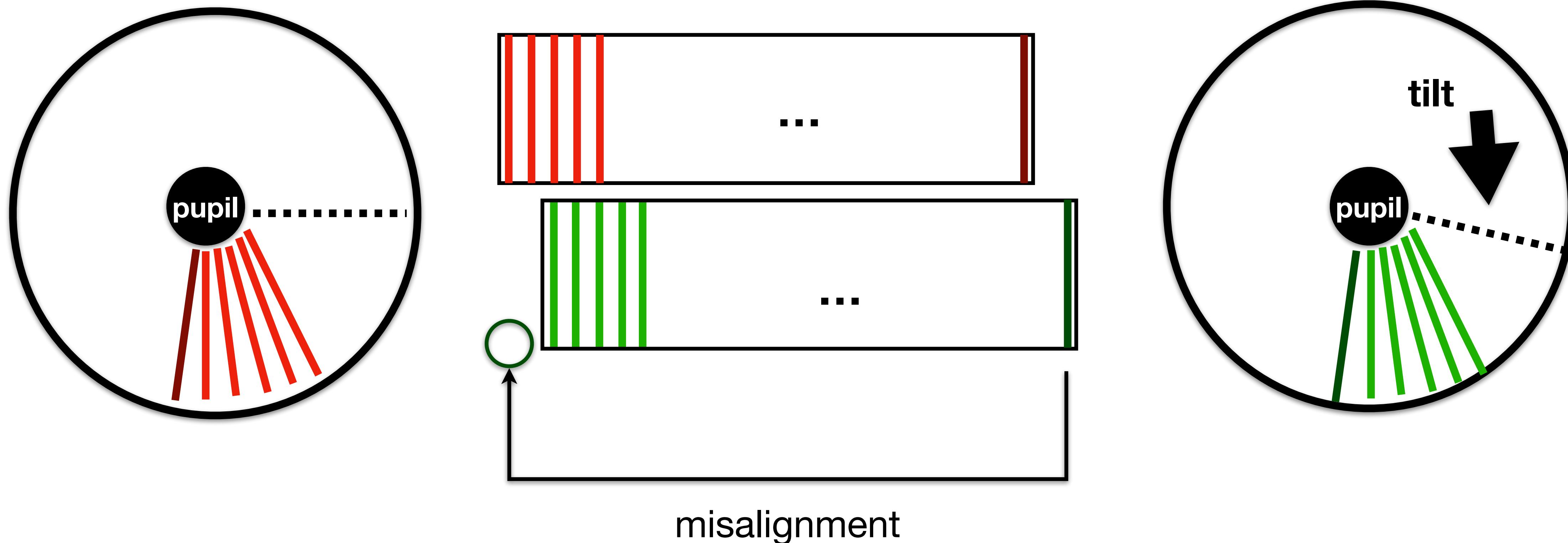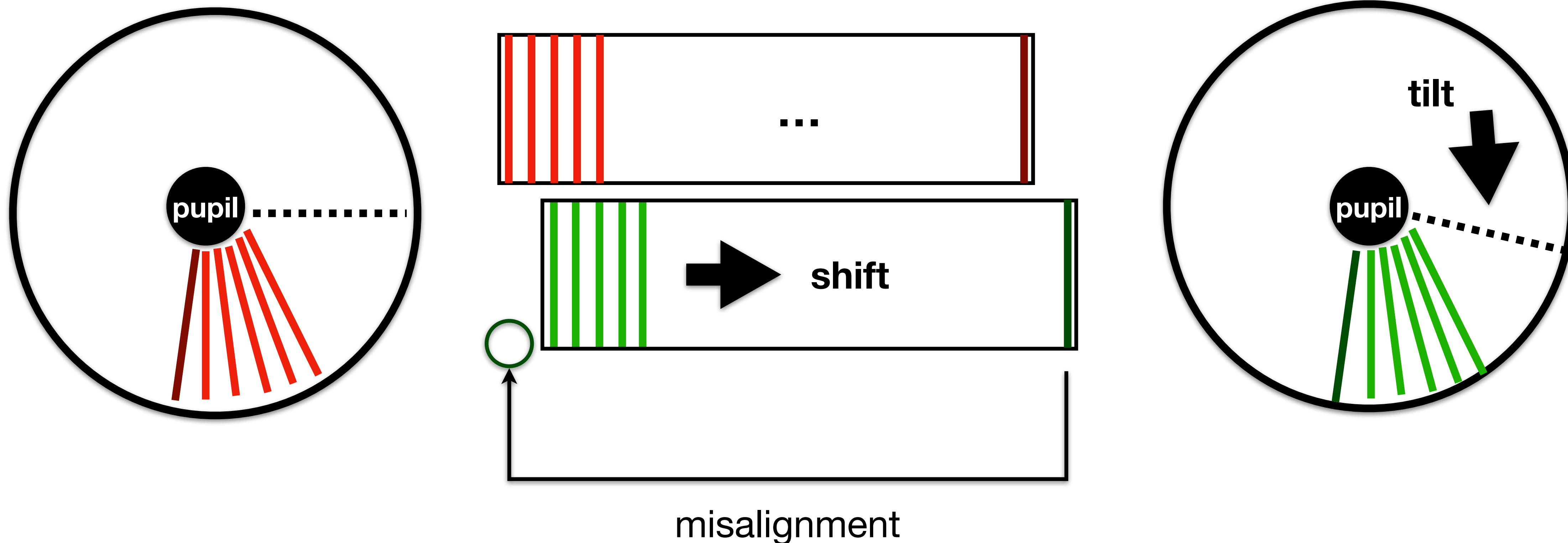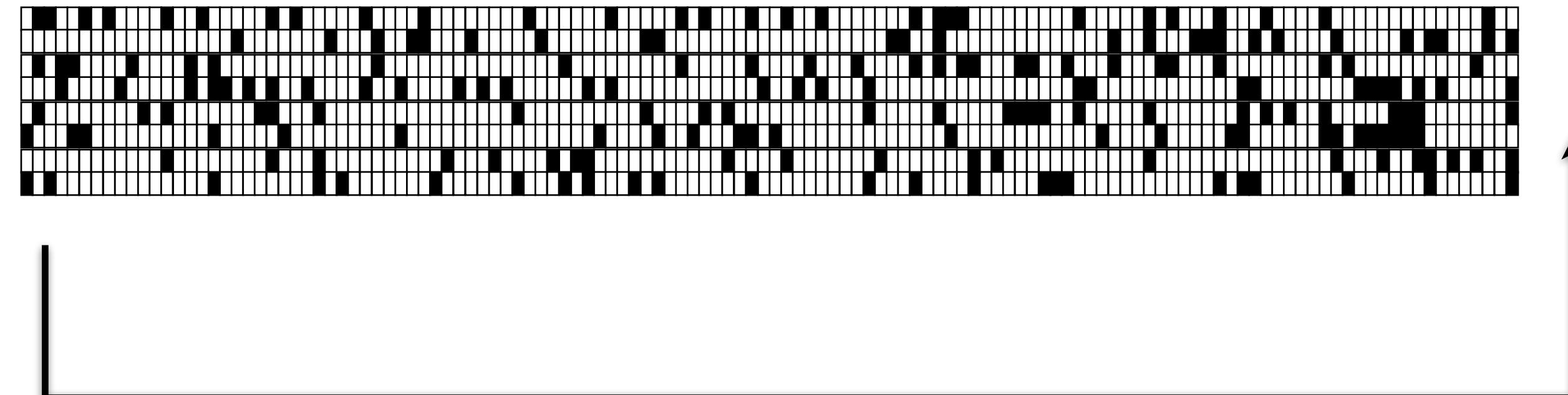
Feature Matching

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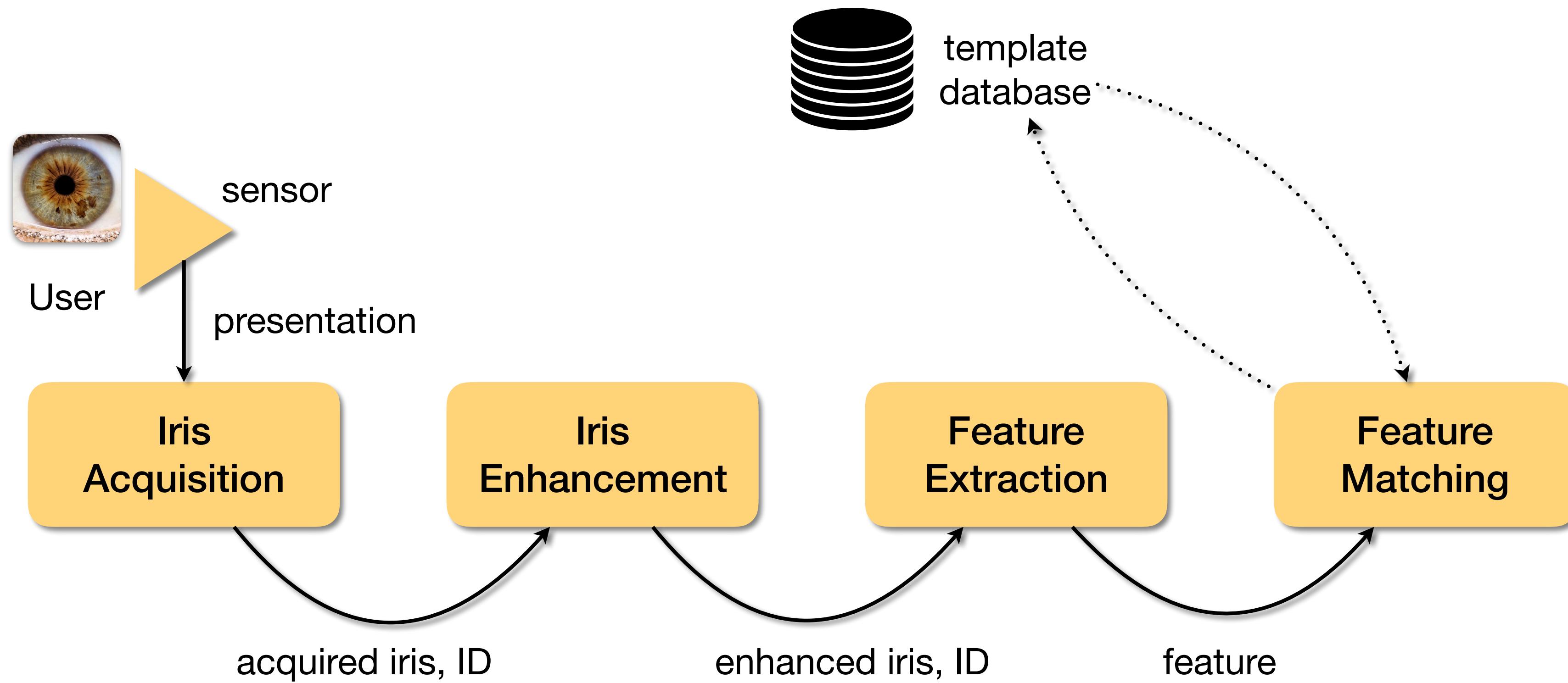
Problems (2/2)
How to deal with iris rotations?
Solution: provide different shifts
for one of the iris codes.
Compute various normalized
Hamming distances (one for each shift).
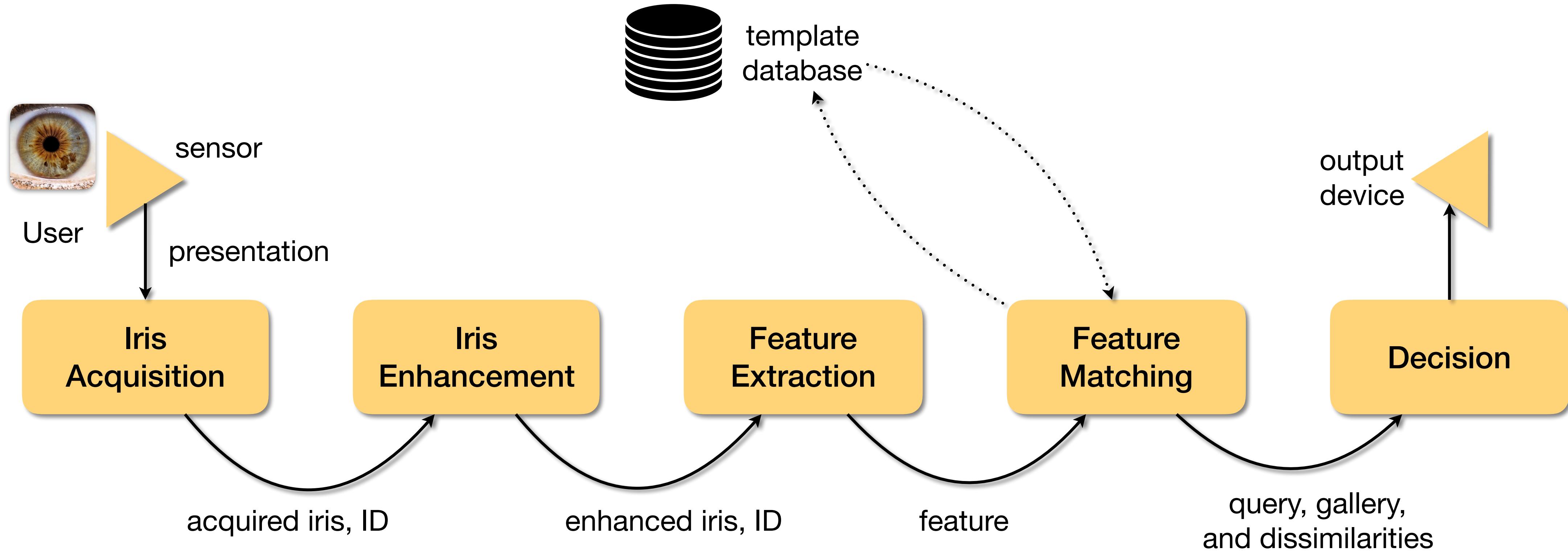
Take the smallest distance as the score.

GROANING

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Iris Recognition

template database

User

sensor

presentation

Iris Acquisition

Iris Enhancement

Feature Extraction

Feature Matching

acquired iris, ID

enhanced iris, ID

feature

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Iris Recognition

template
database

sensor

User

presentation

| Iris Acquisition | Iris Enhancement | Feature Extraction | Feature Matching | Decision |

output
device

acquired iris, ID   enhanced iris, ID   feature   query, gallery, and dissimilarities

Iris Recognition

template database

sensor

User

presentation

output device

Iris Acquisition

Iris Enhancement

Feature Extraction

Feature Matching

Decision

acquired iris, ID

enhanced iris, ID

feature

Use distance threshold.

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# Domain-Specific BSIF Codes

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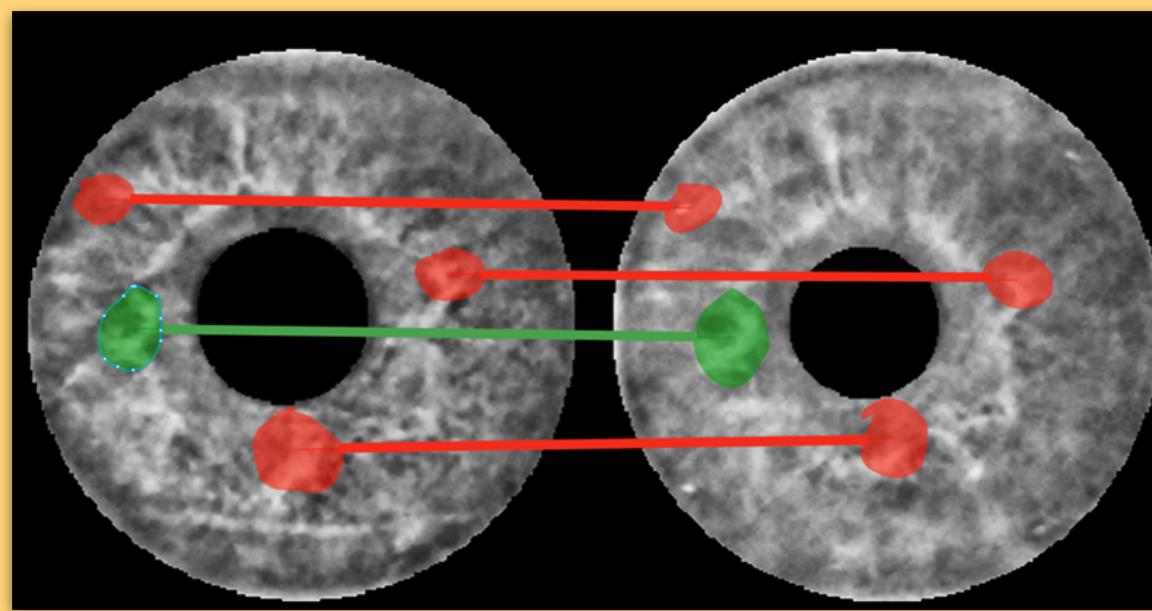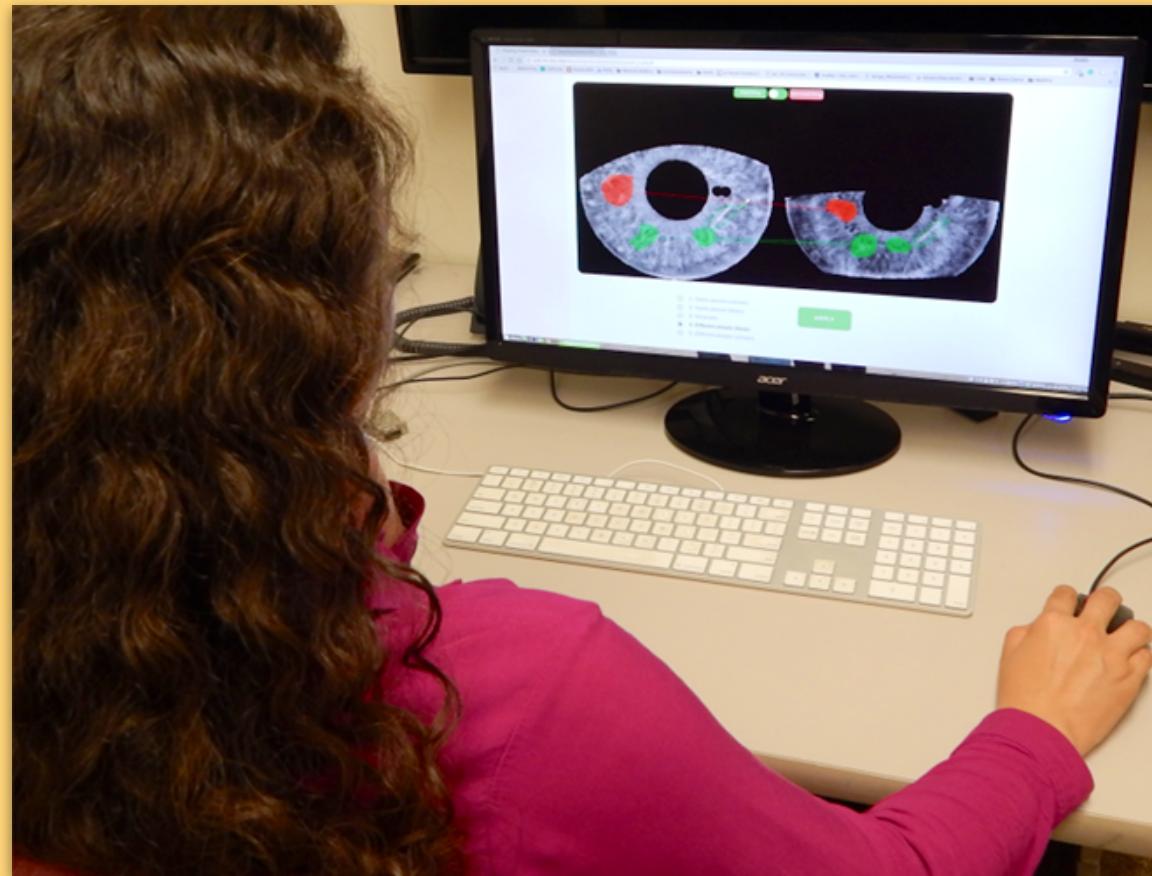
What is the gain of learning from irises?

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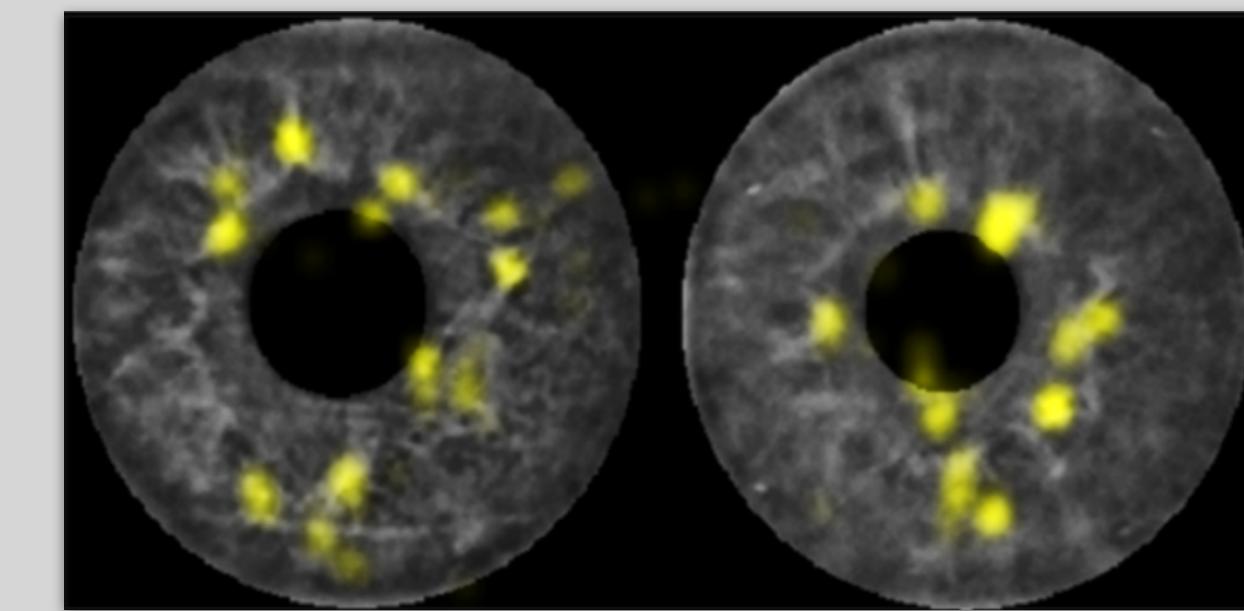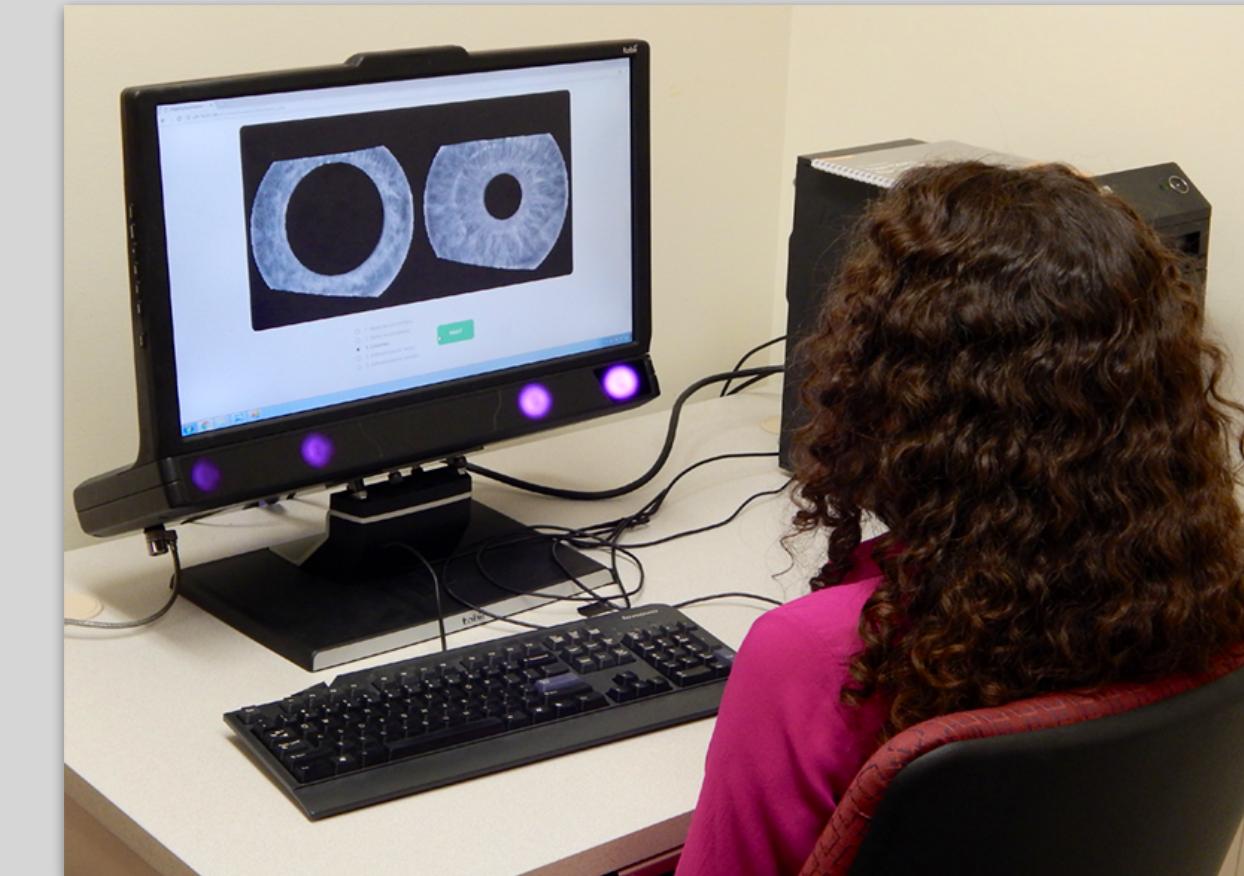
Domain-Specific BSIF Codes

How to Select Iris Patches?

Manual Annotation

Eye-Tracker Data

Domain-Specific BSIF Codes

Annotation Tool

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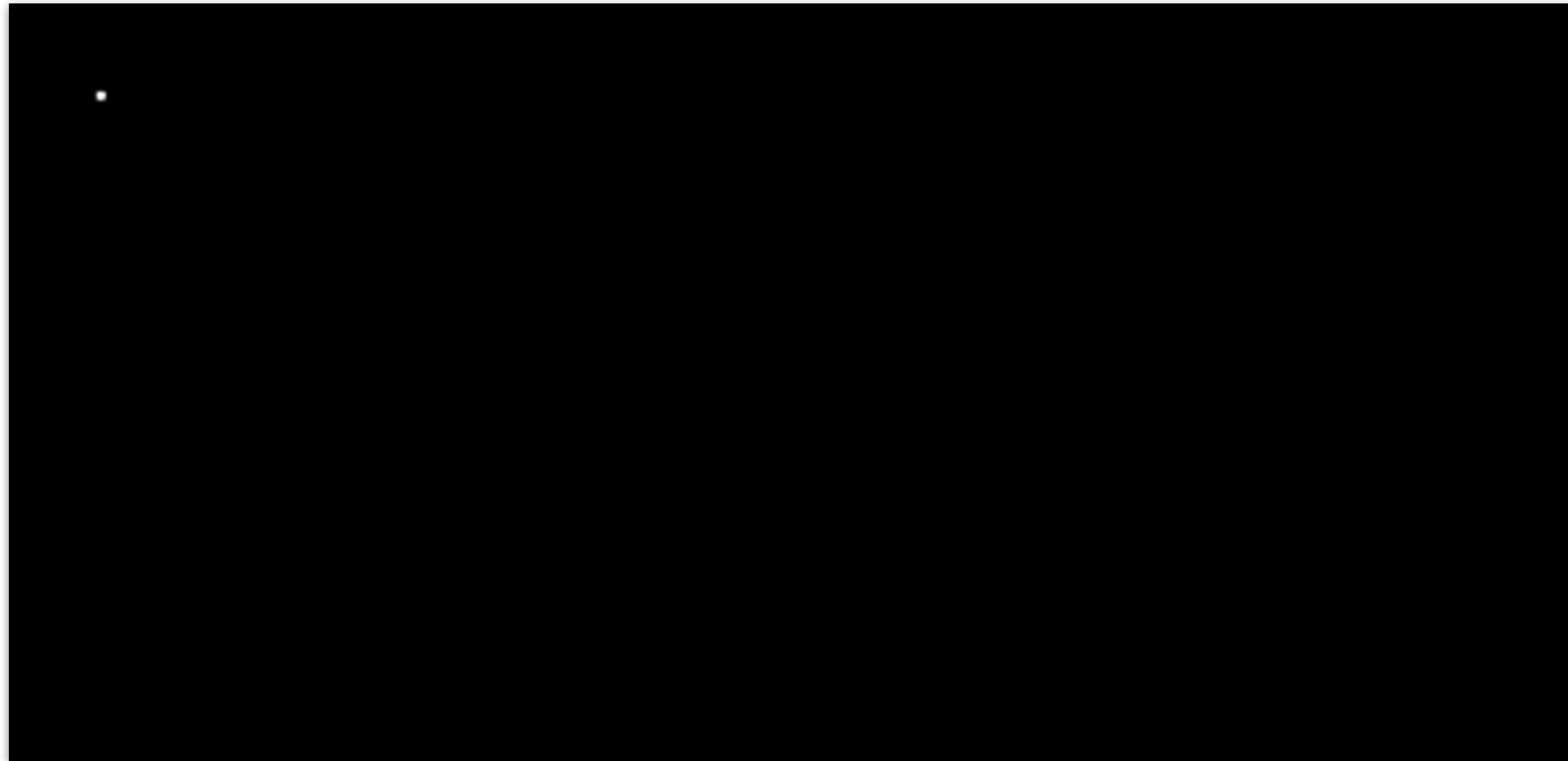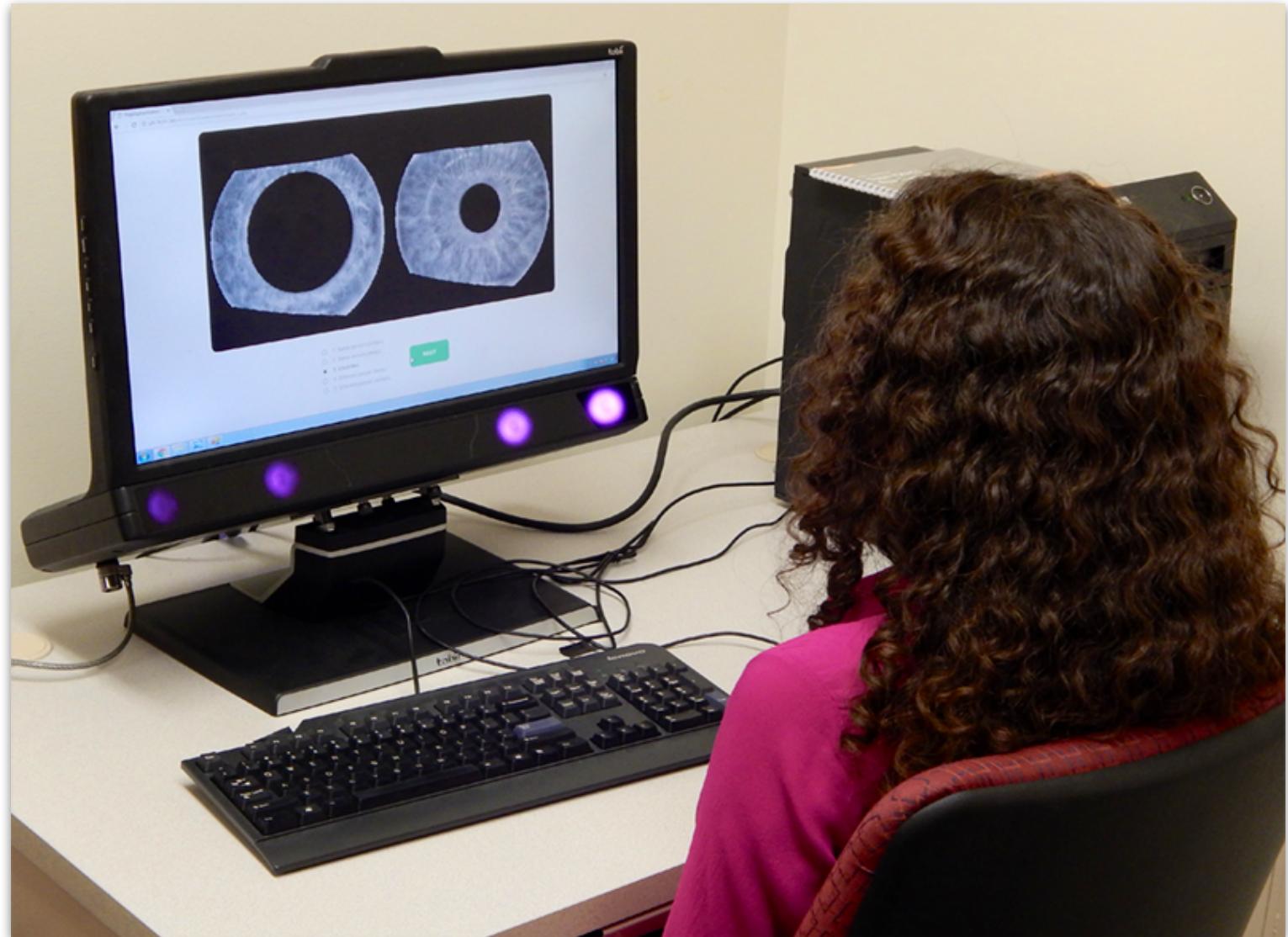
Paper.js
Web-browser drawing library.

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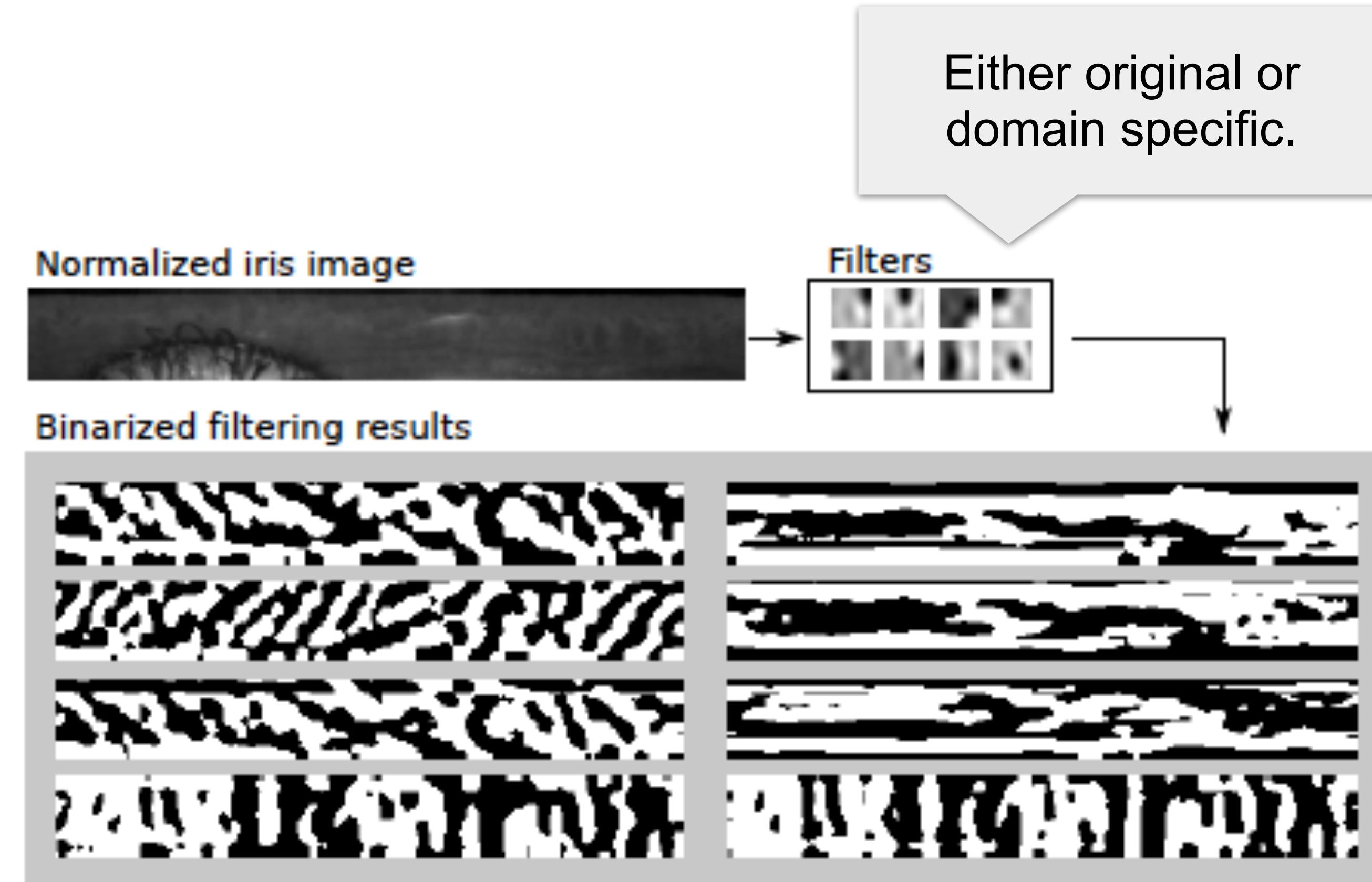
Domain-Specific BSIF Codes

Eye Tracker

Domain-Specific BSIF Codes
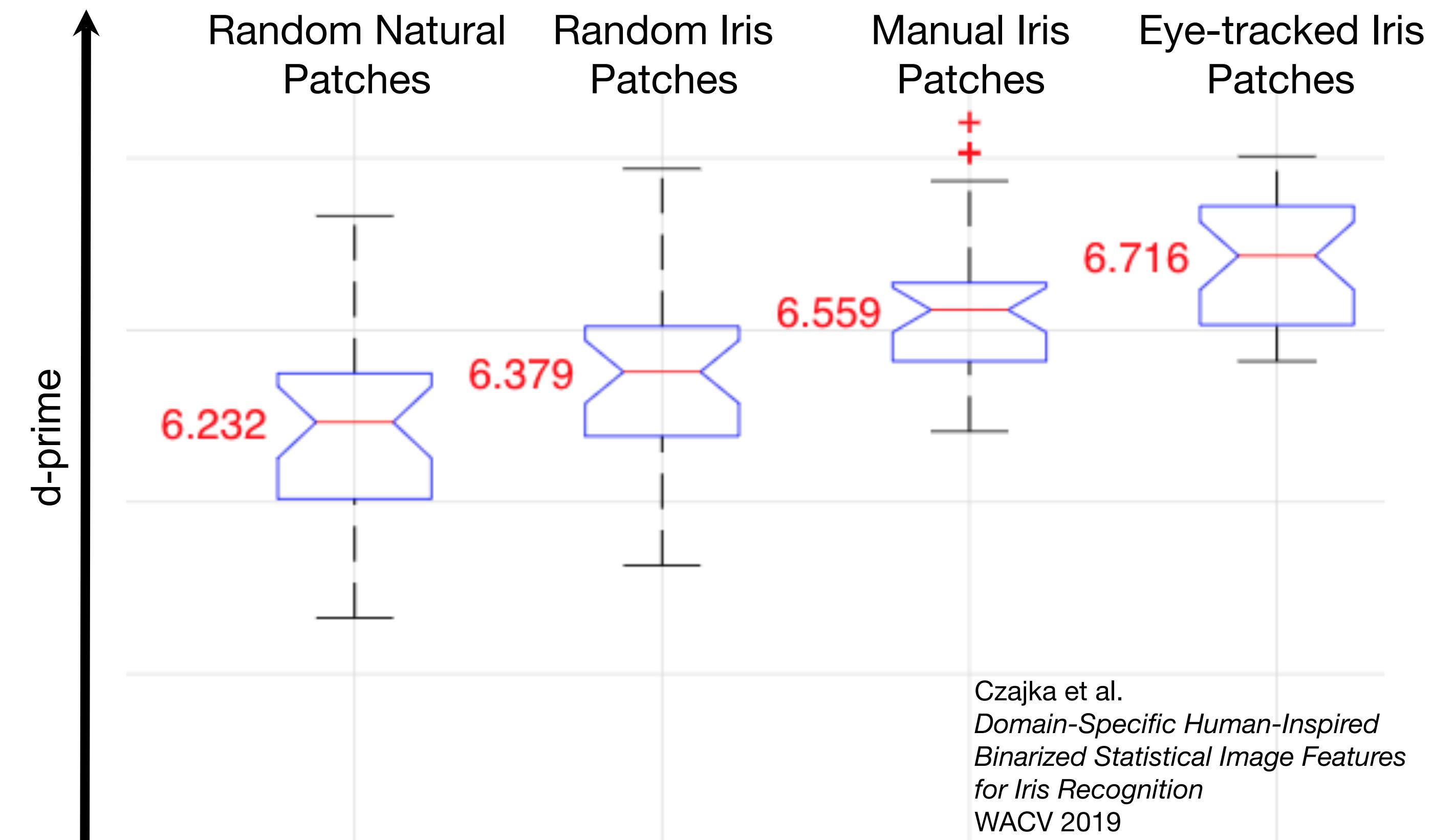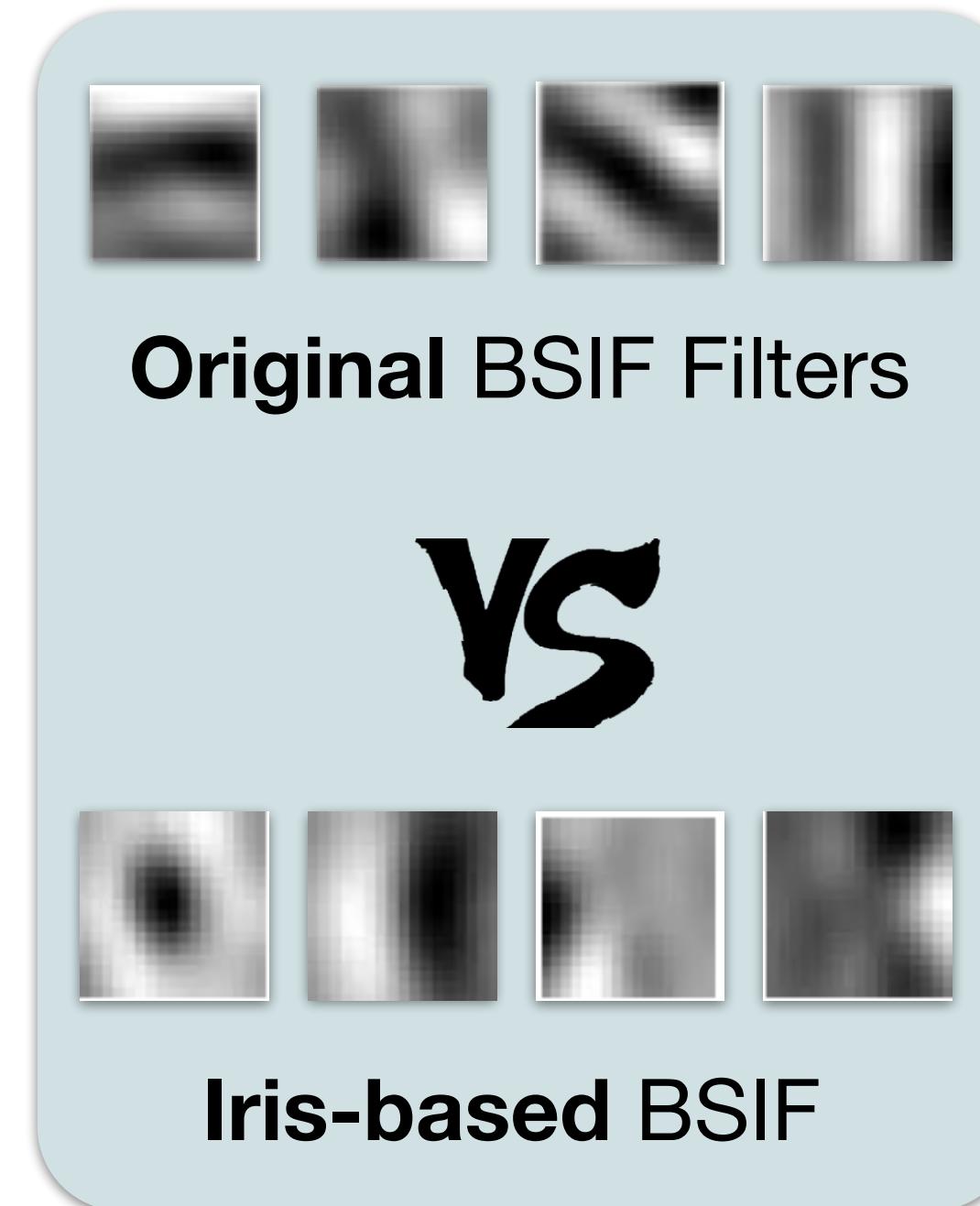
Application

Either original or domain specific.

Normalized iris image

Filters
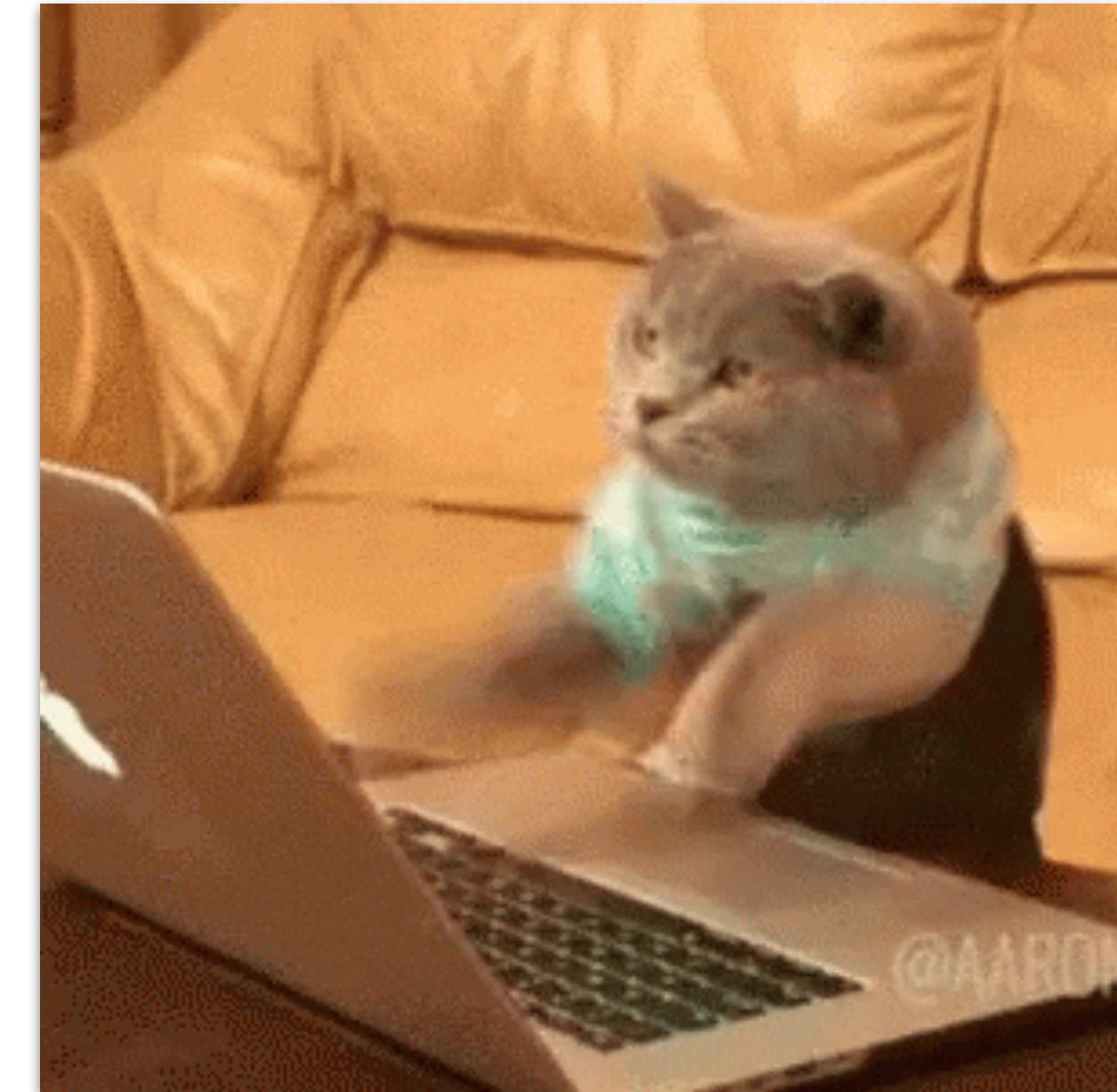
Binarized filtering results

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 | Random Iris Patches | Manual Iris Patches | Eye-tracked Iris Patches

d-prime

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?

**Iris Recognition
Coding Class**

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