

Iris Recognition III

CSE 40537/60537 Biometrics

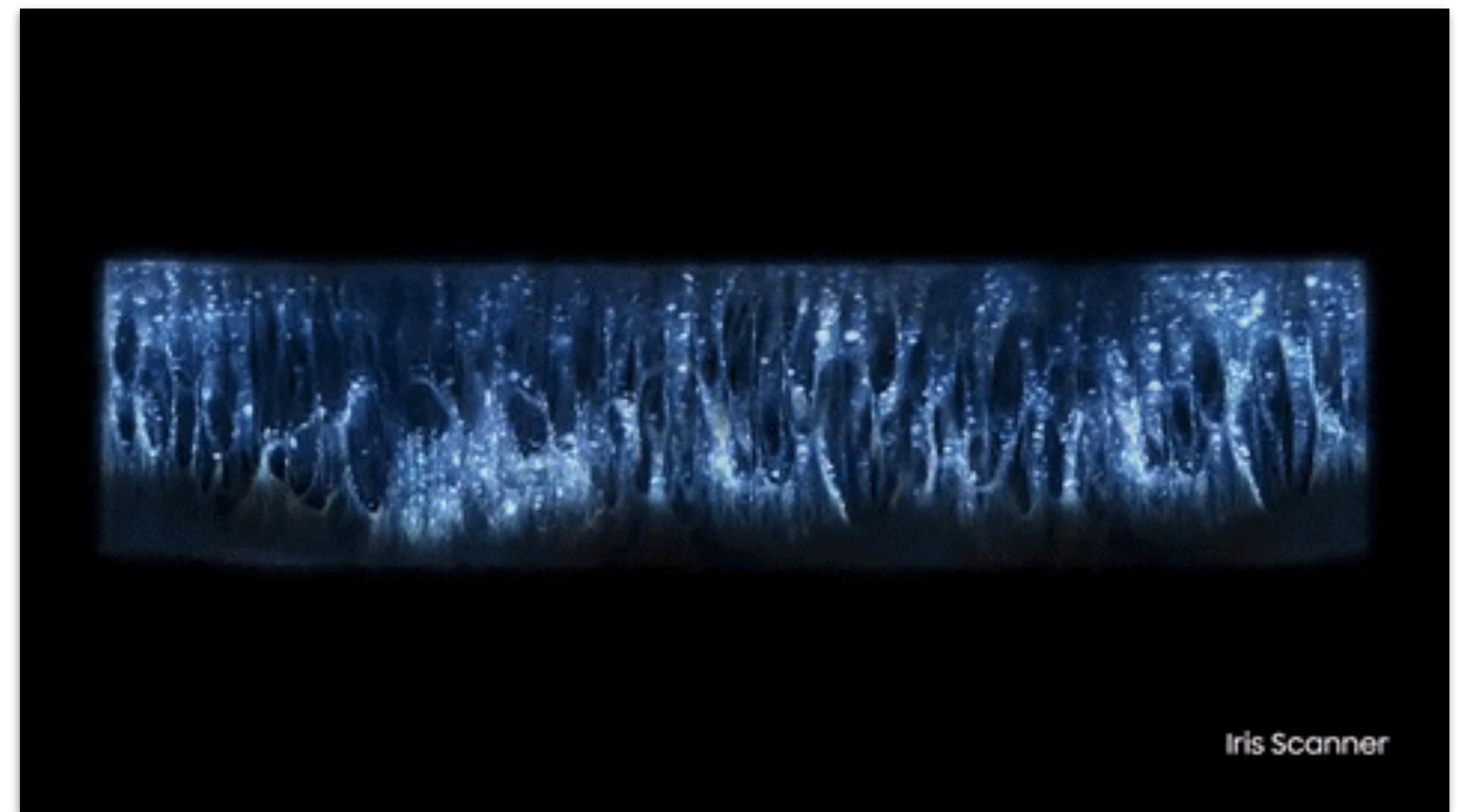
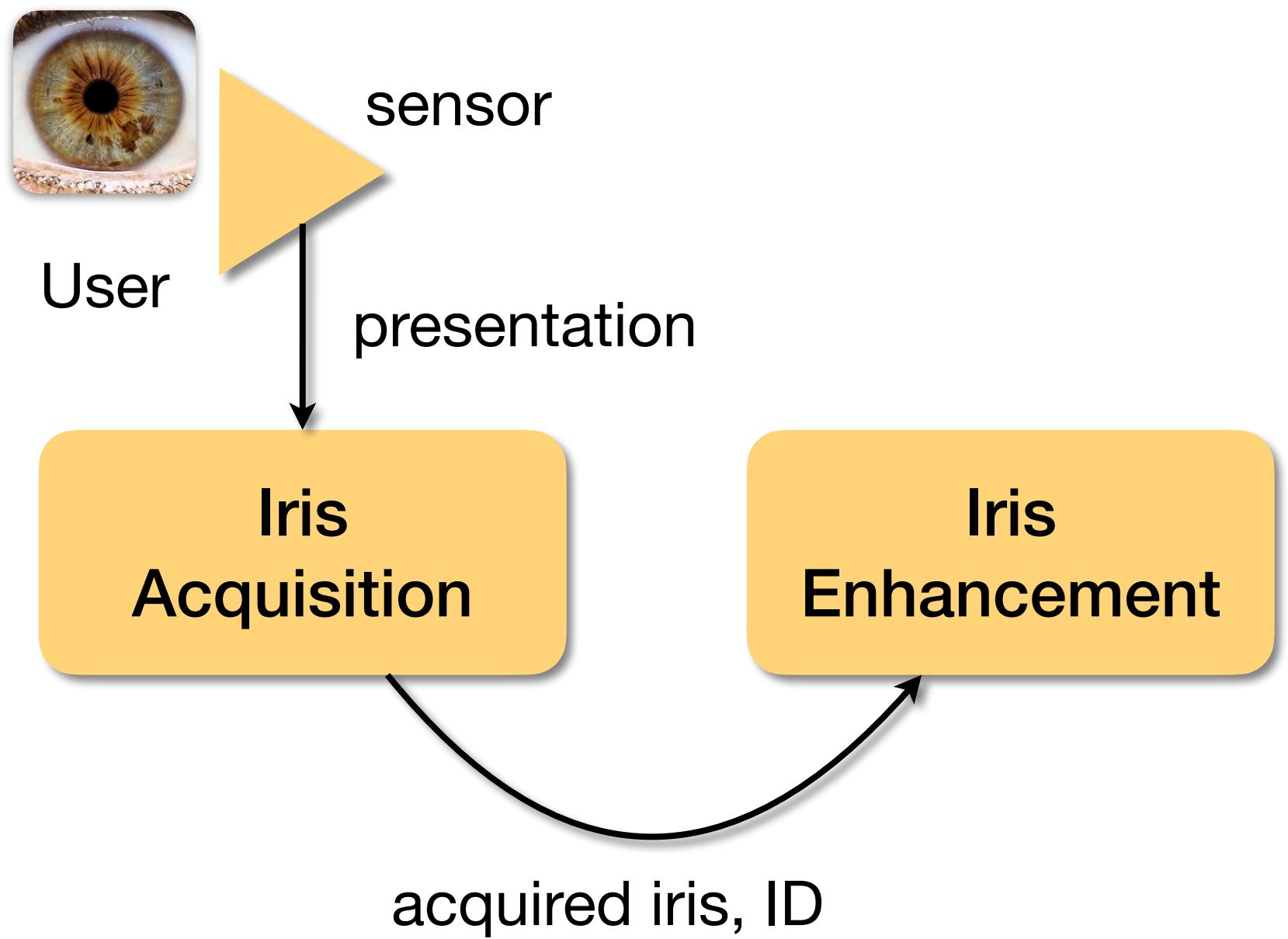
Daniel Moreira
Spring 2022



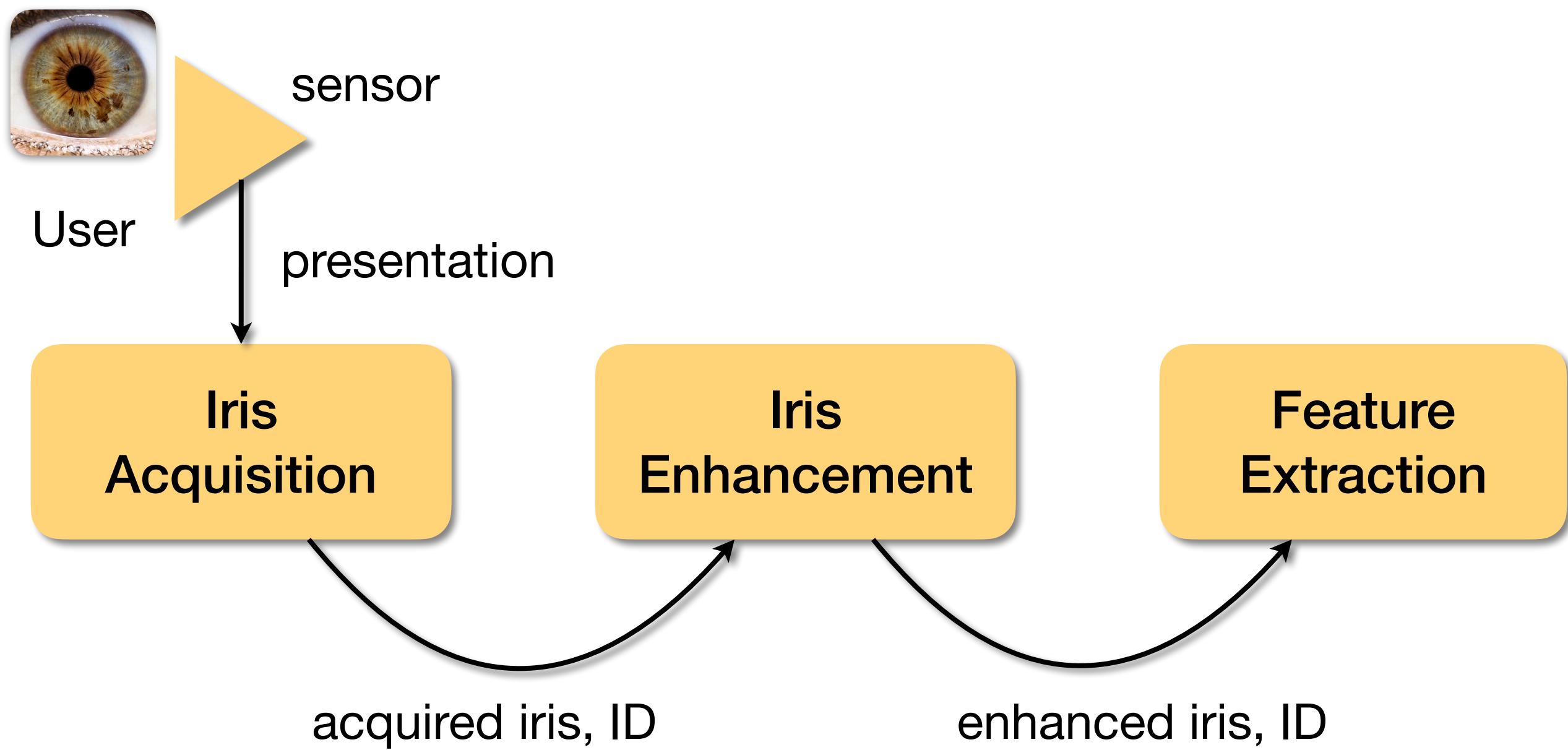
Today you will...

Get to know
Iris description and matching.

Iris Recognition



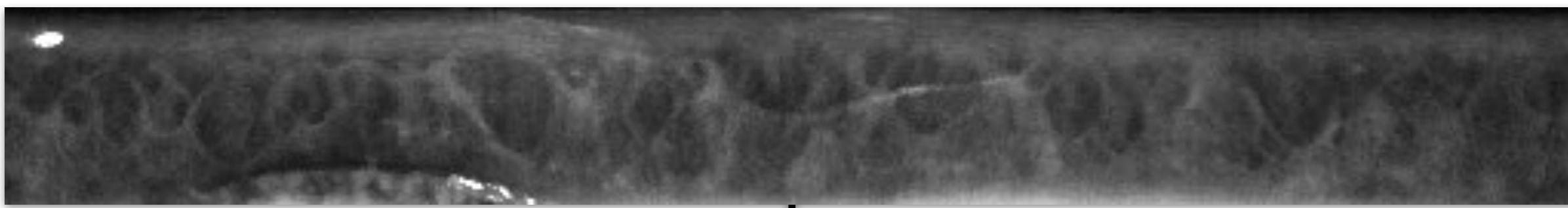
Iris Recognition



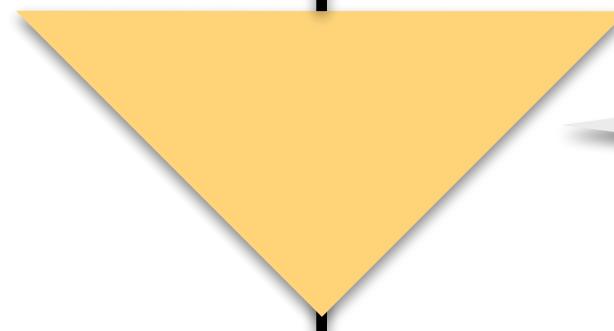
Feature Extraction

Typical Description Framework

normalized iris

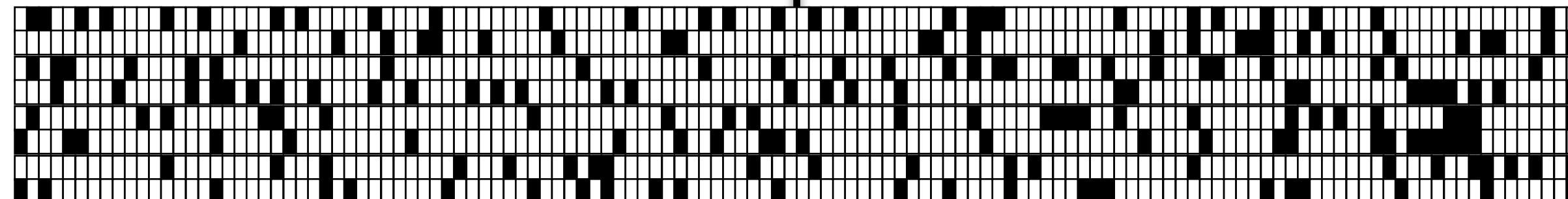


signal processing / image filters



Let's see 3 methods!

binary iris code

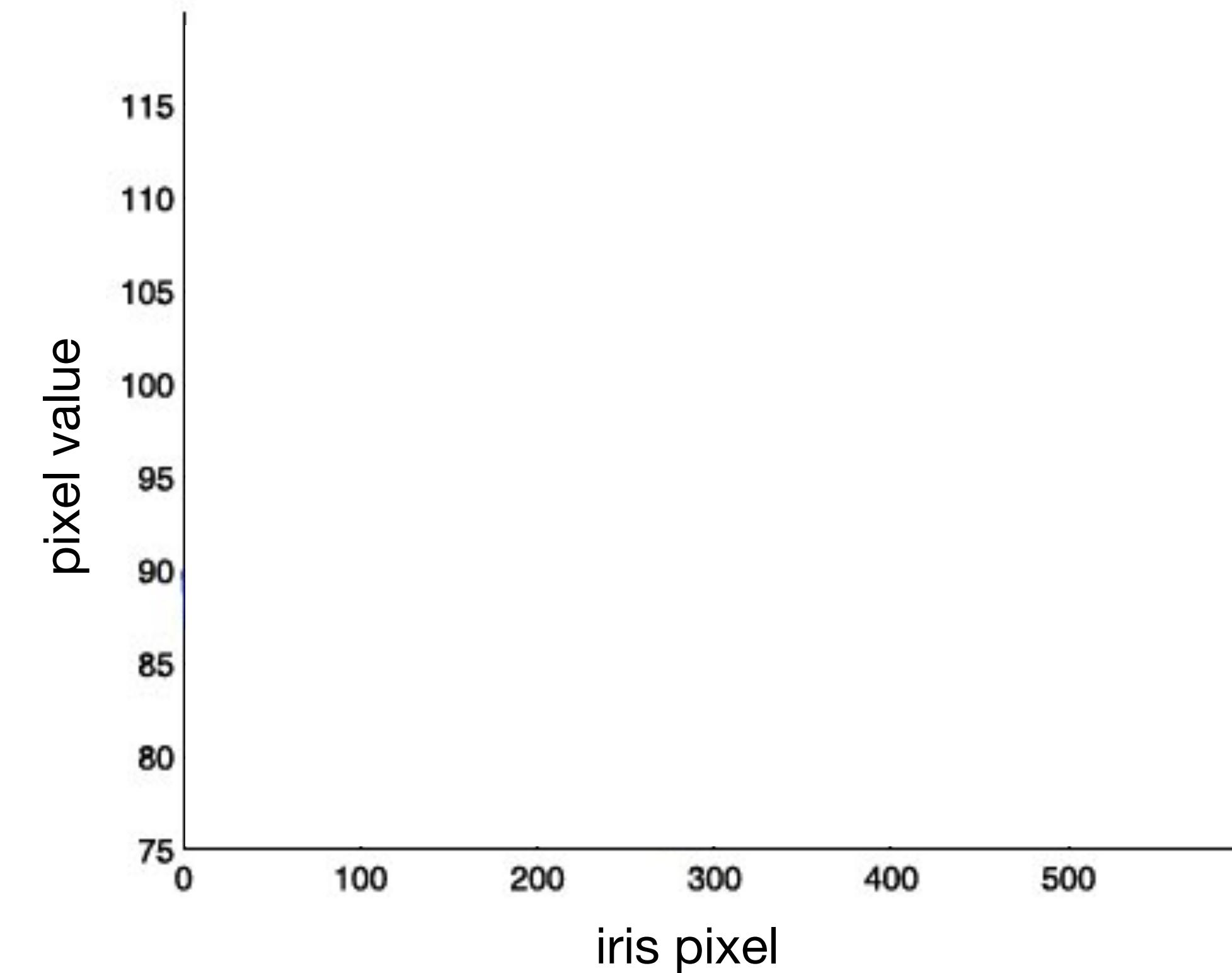
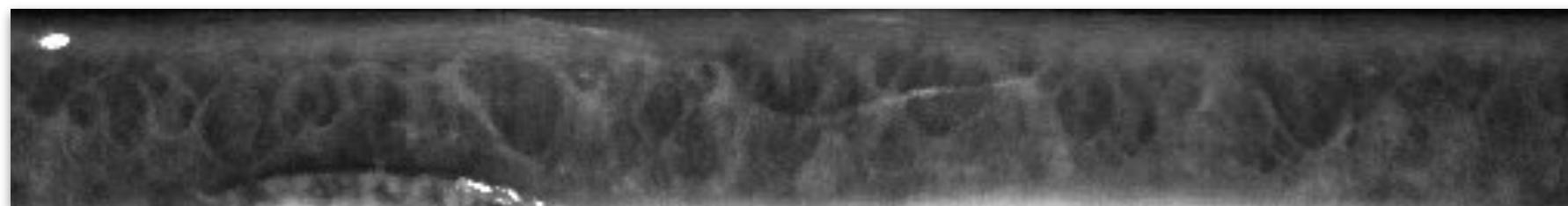


Feature Extraction

Zero-Crossing Approach (1/3)

Proposed by W. W. Boles.

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



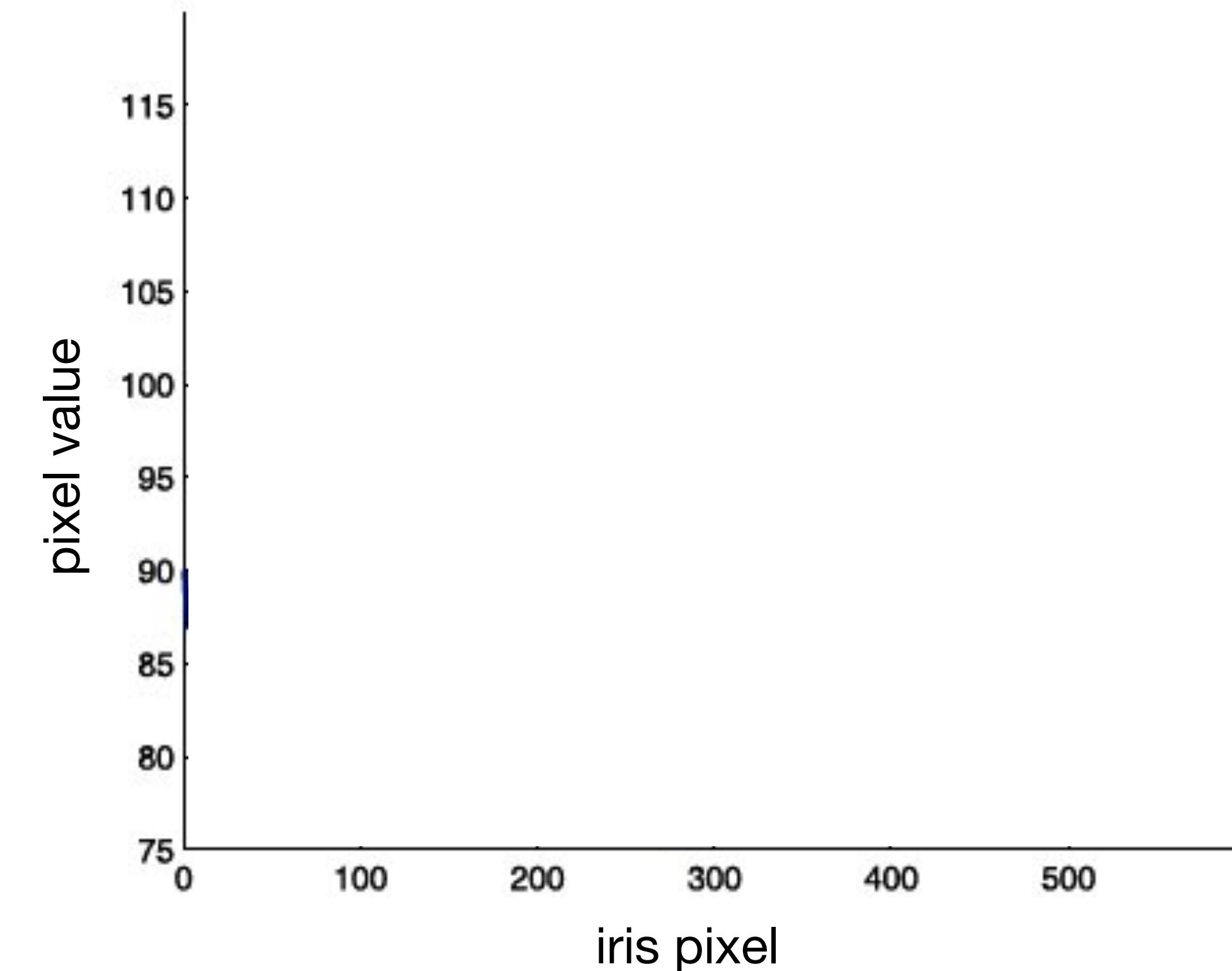
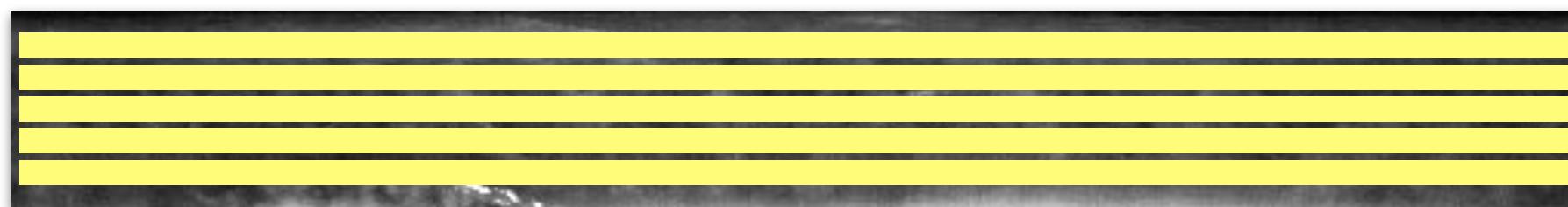
Feature Extraction

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Dr. Adam Czajka

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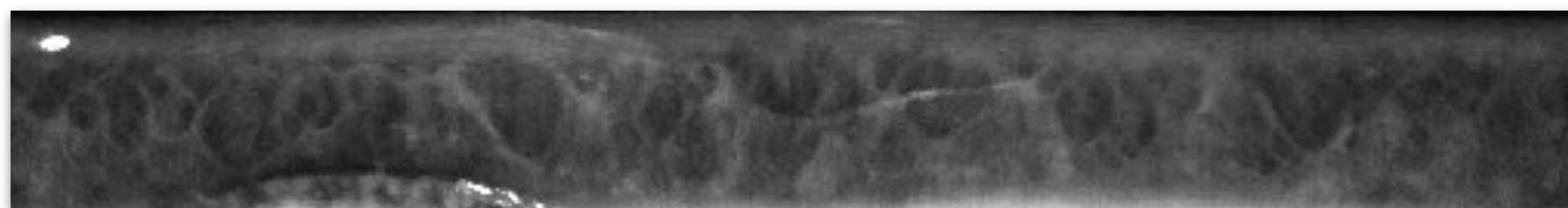


Feature Extraction

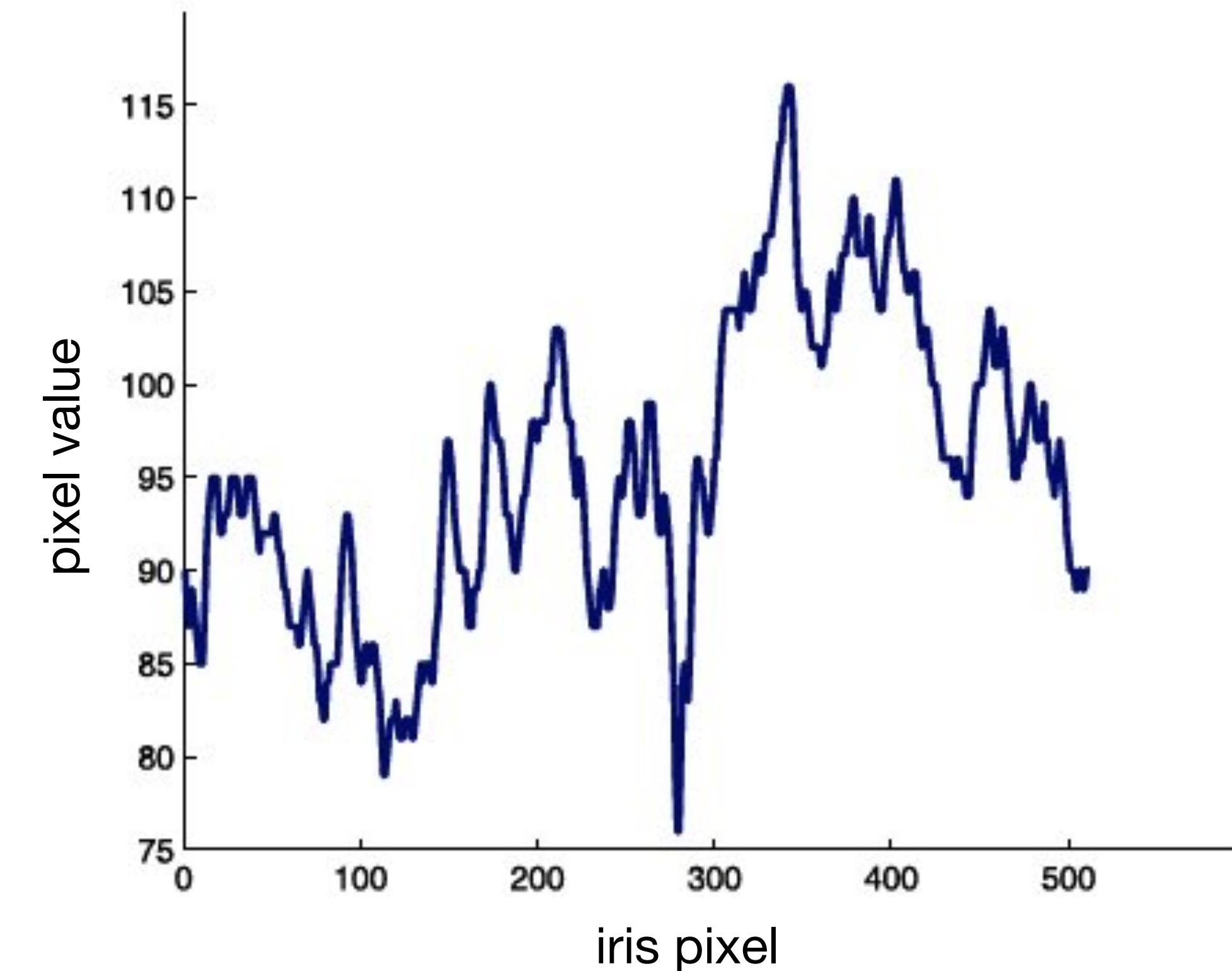
Zero-Crossing Approach (1/3)

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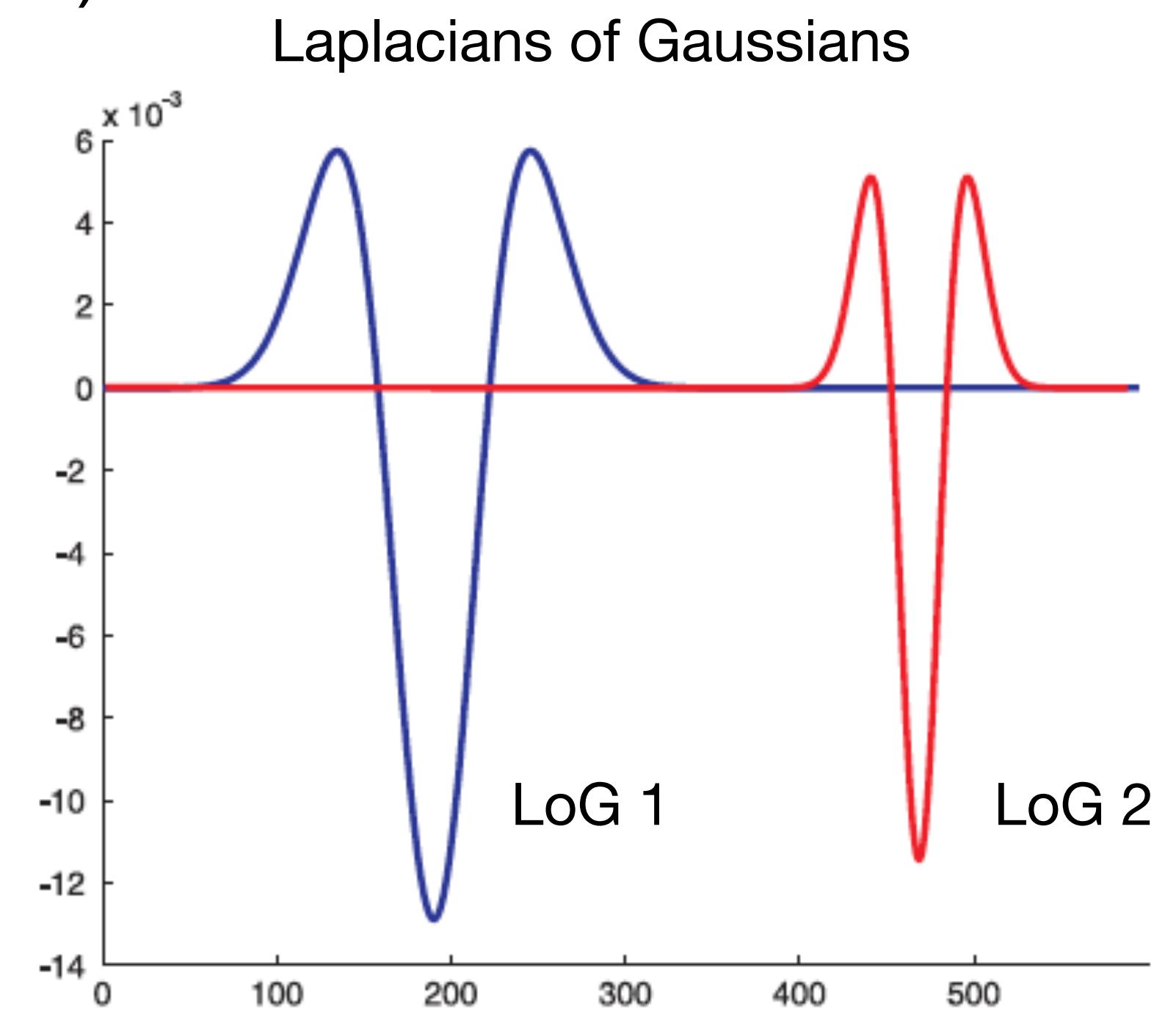
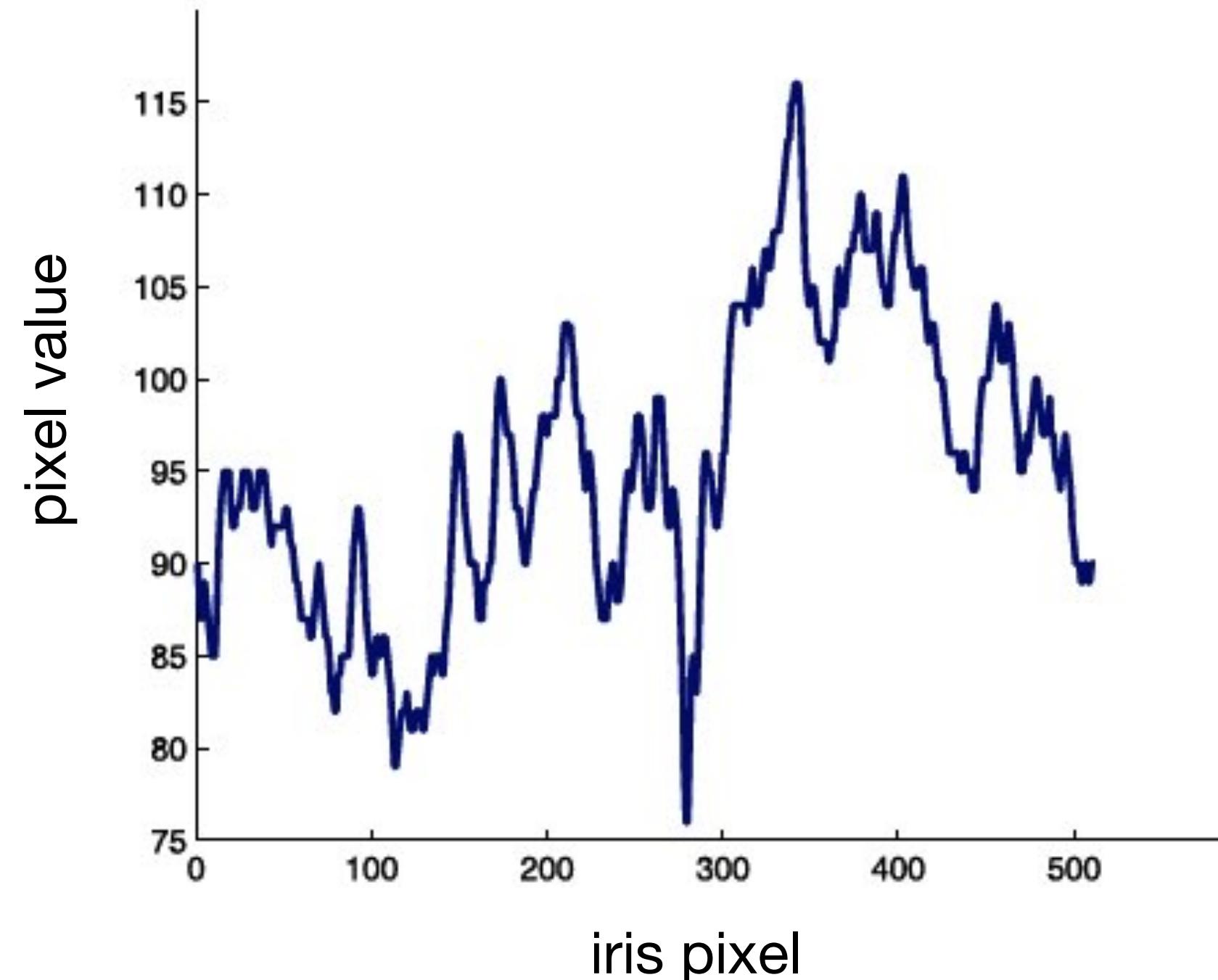
Dr. Adam Czajka



Feature Extraction

Zero-Crossing Approach (1/3)

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

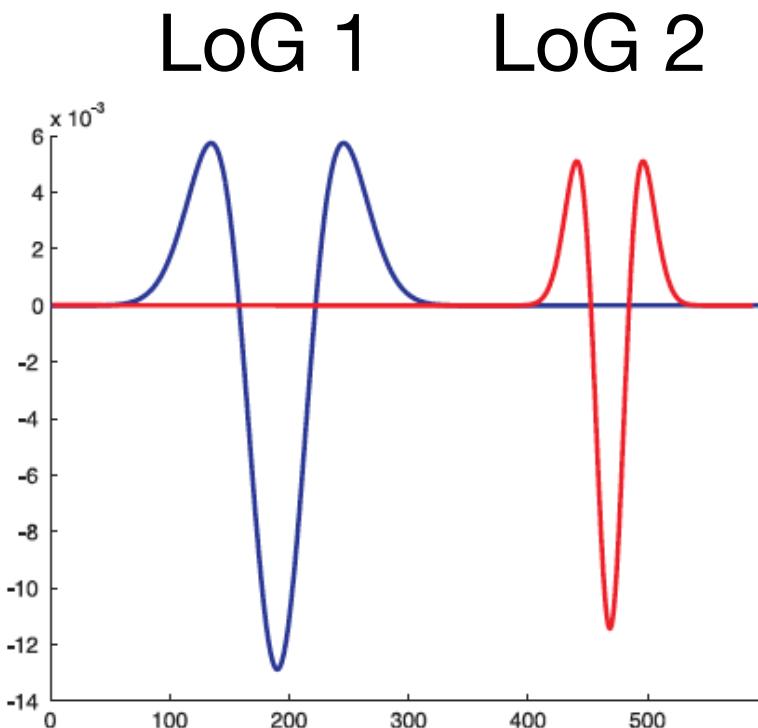
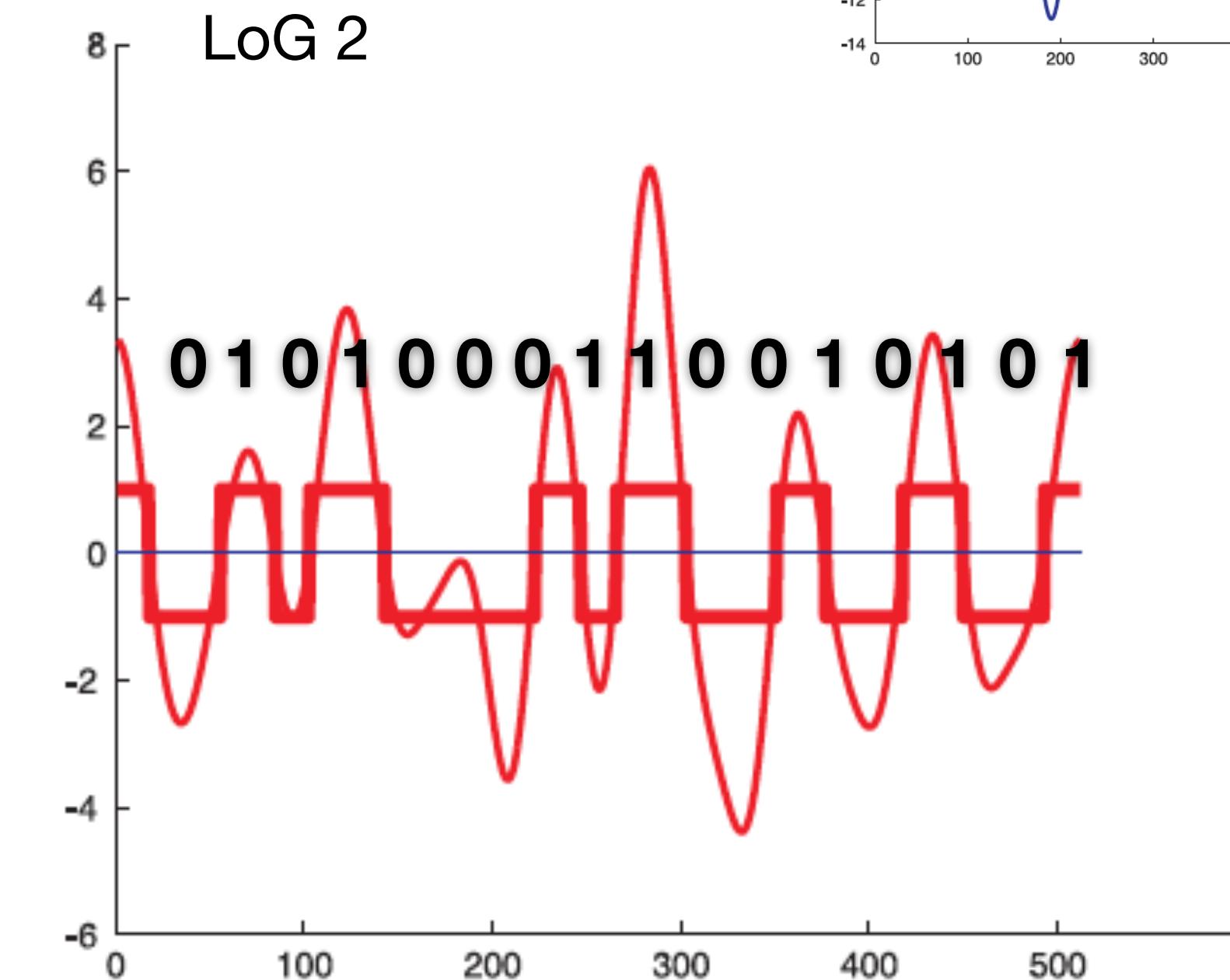
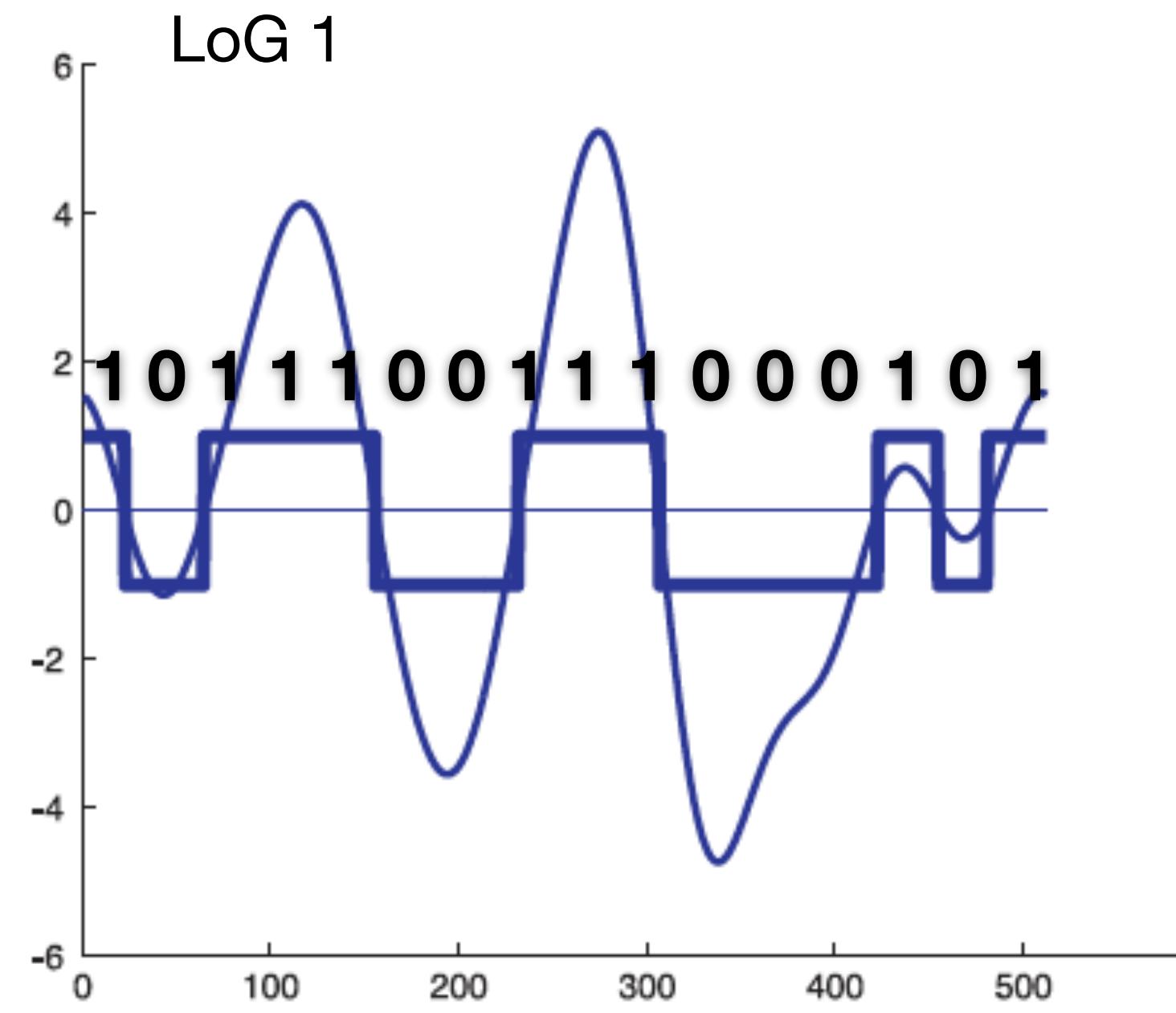


Dr. Adam Czajka

Feature Extraction

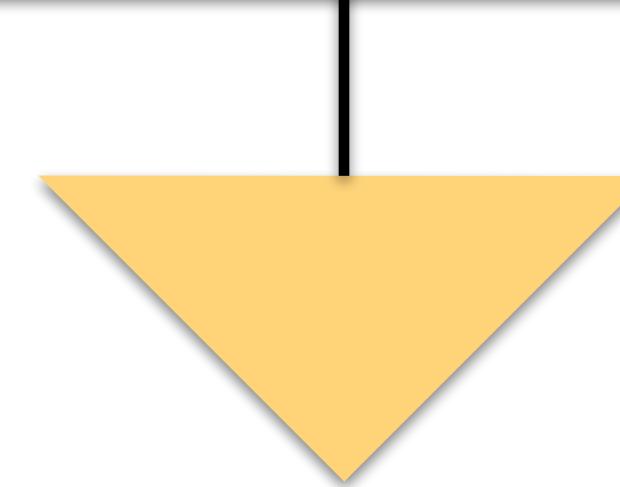
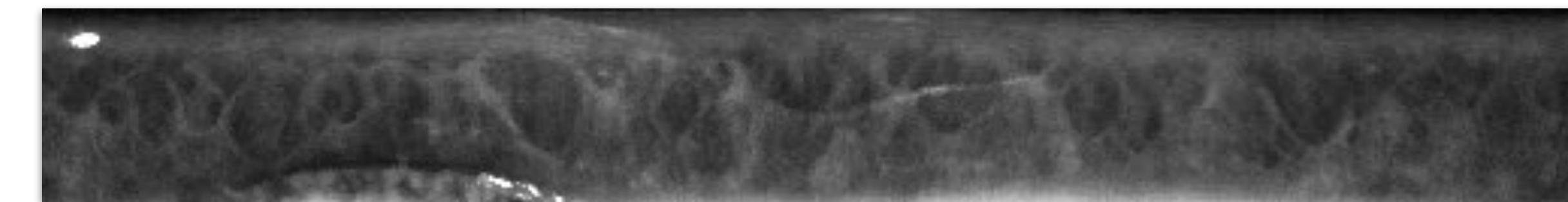
Zero-Crossing Approach (1/3)

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



Feature Extraction

Zero-Crossing Approach (1/3)



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

concatenation

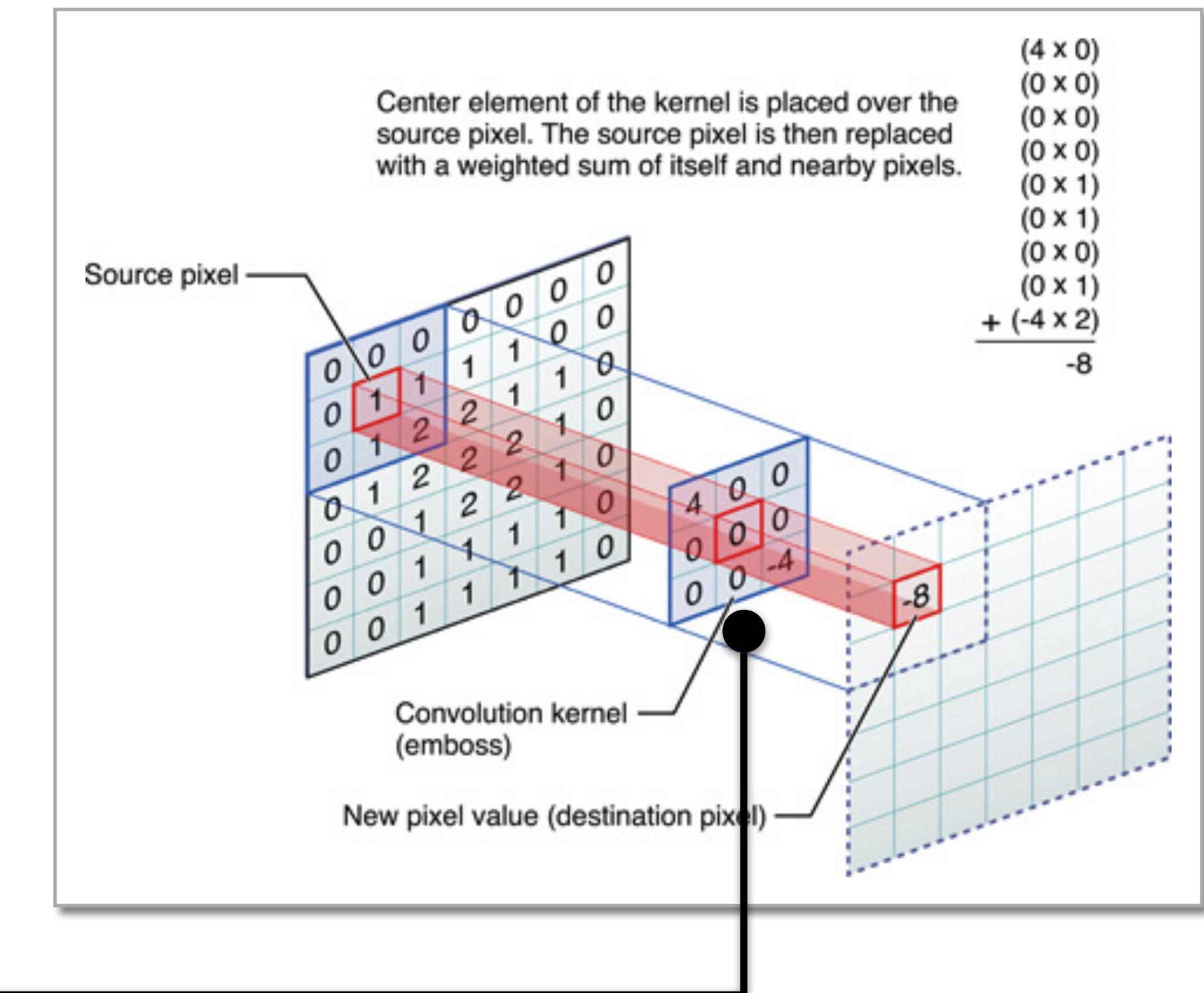
Feature Extraction

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.



Source:<https://developer.apple.com/library/archive/documentation/Performance/Conceptual/vImage/ConvolutionOperations/ConvolutionOperations.html>

Feature Extraction

2D-Gabor Filtering Approach (2/3)

Proposed by John Daugman.

Empirical selection of a proper Gabor wavelet
(adequate to encode iris texture).

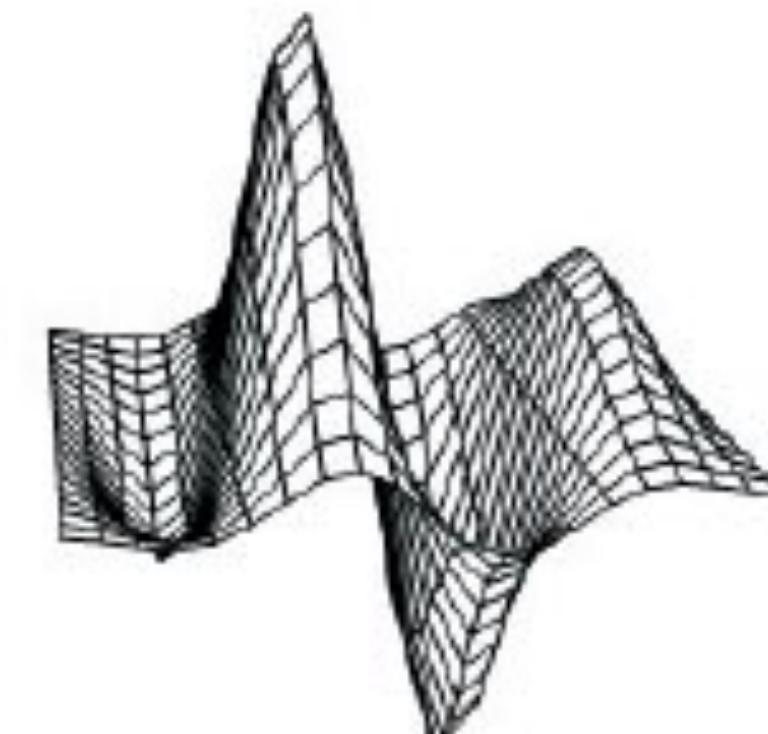
Gabor wavelets are a good model of neural receptive fields found in the visual cortex.

Filter 1



wavelet real component

Filter 2



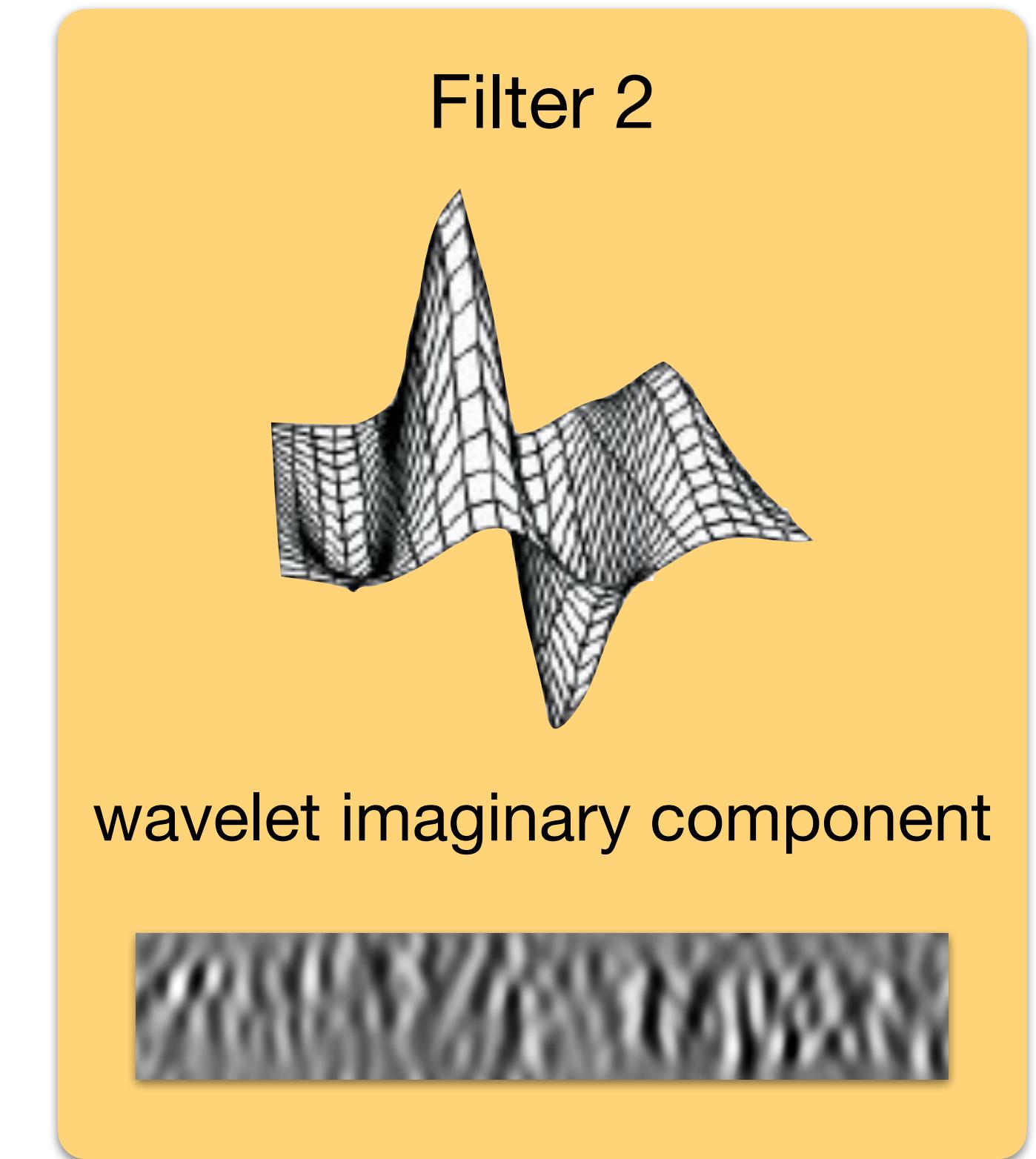
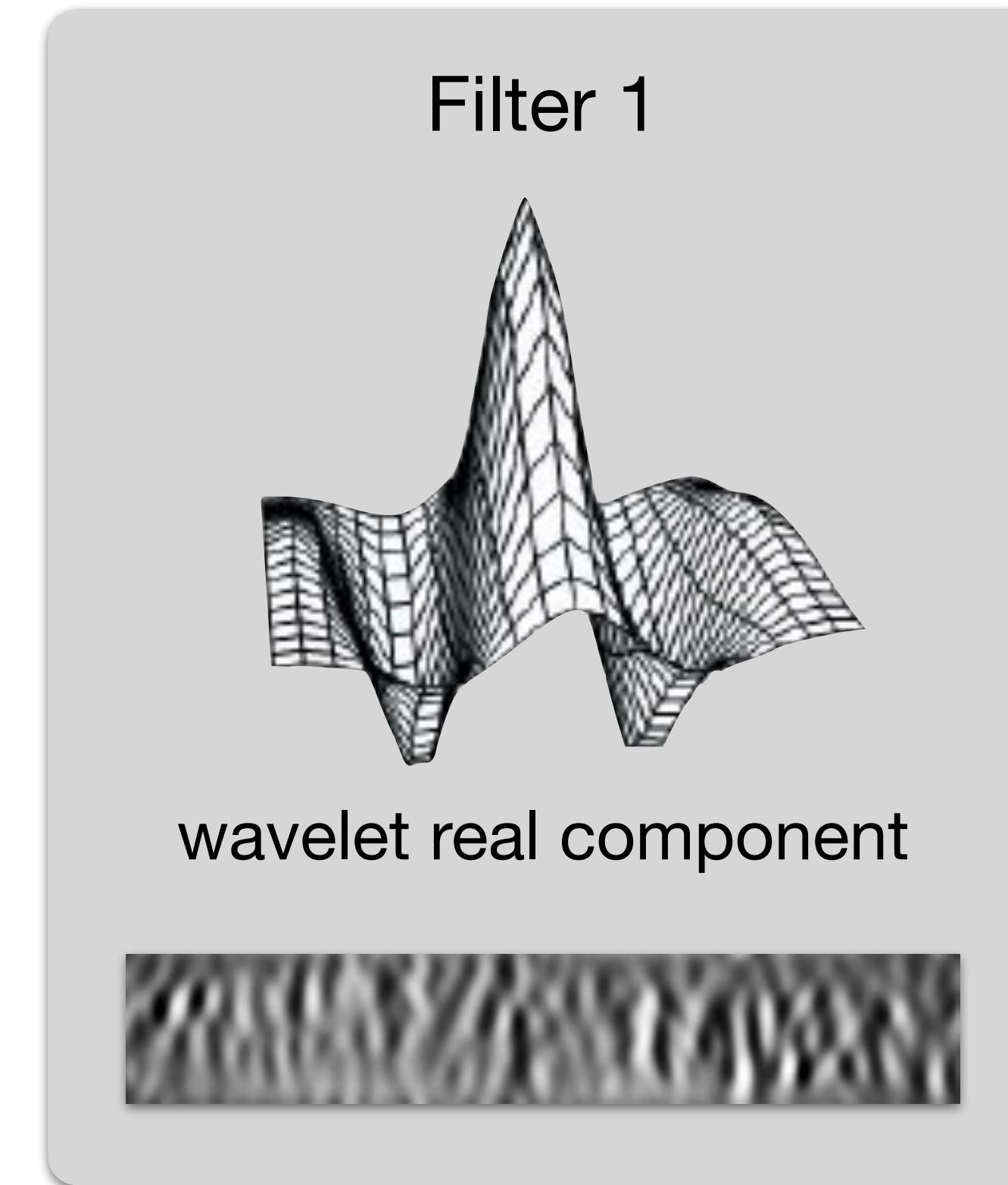
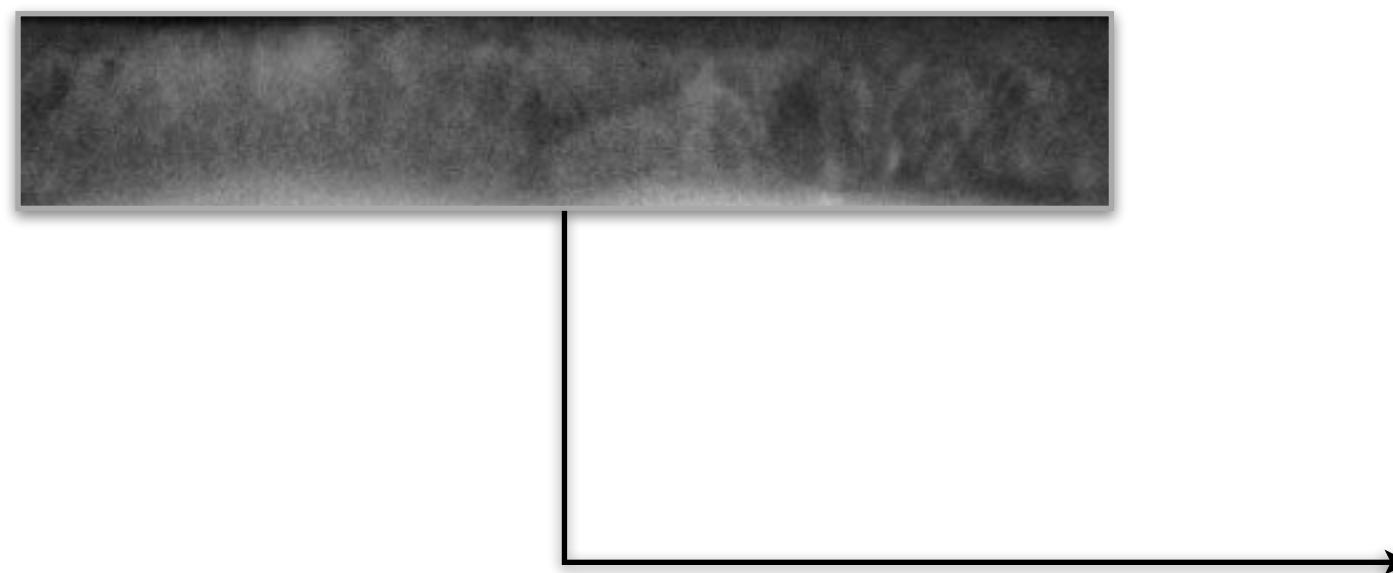
wavelet imaginary component

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

Feature Extraction

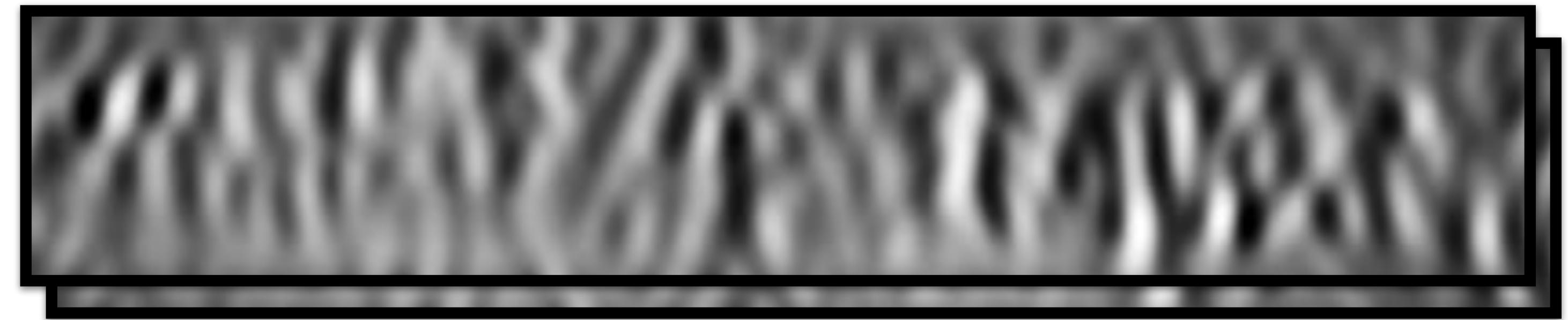
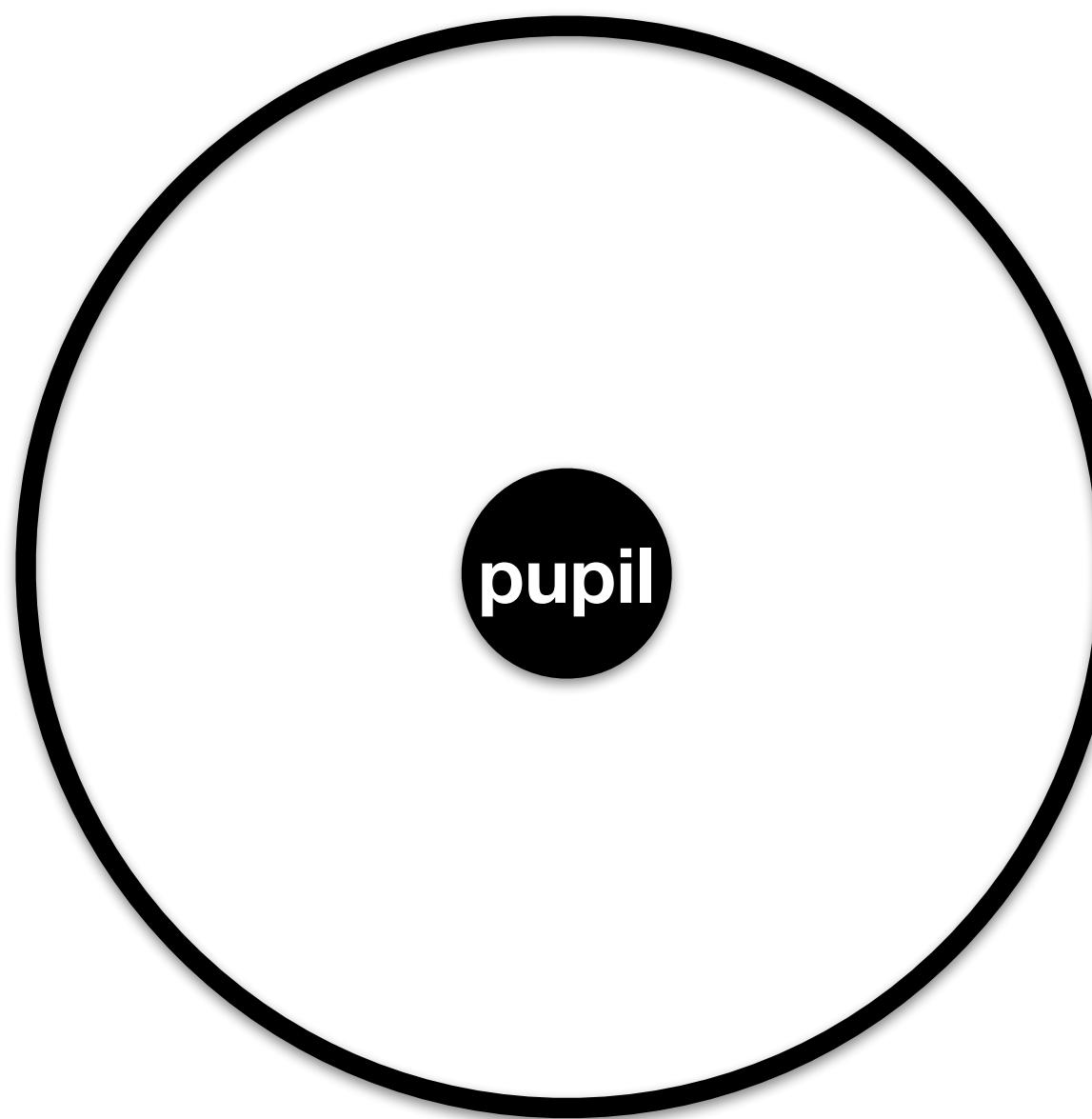
2D-Gabor Filtering Approach (2/3)

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



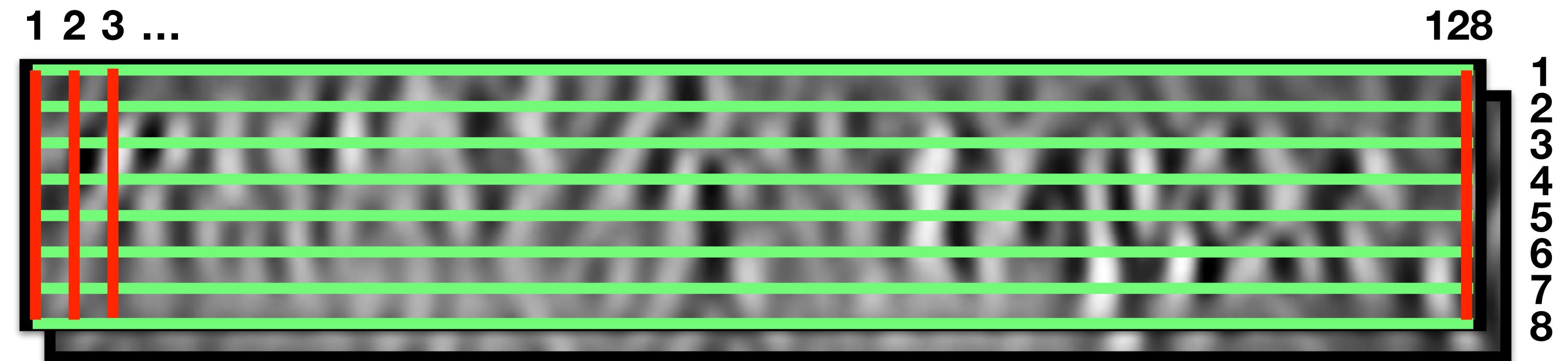
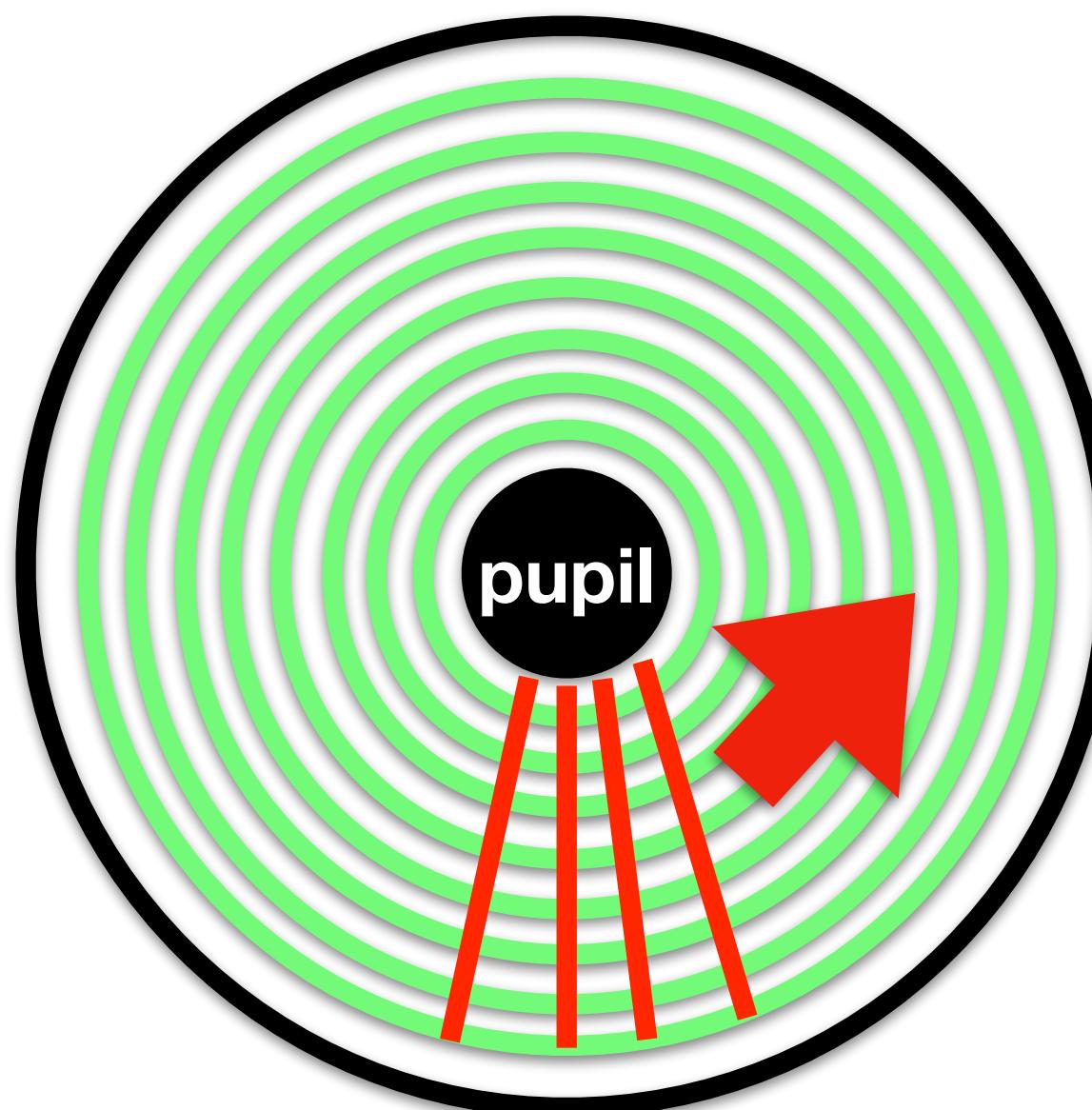
Feature Extraction

2D-Gabor Filtering Approach (2/3)



Feature Extraction

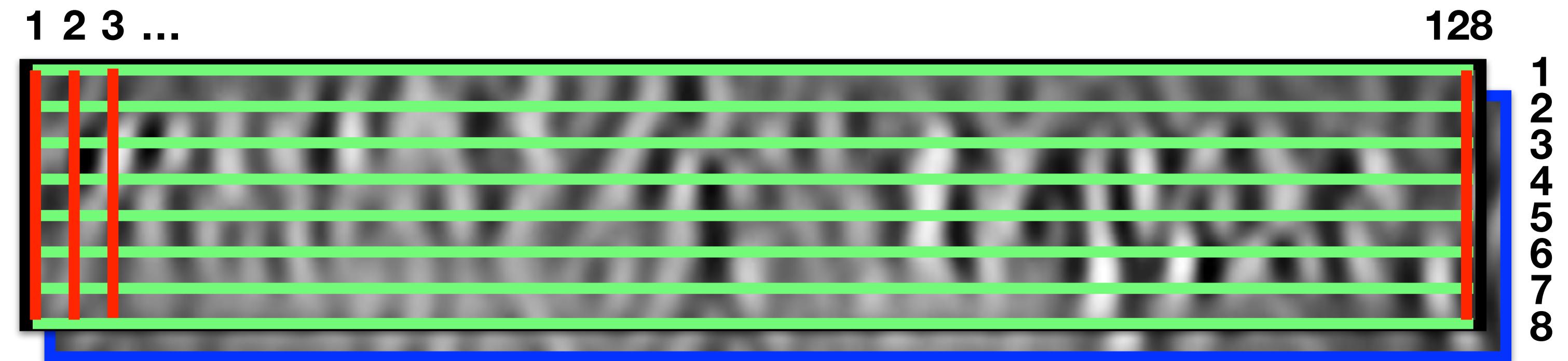
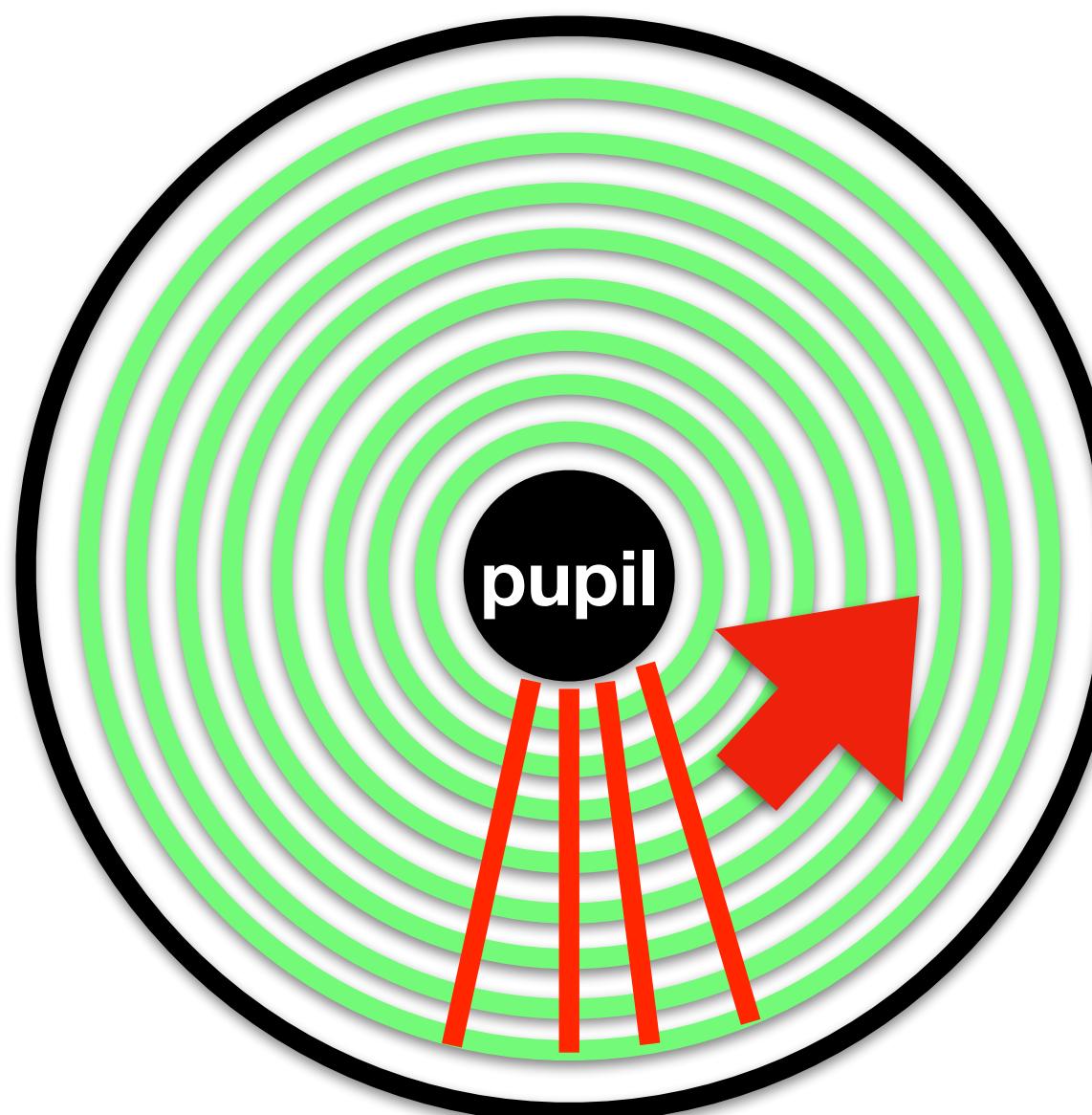
2D-Gabor Filtering Approach (2/3)



Number of cells: $8 \times 128 = 1024$

Feature Extraction

2D-Gabor Filtering Approach (2/3)

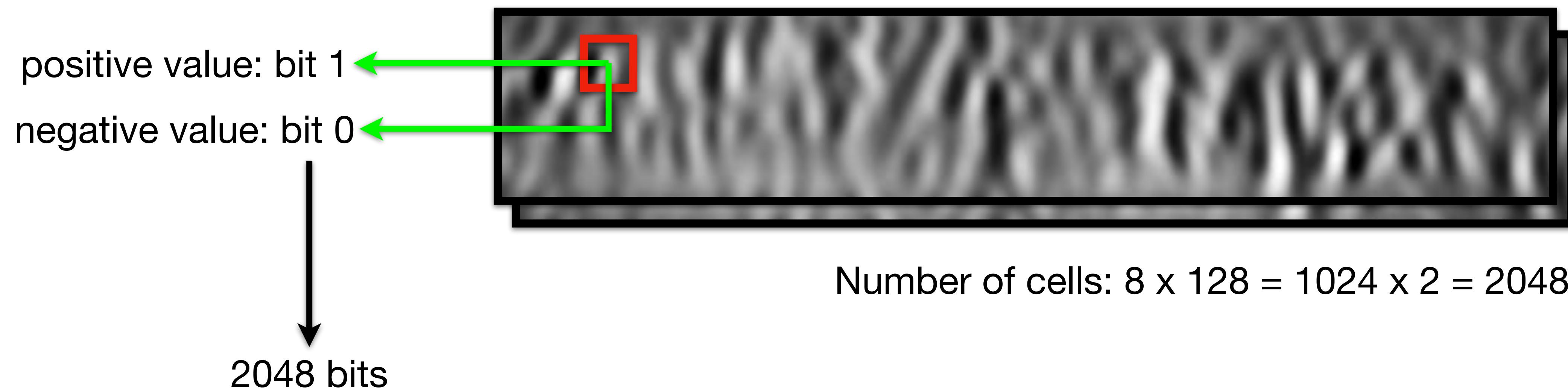


Number of cells: $8 \times 128 = 1024 \times 2 = 2048$

Feature Extraction

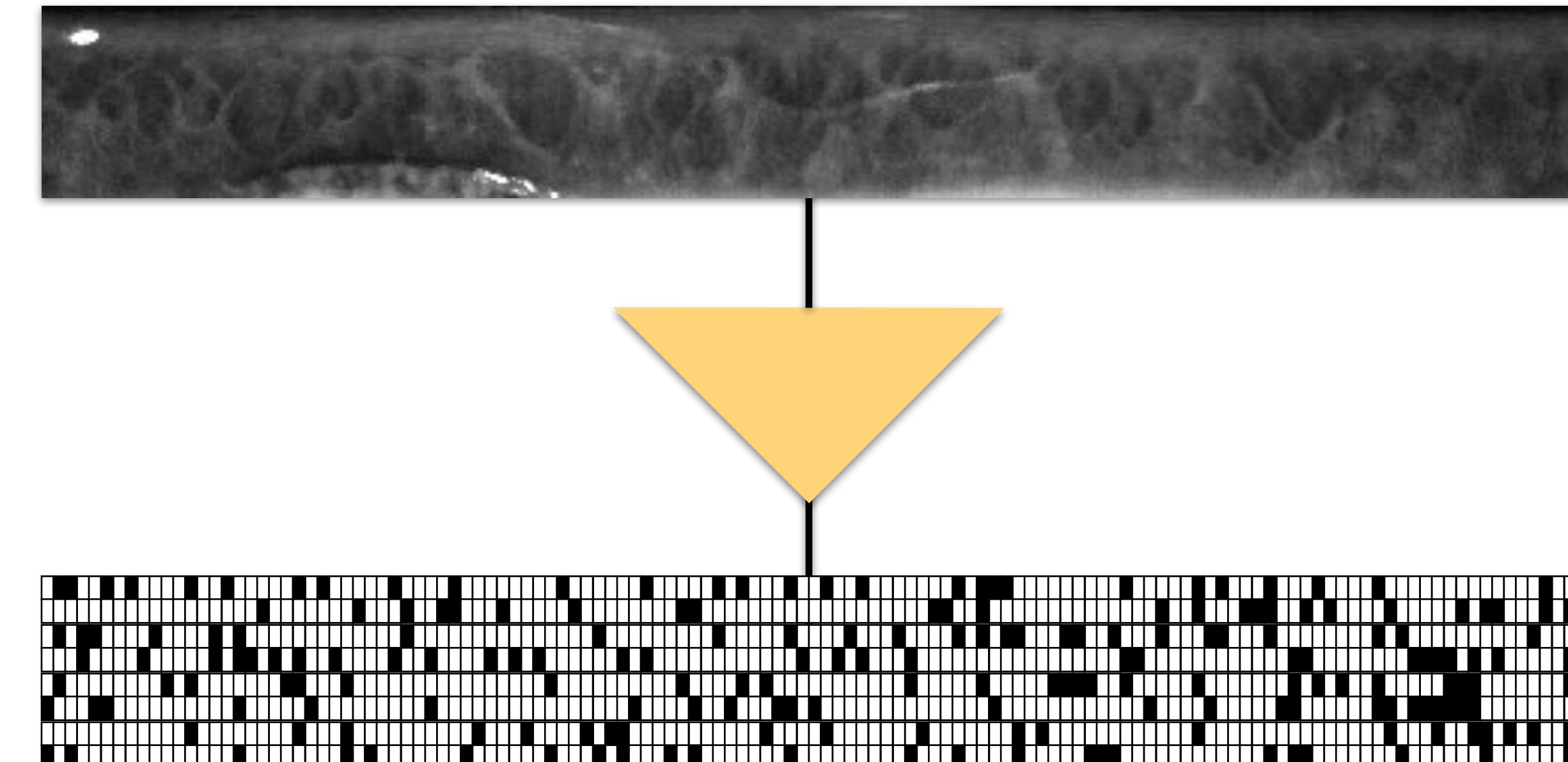
2D-Gabor Filtering Approach (2/3)

Take one cell...



Feature Extraction

2D-Gabor Filtering Approach (2/3)



**2048 bits
IrisCode**

Feature Extraction

BSIF Approach (3/3)

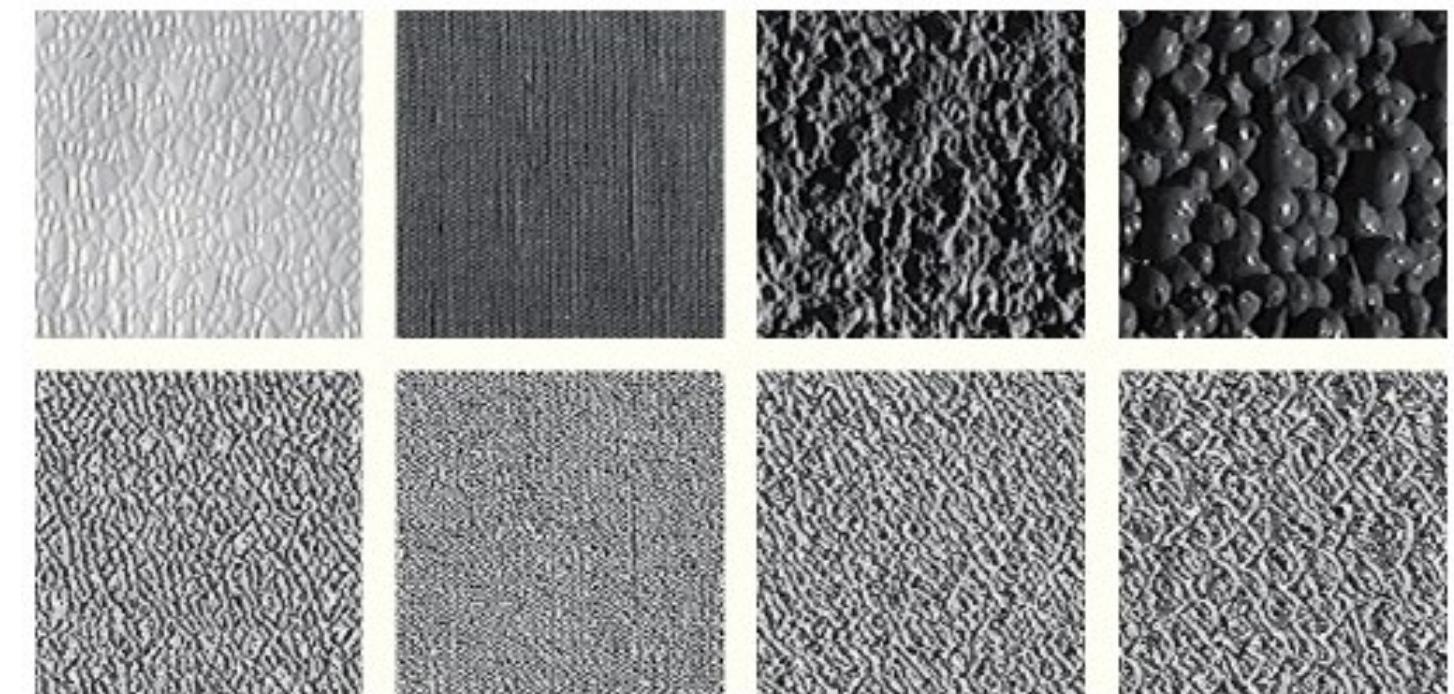
Binarized Statistical Image Features (BSIF)

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.

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 $l \times l$ 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.

Feature Extraction

BSIF Approach (3/3)

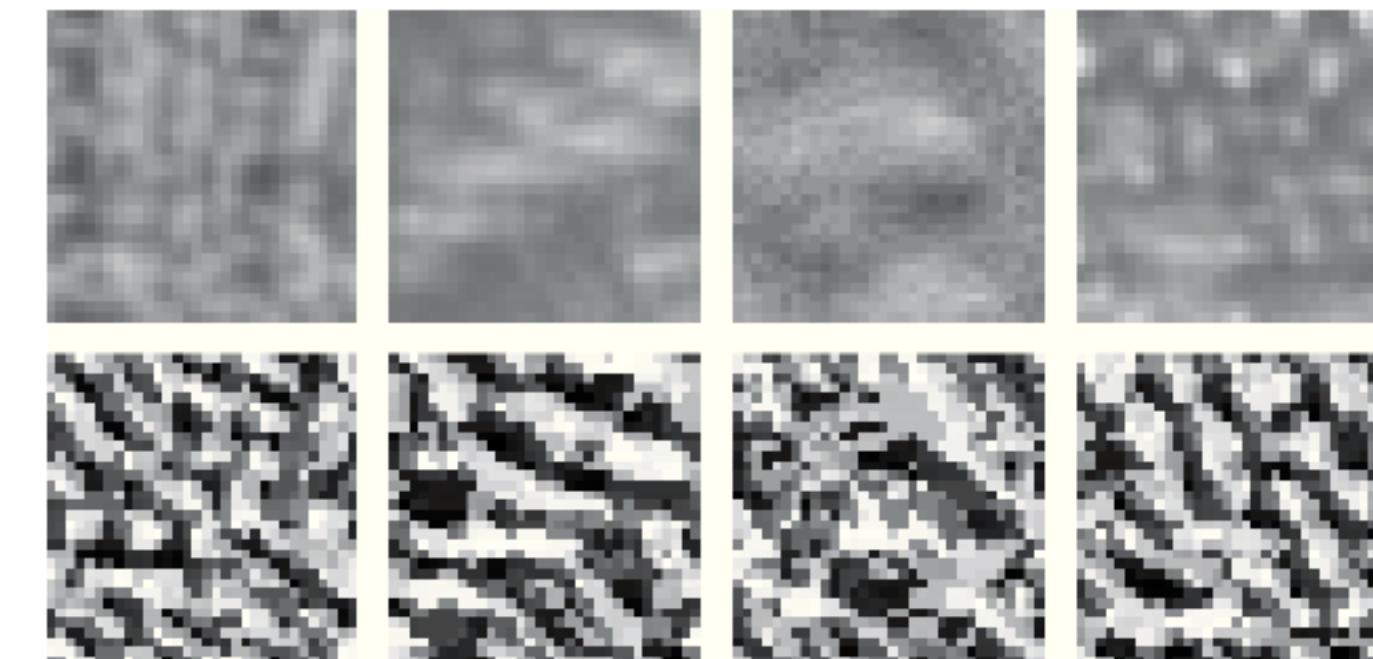
Kannala and Rahtu

BSIF: Binarized Statistical Image Features

ICPR 2012

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.

BSIF code examples

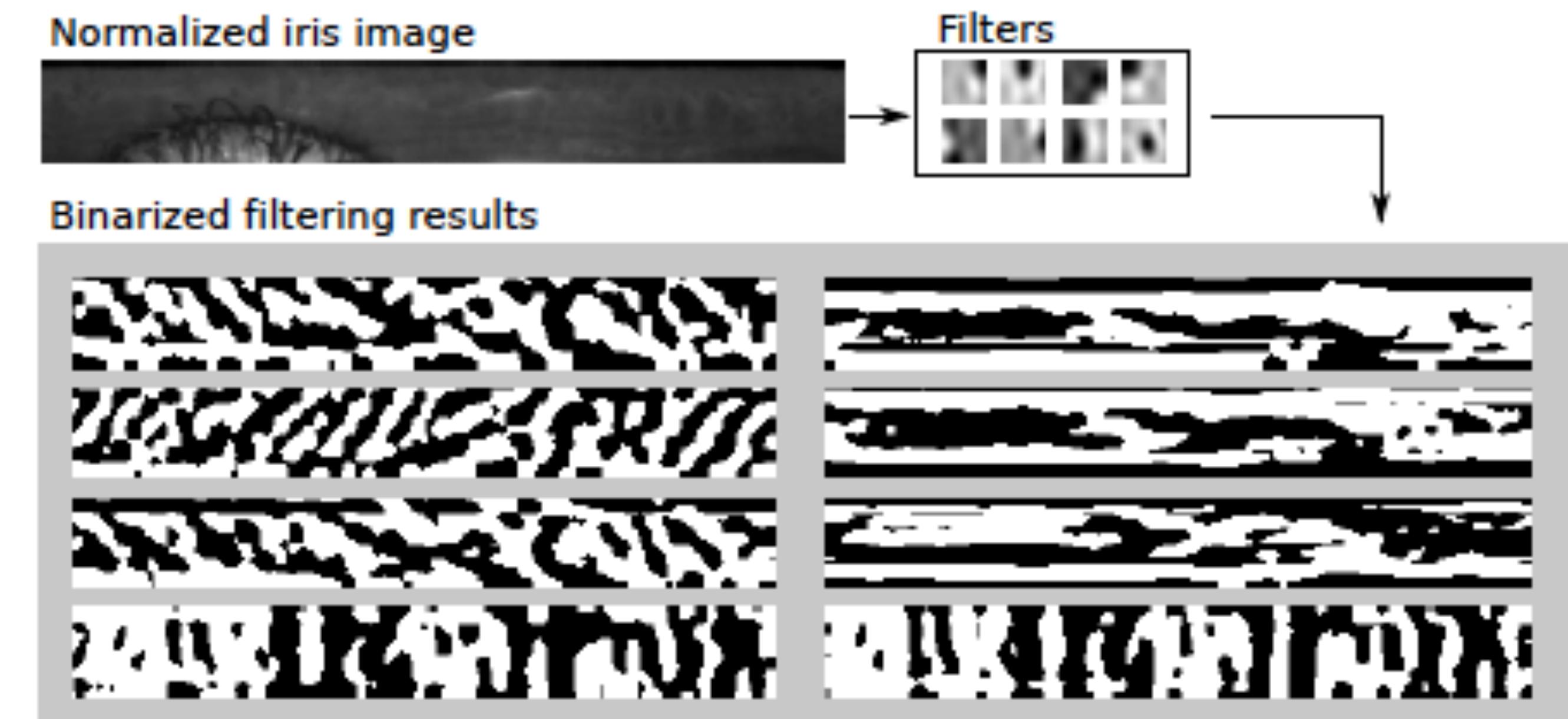
Feature Extraction

BSIF Approach (3/3)

In the case of irises...

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

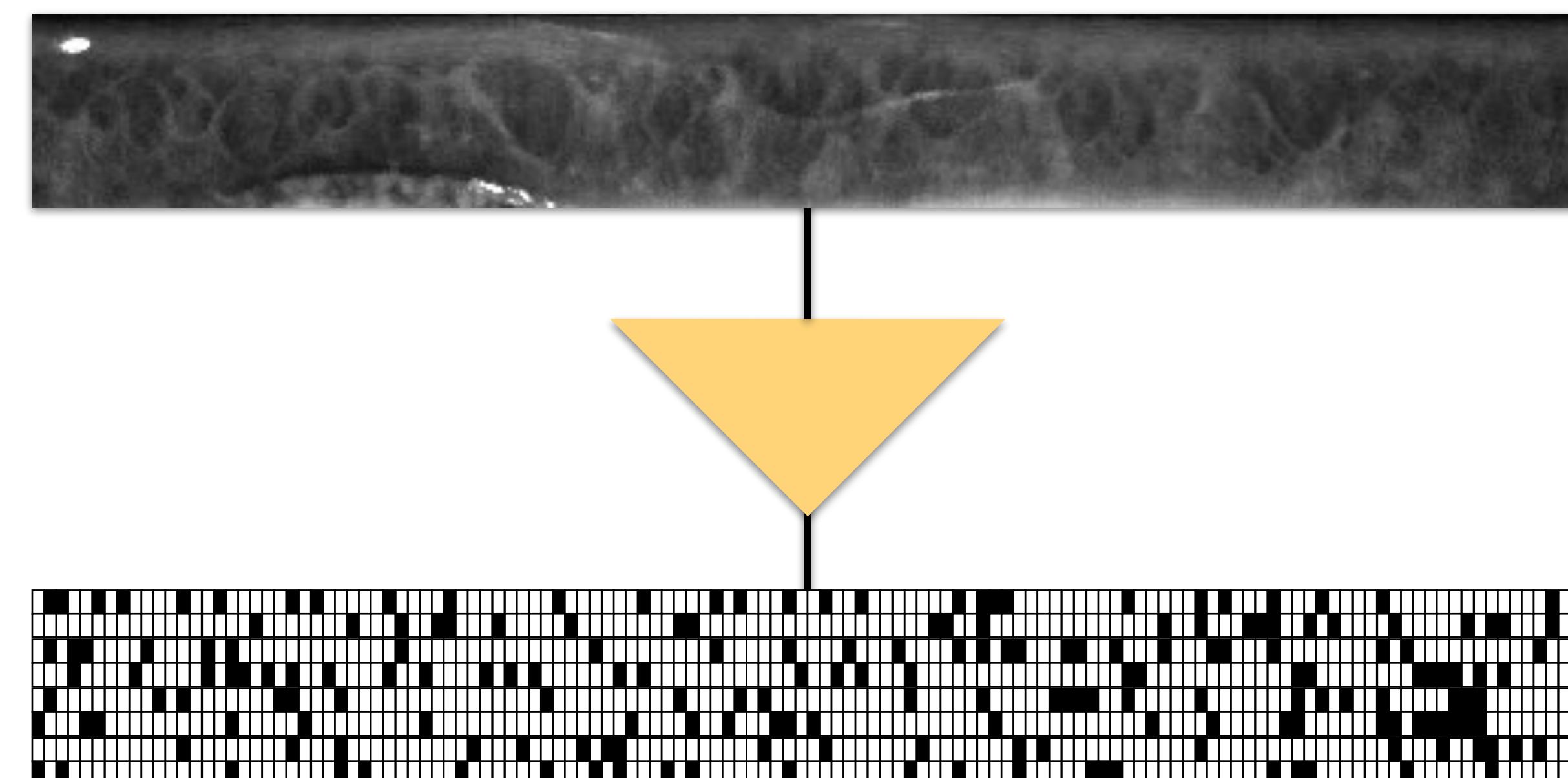
Czajka et al.
*Domain-Specific Human-Inspired
Binarized Statistical Image Features
for Iris Recognition*
WACV 2019



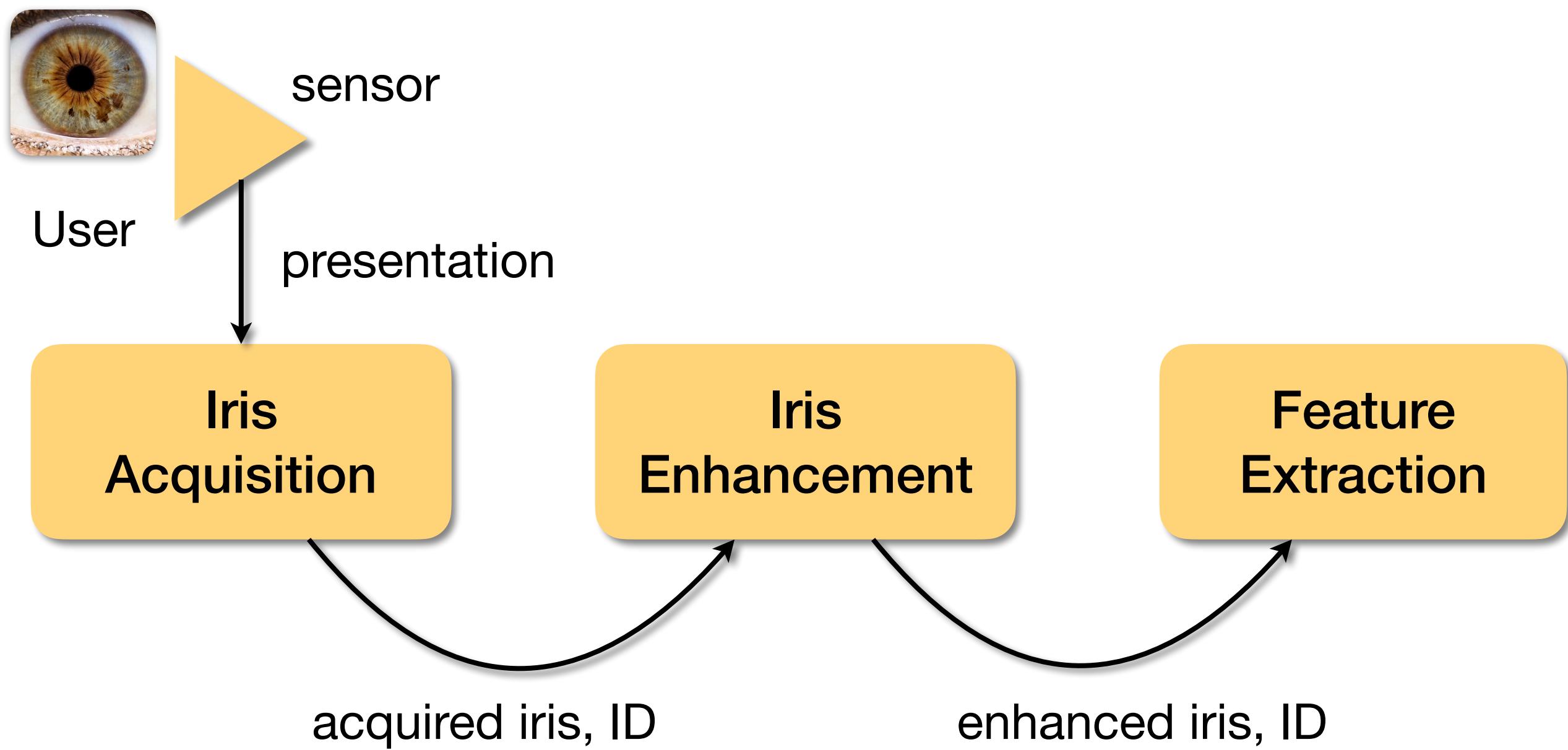
Feature Extraction

BSIF Approach (3/3)

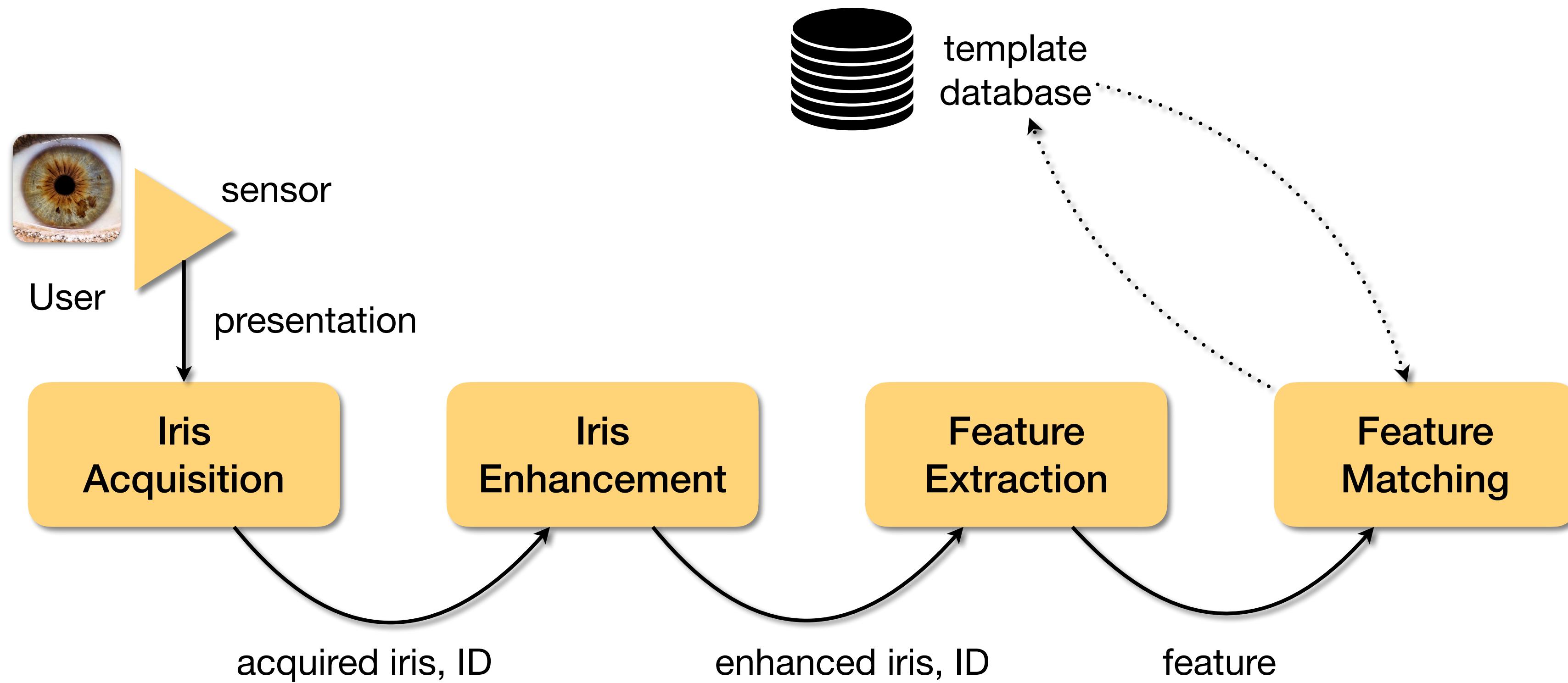
In the case of irises...



Iris Recognition



Iris Recognition



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

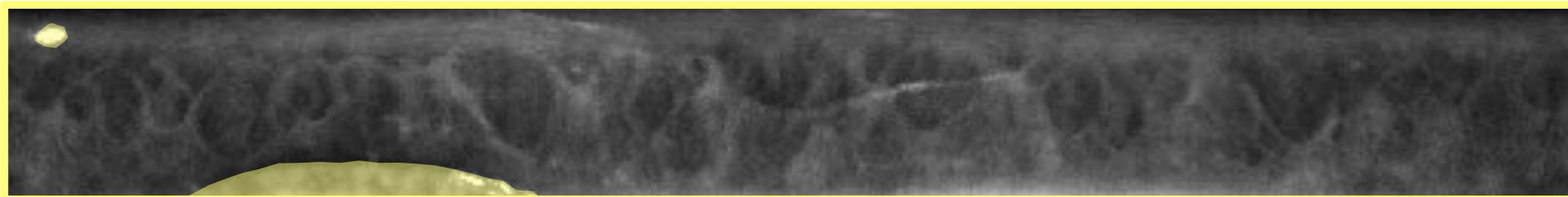
Feature Matching

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

$$dist = \frac{\text{bitwise_sum}(I_1 \text{ XOR } I_2 \text{ AND } M_1 \text{ AND } M_2)}{\text{bitwise_sum}(M_1 \text{ AND } M_2)}$$

Only cells considered by both masks are used.

Feature Matching

How to Compare Binary Codes?

Problems (2/2)

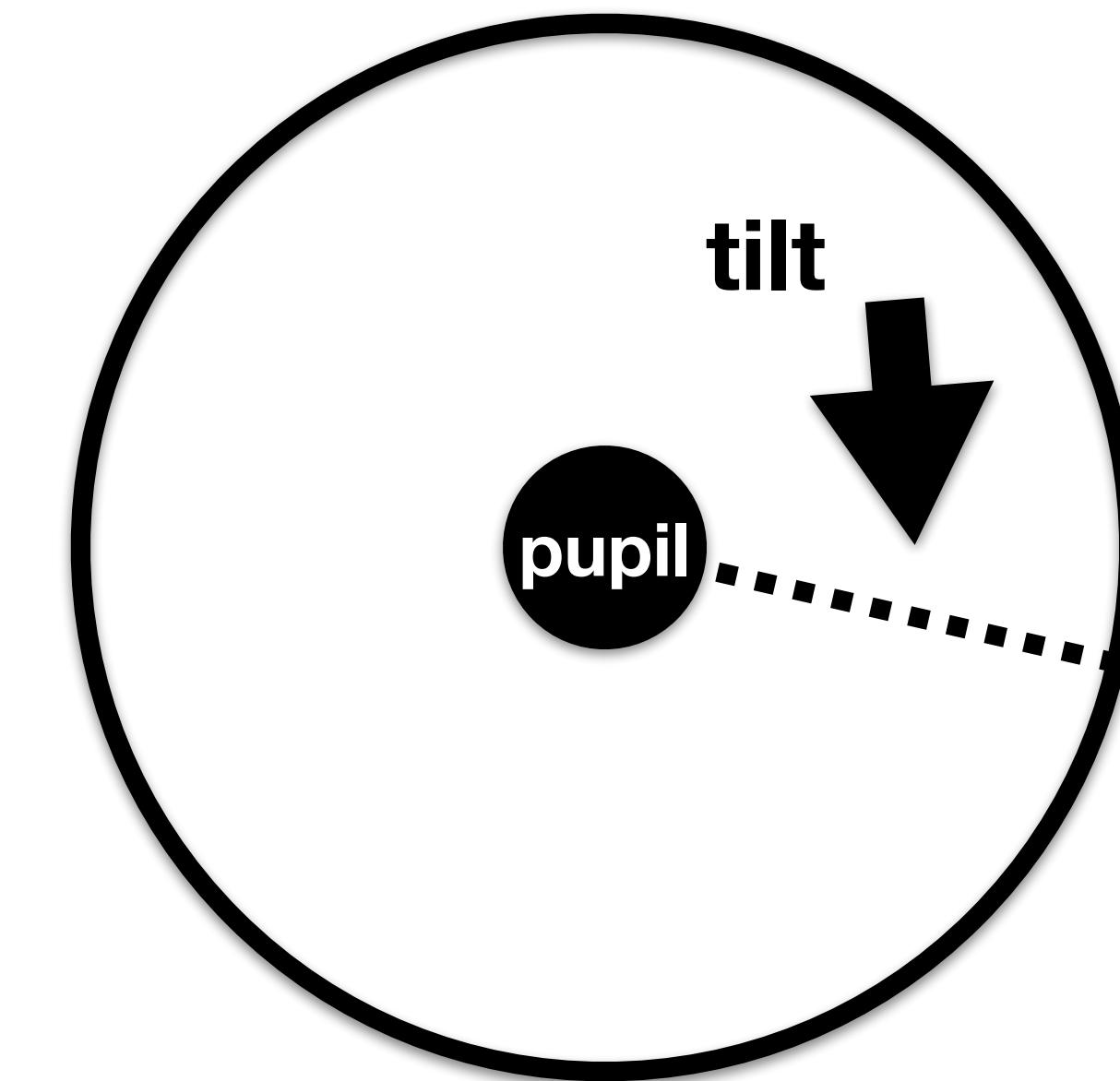
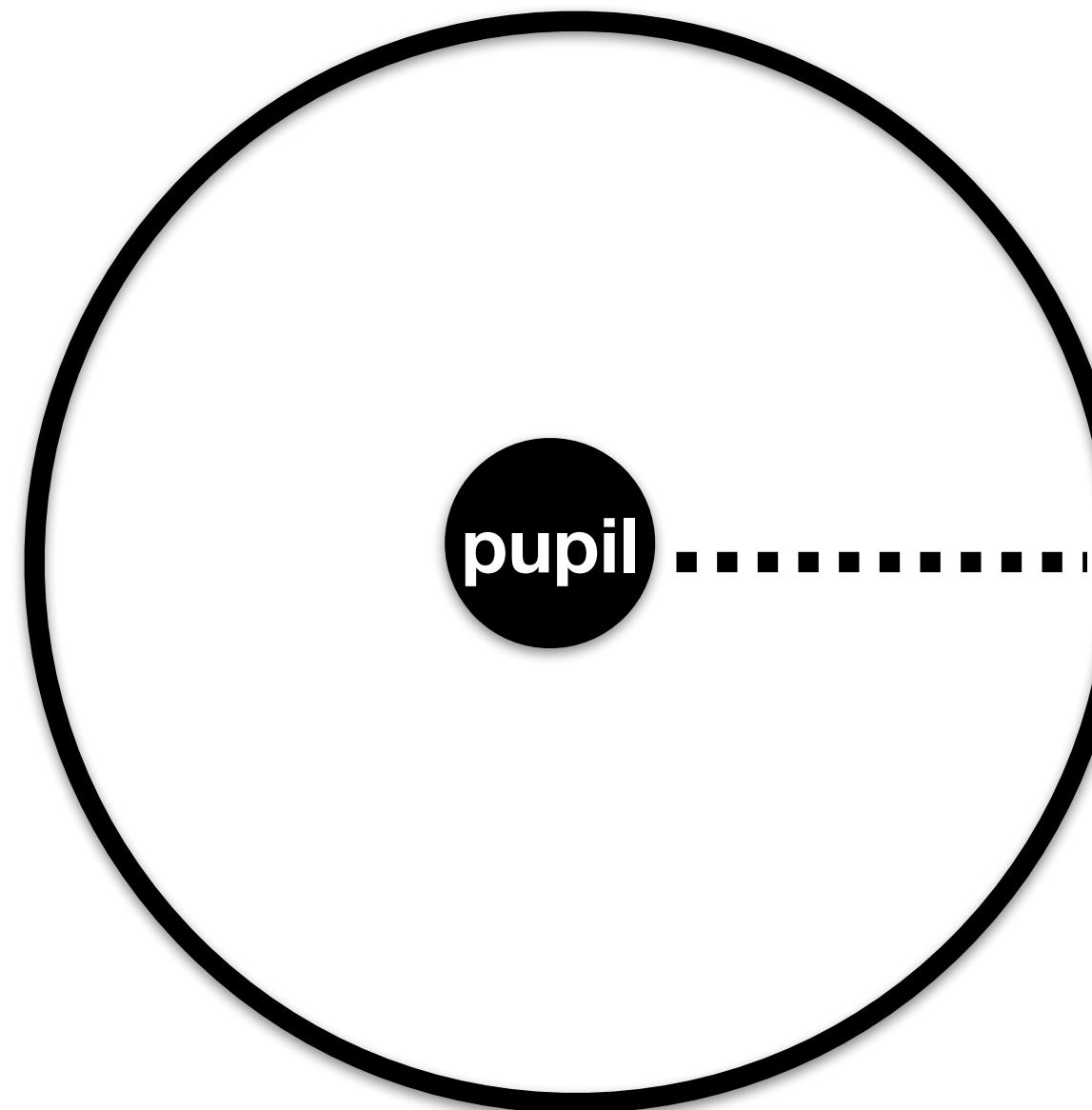
How to deal with iris rotations?

They happen when heads are tilted...



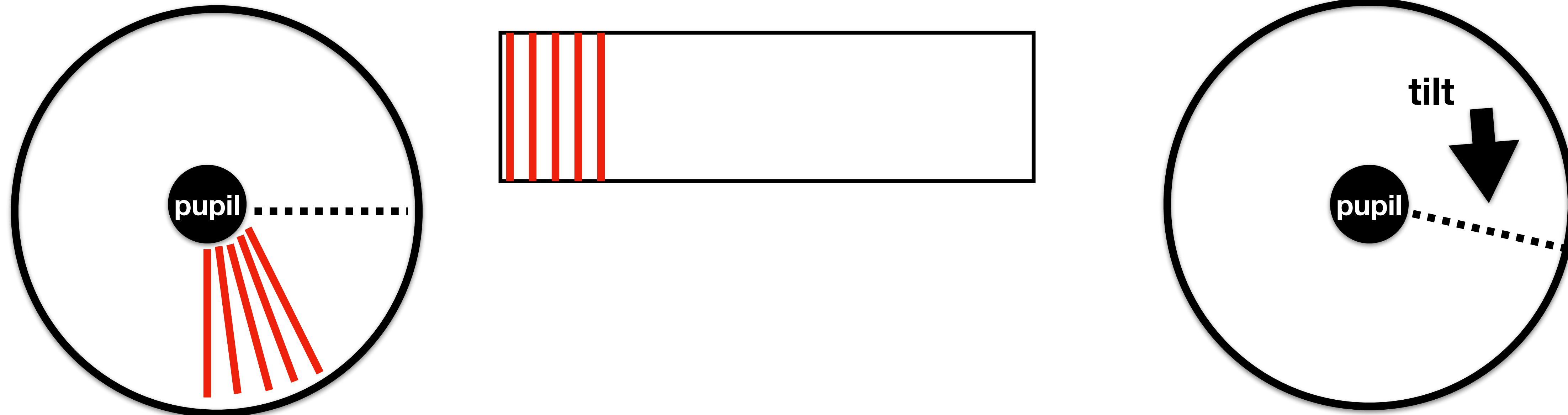
Feature Matching

How to match with iris rotations?



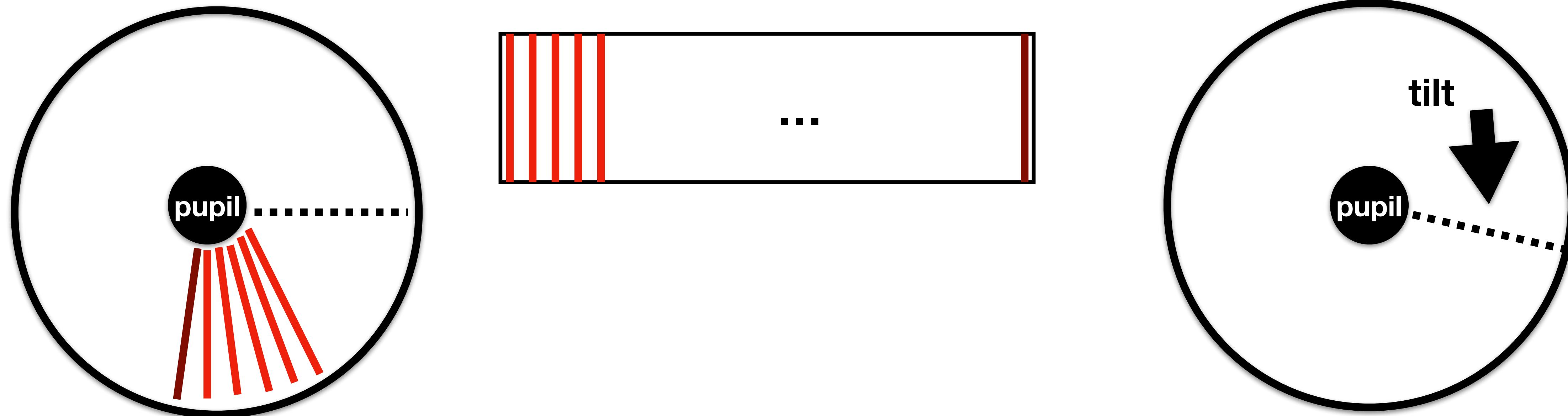
Feature Matching

How to match with iris rotations?



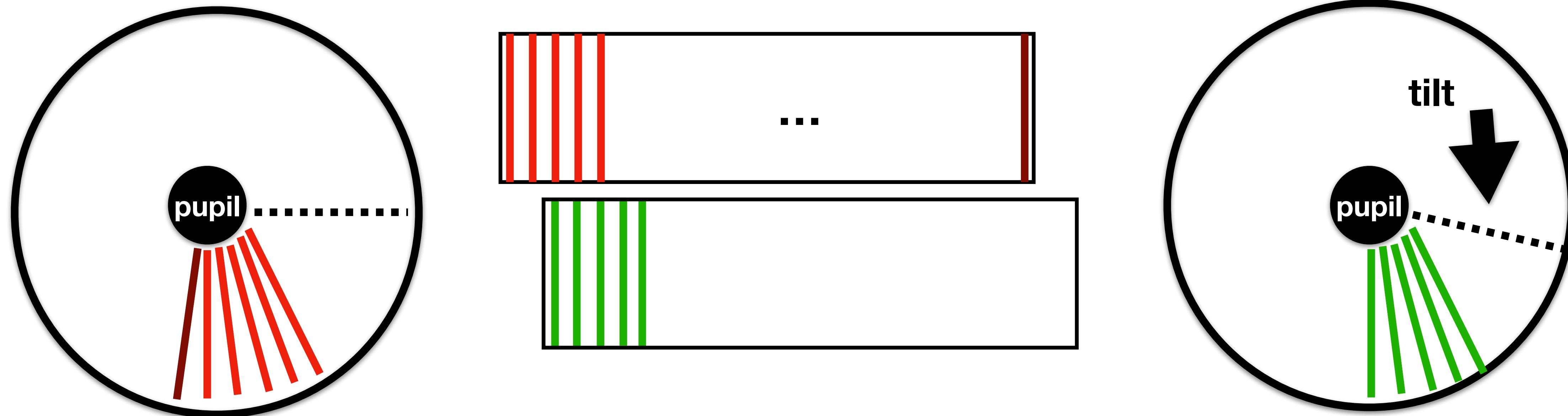
Feature Matching

How to match with iris rotations?



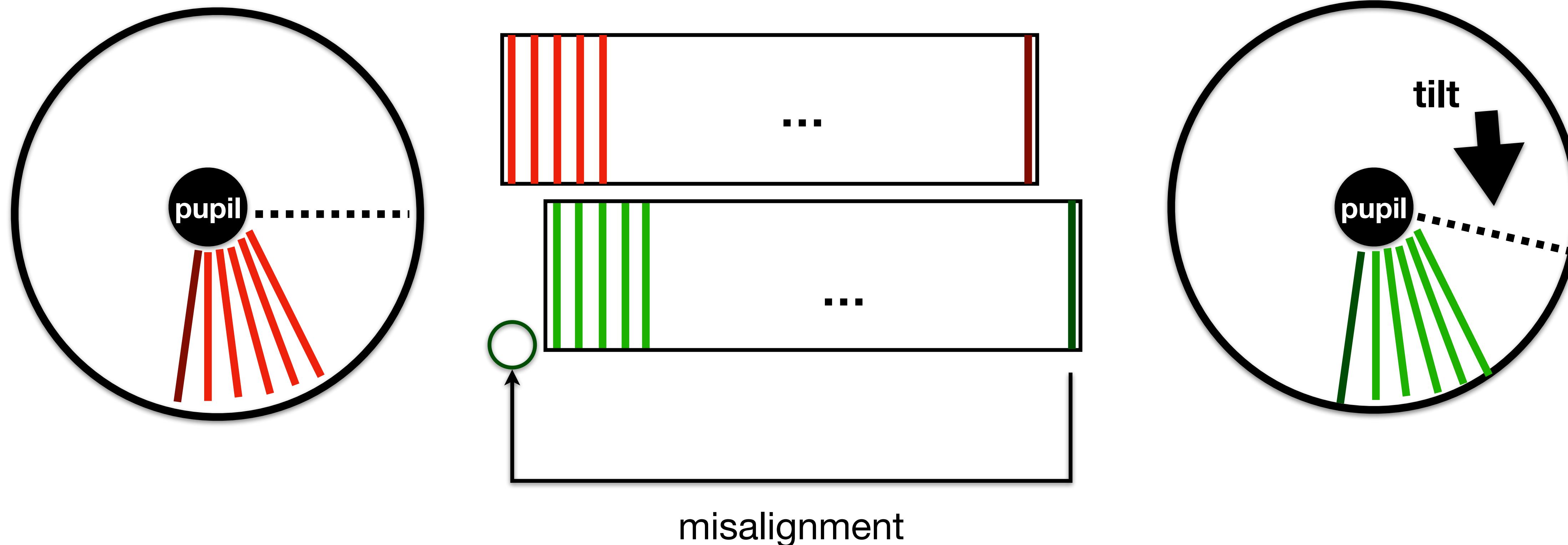
Feature Matching

How to match with iris rotations?



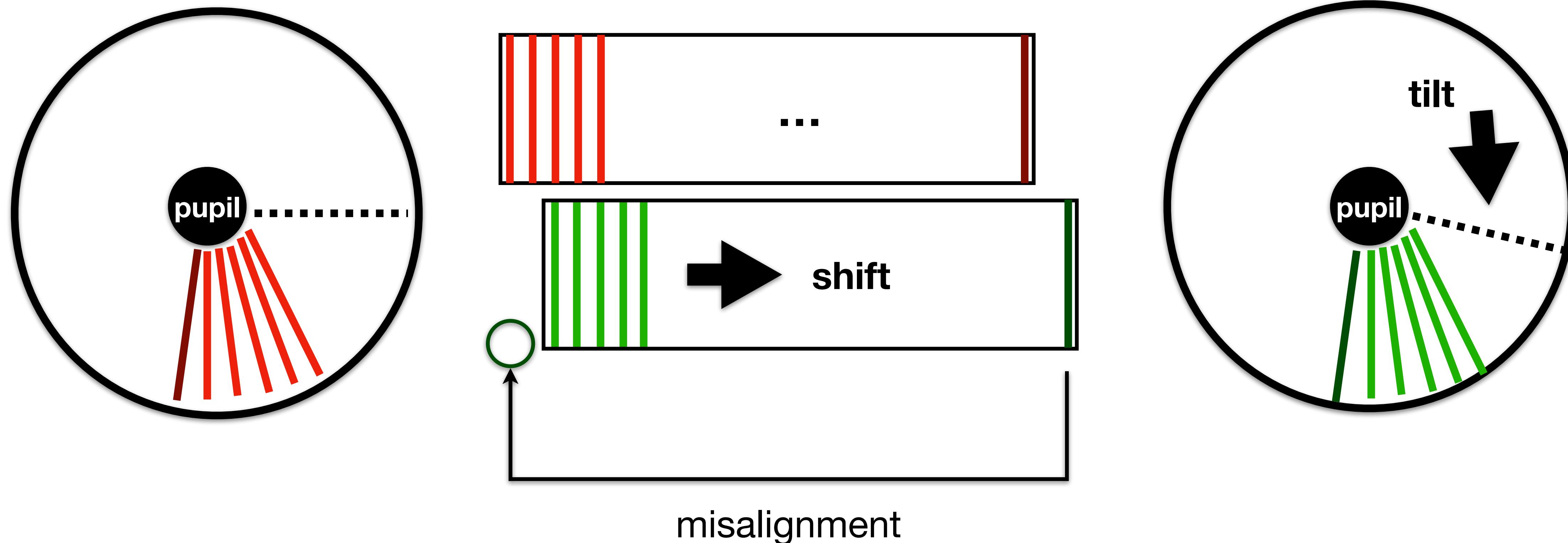
Feature Matching

How to match with iris rotations?



Feature Matching

How to match with iris rotations?



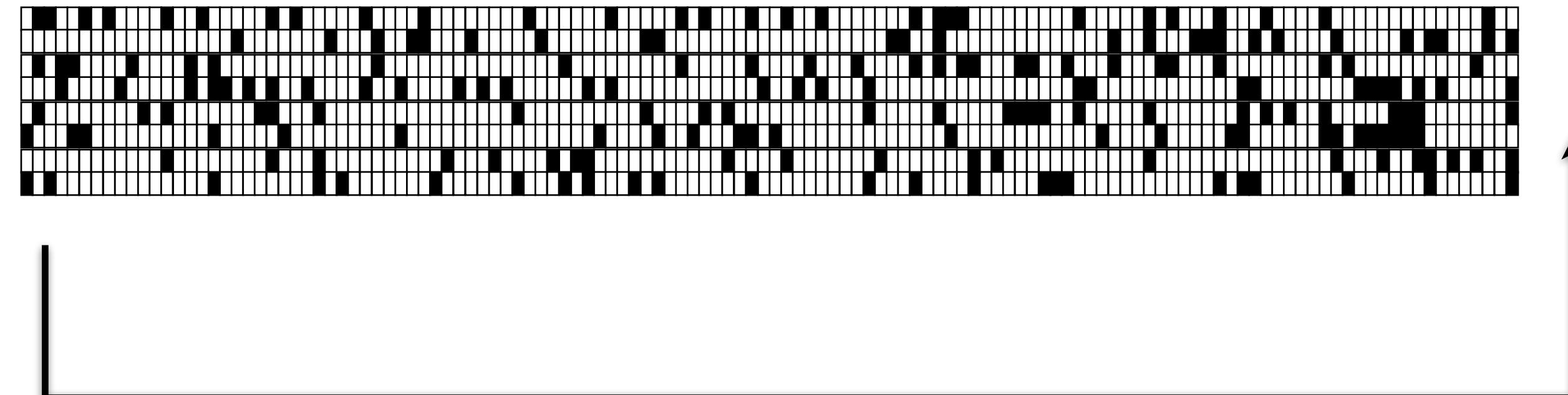
Feature Matching

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?

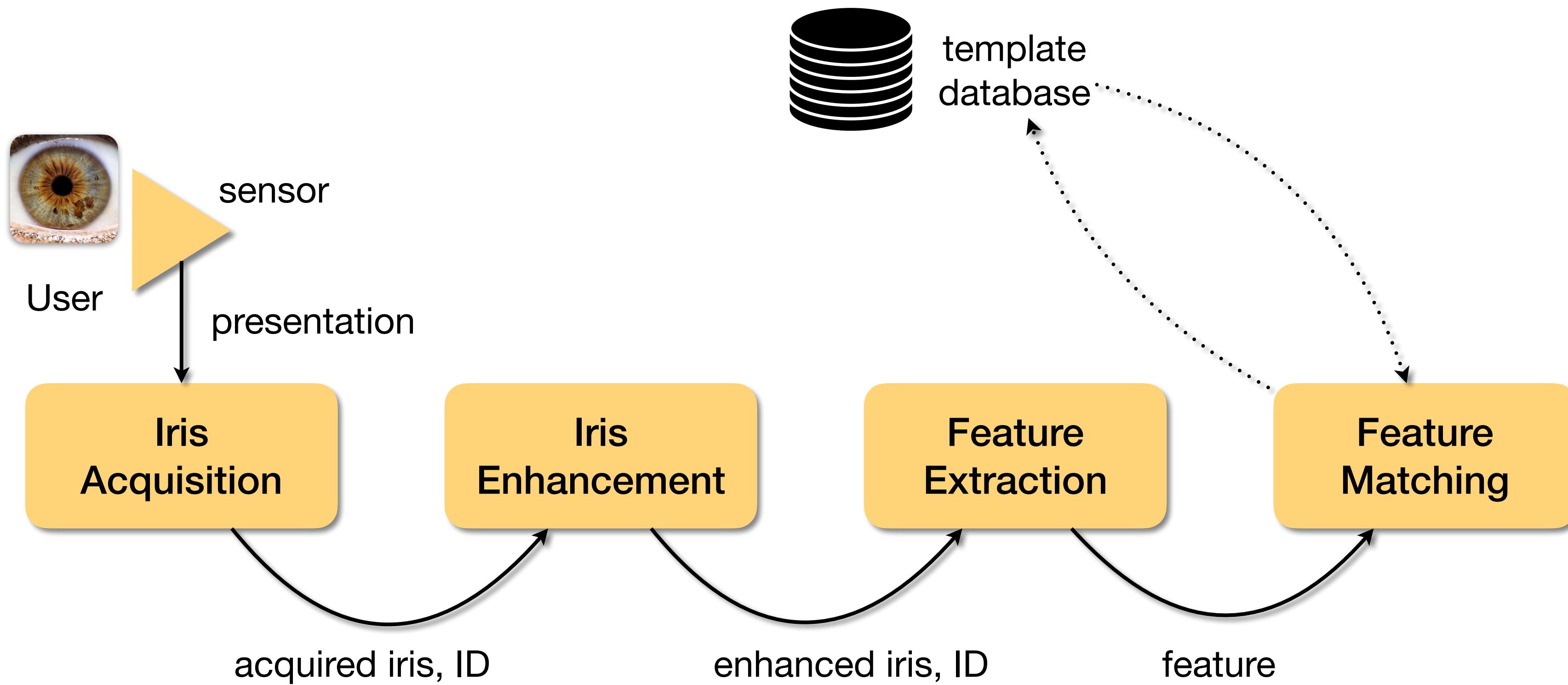
Solution: provide different shifts
for one of the iris codes.

Compute various normalized
Hamming distances (one for each shift).

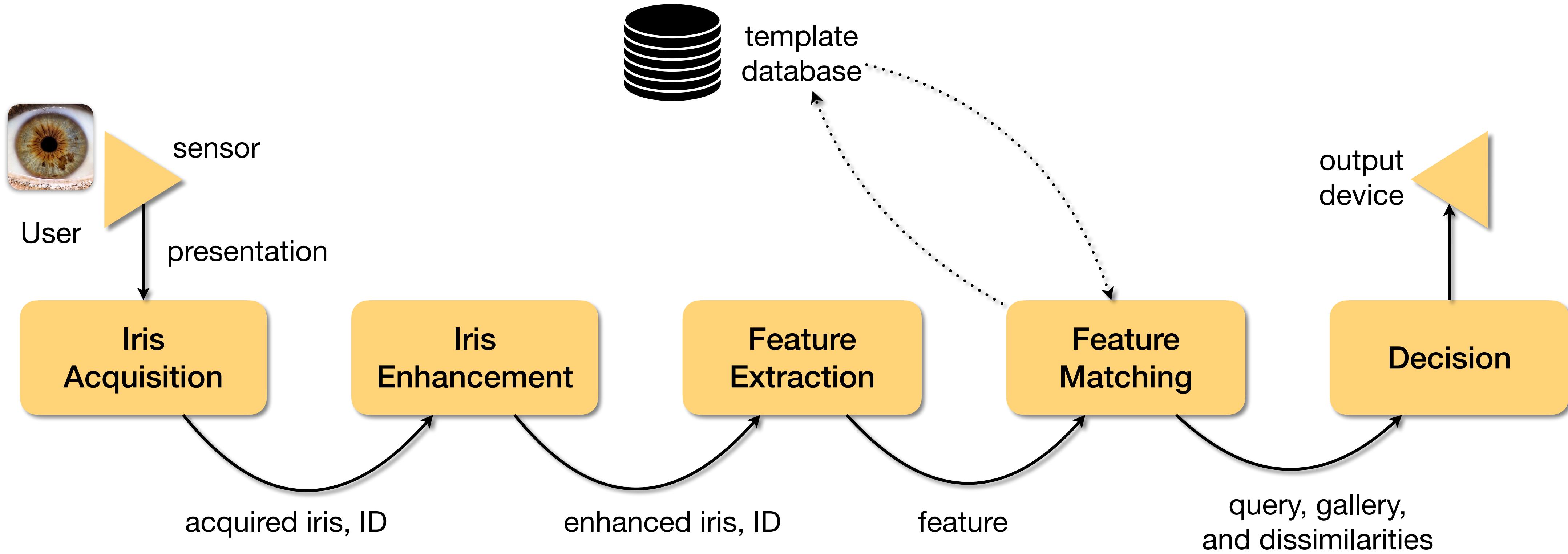


Take the smallest distance as the score.

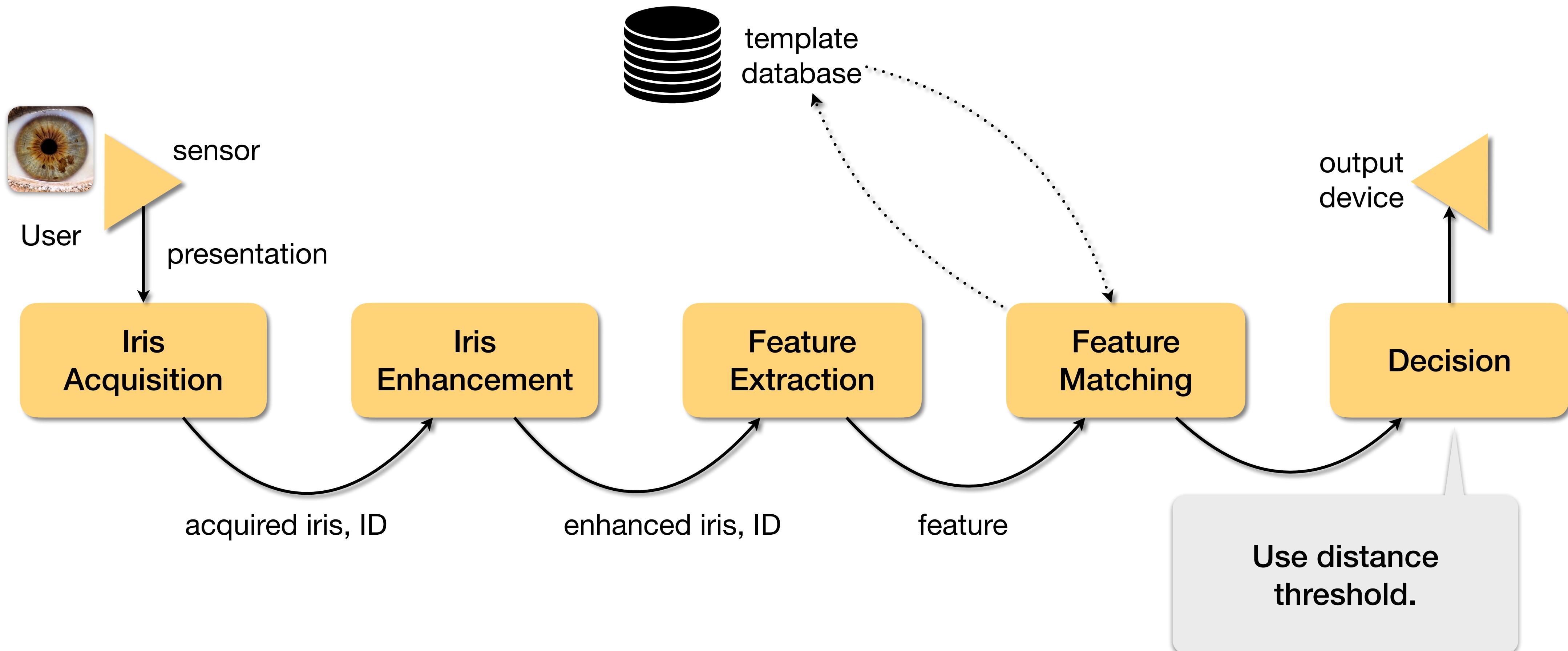
Iris Recognition



Iris Recognition



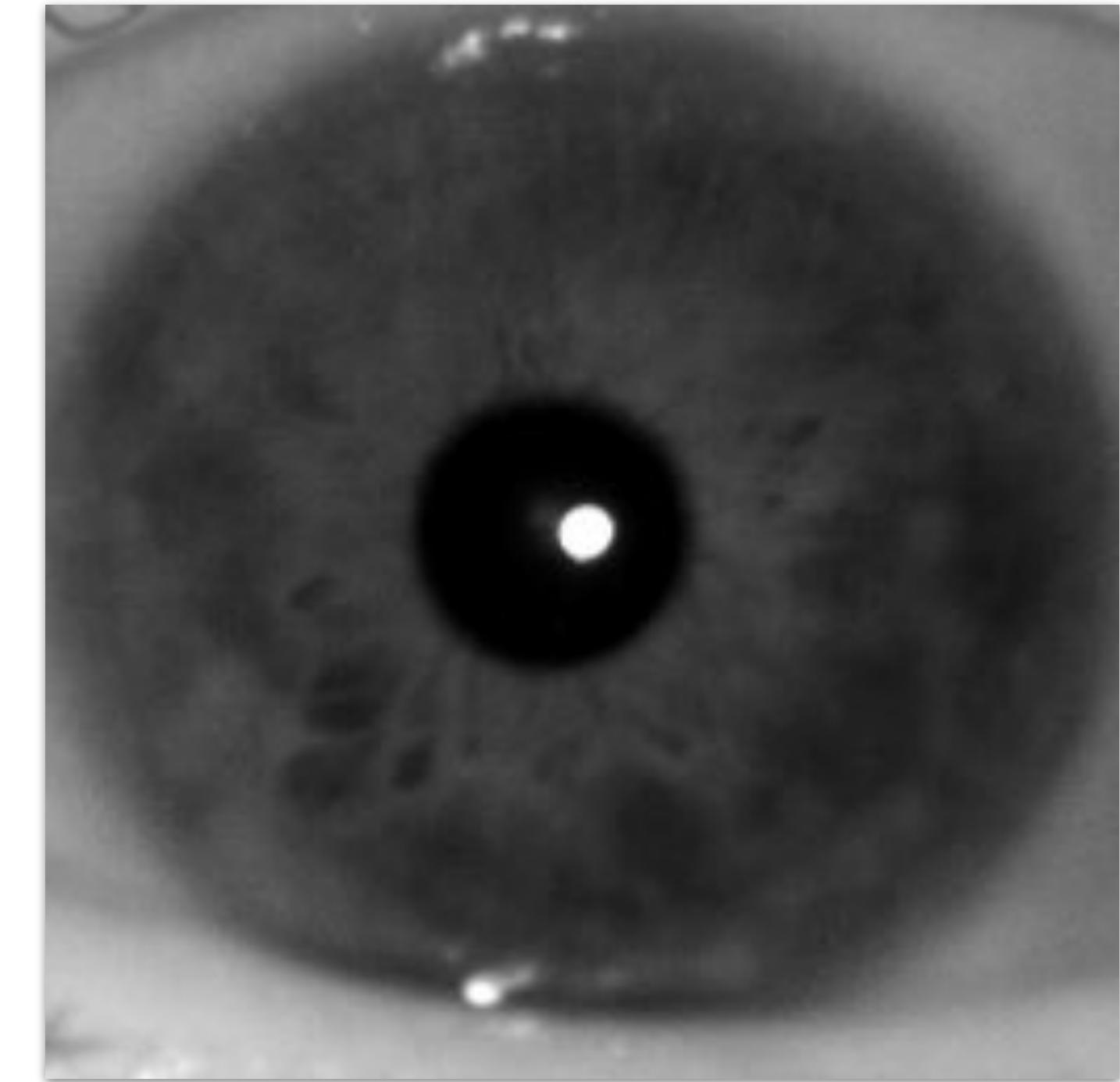
Iris Recognition



Domain-Specific BSIF Codes



Original BSIF:
Natural images to learn filters.

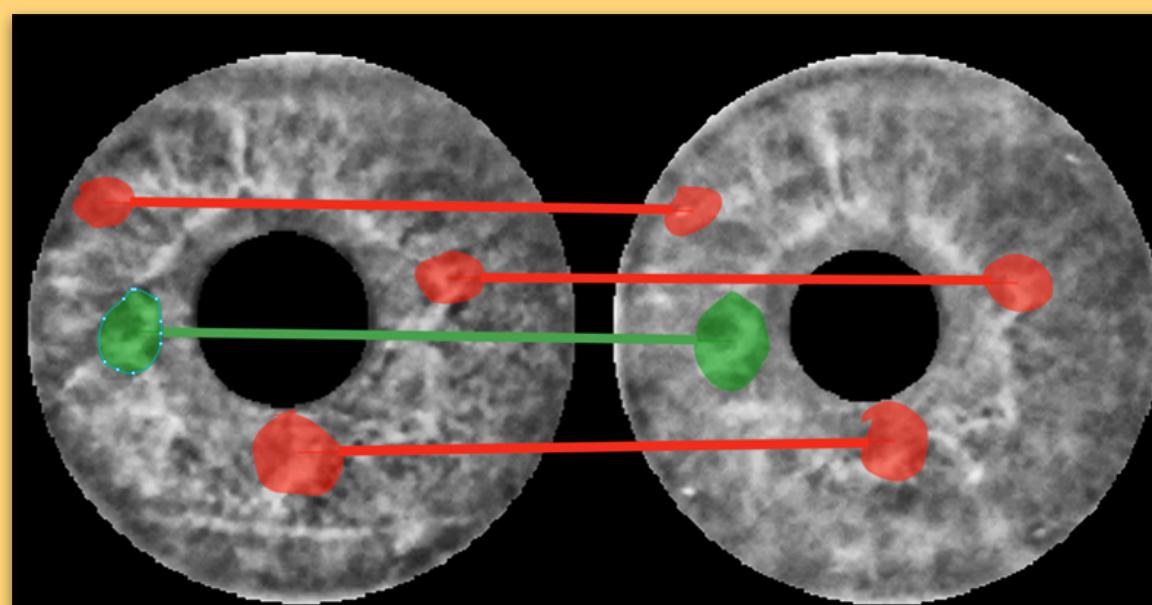
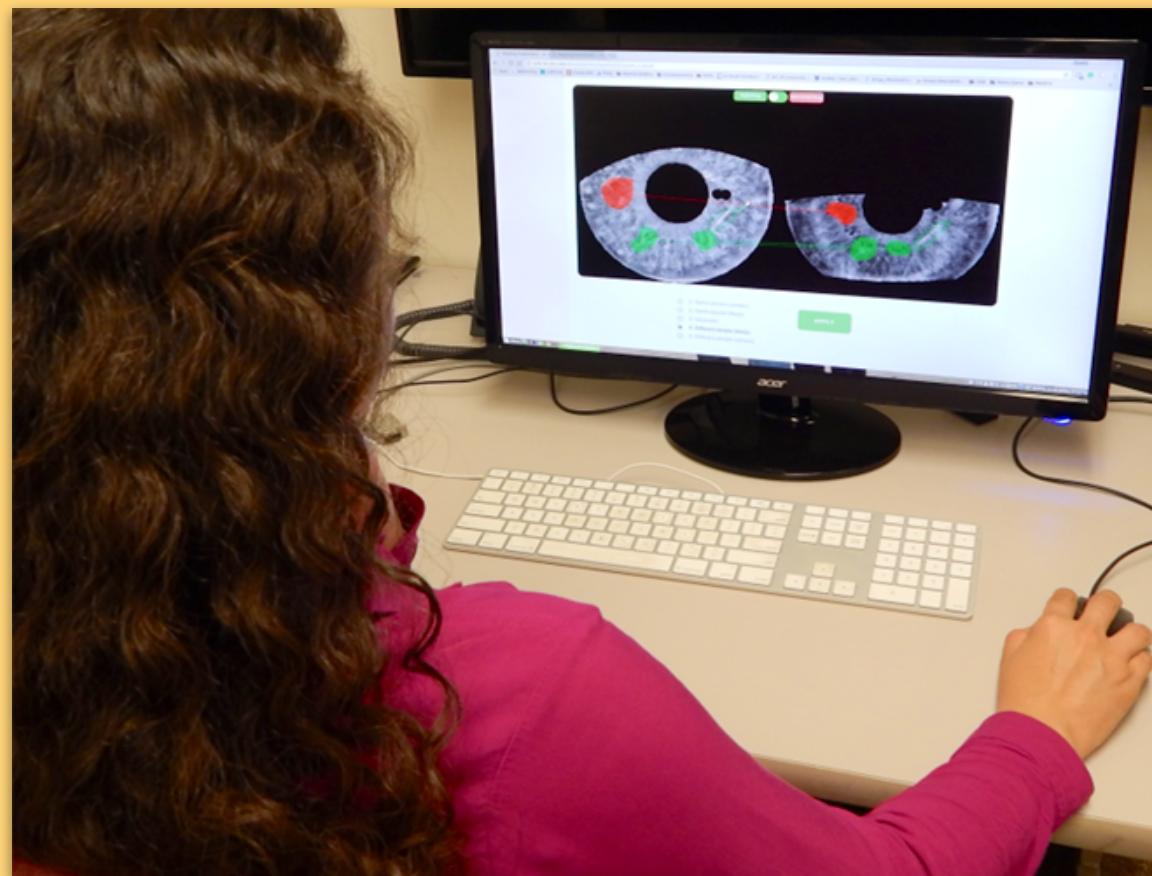


**What is the gain of learning
from irises?**

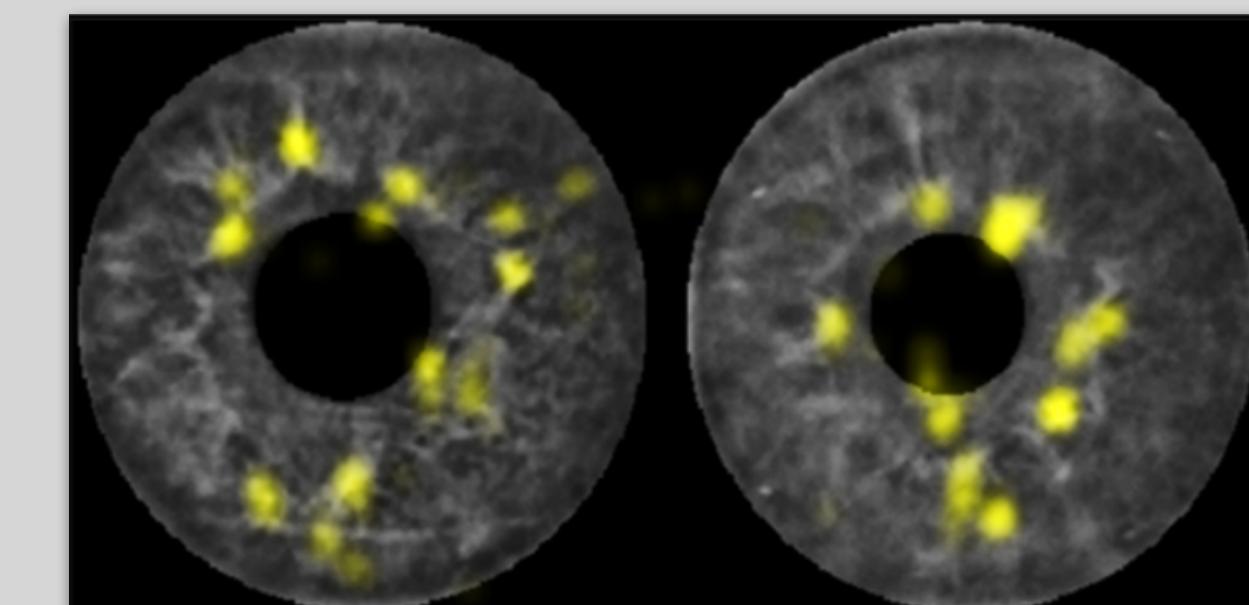
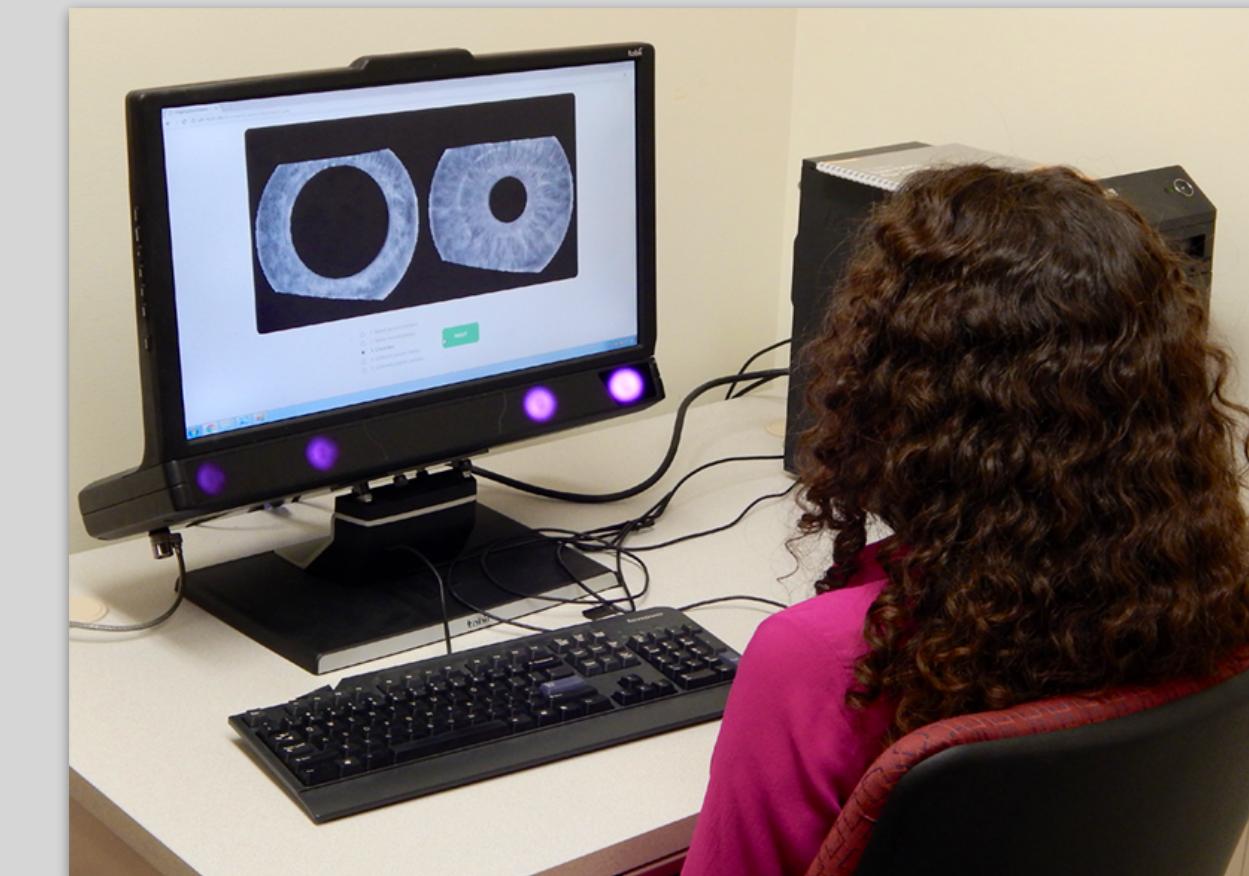
Domain-Specific BSIF Codes

**How to Select
Iris Patches?**

Manual Annotation

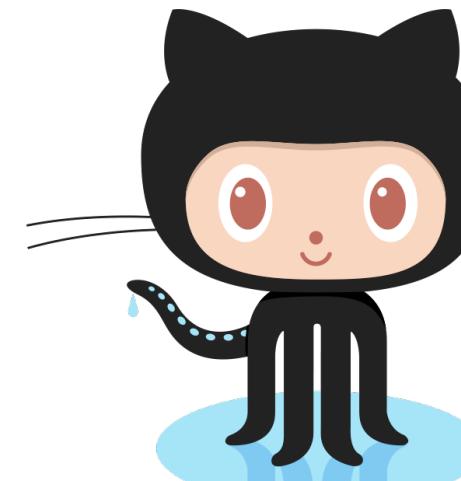


Eye-Tracker Data

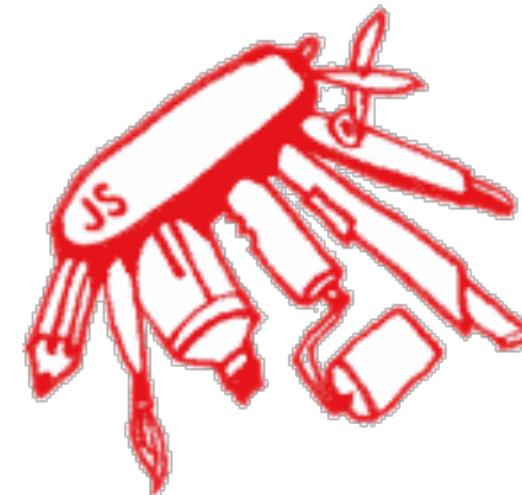


Domain-Specific BSIF Codes

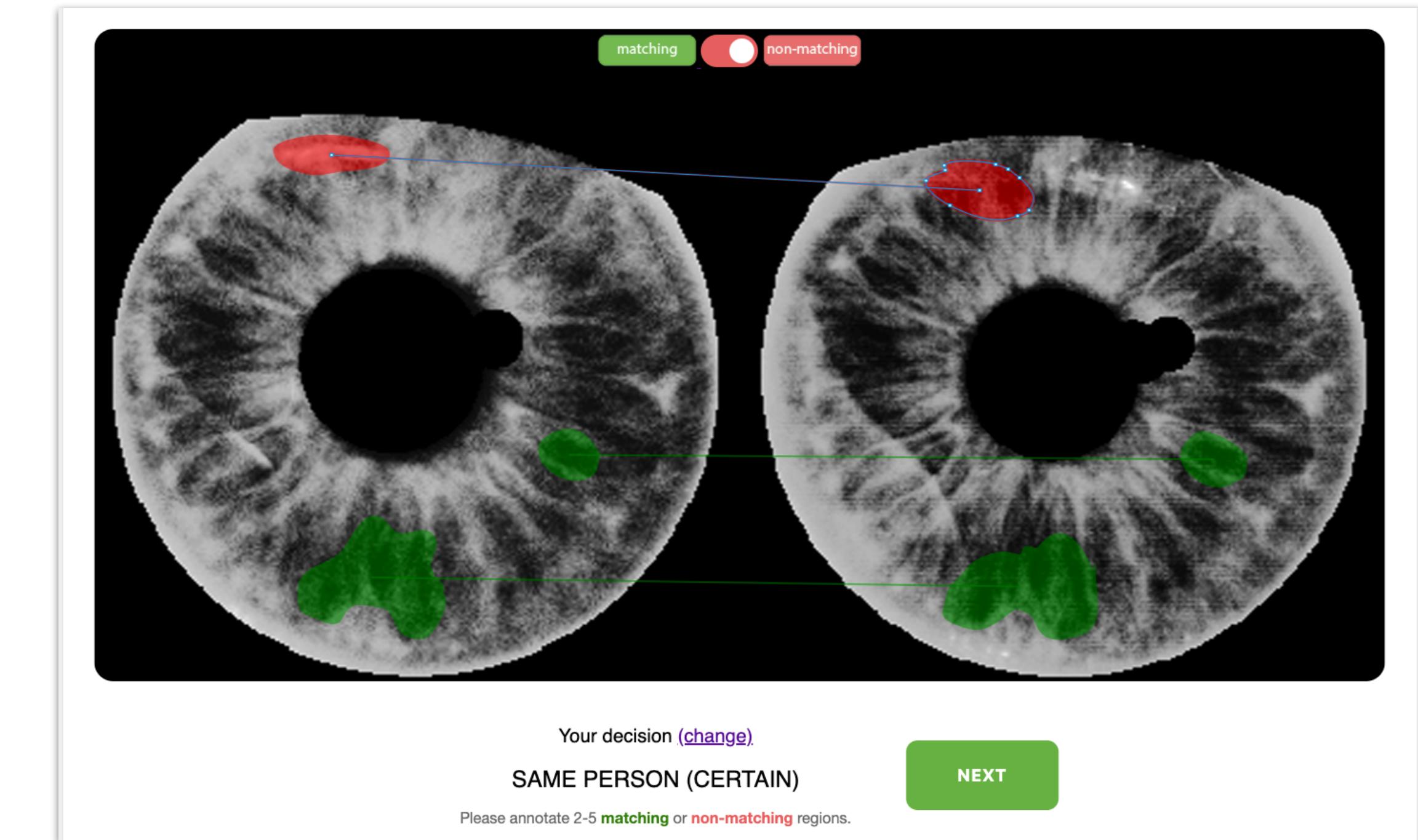
Annotation Tool



Available at
[https://github.com/
danielmoreira/iris-examination](https://github.com/danielmoreira/iris-examination)

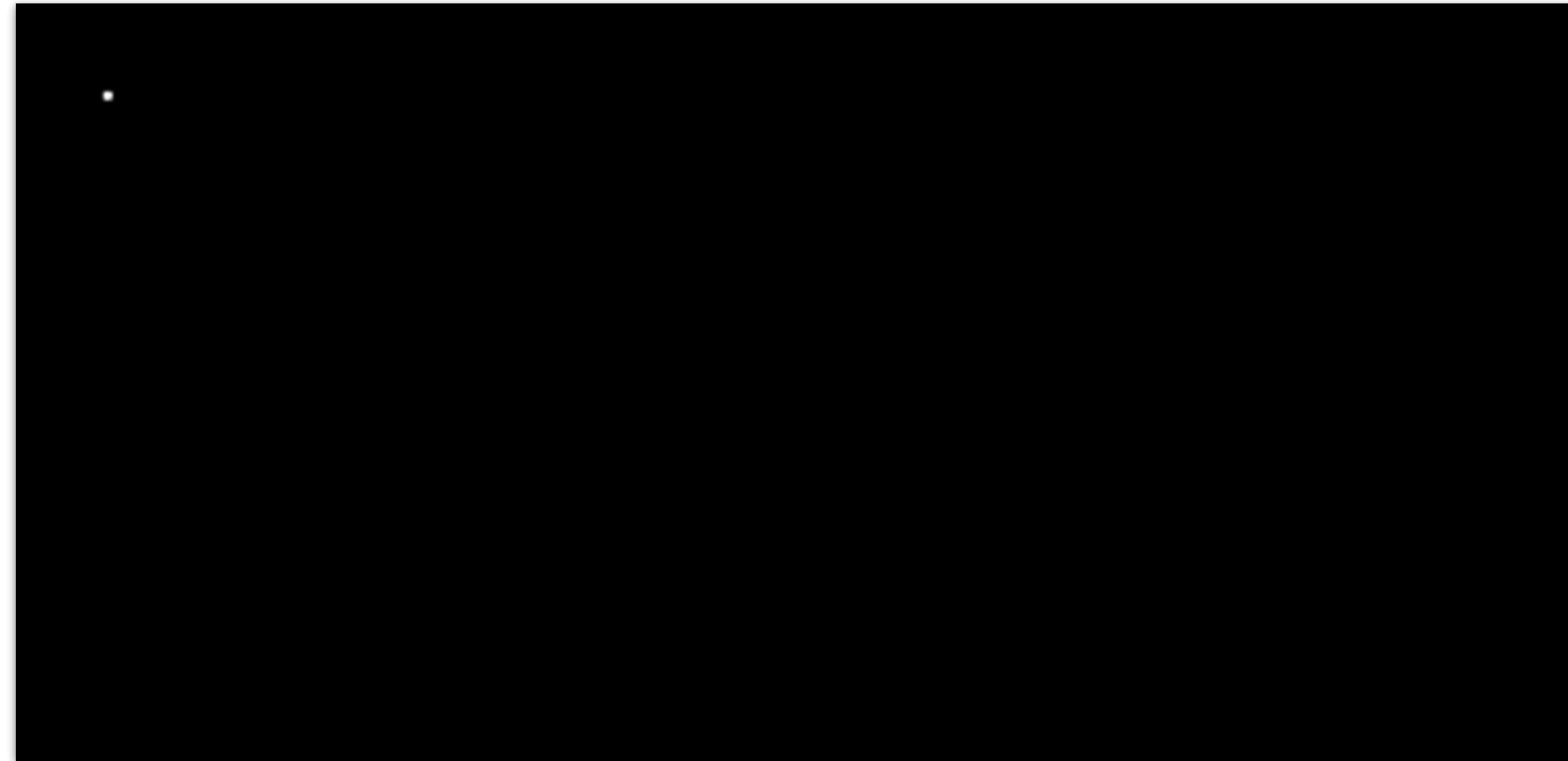
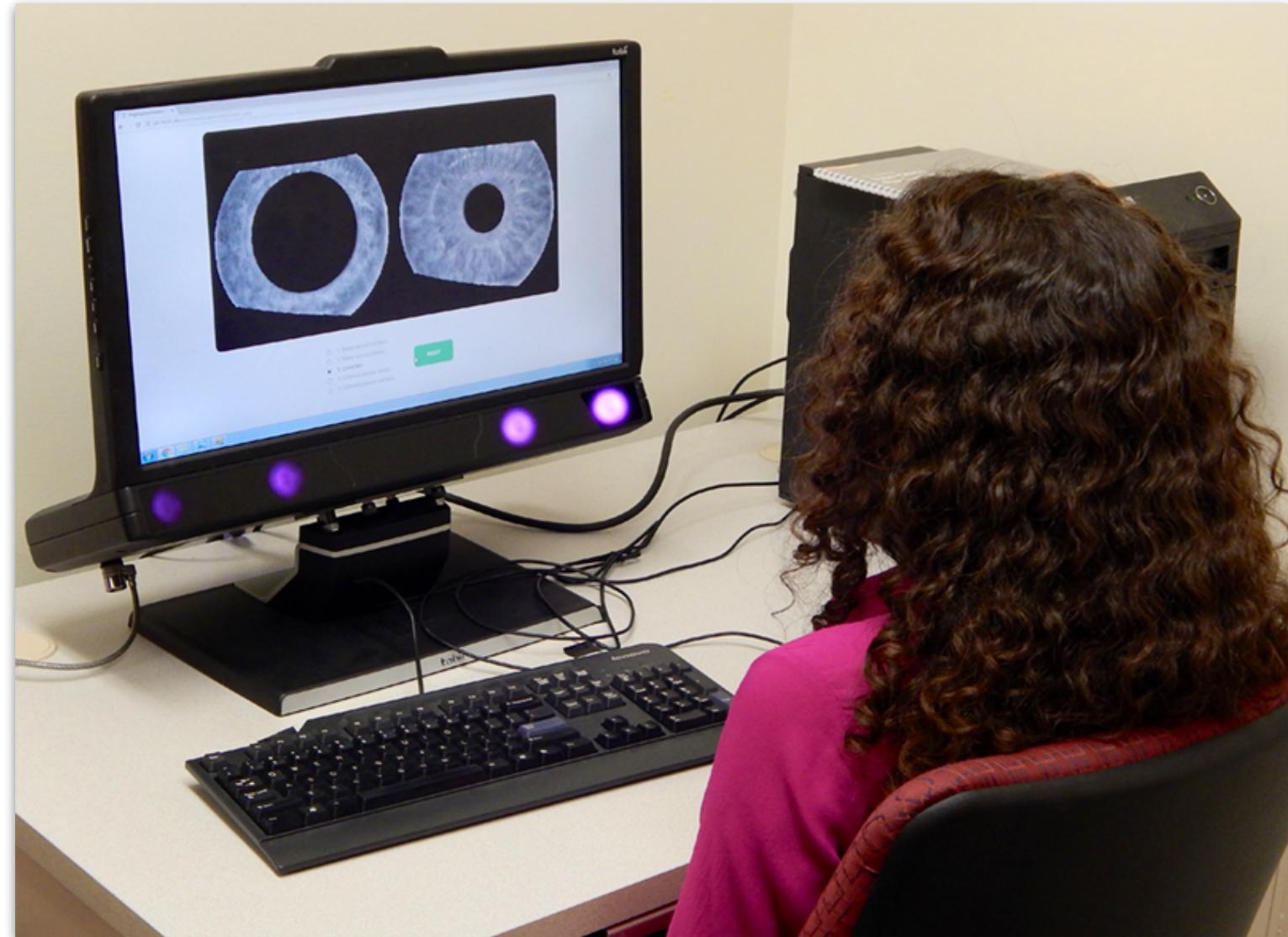


Paper.js
Web-browser drawing library.



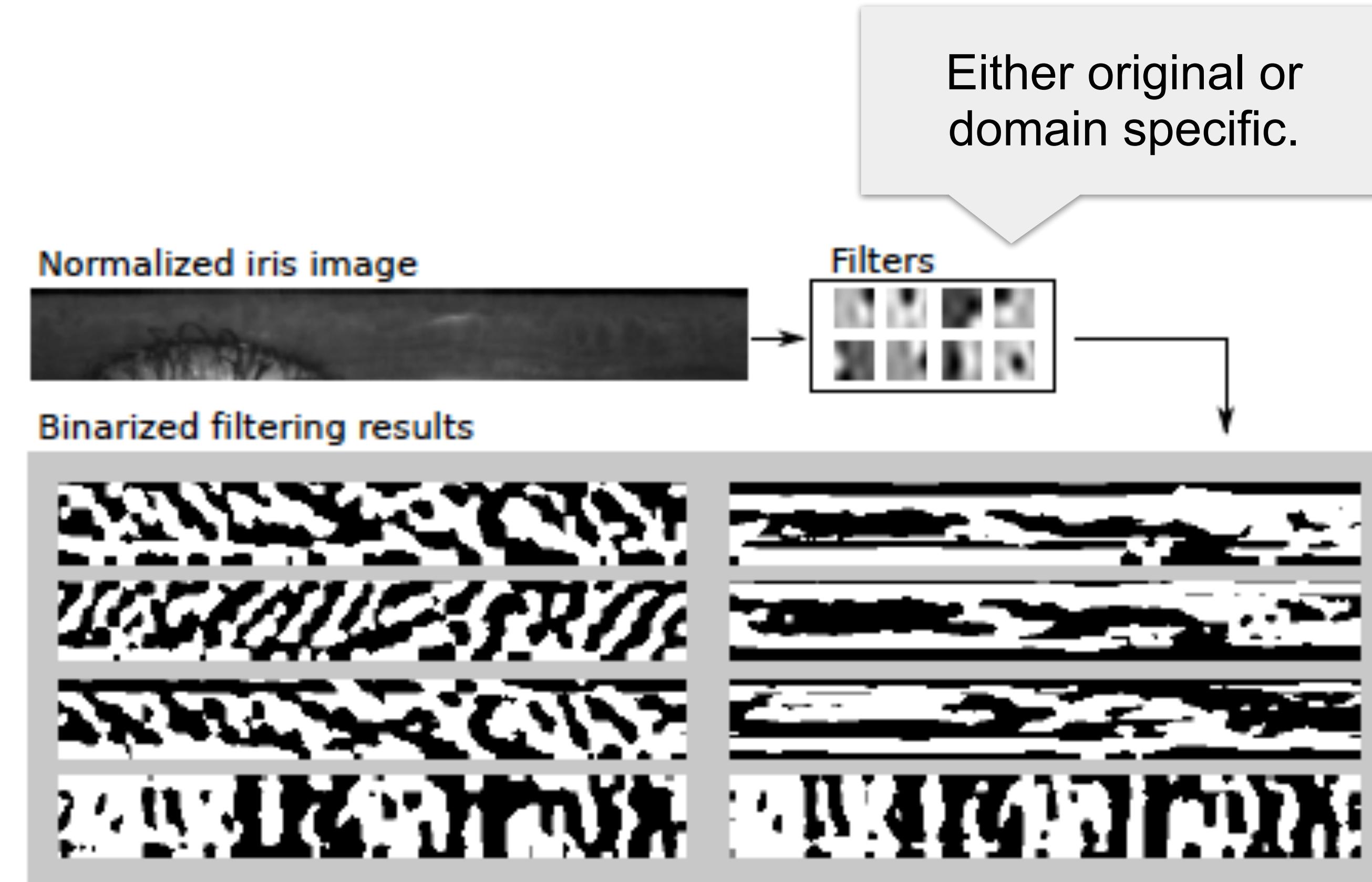
Domain-Specific BSIF Codes

Eye Tracker



Domain-Specific BSIF Codes

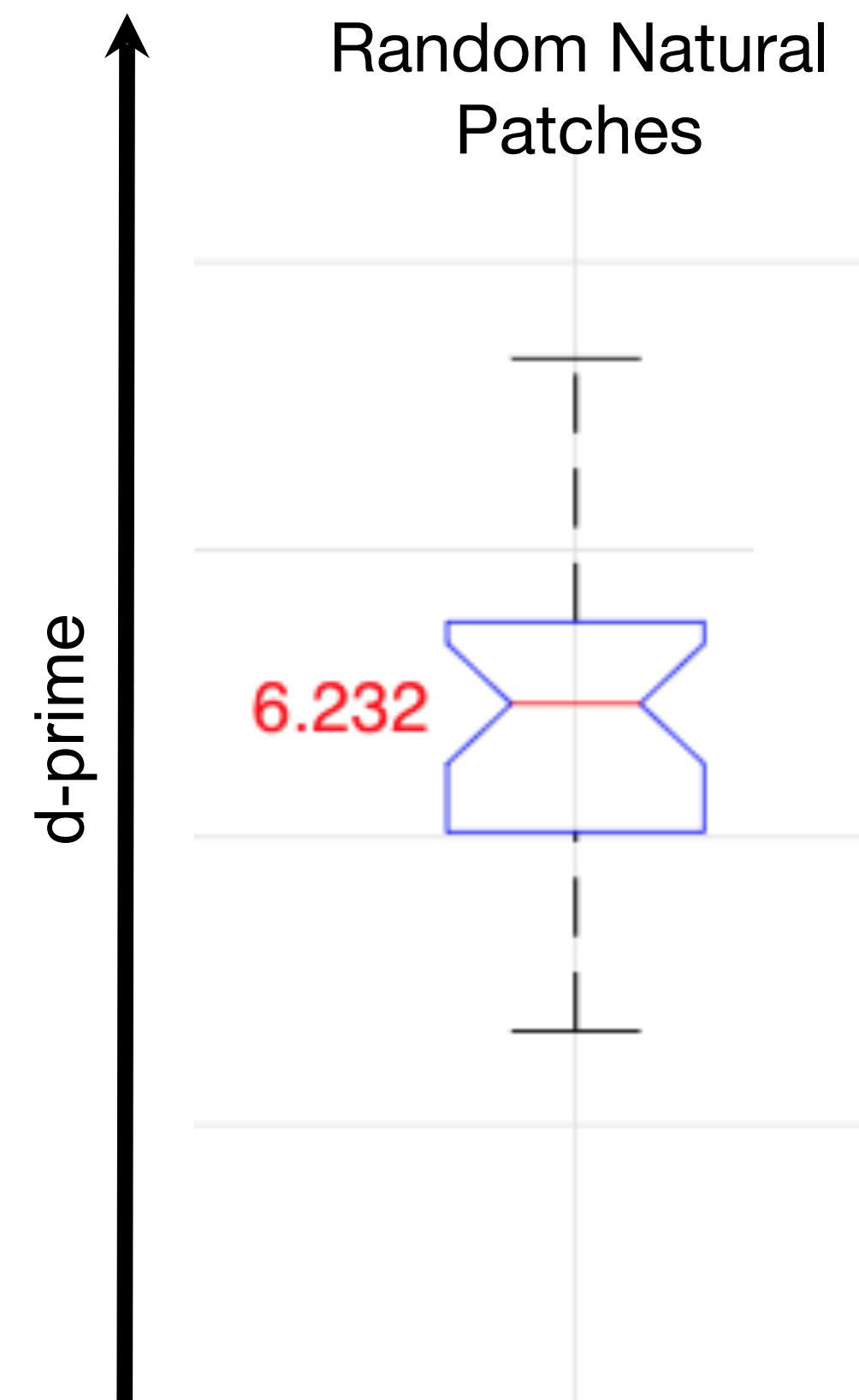
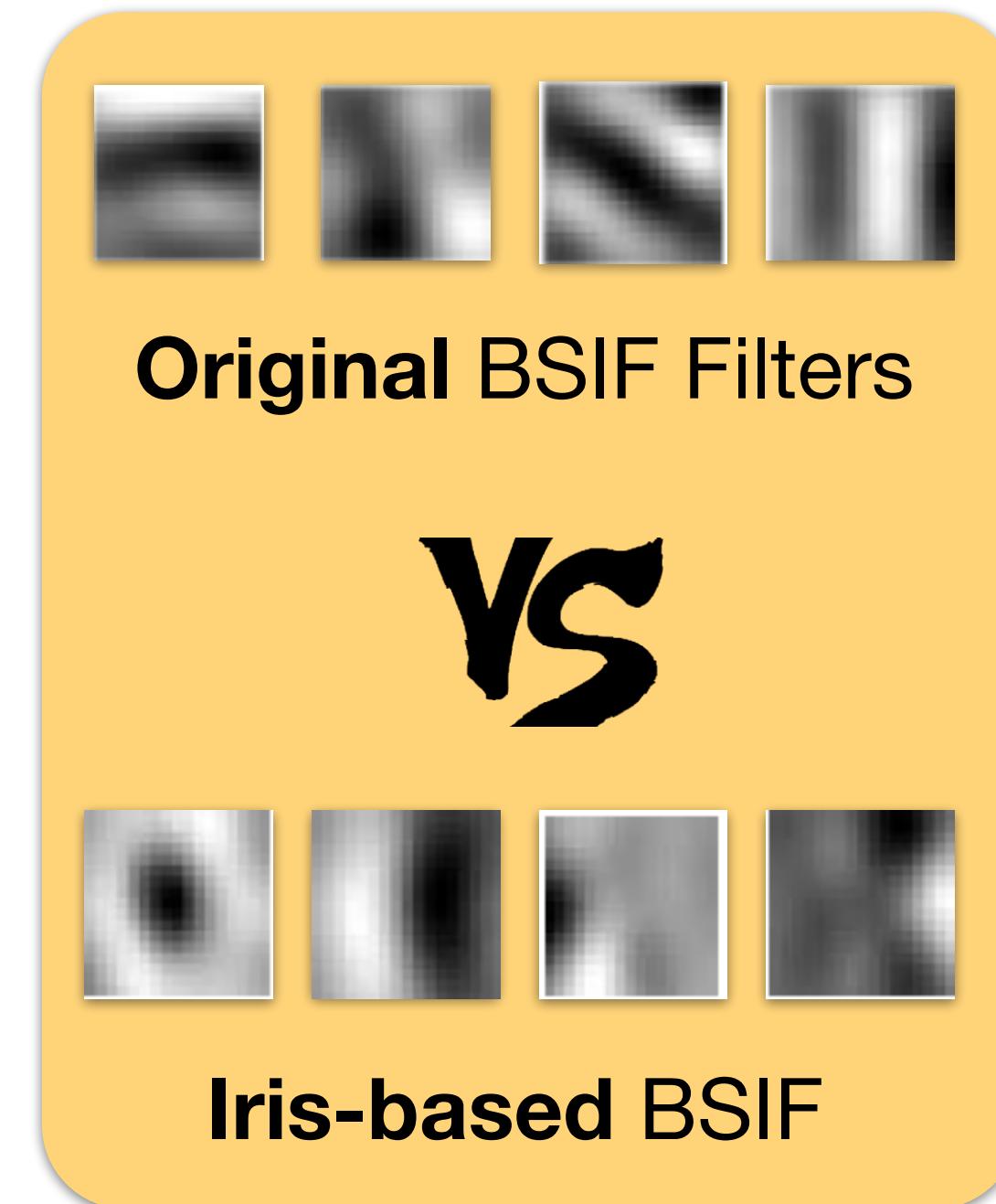
Application



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

Domain-Specific BSIF Codes

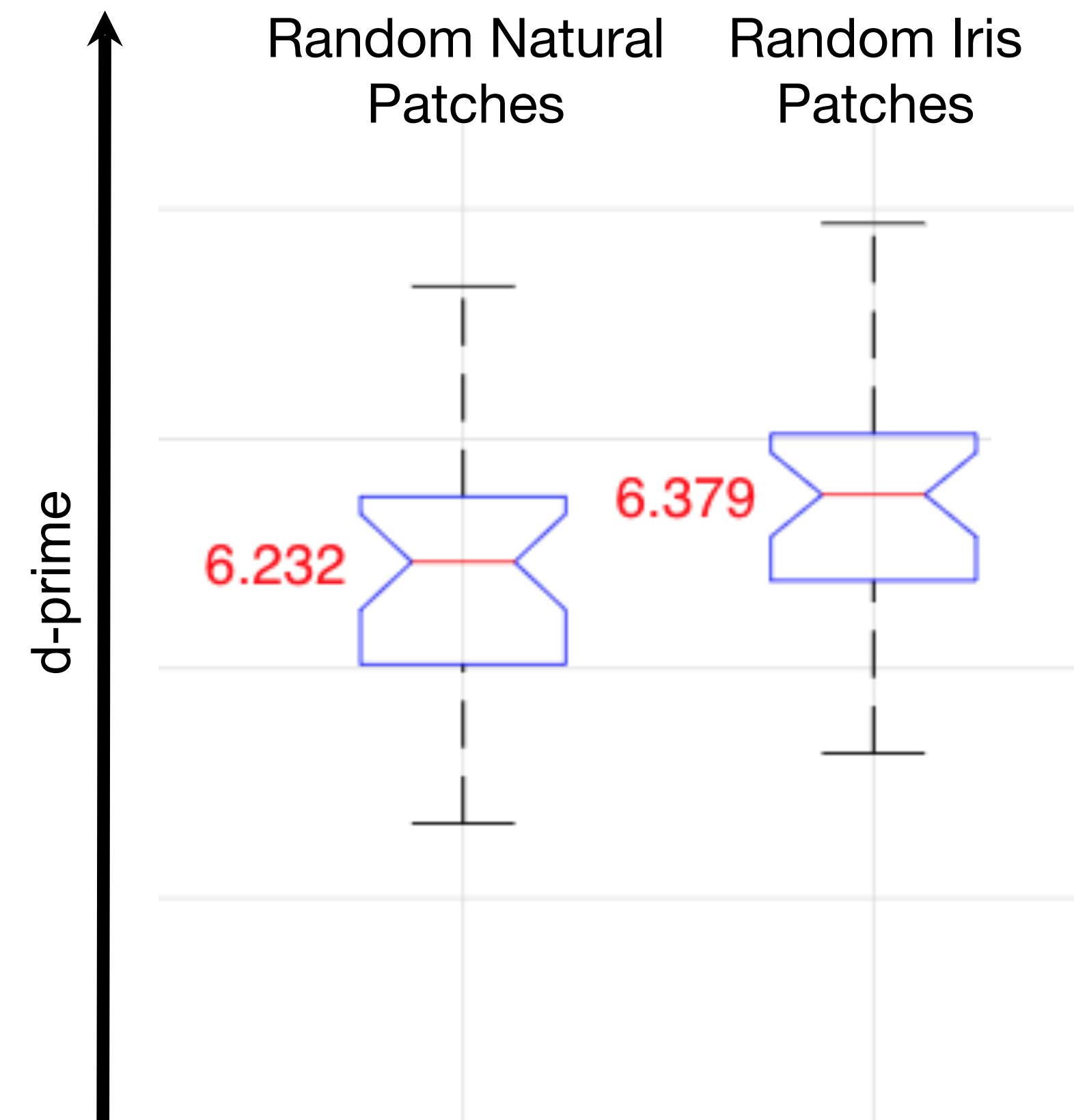
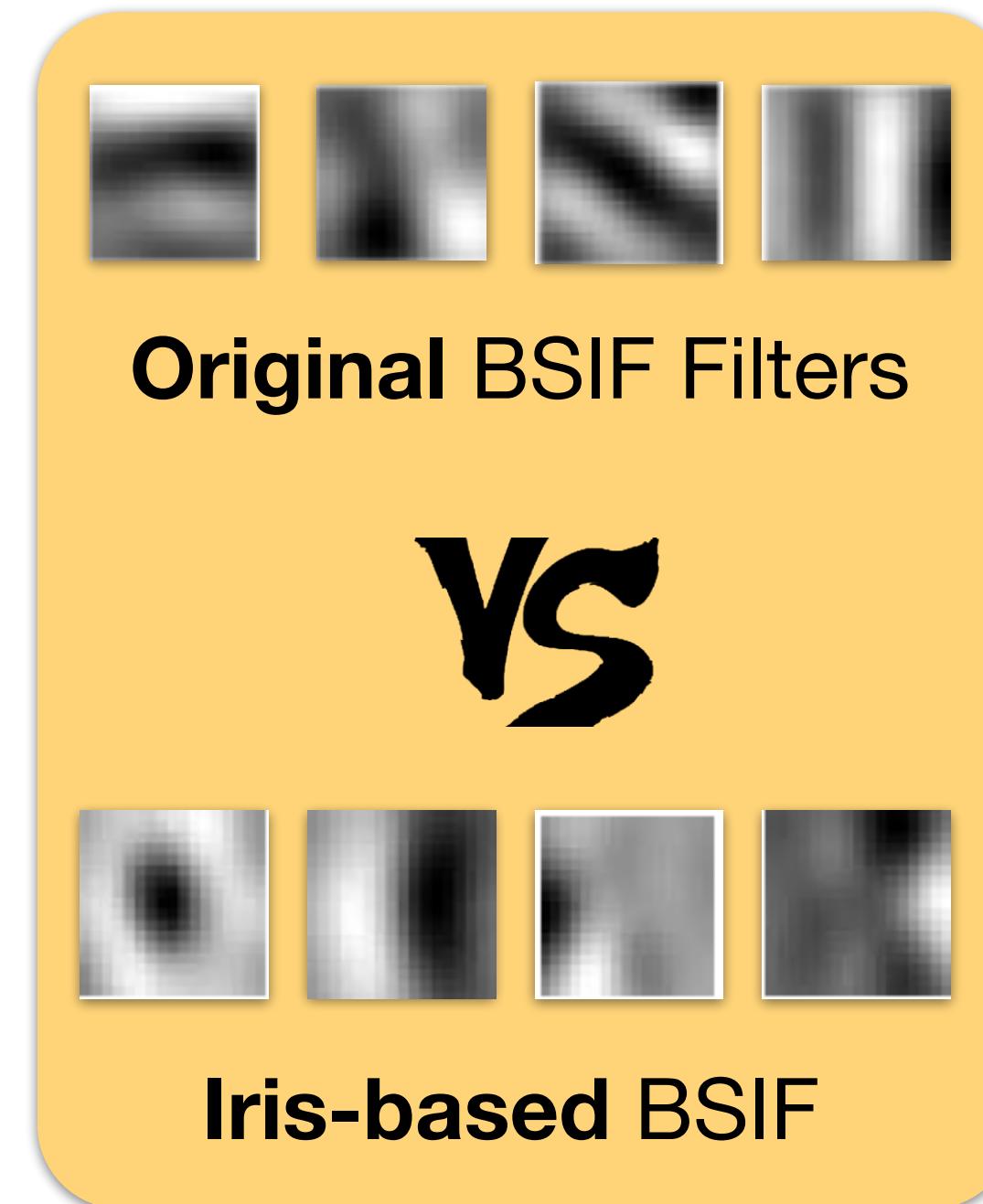
Results



Czajka et al.
*Domain-Specific Human-Inspired
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WACV 2019

Domain-Specific BSIF Codes

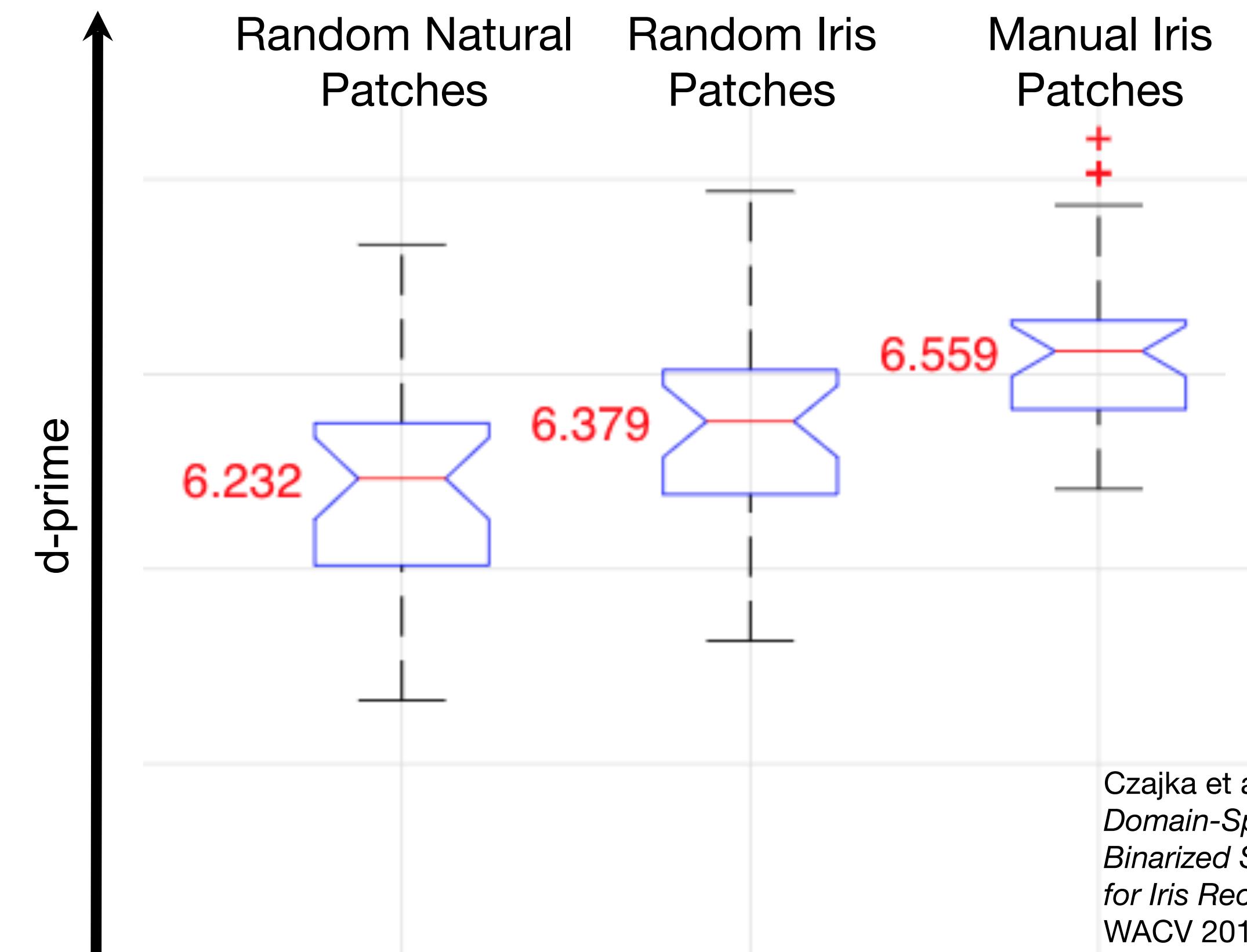
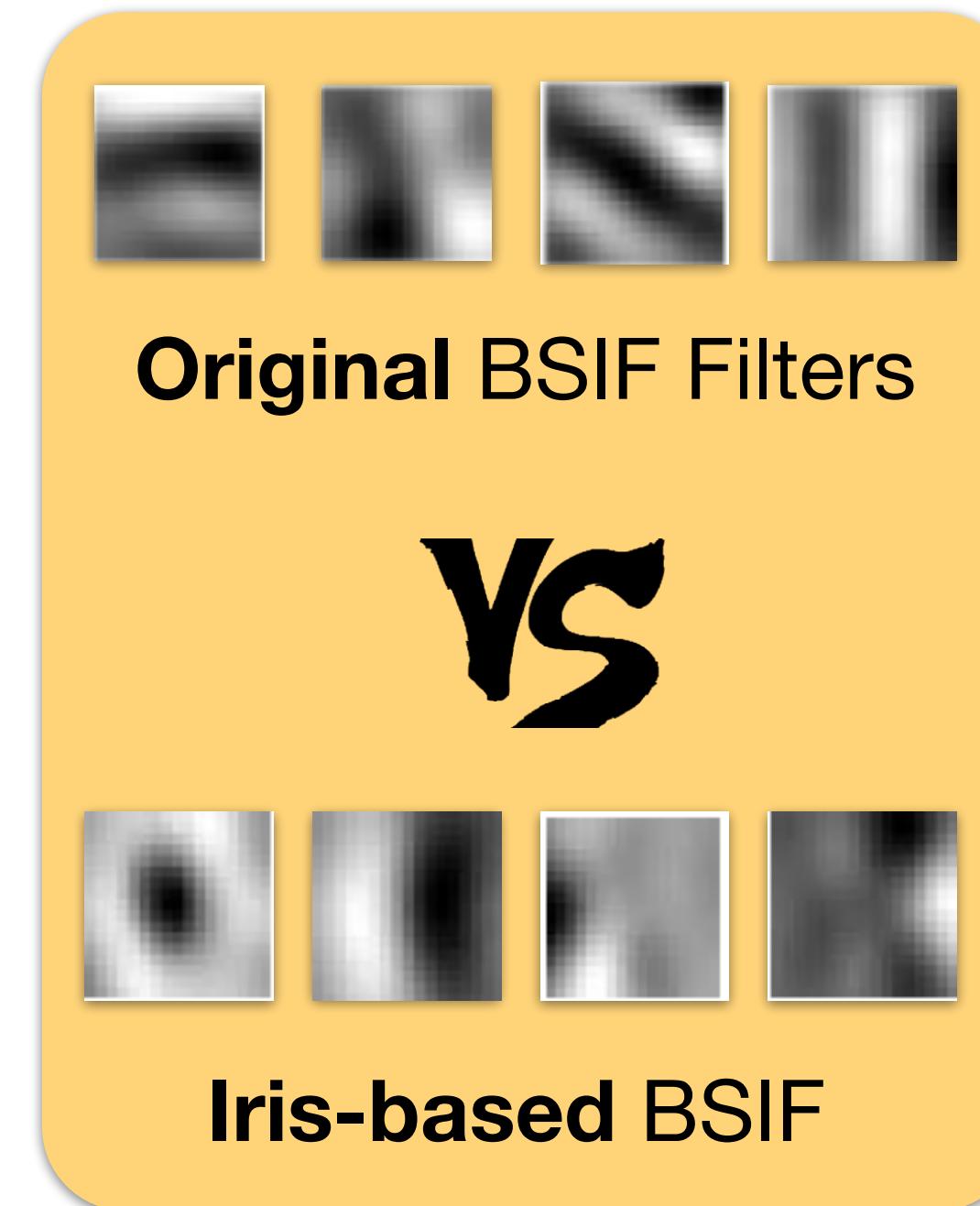
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Domain-Specific BSIF Codes

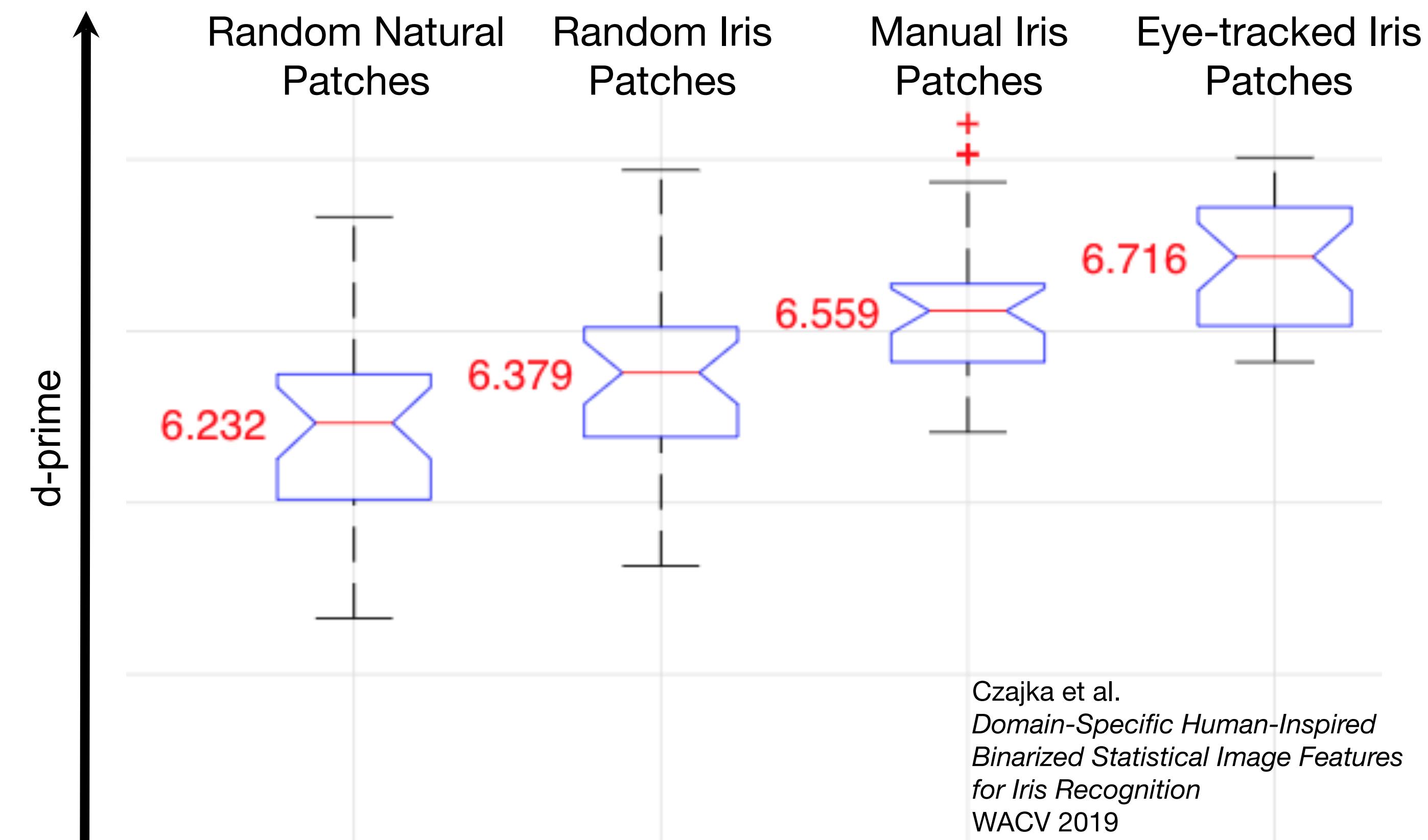
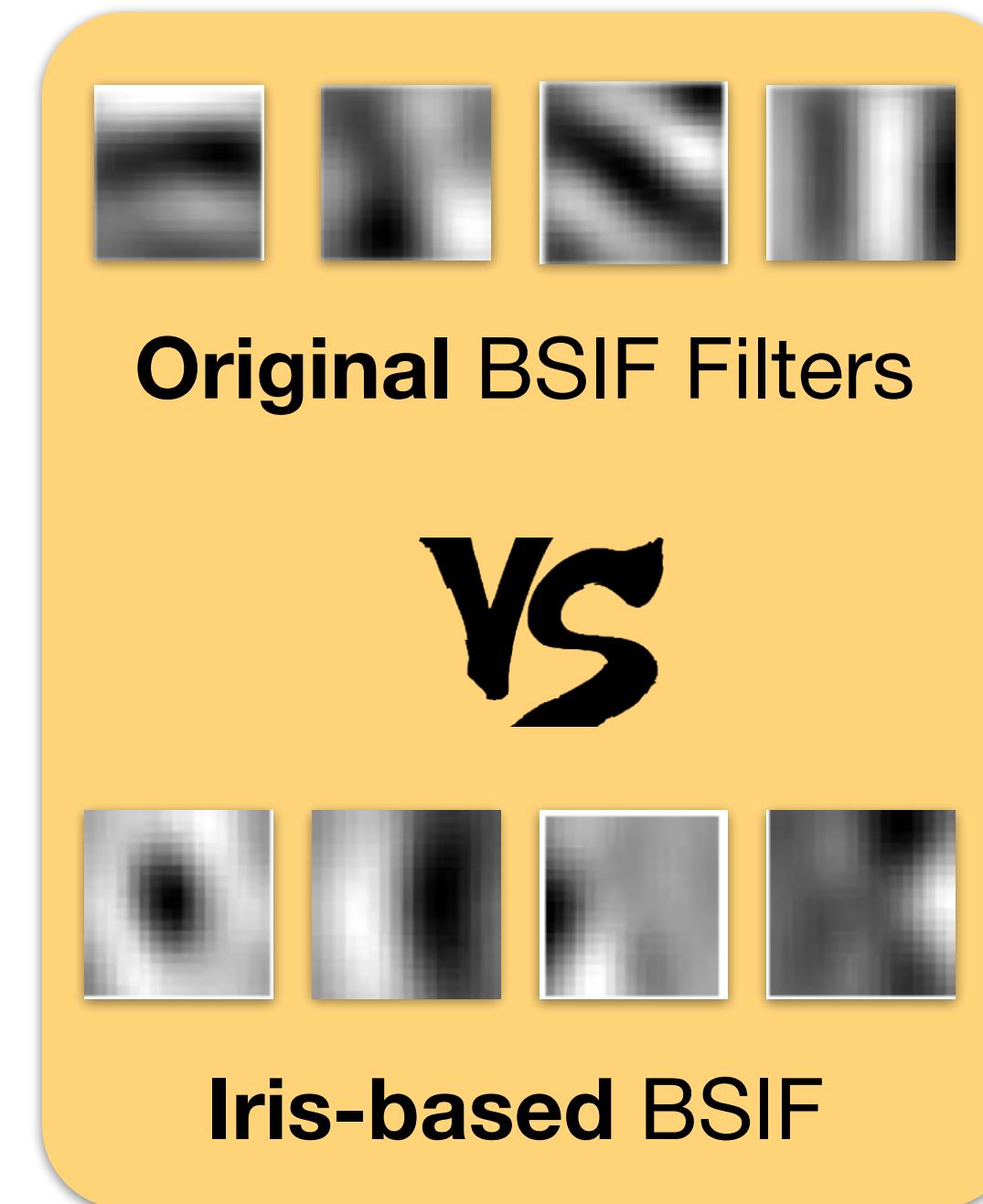
Results



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Domain-Specific BSIF Codes

Results



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S'up Next?

**Fingerprint Recognition
Coding Class**

