# Iris Recognition II

COMP 388-002/488-002 Biometrics

**Daniel Moreira**

Fall 2024


LOYOLA
UNIVERSITY CHICAGO

# Today we will…

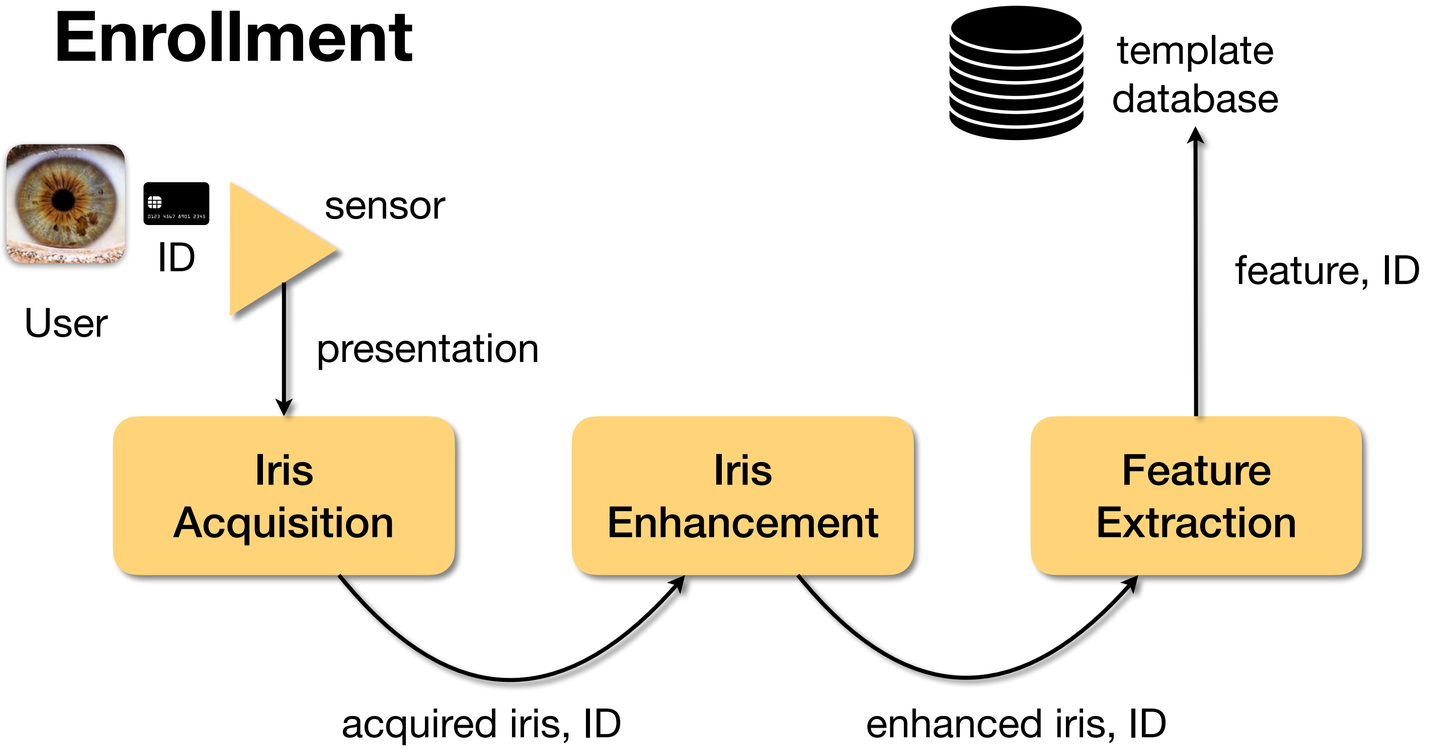
*Get to know*
Iris acquisition and enhancement.

# Today’s Attendance

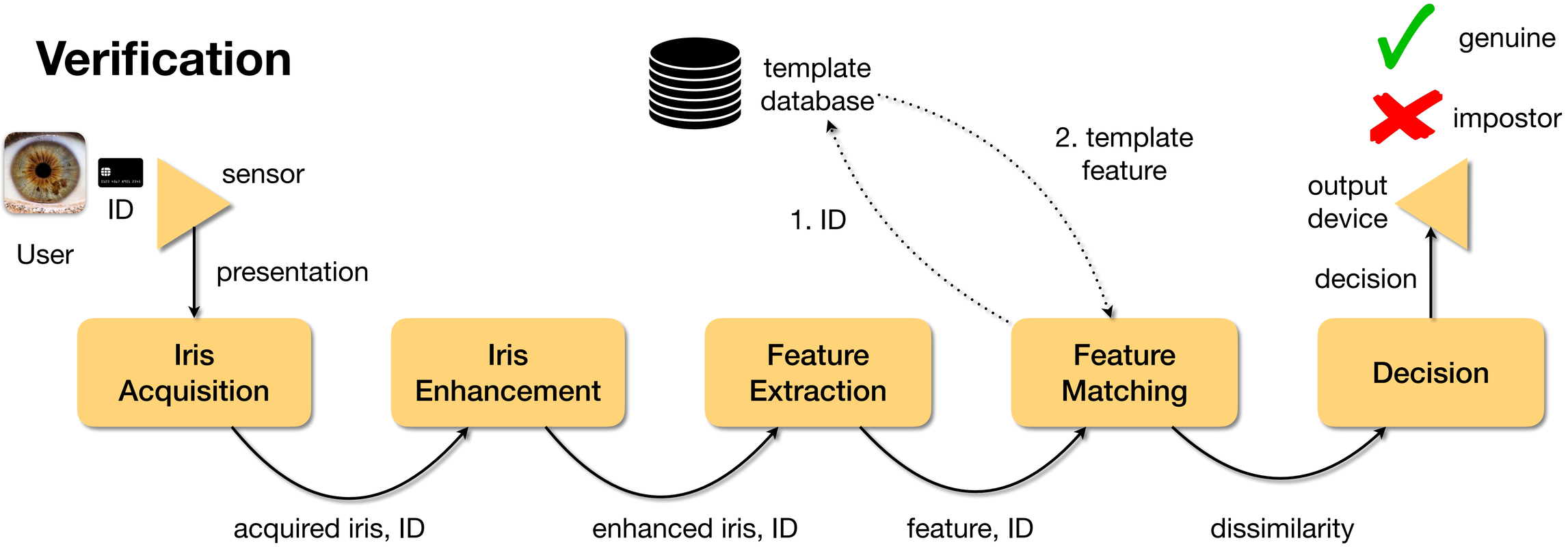
**Please fill out the form**

https://forms.gle/LwQxV9ZoKeVwwnWZ8

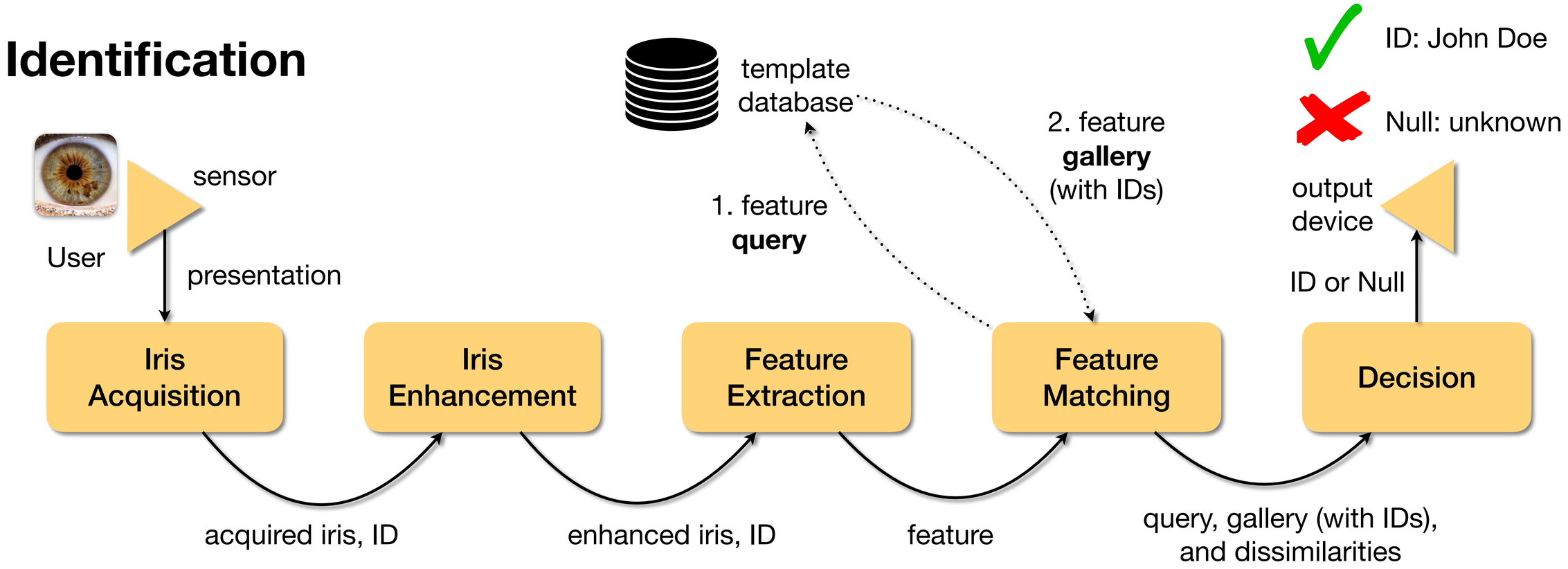
# Iris Recognition



# Iris Recognition



# Iris Recognition



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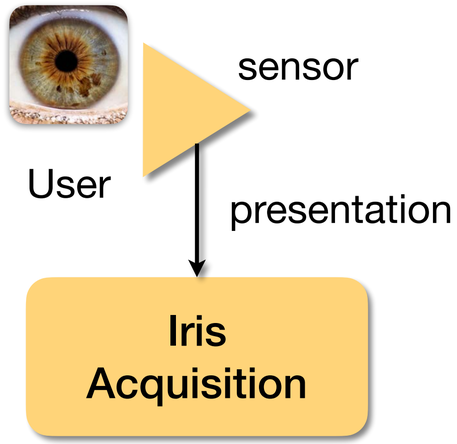
# Iris Recognition



# Acquisition

## On-line

Schiphol Airport

## Off-line

?

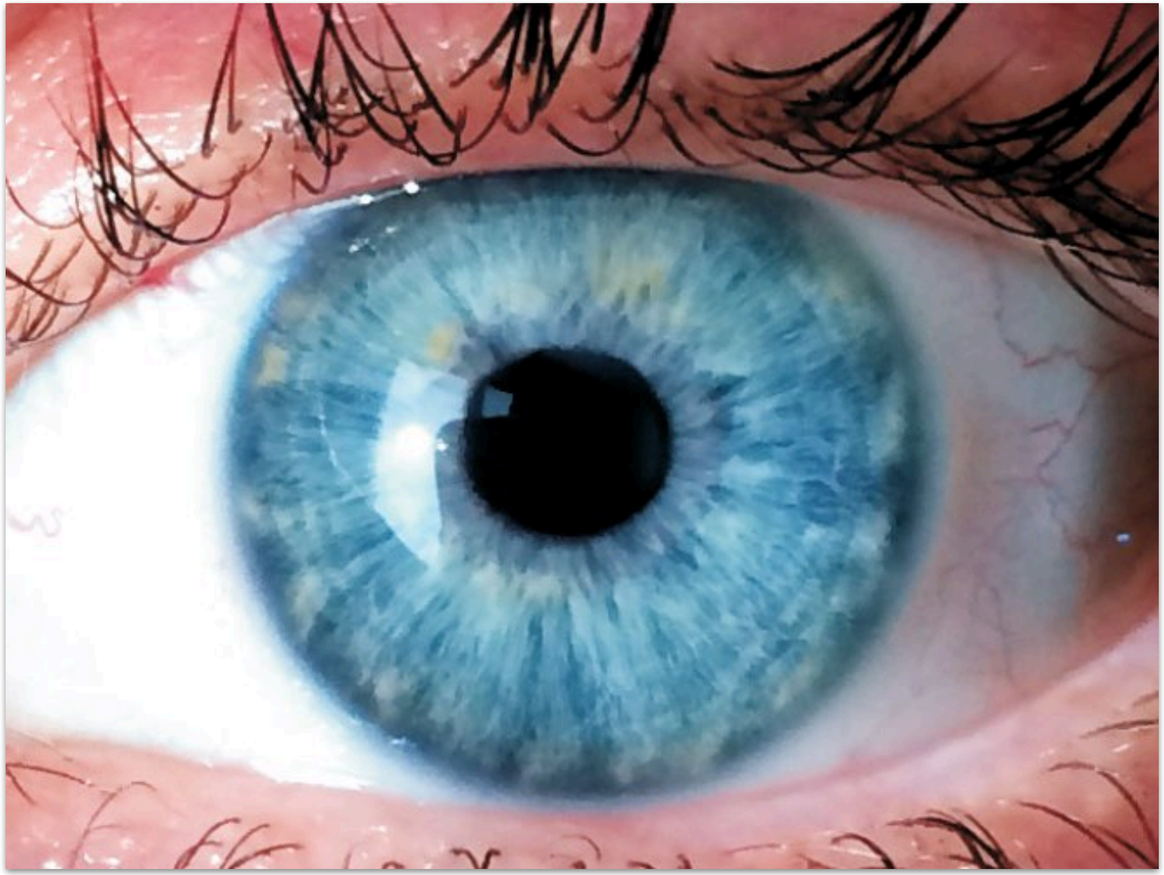
It depends on the resolution and angle of capture.

# Acquisition

**Iris Capture**
Visible light.

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

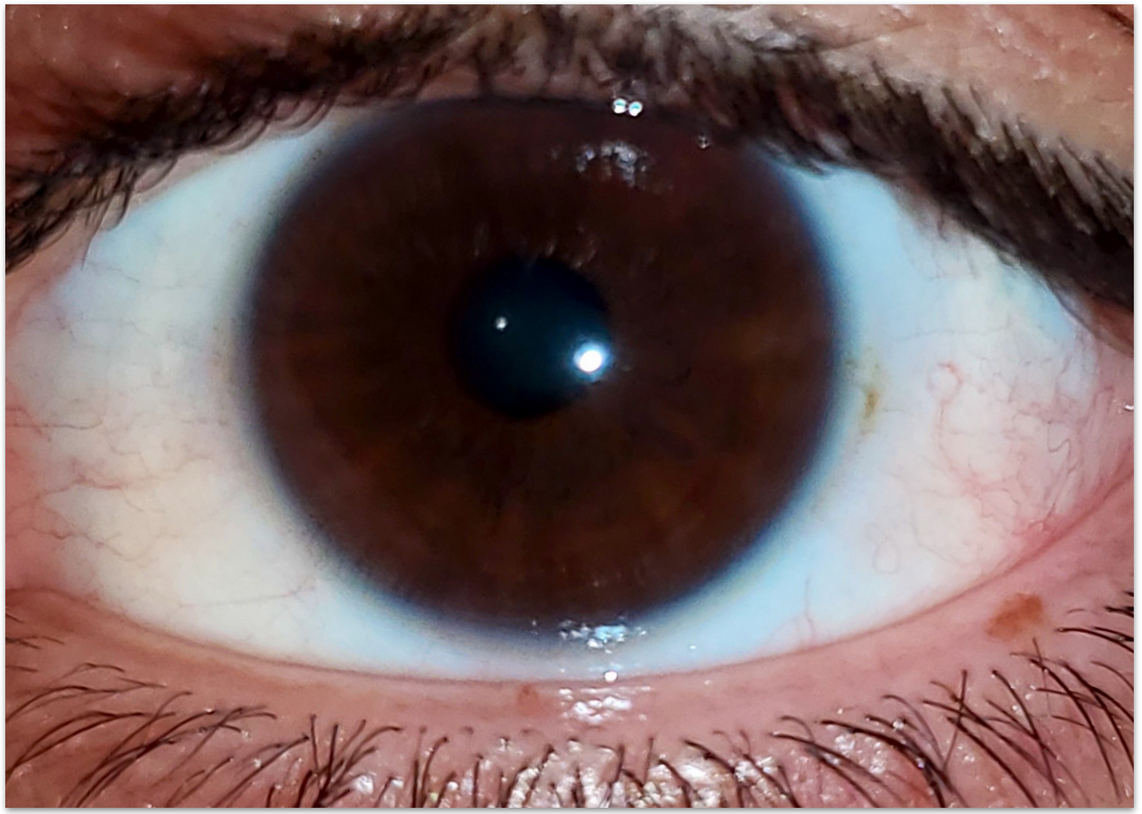
Dr. Adam Czajka



# Acquisition

**Iris Capture**
Visible light.

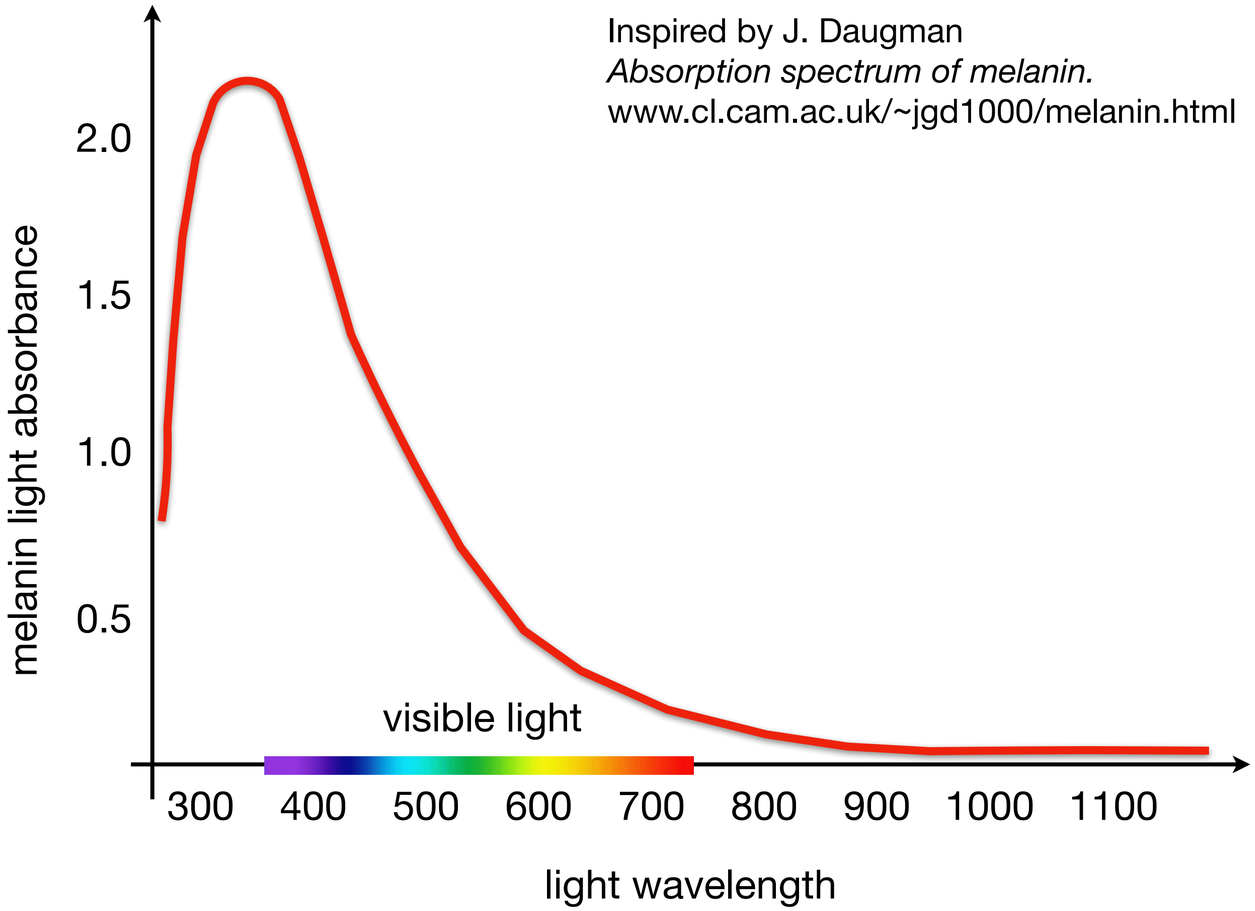
Can you see the iris texture (crypts, furrows, and collarette)?



# Acquisition

**Iris Capture**
Visible light.

Melanin poses a challenge to visible-light iris recognition.




Inspired by J. Daugman
*Absorption spectrum of melanin.*
www.cl.cam.ac.uk/~jgd1000/melanin.html



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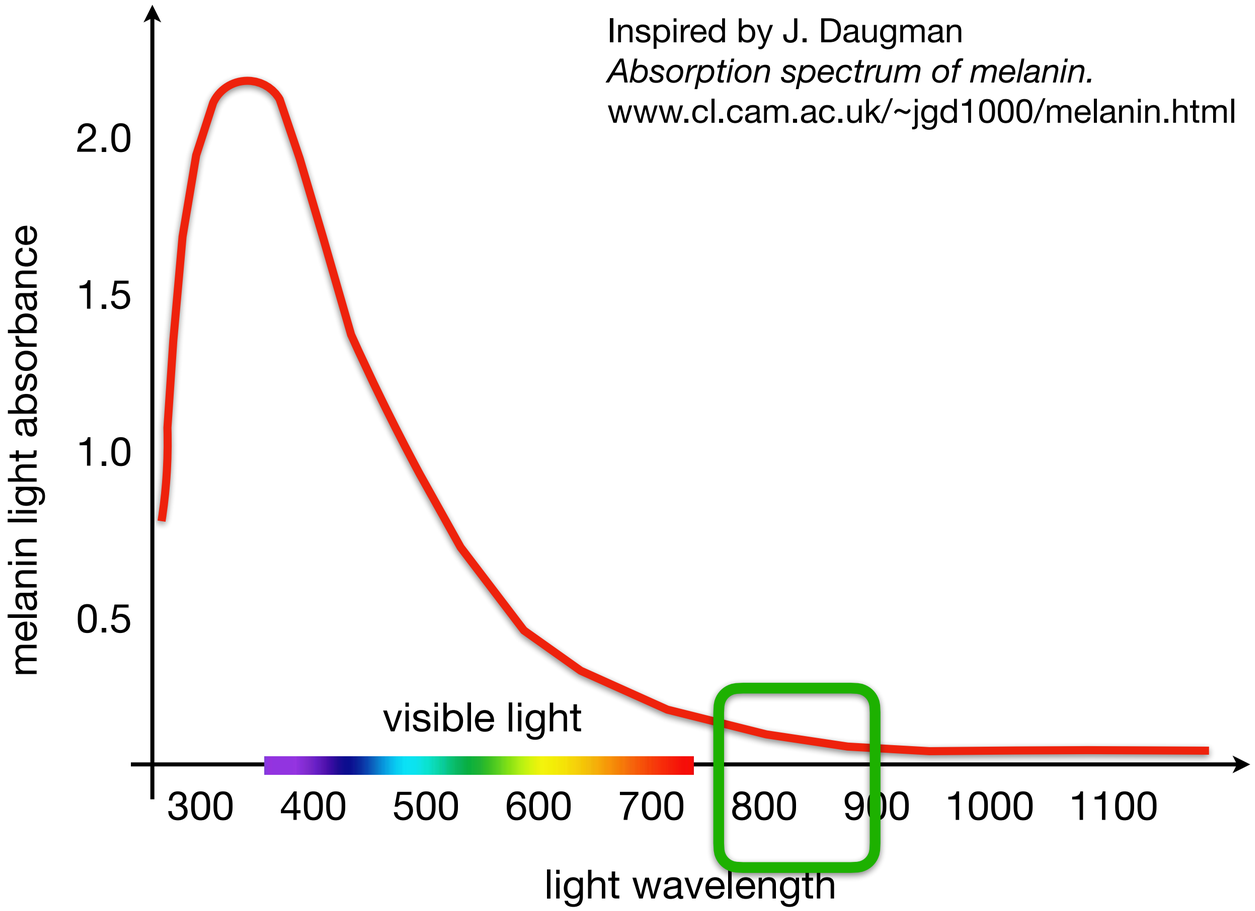
# Acquisition

**Iris Capture**
Solution: near-infrared (NIR) light.

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



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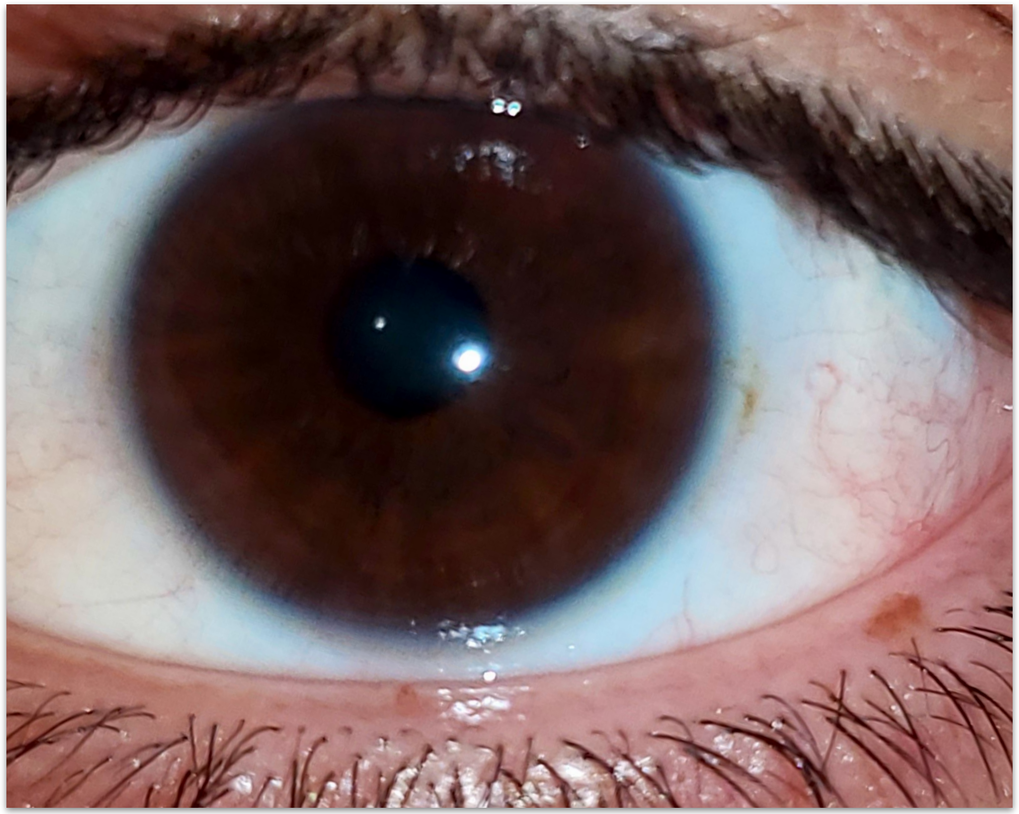
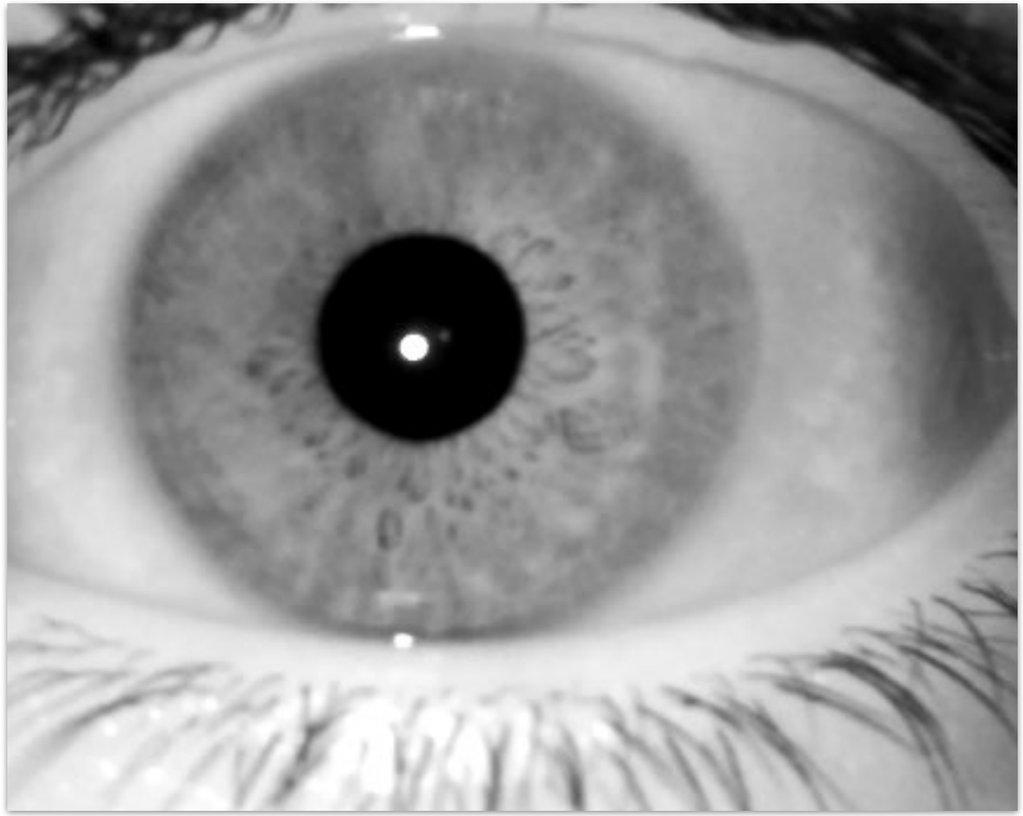
# Acquisition



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 ($MPE$):

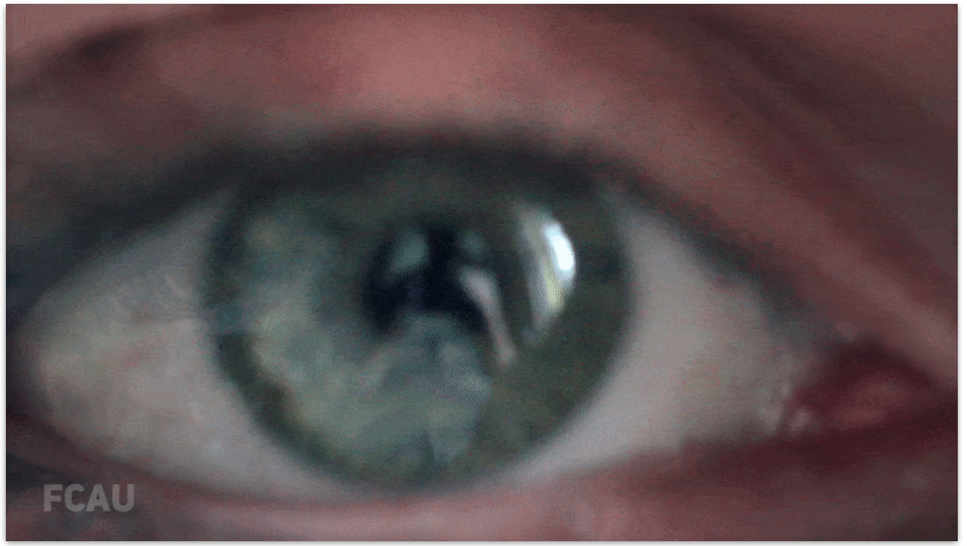
$$MPE < 0.1 \times MPE_{max}$$

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.

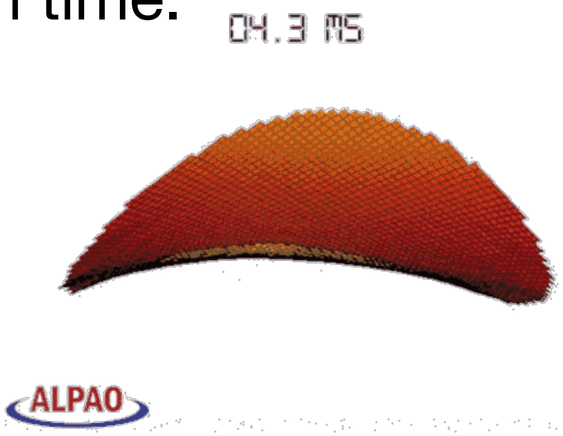
https://www.youtube.com/watch?v=bolNgCrCZW0


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

# Acquisition

**Sensors**
With almost no cooperation.

**Deformable Mirrors**
Similar to astronomical telescopes.
Fast adaptation at presentation time.
Capture at 1.5-2.5m
of distance.




Dr. Adam Czajka


AOptix Insight SD, 2008

# Acquisition

**Sensors**
Current trend: miniaturization.

**Example 1**
Android-based
*Fidelys* smartwatch.


linuxgizmos.com/
worlds-first-iris-recognition-smartwatch-runs-android

# Acquisition

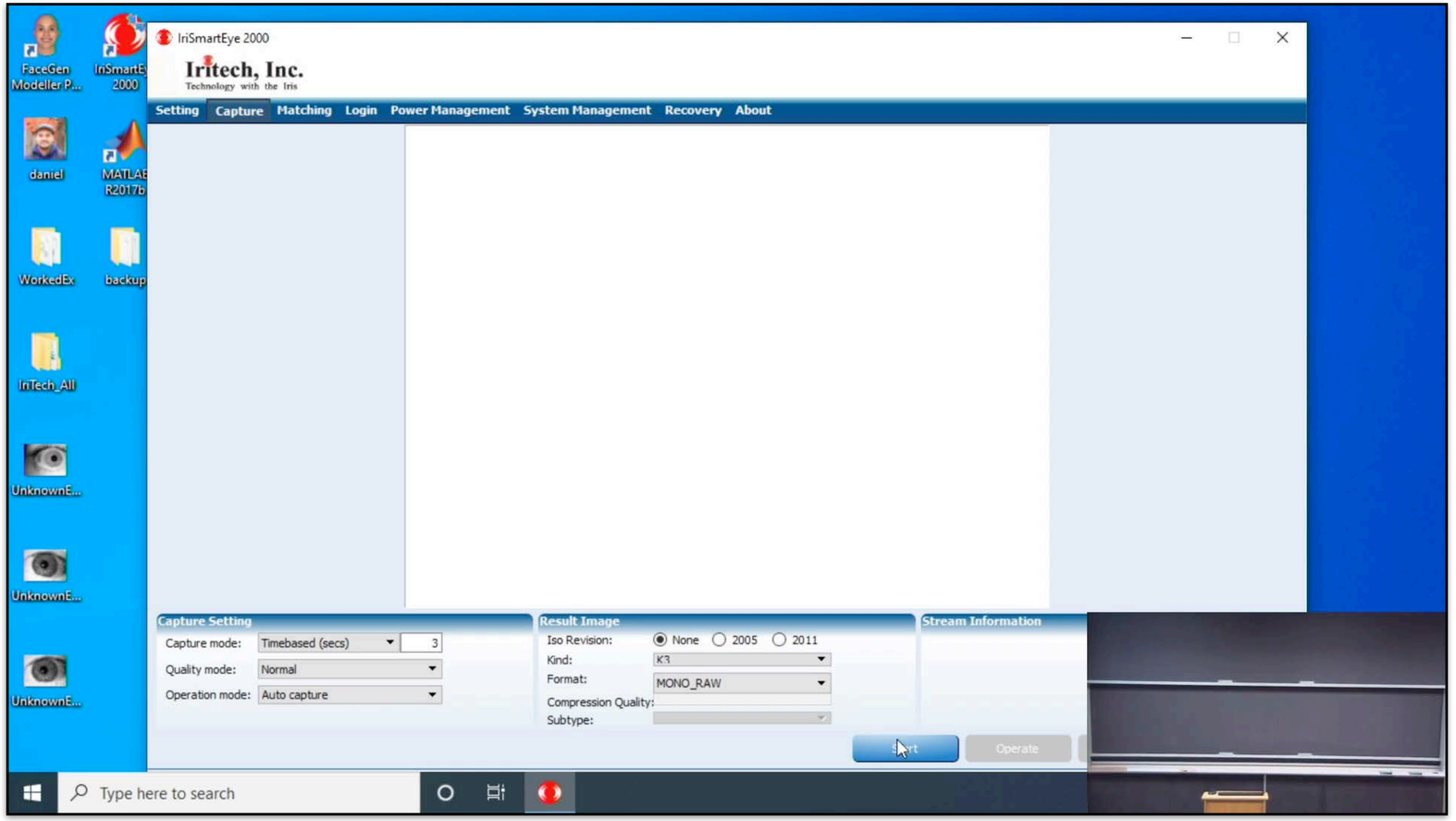
**Sensors**
Current trend: miniaturization.

**Example 2**
IriShield USB

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


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

# Acquisition



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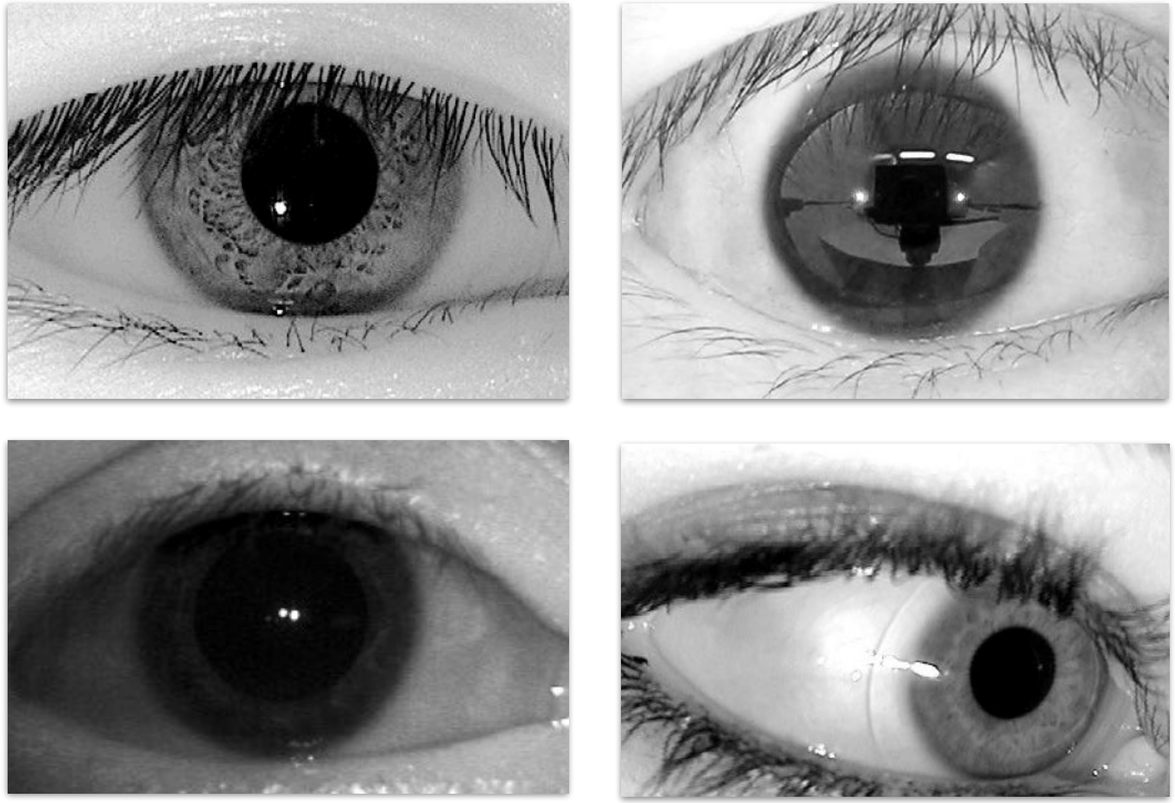
# Acquisition

**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.

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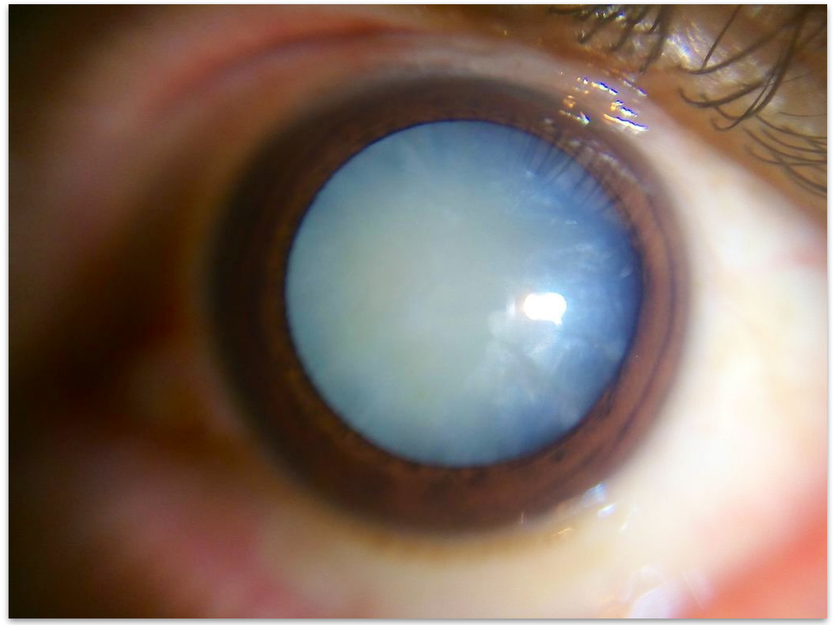
# Acquisition

**Challenges**

**Diseases**
E.g., cataracts, conjunctivitis.
Is iris visible?
Is the disease contagious?

commons.wikimedia.org



E.g., cataracts.

# Acquisition

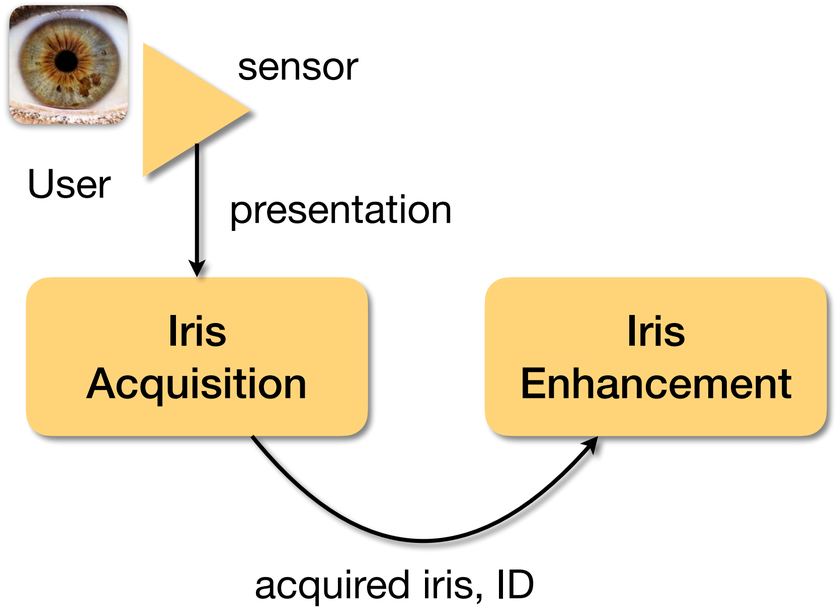
**Challenges**

**Attacks**
Obfuscation with texturized contact lenses.

Presentation attack.

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

# Iris Recognition

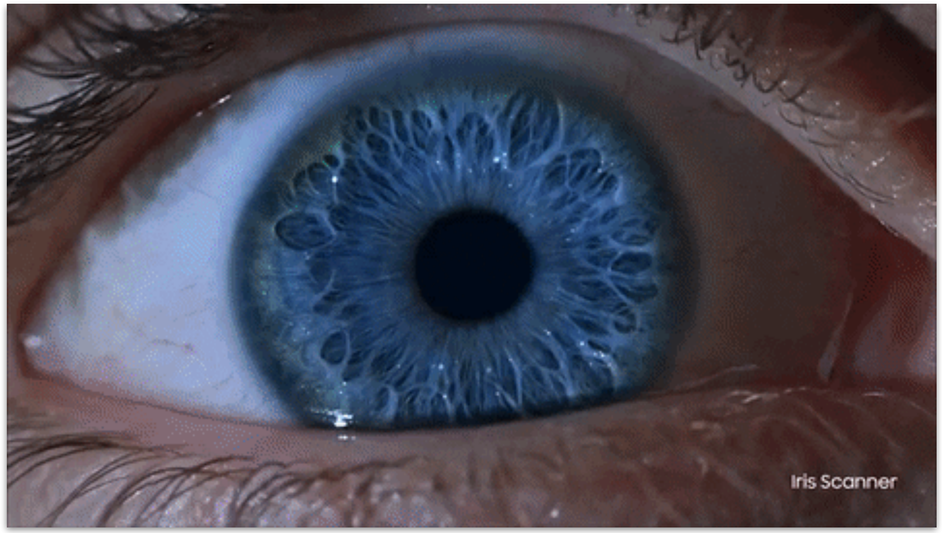


# Enhancement

**Steps**

**Segmentation**
Keep only useful information
(iris texture).

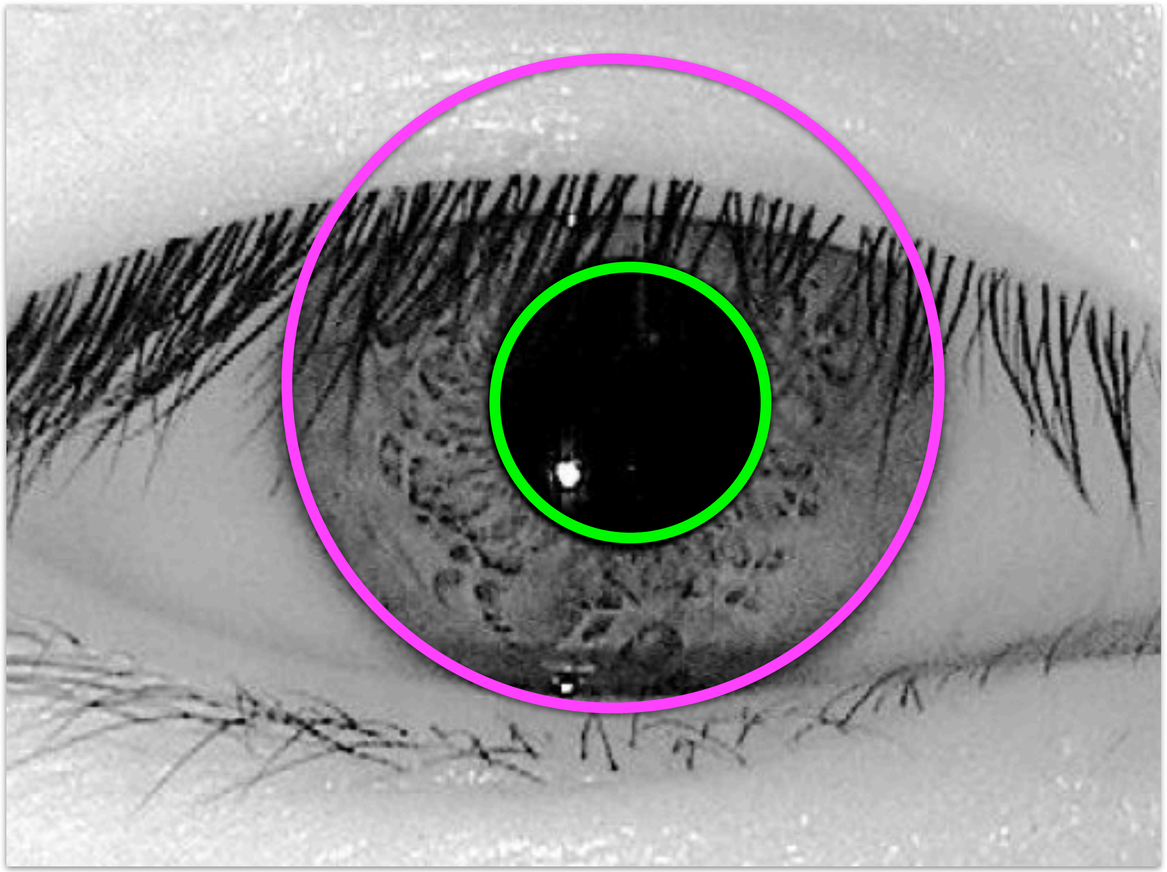
**Normalization**
Make different captures of the same
iris look as similar as possible.



# Enhancement

**Segmentation (1/2)**

**Iris and Pupil Localization**
Localize limbus and pupillary boundaries.



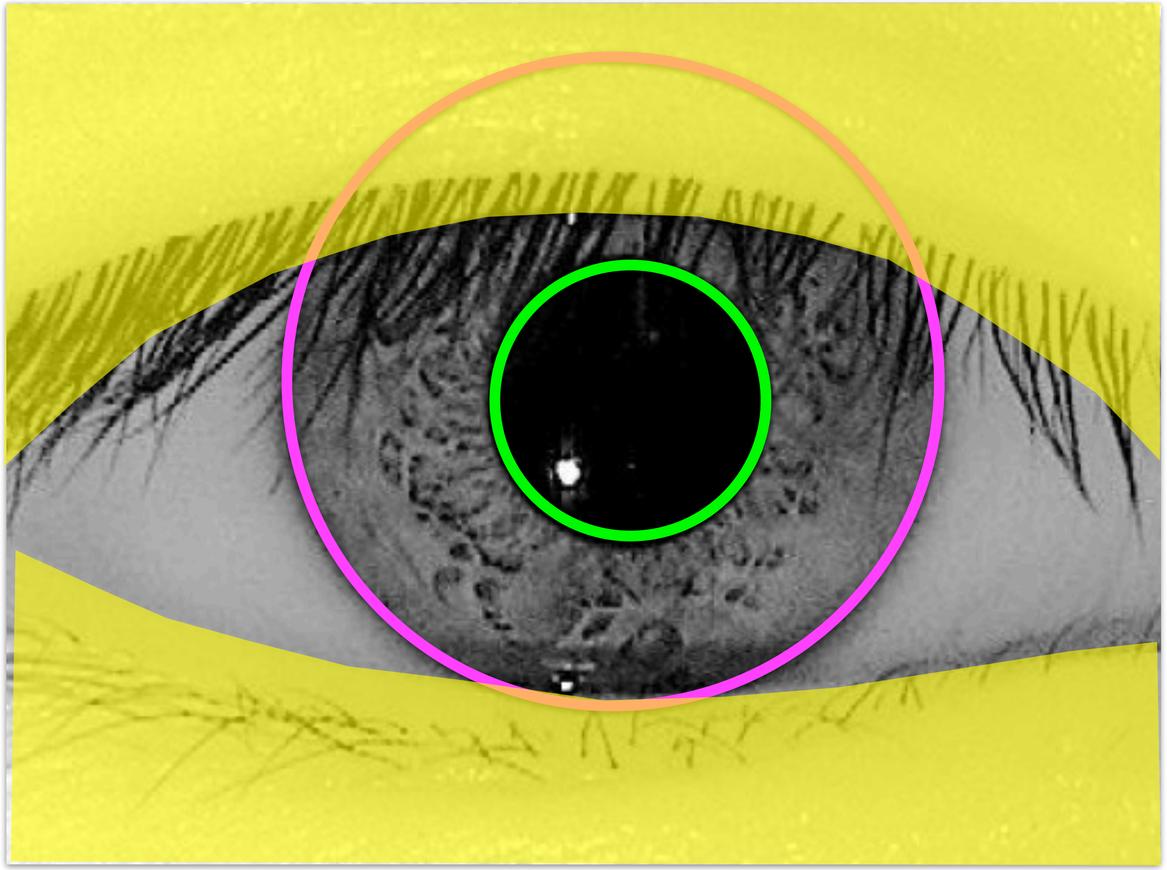
http://www.cse.nd.edu/BTAS_07/John_Daugman_BTAS.pdf

# Enhancement

**Segmentation (1/2)**

**Iris and Pupil Localization**
Localize limbus and pupillary boundaries.

**Eyelid, Eyelash, and Specular Reflection Detection**
Deal with iris texture occlusions.



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# Enhancement

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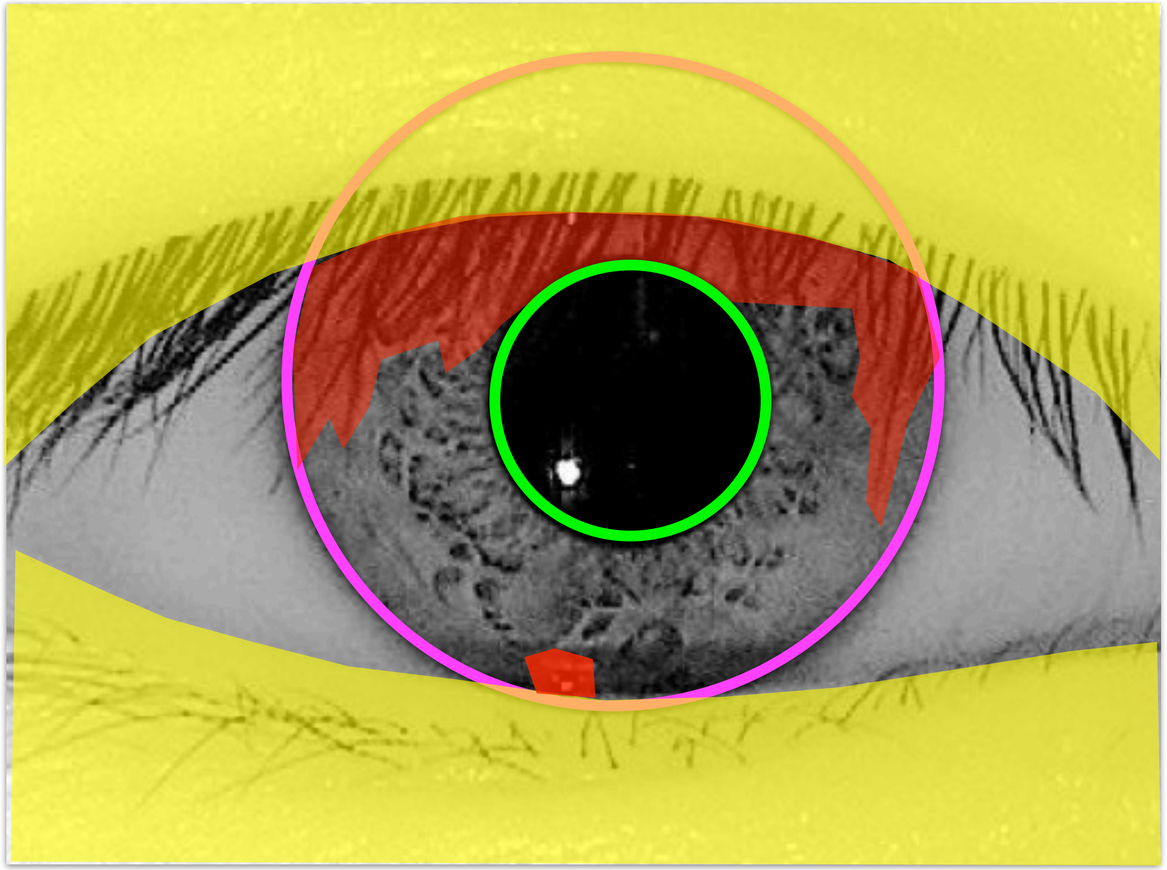


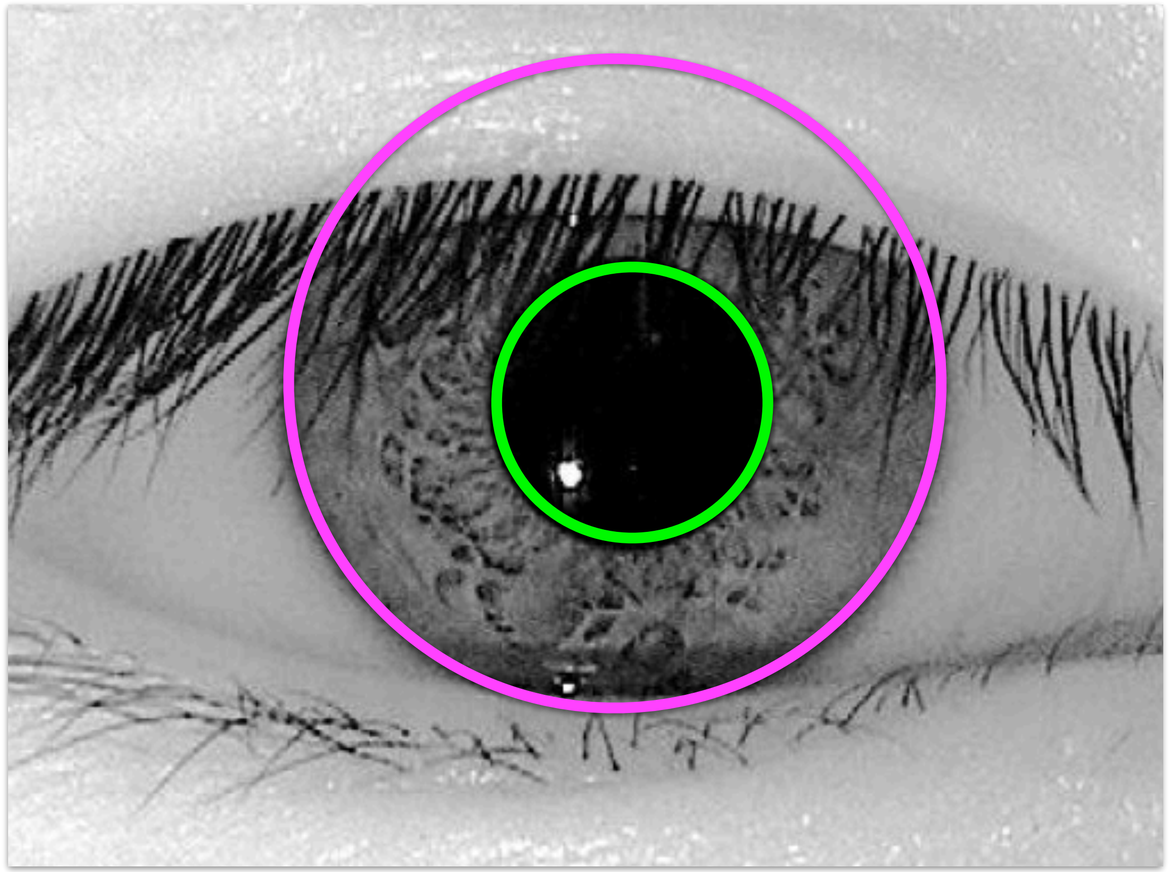
http://www.cse.nd.edu/BTAS_07/John_Daugman_BTAS.pdf

# 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.



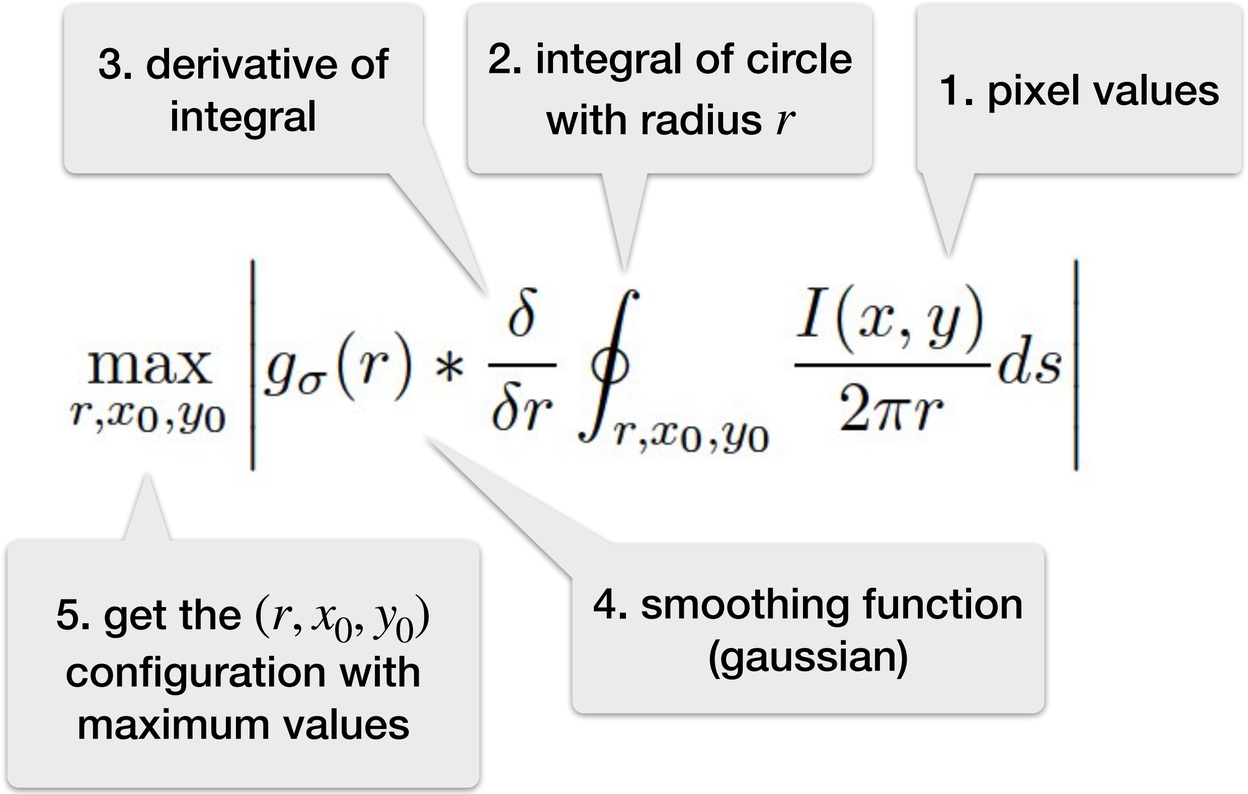
http://www.cse.nd.edu/BTAS_07/John_Daugman_BTAS.pdf

# Enhancement

**Segmentation (1/2)**

**Iris and Pupil Localization**
Method 1: Integral-differential operator

Strategy:
Try various values for $(r, x_0, y_0)$.



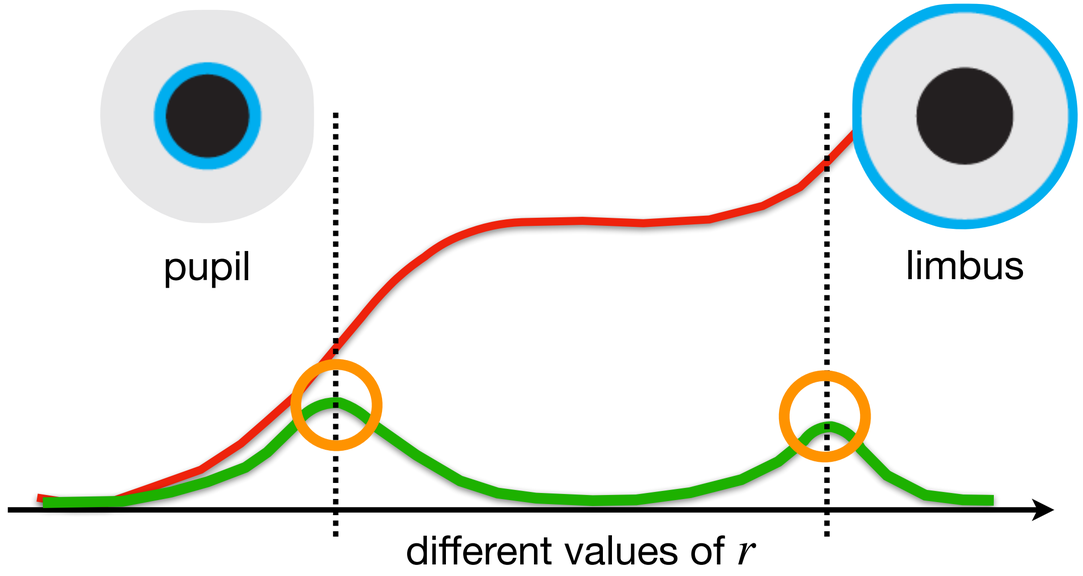
# Enhancement

**Segmentation (1/2)**

**Iris and Pupil Localization**
Method 1: Integral-differential operator

Strategy:
Try various values for $(r, x_0, y_0)$.

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

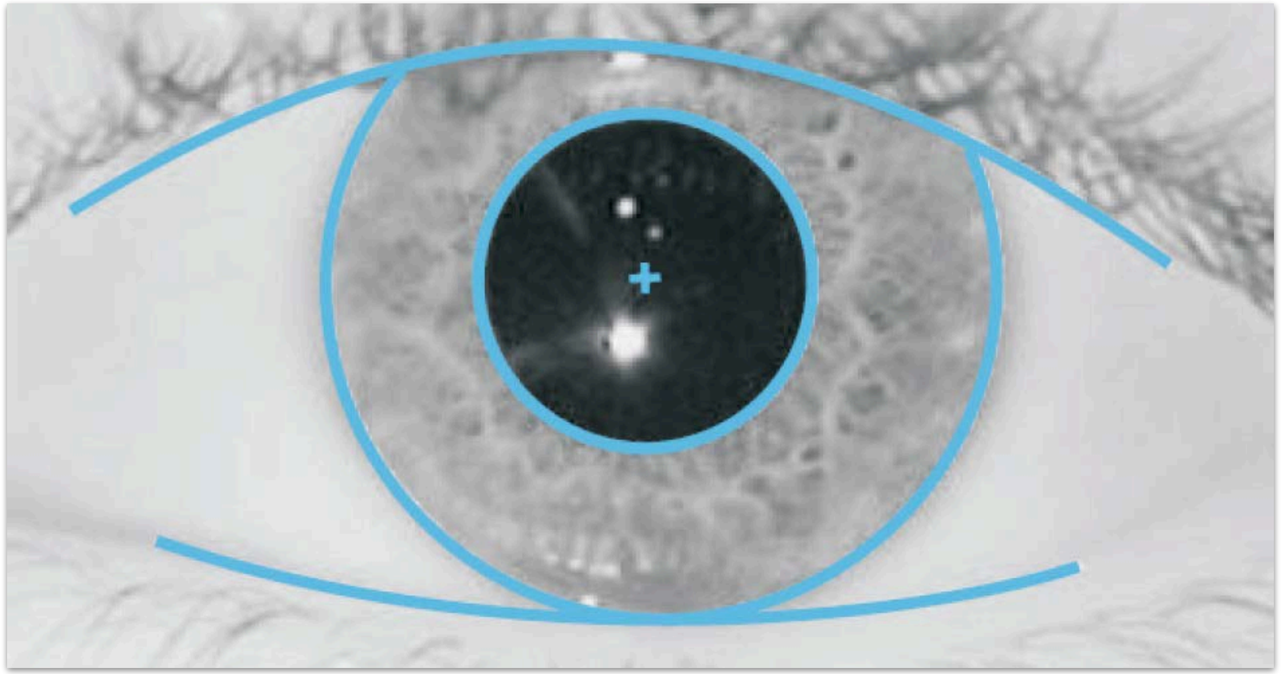


# Enhancement

## Segmentation (1/2)

**Iris and Pupil Localization**
Method 1: Integral-differential operator

J. Daugman
*How Iris Recognition Works*
IEEE TCSVT, 2004

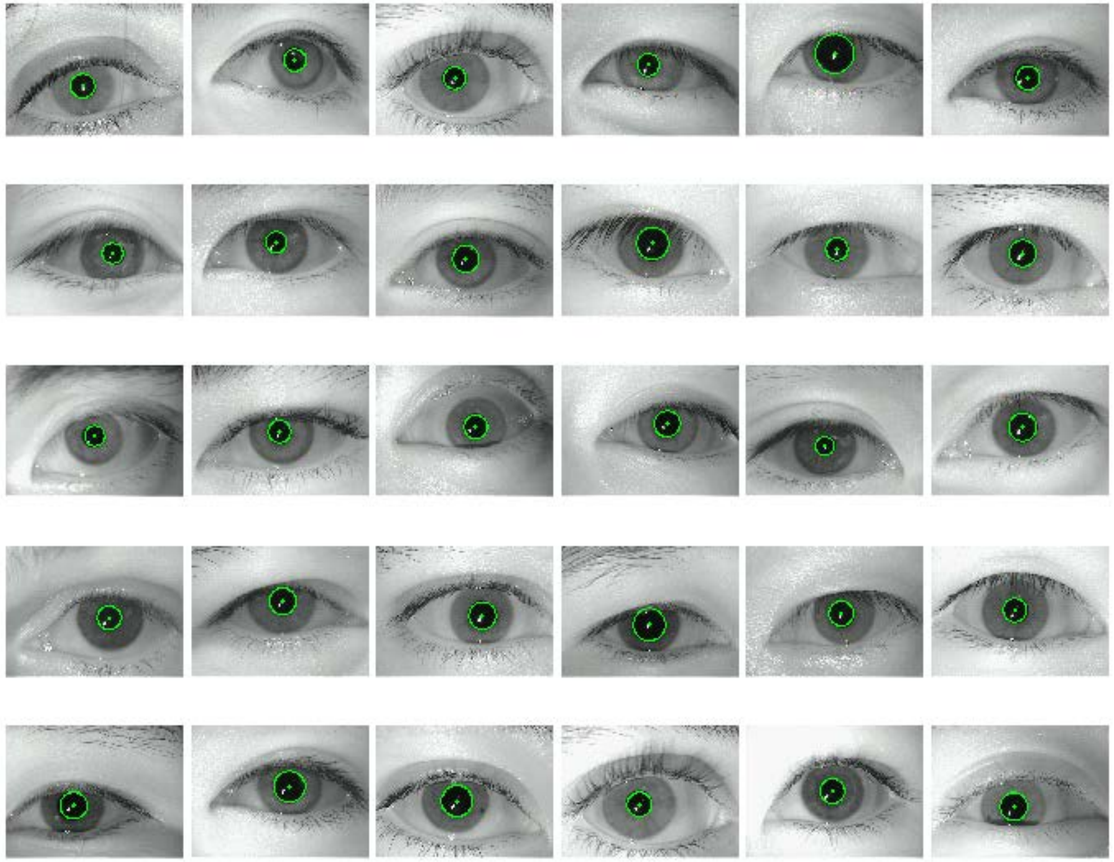


result example

# Enhancement

**Segmentation (1/2)**

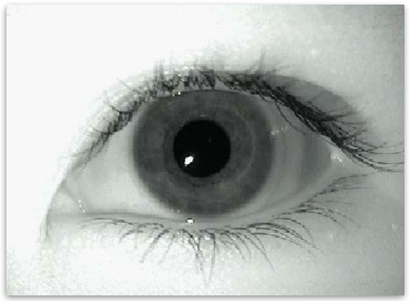
**Iris and Pupil Localization**
Method 2: Image processing ending with Hough circle transform.



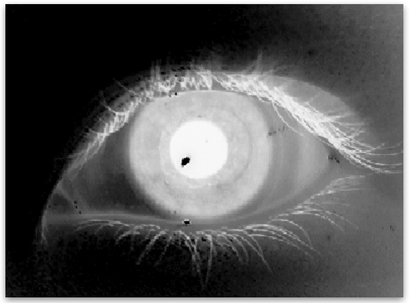
https://github.com/olesia-midiana/iris-recognition-py

# Enhancement

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

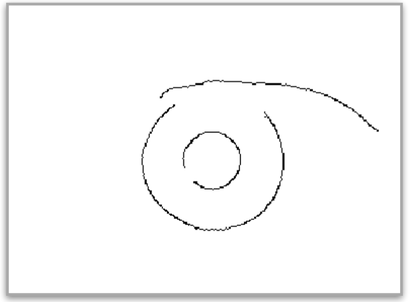


1.grayscale

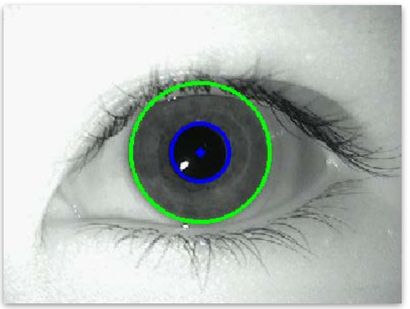


2. inverted

3. median blur



4. Canny edge detector

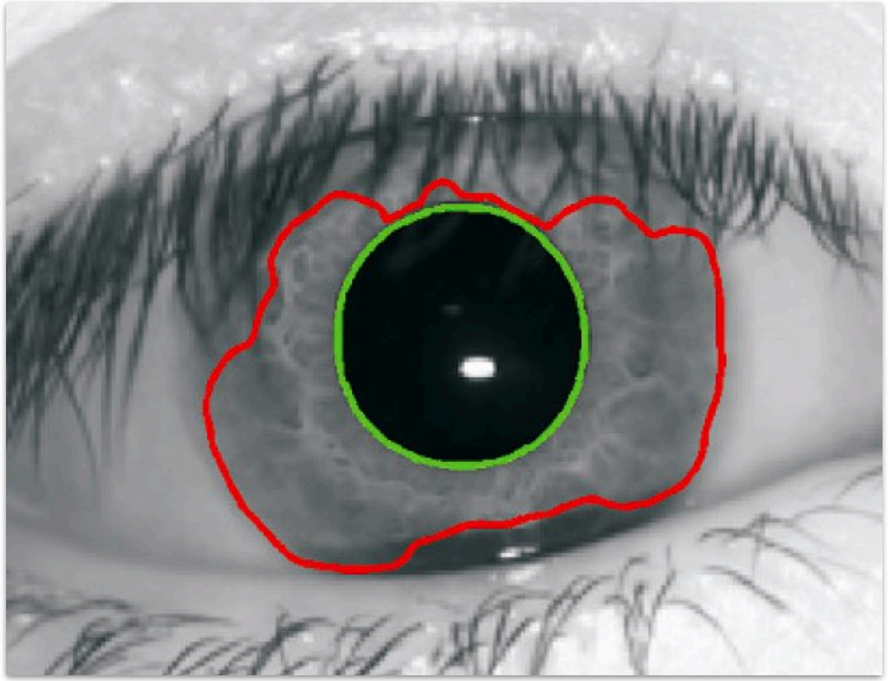


5. Hough circle transform

# 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.

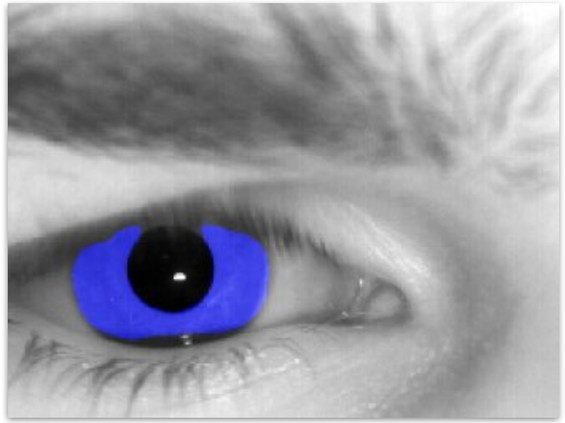


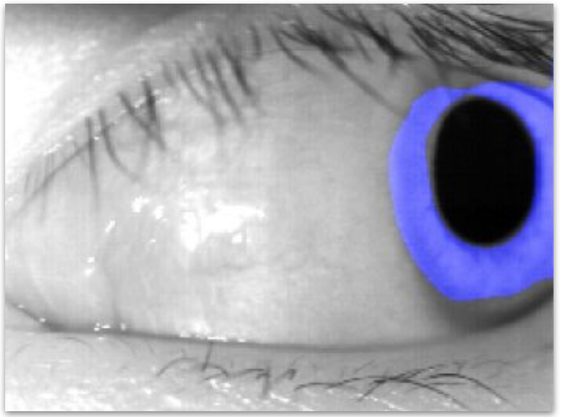
Gutfeter
*Active contours for iris segmentation.*
BSc Thesis, WUT, 2010

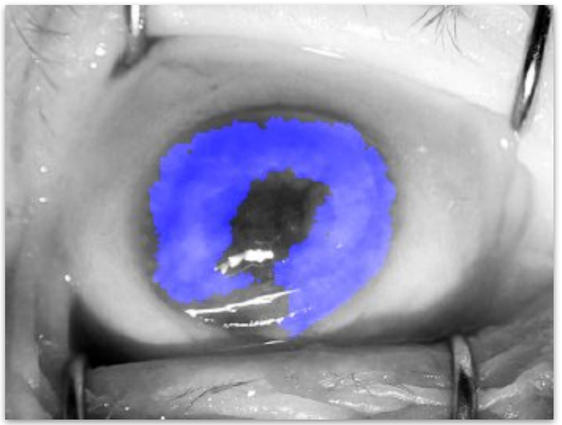
# Enhancement

**Segmentation (1/2)**

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





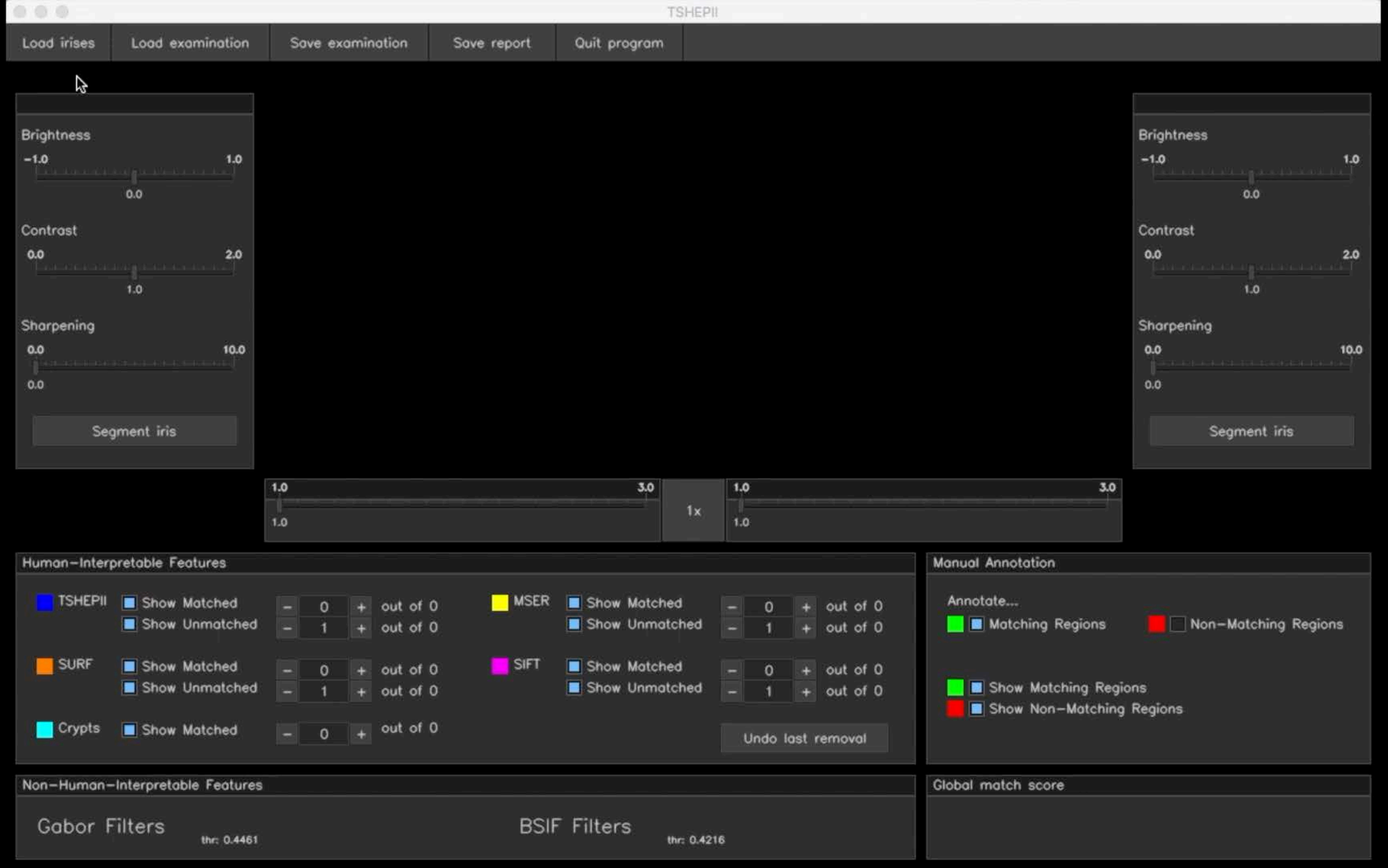


Kerrigan et al.
*Iris Recognition with Image Segmentation Employing Retrained Off-the-Shelf Deep Neural Networks*
https://arxiv.org/abs/1901.01028, 2019

# Enhancement

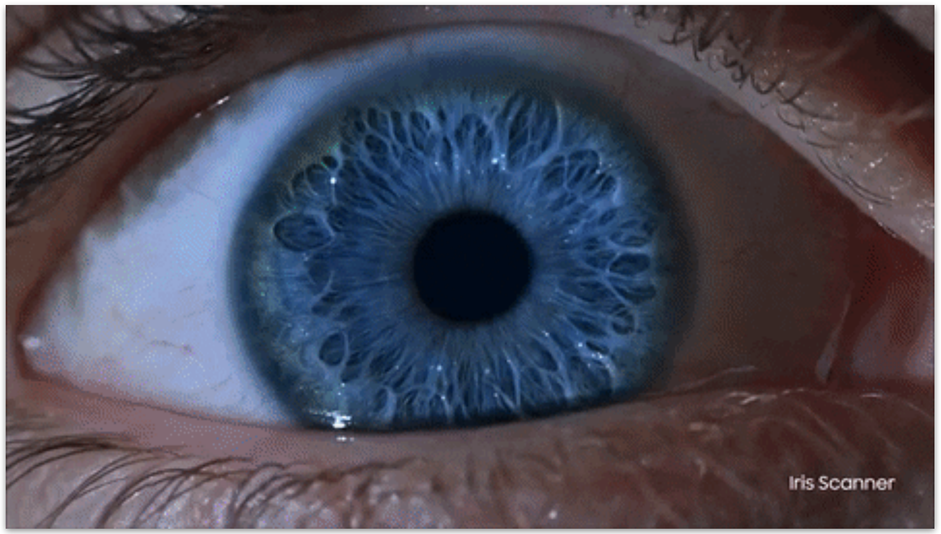
**Segmentation (1/2)**

**Manual Segmentation**
Next slide: iris recognition tool developed at Notre Dame.

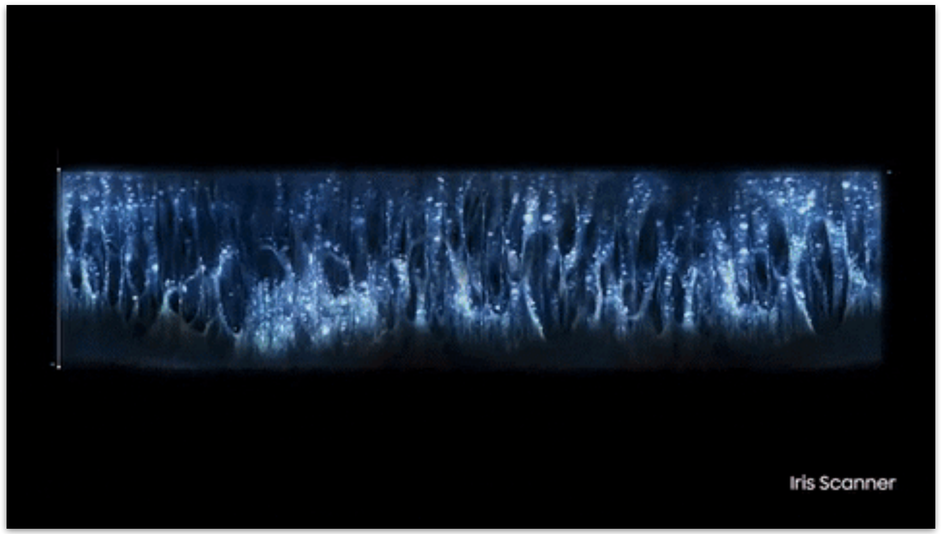

TSHEPII
Load irises
Load examination
Save examination
Save report
Quit program
Brightness
-1.0
1.0
0.0
Contrast
0.0
2.0
1.0
Sharpening
0.0
10.0
0.0
Segment iris
Brightness
-1.0
1.0
0.0
Contrast
0.0
2.0
1.0
Sharpening
0.0
10.0
0.0
Segment iris
1.0
3.0
1.0
1x
1.0
3.0
1.0
Human-Interpretable Features
TSHEPII
Show Matched
Show Unmatched
0
out of 0
1
out of 0
SURF
Show Matched
Show Unmatched
0
out of 0
1
out of 0
Crypts
Show Matched
0
out of 0
MSER
Show Matched
Show Unmatched
0
out of 0
1
out of 0
SIFT
Show Matched
Show Unmatched
0
out of 0
1
out of 0
Undo last removal
Manual Annotation
Annotate...
Matching Regions
Non-Matching Regions
Show Matching Regions
Show Non-Matching Regions
Non-Human-Interpretable Features
Gabor Filters
thr: 0.4461
BSIF Filters
thr: 0.4216
Global match score

# Enhancement

## Normalization (2/2)



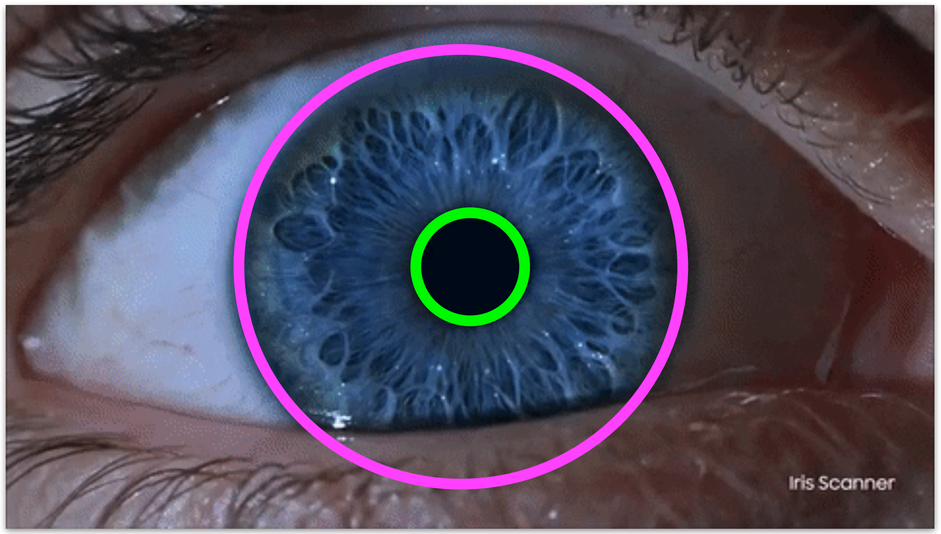

source



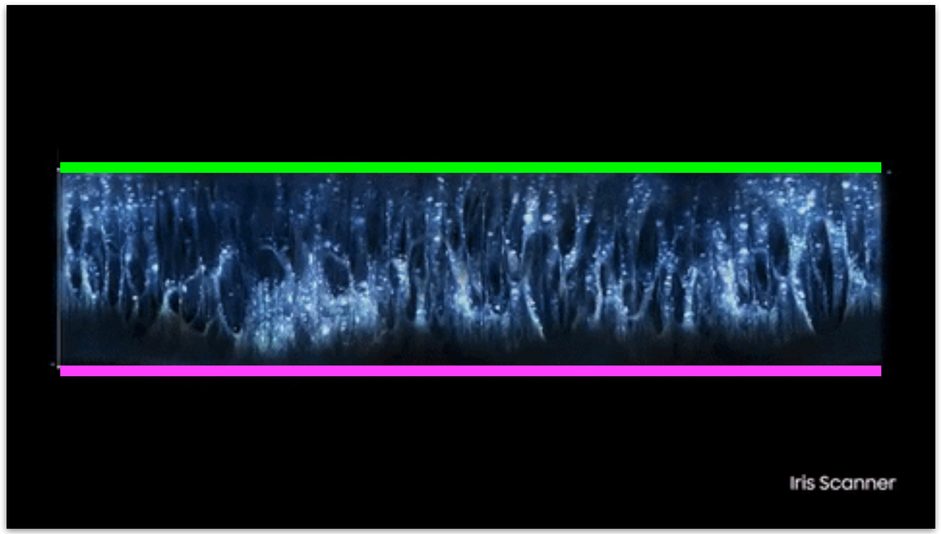

target

# Enhancement

## Normalization (2/2)



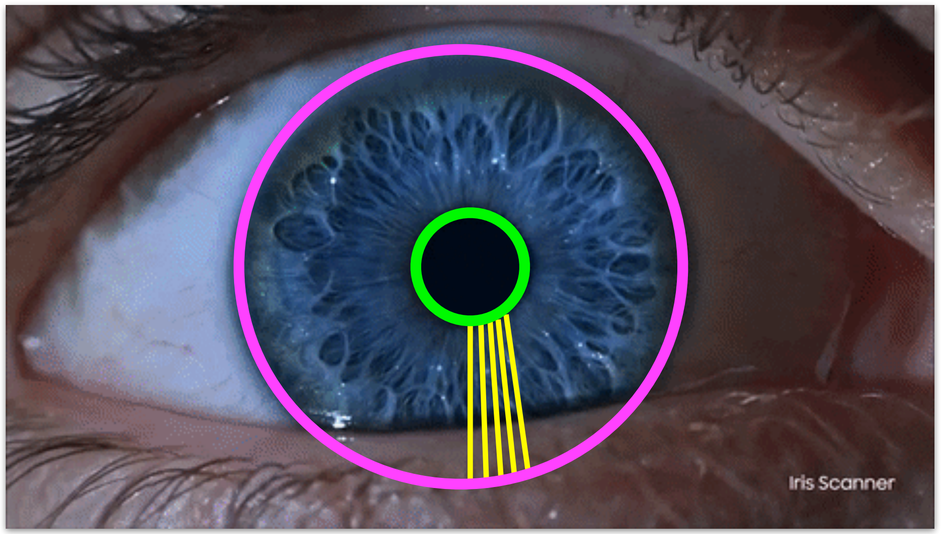

source



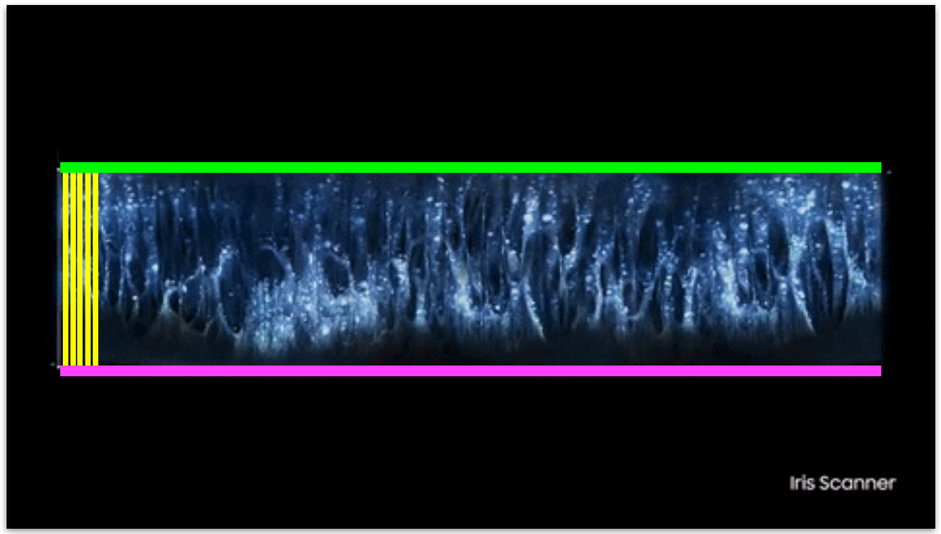

target

# Enhancement

## Normalization (2/2)



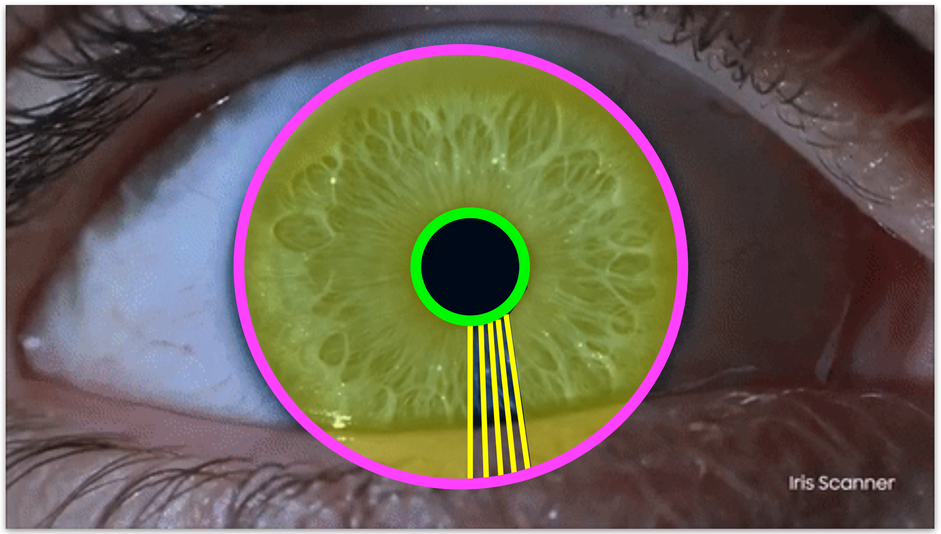

source



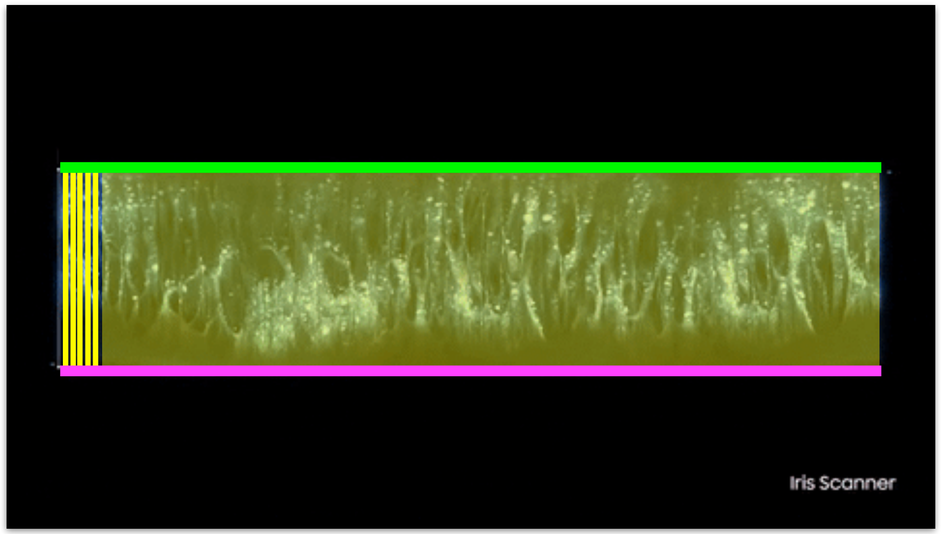

target

# Enhancement

## Normalization (2/2)

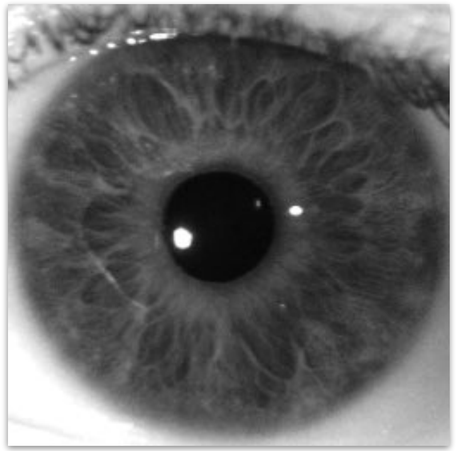


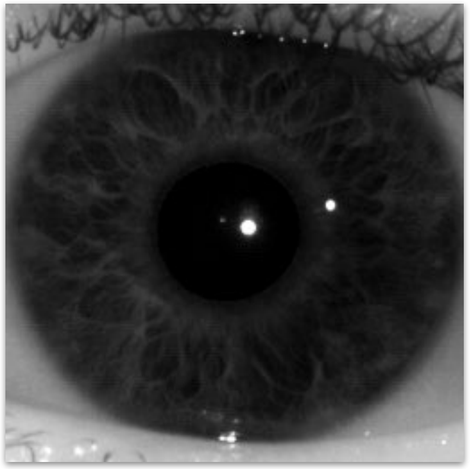

source




target

# Enhancement





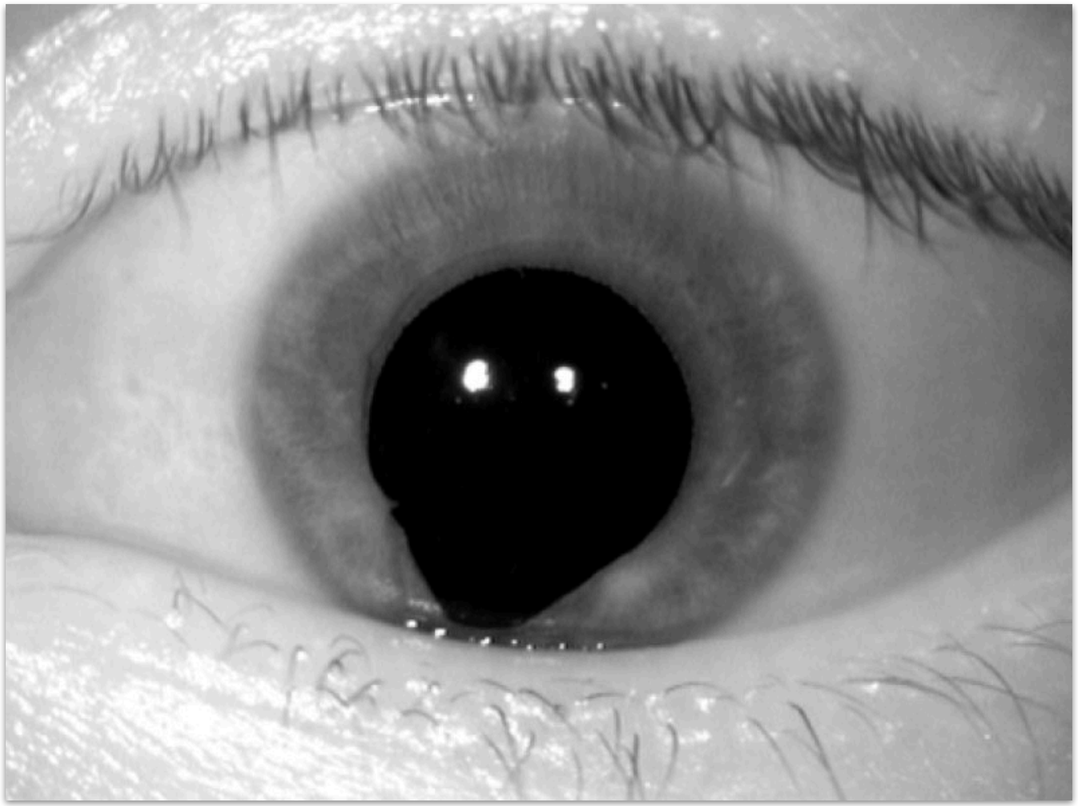
# Enhancement

**Limitations**

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

# Enhancement

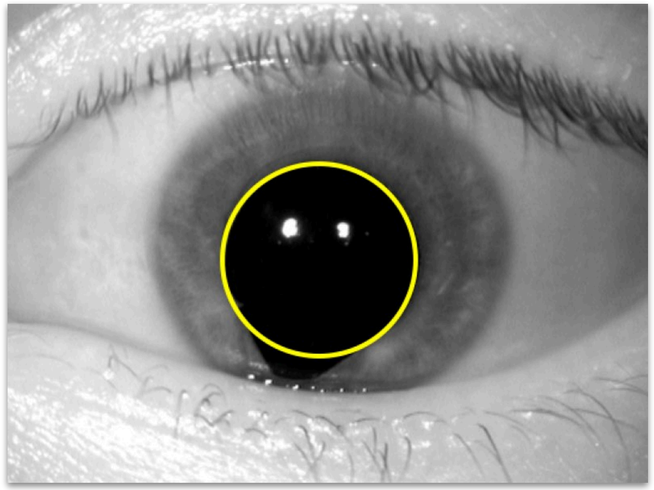
Dr. Adam Czajka

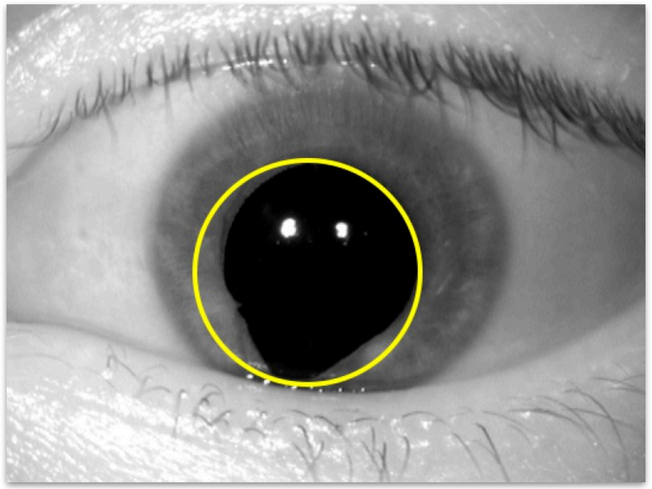


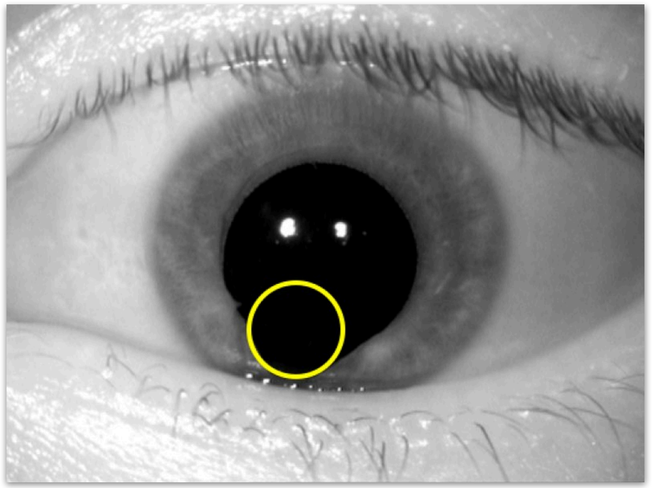
coloboma condition

# Enhancement

Dr. Adam Czajka



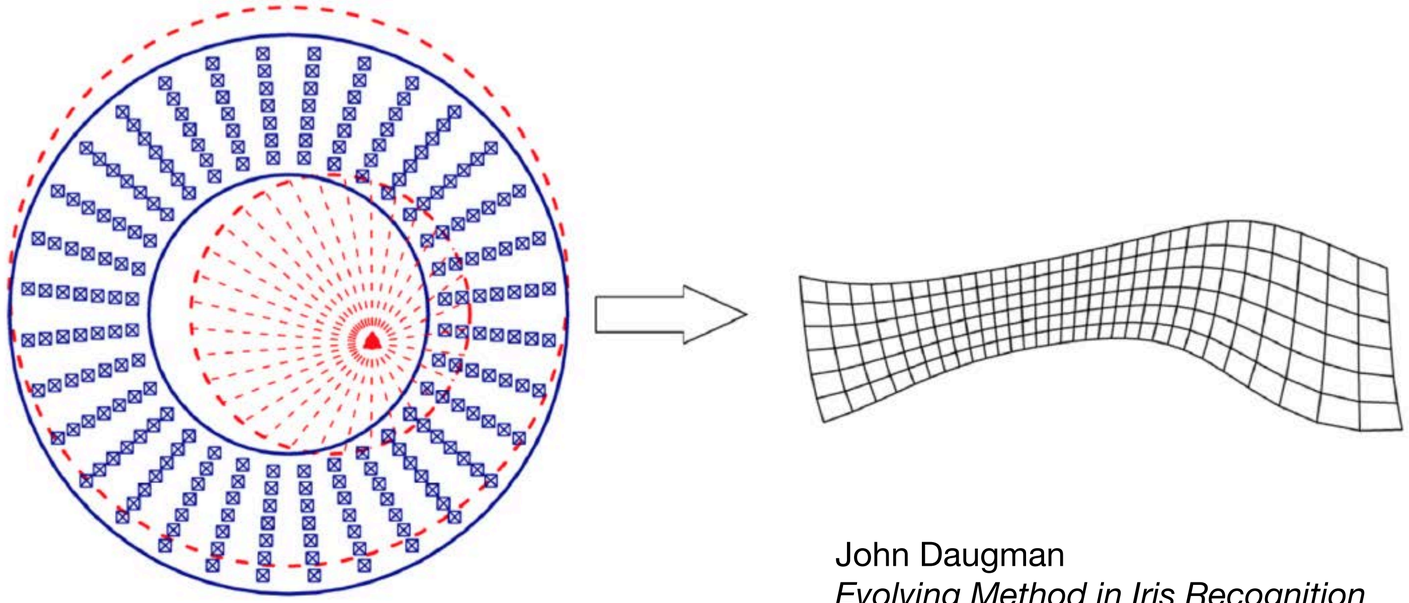




# Enhancement

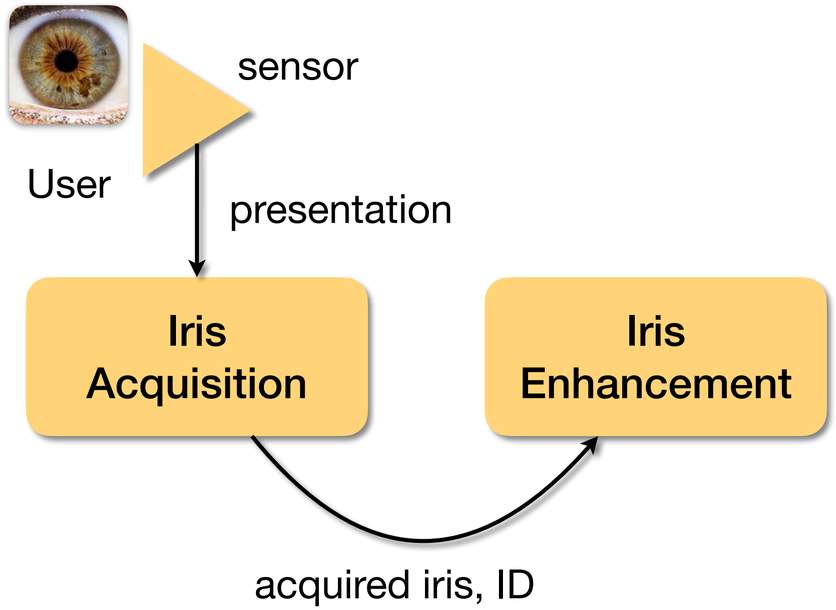
**Limitations**

**Normalization**
Forcing circular models may lead to poor mapping.

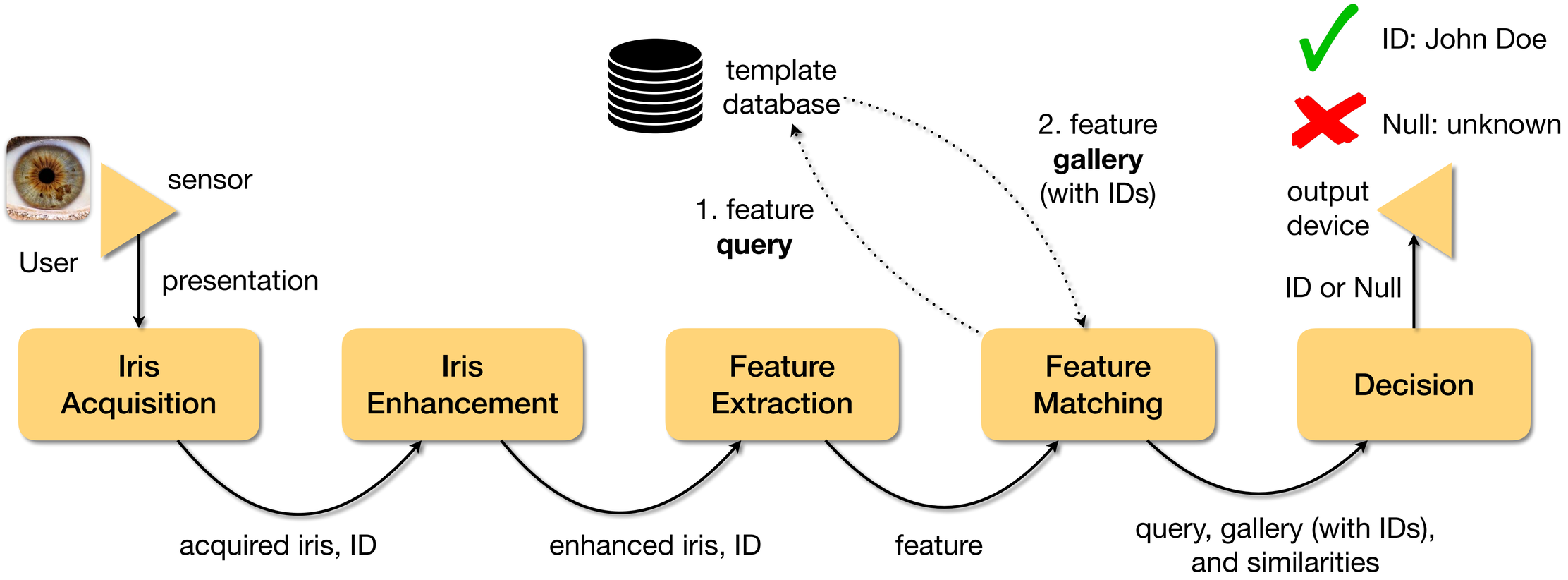


John Daugman
*Evolving Method in Iris Recognition*
BTAS, 2012

# 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/HAZC1P.