Iris Recognition II

CSE 40537/60537 Biometrics

Daniel Moreira

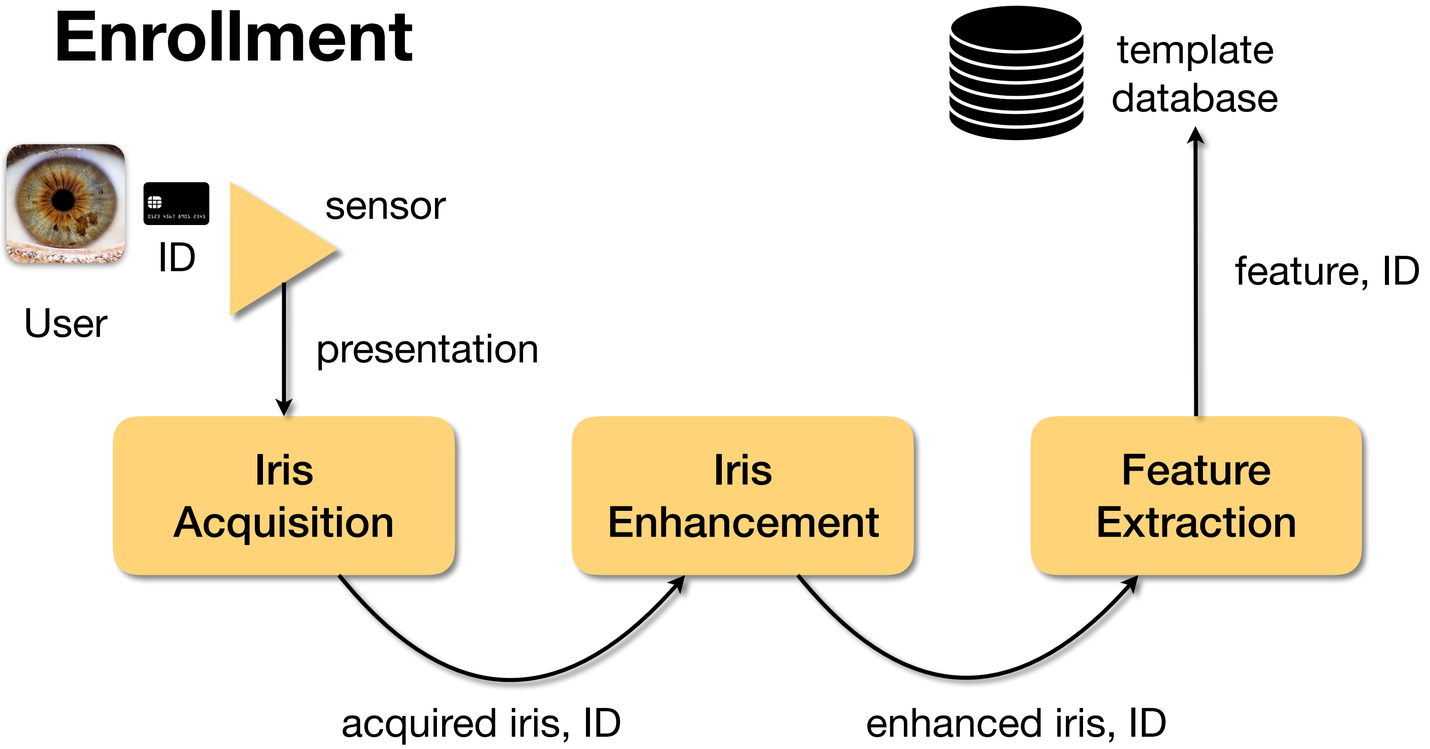
Spring 2020

UNIVERSITY OF NOTRE DAME

Today you will…

Get to know
Iris acquisition and enhancement.

Iris Recognition



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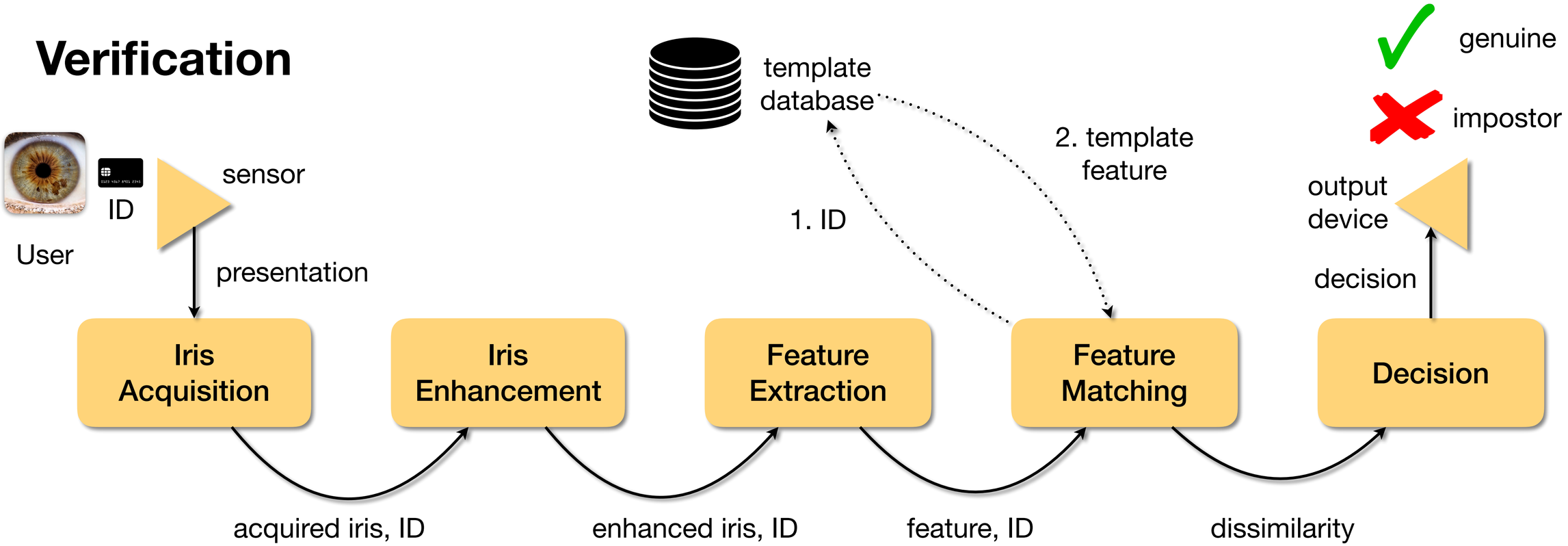
Iris Recognition



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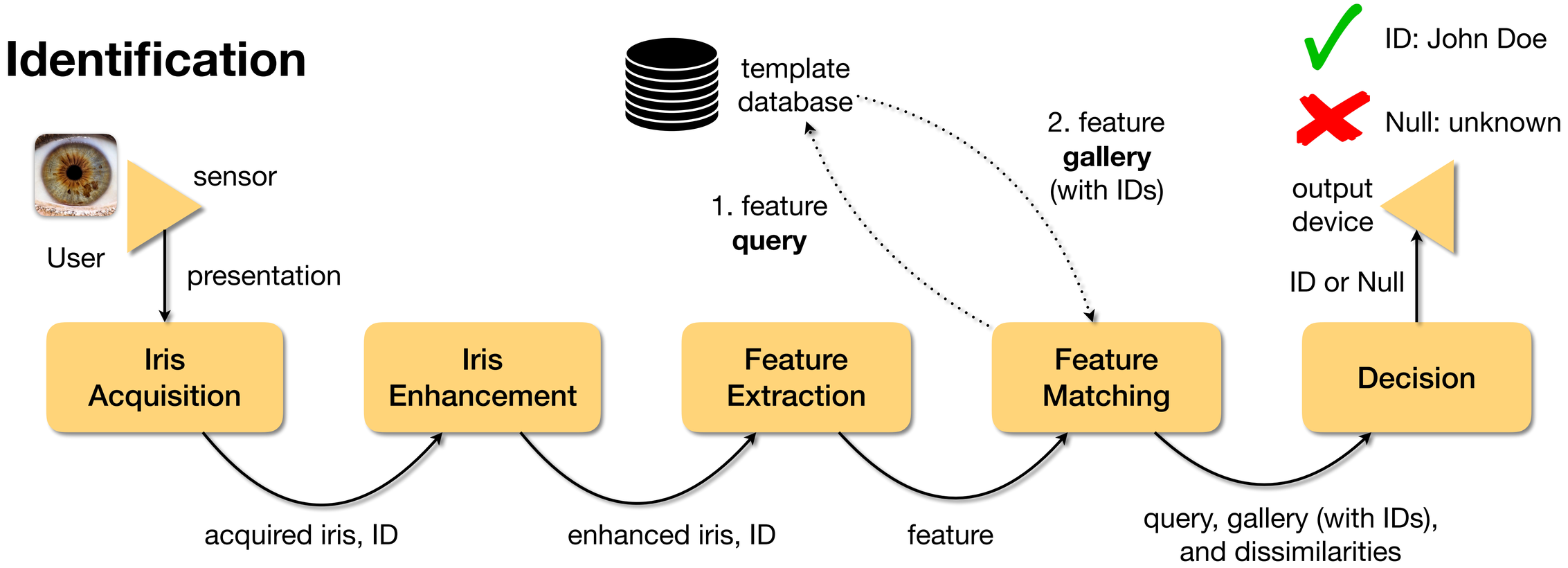
Iris Recognition



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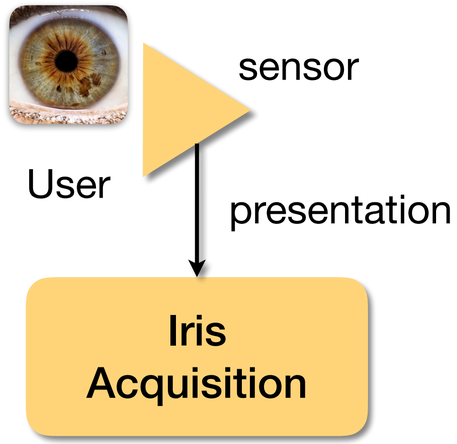
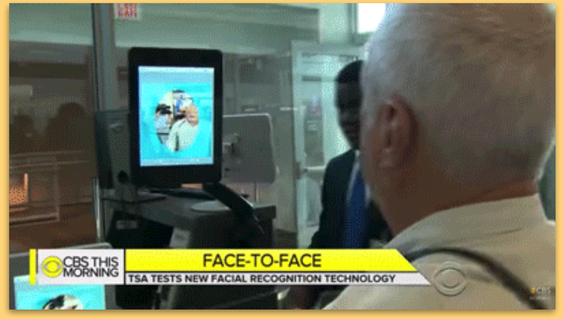
Iris Recognition



Acquisition

On-line



https://www.youtube.com/watch?v=BYN4oF_bi4c

Schiphol Airport

Off-line

?

It depends on the resolution and angle of capture.

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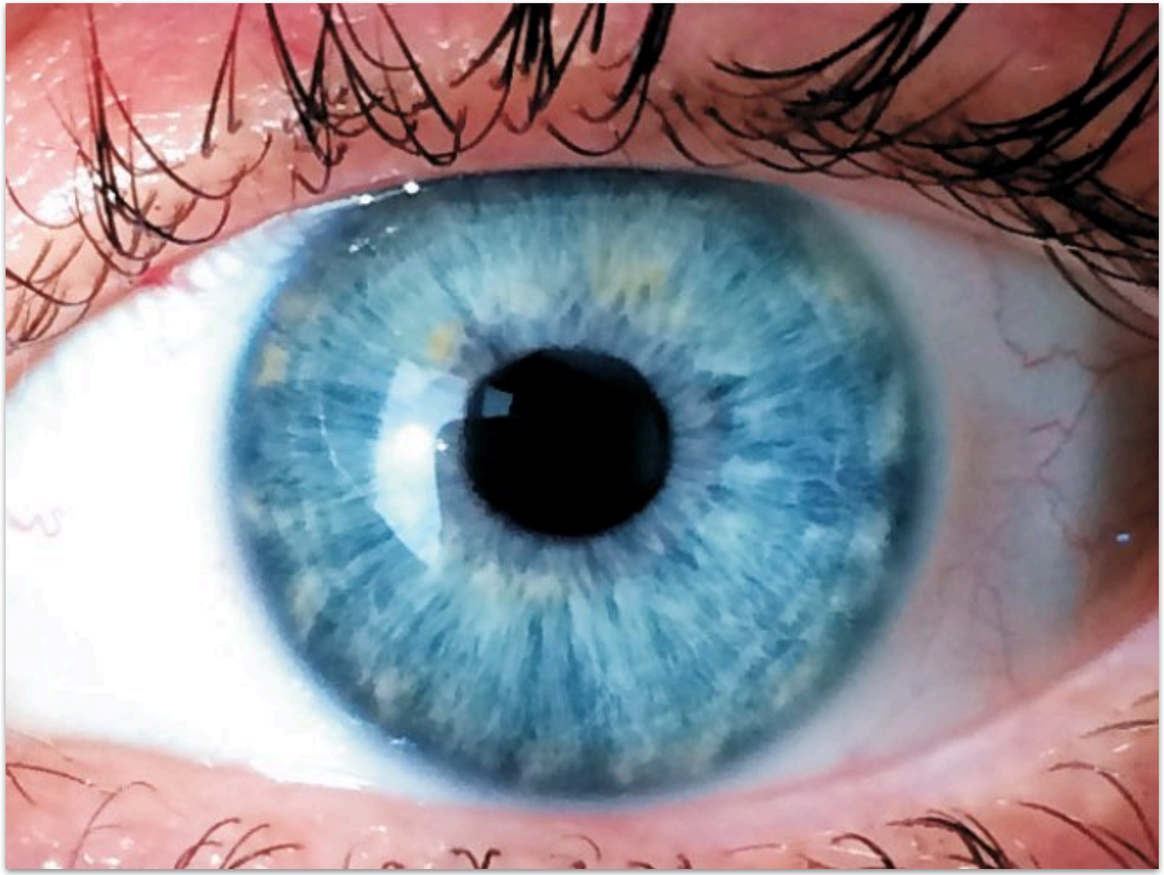
Acquisition

Dr. Adam Czajka

Iris Capture
Visible light.

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



Acquisition

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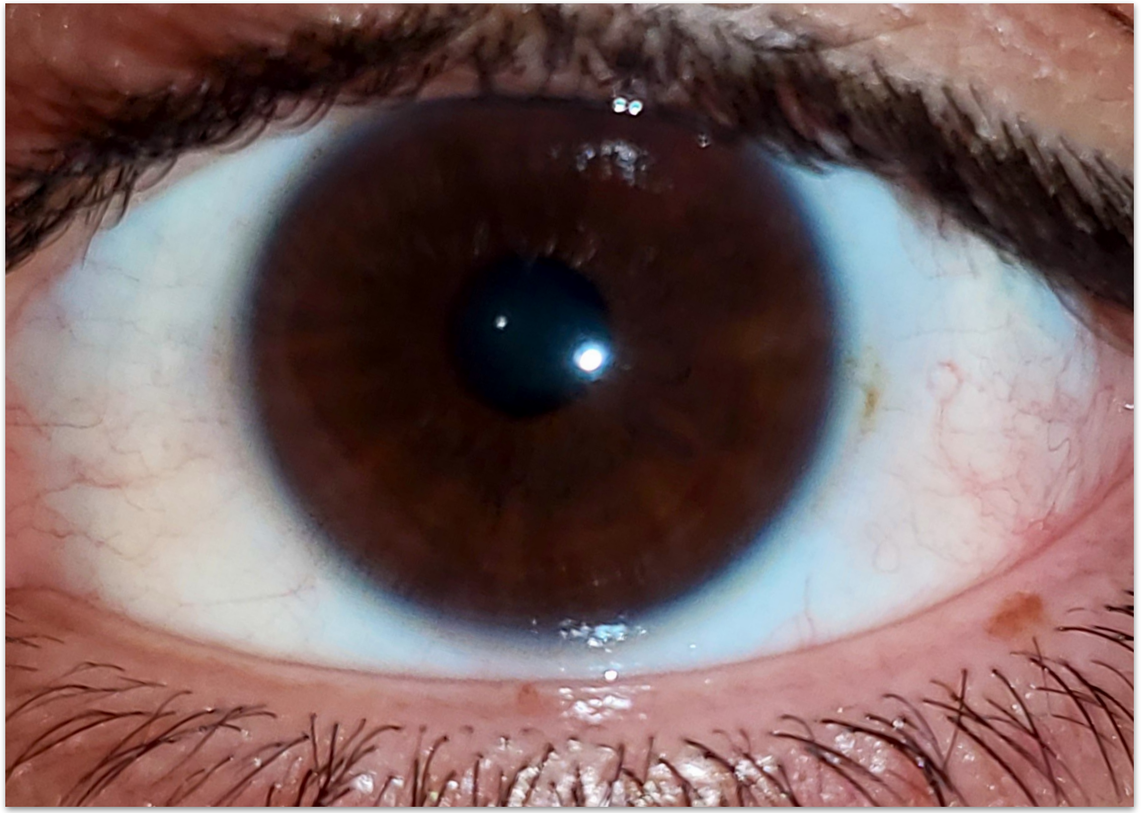
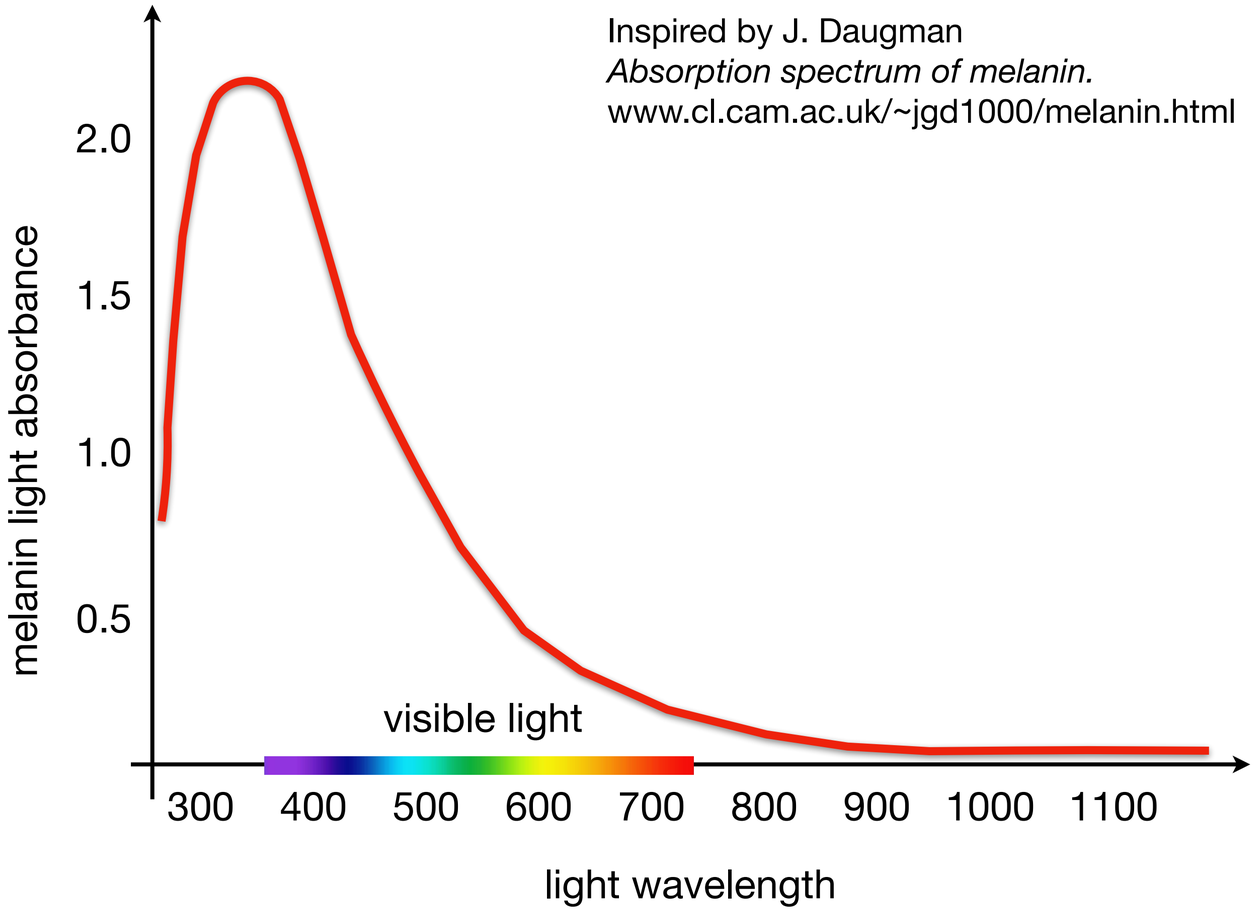


Acquisition

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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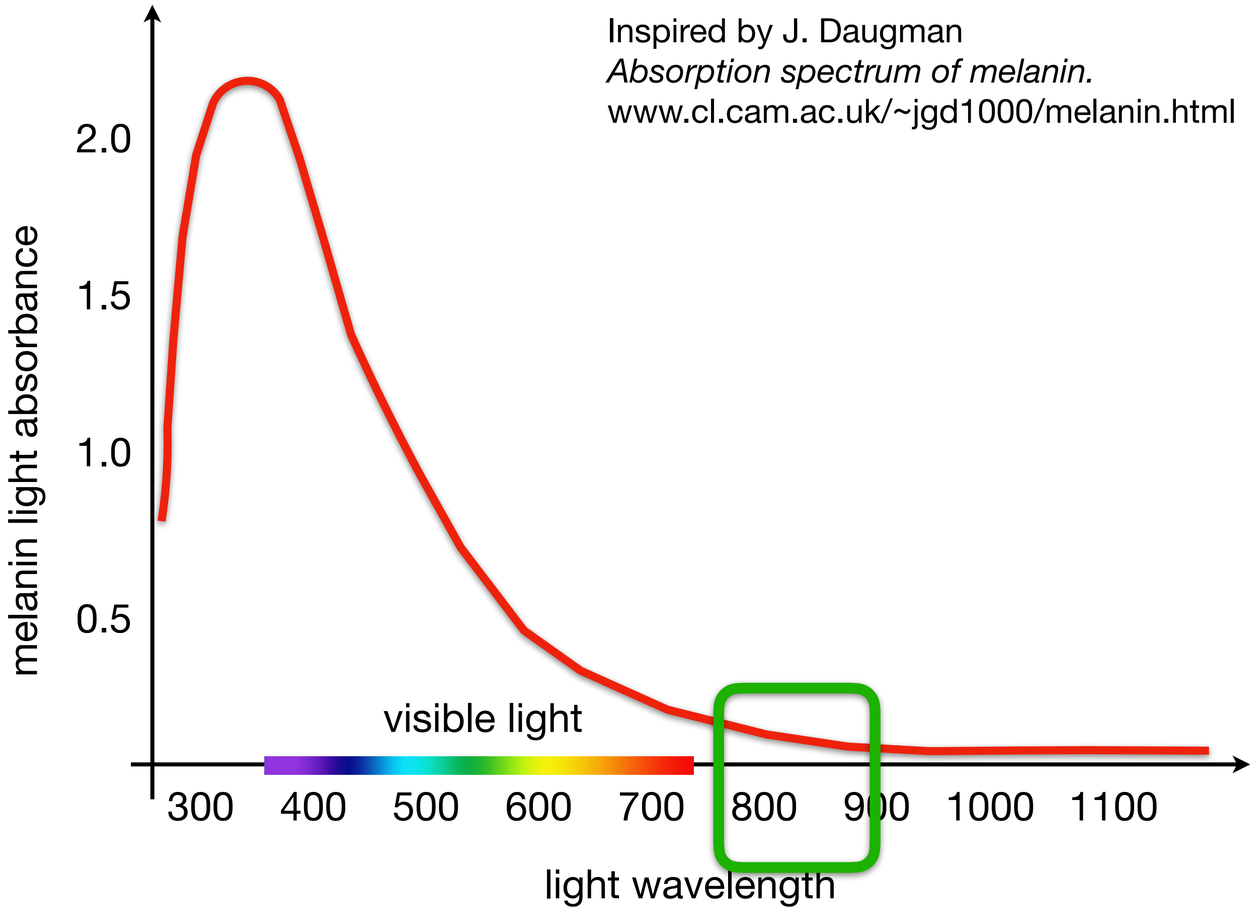
Acquisition

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

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



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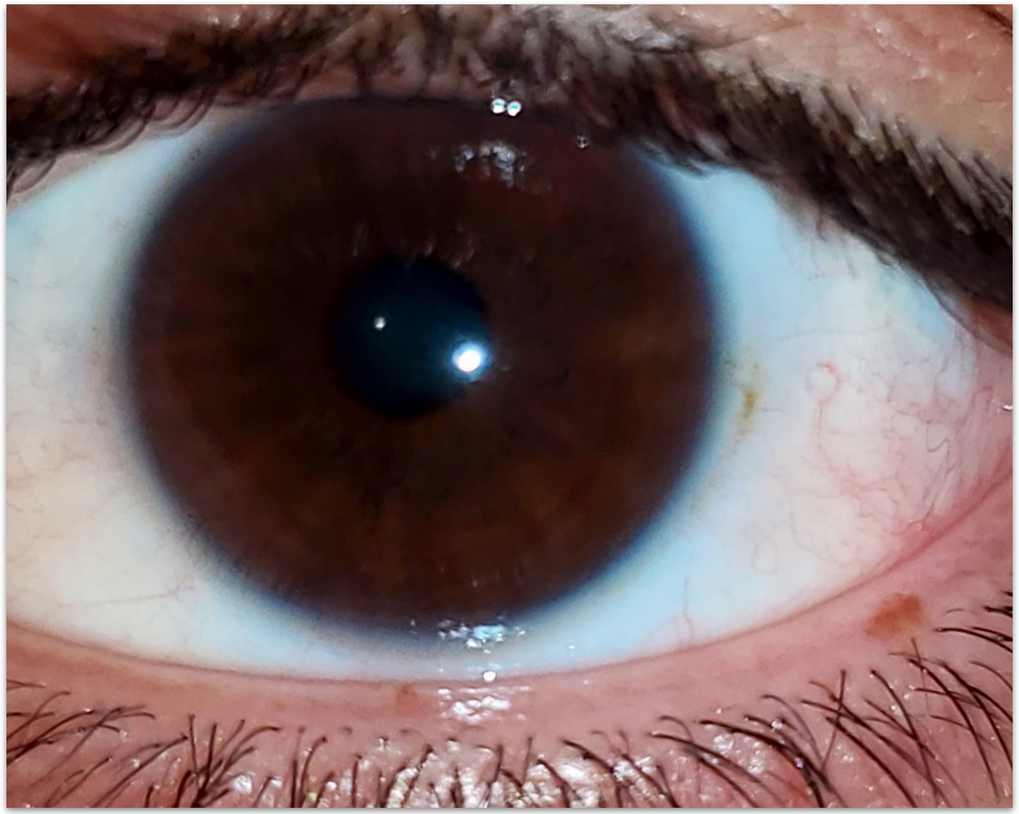
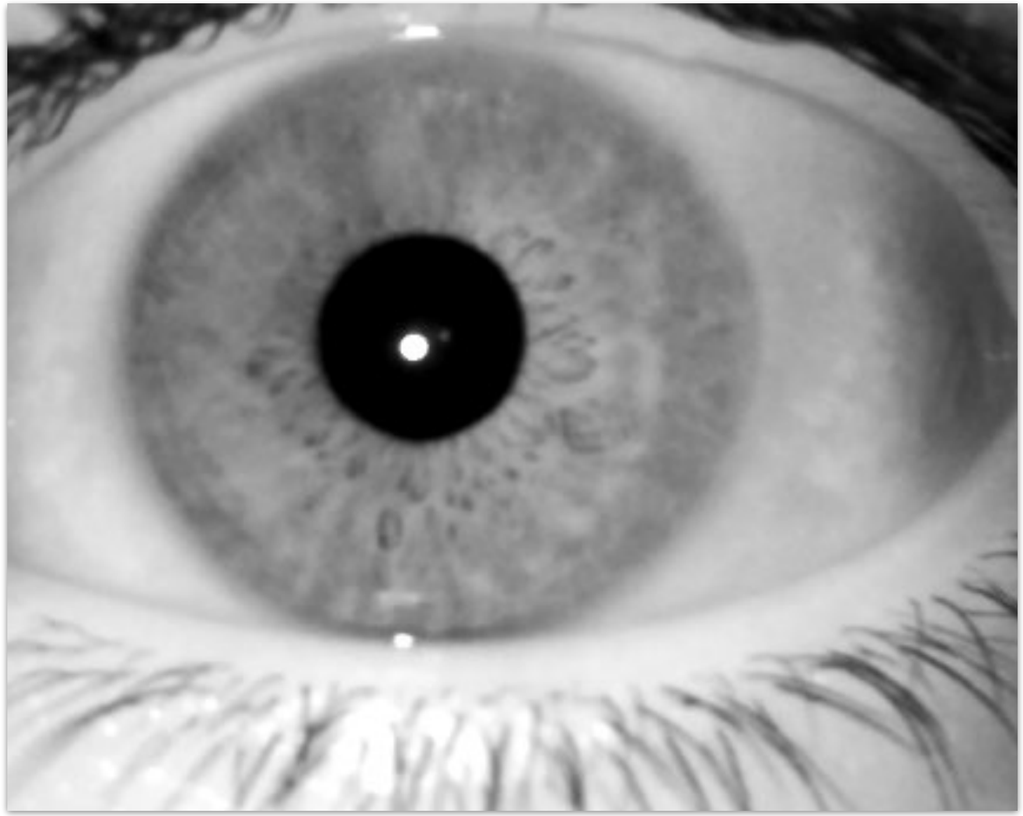
Acquisition



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

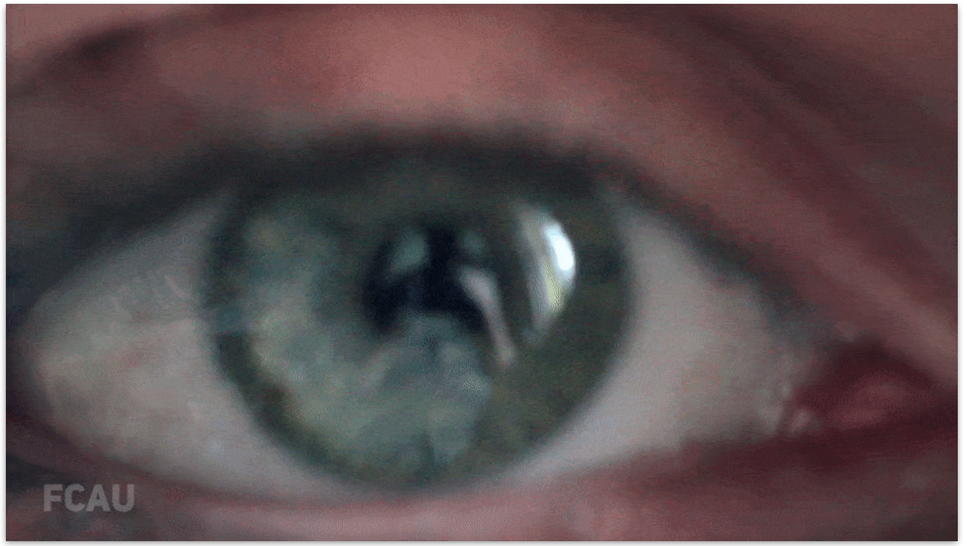
Acquisition

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



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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.

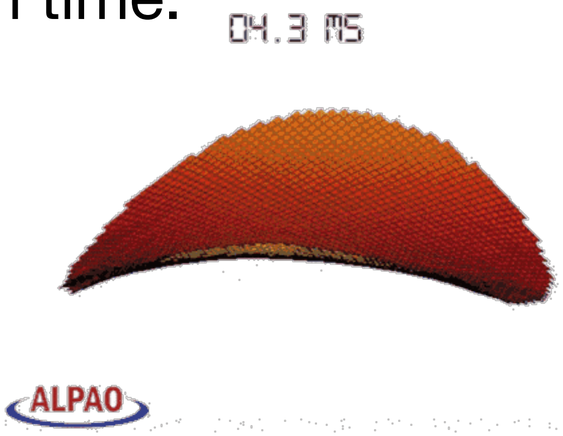
https://www.youtube.com/watch?v=bolNgCrCZW0

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

See demonstration.

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

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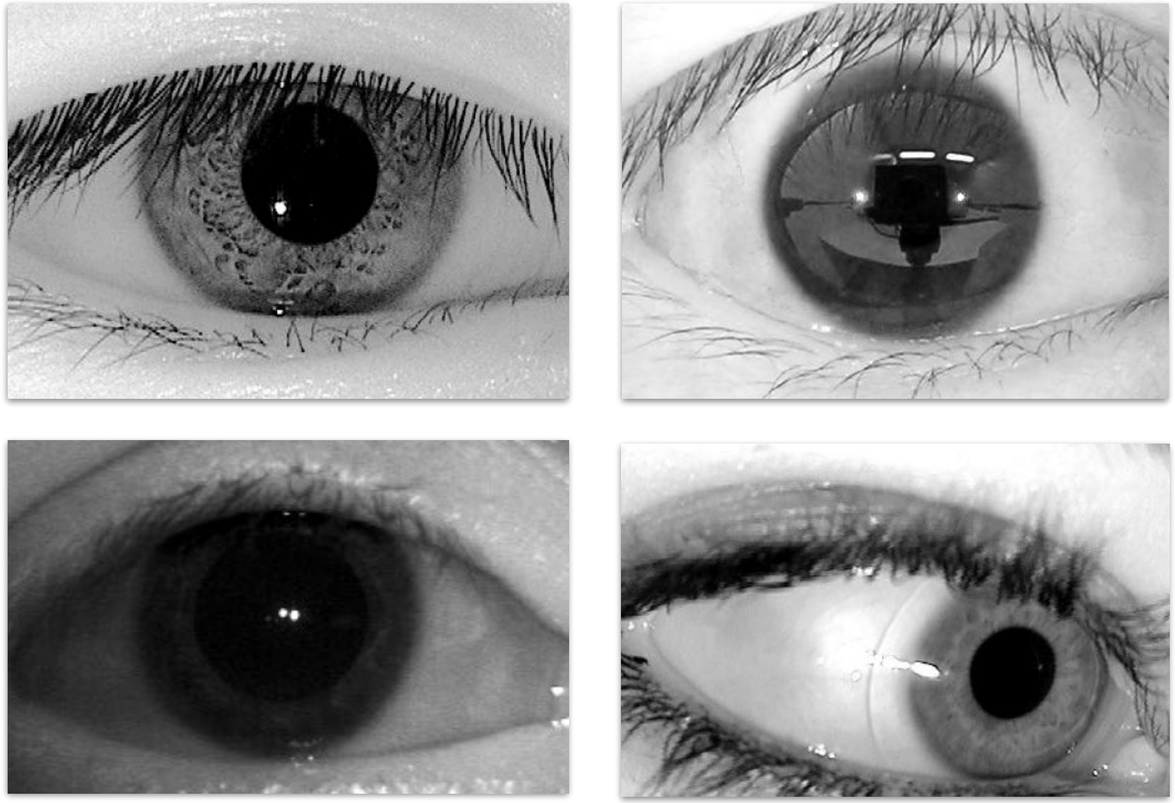
Acquisition

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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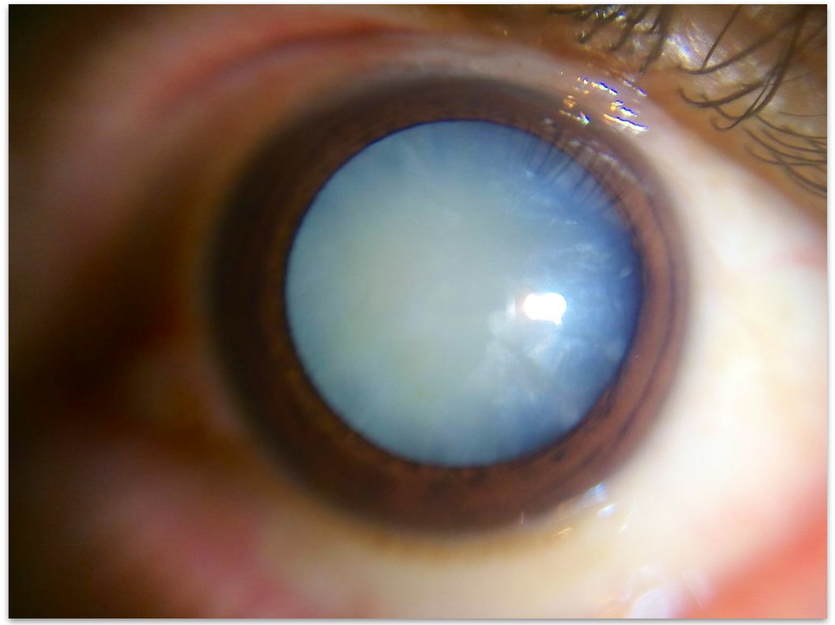
Acquisition

Challenges

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

commons.wikimedia.org



E.g., cataracts.

Acquisition

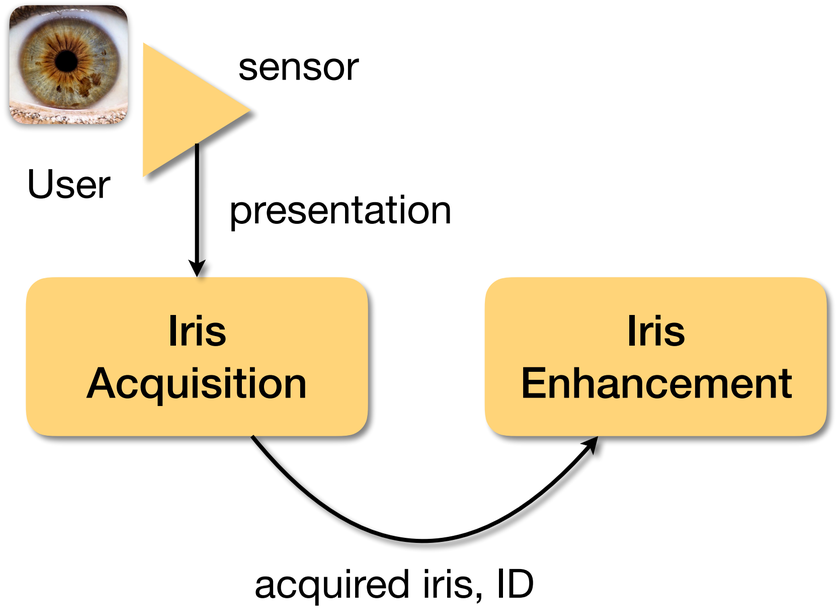
Challenges

Attacks
Obfuscation with texturized contact lenses.

Presentation attack
(see demonstration).

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

Iris Recognition

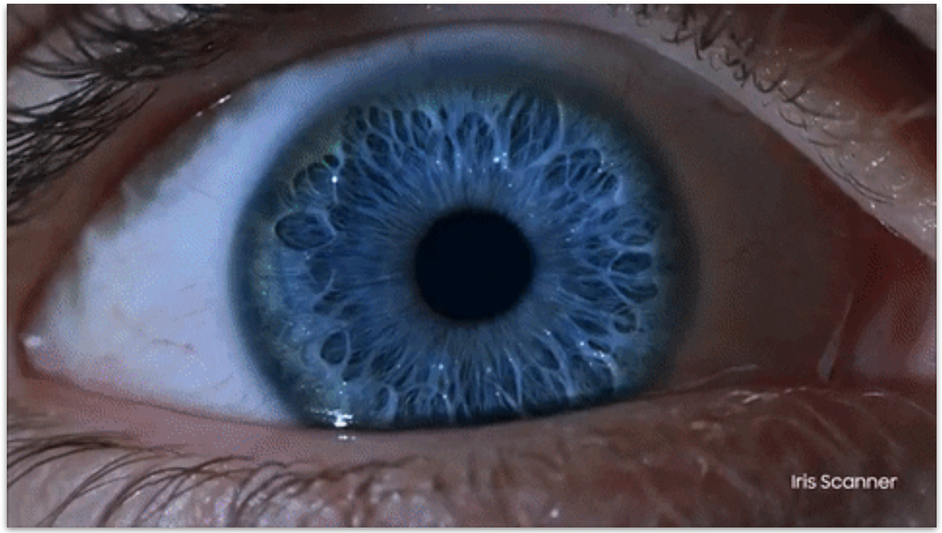


Enhancement

Steps

Segmentation
Keep only useful information
(iris texture).

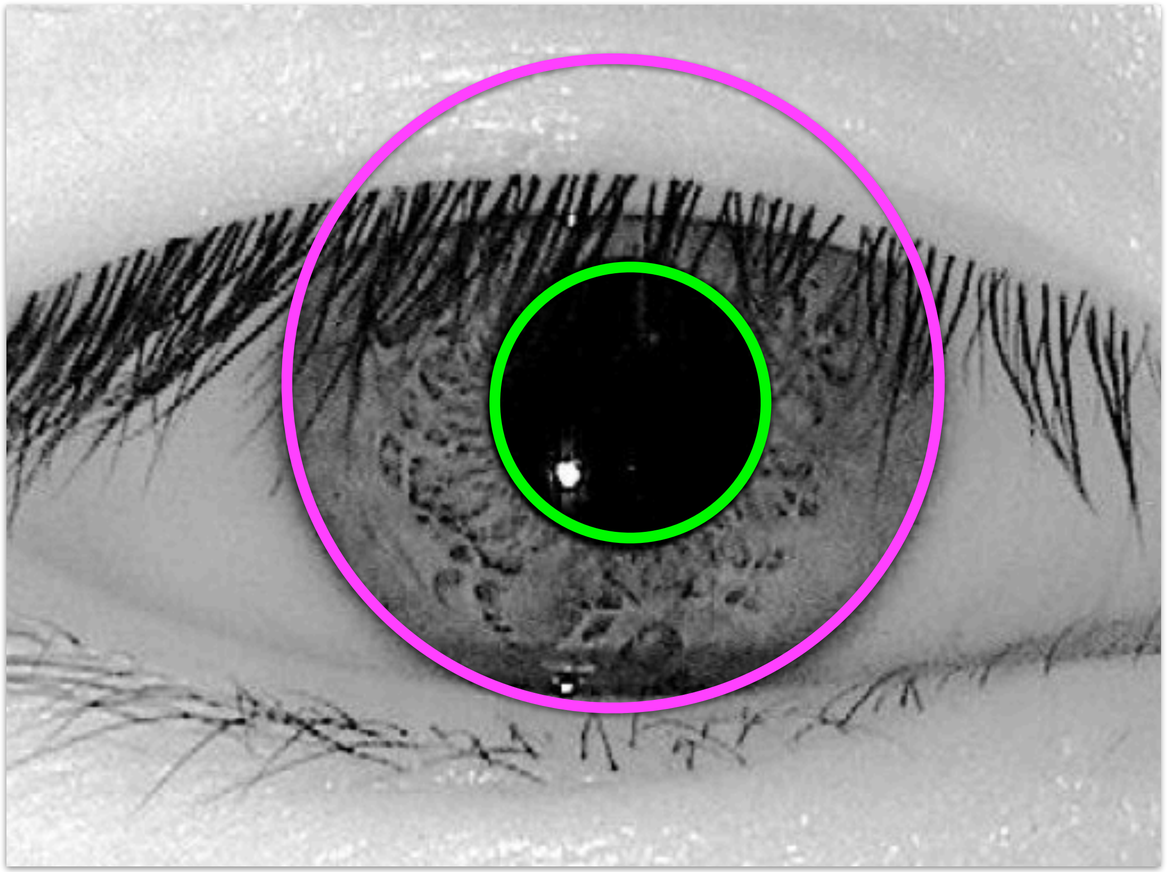
Normalization
Make different captures of the same
iris look as similar as possible.



Enhancement

Segmentation (1/2)

Iris and Pupil Localization
Localize limbus and pupillary boundaries.



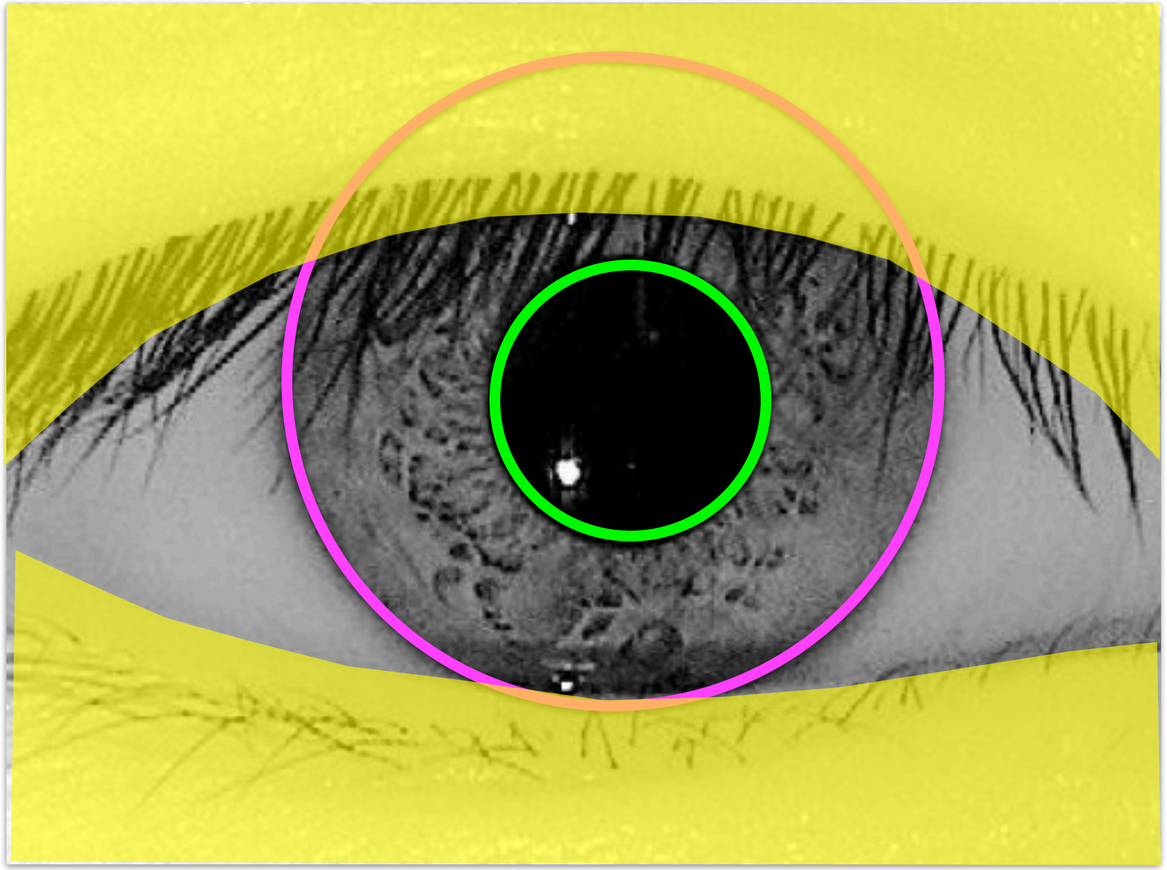
http://www.cse.nd.edu/BTAS_07/John_Daugman_BTAS.pdf

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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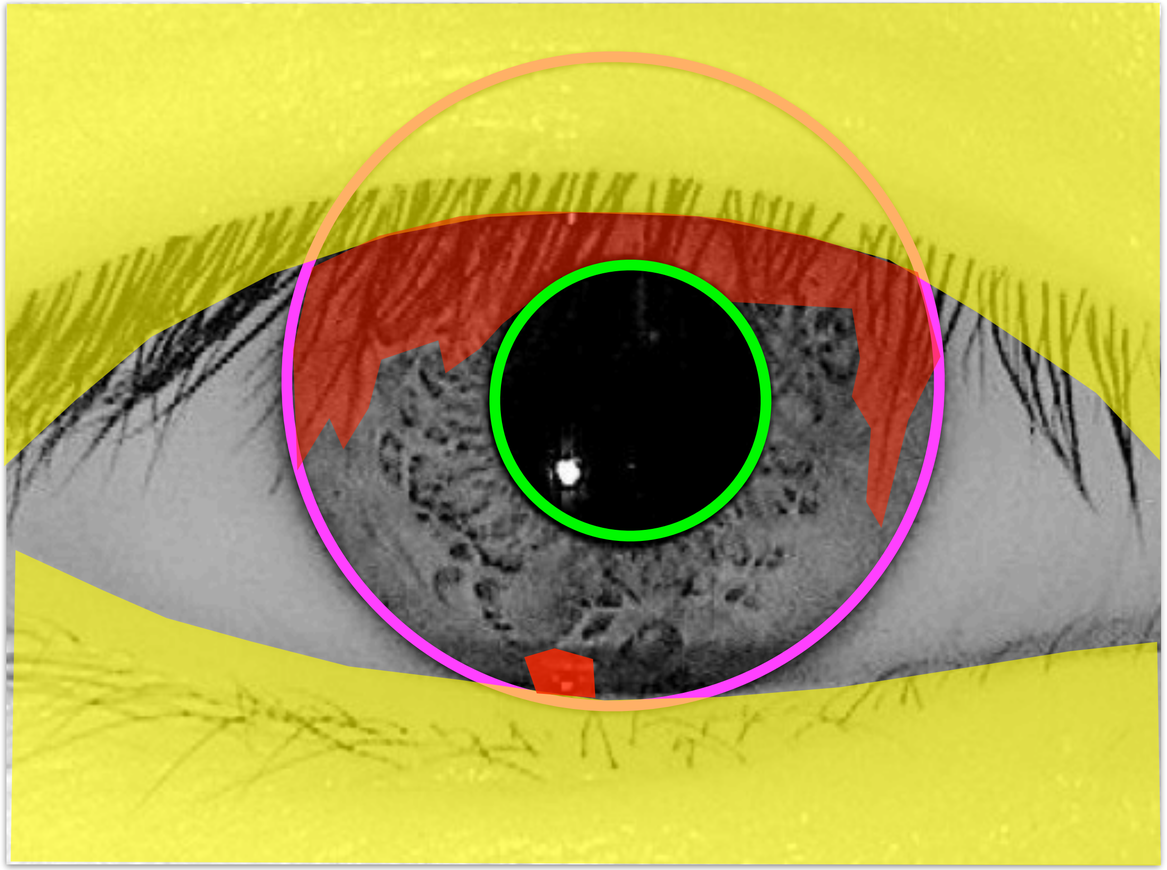


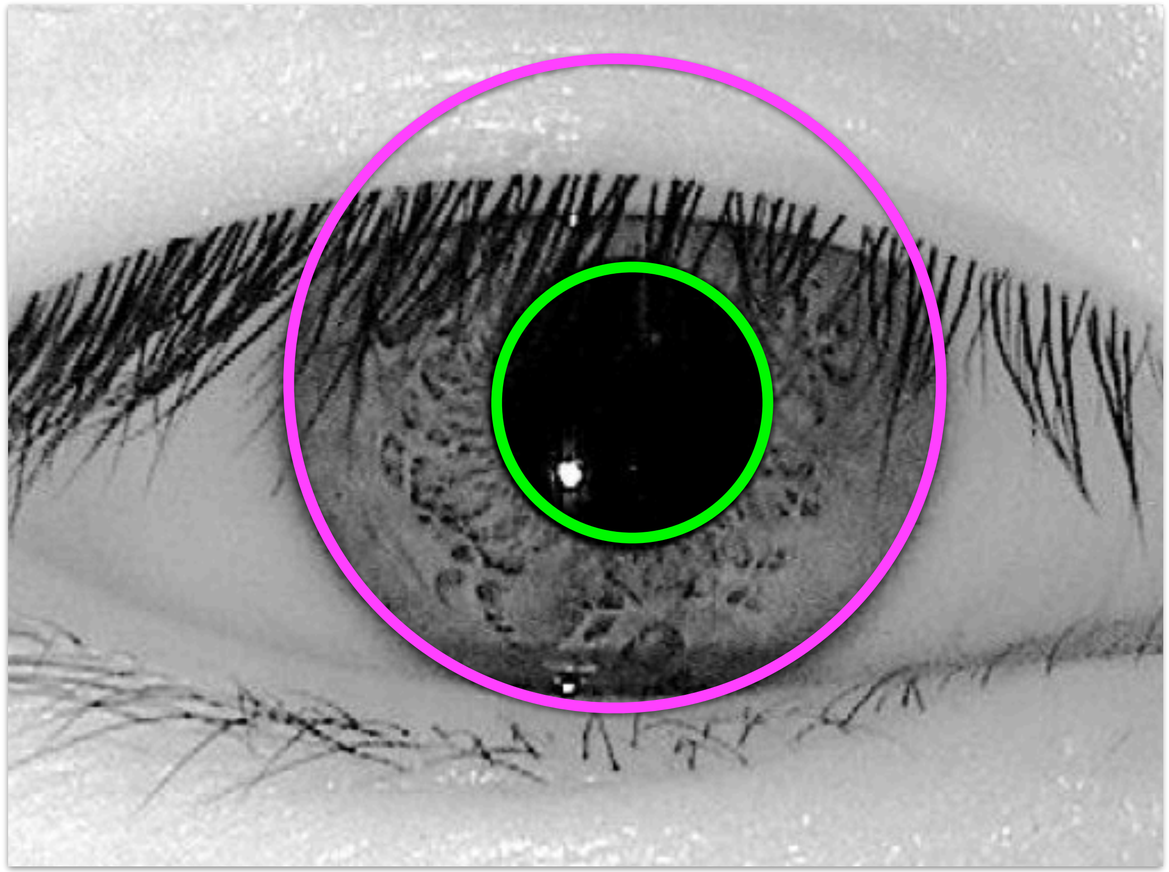
http://www.cse.nd.edu/BTAS_07/John_Daugman_BTAS.pdf

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.



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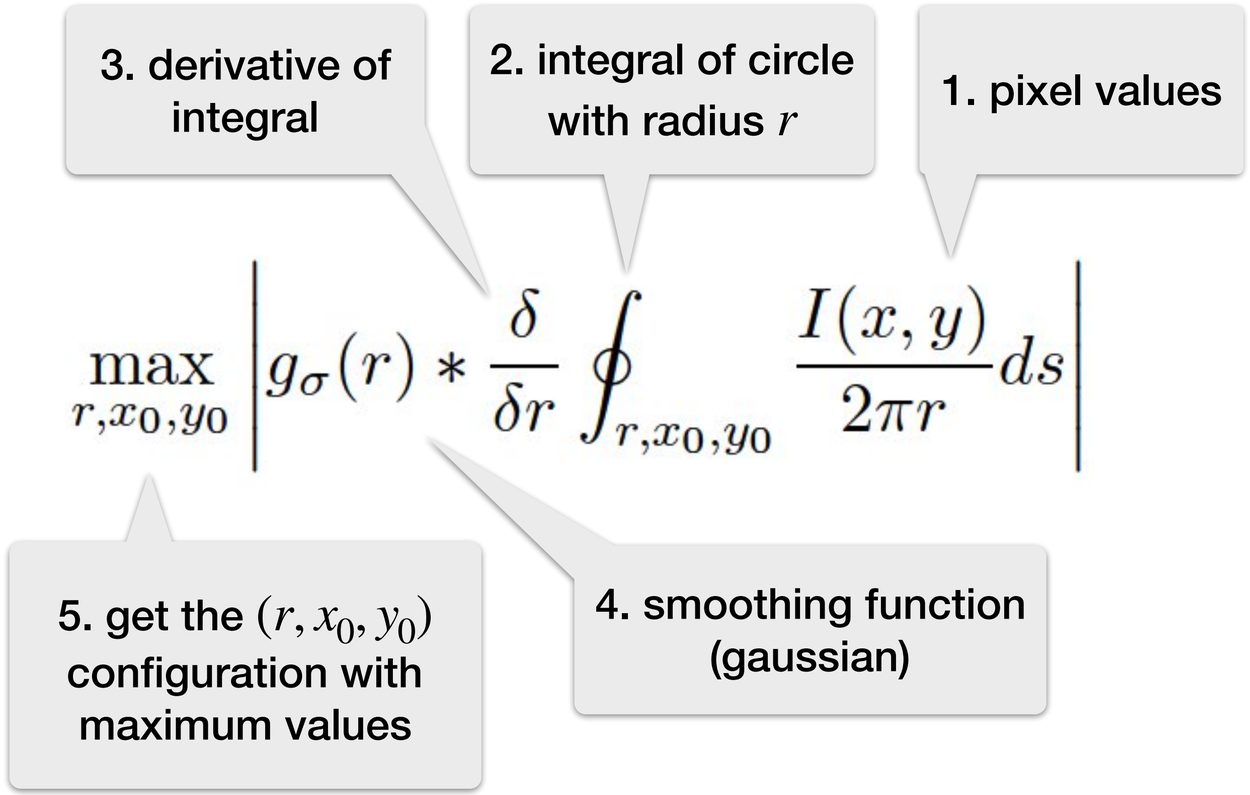
Enhancement

Segmentation (1/2)

Iris and Pupil Localization
Method 1: Integral-differential operator

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



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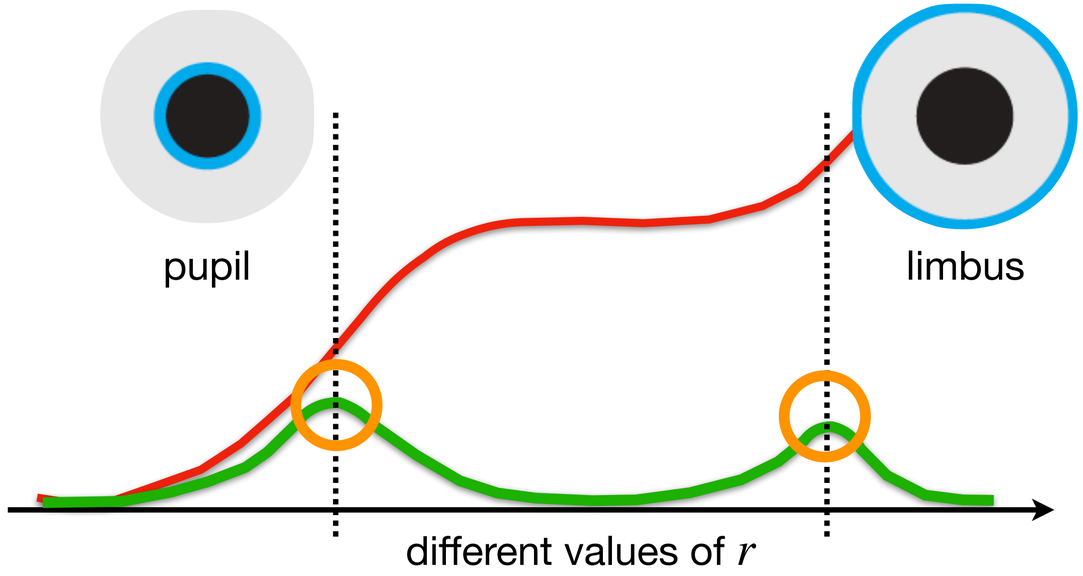
Enhancement

Segmentation (1/2)

Iris and Pupil Localization
Method 1: Integral-differential operator

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

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



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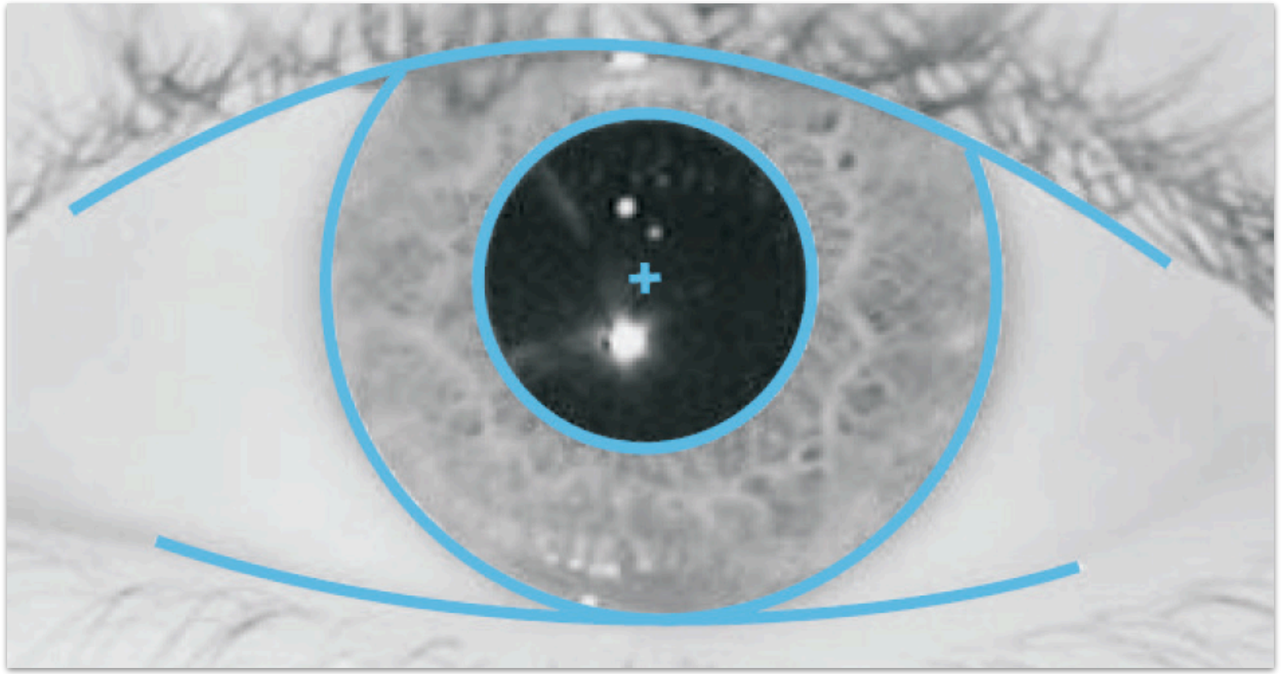
Enhancement

Segmentation (1/2)

Iris and Pupil Localization
Method 1: Integral-differential operator

J. Daugman
How Iris Recognition Works
IEEE TCSVT, 2004

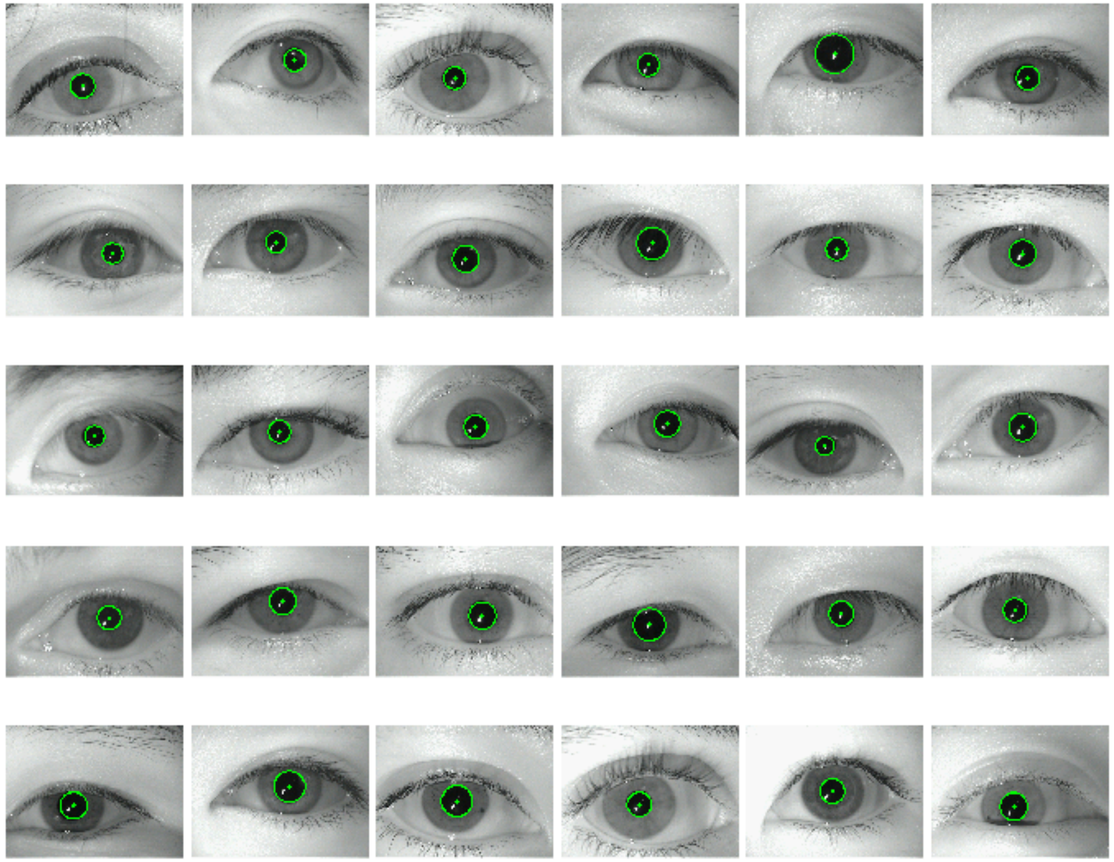


result example

Enhancement

Segmentation (1/2)

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

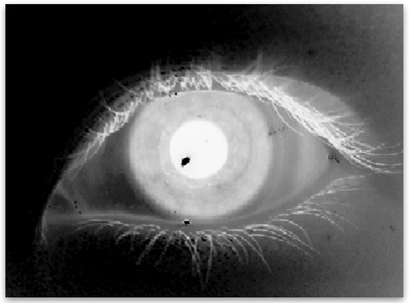


https://github.com/olesia-midiana/iris-recognition-py

Enhancement

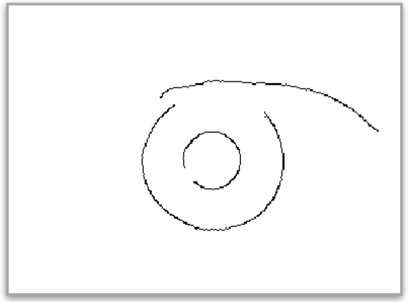
https://github.com/olesia-midiana/iris-recognition-py

1.grayscale

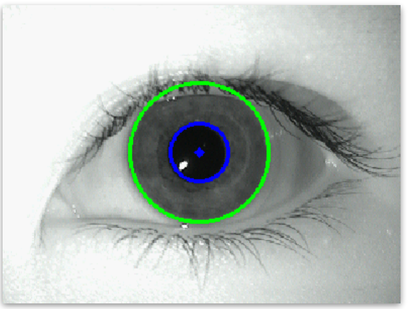


2. inverted

3. median blur



4. Canny edge detector

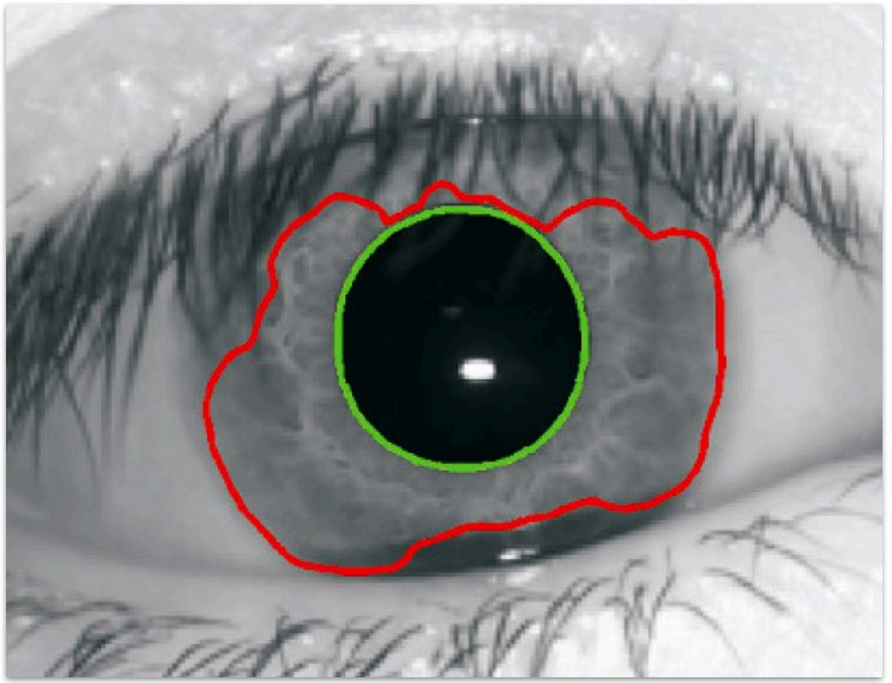


5. Hough circle transform

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.

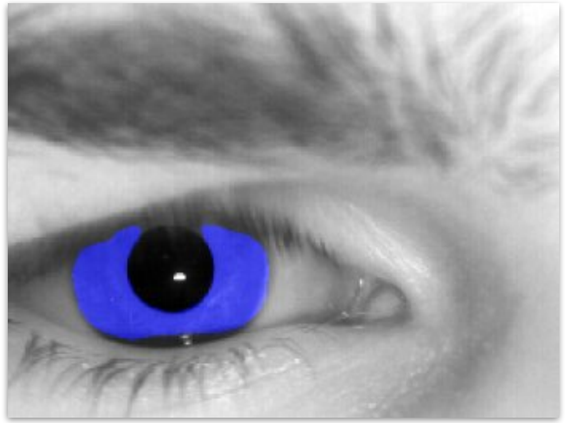


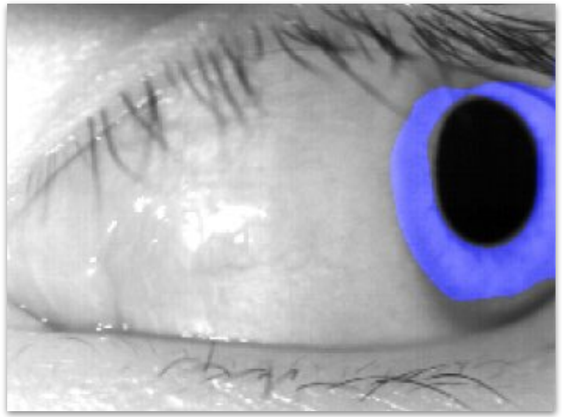
Gutfeter
Active contours for iris segmentation.
BSc Thesis, WUT, 2010

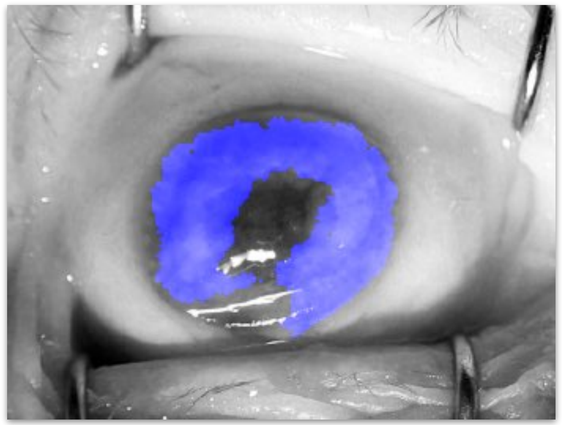
Enhancement

Segmentation (1/2)

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





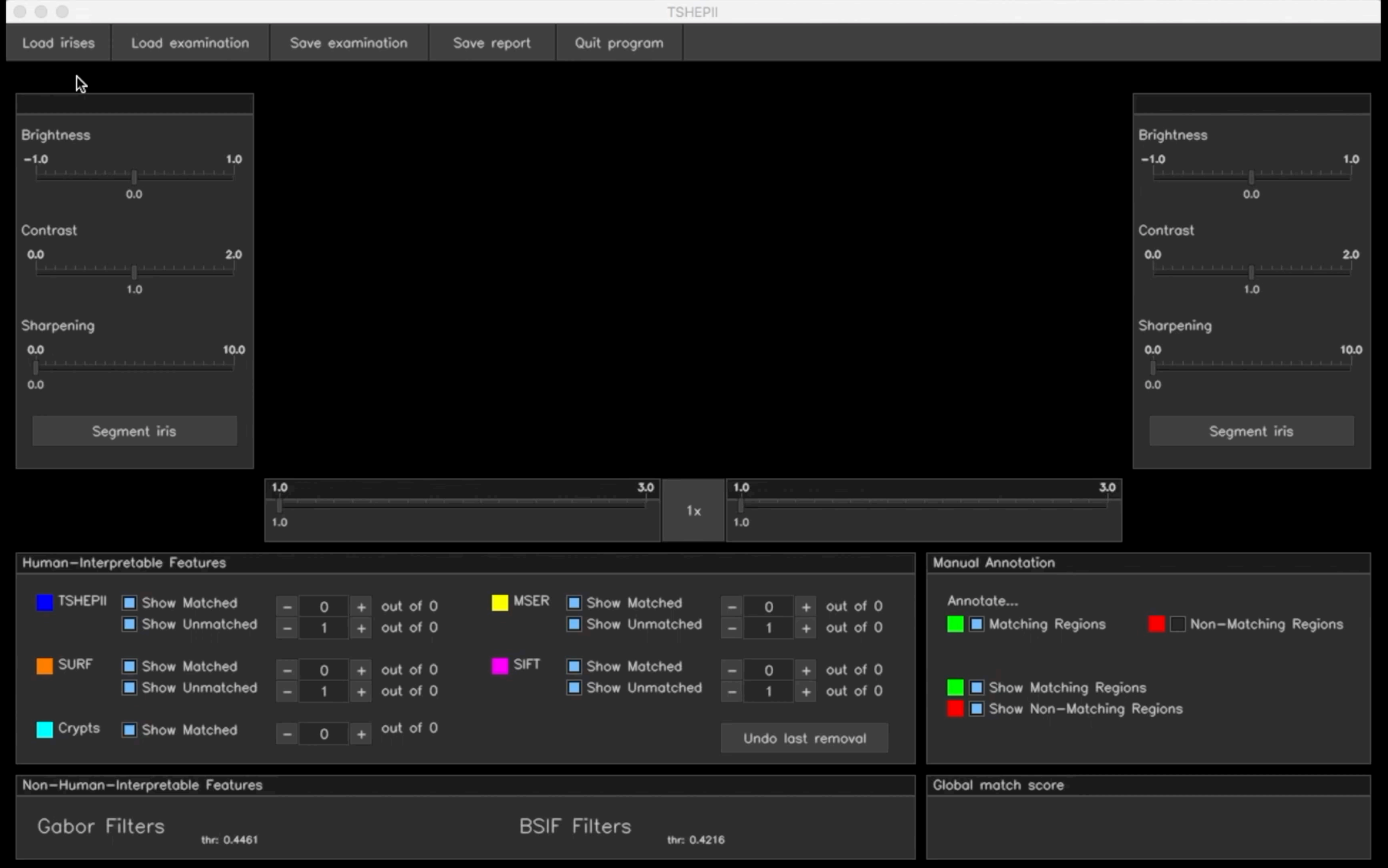


Kerrigan et al.
Iris Recognition with Image Segmentation Employing Retrained Off-the-Shelf Deep Neural Networks
https://arxiv.org/abs/1901.01028, 2019

Enhancement

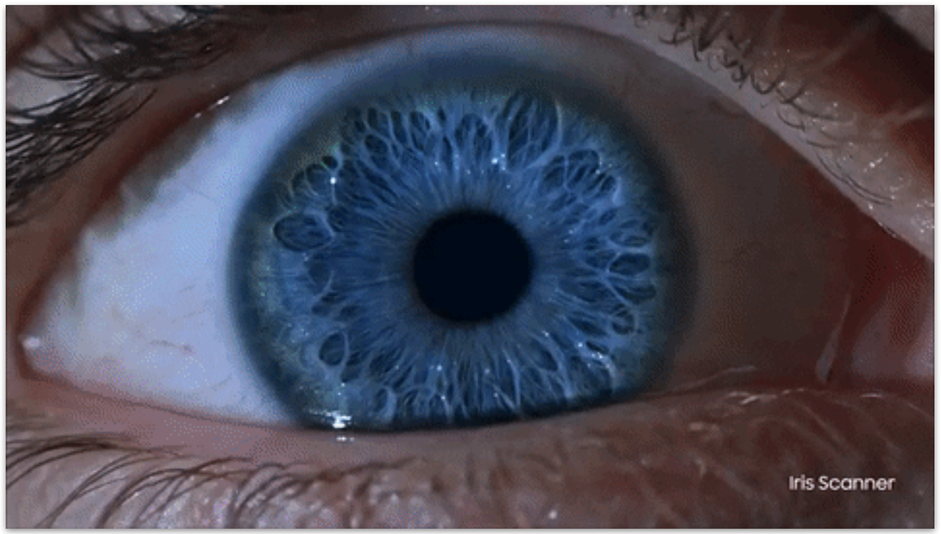
Segmentation (1/2)

Manual Segmentation
Next slide: iris recognition tool
that we have 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)



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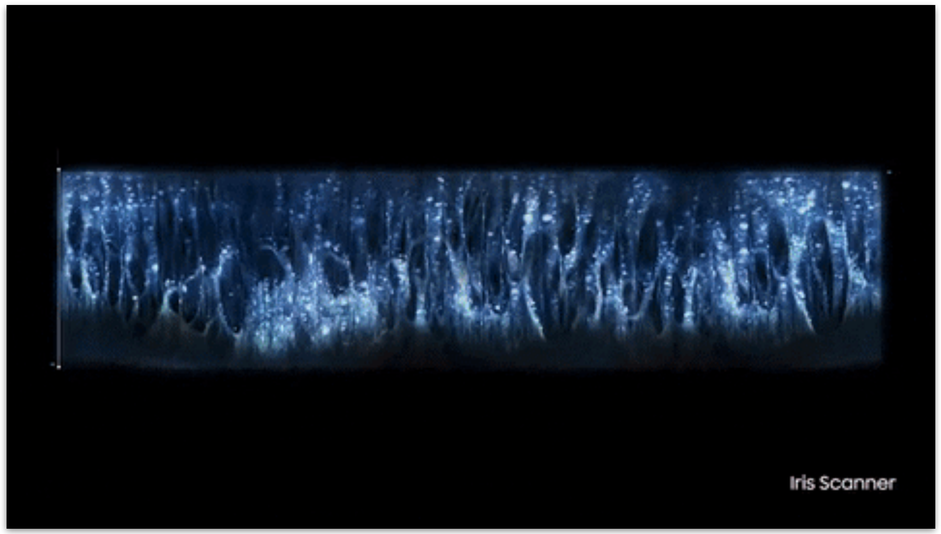
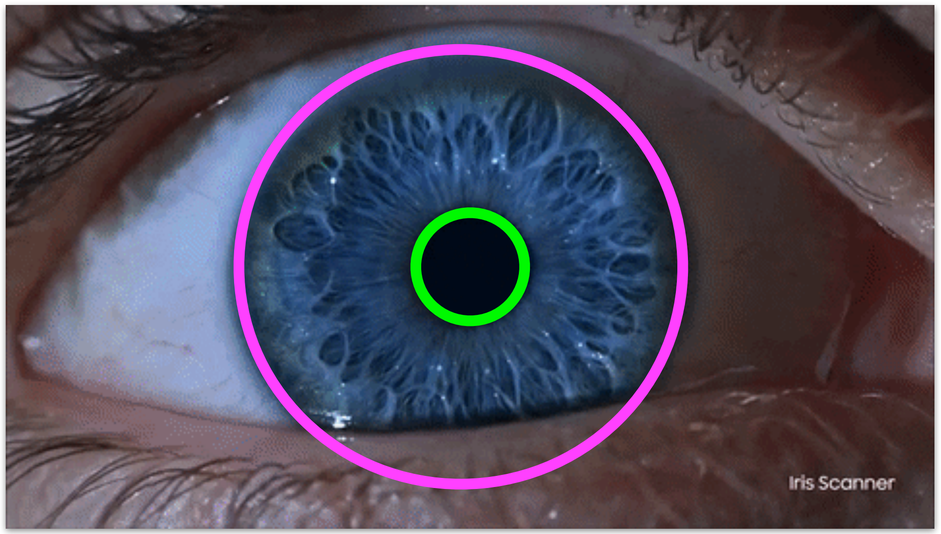


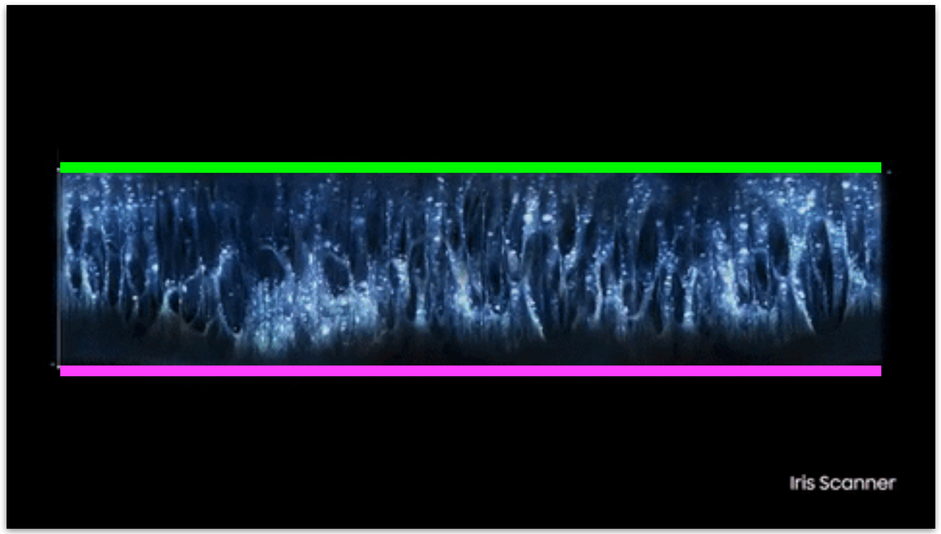
target

Enhancement

Normalization (2/2)



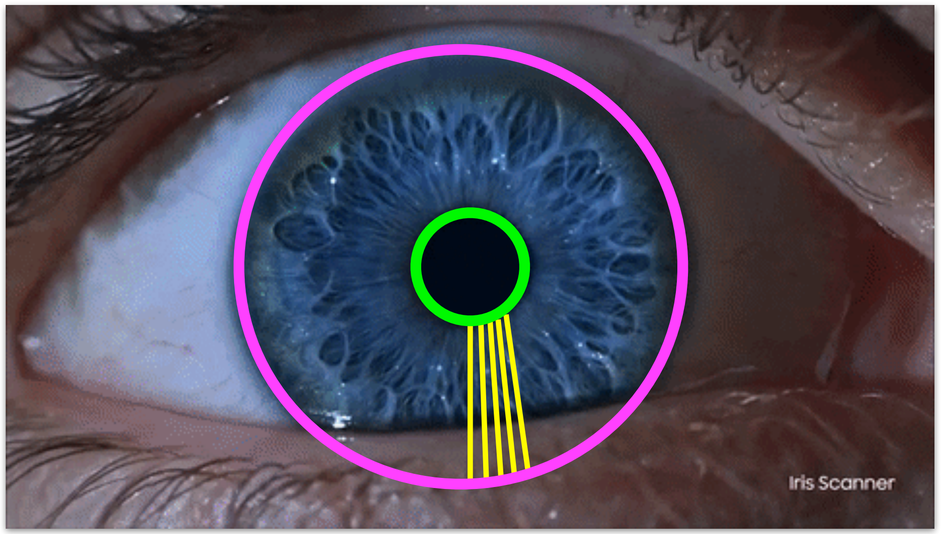
source



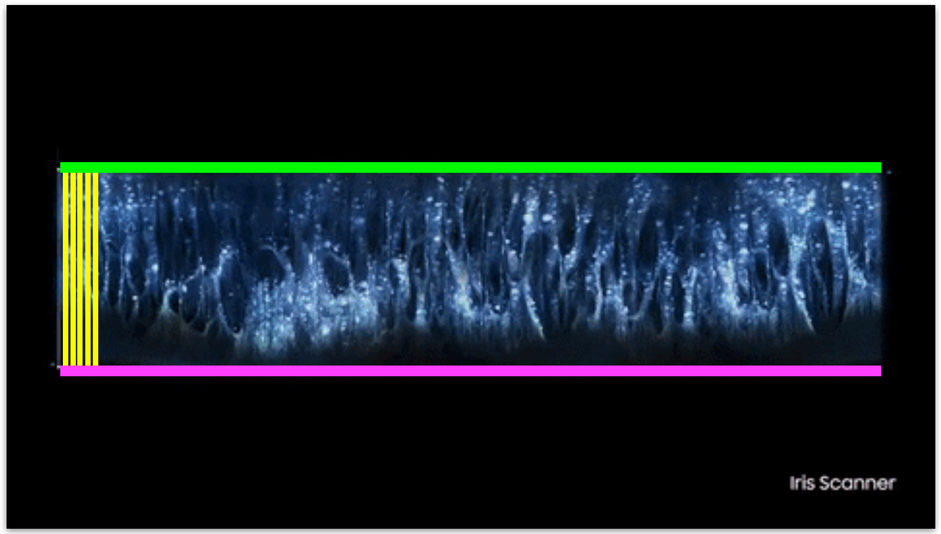
target

Enhancement

Normalization (2/2)



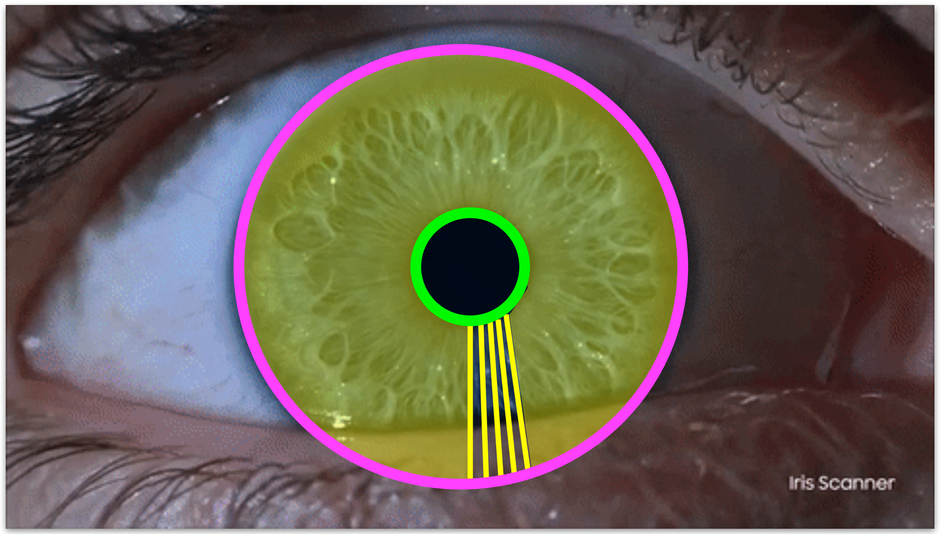
source



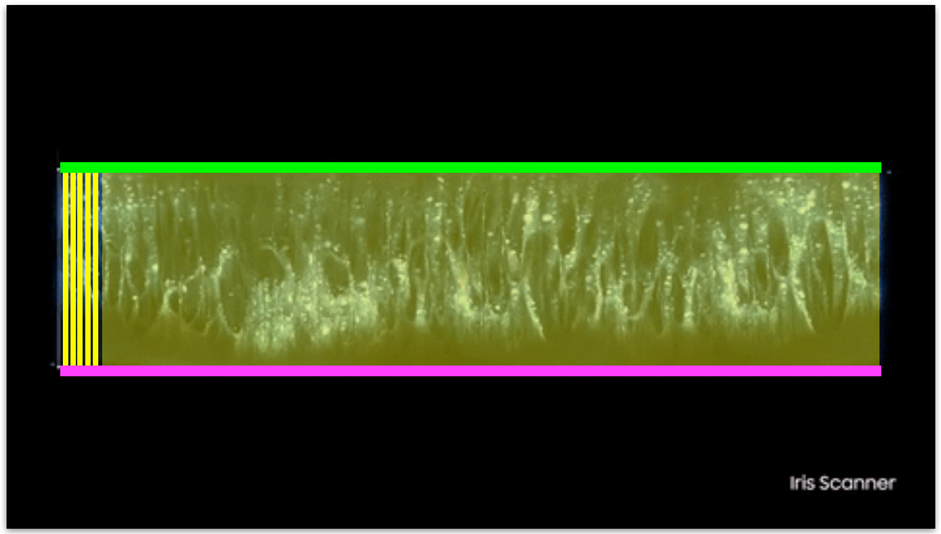
target

Enhancement

Normalization (2/2)

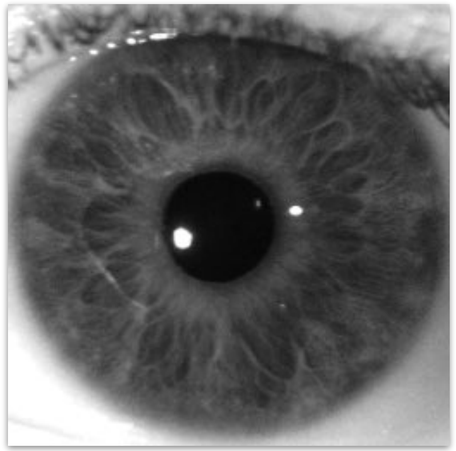


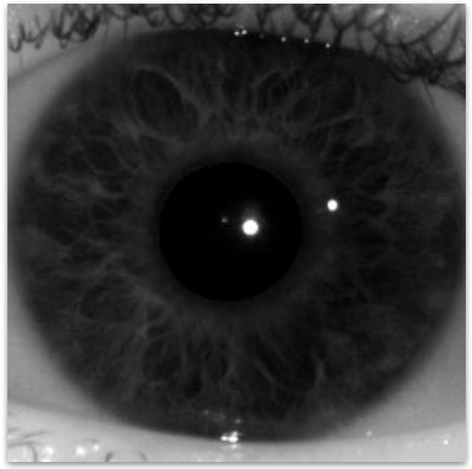
source



target

Enhancement





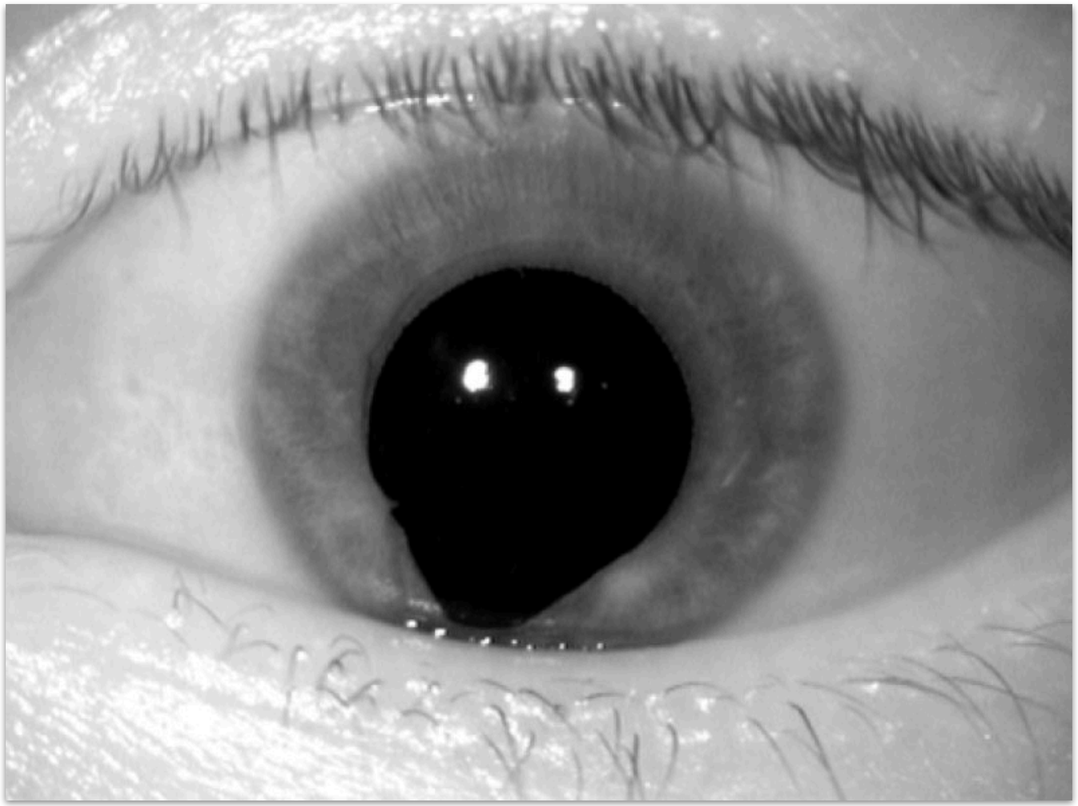
Enhancement

Limitations

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

Enhancement

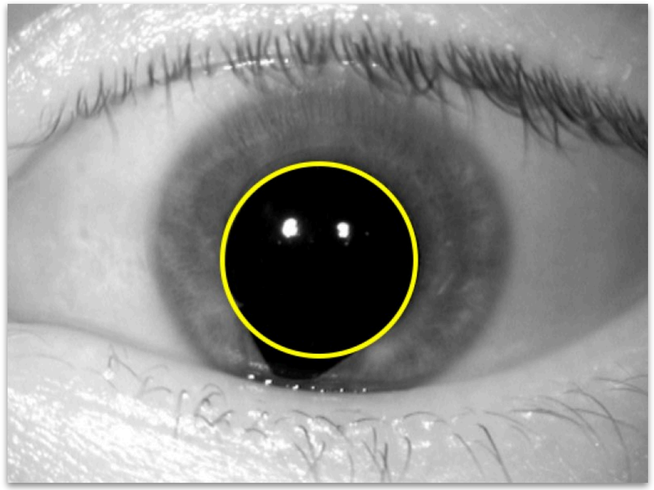
Dr. Adam Czajka

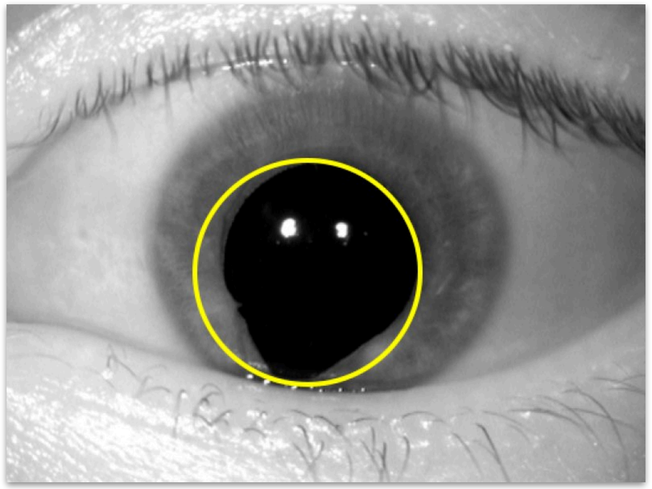


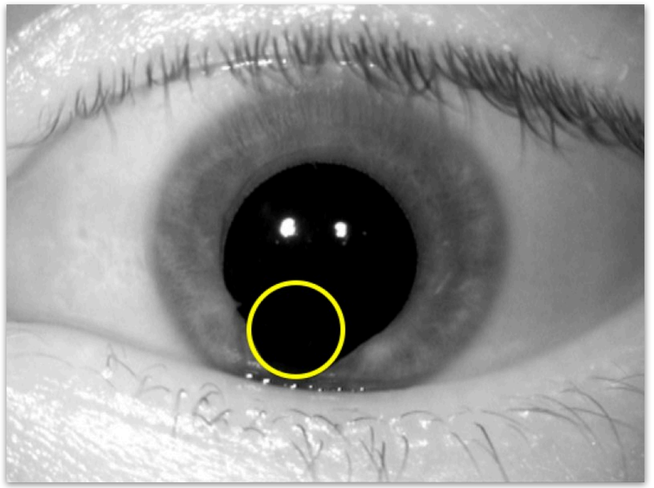
coloboma condition

Enhancement

Dr. Adam Czajka



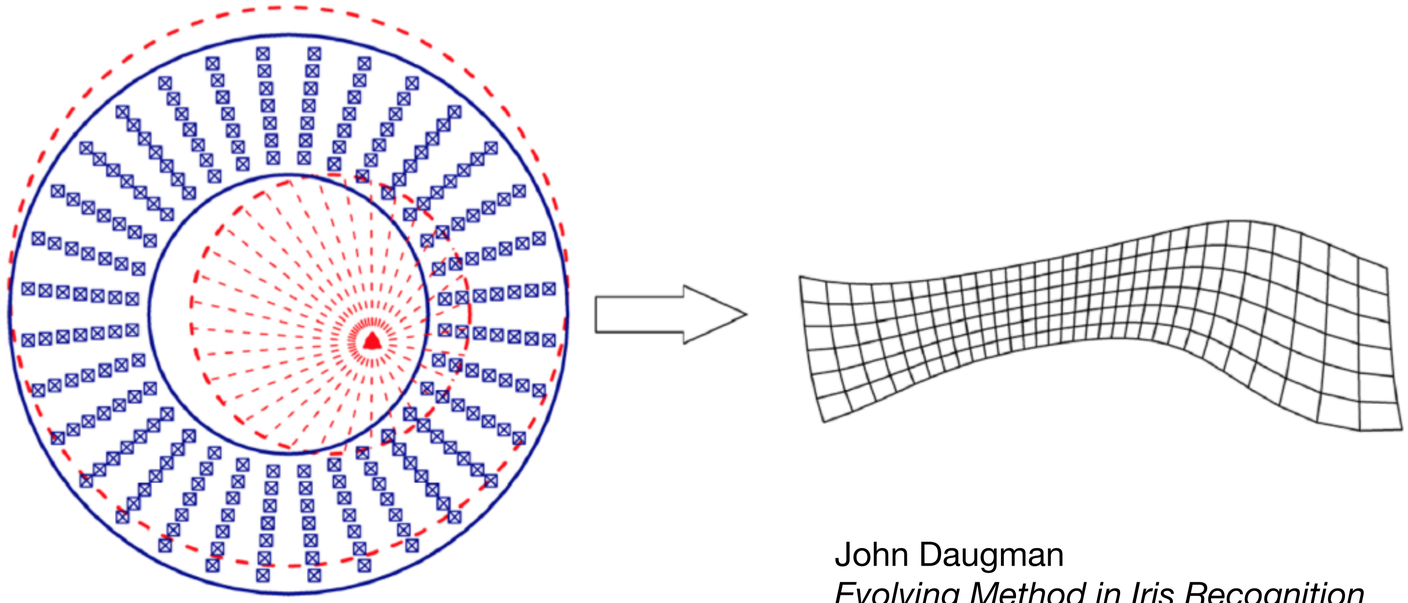




Enhancement

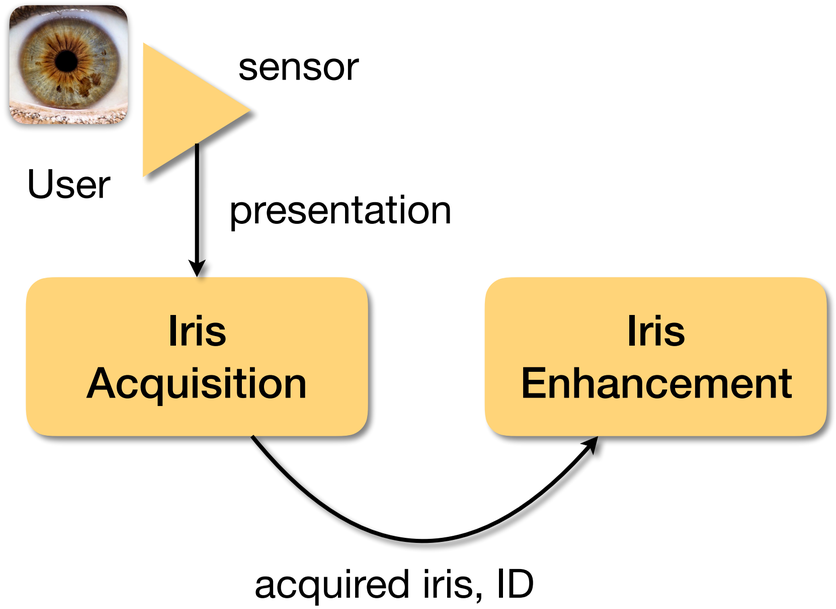
Limitations

Normalization
Forcing circular models may lead to poor mapping.

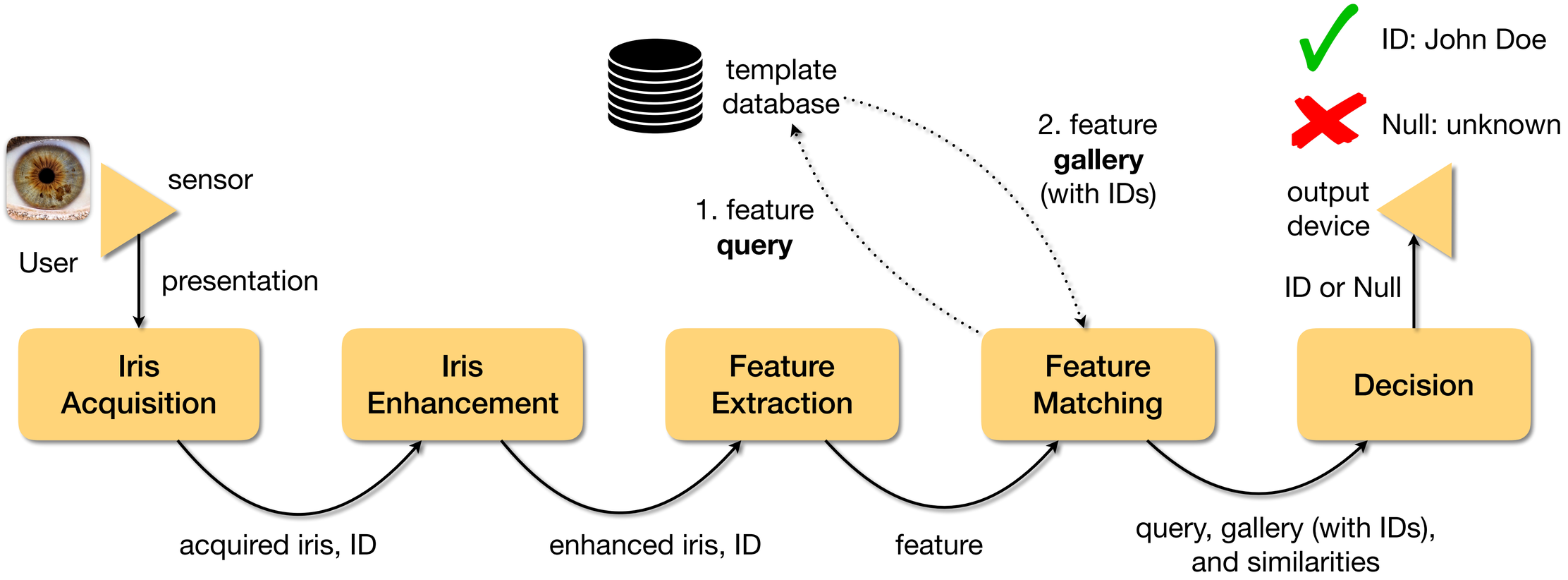


John Daugman
Evolving Method in Iris Recognition
BTAS, 2012

Iris Recognition



Iris Recognition



S’up Next?

Iris Description and Matching

Acknowledgments

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Thank you, professors, for kindly allowing me to use your material.

https://engineering.nd.edu/profiles/aczajka
https://www.wjscheirer.com/

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