

Iris Recognition II

COMP 388-002/488-002 Biometrics

Daniel Moreira
Fall 2023



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Today you will...

Get to know
Iris acquisition and enhancement.



Today's attendance

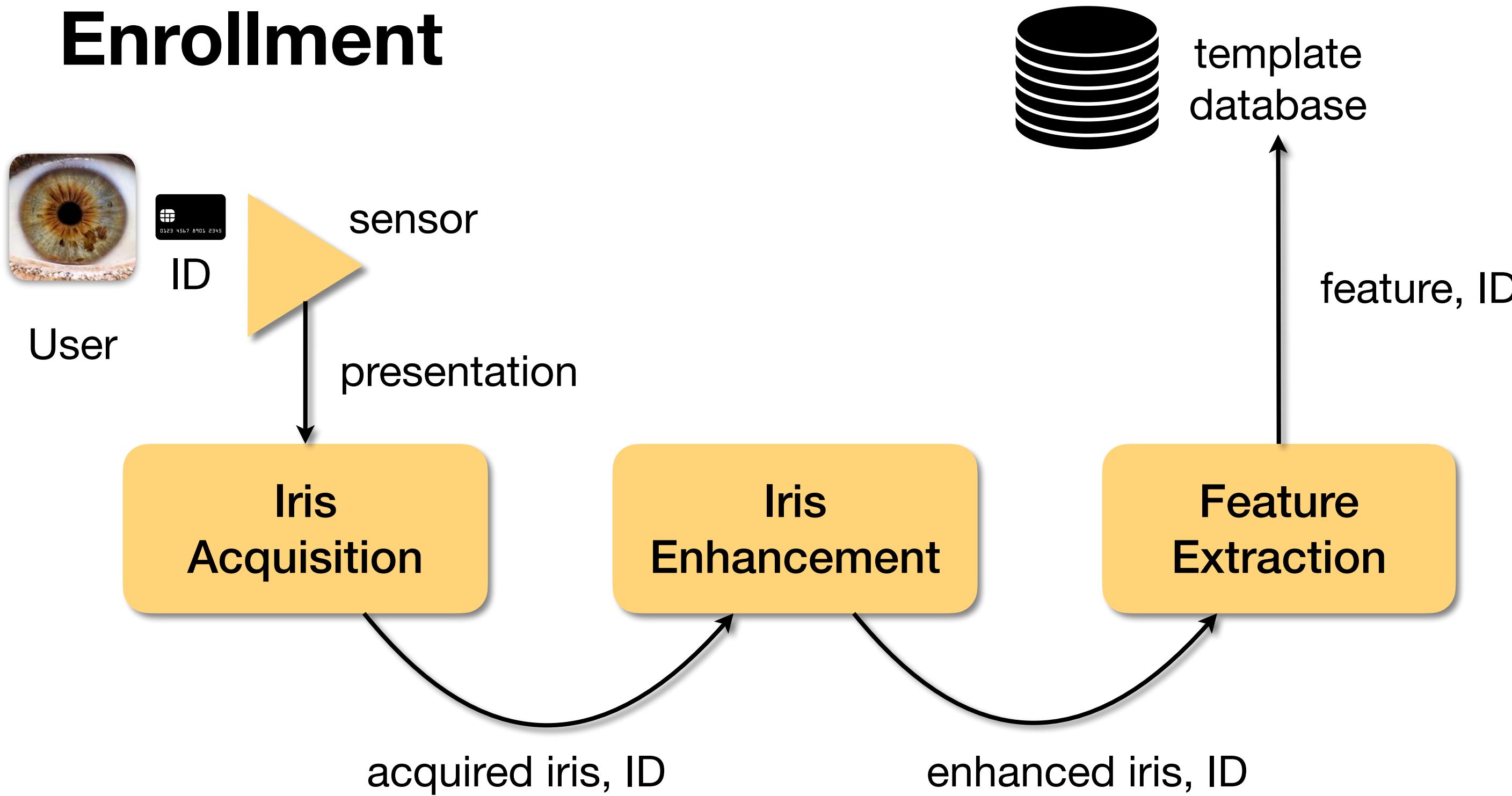
Please fill out the form

<https://forms.gle/d22Tcr5R7cyVwpa99>



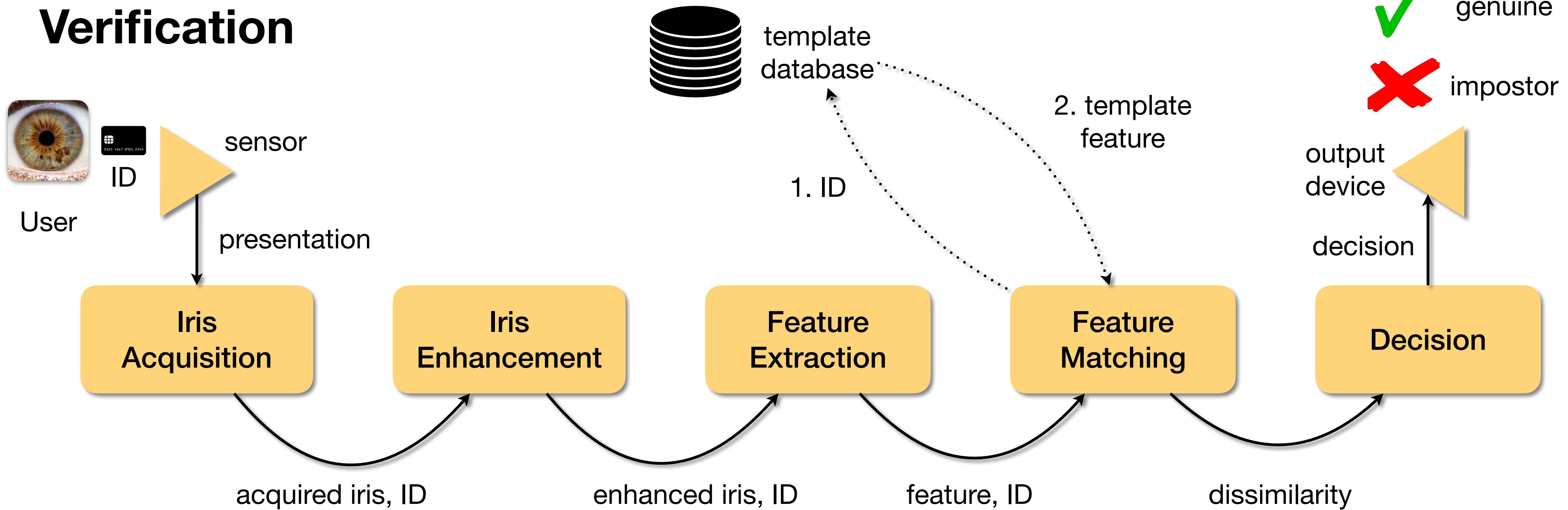
Iris Recognition

Enrollment



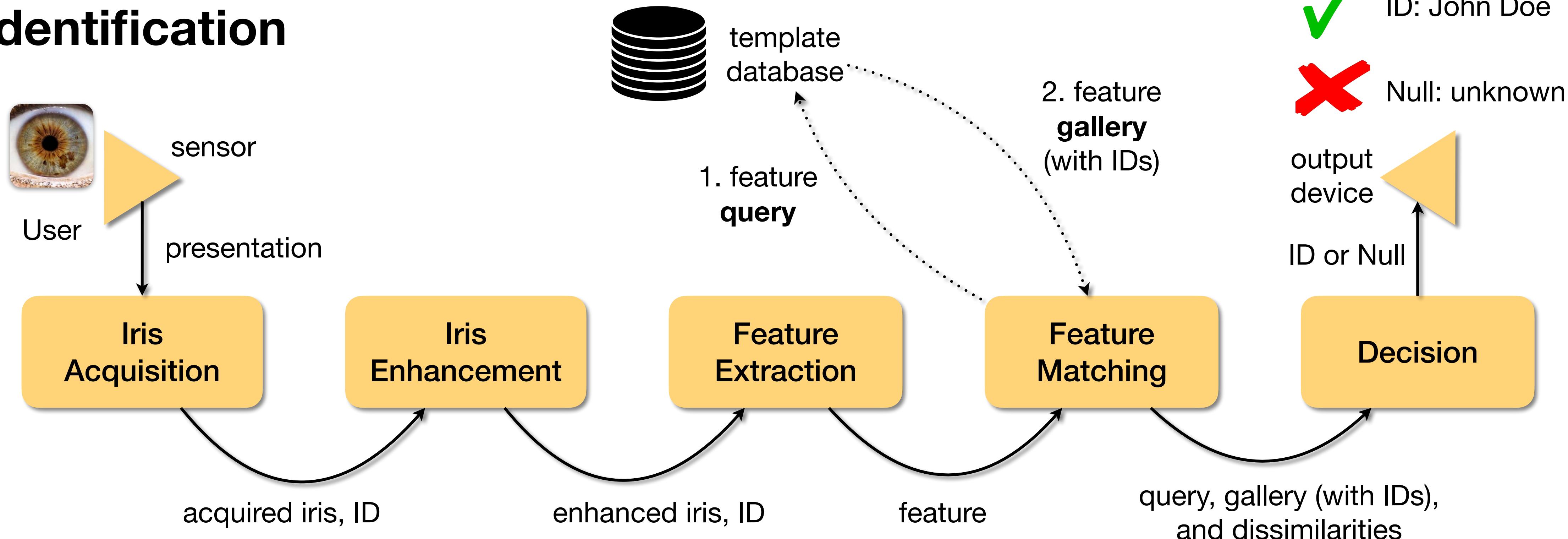
Iris Recognition

Verification

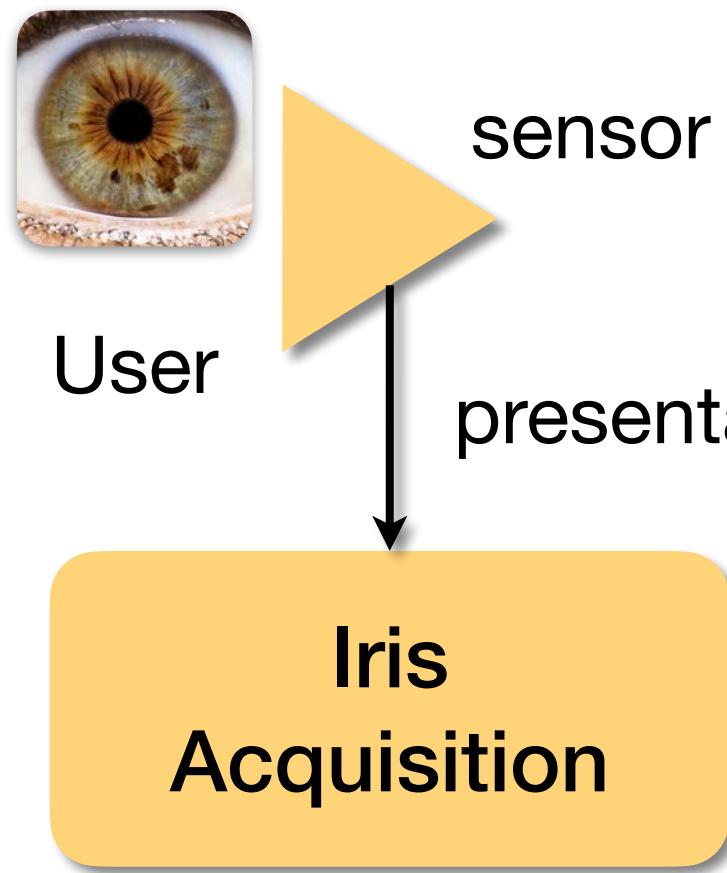


Iris Recognition

Identification



Iris Recognition



Acquisition

On-line



Schiphol Airport

Off-line



It depends on
the resolution
and angle of
capture.

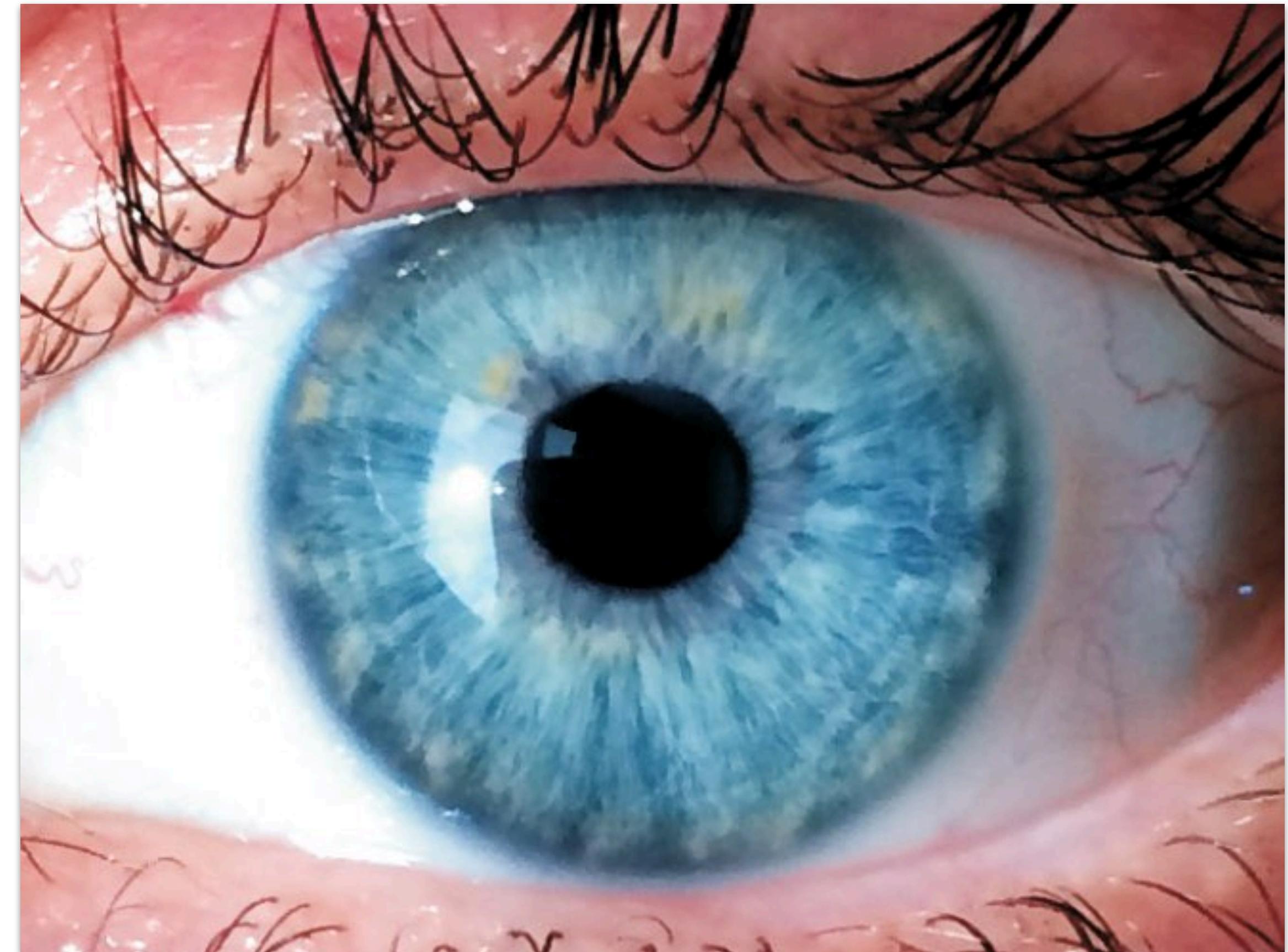
Acquisition

Dr. Adam Czajka

Iris Capture

Visible light.

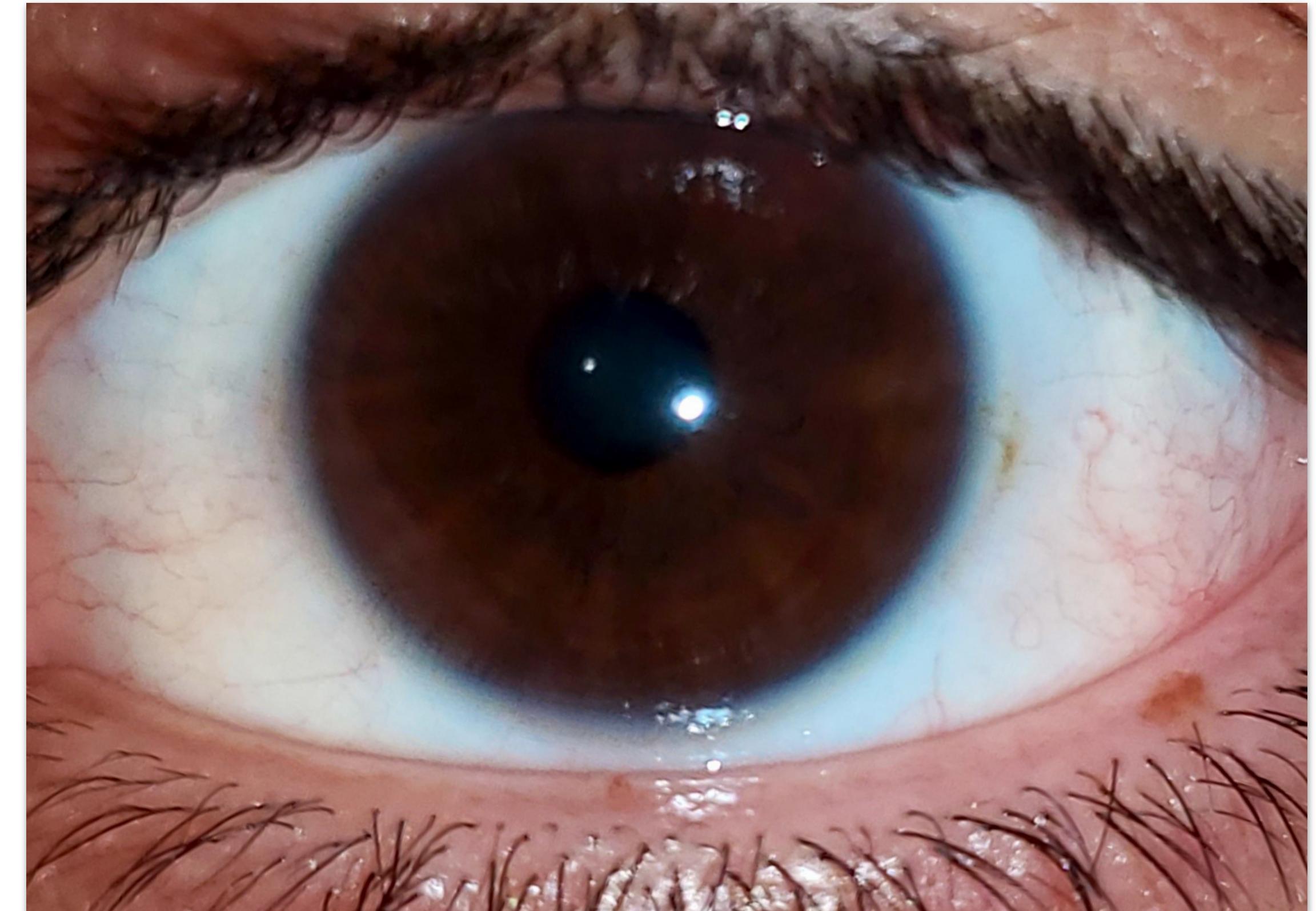
Can you see the iris texture
(crypts, furrows, and collarette)?



Acquisition

Iris Capture
Visible light.

Can you see the iris texture
(crypts, furrows, and collarette)?

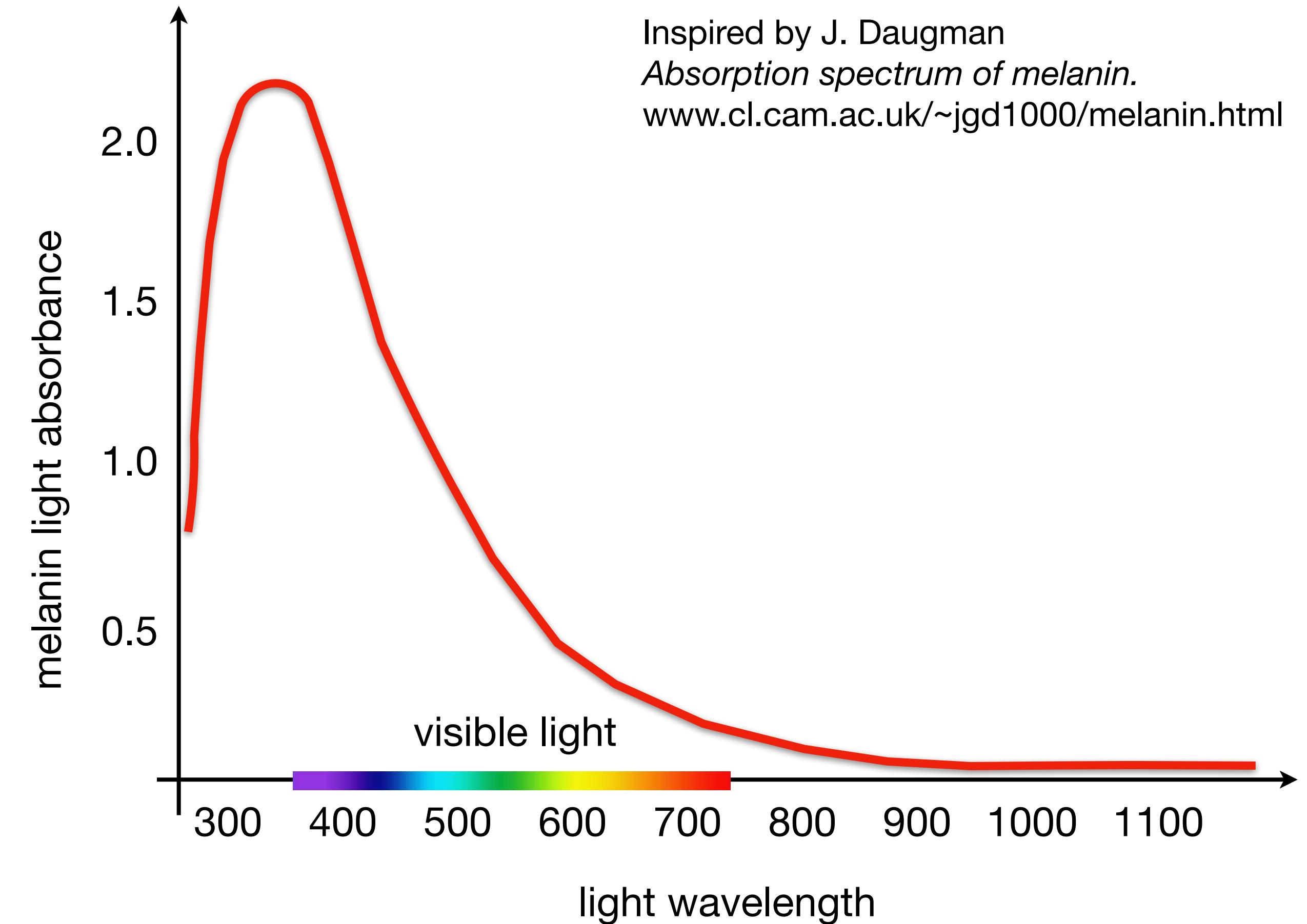


Acquisition

Iris Capture

Visible light.

Melanin poses a challenge to visible-light iris recognition.

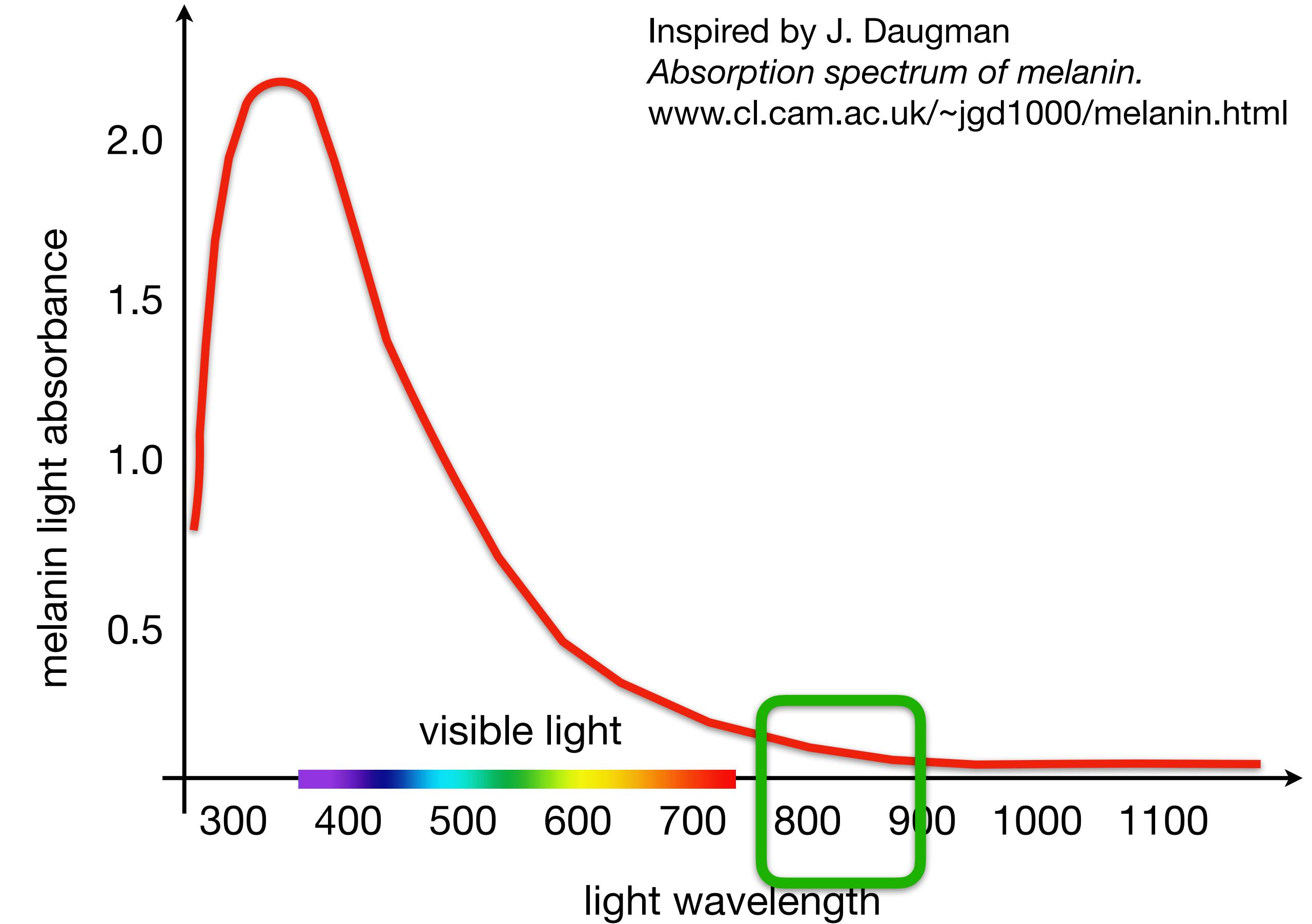


Acquisition

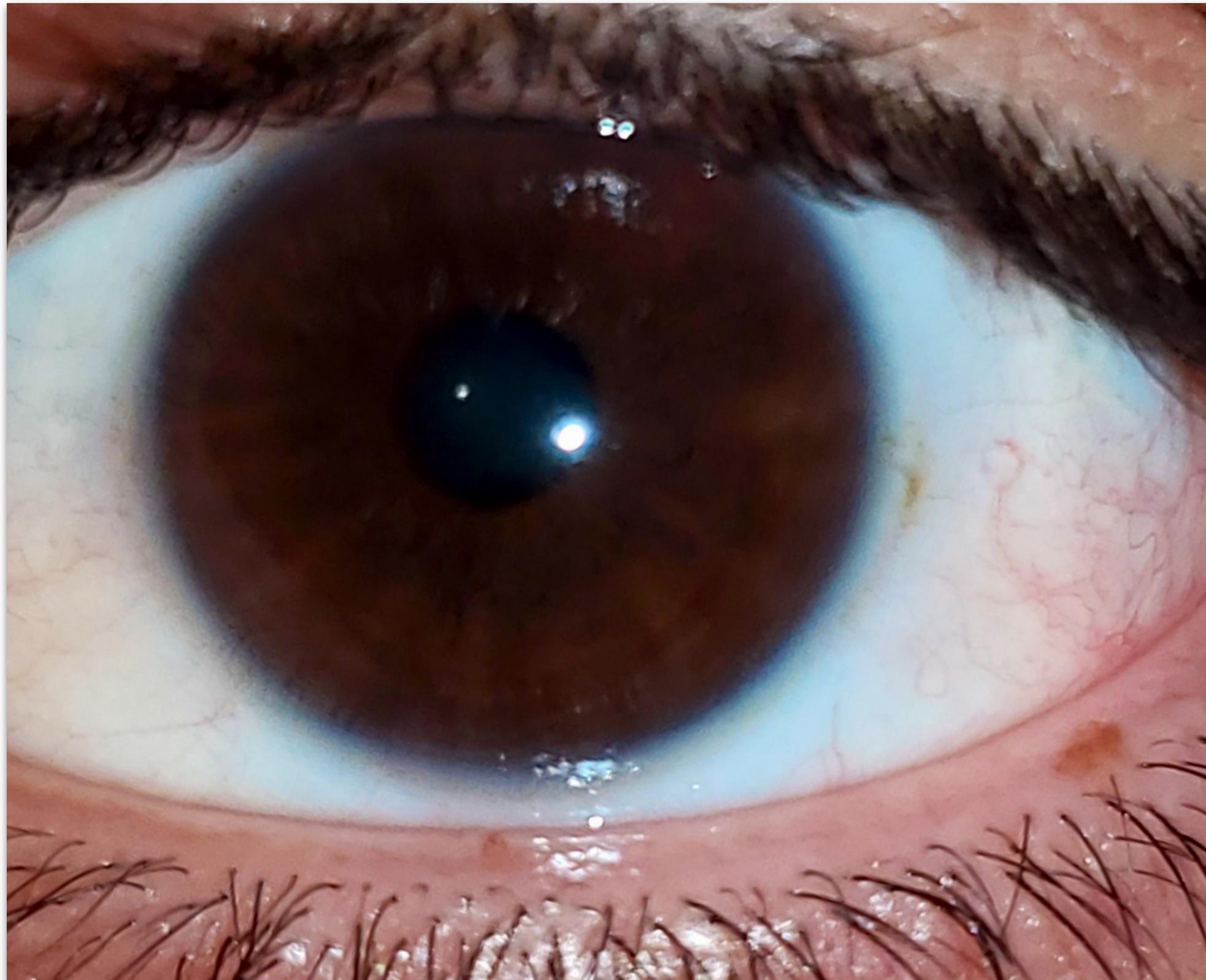
Iris Capture

Solution: near-infrared (NIR) light.

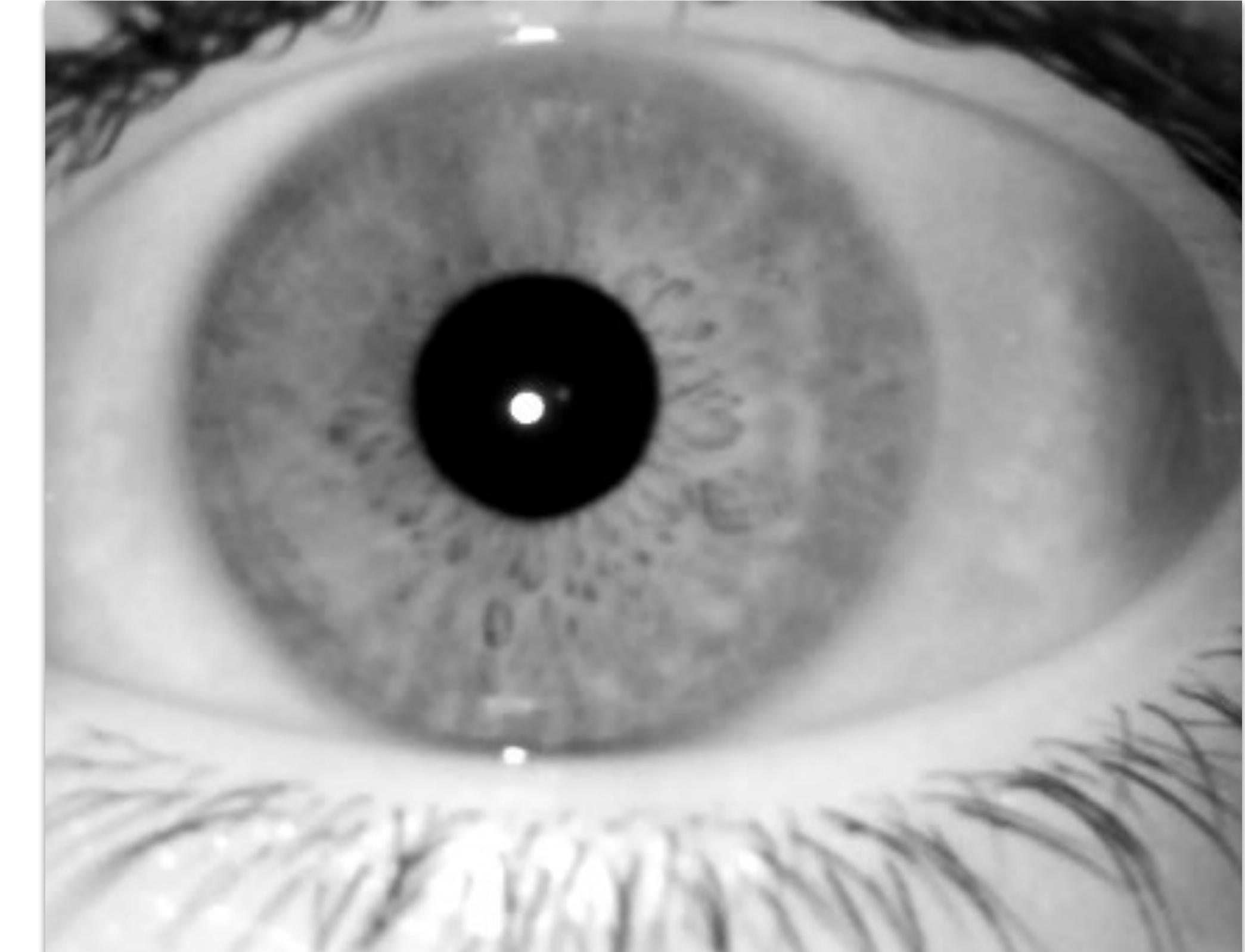
□ Typical wavelengths used by sensors: 750-890 nm.



Acquisition



visible light



NIR

Acquisition

Standards

Eye Safety

IEC 60825-1:1993

(+ addendum A1:1997 and A2:2001),
ANSI RP-27.1-96



Maximum Permissible Exposure (*MPE*):

$$MPE < 0.1 \times MPE_{max}$$

→ eye damage due to
light exposure

Acquisition

Standards

Image Quality

ISO/IEC 19794-6 and ISO/IEC 29794-6

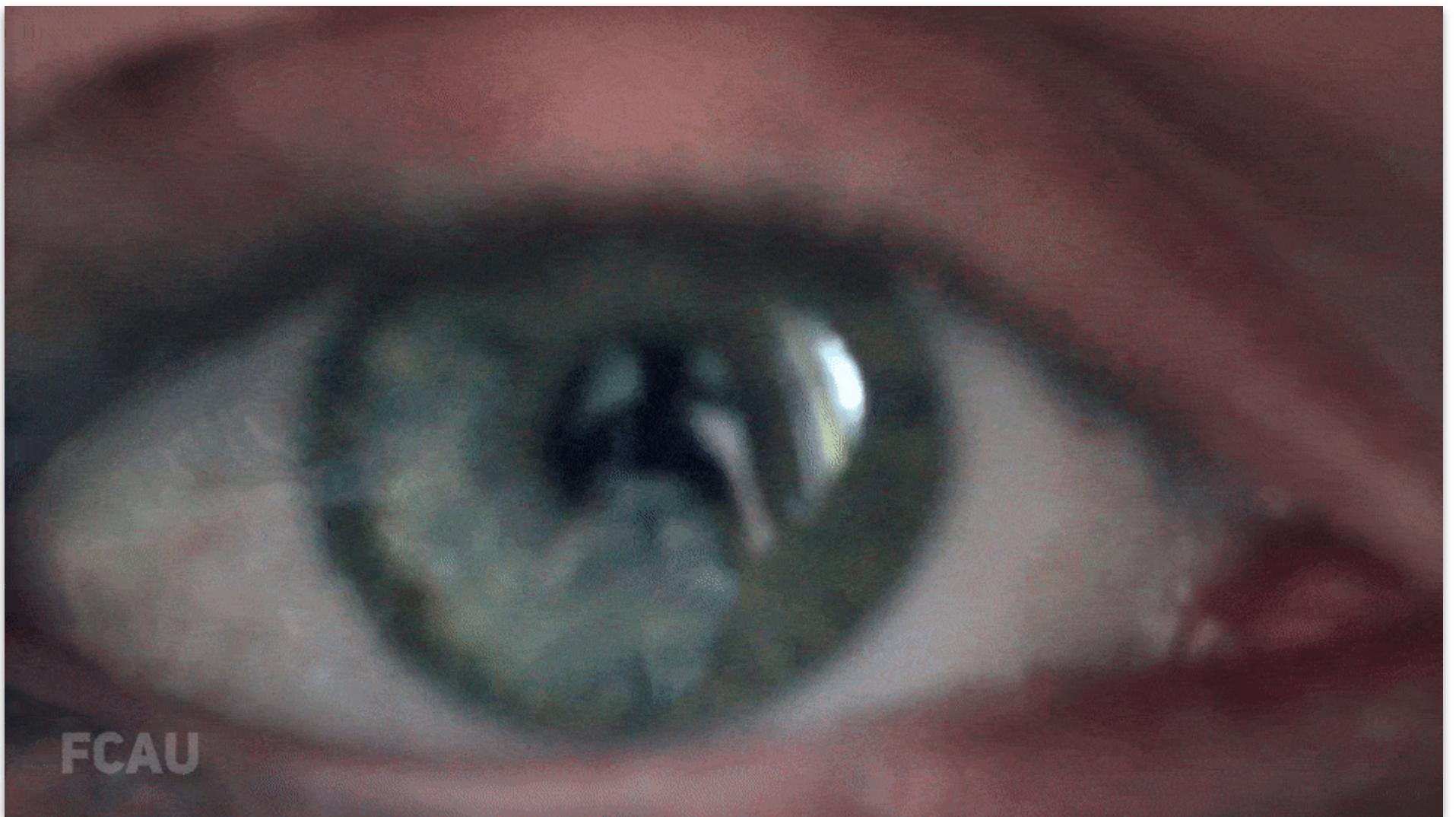
wavelength: 700-900 nm

resolution: \geq 20 lines per iris diameter

non-occluded iris area: \geq 70%

gray scale: \geq 6 bits

typical resolution: 640 x 480 pixels



Acquisition

Sensors

With cooperation.

Jim Wilson / The New York Times



LG Iris Access 3000

Dr. Adam Czajka



CrossMatch

Dr. Adam Czajka



IG-AD100

Acquisition

Sensors

With almost no cooperation.

Multiple-Resolution Cameras

Wide-angle camera for face detection.
Narrow-angle cameras for iris capture.

<https://www.youtube.com/watch?v=boINgCrCZW0>



Sarnoff Corp., Iris-on-the-move Gate

Acquisition

Dr. Adam Czajka

Sensors

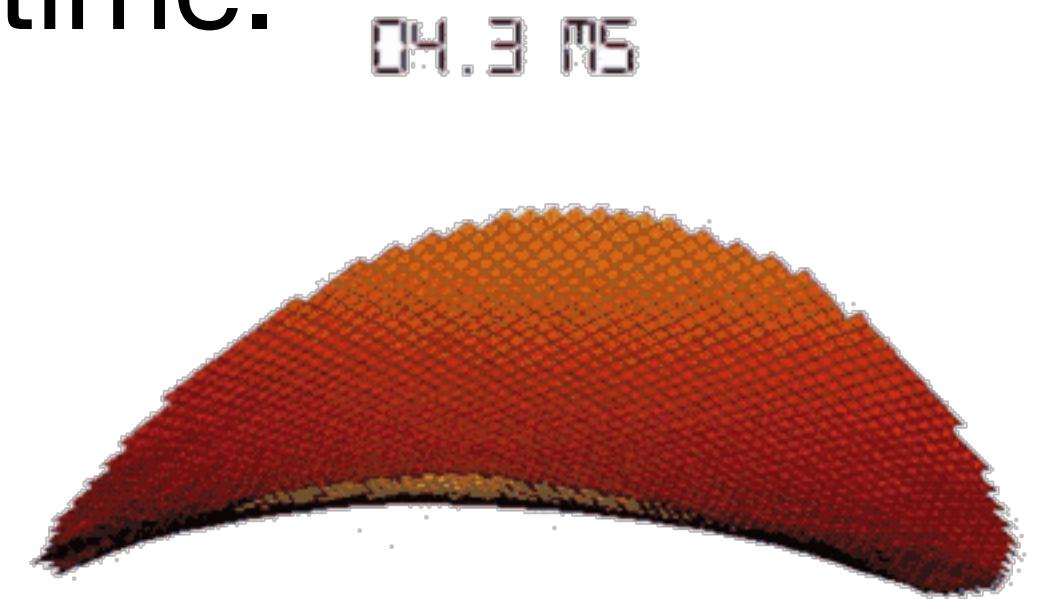
With almost no cooperation.

Deformable Mirrors

Similar to astronomical telescopes.

Fast adaptation at presentation time.

Capture at 1.5-2.5m
of distance.



AOptix Insight SD, 2008



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Acquisition

Sensors

Current trend: miniaturization.

Example 1

Android-based
Fidelys smartwatch.



[linuxgizmos.com/
worlds-first-iris-recognition-smartwatch-runs-android](http://linuxgizmos.com/worlds-first-iris-recognition-smartwatch-runs-android)

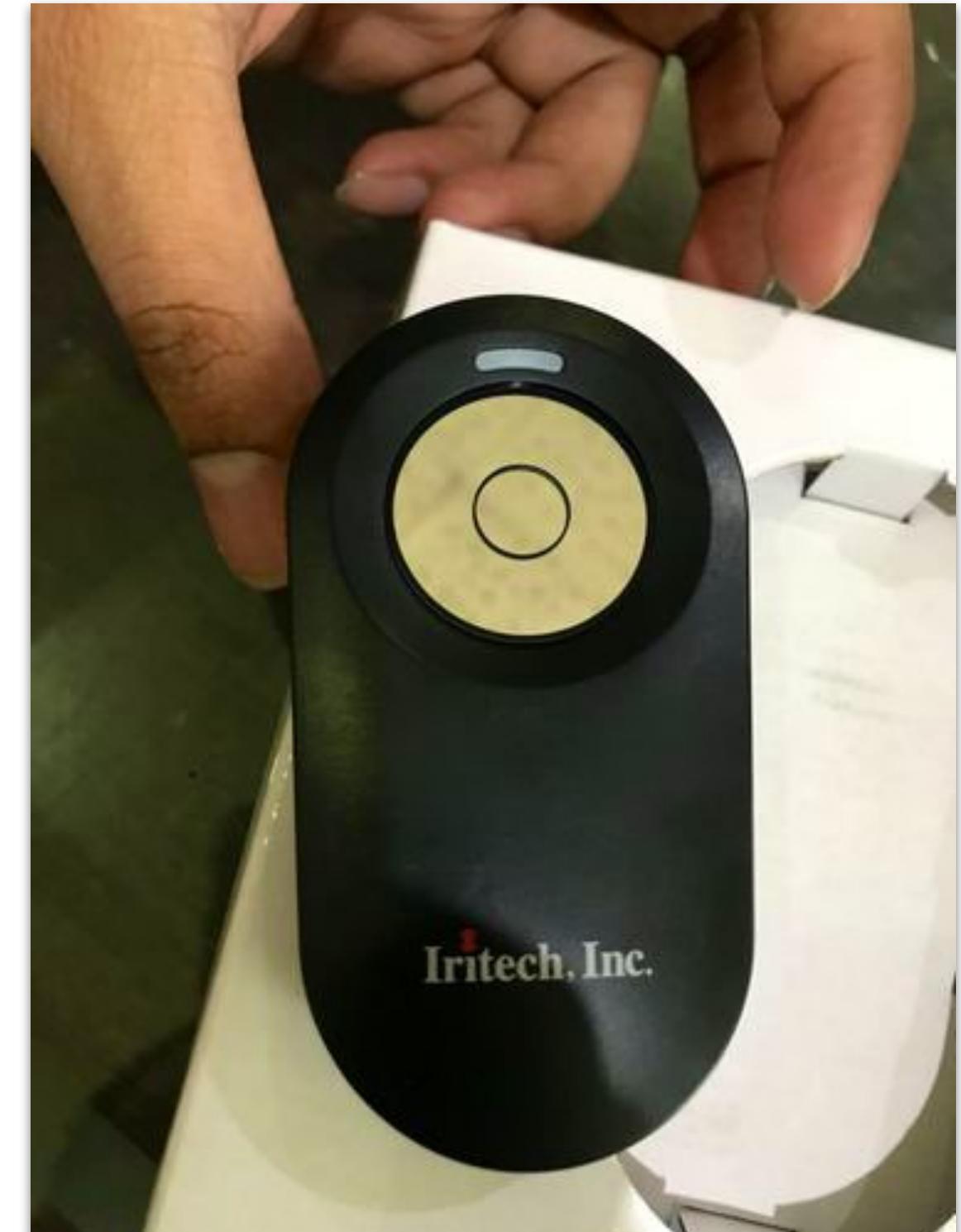
Acquisition

Sensors

Current trend: miniaturization.

Example 2 IriShield USB

This is the one we'll use to collect data.

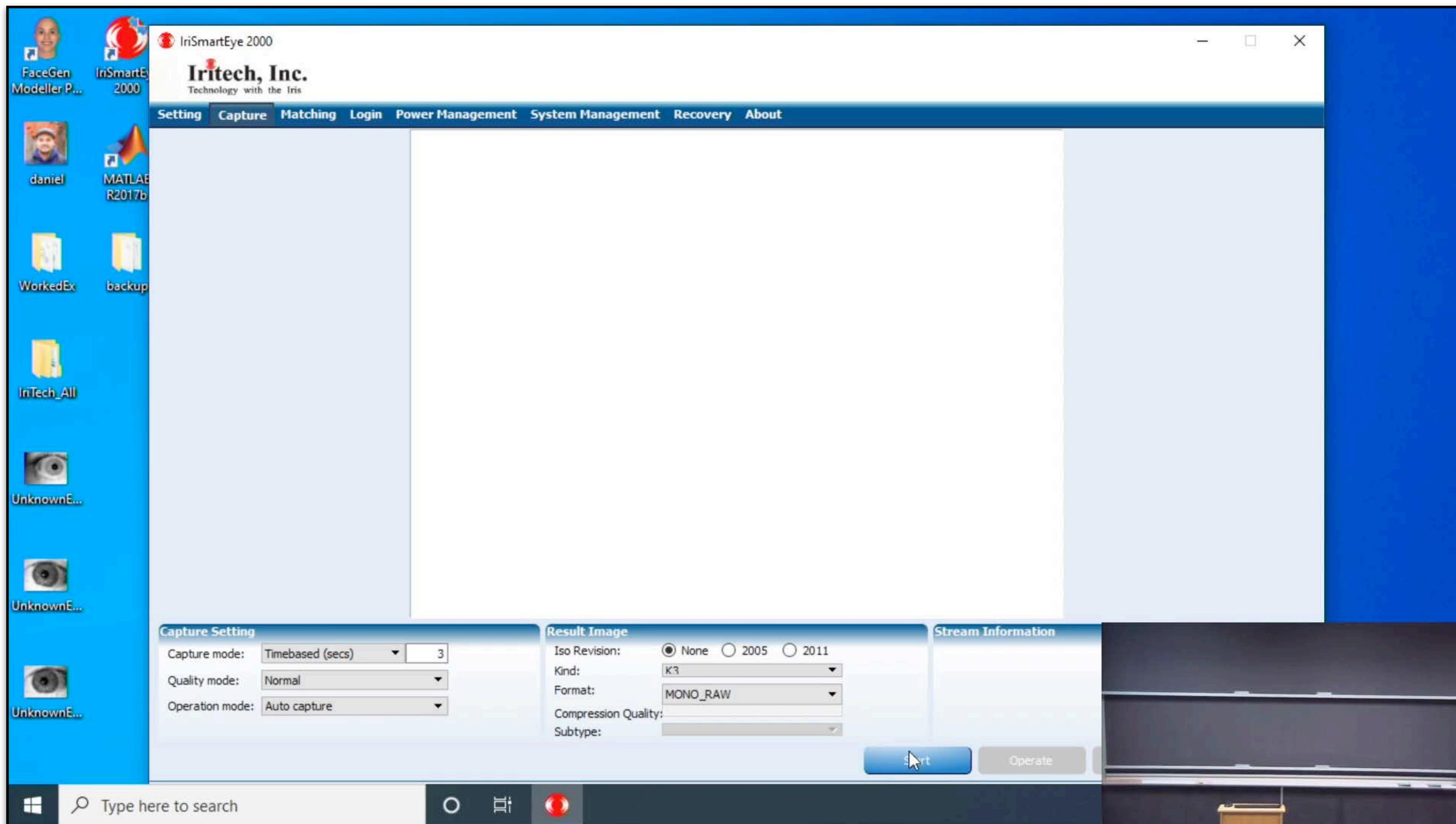


<https://urvashicomputers.com/irishield-mk-2120-series/>



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Acquisition



Acquisition

Challenges

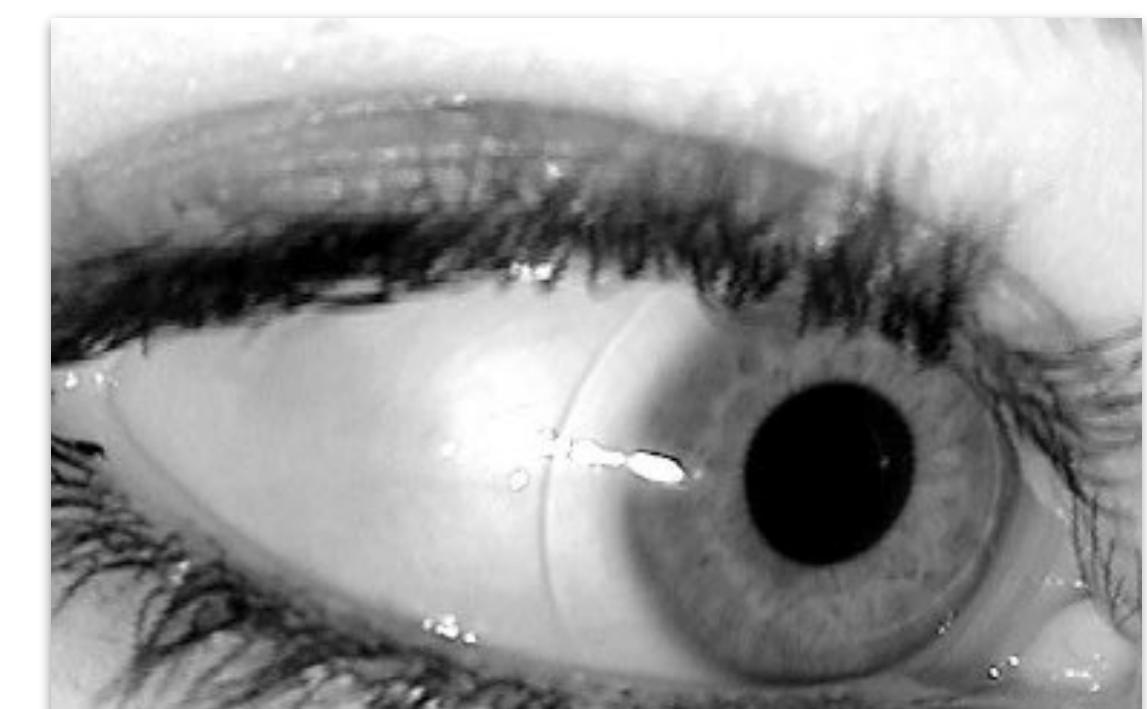
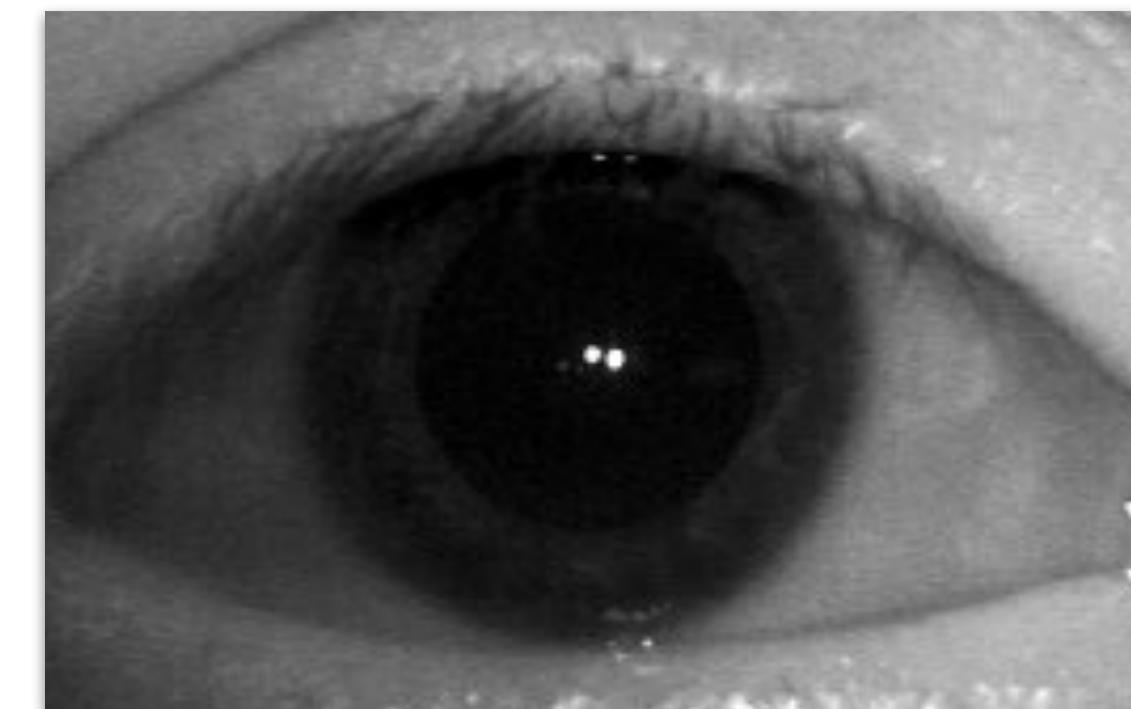
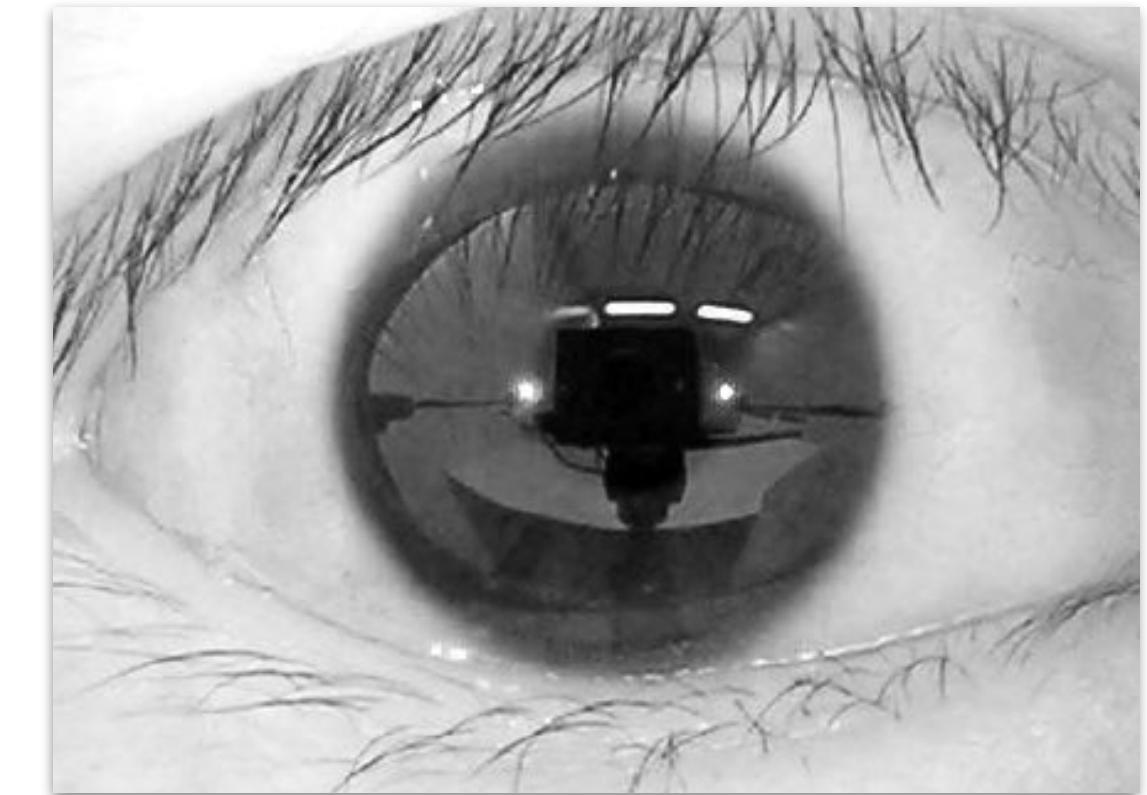
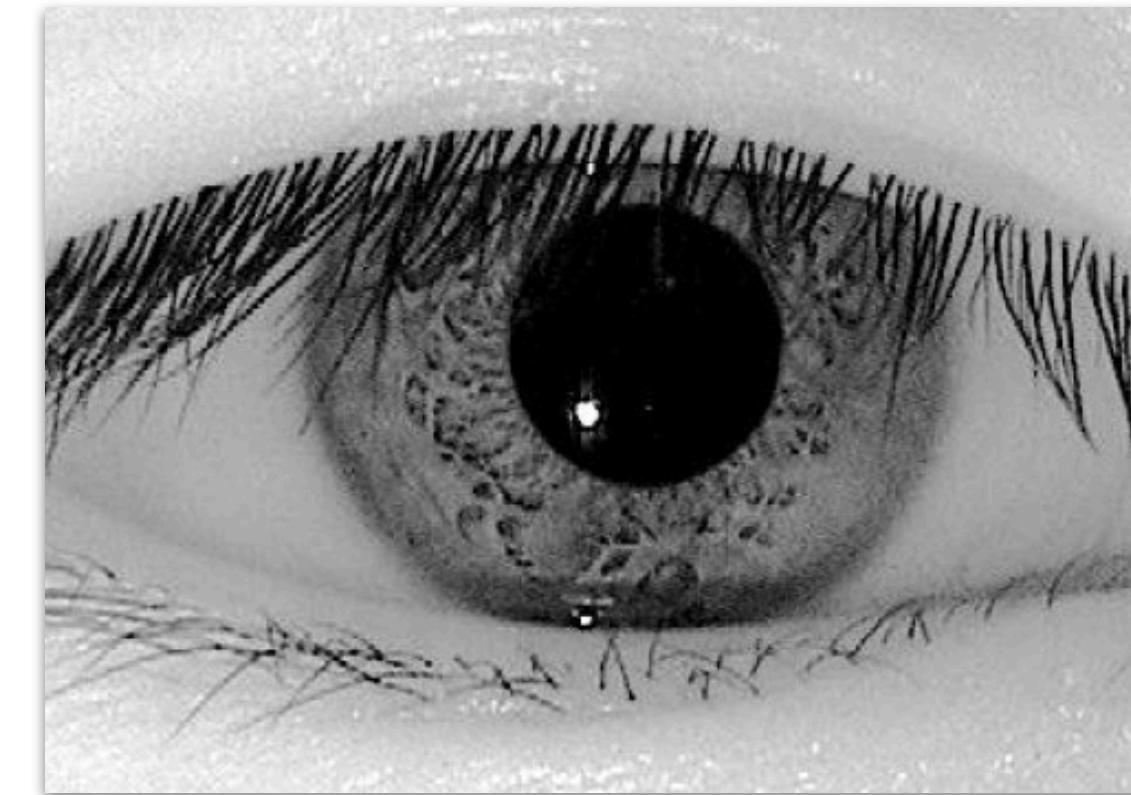
Deformations and Occlusions

Eyelids and eyelashes.

Specular reflections.

Pupil dilation.

Head movement, off-axis gaze.



http://www.cse.nd.edu/BTAS_07/John_Daugman_BTAS.pdf

Acquisition

Challenges

User Cooperation

It is easy for people to protect their irises from capture.



Acquisition

Challenges

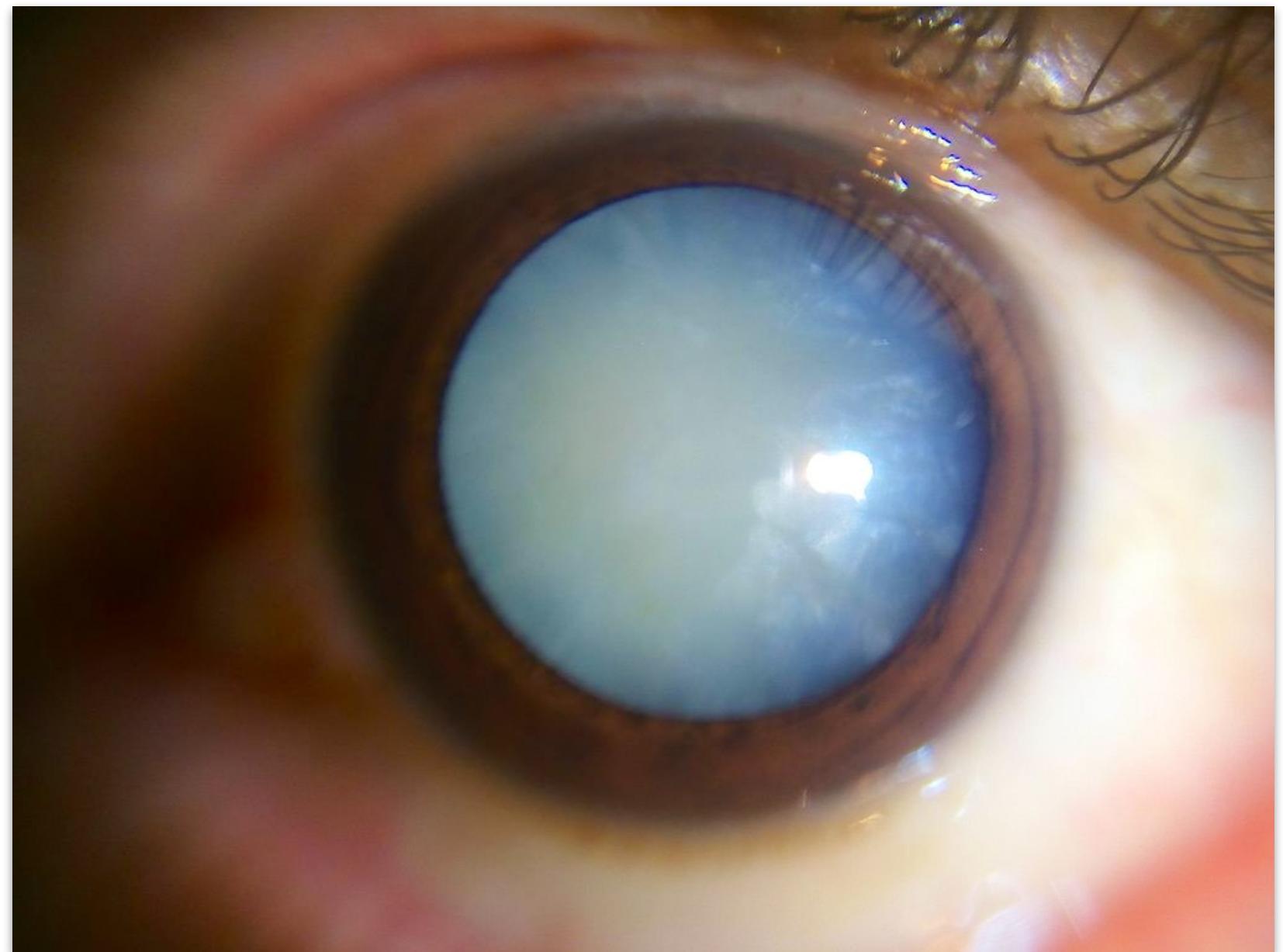
commons.wikimedia.org

Diseases

E.g., cataracts, conjunctivitis.

Is iris visible?

Is the disease contagious?



E.g., cataracts.

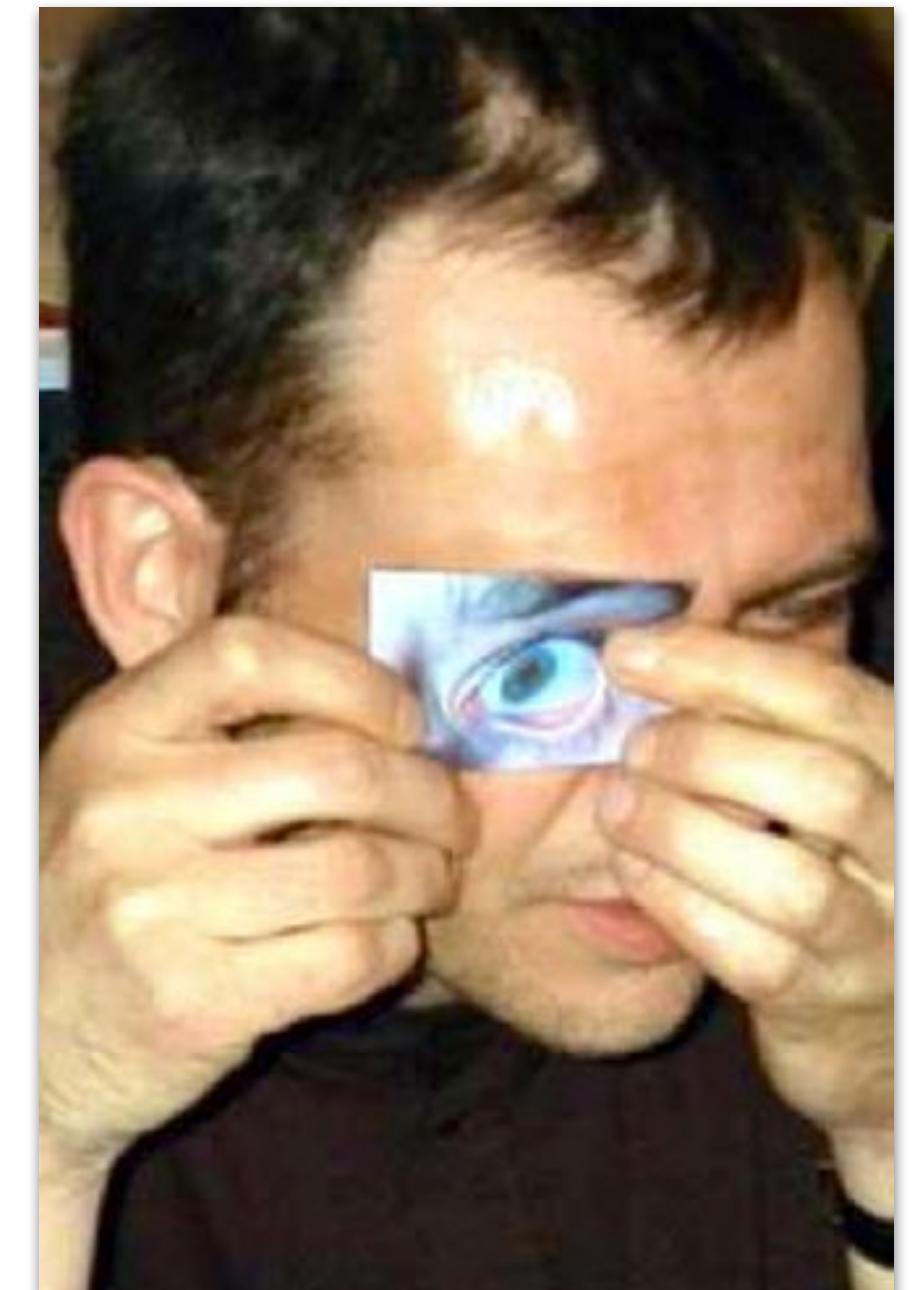
Acquisition

Challenges

Attacks

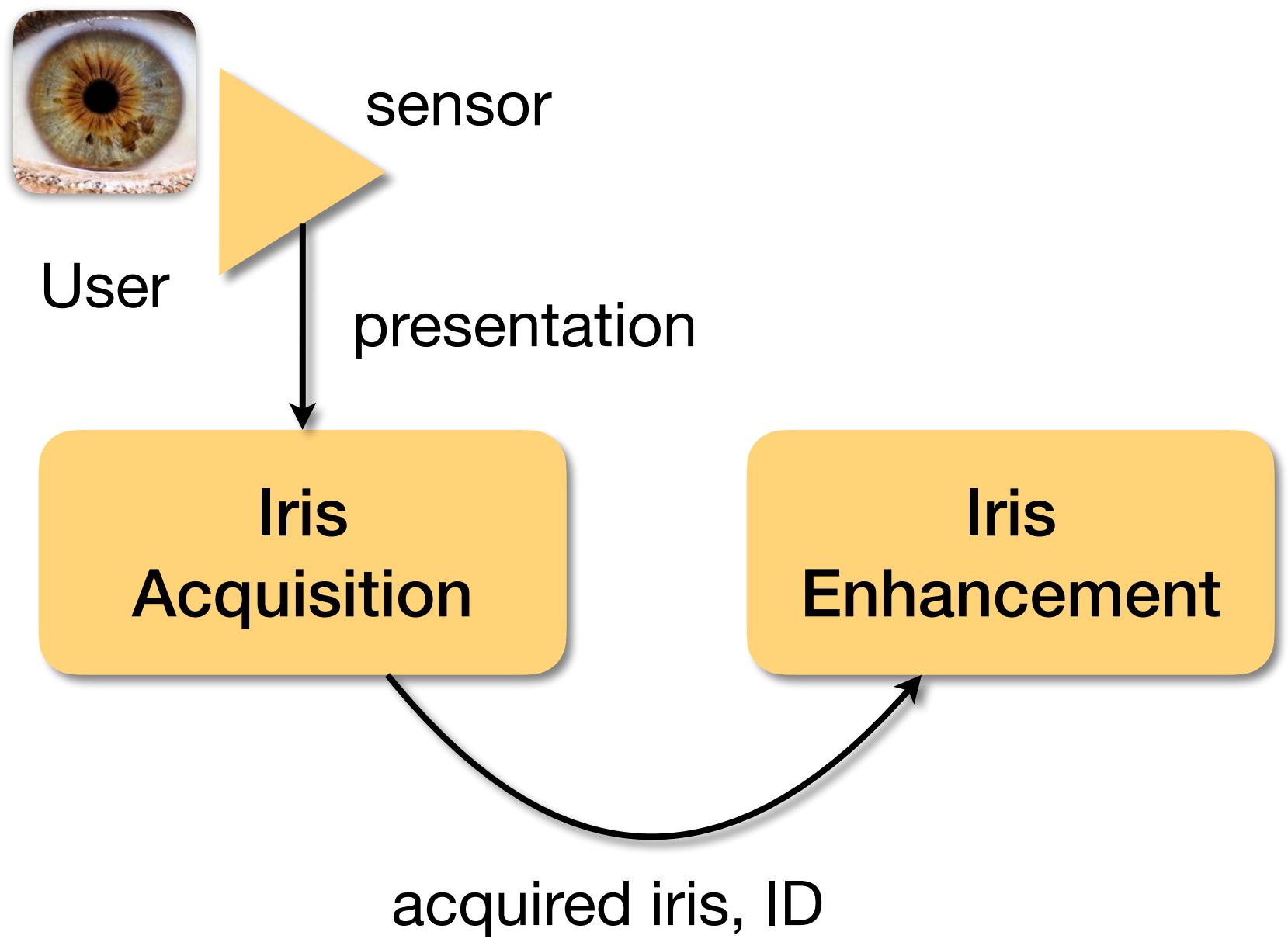
Obfuscation with texturized contact lenses.

Presentation attack.



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

Iris Recognition



Enhancement

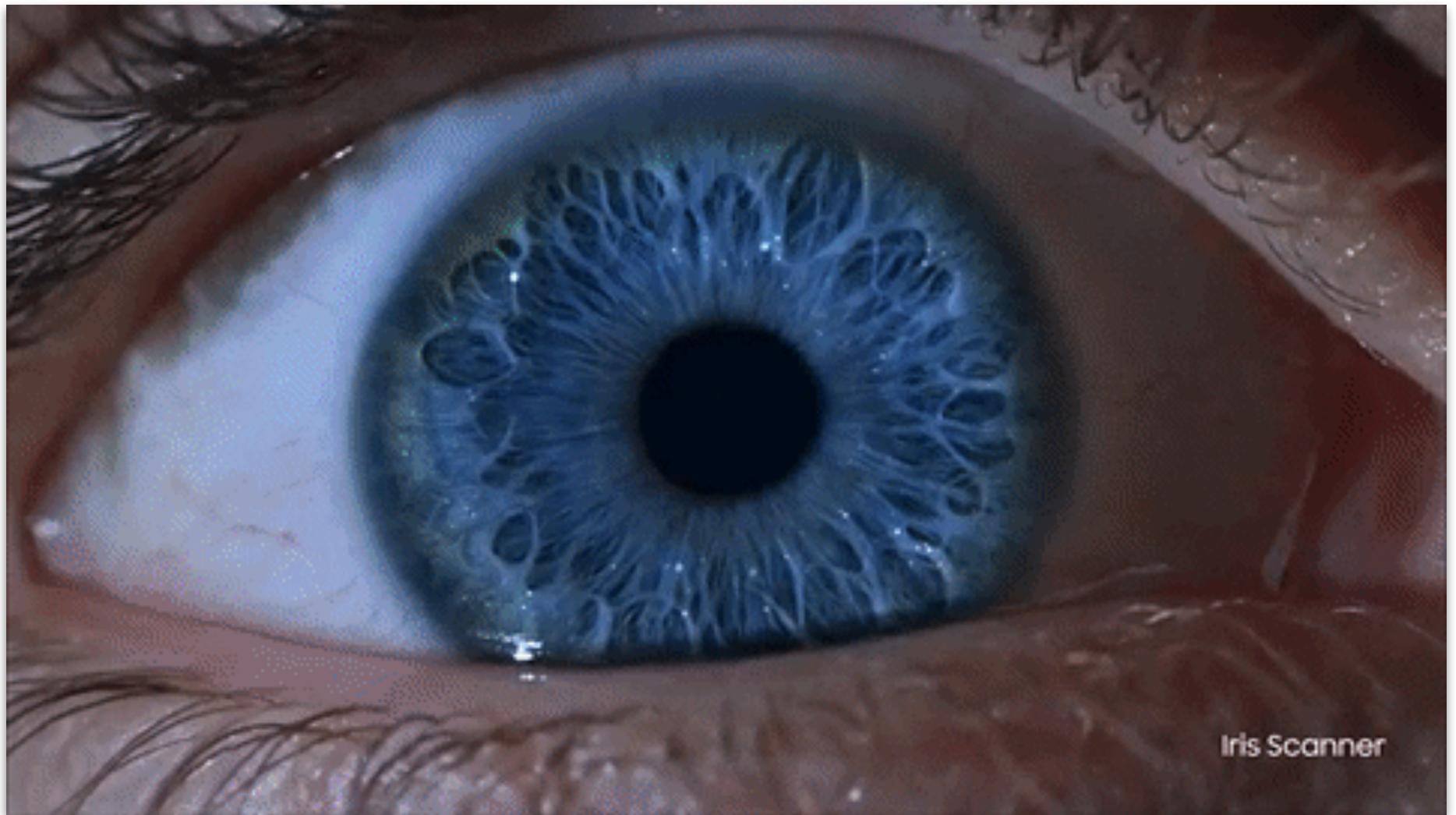
Steps

Segmentation

Keep only useful information
(iris texture).

Normalization

Make different captures of the same
iris look as similar as possible.

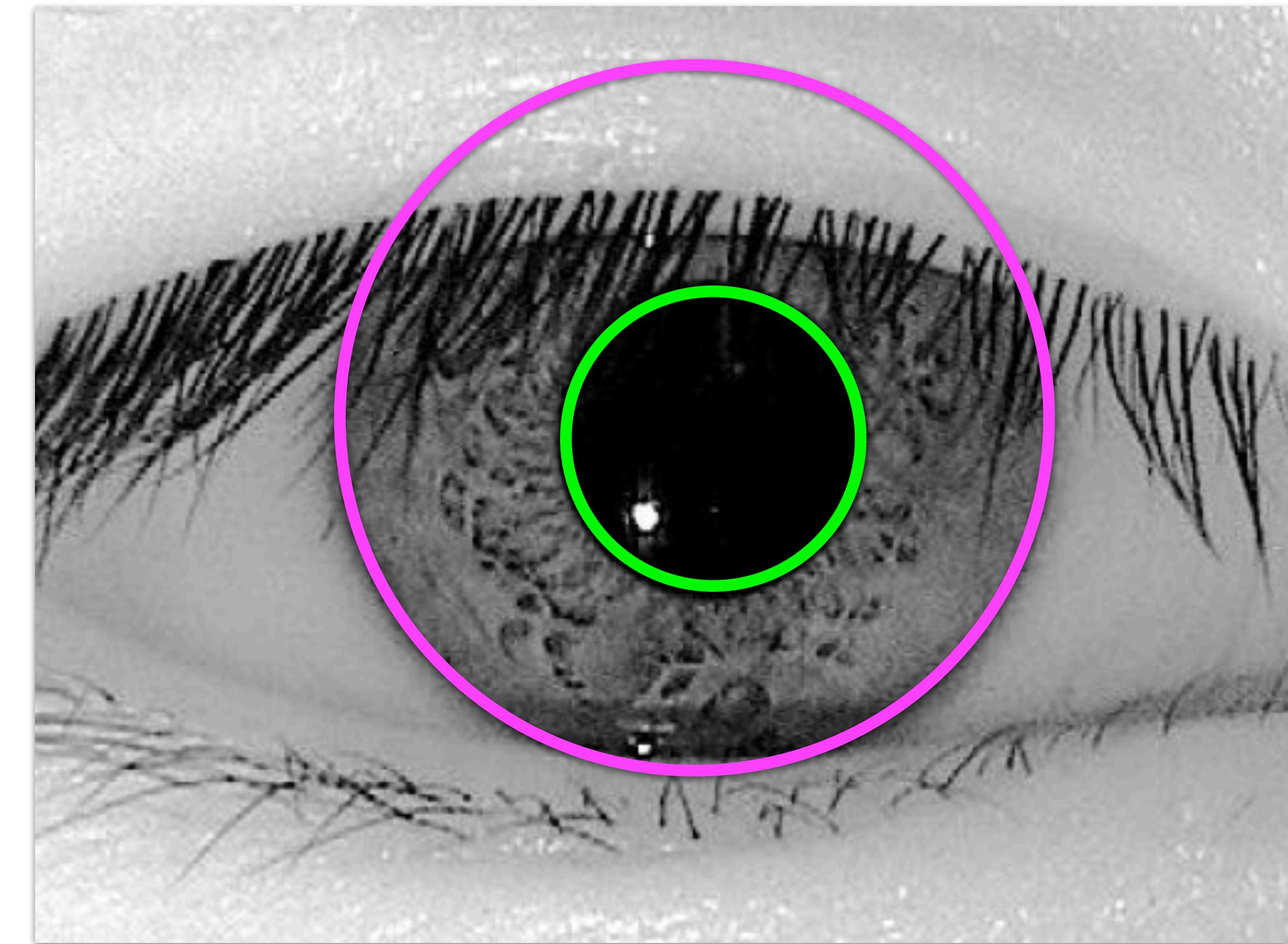


Enhancement

Segmentation (1/2)

Iris and Pupil Localization

Localize limbus and pupillary boundaries.



http://www.cse.nd.edu/BTAS_07/John_Daugman_BTAS.pdf

Enhancement

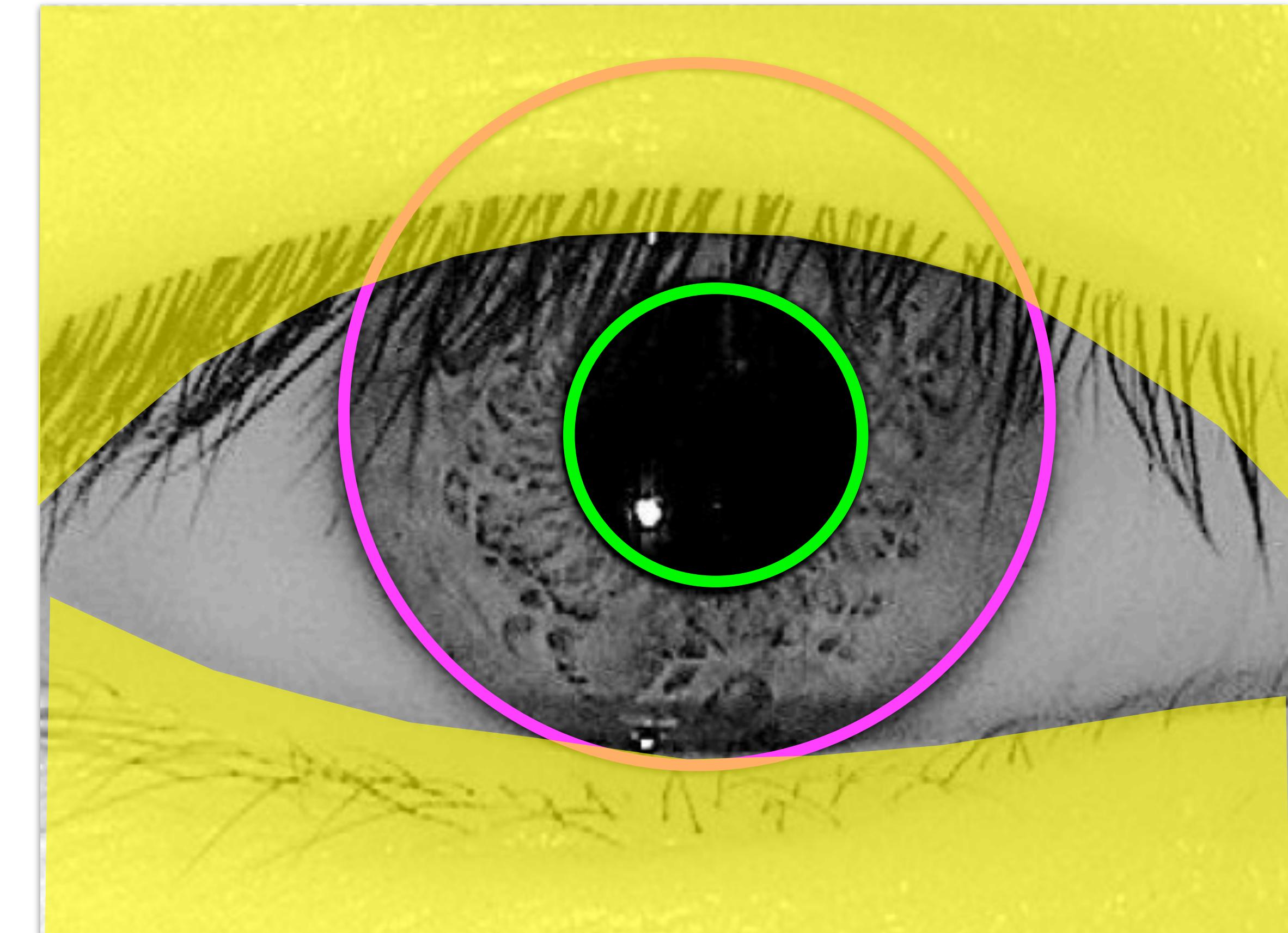
Segmentation (1/2)

Iris and Pupil Localization

Localize limbus and pupillary boundaries.

Eyelid, Eyelash, and Specular Reflection Detection

Deal with iris texture occlusions.



http://www.cse.nd.edu/BTAS_07/John_Daugman_BTAS.pdf

Enhancement

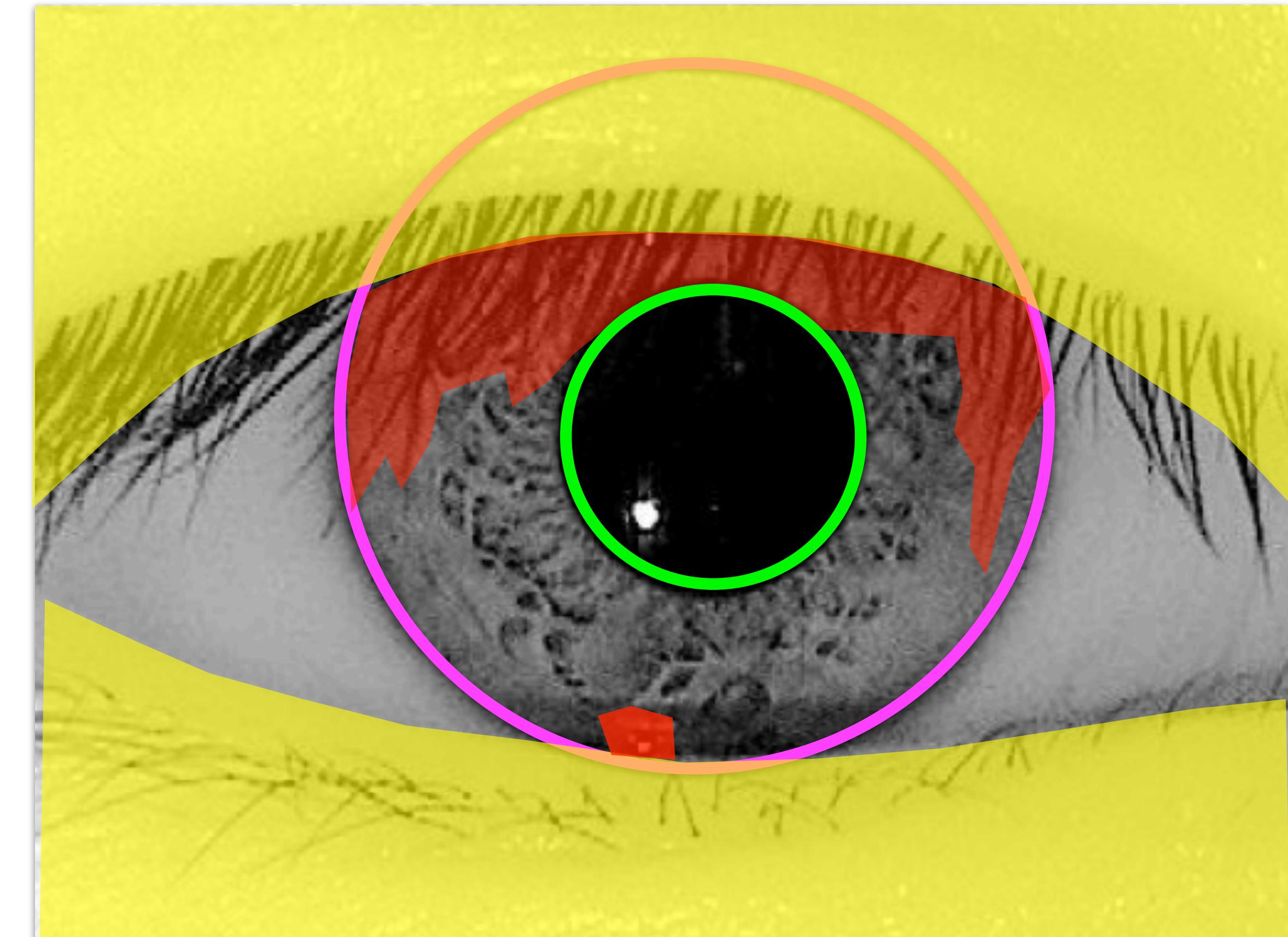
Segmentation (1/2)

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Enhancement

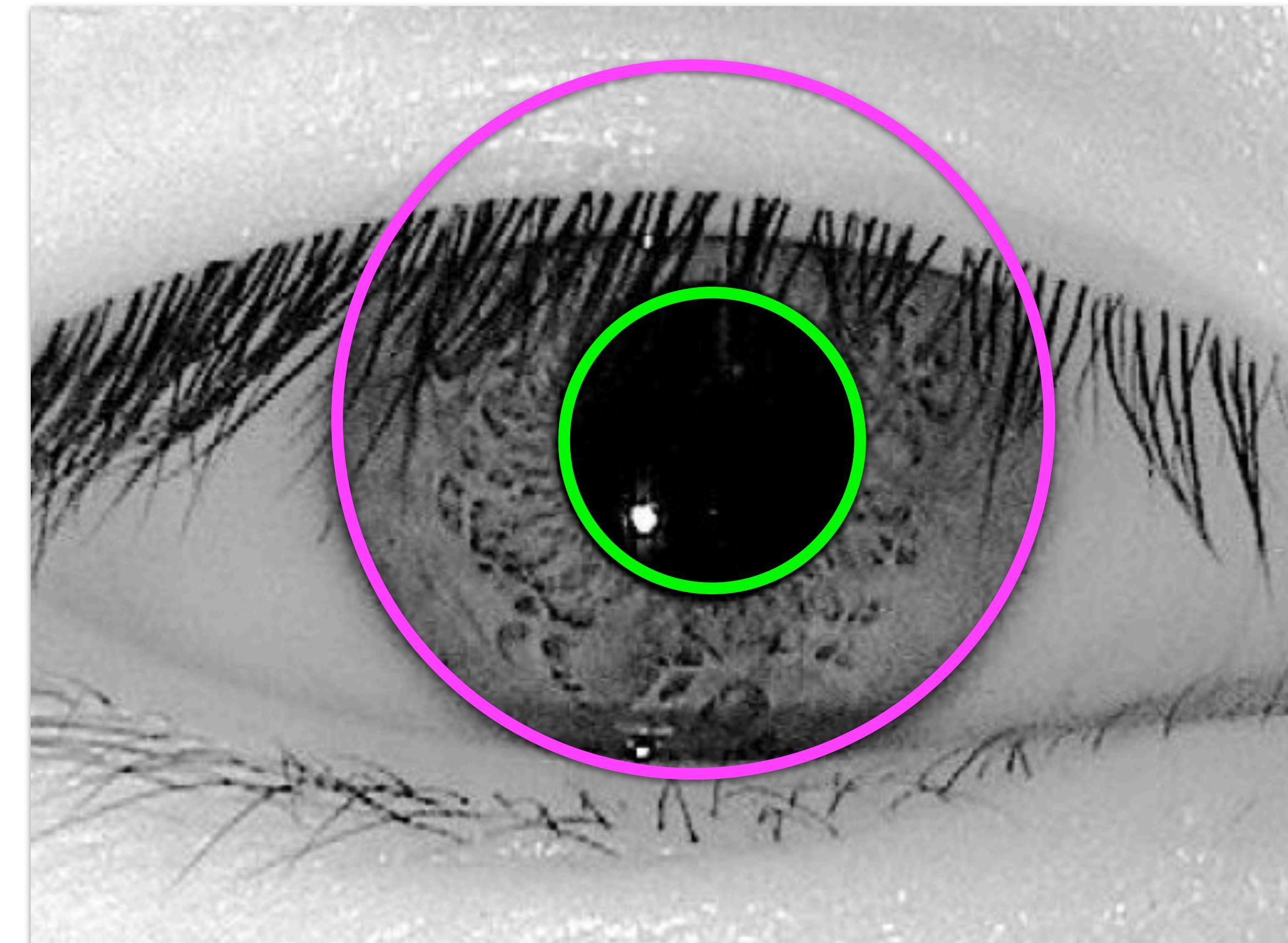
Segmentation (1/2)

Iris and Pupil Localization

Method 1: Integral-differential operator

Objective:

Find (r, x_0, y_0) of **limbus** and
 (r, x_0, y_0) of **pupillary** boundaries.



http://www.cse.nd.edu/BTAS_07/John_Daugman_BTAS.pdf

Enhancement

Segmentation (1/2)

Iris and Pupil Localization

Method 1: Integral-differential operator

Strategy:

Try various values for (r, x_0, y_0) .

3. derivative of integral

2. integral of circle with radius r

1. pixel values

$$\max_{r,x_0,y_0} \left| g_\sigma(r) * \frac{\delta}{\delta r} \oint_{r,x_0,y_0} \frac{I(x, y)}{2\pi r} ds \right|$$

5. get the (r, x_0, y_0) configuration with maximum values

4. smoothing function (gaussian)



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Enhancement

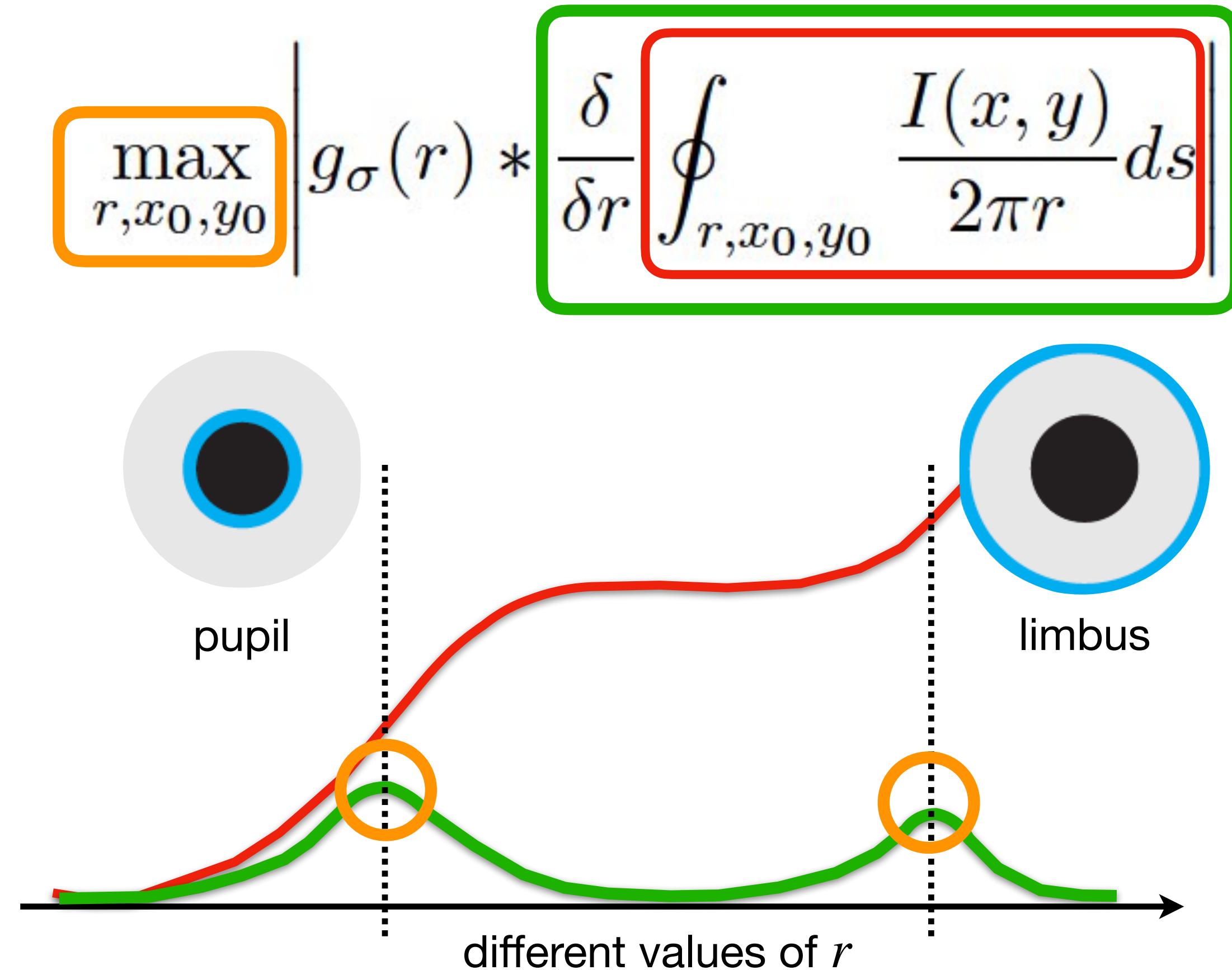
Segmentation (1/2)

Iris and Pupil Localization

Method 1: Integral-differential operator

Strategy:

Try various values for (r, x_0, y_0) .



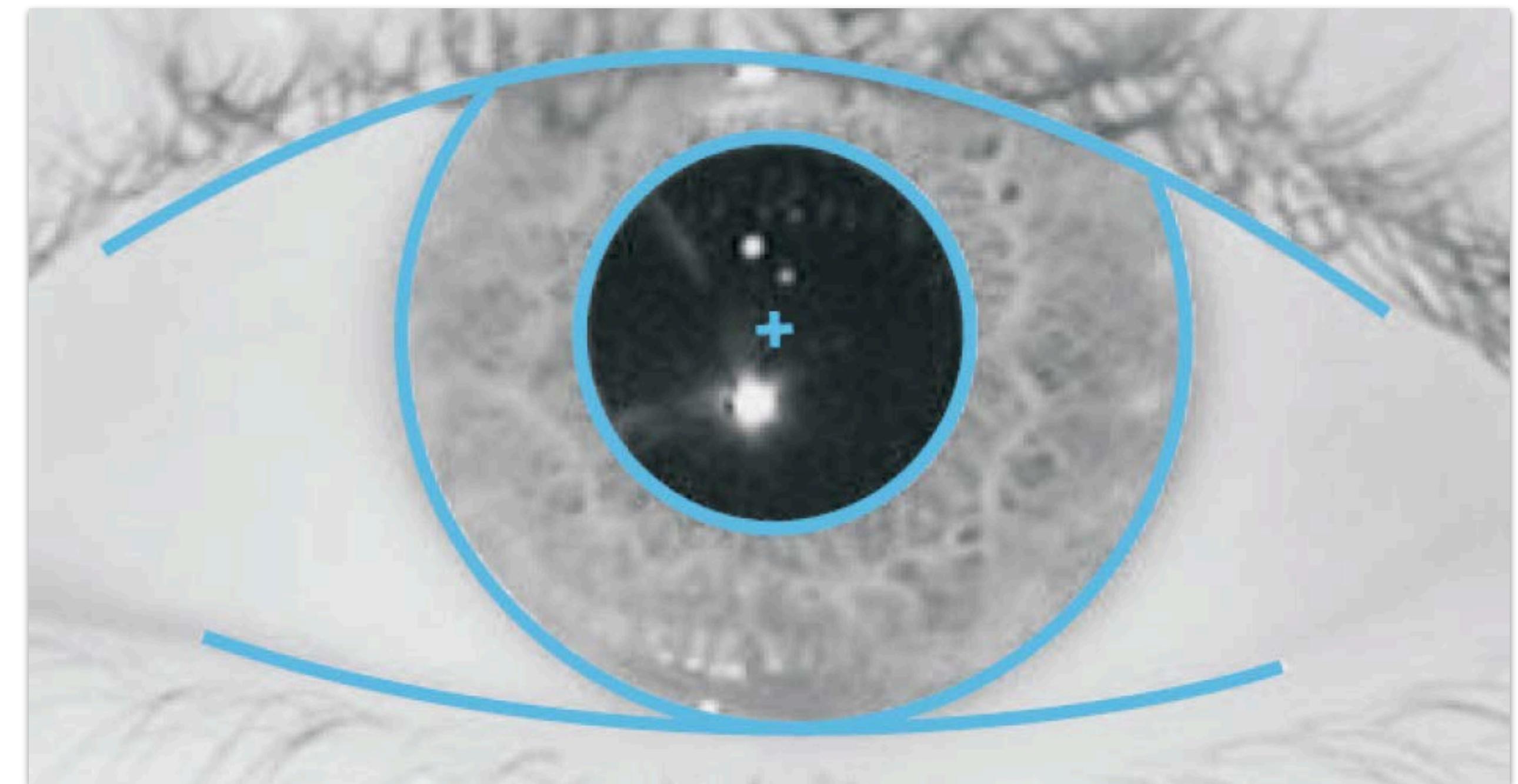
Enhancement

Segmentation (1/2)

Iris and Pupil Localization

Method 1: Integral-differential operator

J. Daugman
How Iris Recognition Works
IEEE TCSVT, 2004



result example

Enhancement

Segmentation (1/2)

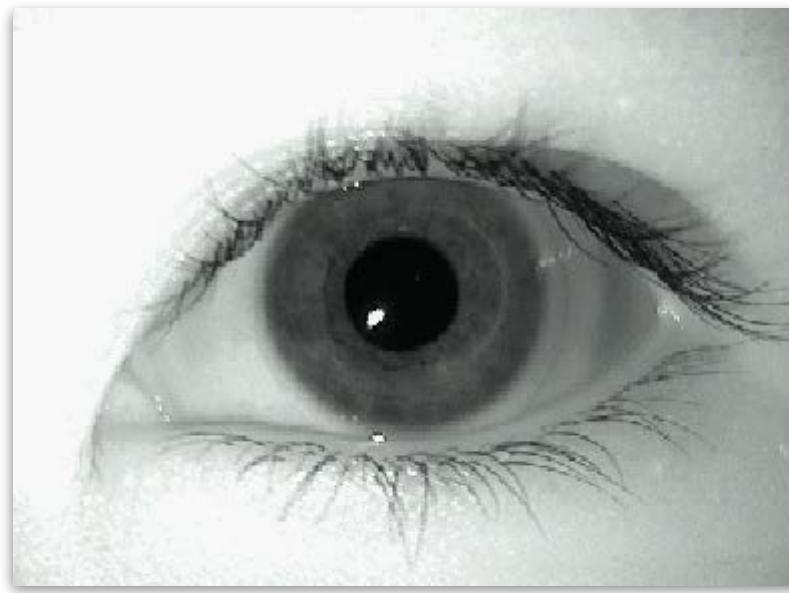
Iris and Pupil Localization

Method 2: Image processing ending with Hough circle transform.

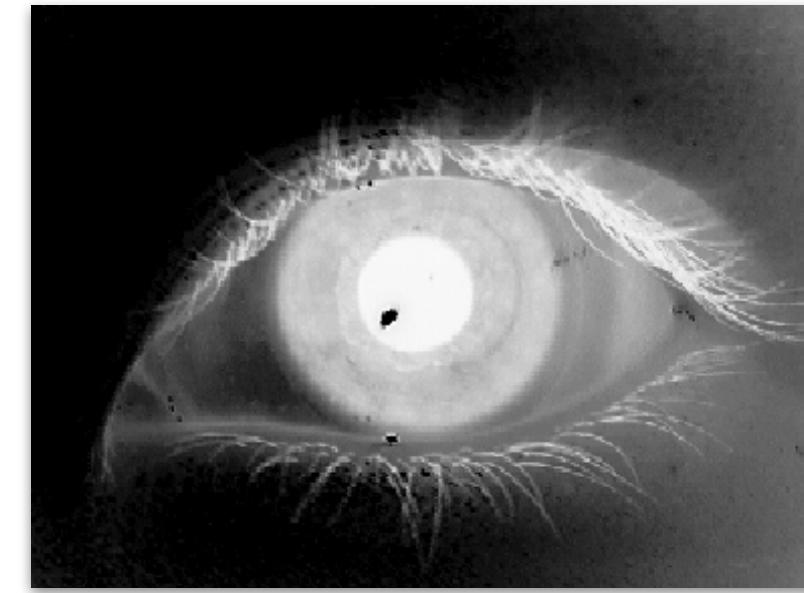


<https://github.com/olesia-midiana/iris-recognition-py>

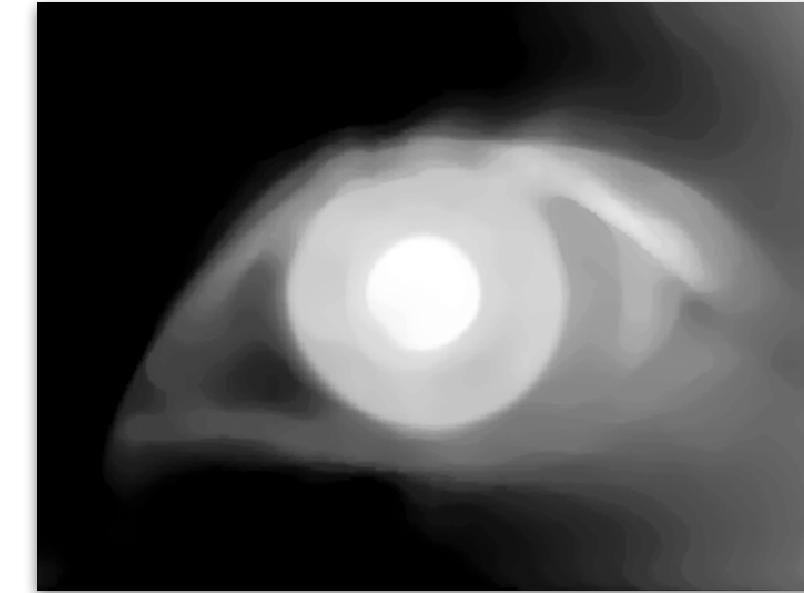
Enhancement



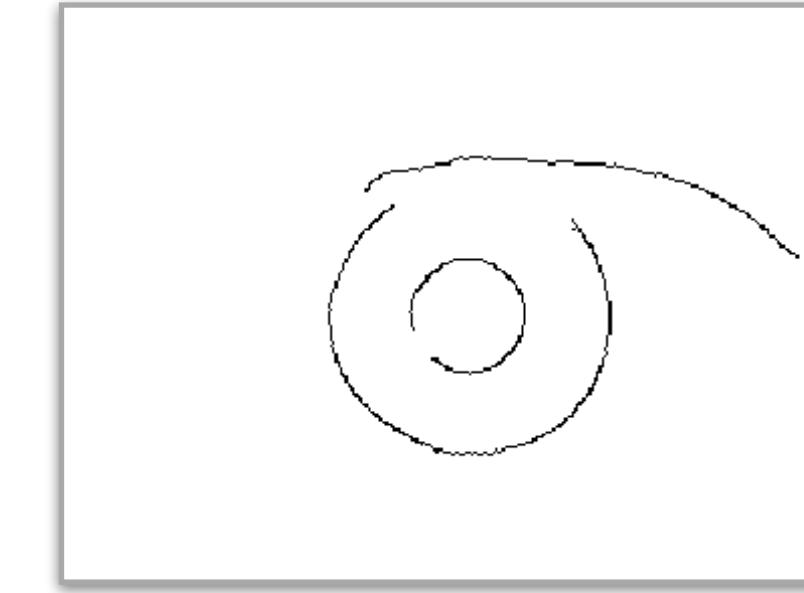
1. grayscale



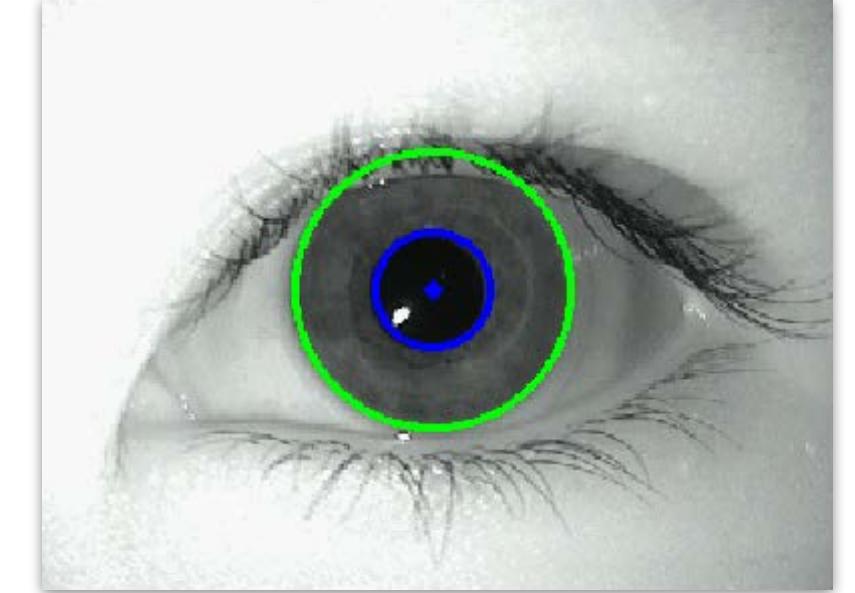
2. inverted



3. median blur



4. Canny edge
detector



5. Hough circle
transform



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Enhancement

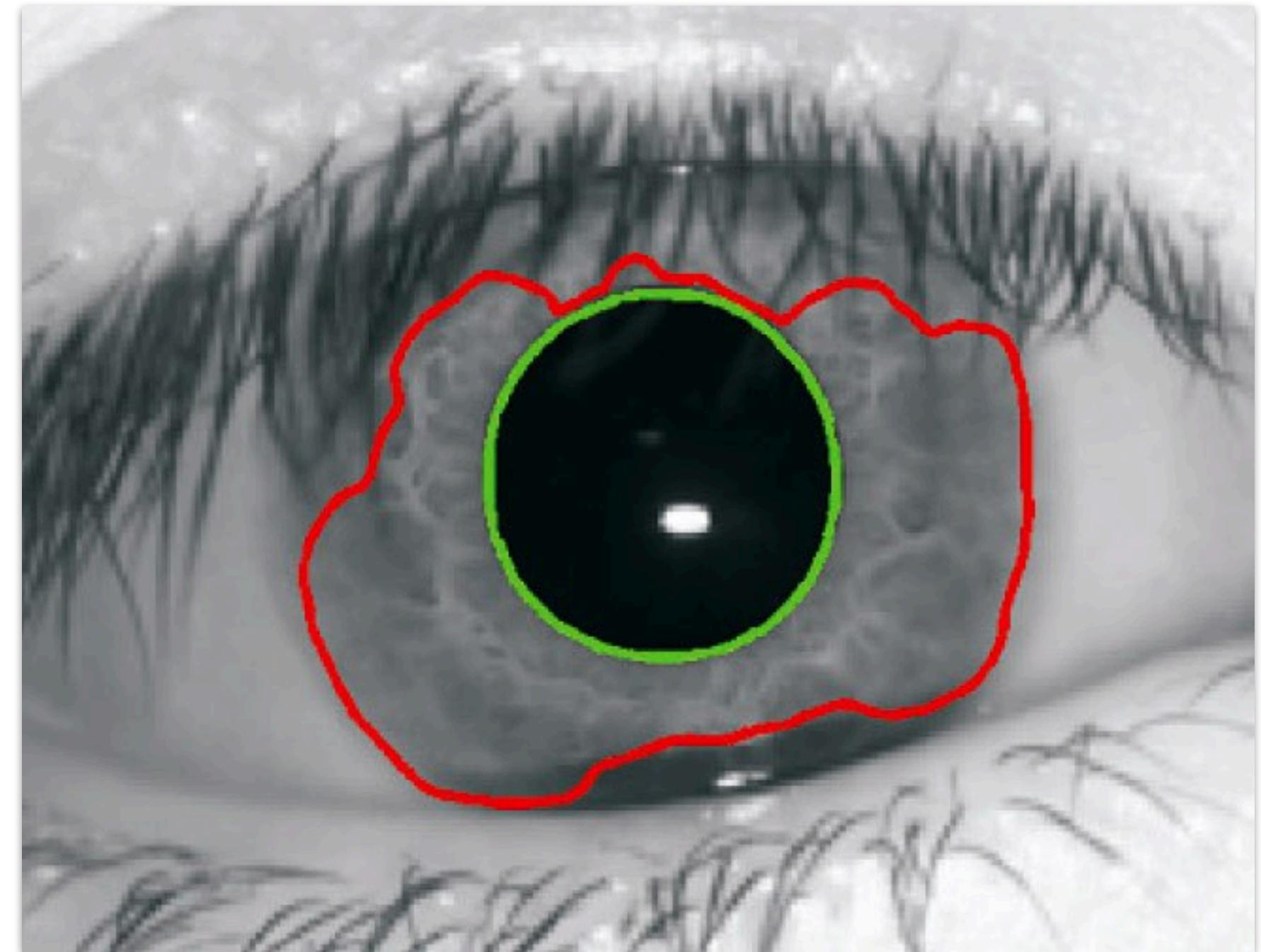
Segmentation (1/2)

Eyelids, eyelashes, specular highlights

Fit of parabolic curves for eyelids.

Active contours (curve evolution)
to avoid eyelashes.

Fit of elliptical curves for specular highlights.
Machine learning from annotated examples.



Gutfeter

Active contours for iris segmentation.
BSc Thesis, WUT, 2010



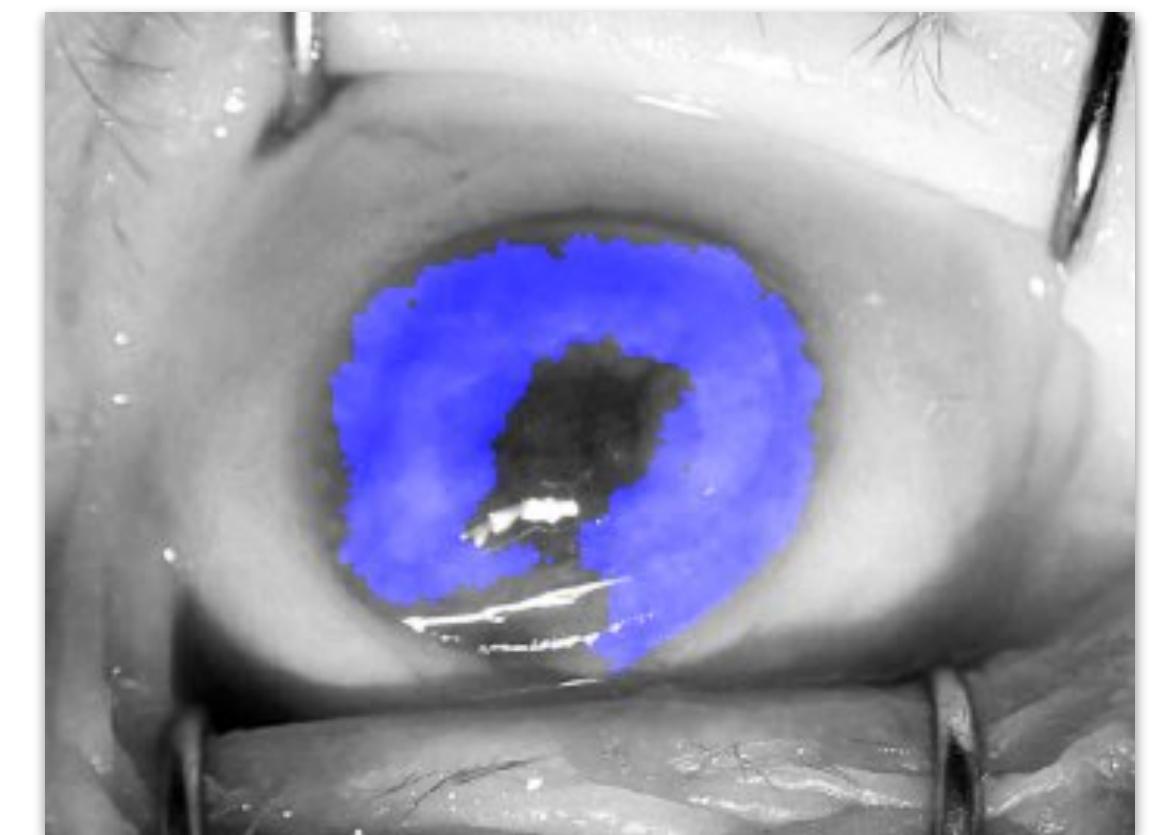
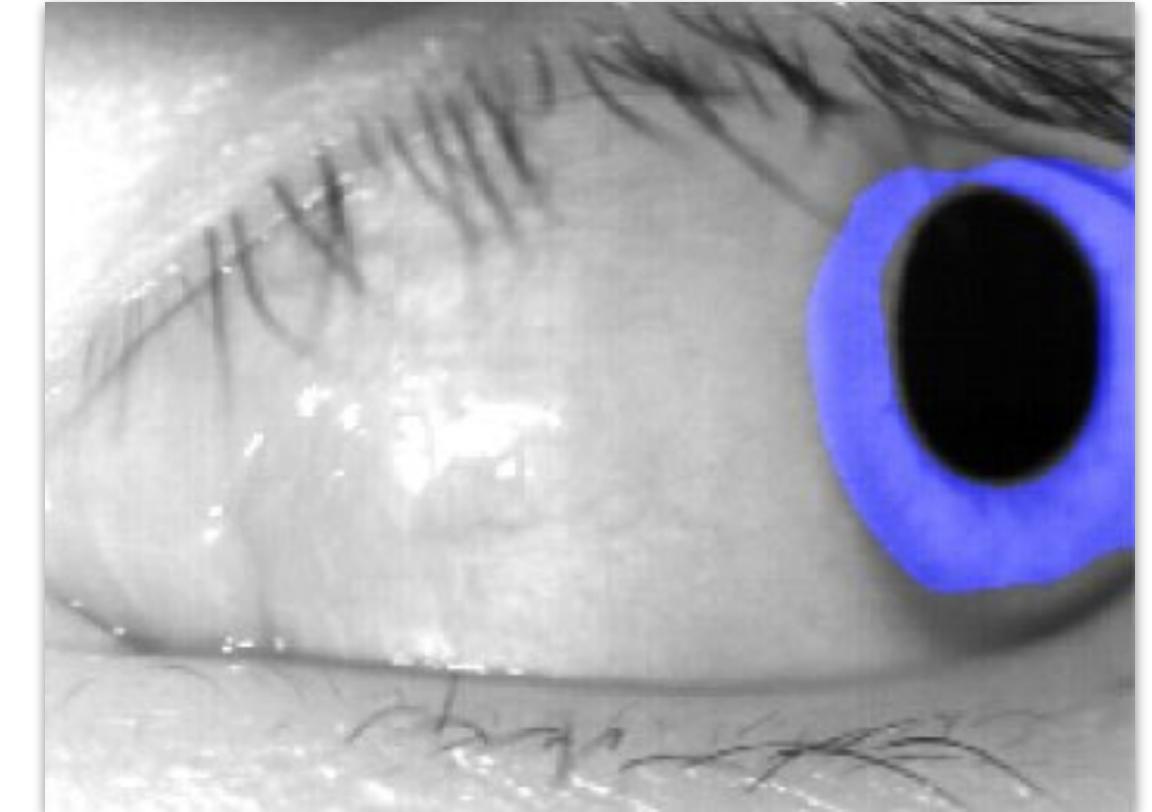
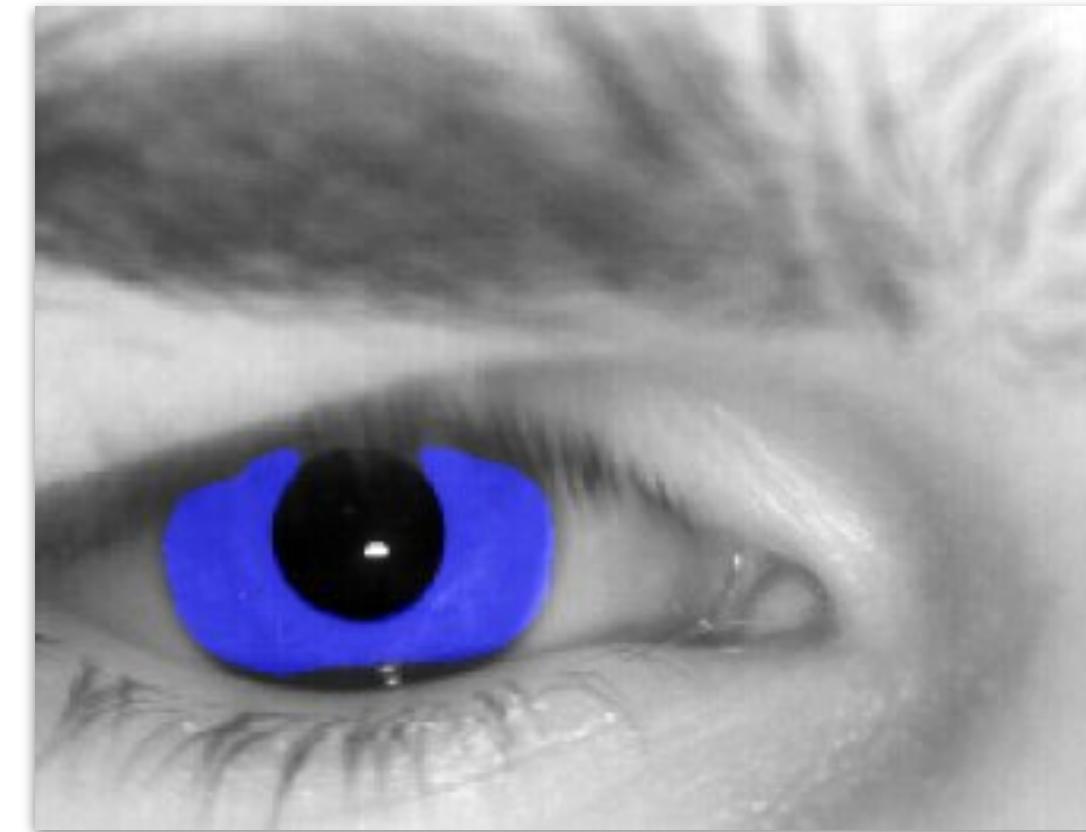
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Enhancement

Segmentation (1/2)

Iris Localization

Convolutional Neural Networks
(machine learning trained with
annotation examples).



Kerrigan et al.
*Iris Recognition with Image
Segmentation Employing
Retrained Off-the-Shelf Deep Neural
Networks*
<https://arxiv.org/abs/1901.01028>, 2019

Enhancement

Segmentation (1/2)

Manual Segmentation

Next slide: iris recognition tool
developed at Notre Dame.



Load irises

Load examination

Save examination

Save report

Quit program

Brightness

-1.0 1.0
0.0

Contrast

0.0 2.0
1.0

Sharpening

0.0 10.0
0.0

Segment iris

Brightness

-1.0 1.0
0.0

Contrast

0.0 2.0
1.0

Sharpening

0.0 10.0
0.0

Segment iris

1.0 3.0
1.0

1x

1.0 3.0
1.0

Human-Interpretable Features

<input checked="" type="checkbox"/> TSHEPII	<input type="checkbox"/> Show Matched	<input type="checkbox"/> Show Unmatched	<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>-</td><td>0</td><td>+</td></tr> <tr><td>-</td><td>1</td><td>+</td></tr> </table>	-	0	+	-	1	+	out of 0	<input checked="" type="checkbox"/> MSER	<input type="checkbox"/> Show Matched	<input type="checkbox"/> Show Unmatched	<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>-</td><td>0</td><td>+</td></tr> <tr><td>-</td><td>1</td><td>+</td></tr> </table>	-	0	+	-	1	+	out of 0
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<input checked="" type="checkbox"/> Crypts	<input type="checkbox"/> Show Matched	<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>-</td><td>0</td><td>+</td></tr> <tr><td>-</td><td>1</td><td>+</td></tr> </table>	-	0	+	-	1	+	out of 0												
-	0	+																			
-	1	+																			

Manual Annotation

Annotate... Matching Regions Non-Matching Regions

Show Matching Regions Show Non-Matching Regions

Undo last removal

Non-Human-Interpretable Features

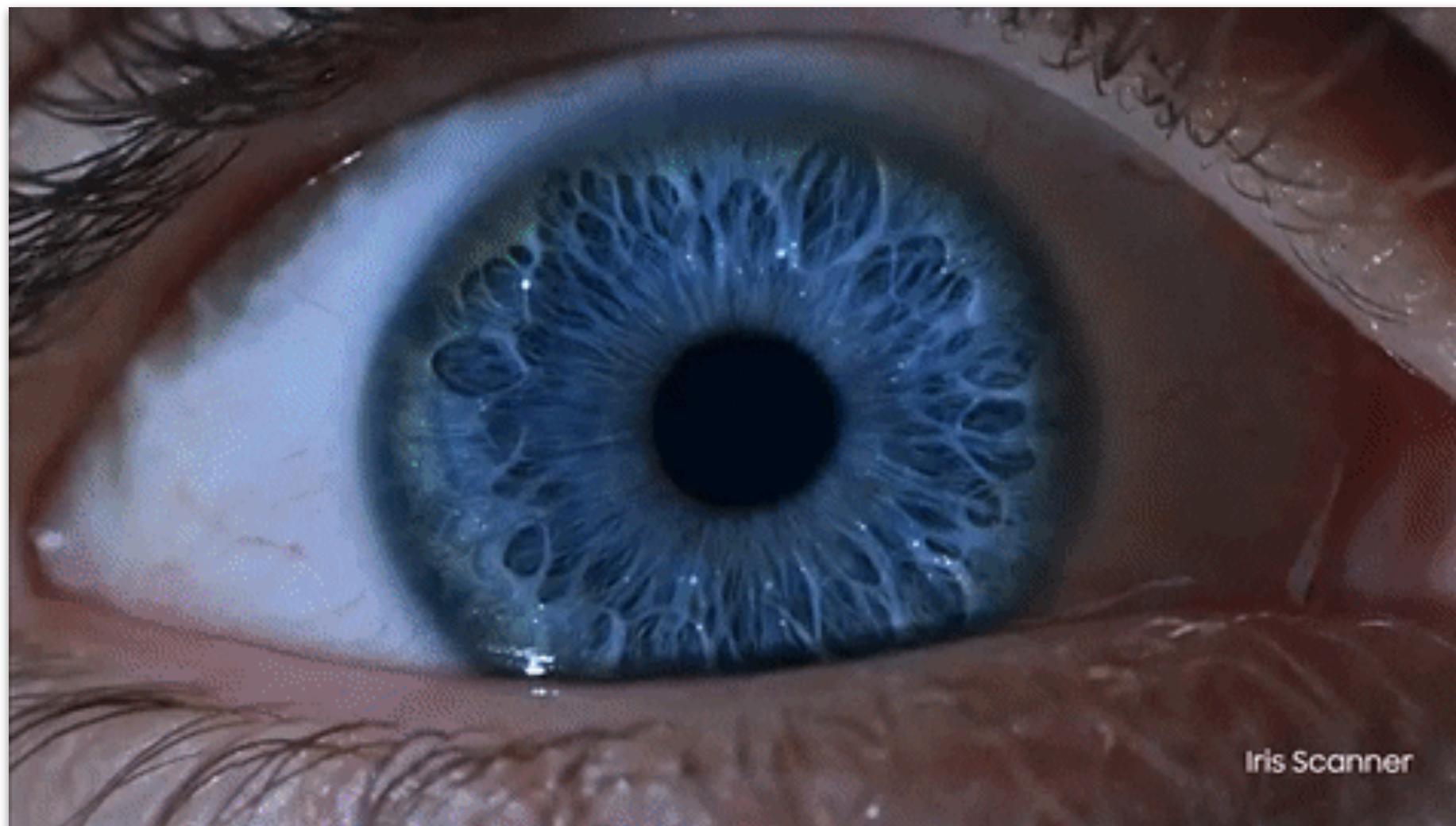
Gabor Filters thr: 0.4461

BSIF Filters thr: 0.4216

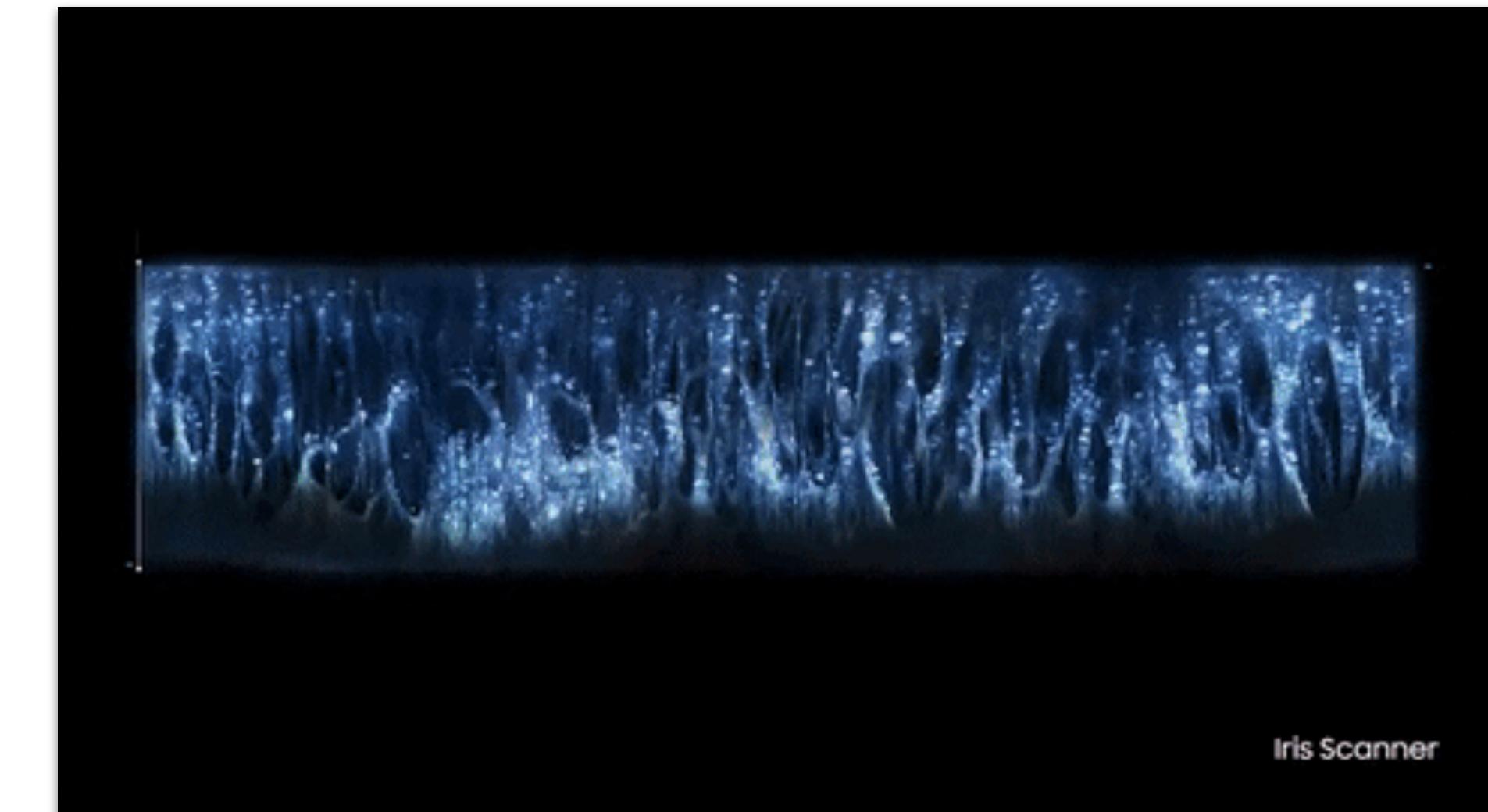
Global match score

Enhancement

Normalization (2/2)



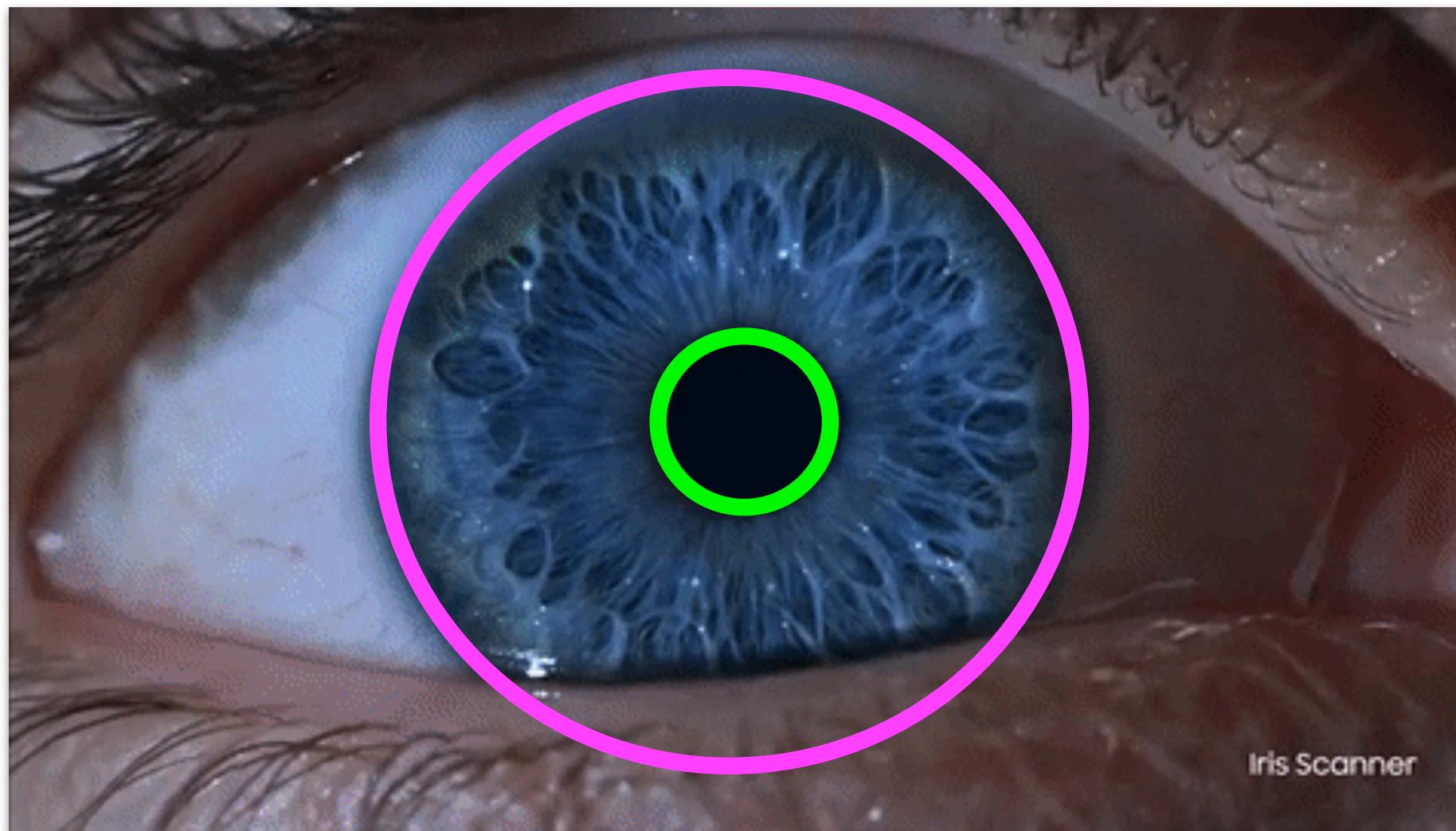
source



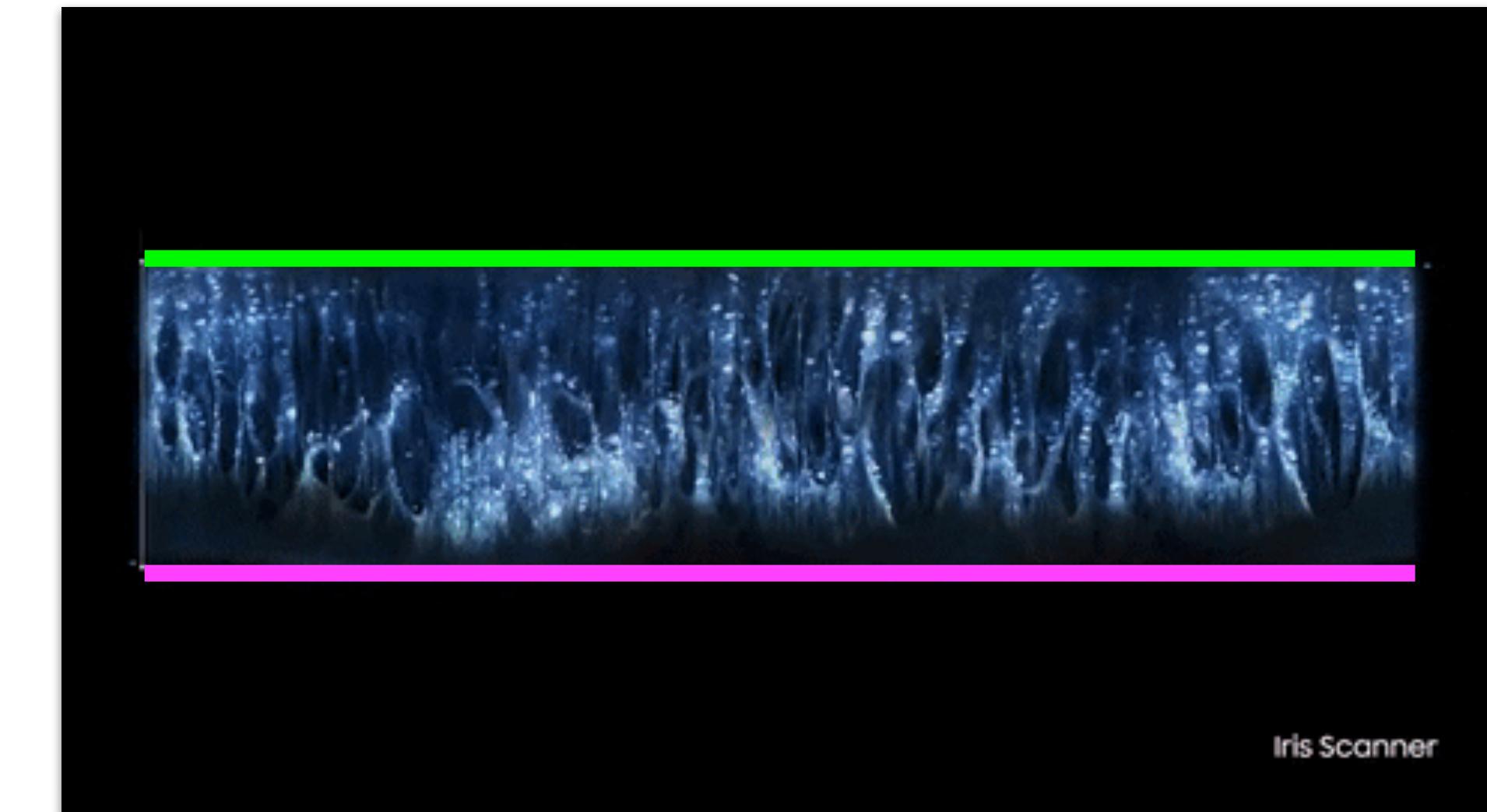
target

Enhancement

Normalization (2/2)



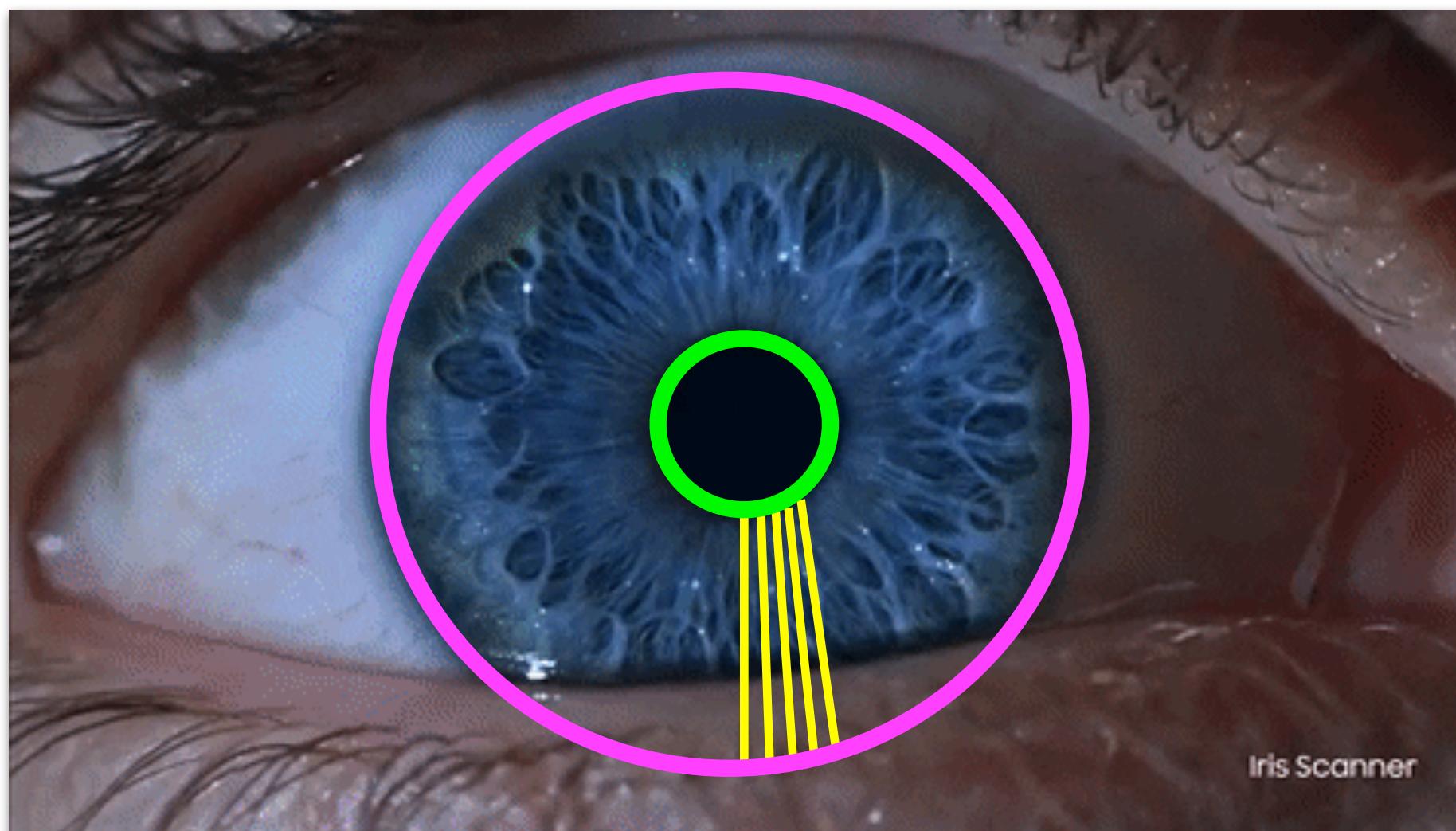
source



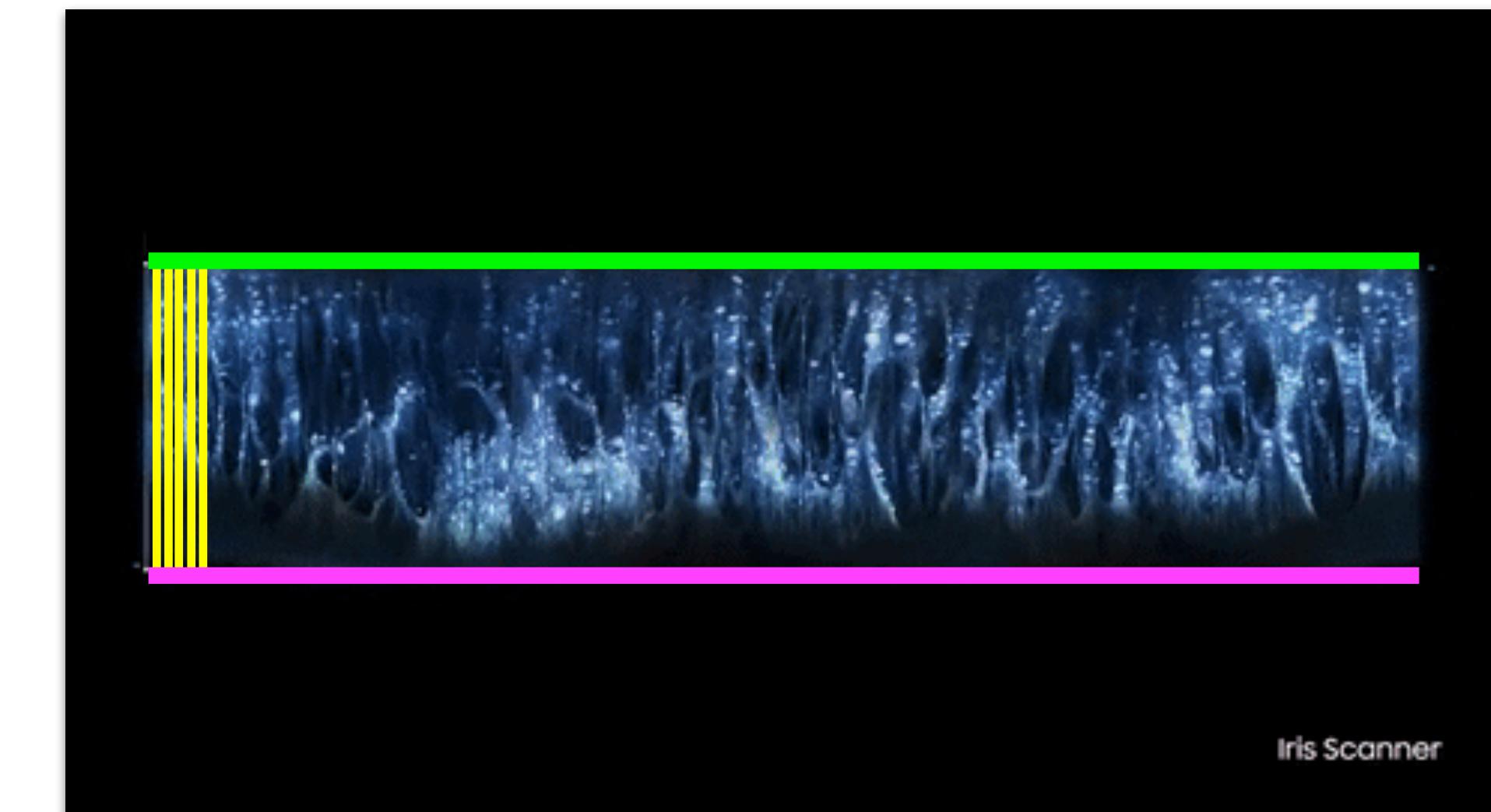
target

Enhancement

Normalization (2/2)



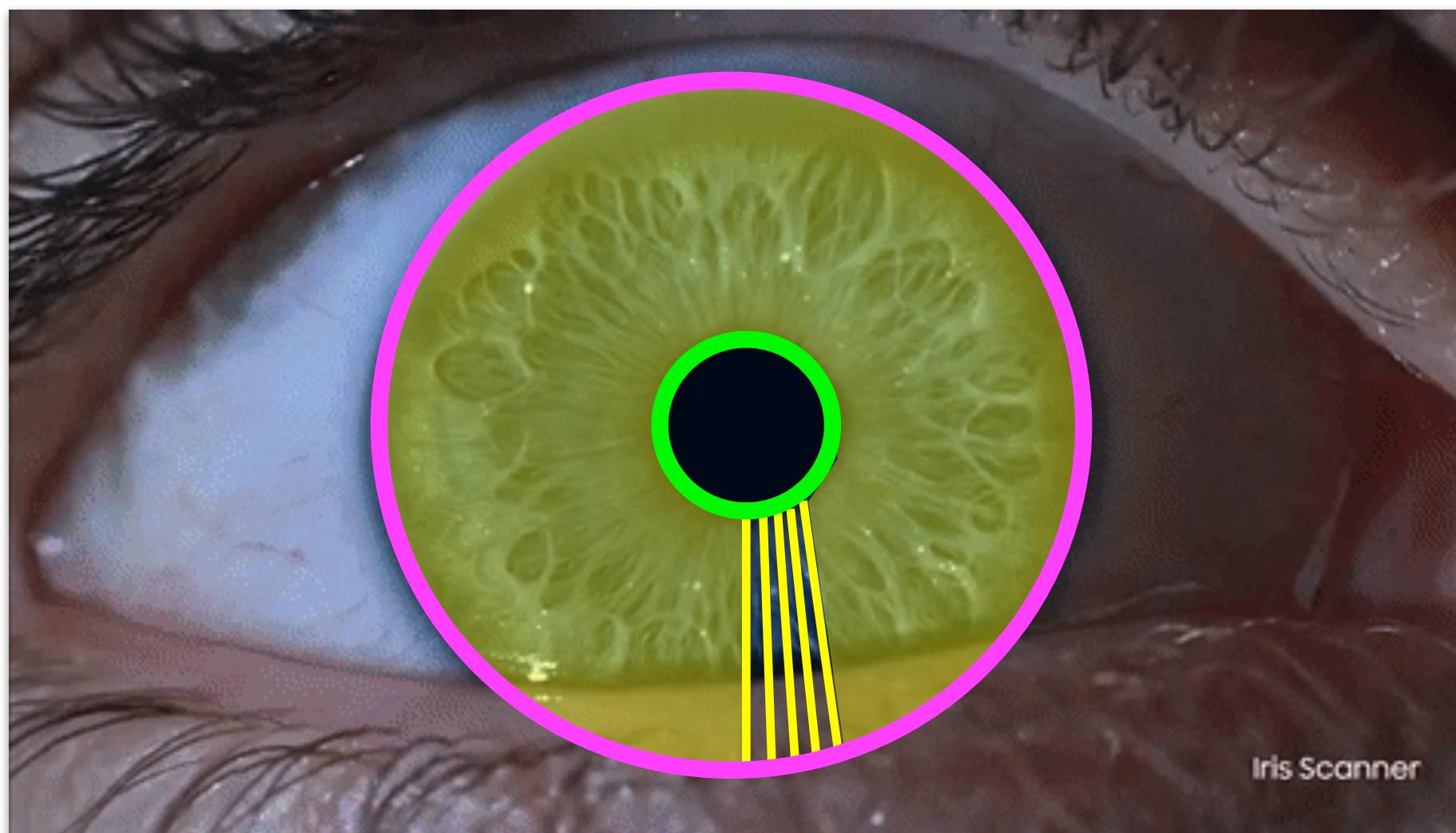
source



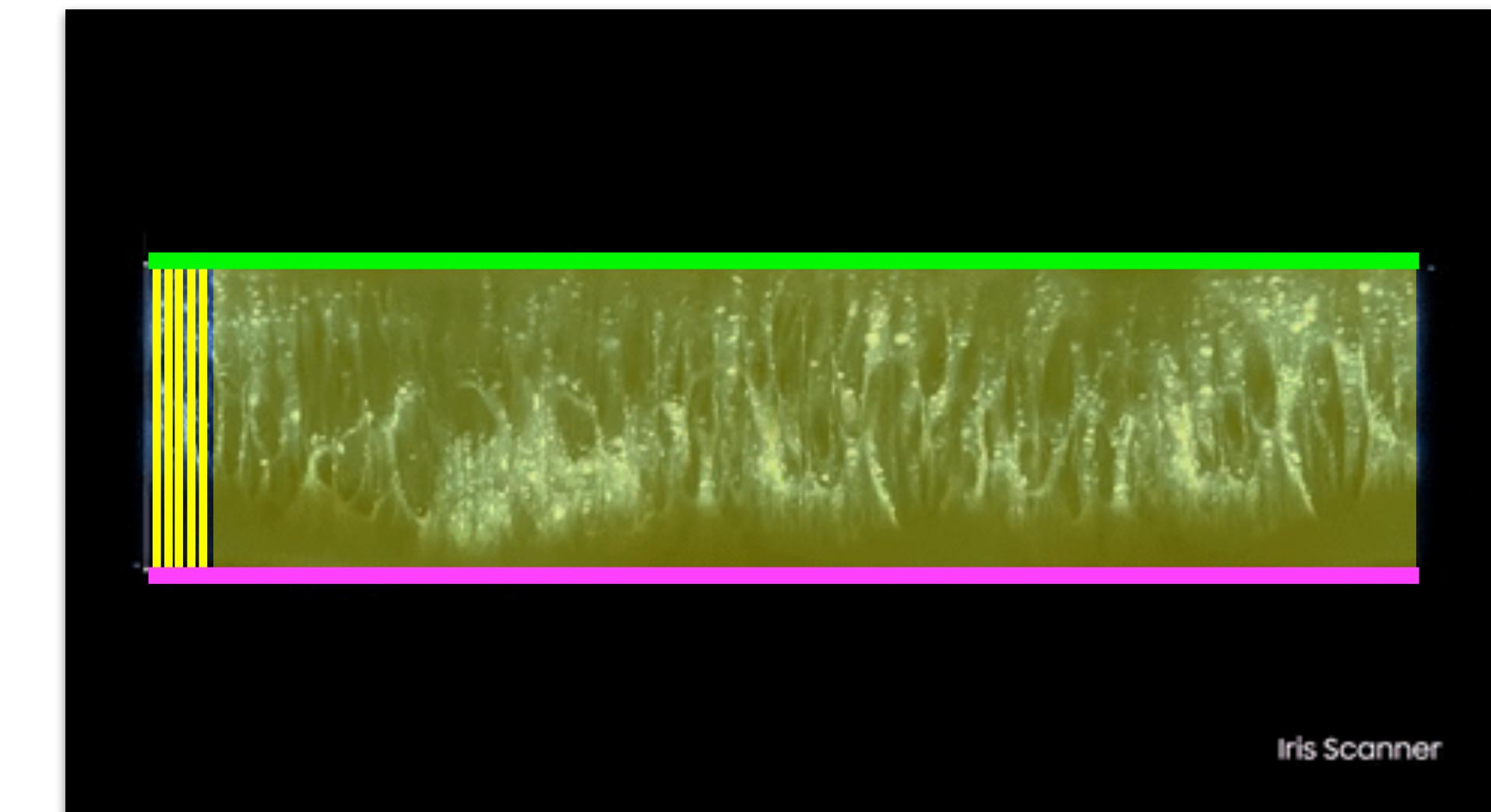
target

Enhancement

Normalization (2/2)

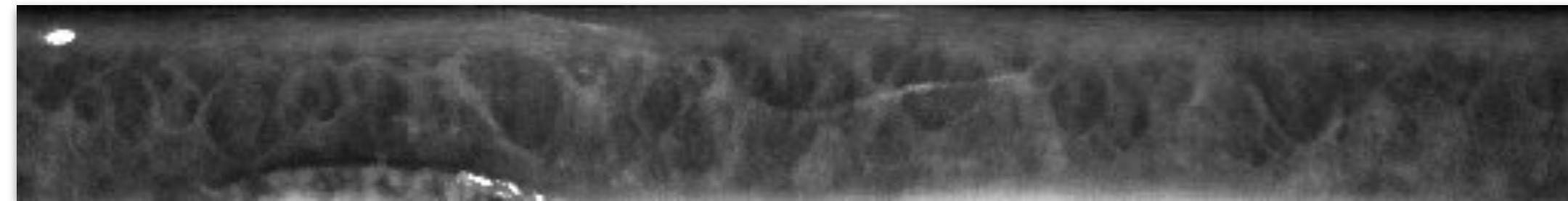
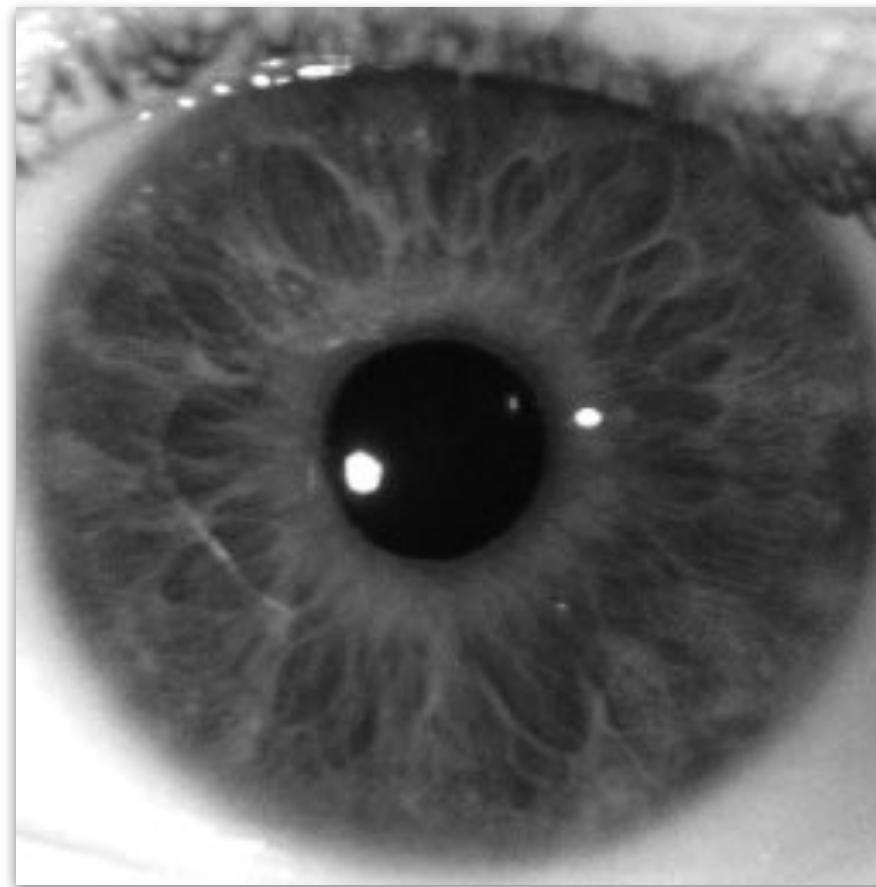


source



target

Enhancement



Enhancement

Limitations

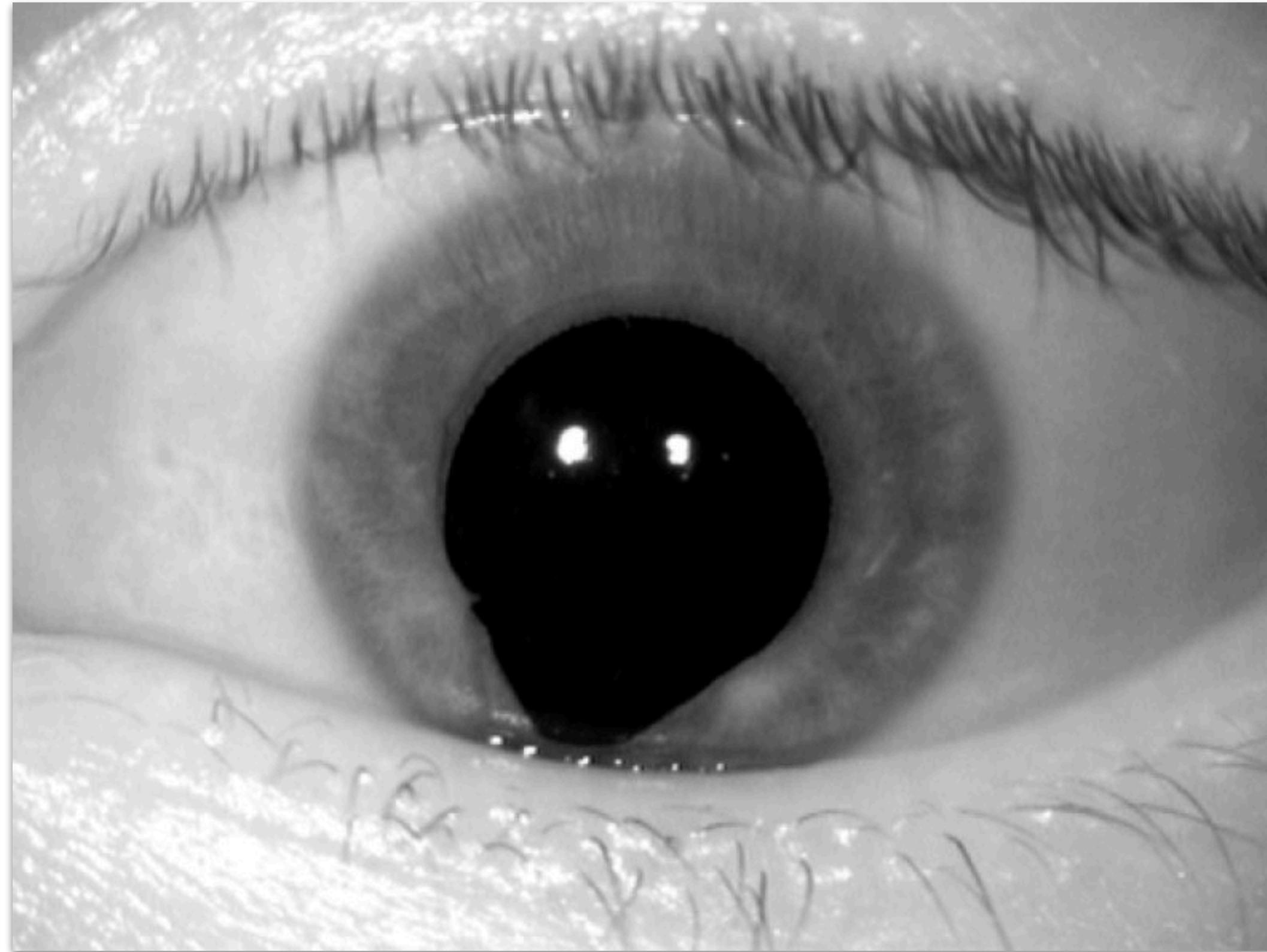
Segmentation

Pupil and iris are not concentric
(pupils are slightly shifted to the nasal corner).
They are not perfectly round.



Enhancement

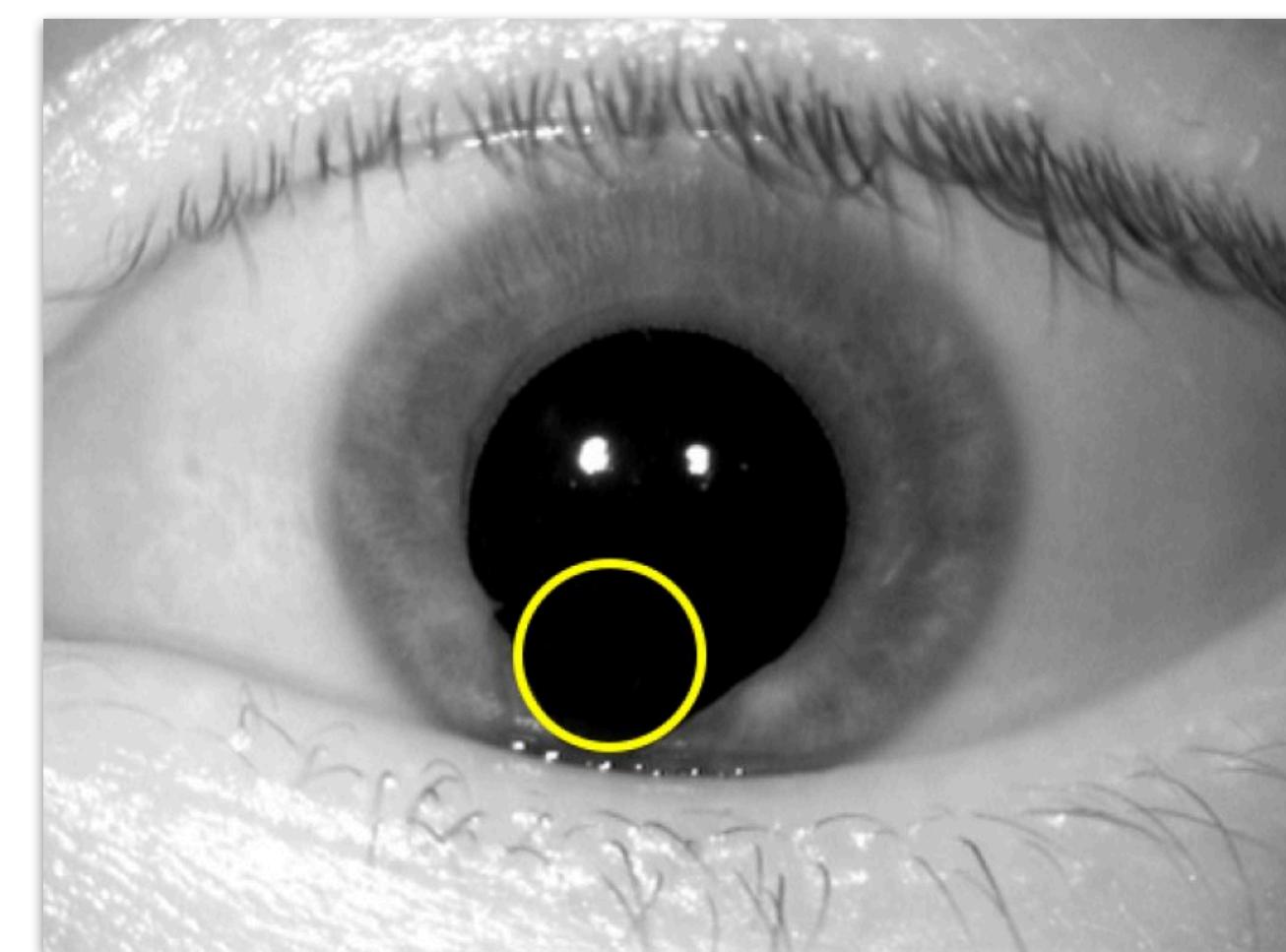
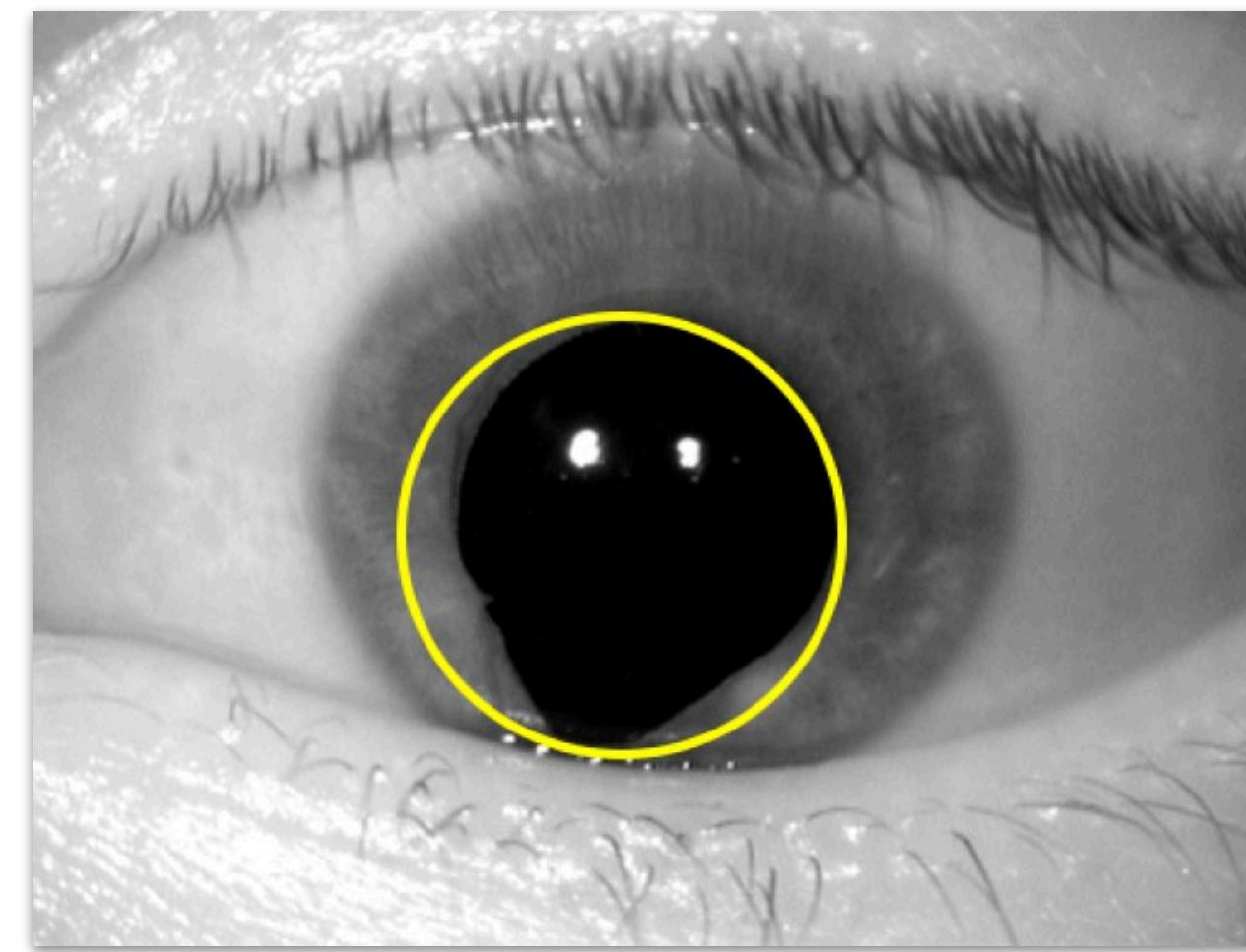
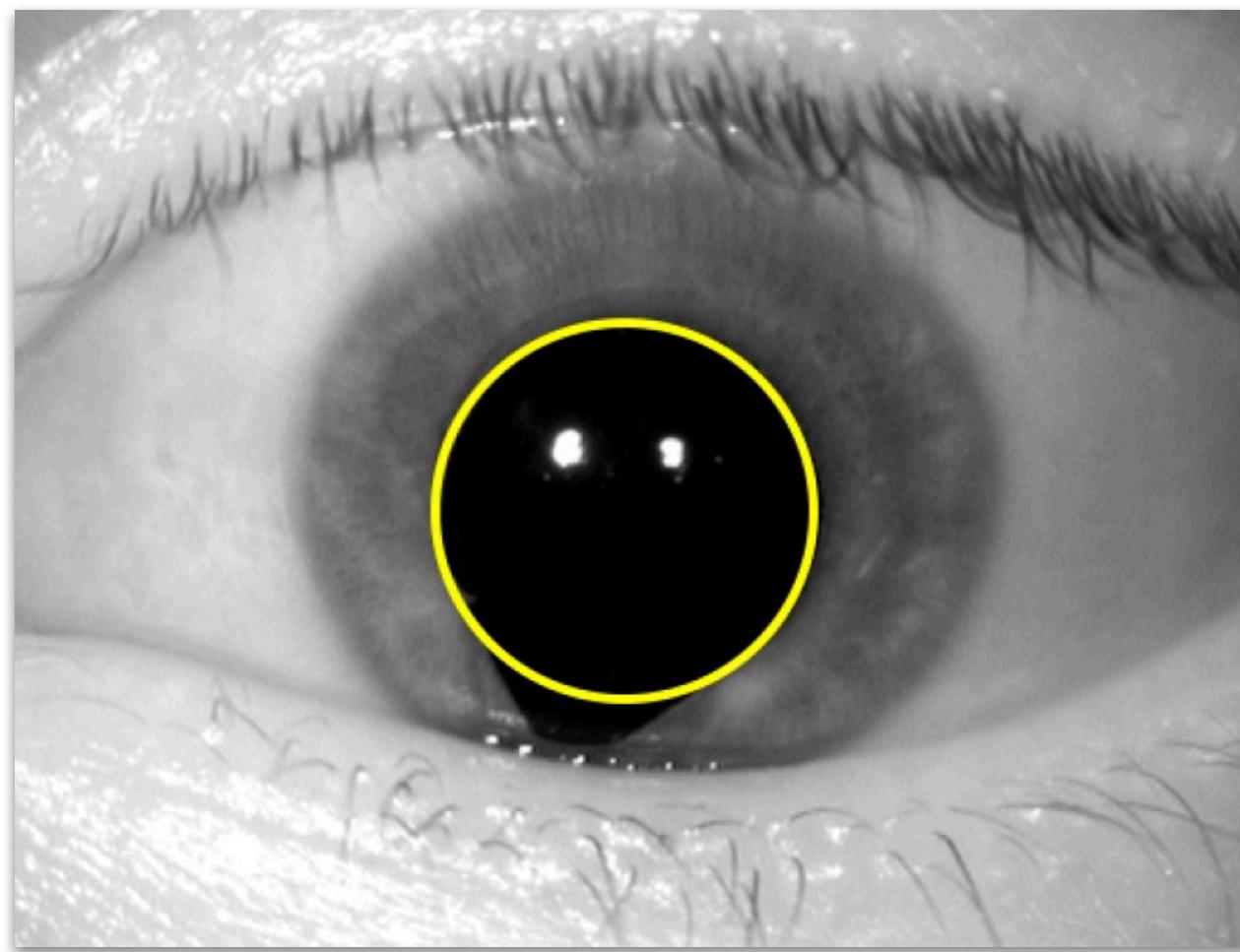
Dr. Adam Czajka



coloboma condition

Enhancement

Dr. Adam Czajka

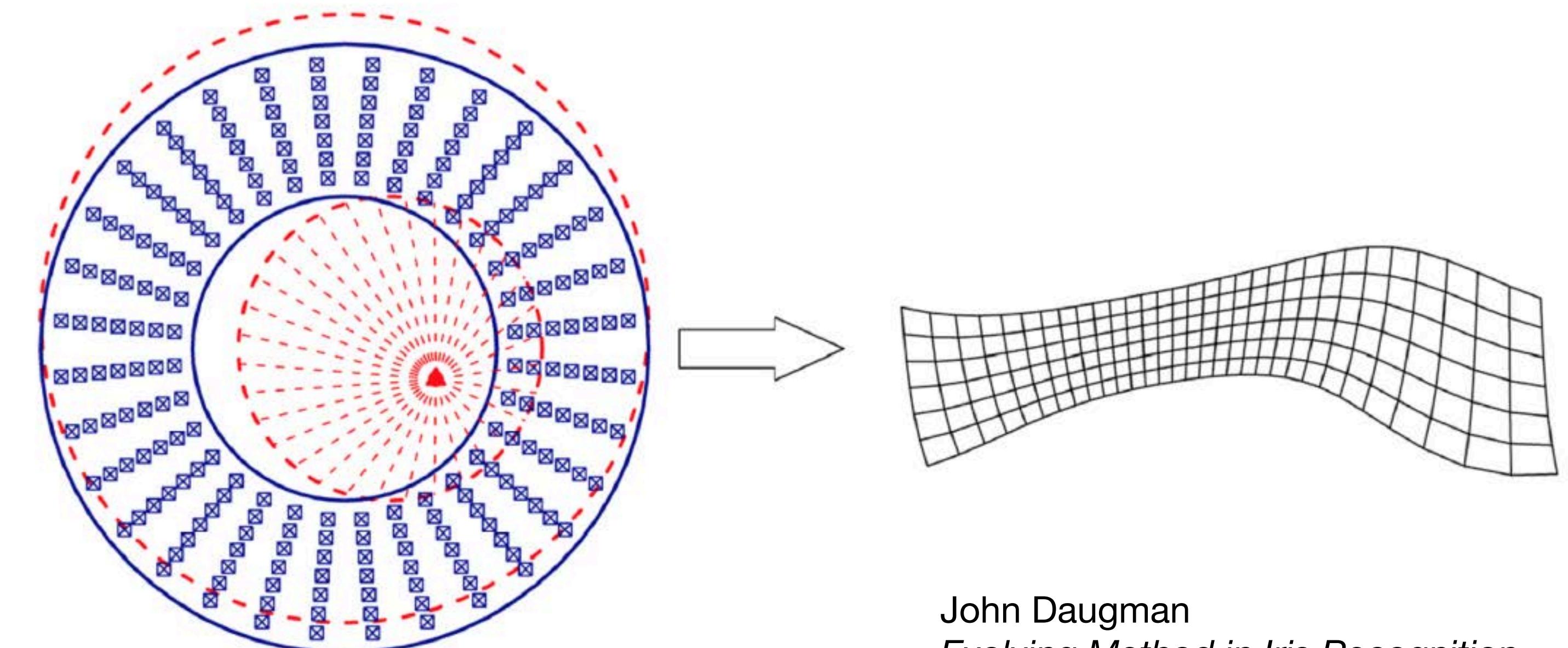


Enhancement

Limitations

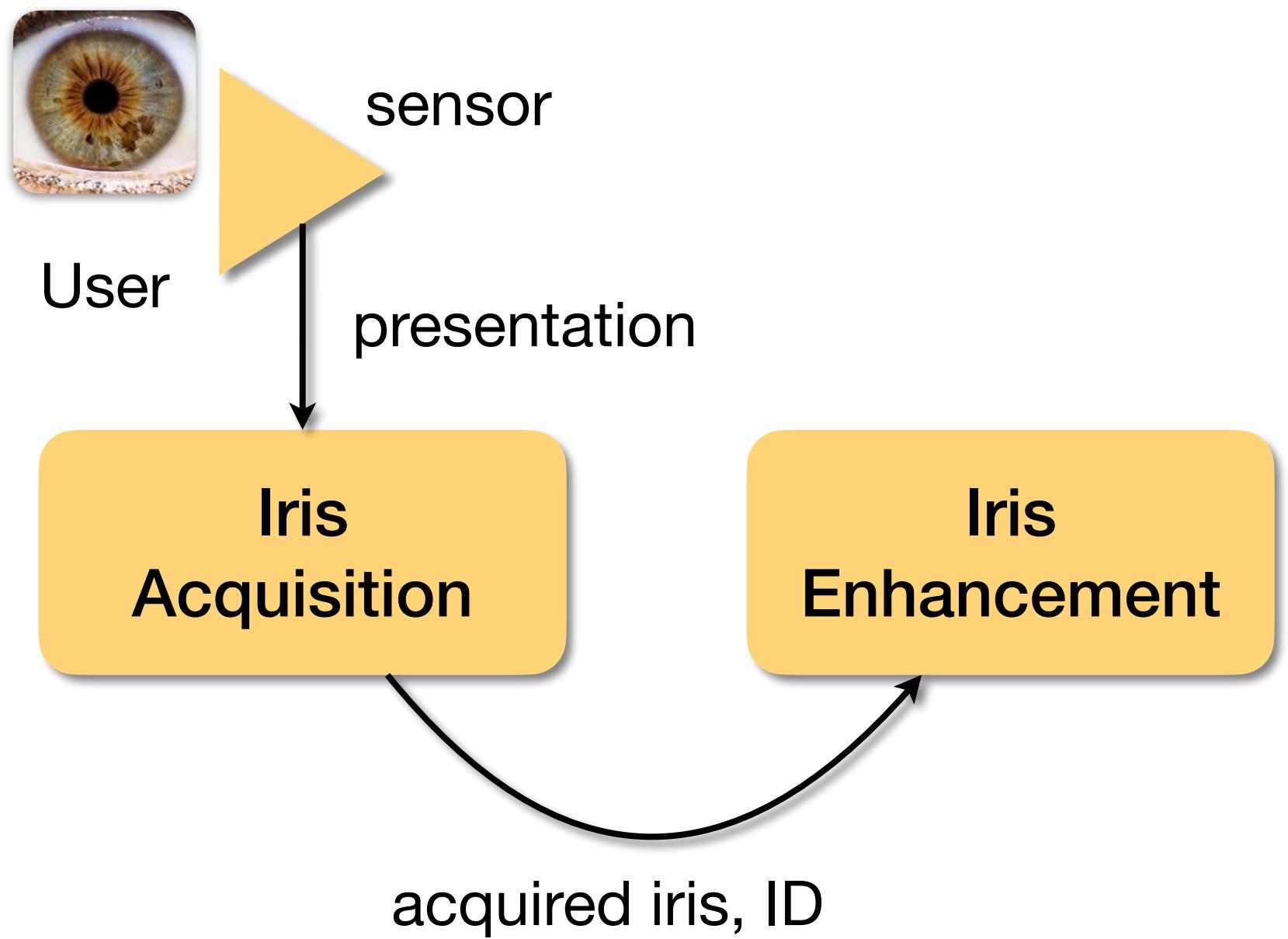
Normalization

Forcing circular models
may lead to poor mapping.

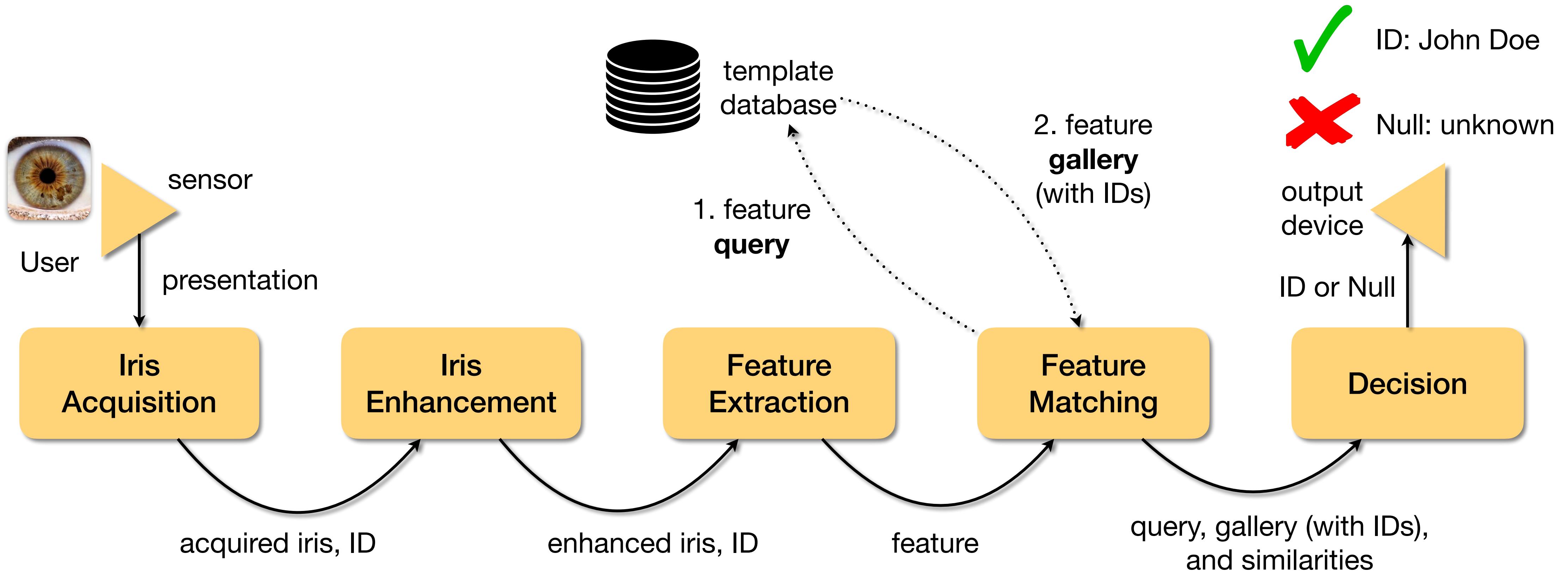


John Daugman
Evolving Method in Iris Recognition
BTAS, 2012

Iris Recognition



Iris Recognition



What's Next?

**Iris Description and
Matching**

**Fill out your
Today-I-missed Statement**
Please visit
<https://sakai.luc.edu/x/PnQvIG>.

