

Iris Recognition I

COMP 388-002/488-002 Biometrics

Daniel Moreira
Fall 2024



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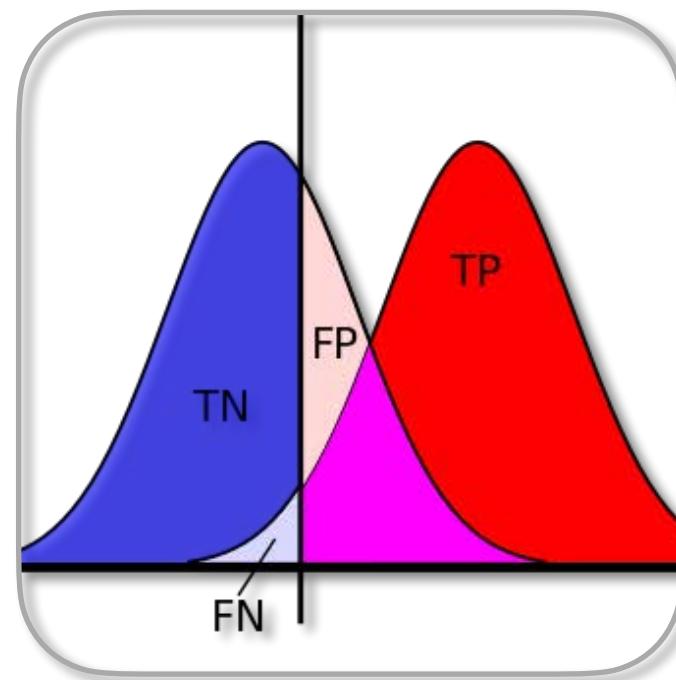
Today we will...

Get to know
Reasons to use irises for recognition.
How irises compare to fingerprints
and to faces.

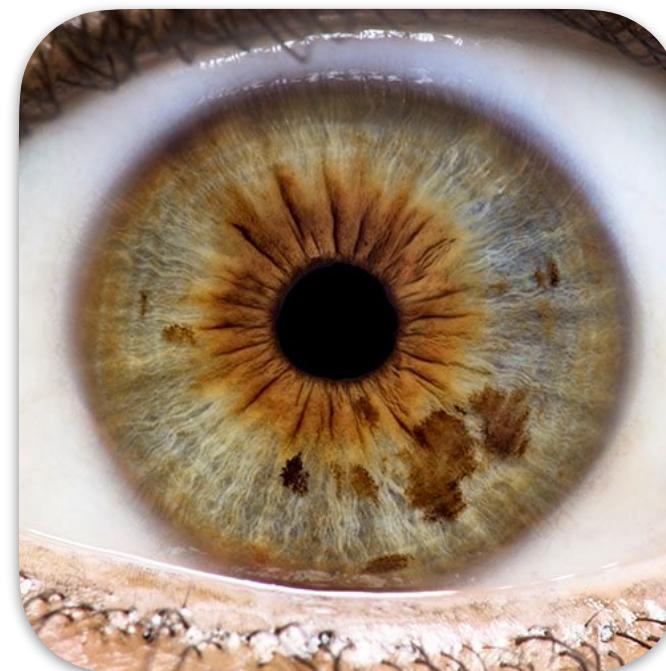


Course Overview

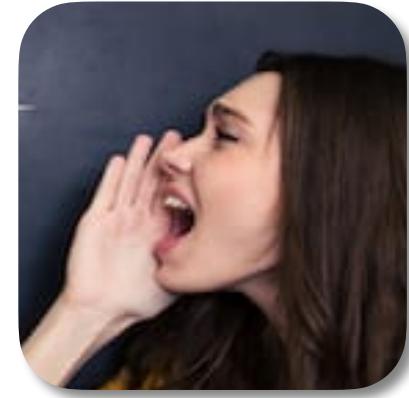
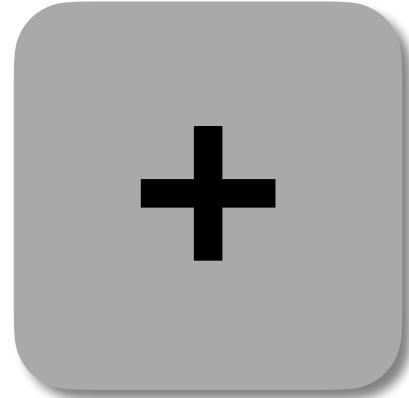
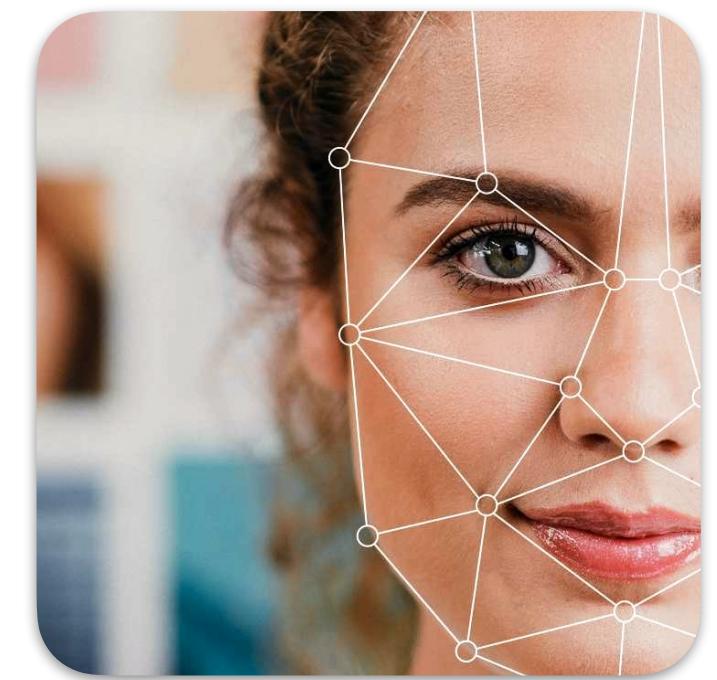
Content



Basics
Concepts
Metrics
Metric implementation



Core Traits (3)
Concepts
Baseline implementation
Data collection
Evaluation
Attacks
Assignments



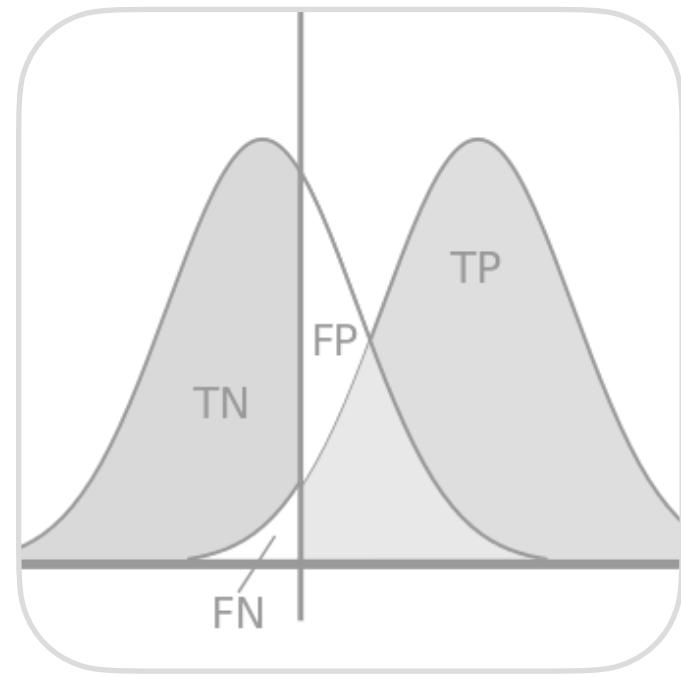
Alternative Traits and Fusion Concepts



Invited Talks (2)
State of the art
Future work

Course Overview

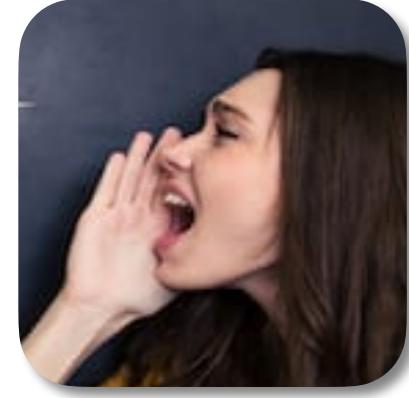
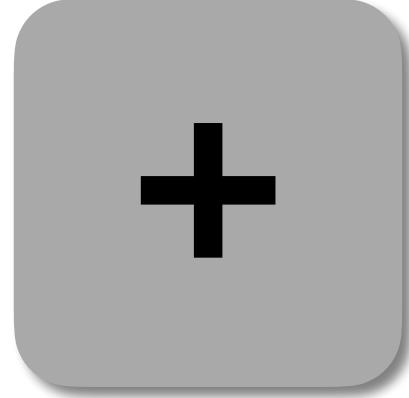
Content



Basics
Concepts
Metrics
Metric implementation



Core Traits (3)
Concepts
Baseline implementation
Data collection
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Alternative Traits and Fusion Concepts



Invited Talks (2)
State of the art
Future work

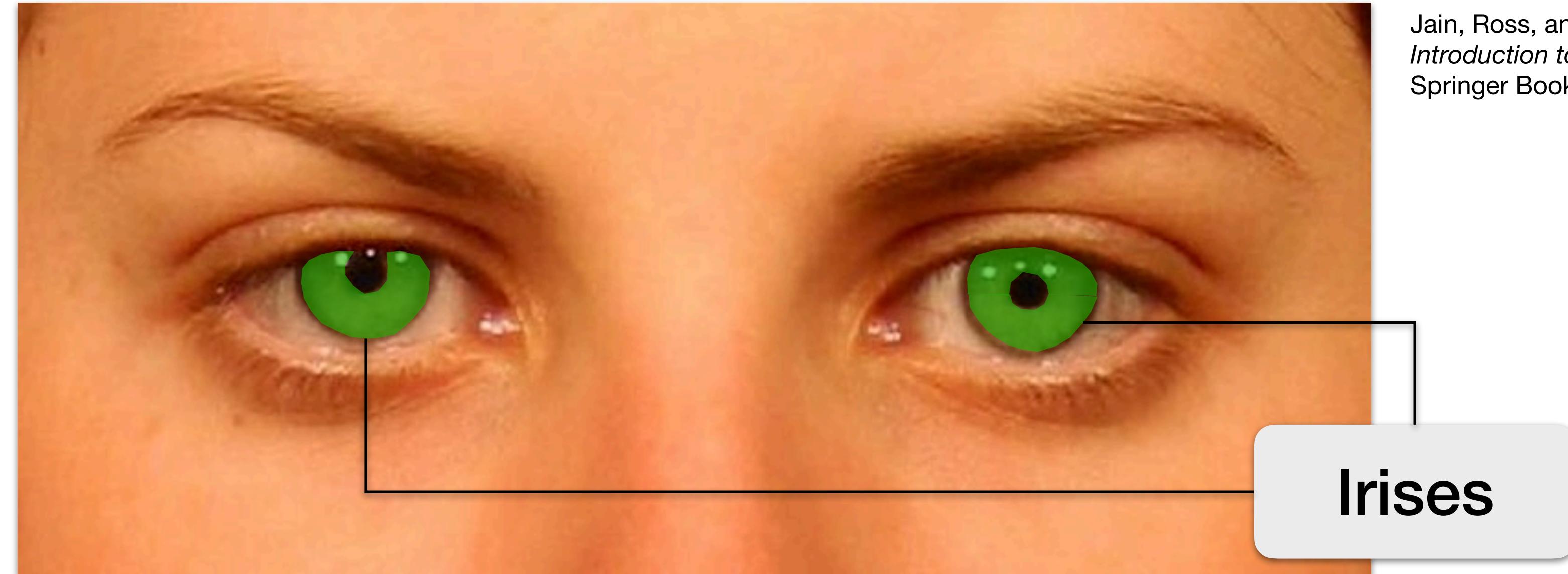
Irides



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

Ocular Region

Irides



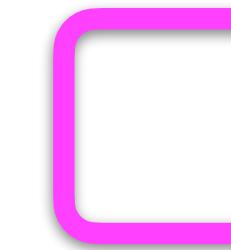
Jain, Ross, and Nadakumar
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Springer Books, 2011

Ocular Region

Anatomy

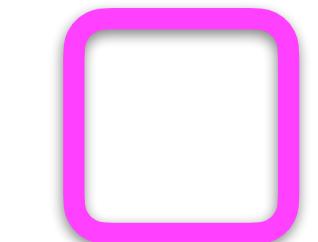
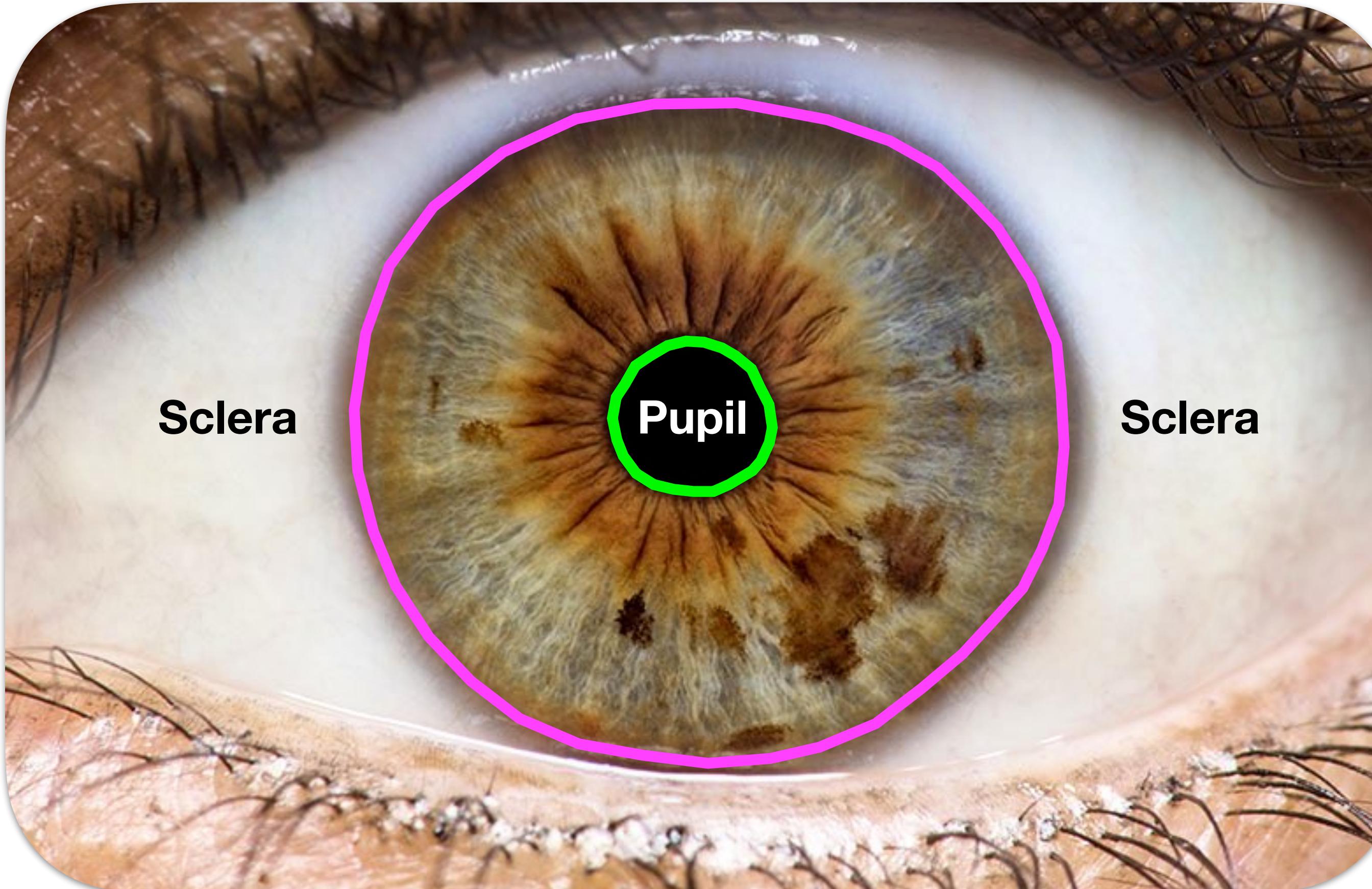


Anatomy

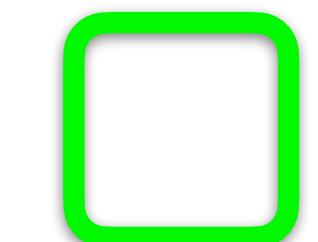


Limbus boundary

Anatomy

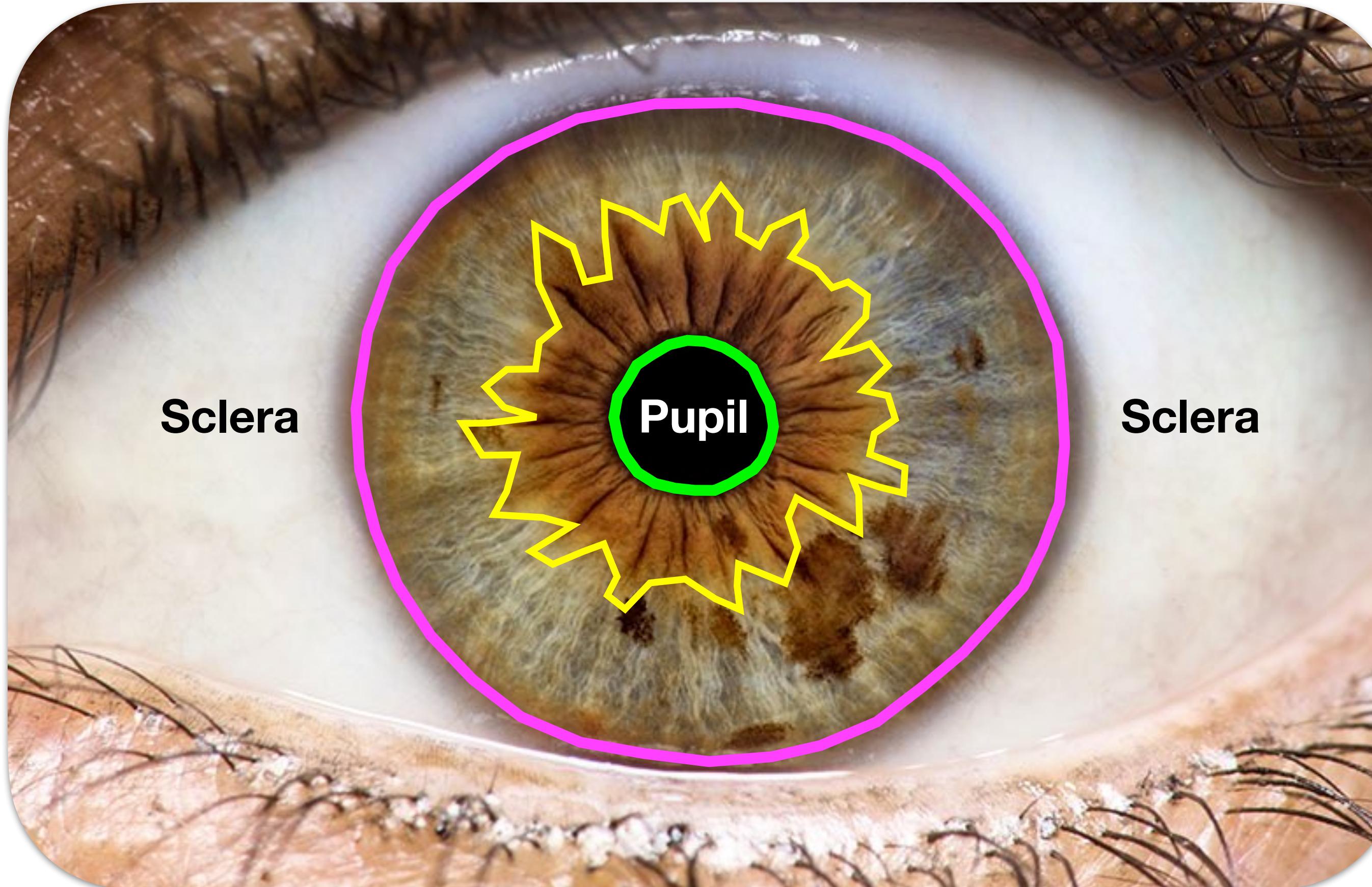


Limbus boundary



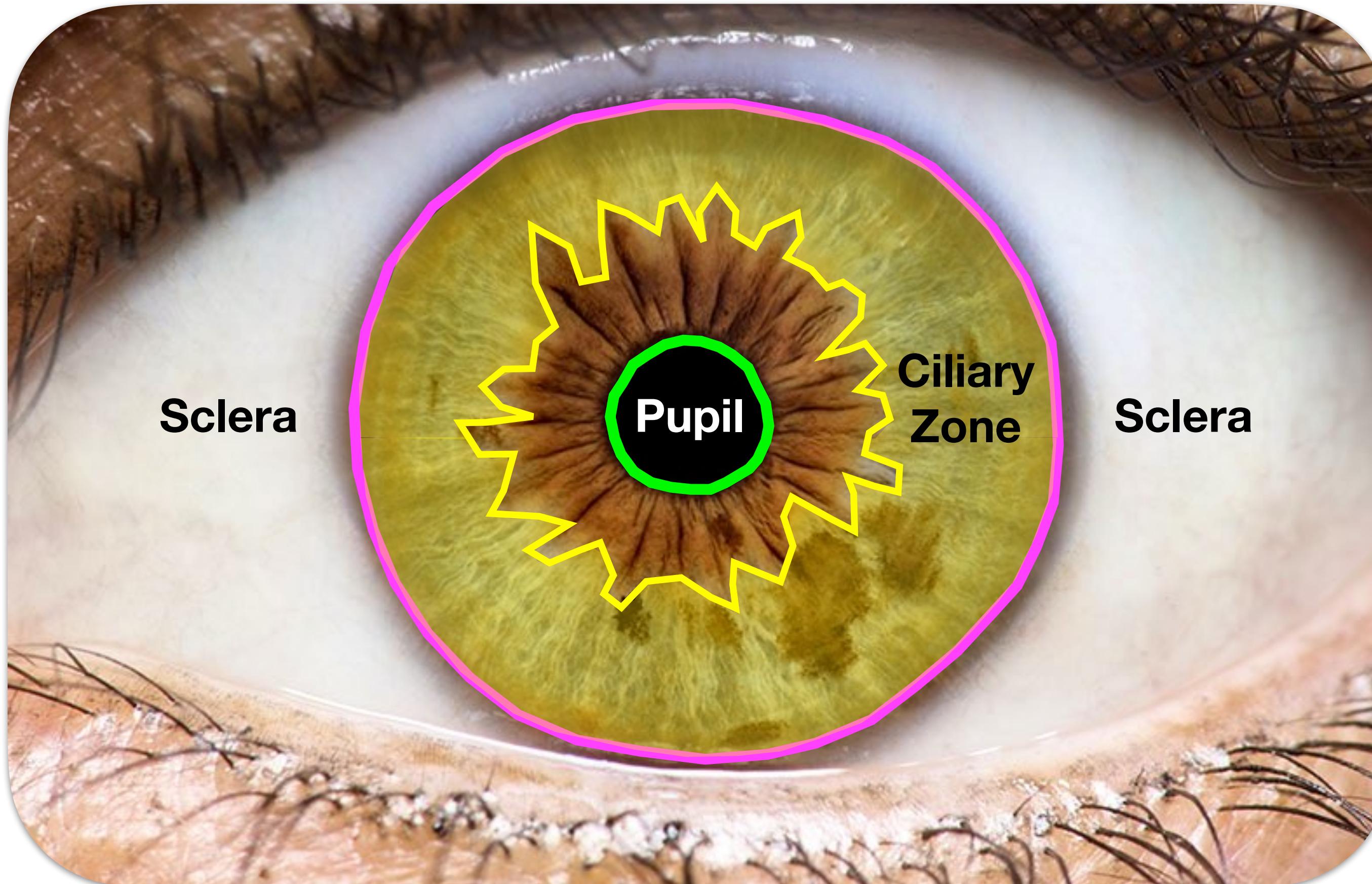
Pupillary boundary

Anatomy



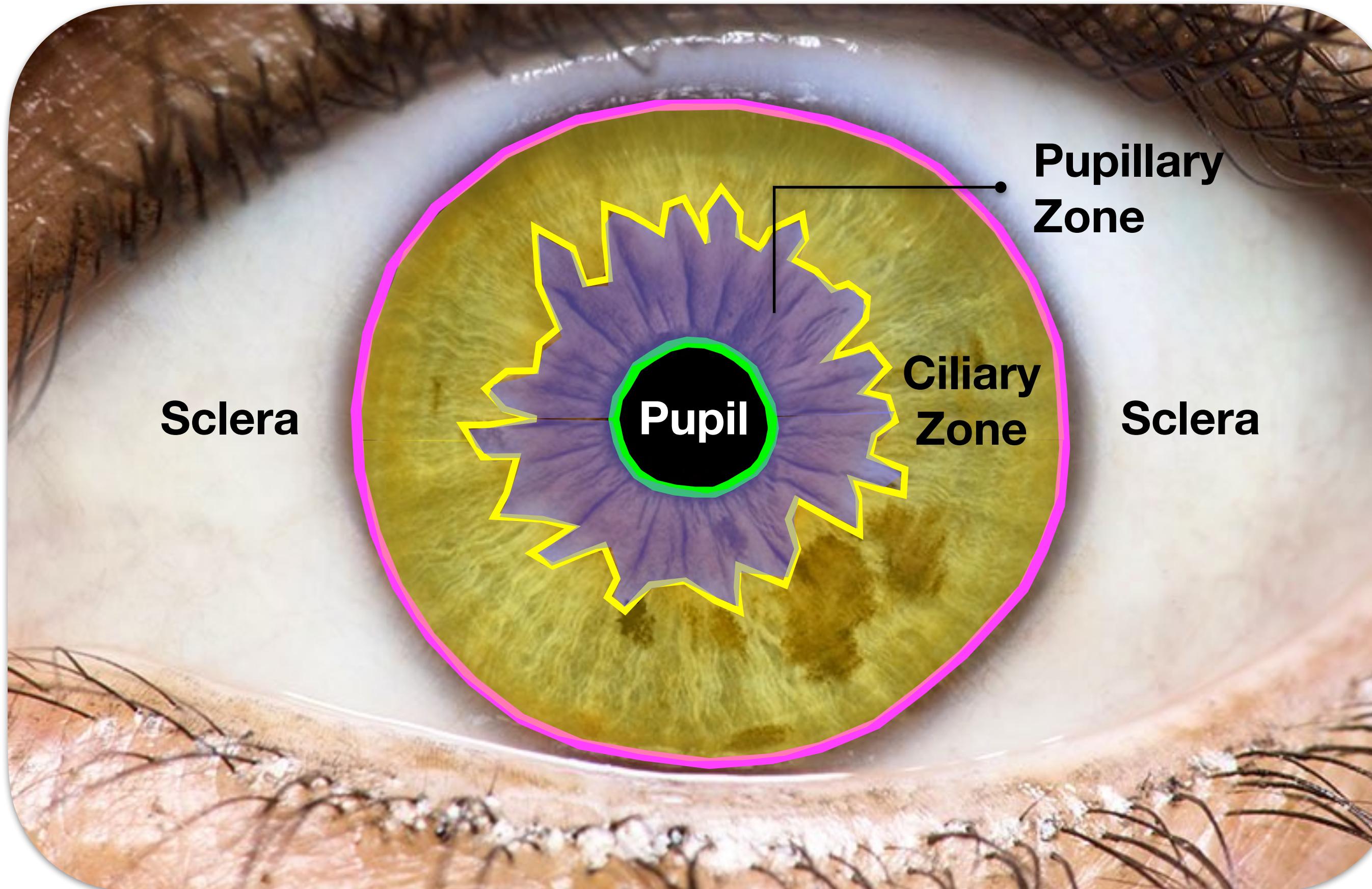
- Limbus boundary
- Pupillary boundary
- Collarette

Anatomy



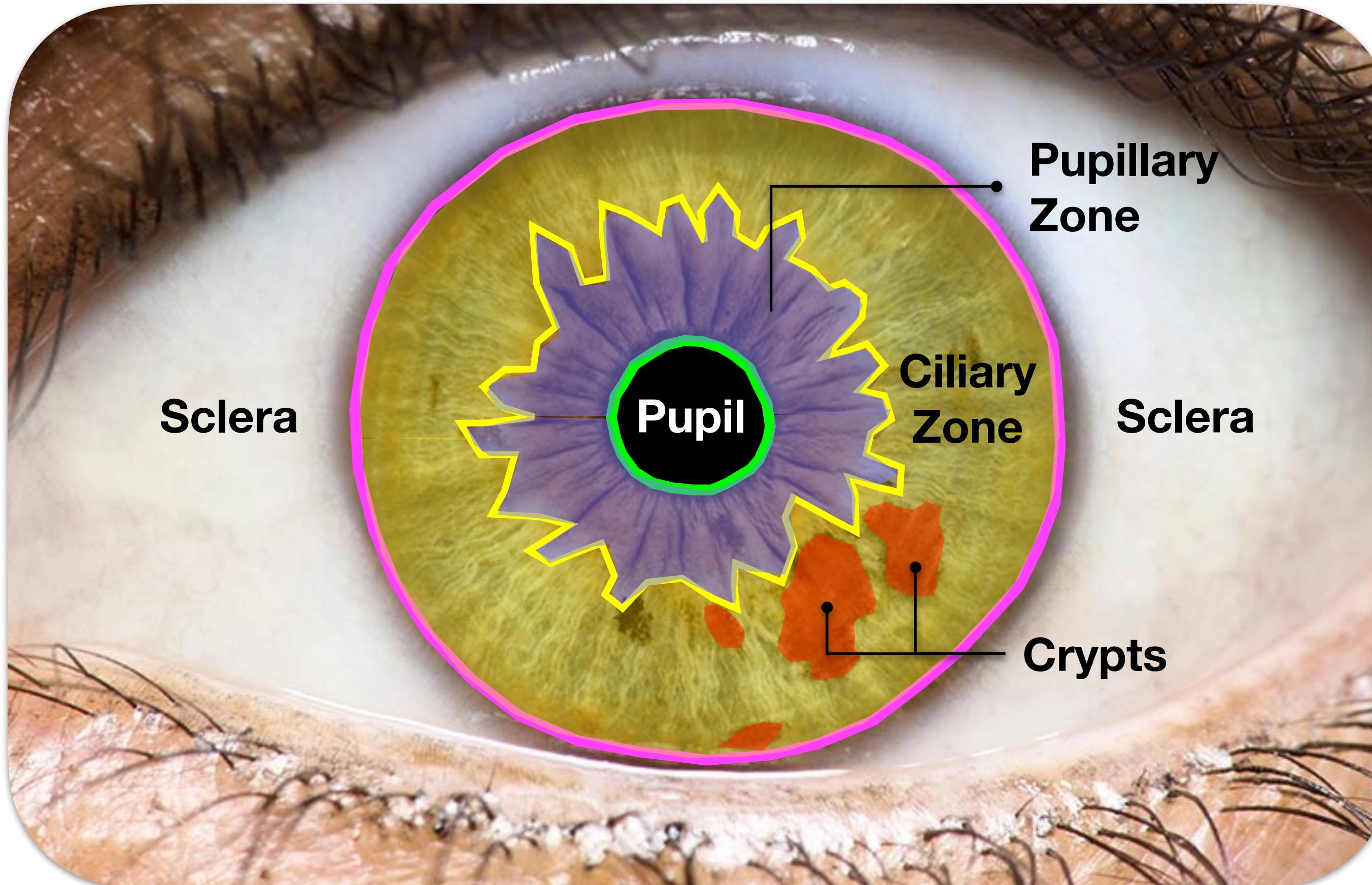
- Limbus boundary
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Anatomy



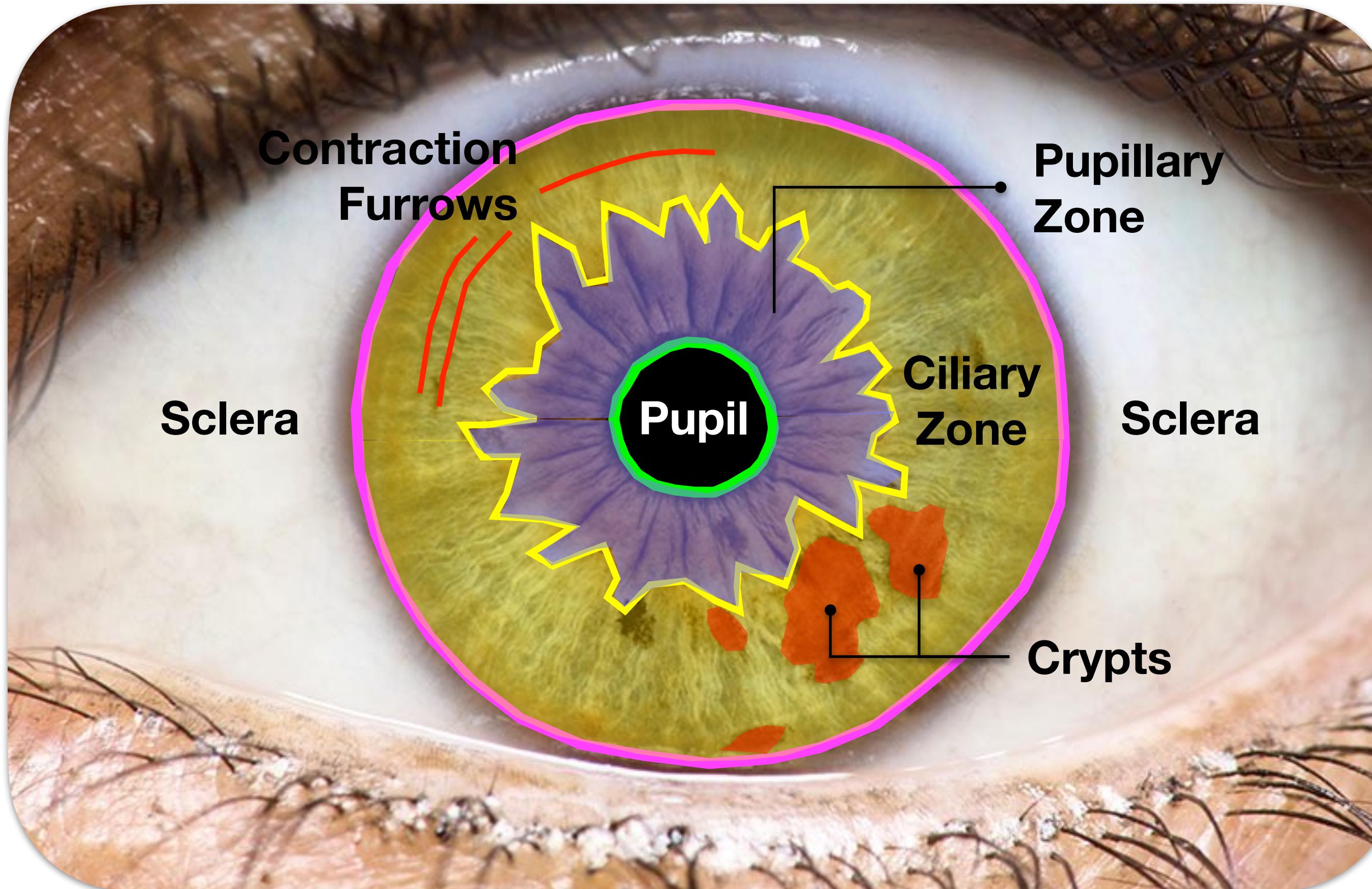
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Anatomy



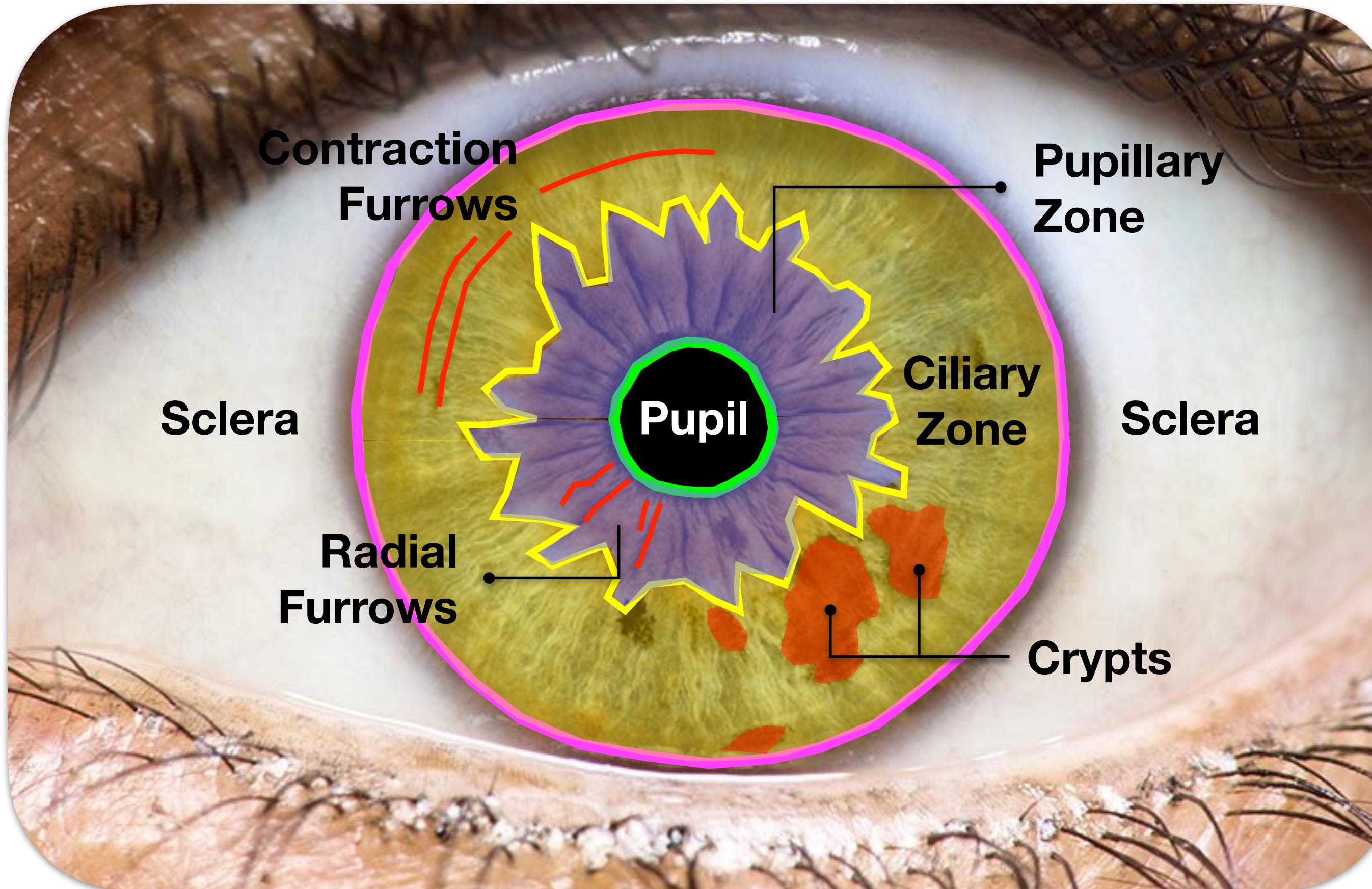
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Anatomy



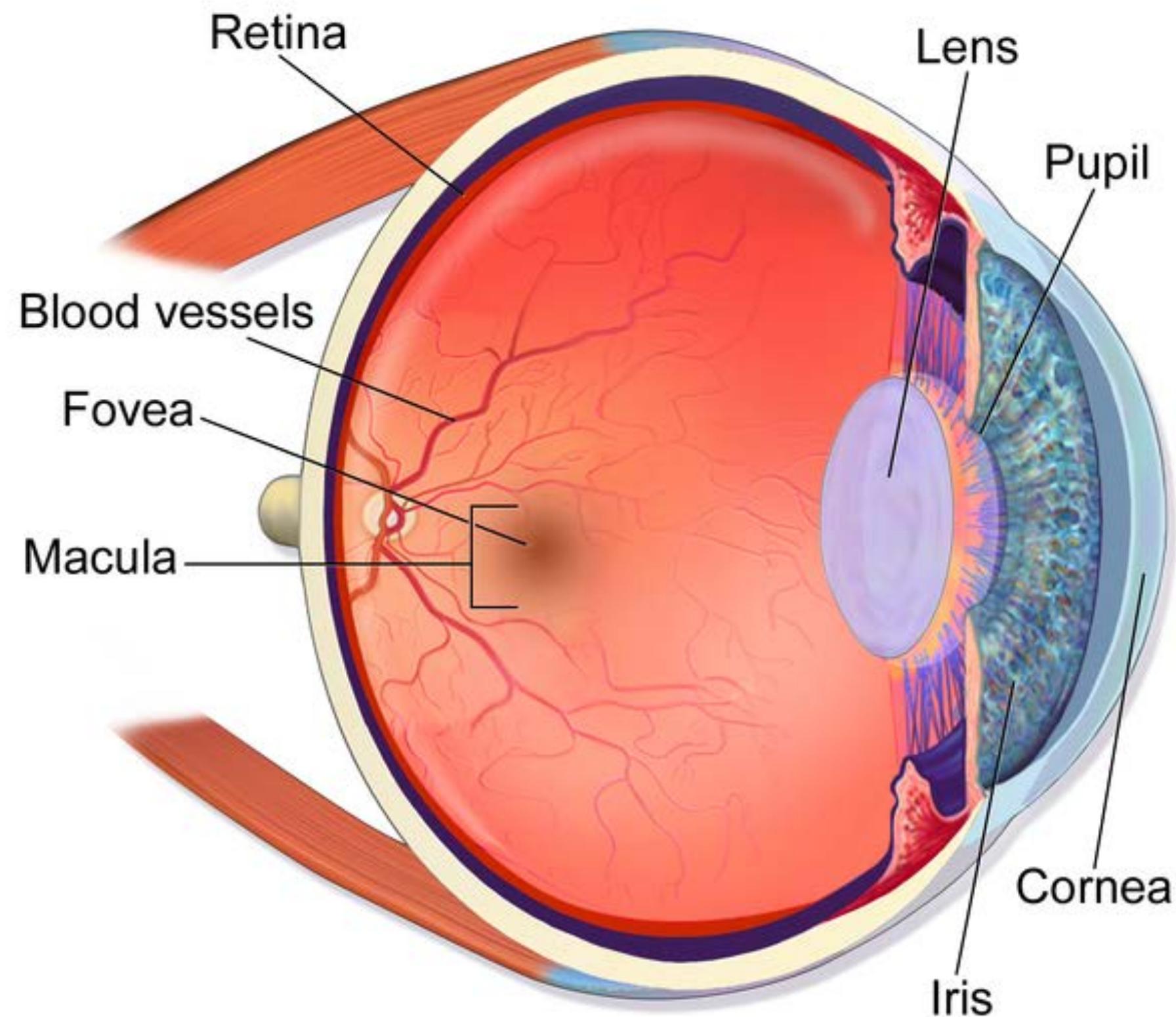
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Anatomy



- Limbus boundary
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Anatomy

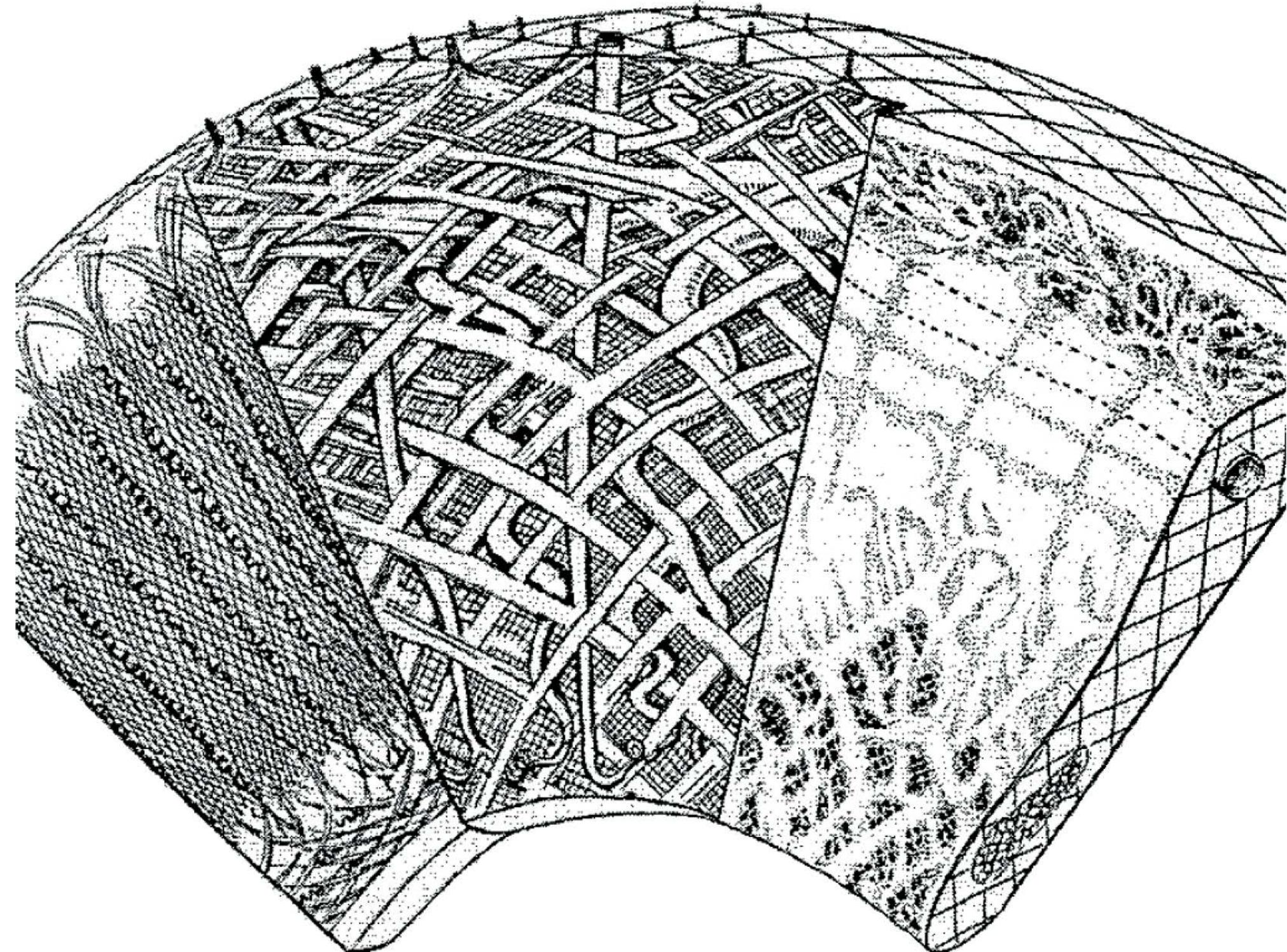


commons.wikimedia.org

Iris

Located behind the cornea and in front of the lens.

Anatomy



Hans Rohen

*Der bau der regenbogenhault beim
menschen und einigen Saugern*
Gegenbaur Morphology Journal, 1951

Iris

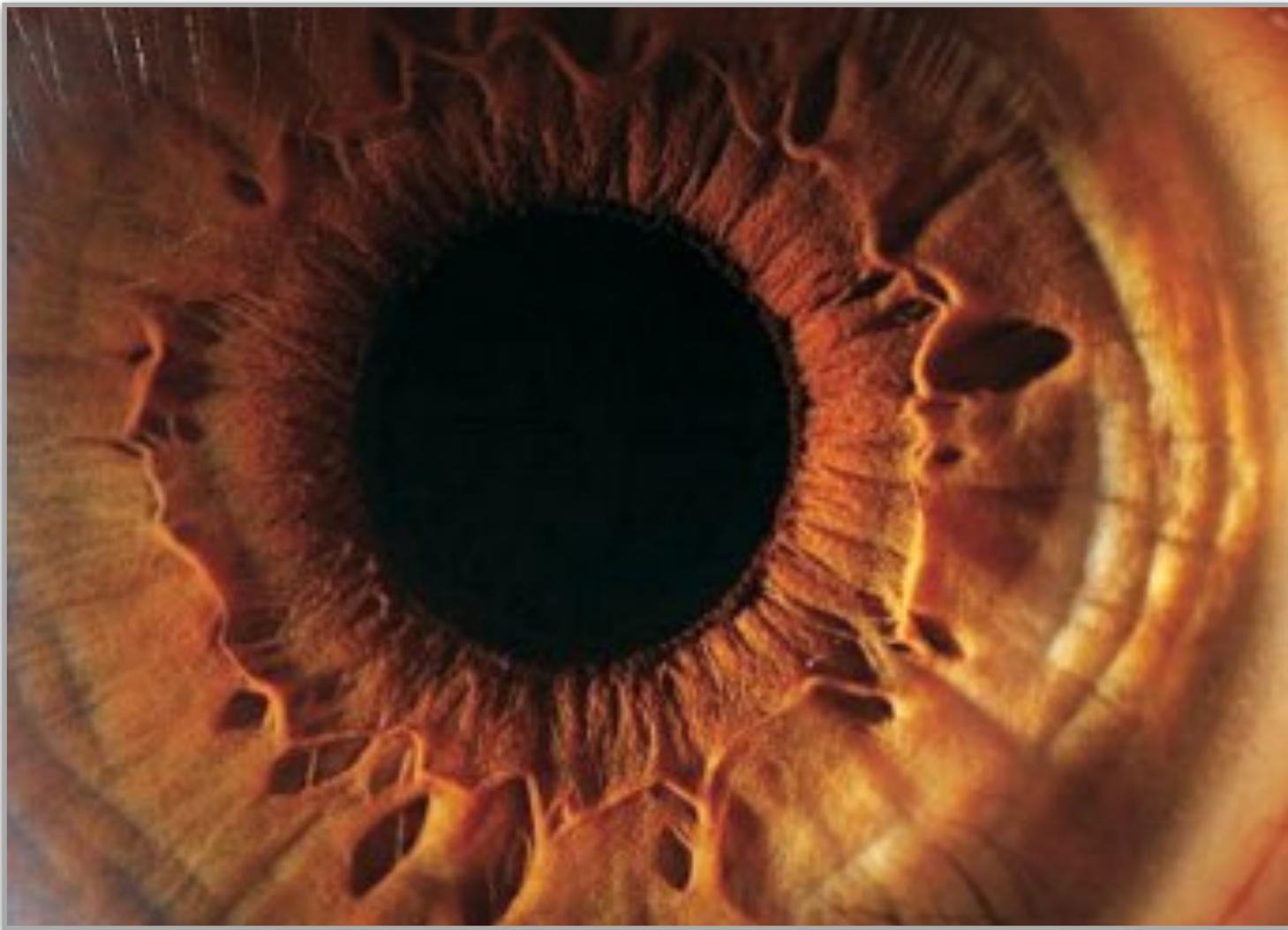
Located behind the cornea and in front of the lens.

Complex mesh of muscle beams, blood vessels, nerves, and pigmented skin.



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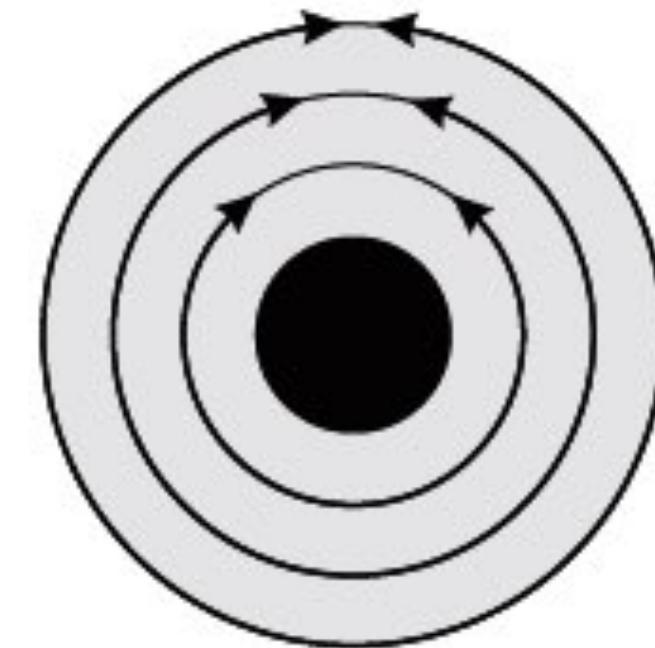
Anatomy



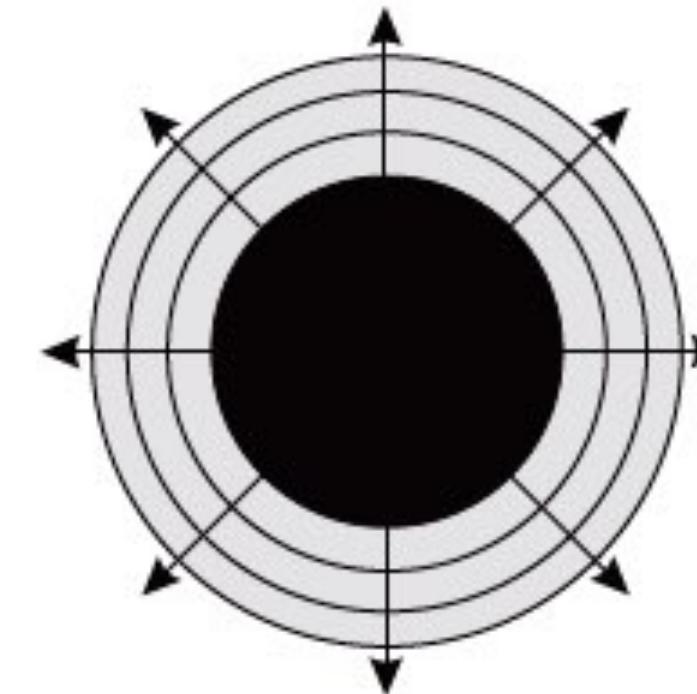
Suren Manvelyan

Anatomy

Adam Czajka

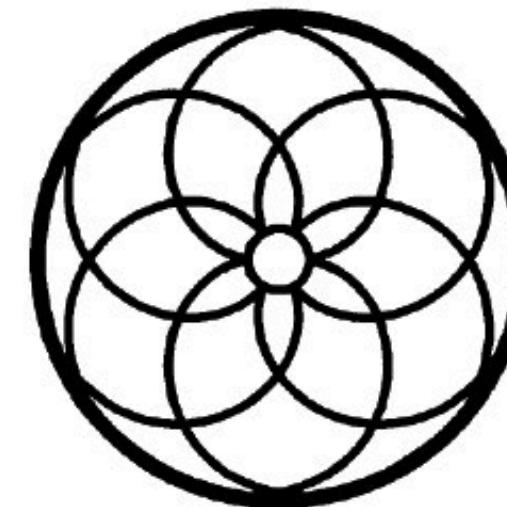


Sphincter Muscles



Dilator Muscles

H. J. Wyatt
*A minimum wear-and-tear
meshwork for the iris.*
Vision Research, 2000



Non-linear constrictions and dilations.

Iris

Located behind the cornea and in front of the lens.

Complex mesh of muscle beams, blood vessels, nerves, and pigmented skin.

Function: regulate the amount of light entering the eye by dilating or contracting the pupil.



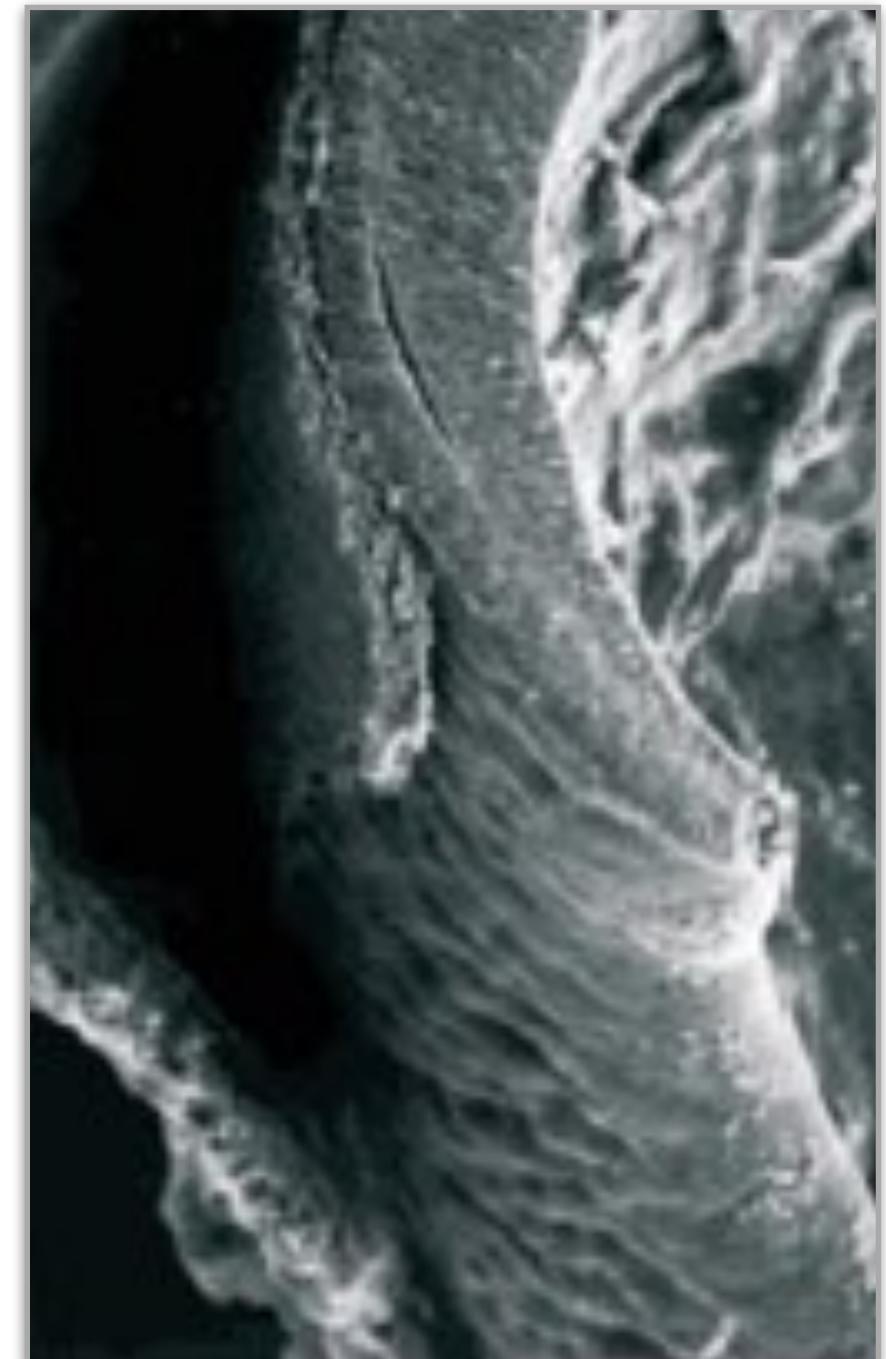
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Genesis

Epigenetic Trait

Development starts in the end of the 2nd month of gestation.

Fully developed by the 8th month of gestation.



Adam Czajka

Genesis

J. Daugman

Evolving Methods in Iris Recognition

BTAS, 2012

Epigenetic Trait

Different gestations will lead to different irises (except for color), even if DNA is the same.

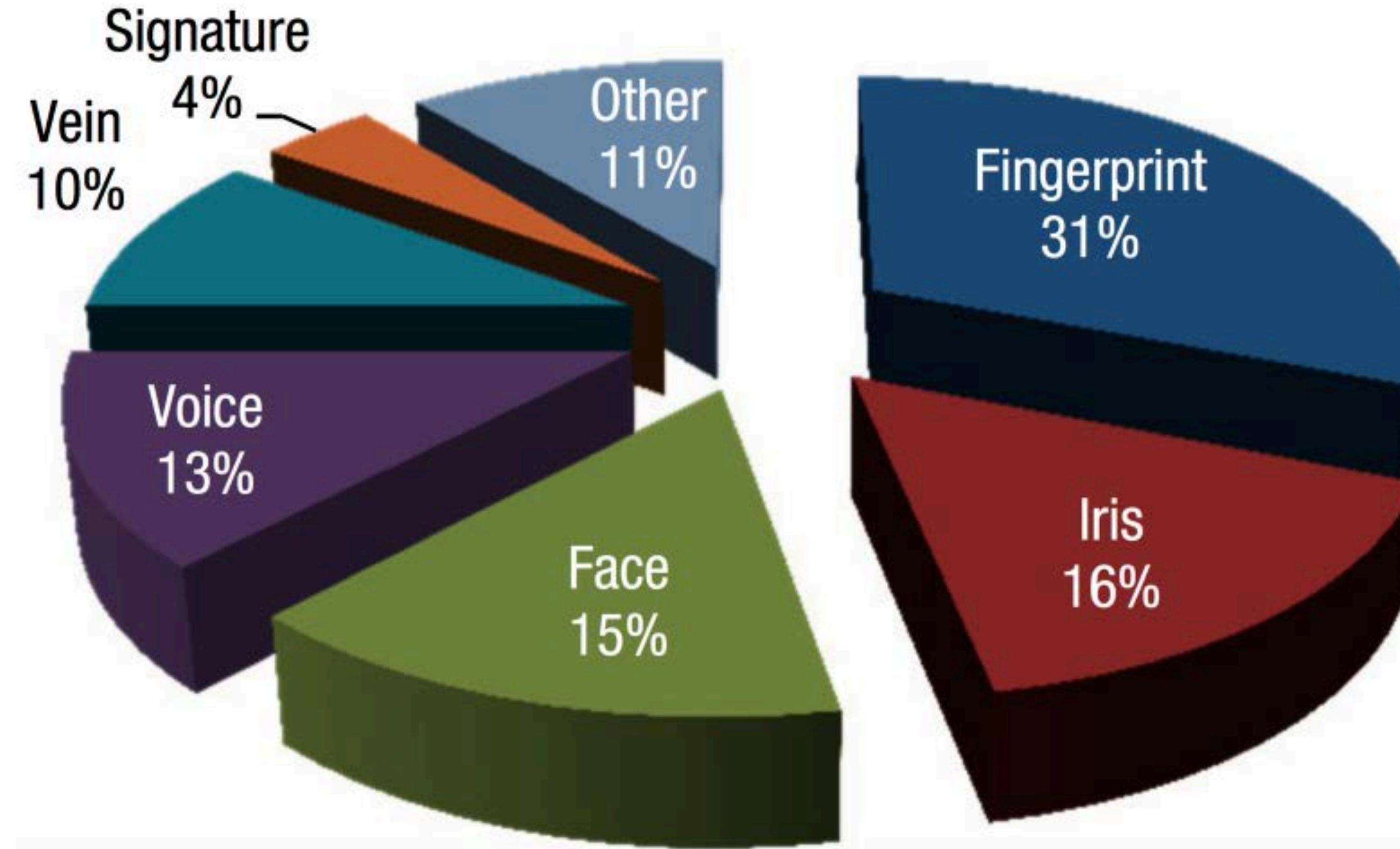
Right and left irises are different.

Identical twins have different irises.



Why Irises?

Market



Source: Mani and Nadeski, *Processing solutions for biometric systems*, Texas Instruments, 2015

Why Irises?

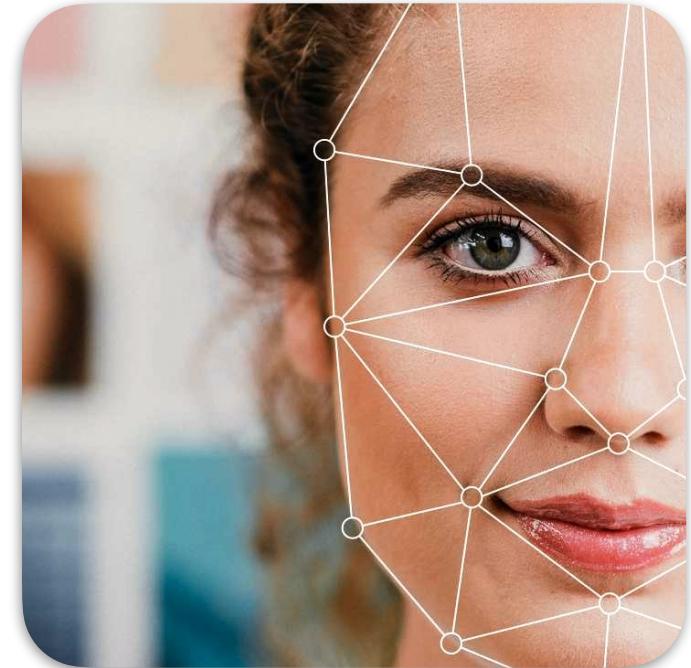
Universality (1/8)

Does everybody have the trait?



Probably

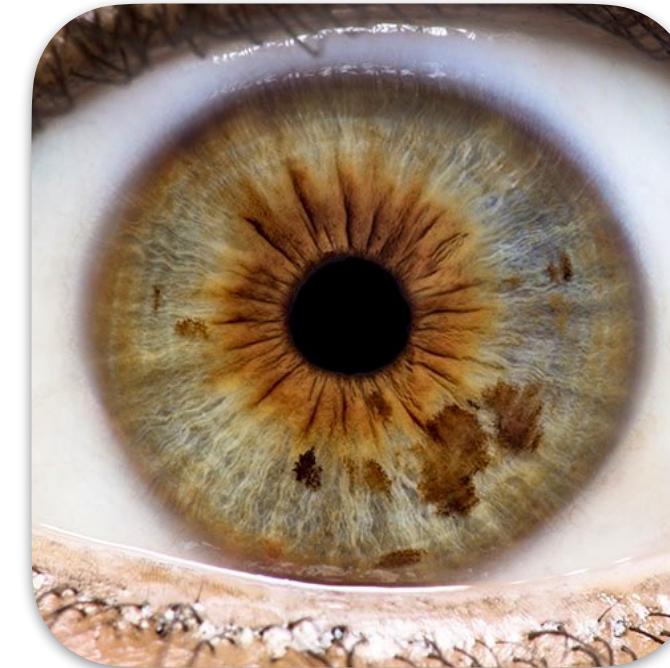
better than



>



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Why Irises?

Uniqueness (2/8)

How likely two or more individuals will present the same trait?



Why Irises?

Uniqueness (2/8)

How likely two or more individuals will present the same trait?

E.g., identical twins

Same faces.

Four different irises.



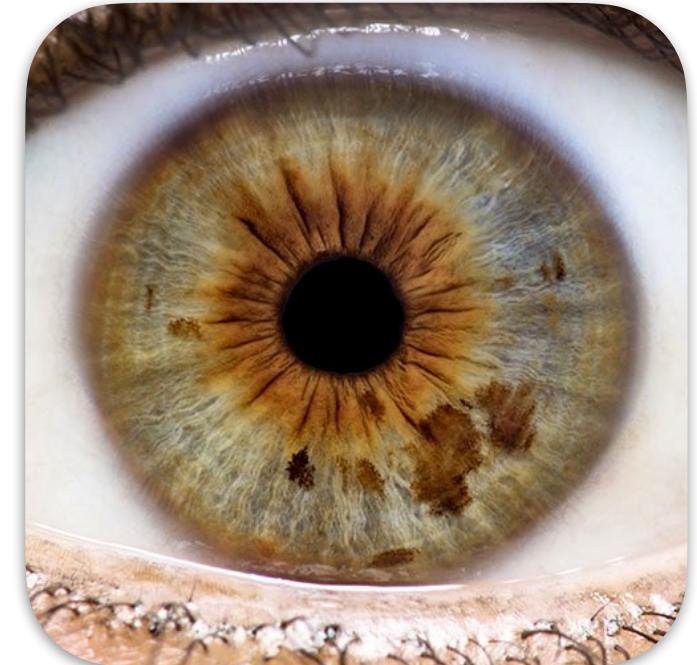
Source: John Daugman
Lecture Notes, 2018

Why Irises?

Permanence (3/8)

How easily does the trait change?

probably



v



v



Why Irises?



Permanence (3/8)

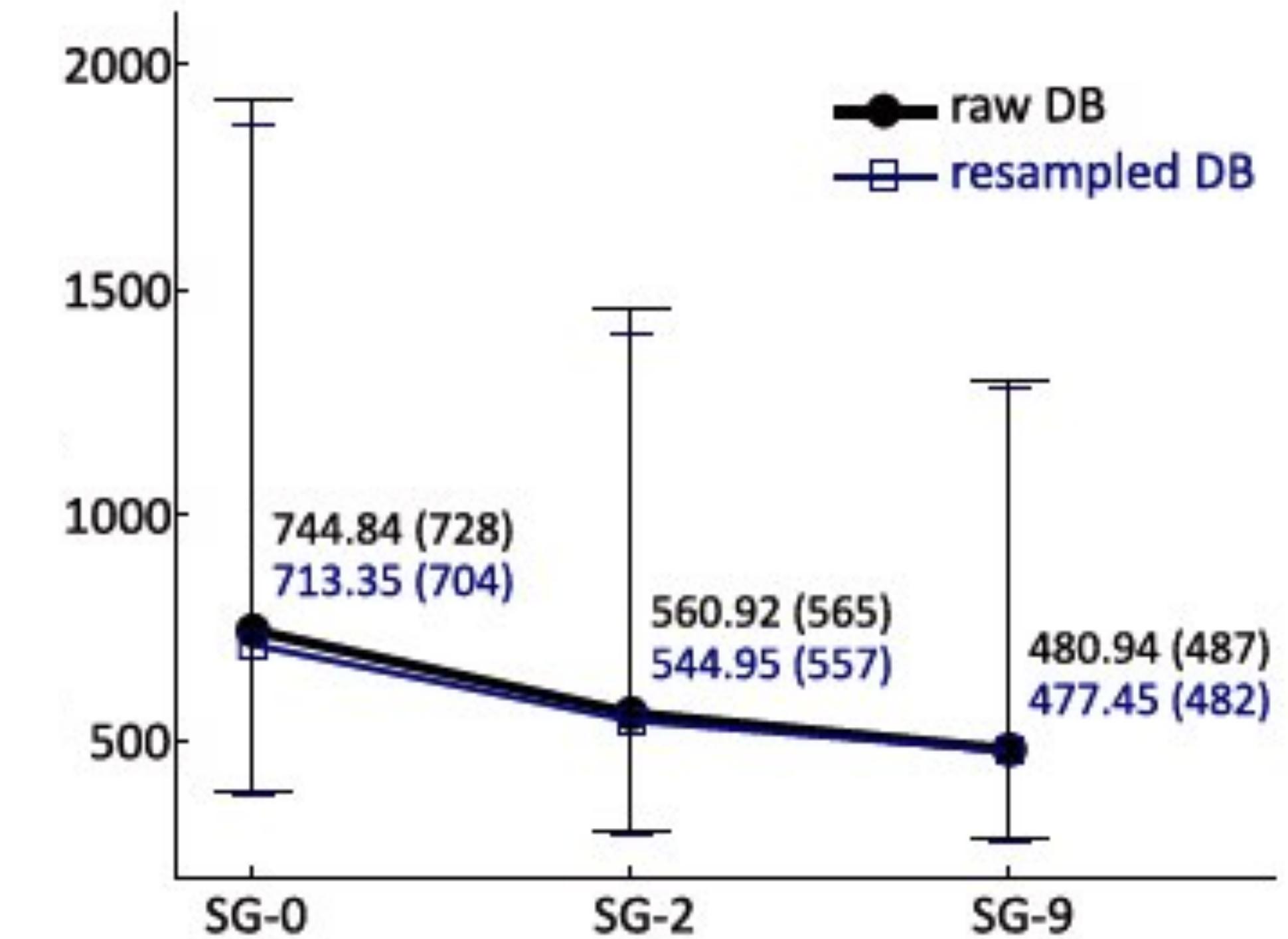
How easily does the trait change?

Needed Research

There seems to be a degradation of True Match Rate (TMR) as a function of time.

A. Czajka

Influence of Iris Template Aging on Recognition Reliability
Springer CCIS, 2014

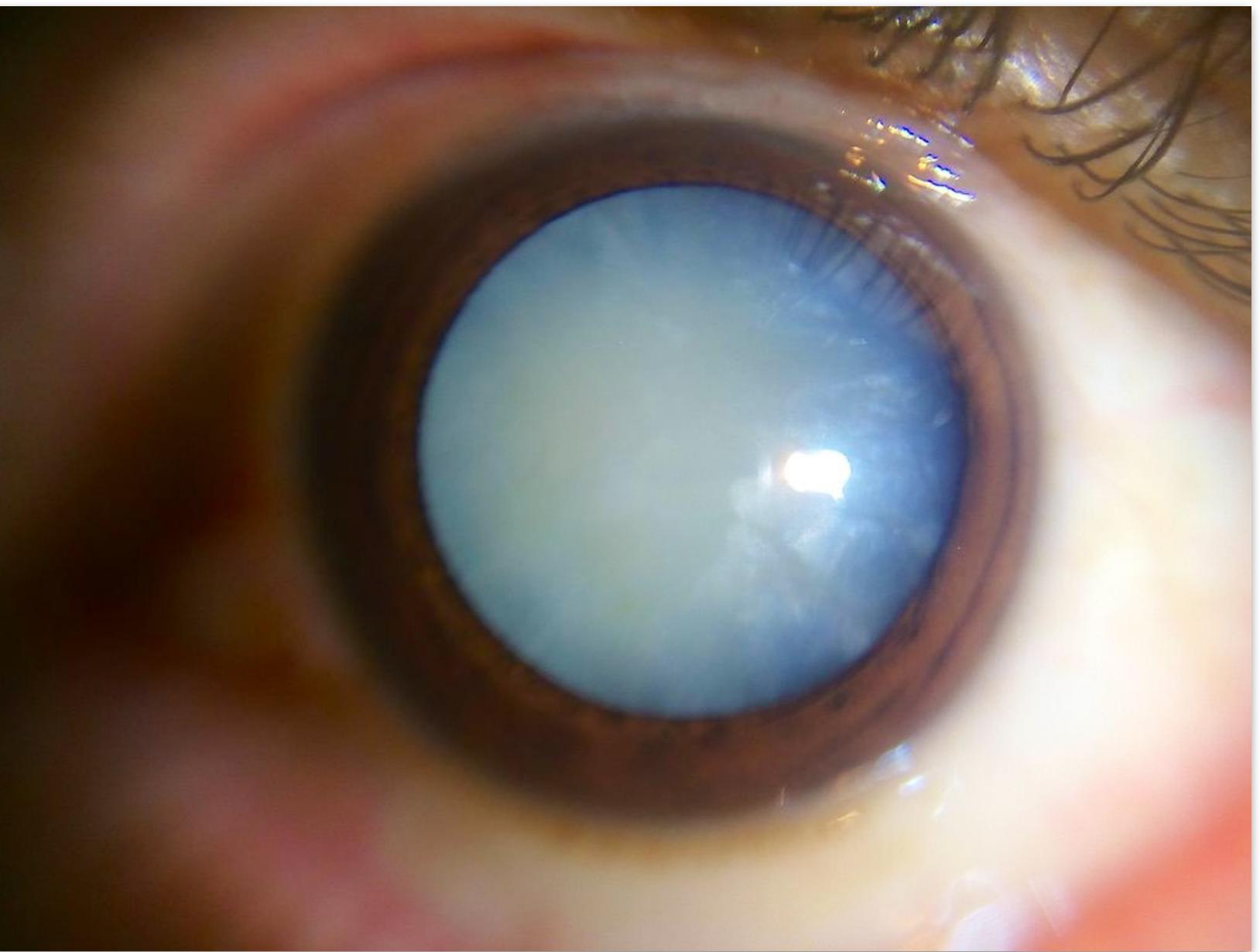


Why Irises?

Permanence (3/8)

How easily does the trait change?

commons.wikimedia.org



Traumas and Diseases

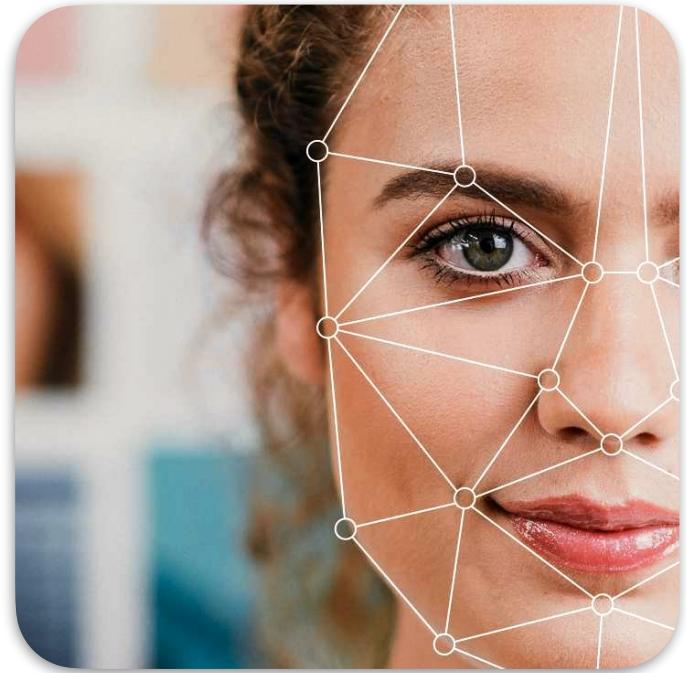
Some traumas and diseases might degrade/change the iris.

E.g., cataracts.

Why Irises?

Measurability (4/8)

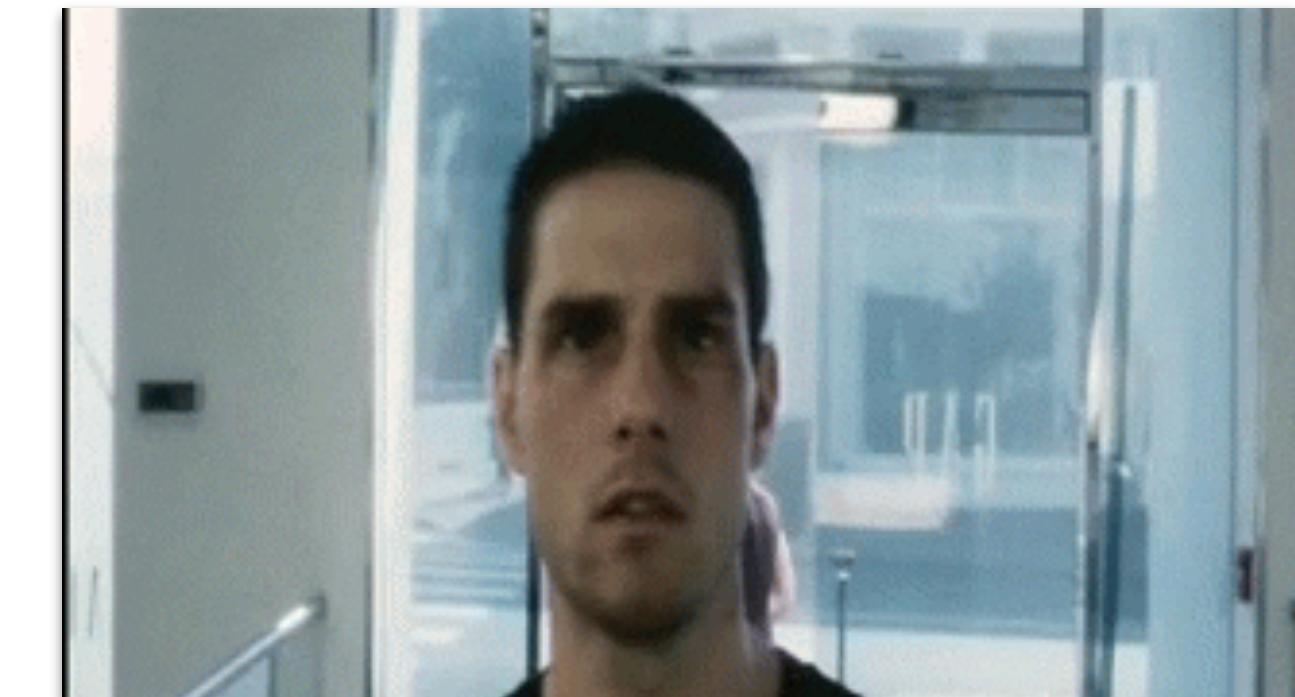
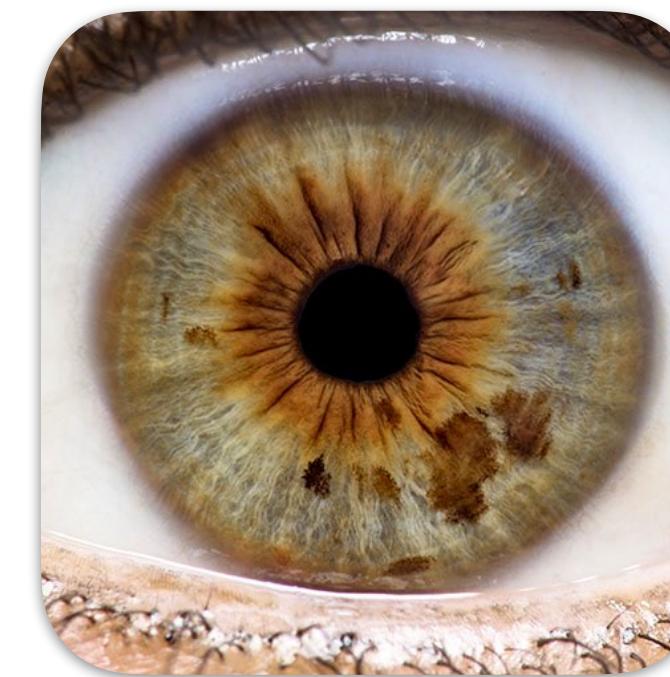
How easy is it to acquire and digitize the trait?



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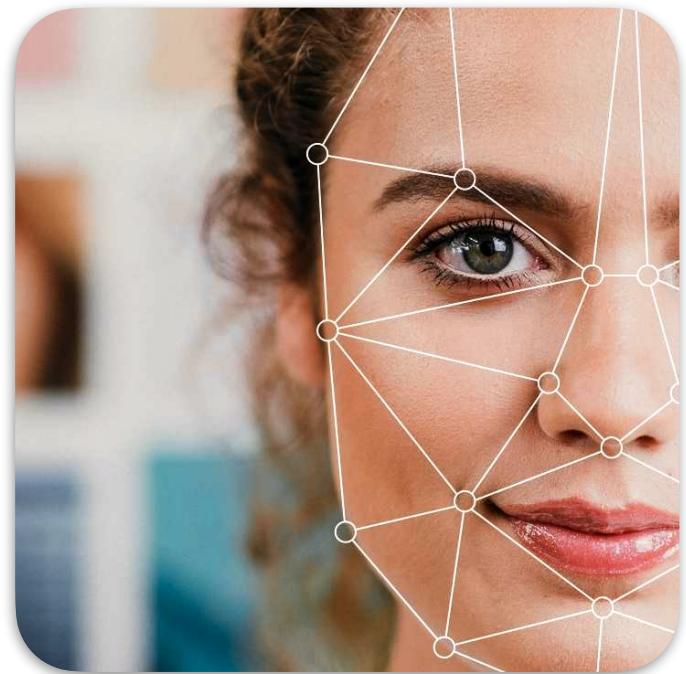


Not there yet.

Why Irises?

Acceptability (5/8)

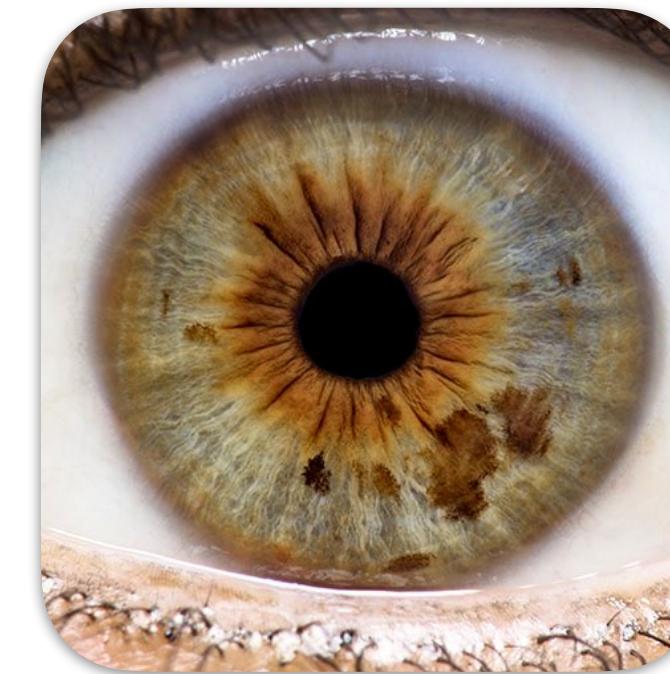
Will individuals collaborate during data collection?



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Why Irises?

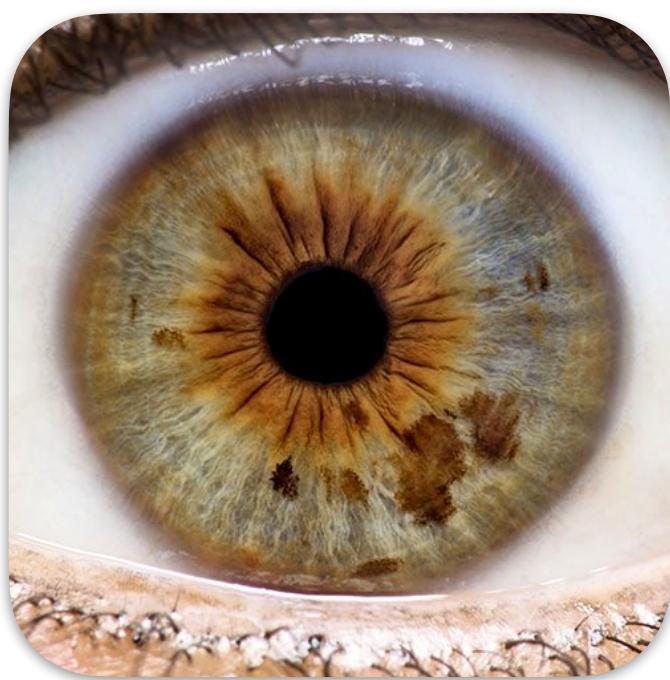
Acceptability (5/8)

Will individuals collaborate during data collection?

Privacy Concerns



Whose fingerprint is this?



Whose iris is this?



Whose face is this?

Why Irises?

Circumvention (6/8)

How hard can the trait be forged or imitated?

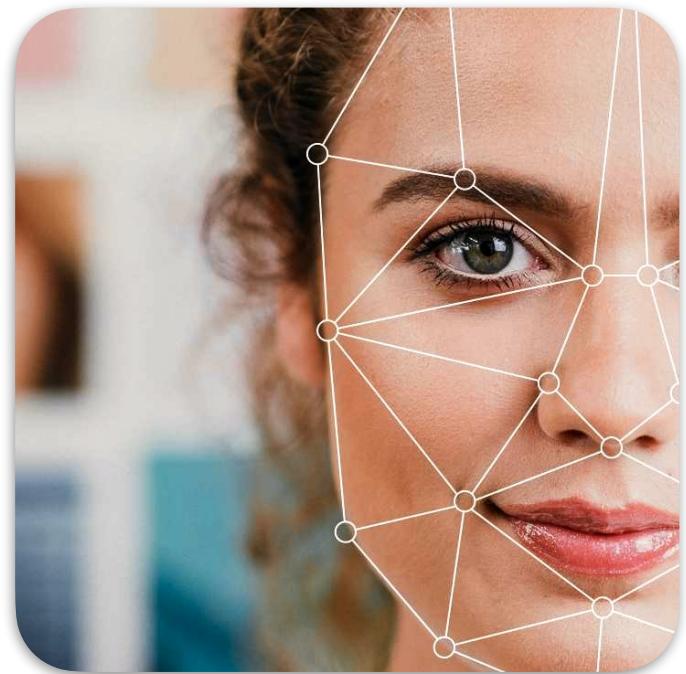


Jain, Ross, and Nadakumar
Introduction to Biometrics
Springer Books, 2011

Why Irises?

Circumvention (6/8)

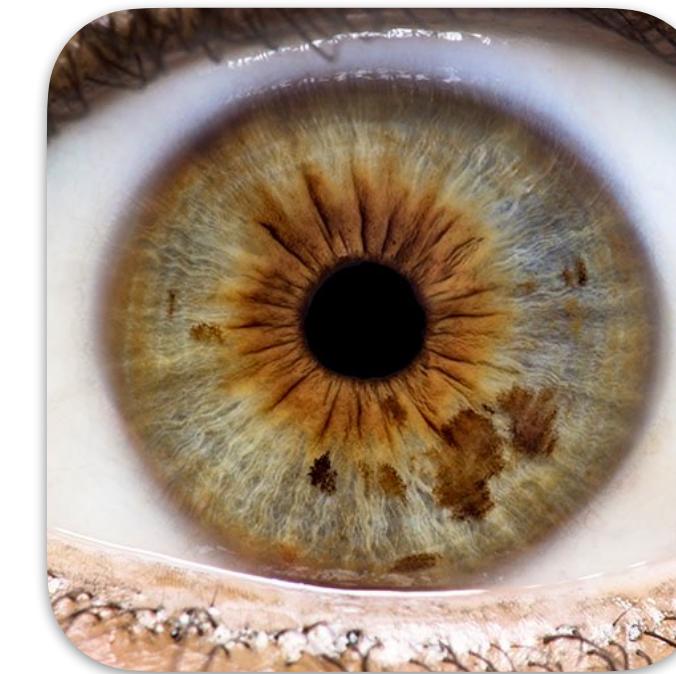
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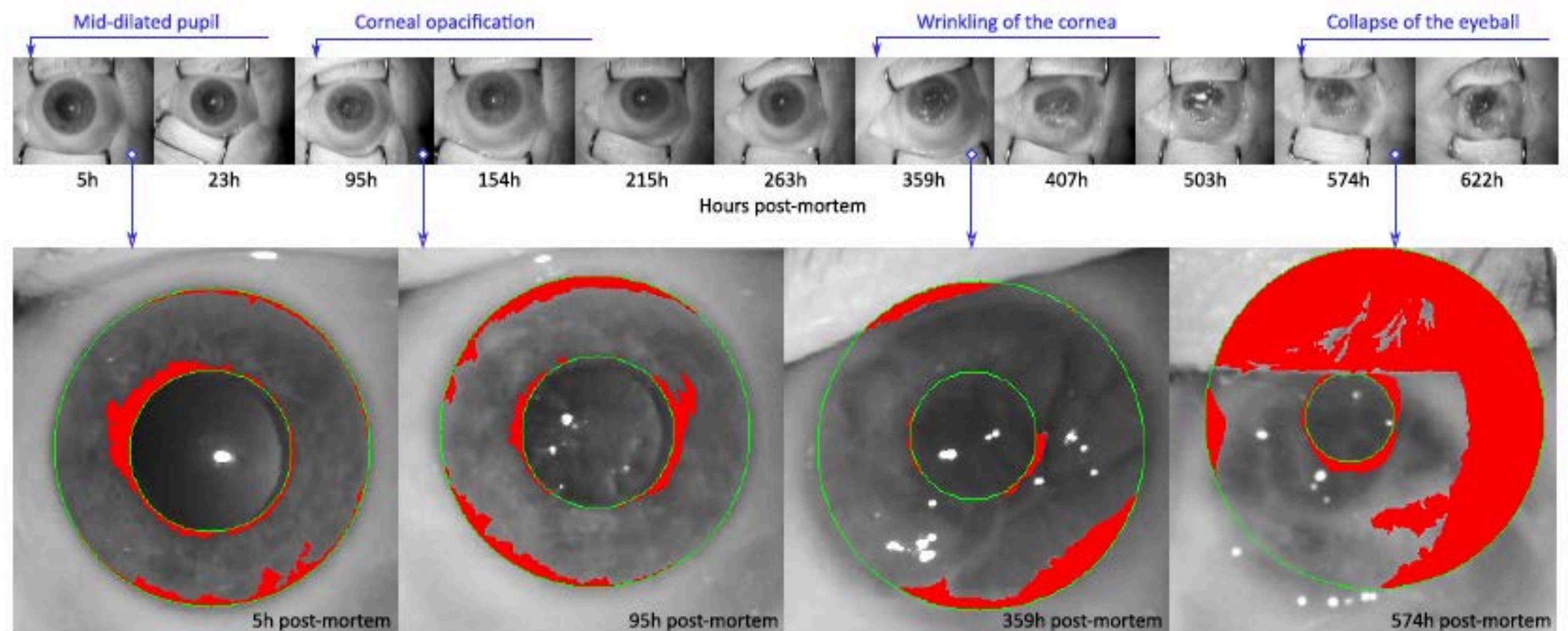
Egad, would it work?

Why Irises?

Circumvention (6/8)

Irises can be used in identification soon after death.

Trokielewicz, Czajka,
and Maciejewicz
Iris Recognition After Death
IEEE TIFS, 2019



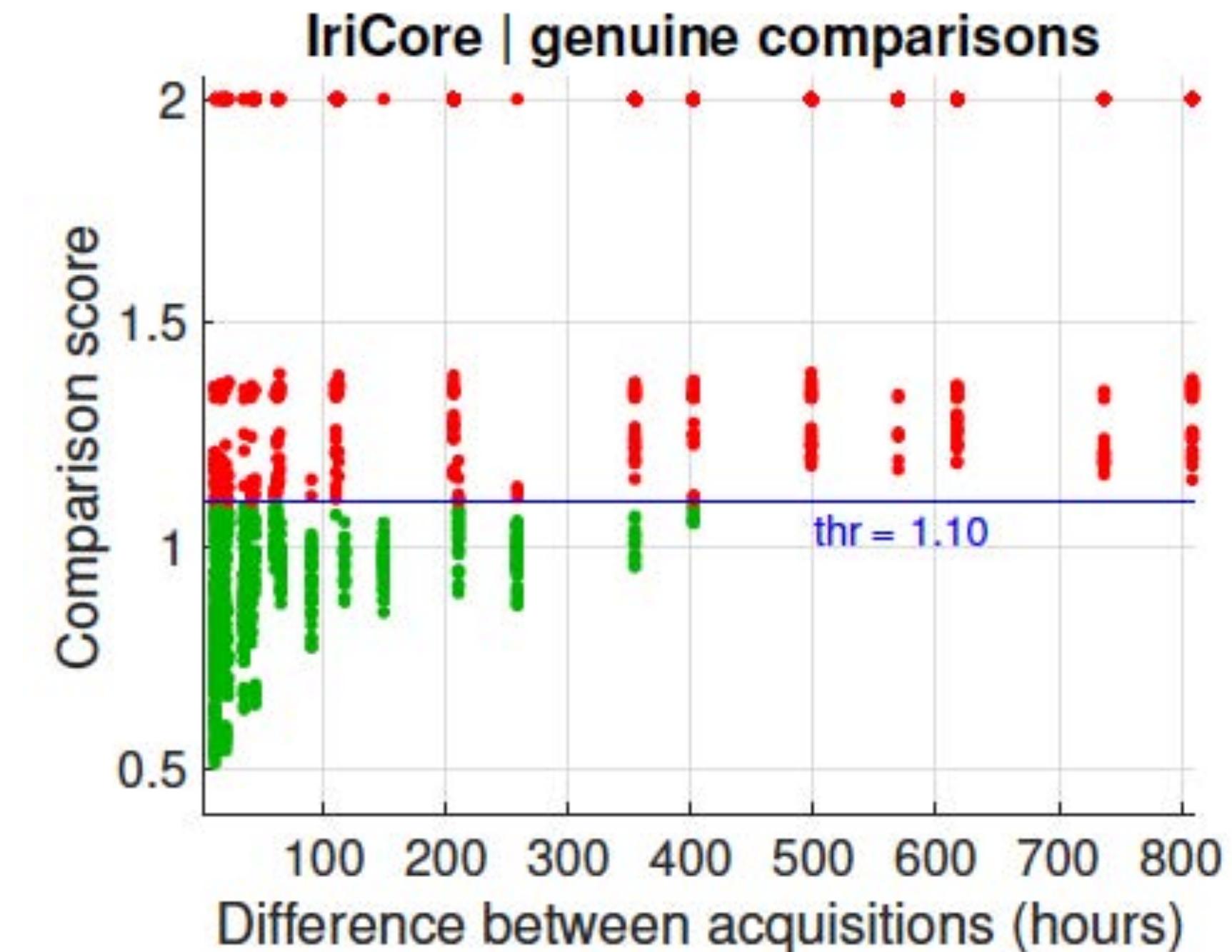
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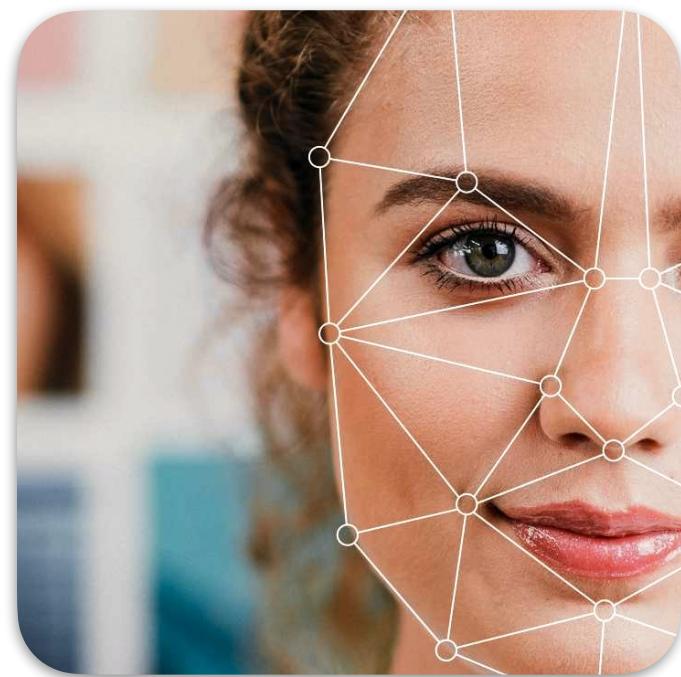
If body is kept in a mortuary,
iris recognition is successful even
17 days after death!



Why Irises?

Performance (7/8)

How good is the trait quantitatively according to objective metrics?



<



?



Why Irises?

Performance (7/8)

How good is the trait quantitatively according to objective metrics?



J. Daugman, 2006

Probing the Uniqueness and Randomness of IrisCodes

IEEE Proceedings, vol. 94, no. 11



200 billion
comparisons



Nearly perfect
match rates



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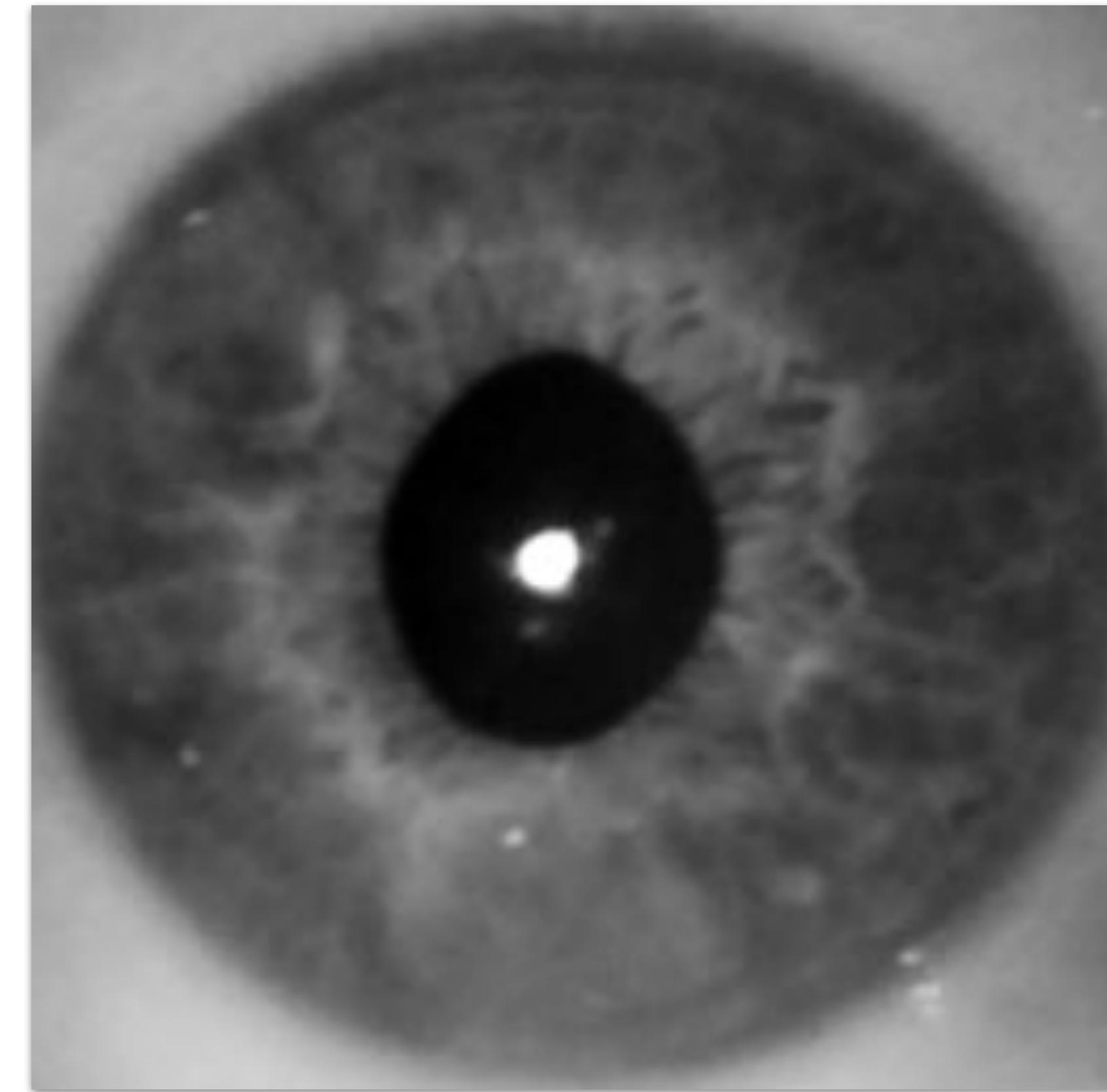
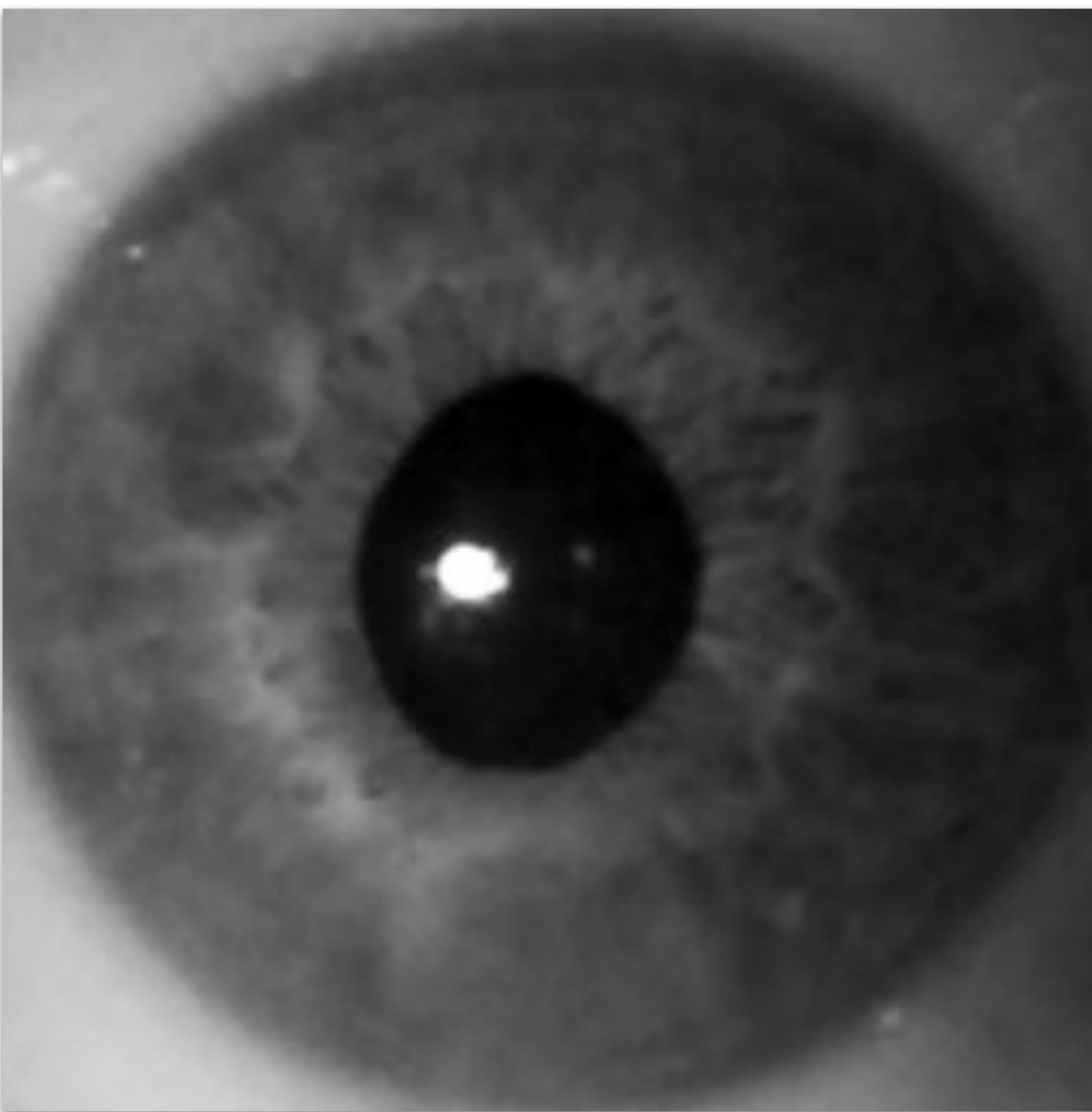
Why Irises?

Explainability (8/8)

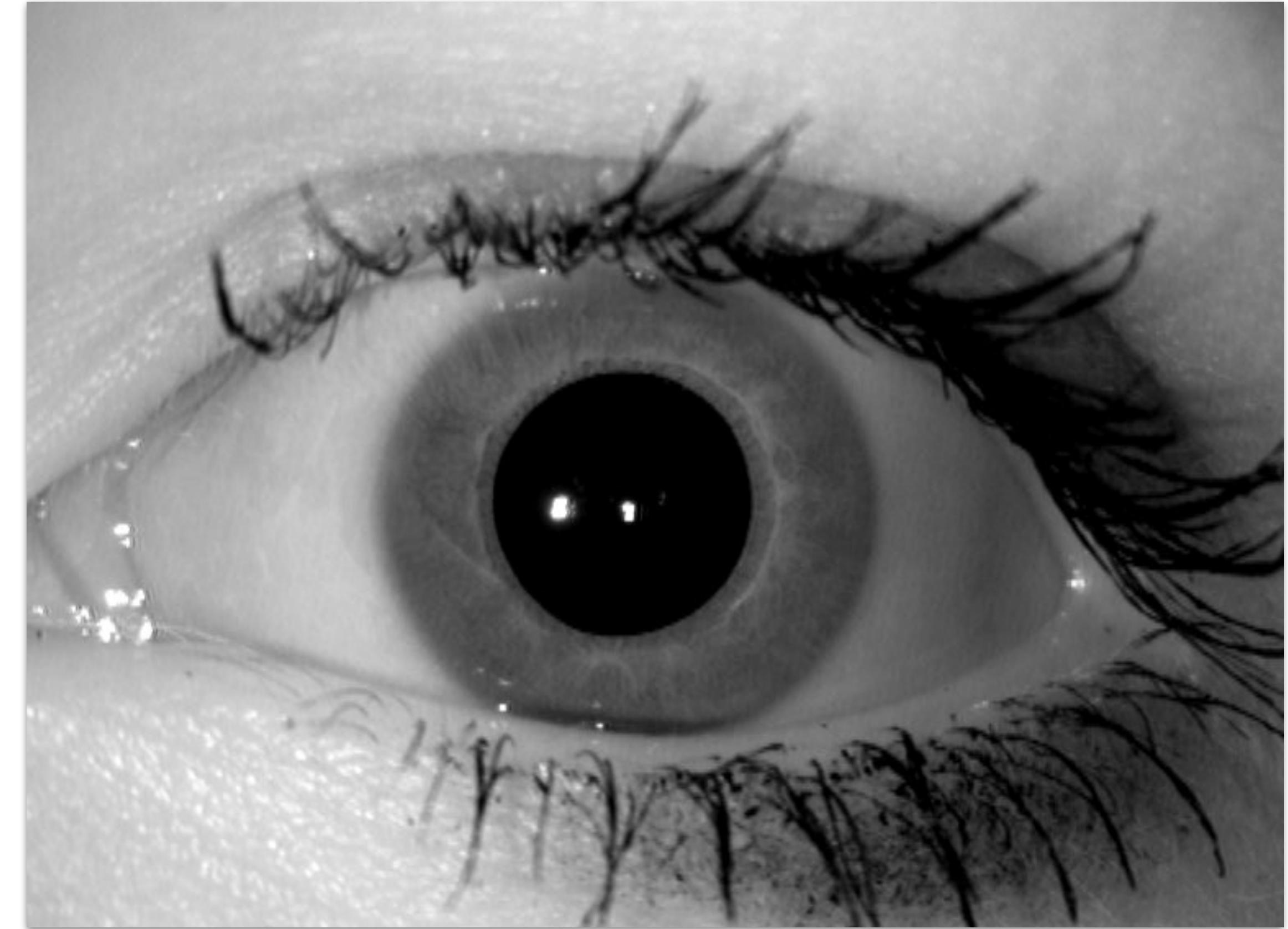
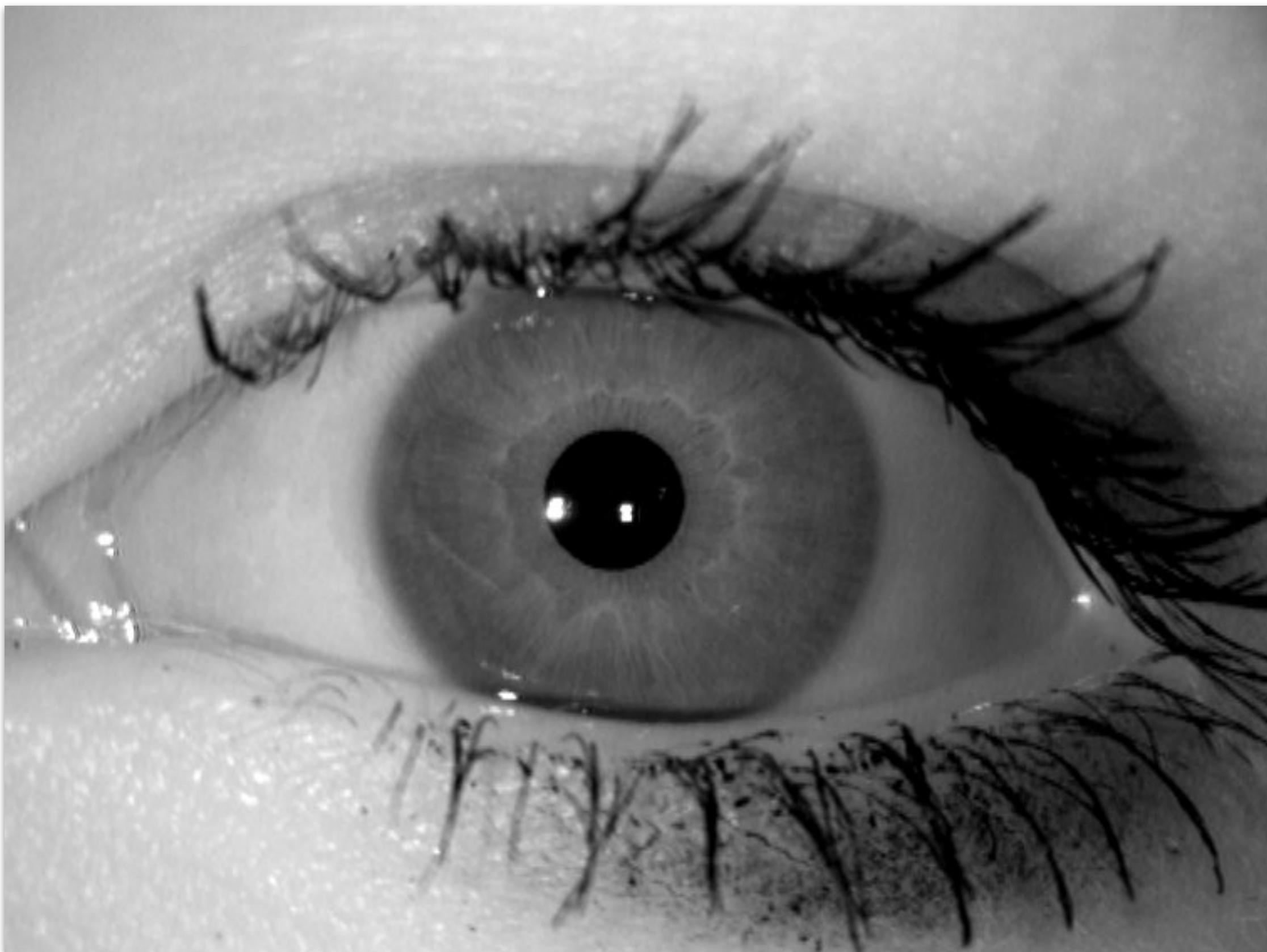
How easy is it for the everyman to understand the trait comparison?



Same Person?

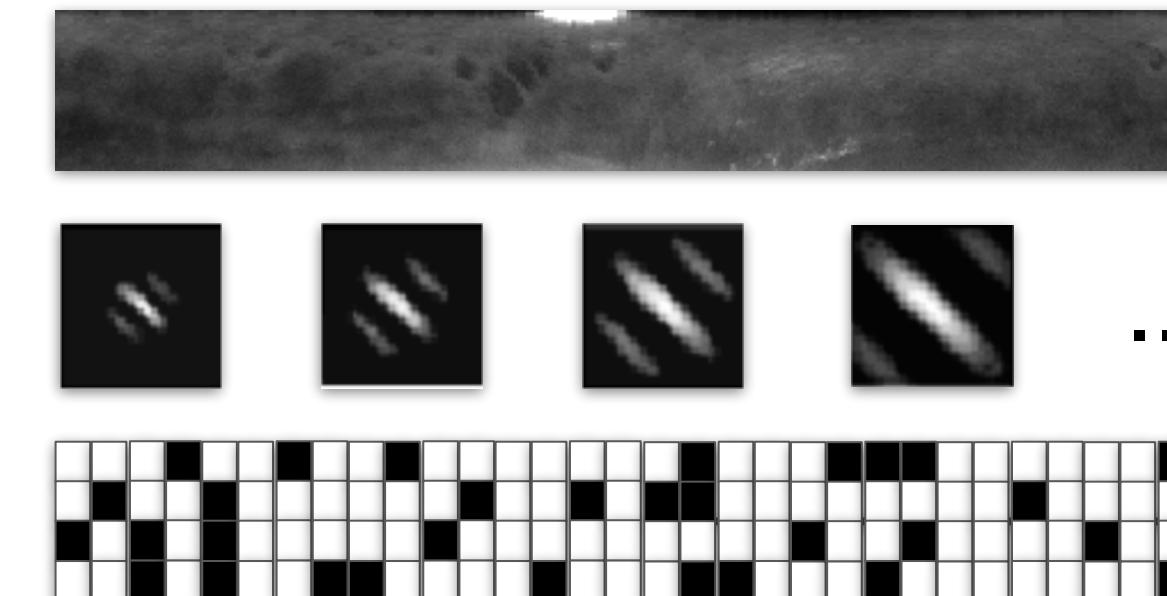
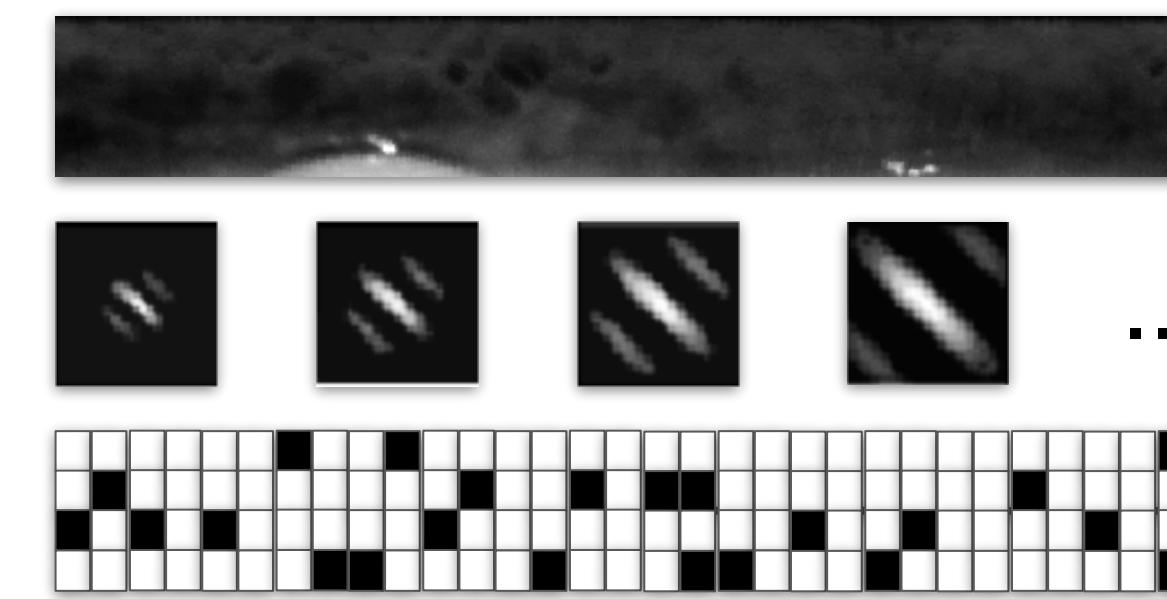
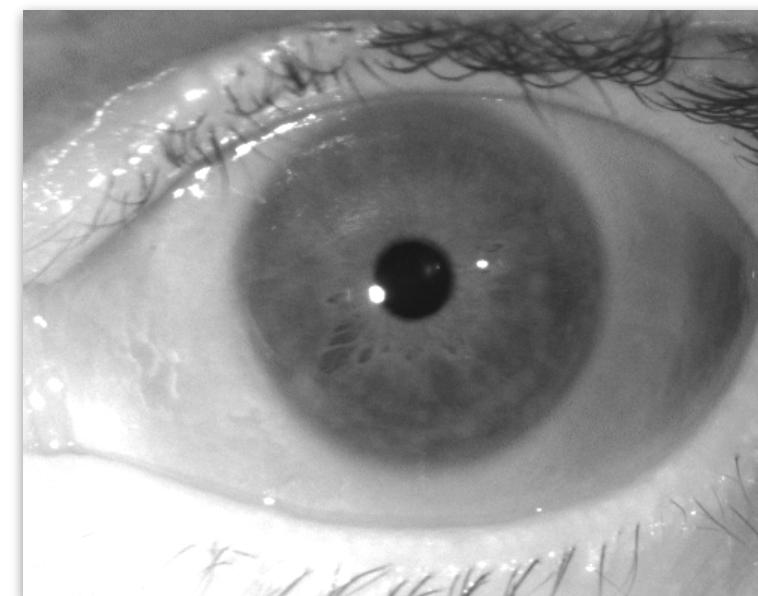
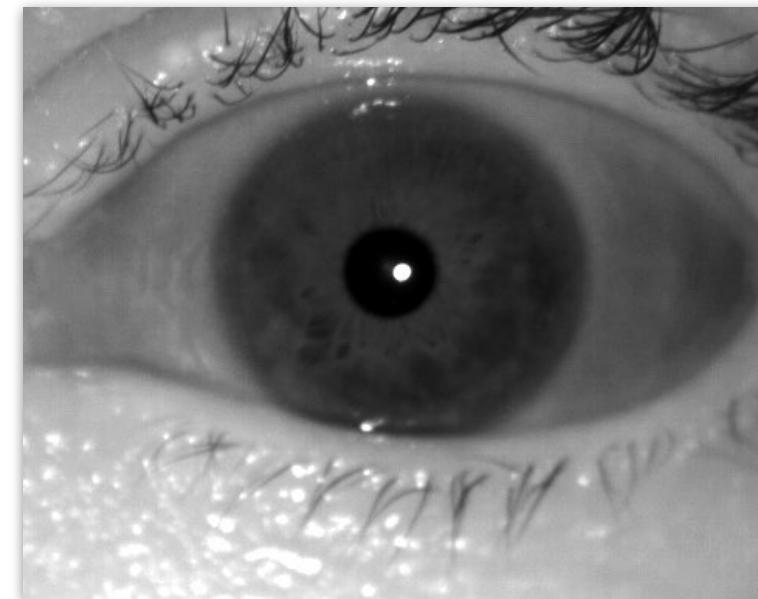


Same Person?



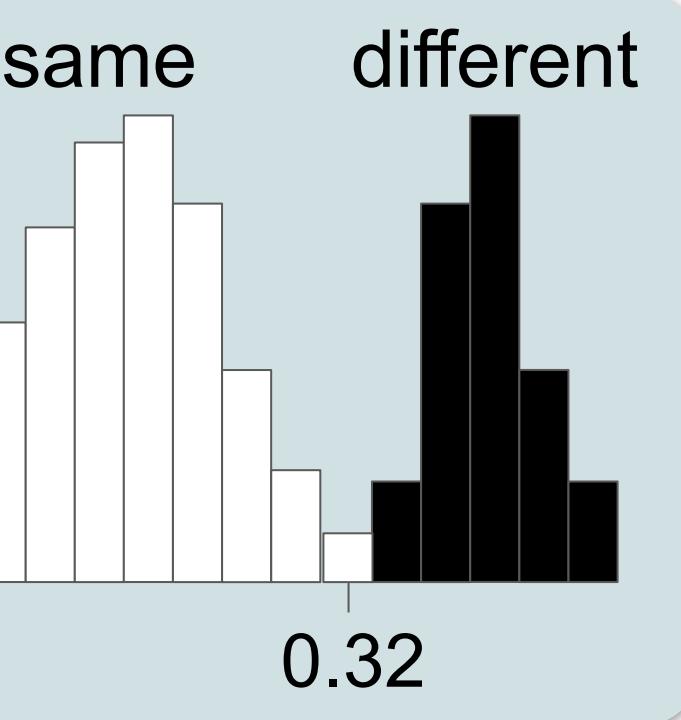
Iris Recognition

In a Nutshell



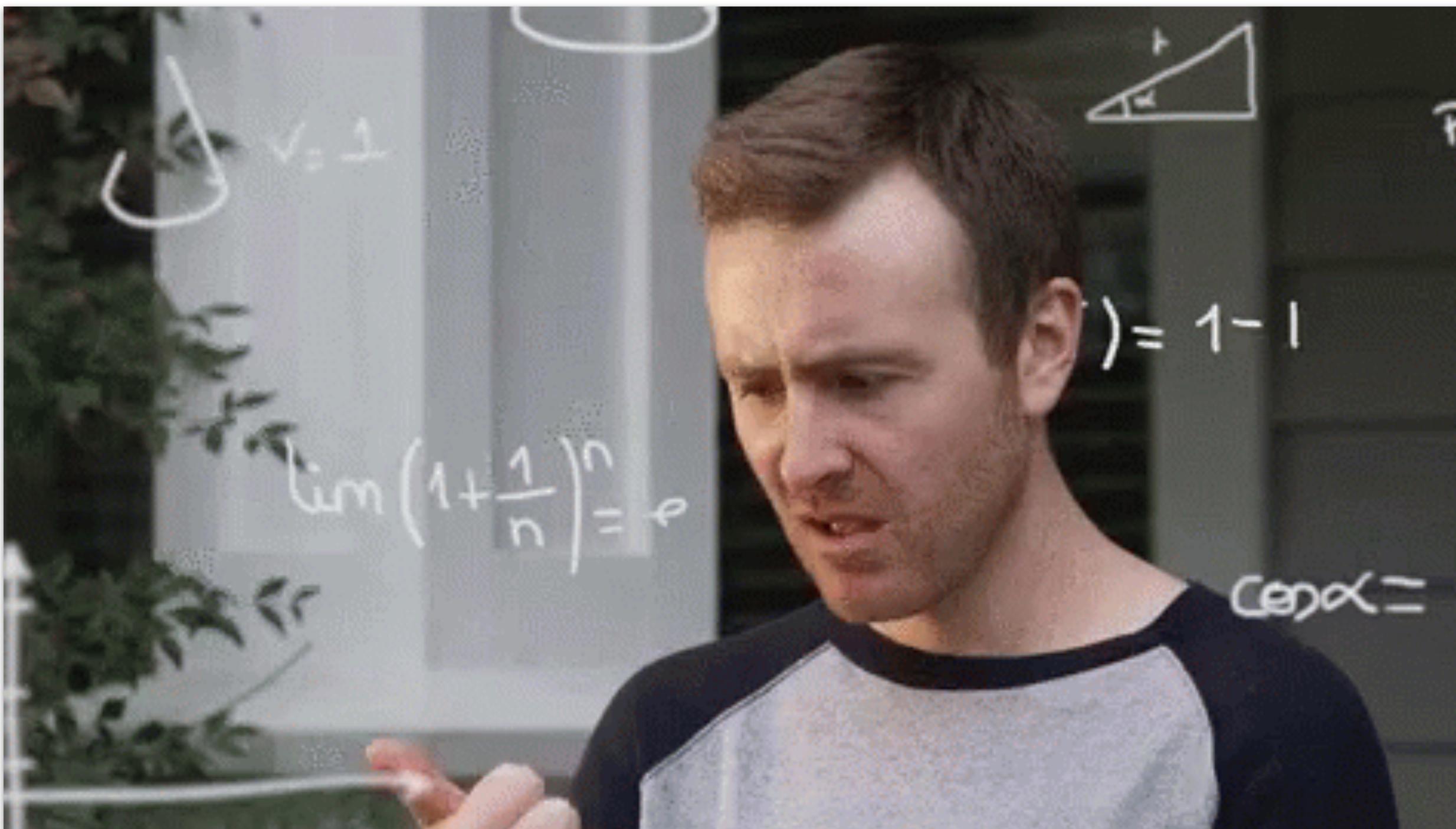
Hamming
Distance

0.25



Yes

Easy, right?



Explainable Iris Recognition



How can we make it
meaningful to the
everyman?

Explainable Iris Recognition



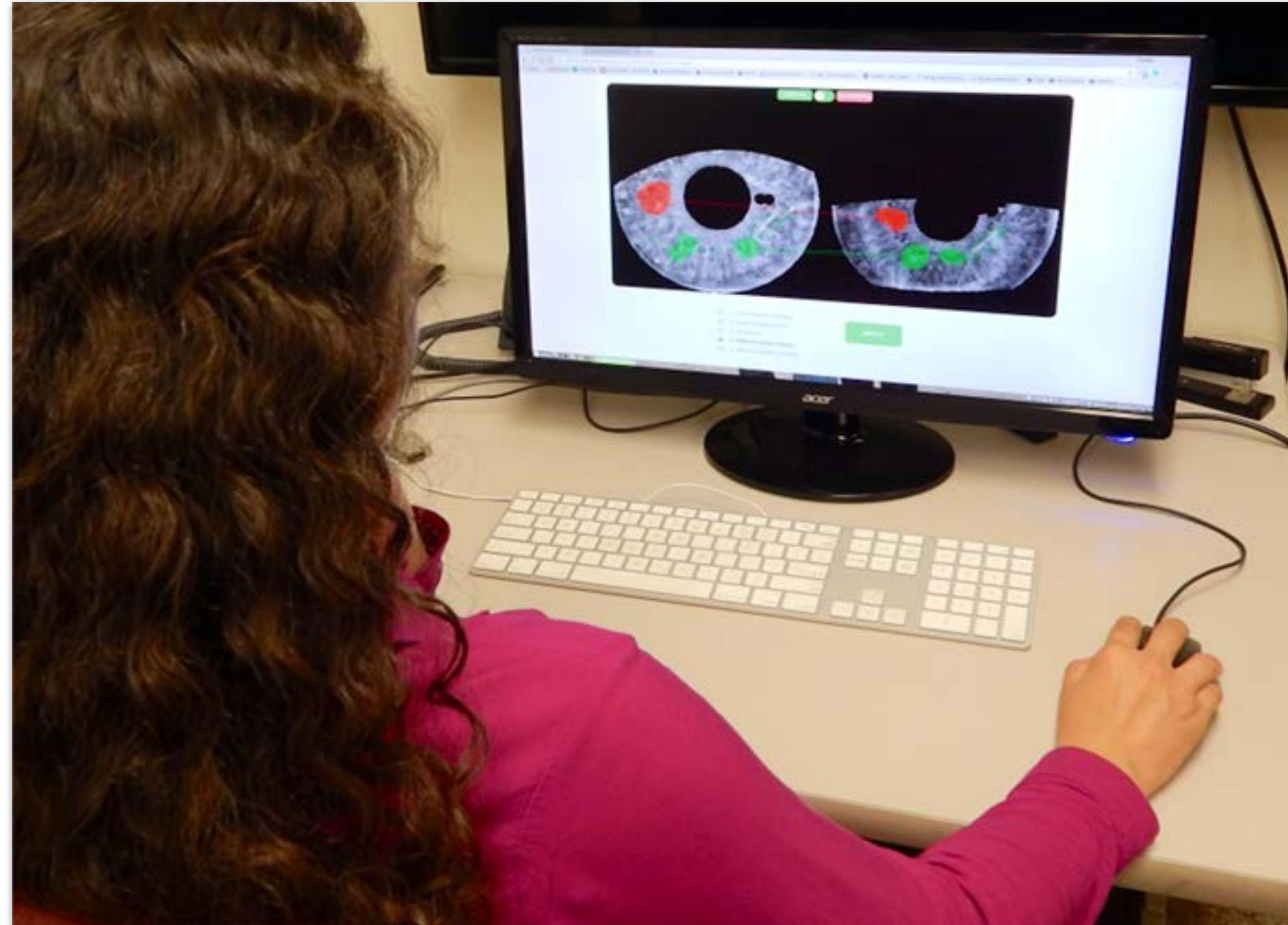
People have the right to obtain **an explanation of decisions** made about them by algorithms.

Explainable Iris Recognition



How to convince
people who do not
possess image
processing
expertise?

Explainable Iris Recognition

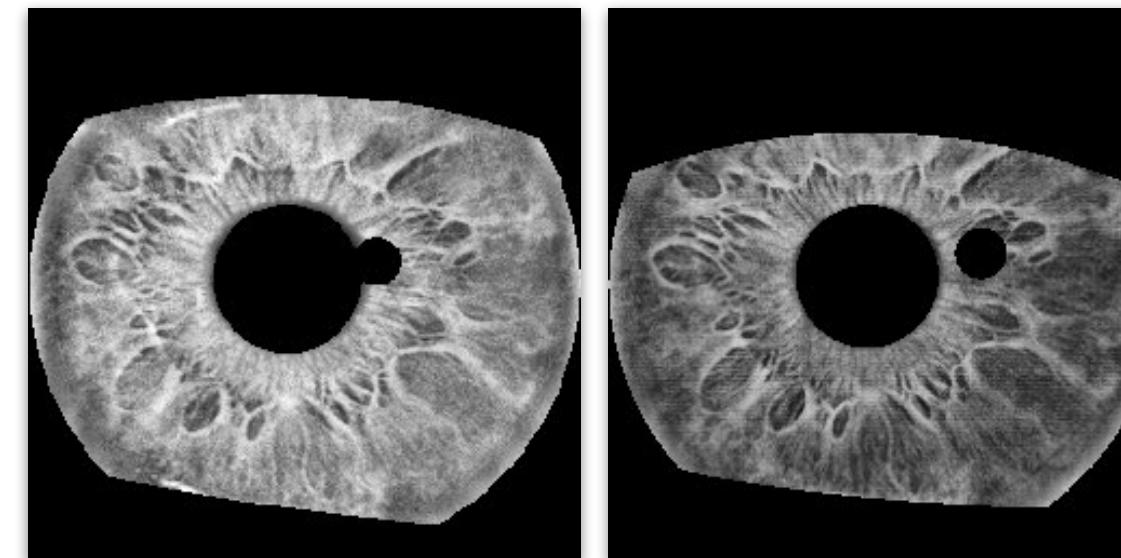


How should we start?

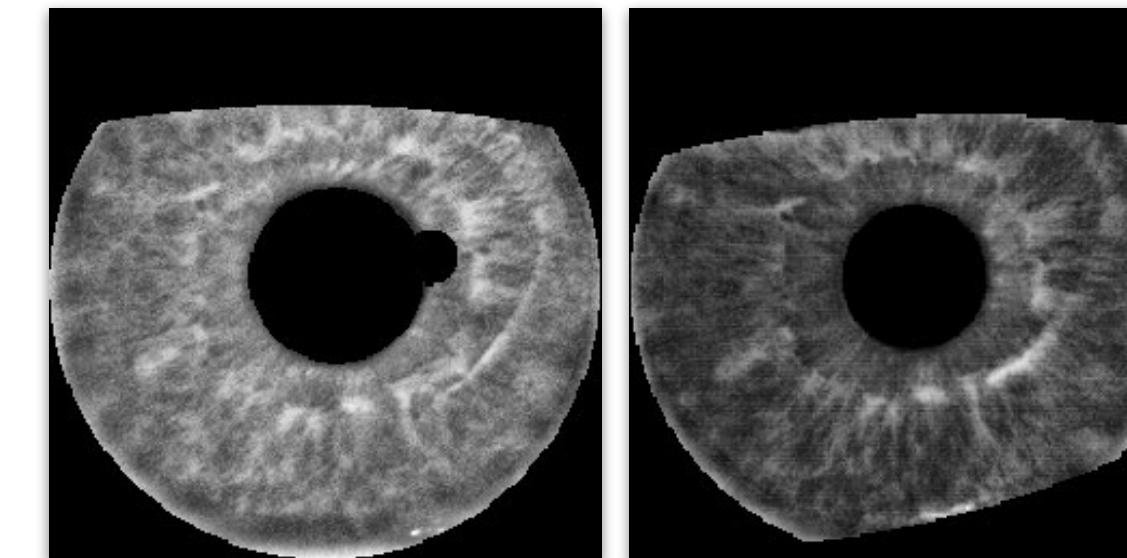
Ask a human:
**How do people perform
iris recognition?**

Human Experiments

Dataset



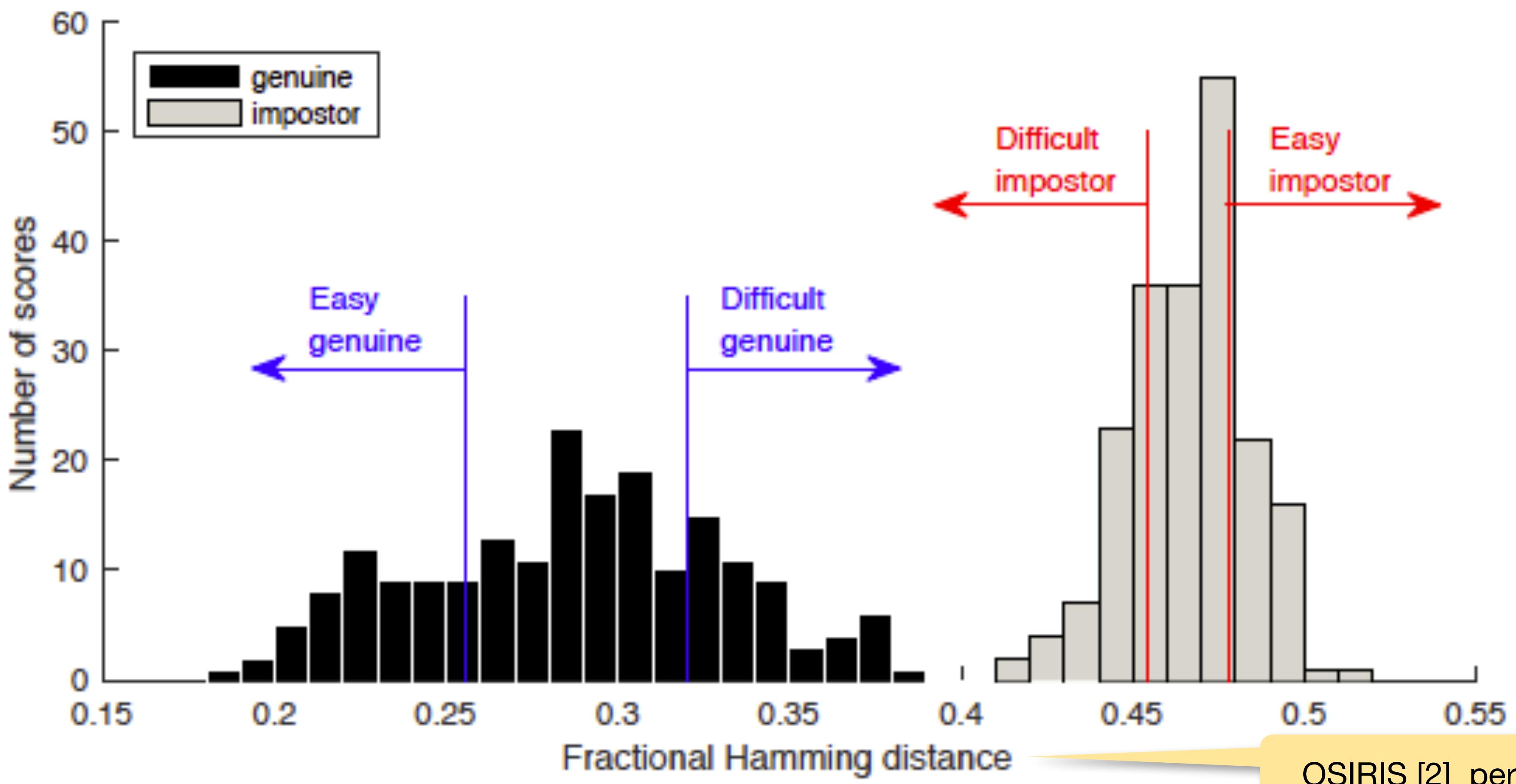
Easy for an automated solution



Hard for an automated solution

Source:
NDCrossSensor-Iris-2013 dataset [1].

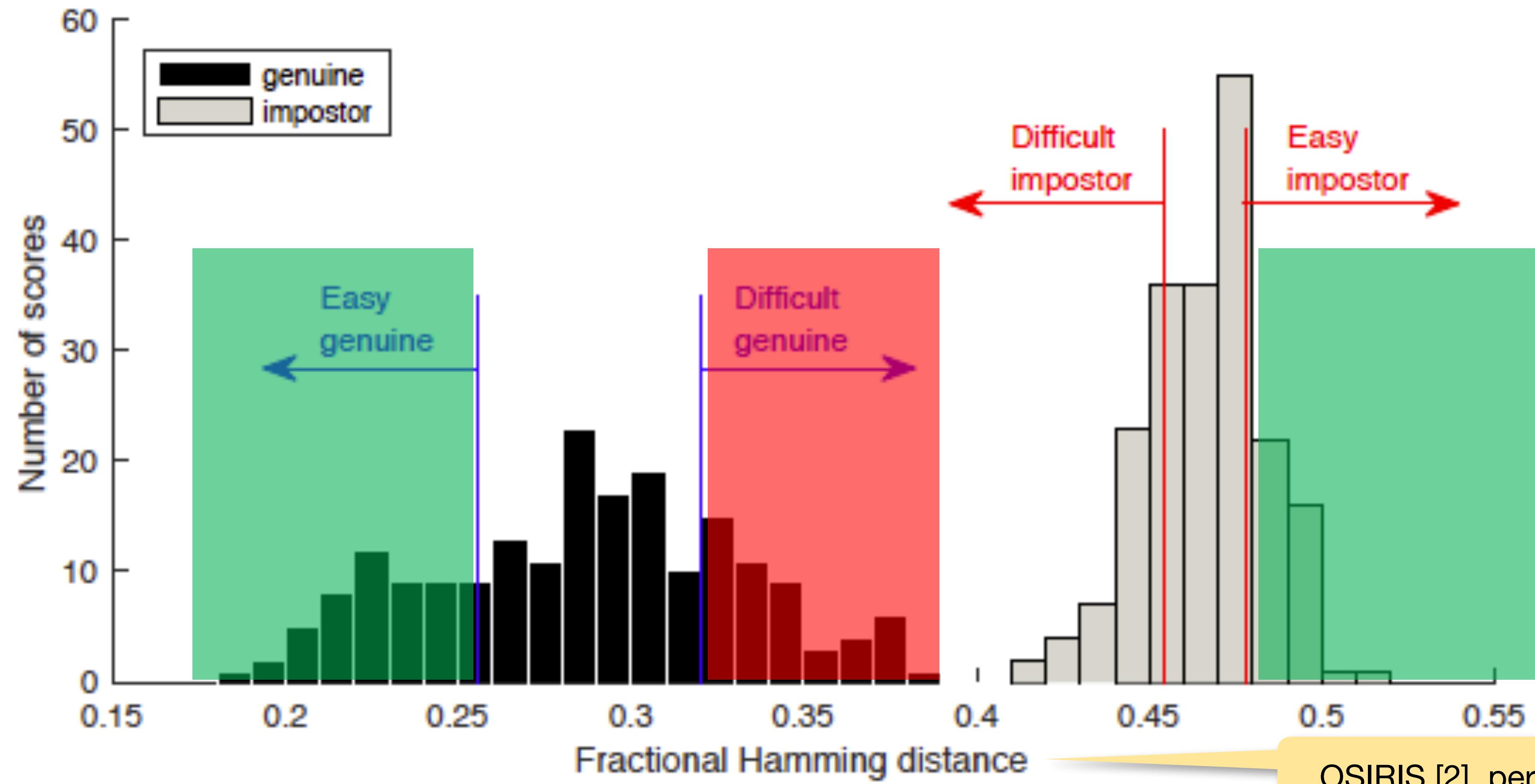
[1] Collection ND-CrossSensor-Iris-2013
Computer Vision Research Laboratory at the University of Notre Dame, 2013.



[2] OSIRIS: An open source iris recognition software.
Othman et al. Elsevier Pattern Recognition Letters, 82(2):124–131, 2016



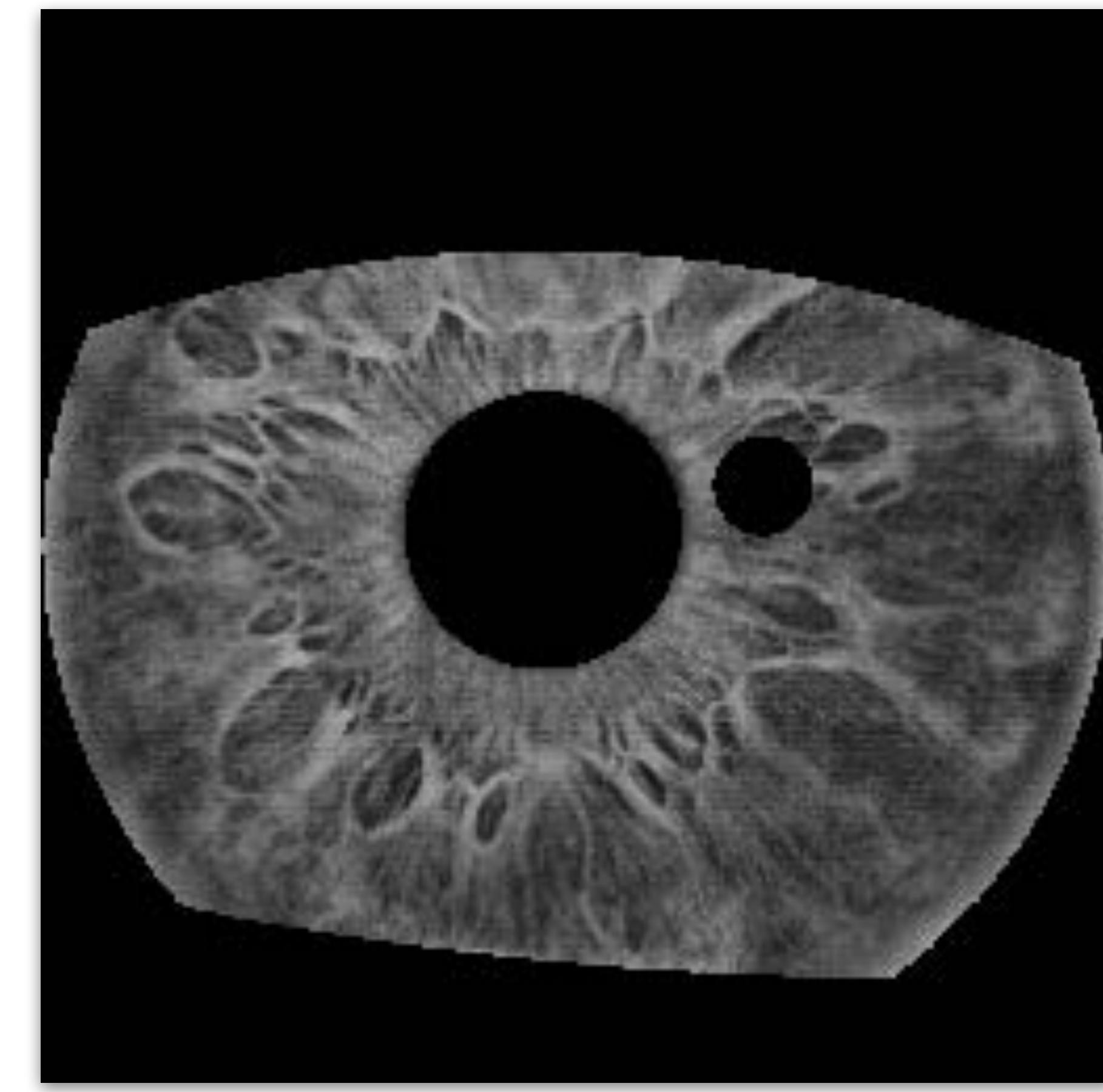
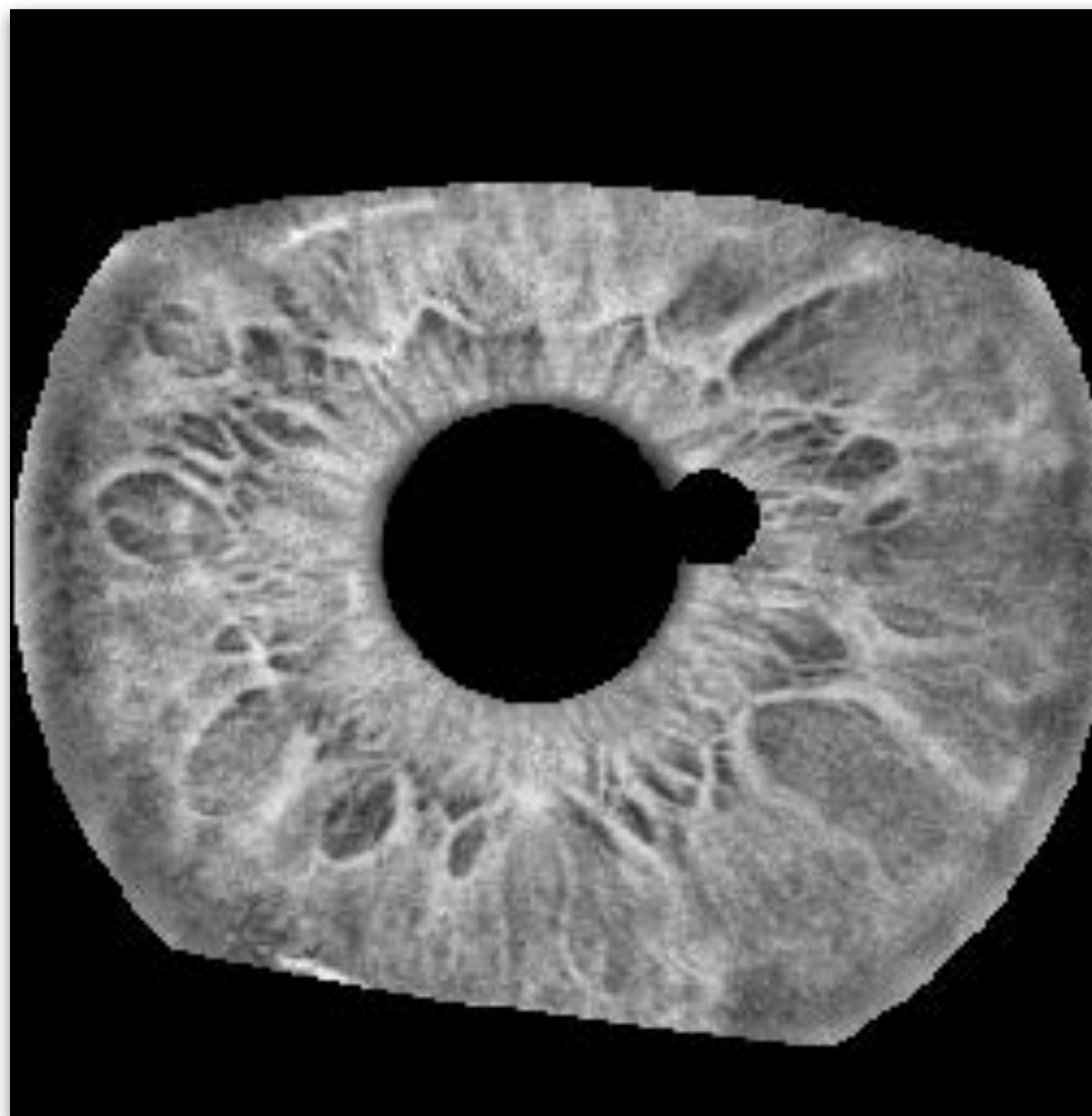
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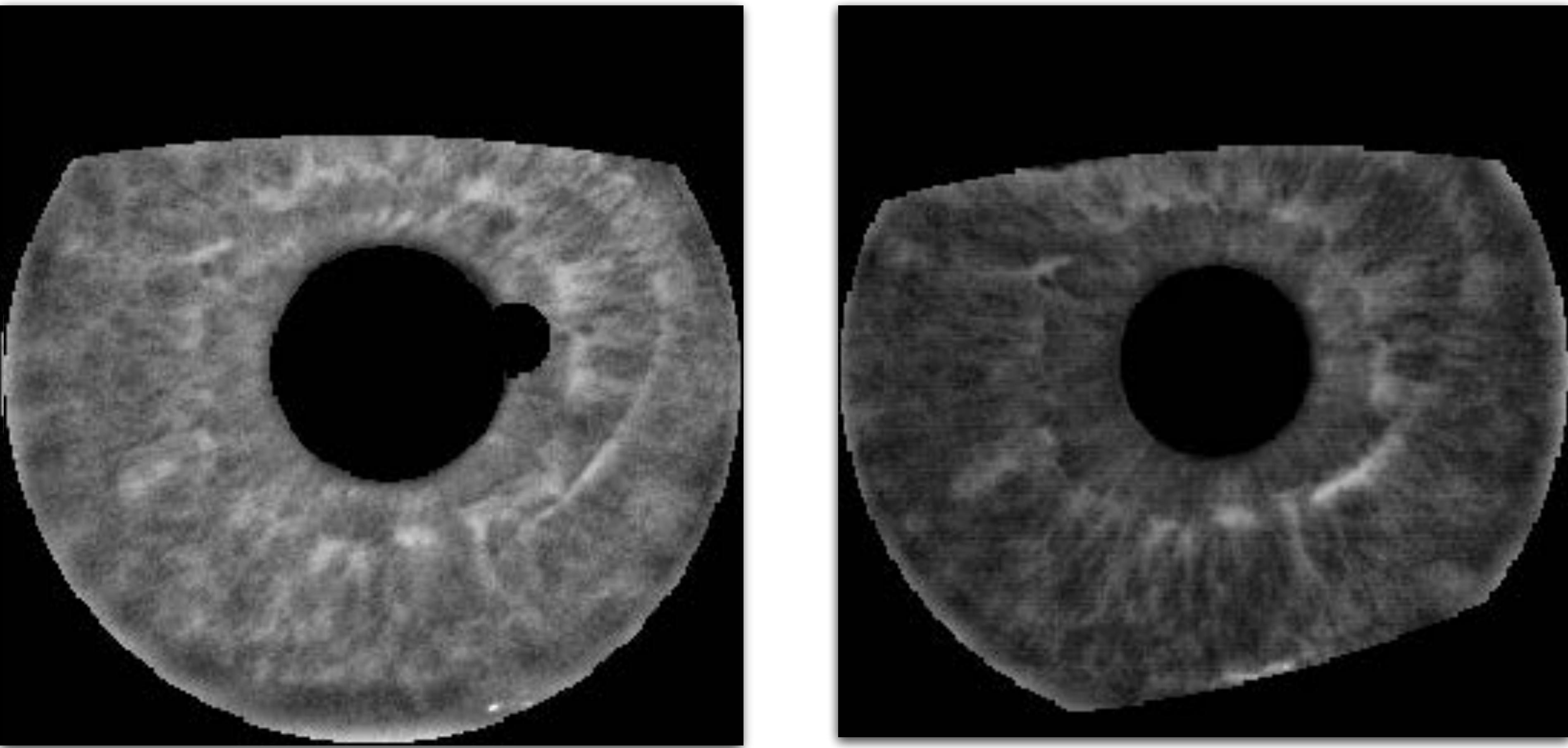
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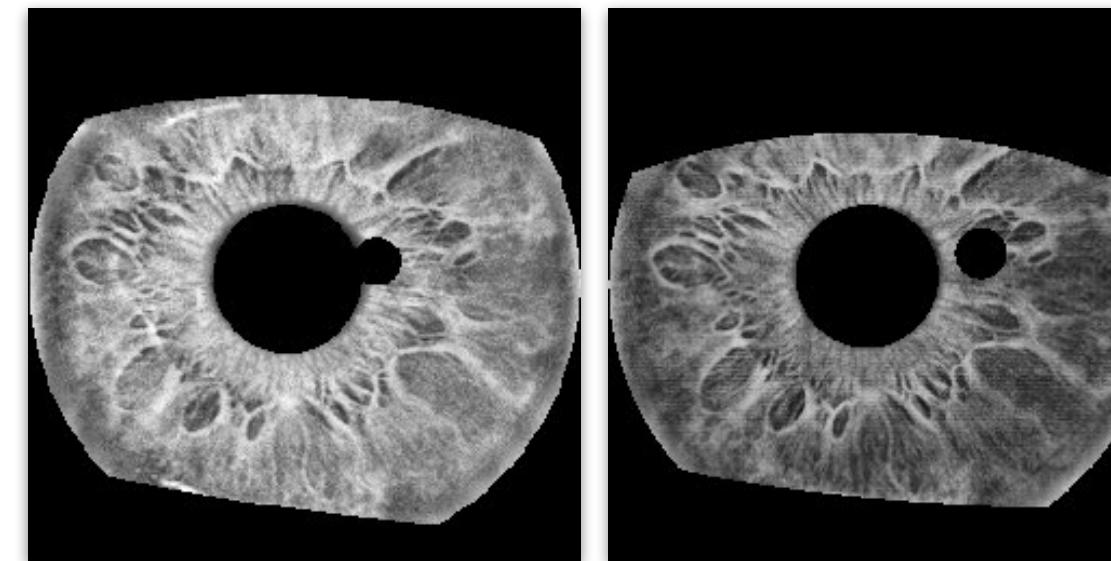
Easy for an automated solution



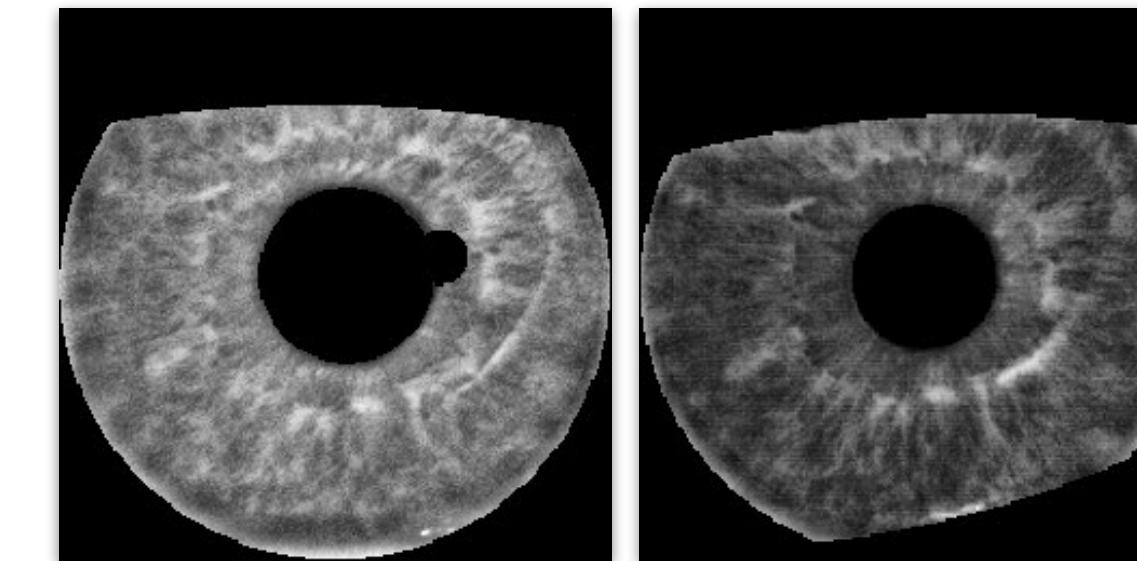
Hard for an automated solution

Human Experiments

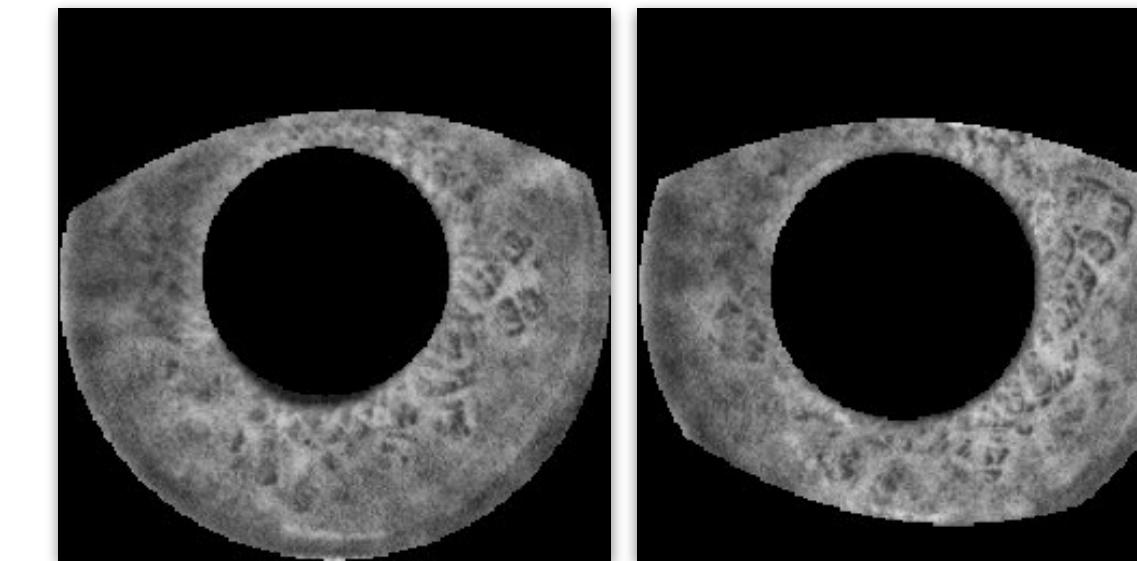
Dataset



Easy for an automated solution



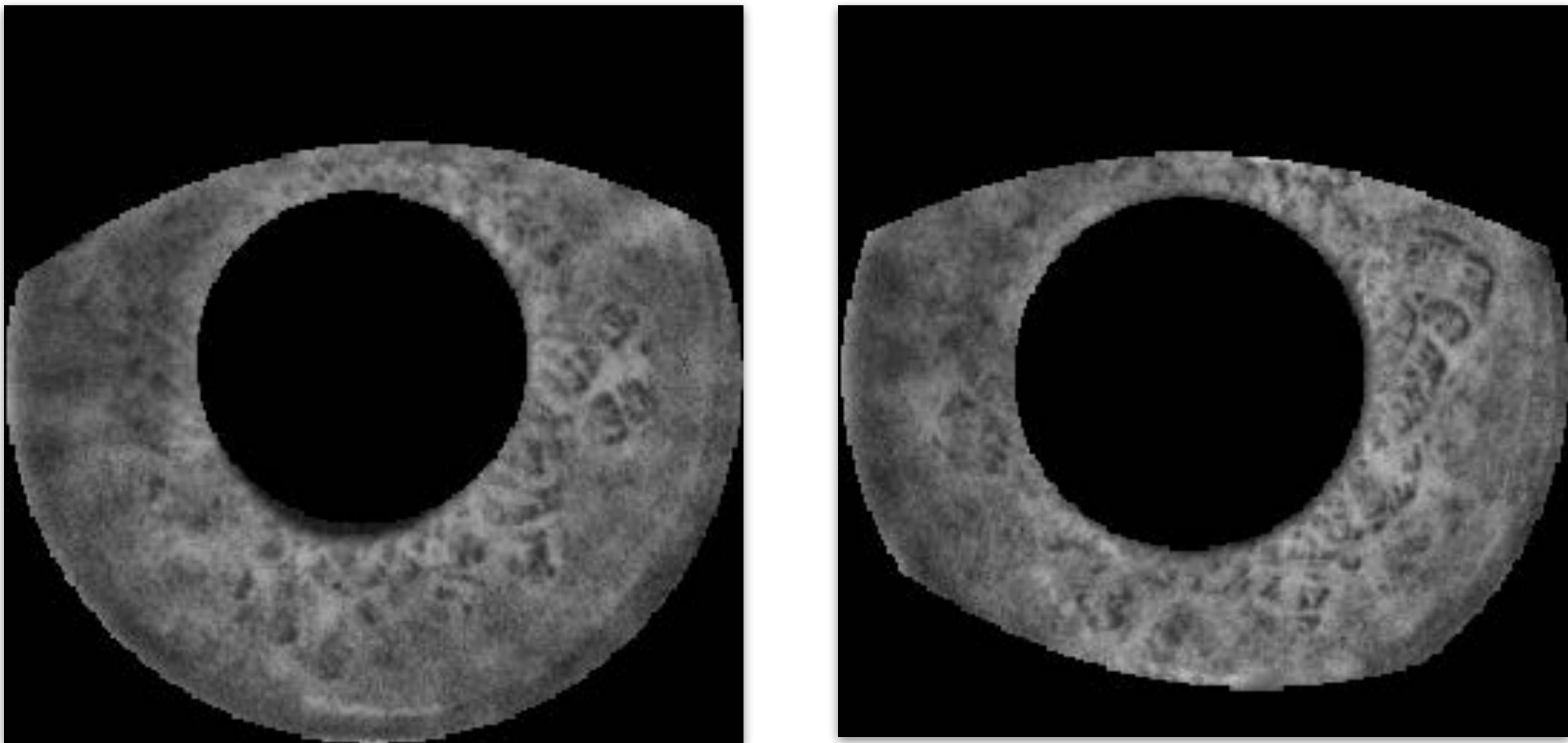
Hard for an automated solution



Twins'

Source:
Hollingsworth et al. [3]

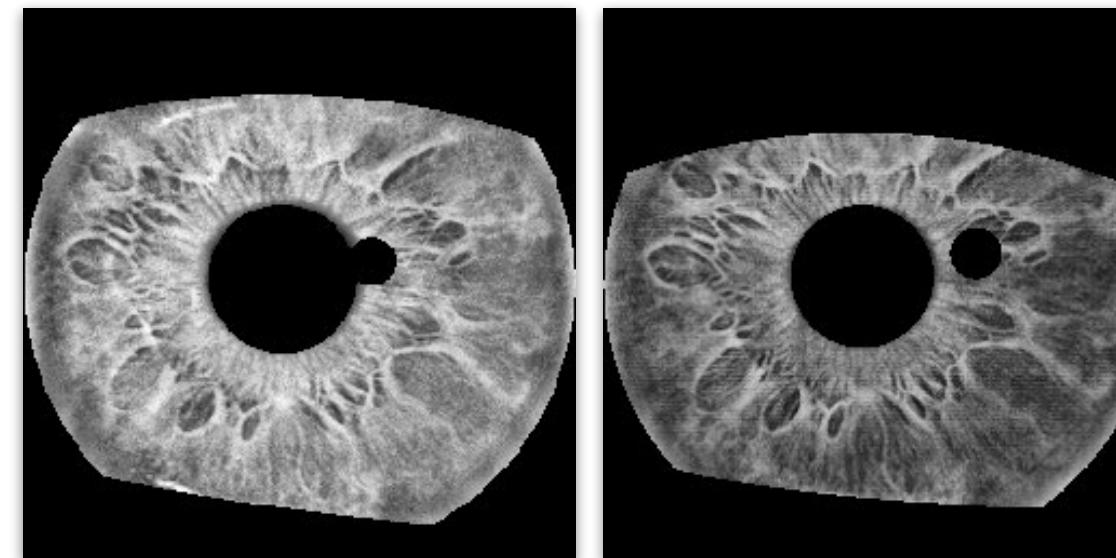
[3] Genetically identical irises have texture similarity that is not detected by iris biometrics.
Hollingsworth et al. Elsevier Computer Vision and Image Understanding, 115(11):1493–1502, 2011.



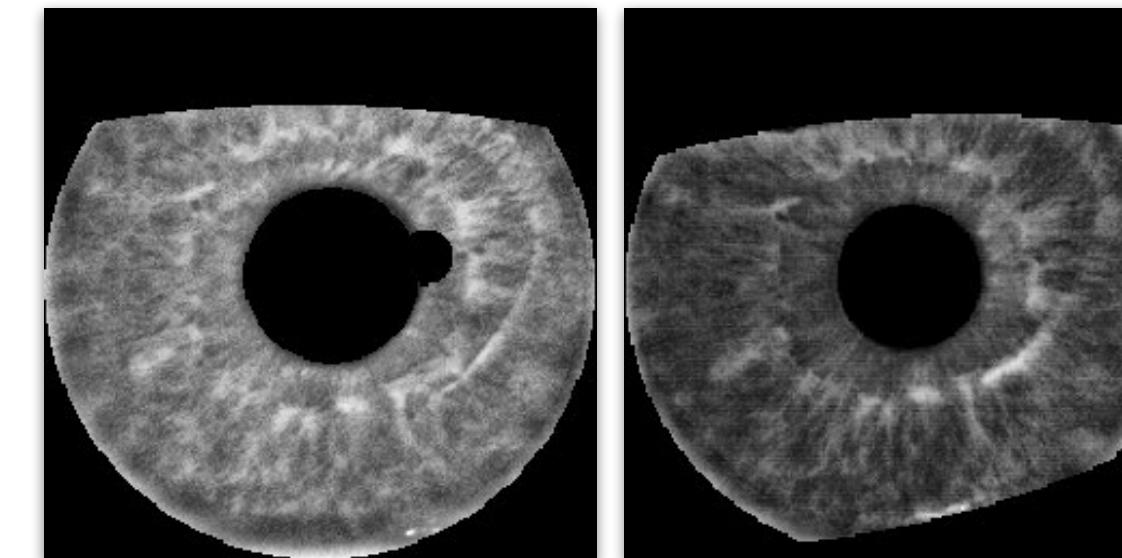
Twins'

Human Experiments

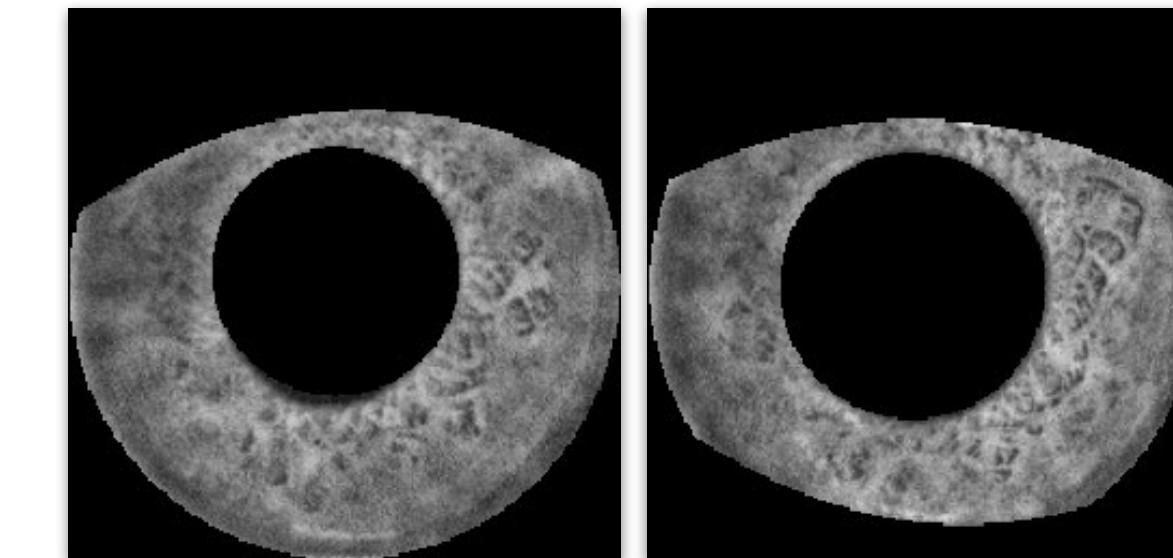
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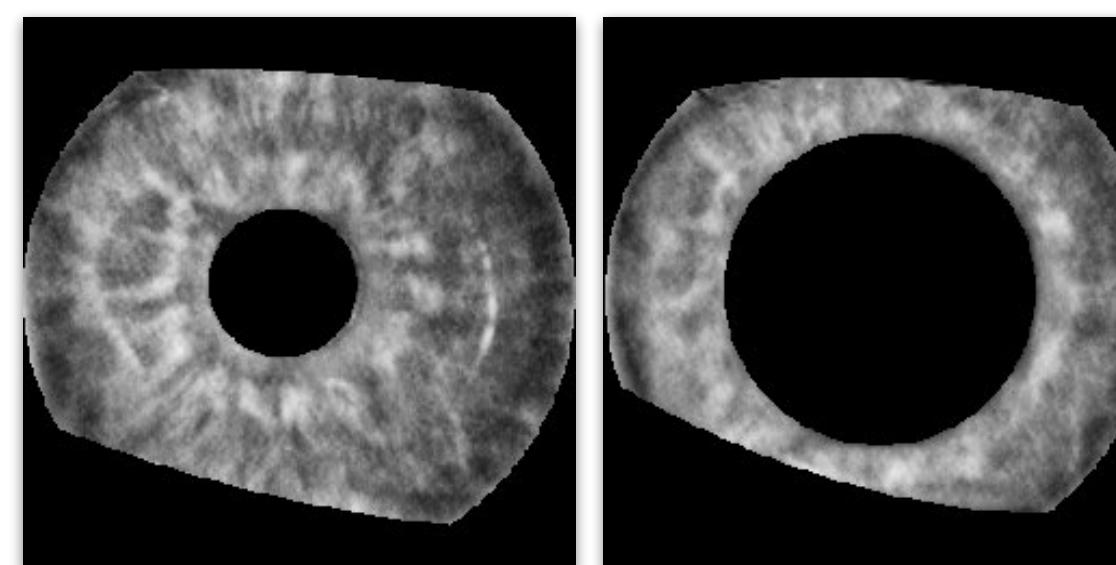
Easy for an automated solution



Hard for an automated solution



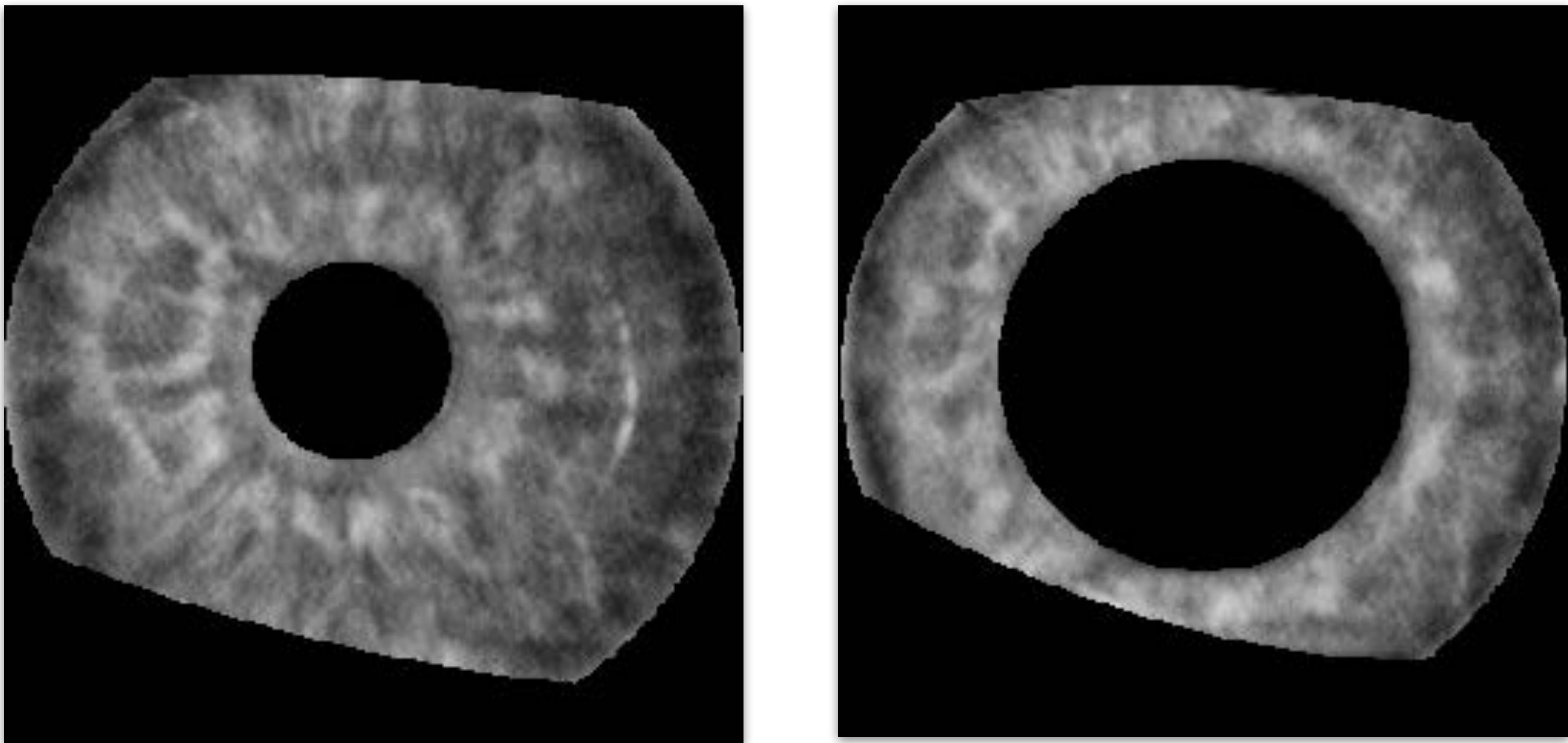
Twins'



Pupil dynamic

Source:
Hollingsworth et al. [3]

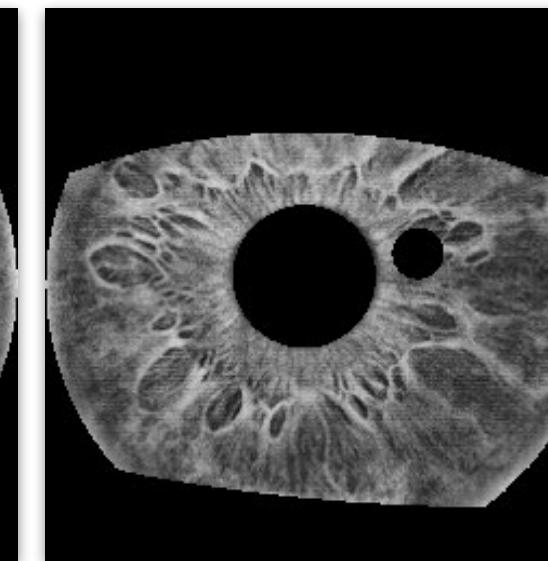
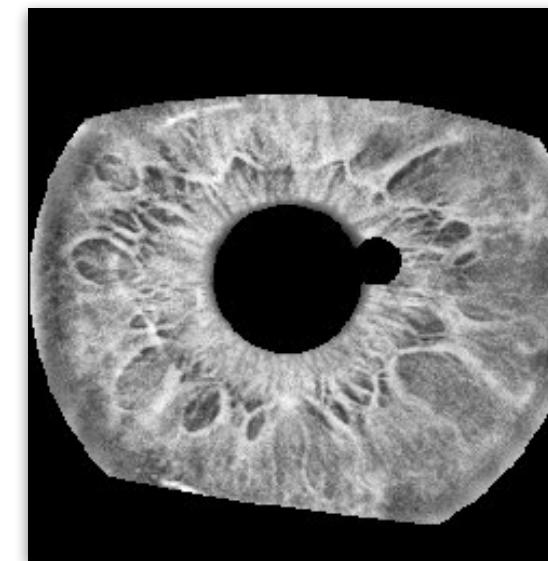
[3] Genetically identical irises have texture similarity that is not detected by iris biometrics. Hollingsworth et al.
Elsevier Computer Vision and Image Understanding, 115(11):1493–1502, 2011.



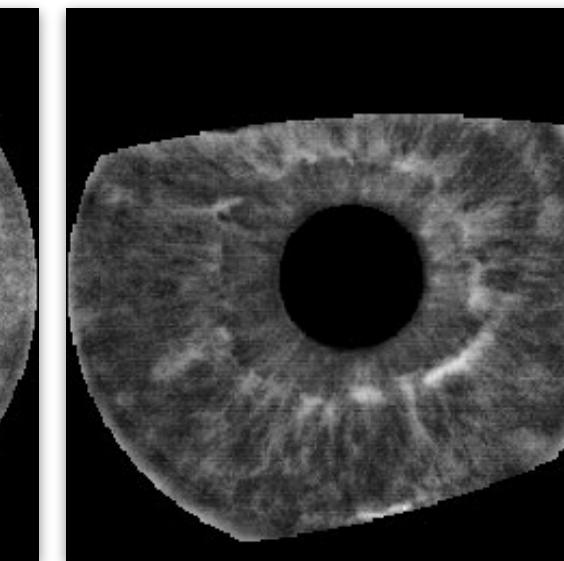
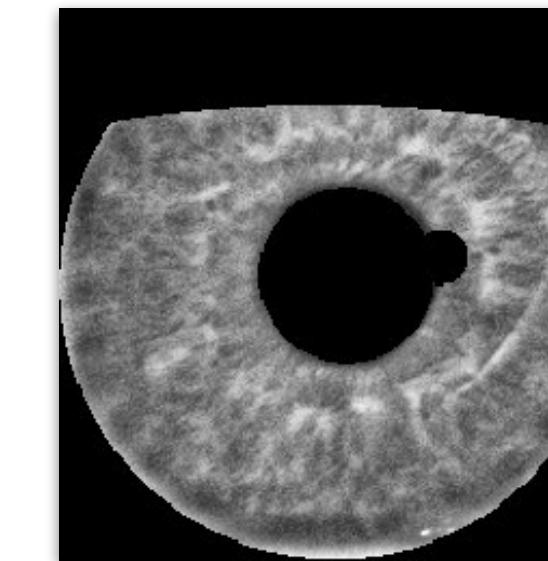
Pupil-dynamic

Human Experiments

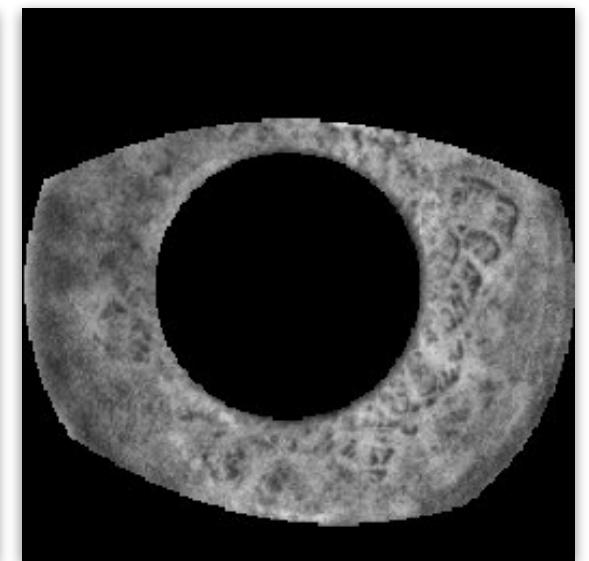
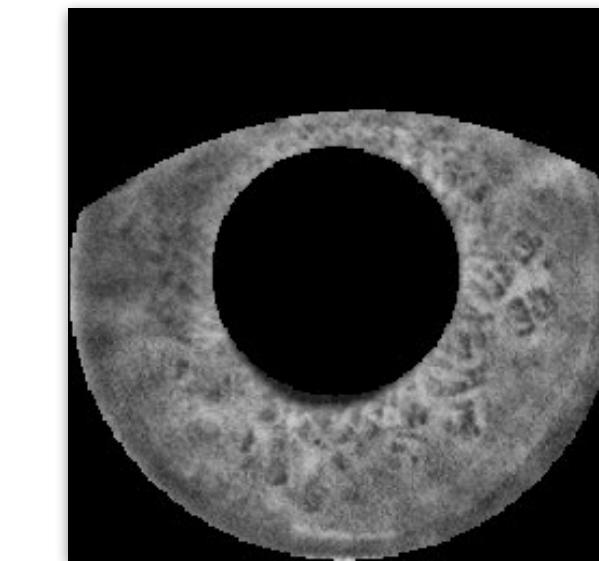
Dataset



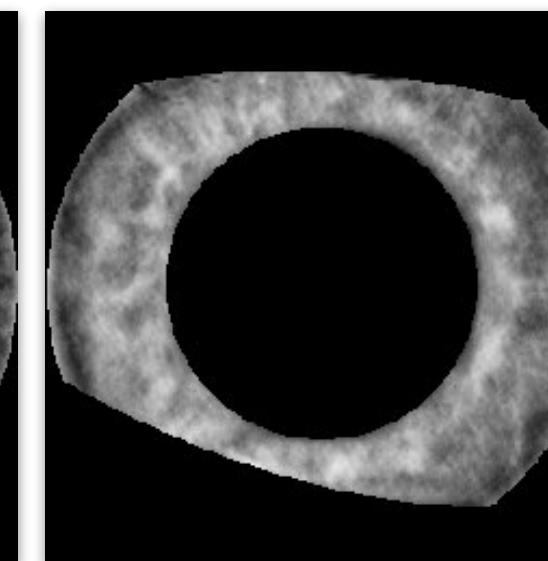
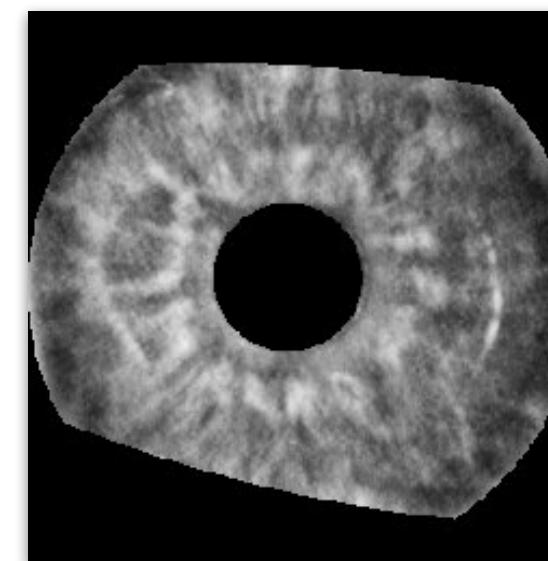
Easy for an automated solution



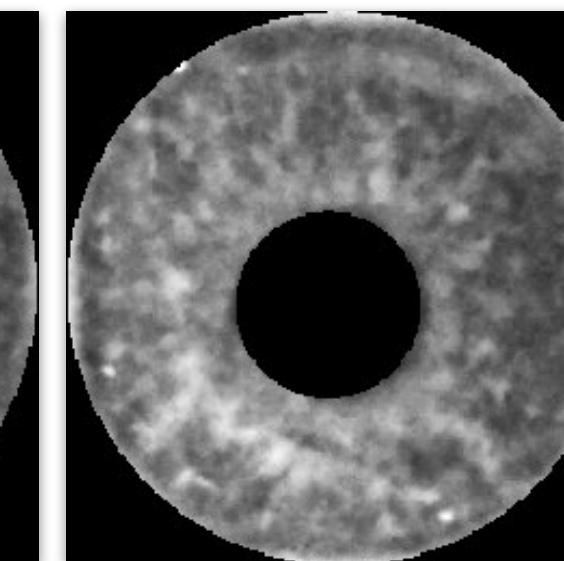
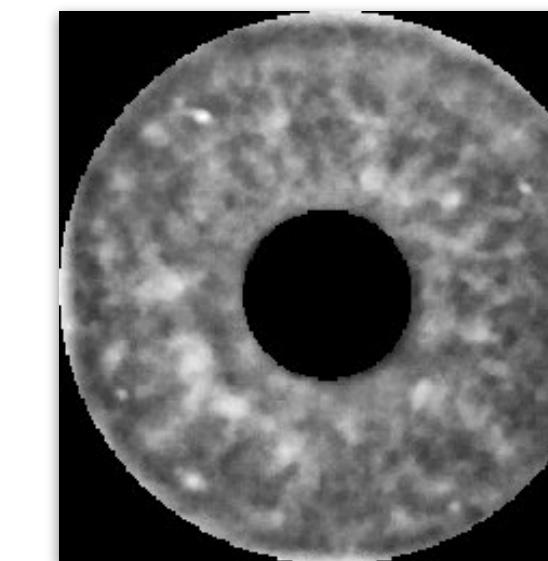
Hard for an automated solution



Twins'



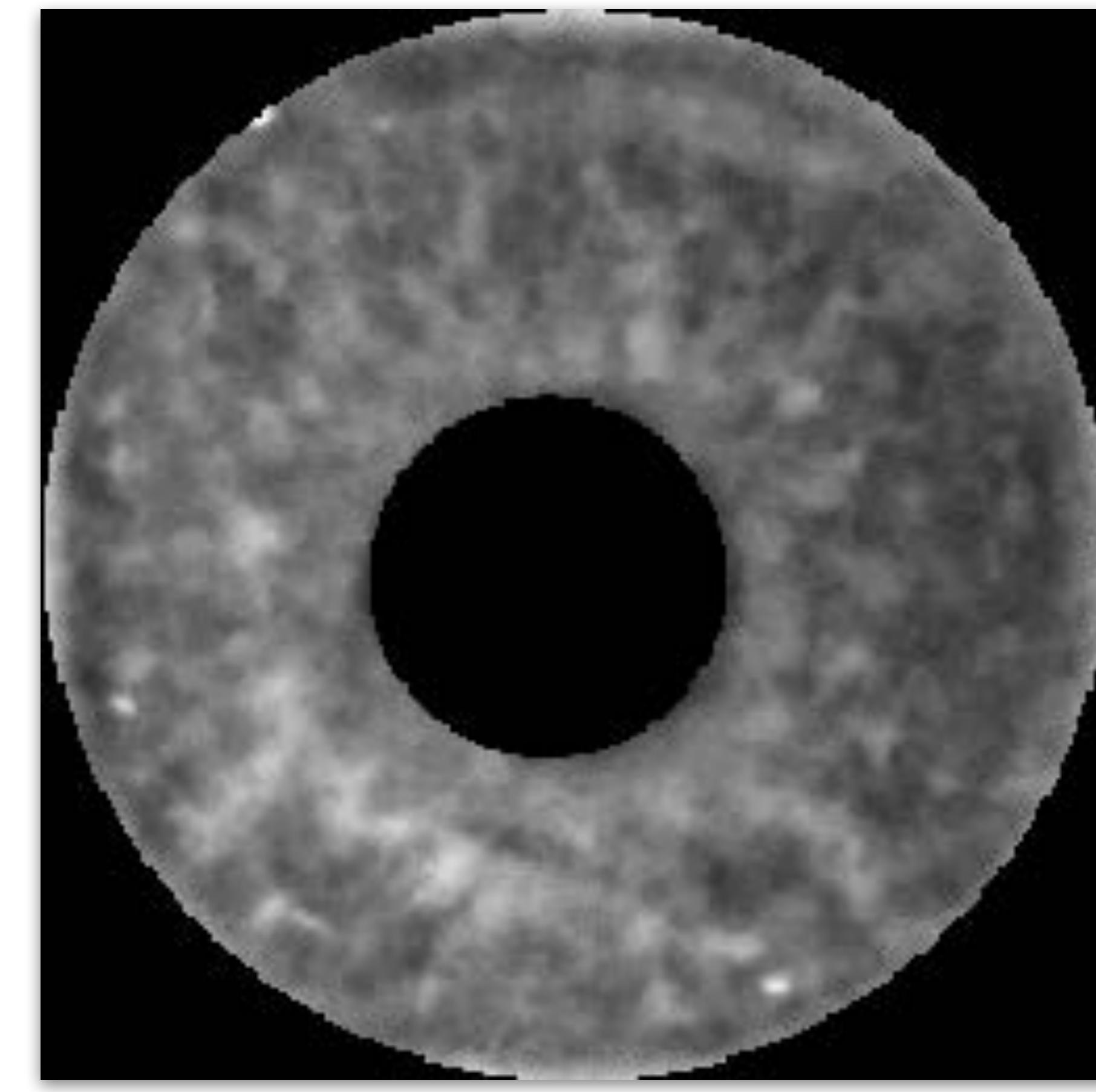
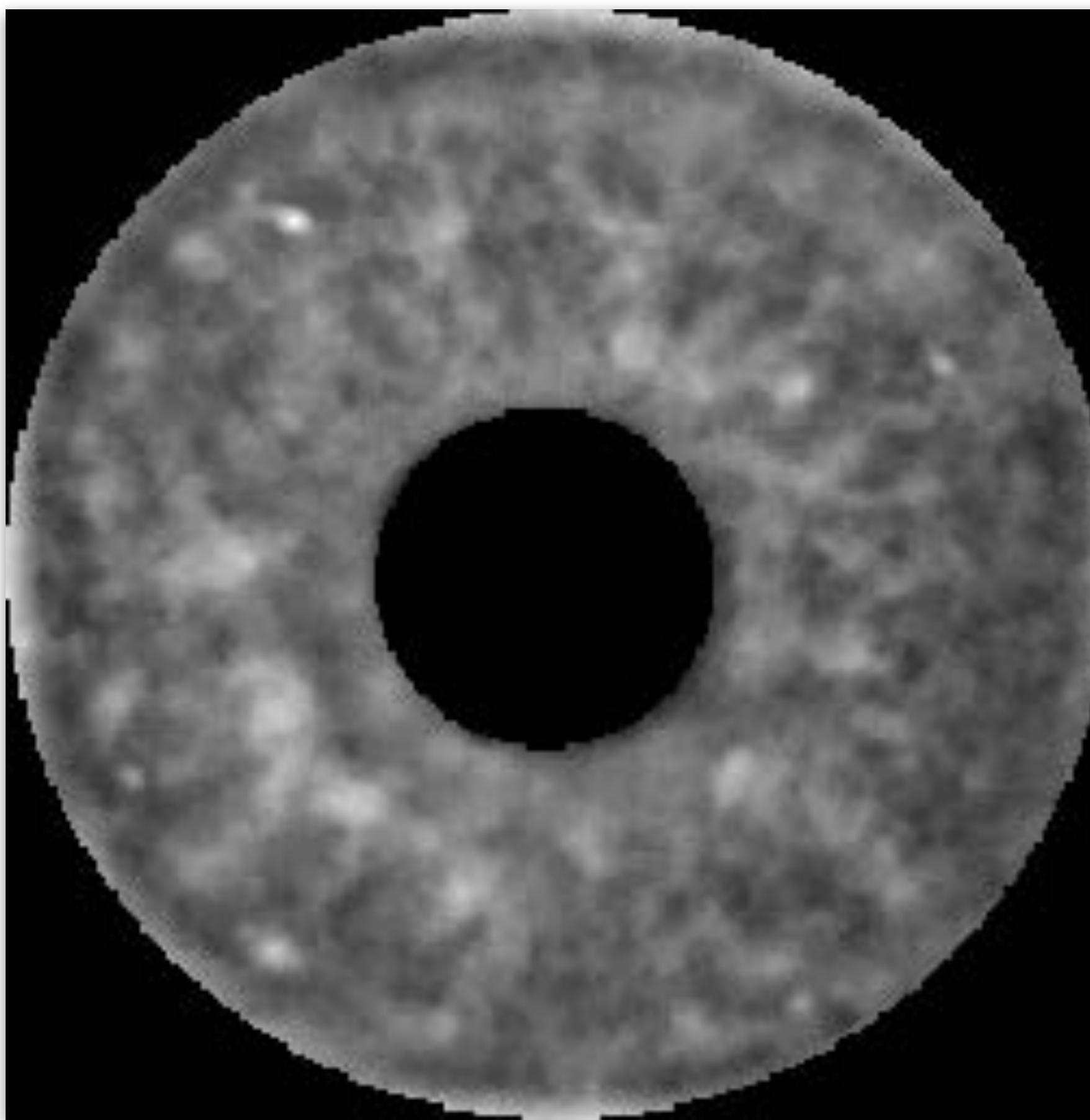
Pupil dynamic



Deceased

Source:
Warsaw-BioBase-Disease-Iris v2.1 [4]

[4] Database of iris images acquired in the presence of ocular pathologies and assessment of iris recognition reliability for disease affected eyes. Trokielewicz et al. IEEE Intl. Conference on Cybernetics, 2015.

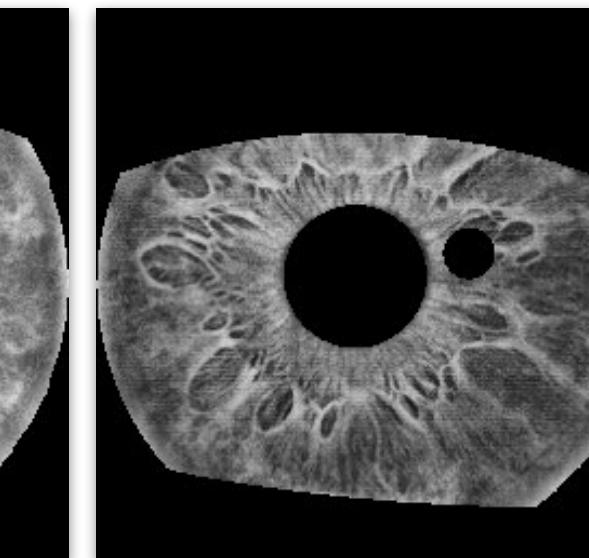
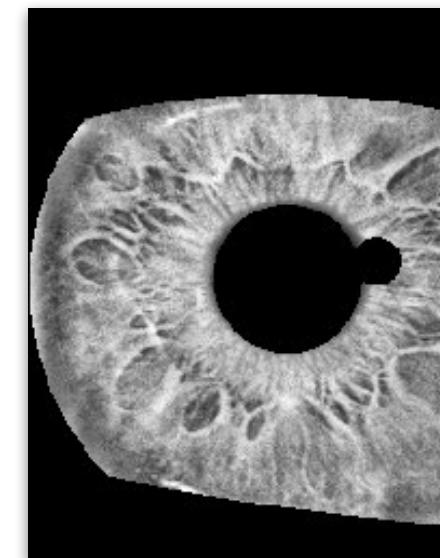


Deceased

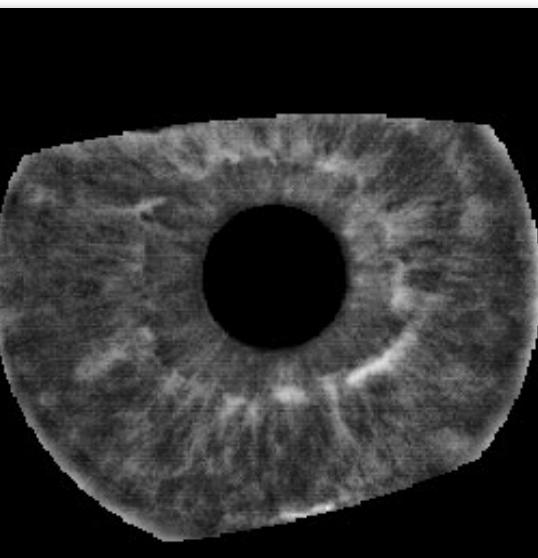
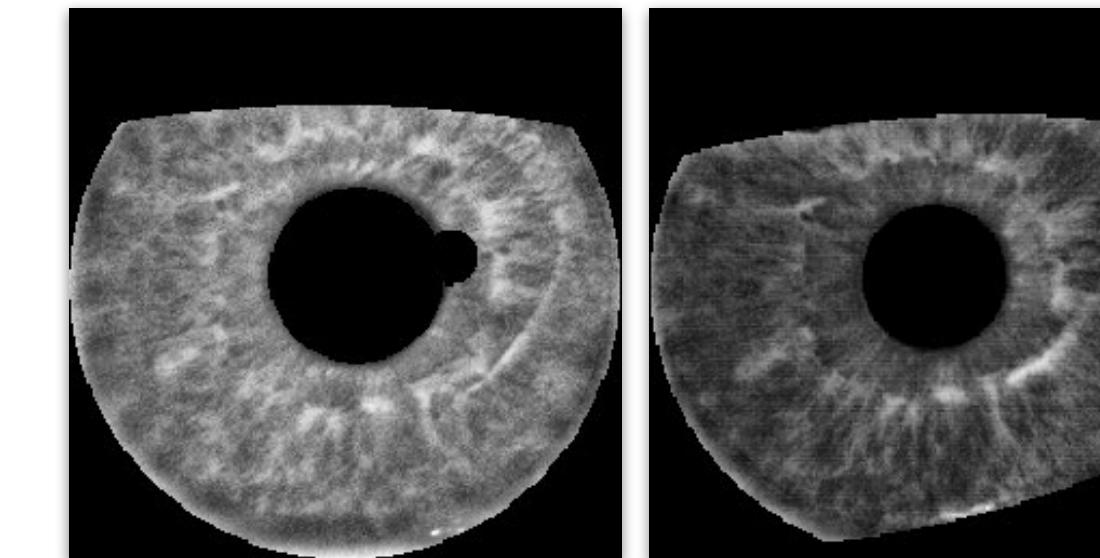
Human Experiments

Dataset

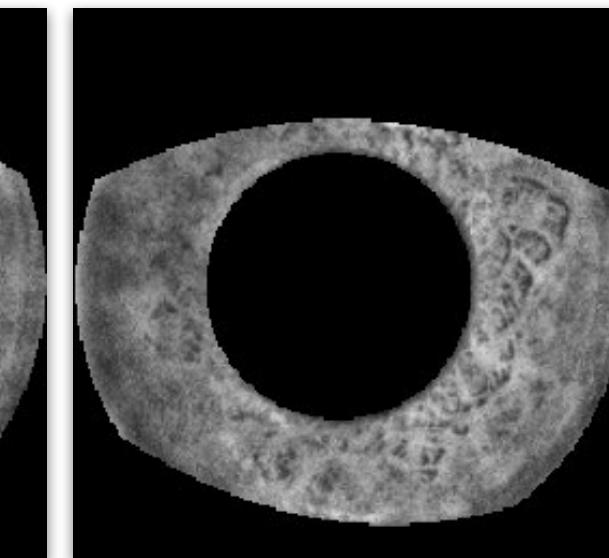
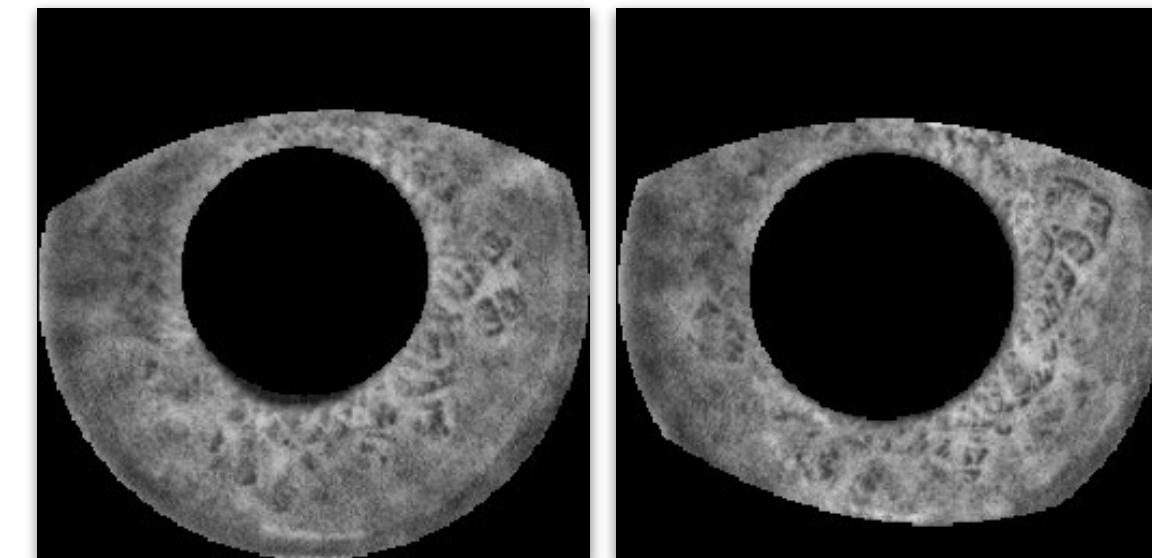
[5] Human iris recognition in post-mortem subjects: Study and database.
Trokielewicz et al. IEEE Intl. Conference on Biometrics: Theory, Applications and Systems, 2016.



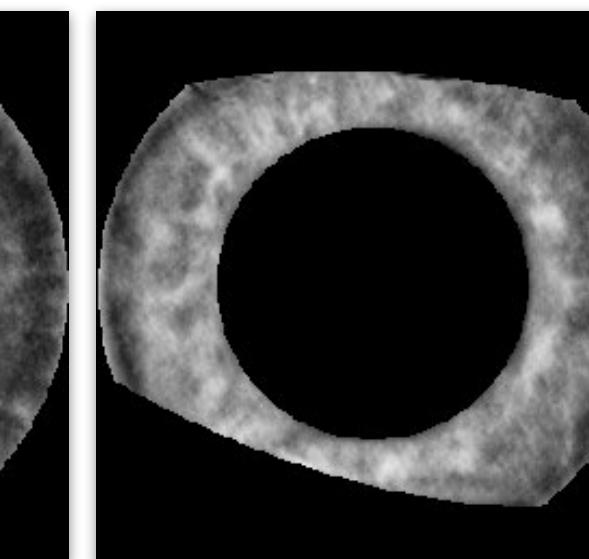
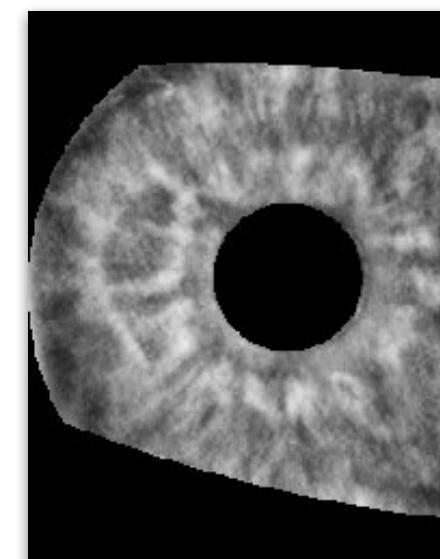
Easy for an automated solution



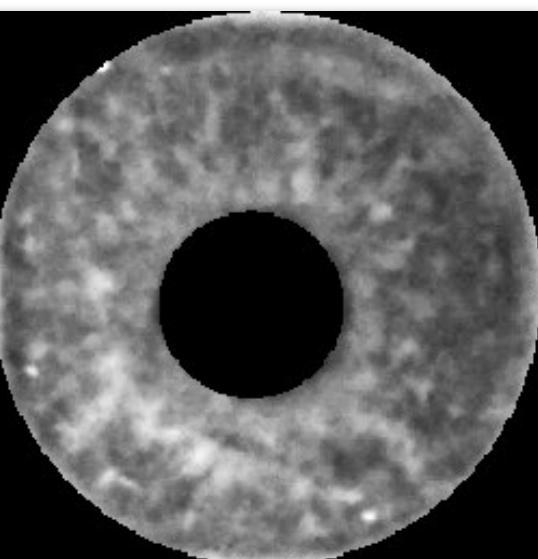
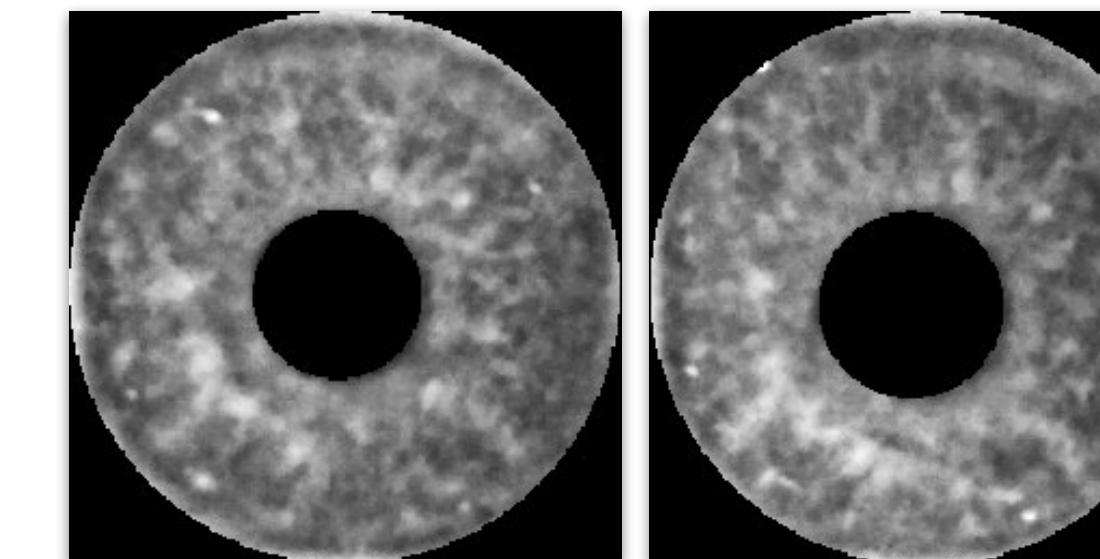
Hard for an automated solution



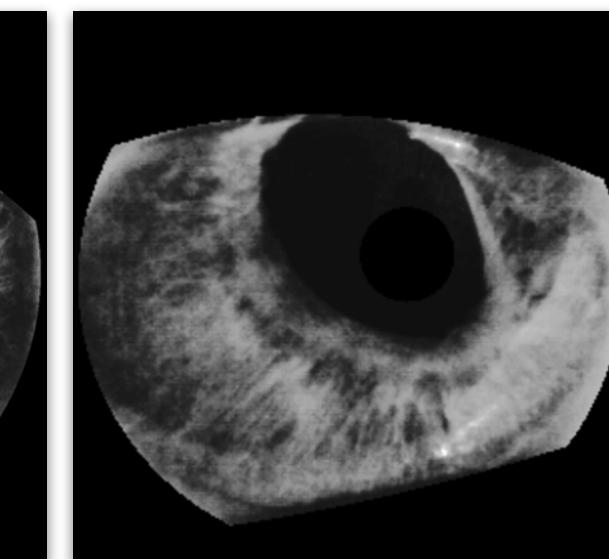
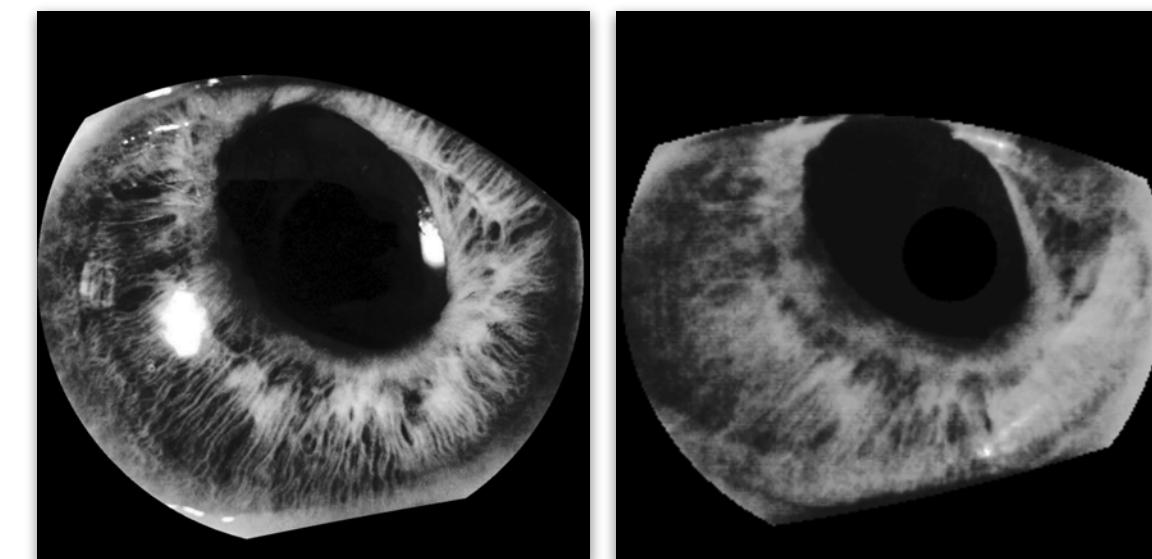
Twins'



Pupil dynamic

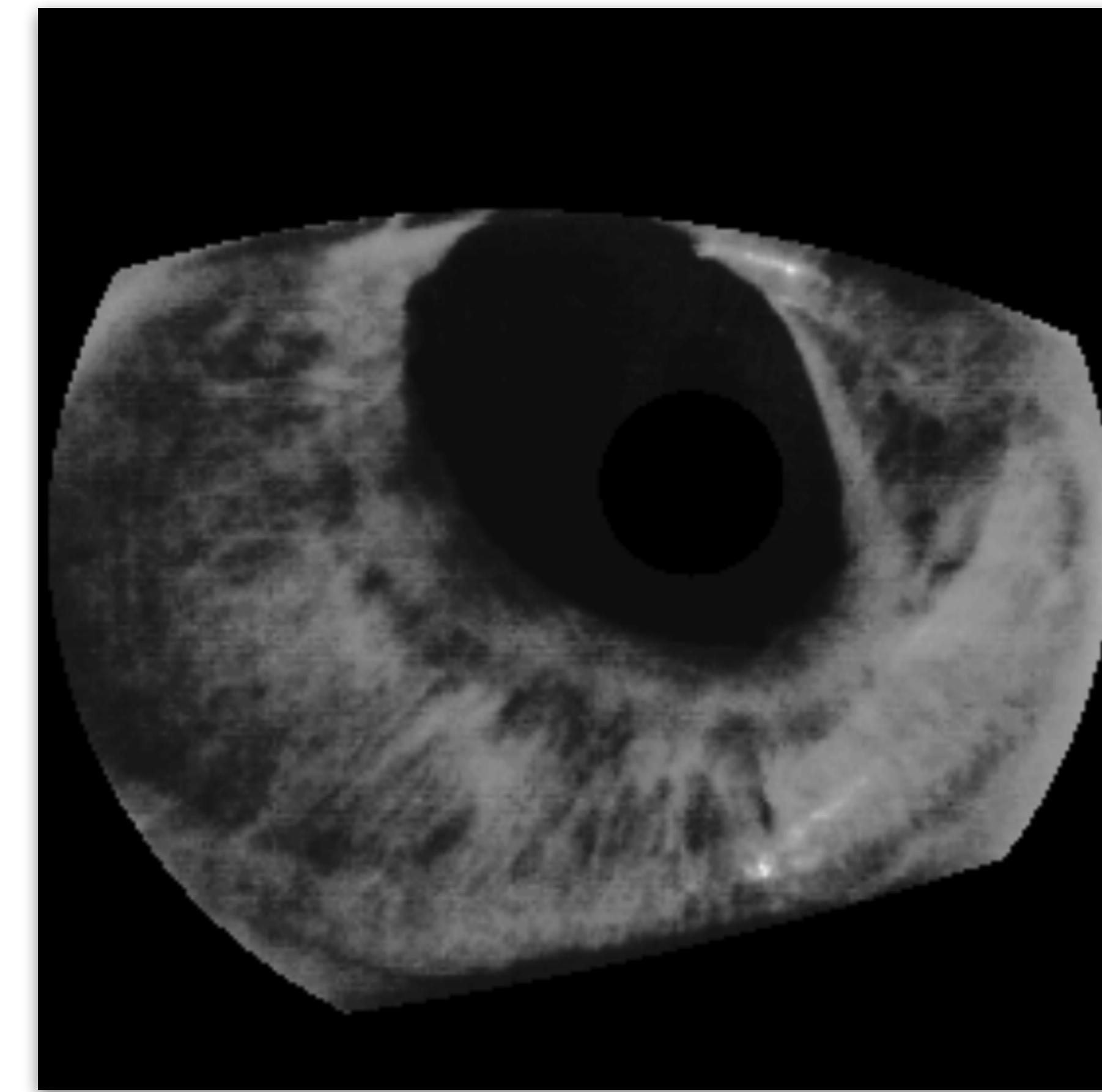
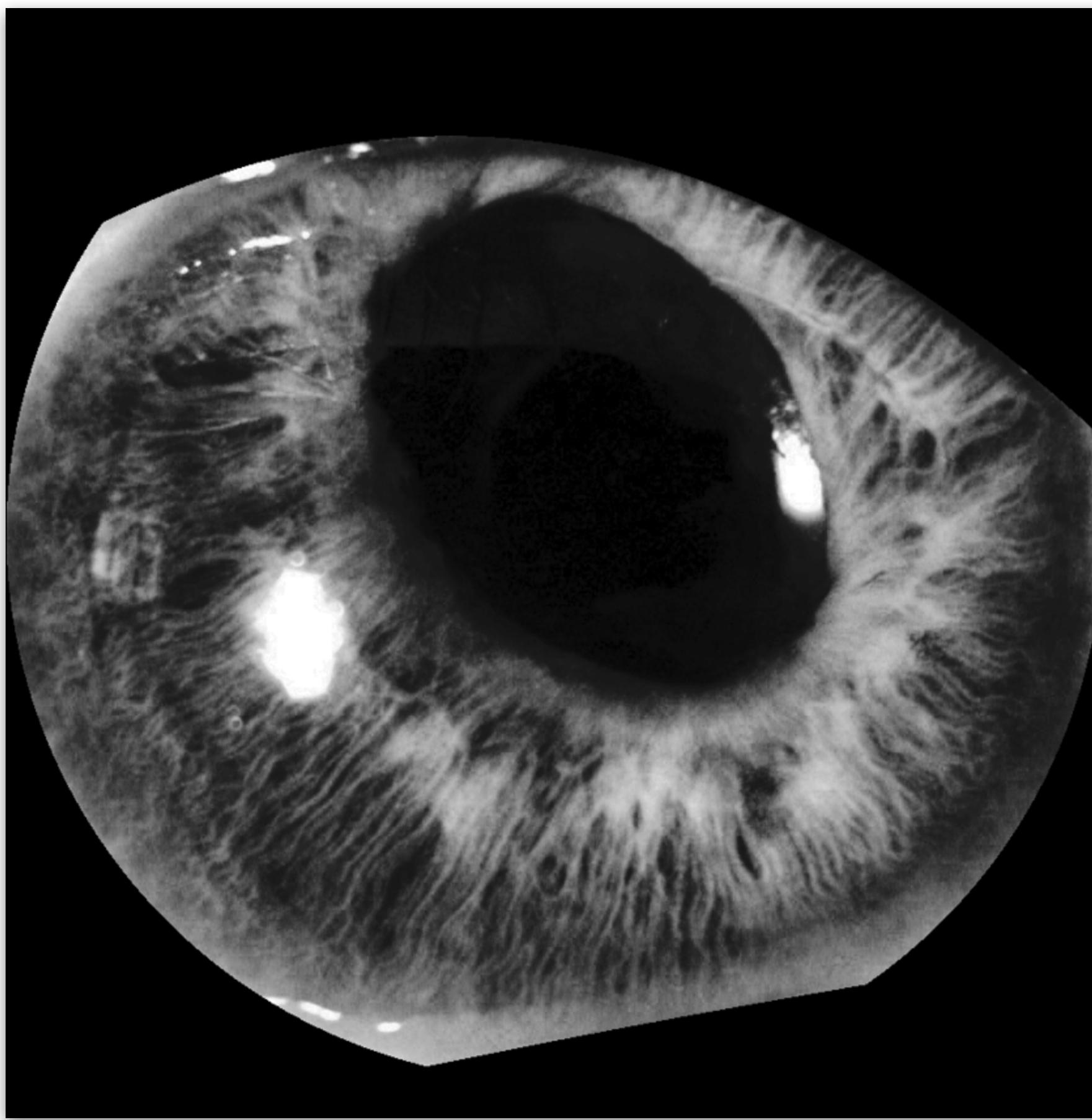


Deceased



Disease-affected

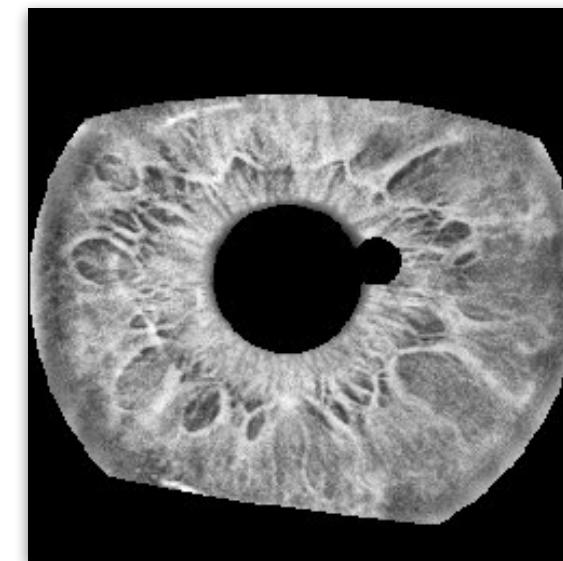
Source: Warsaw-BioBase-Post-Mortem-Iris v1.0 [5]



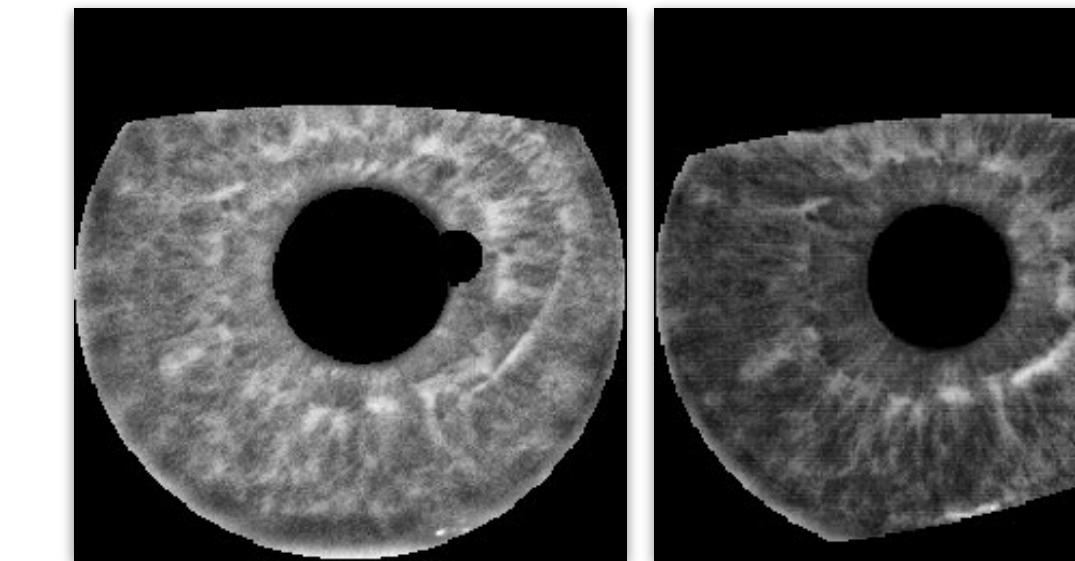
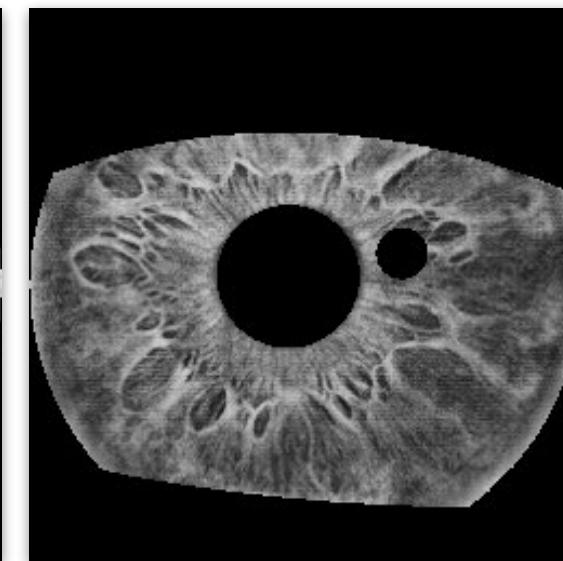
Disease-affected

Human Experiments

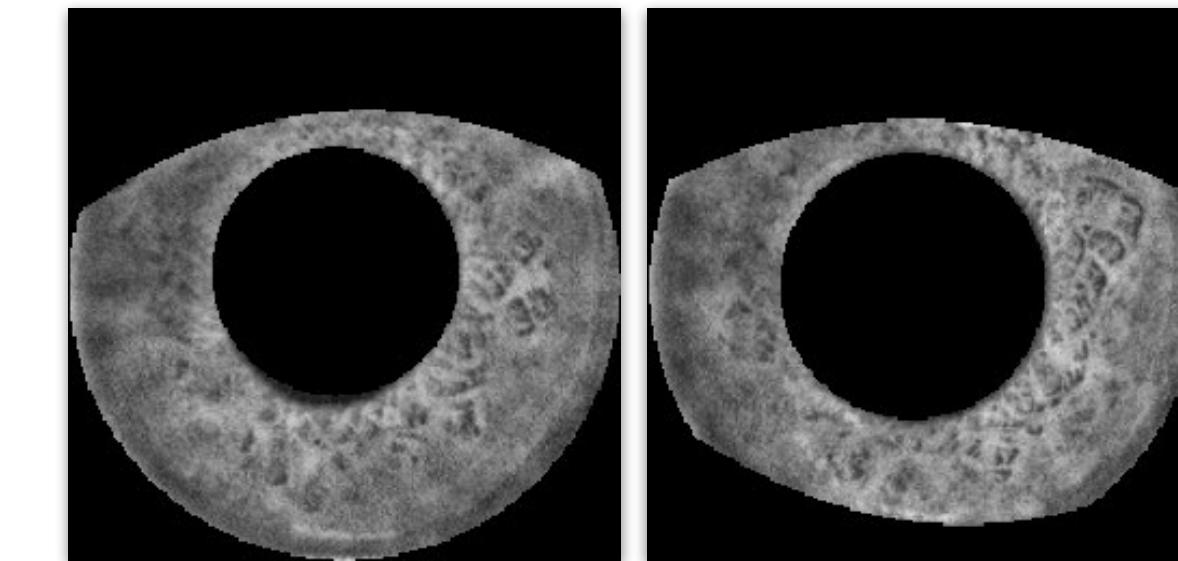
Dataset



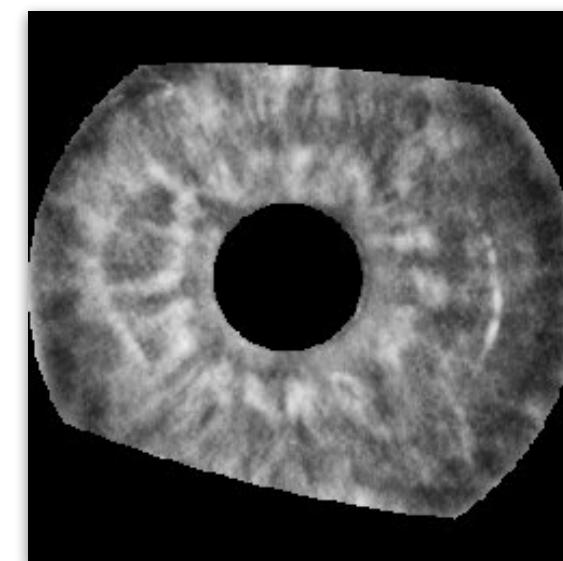
Easy for an automated solution



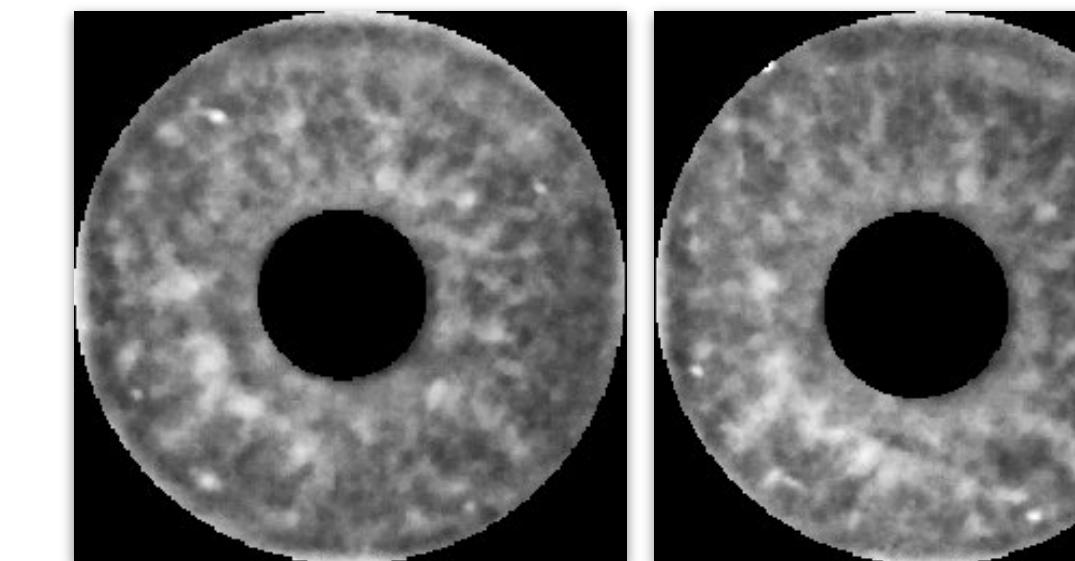
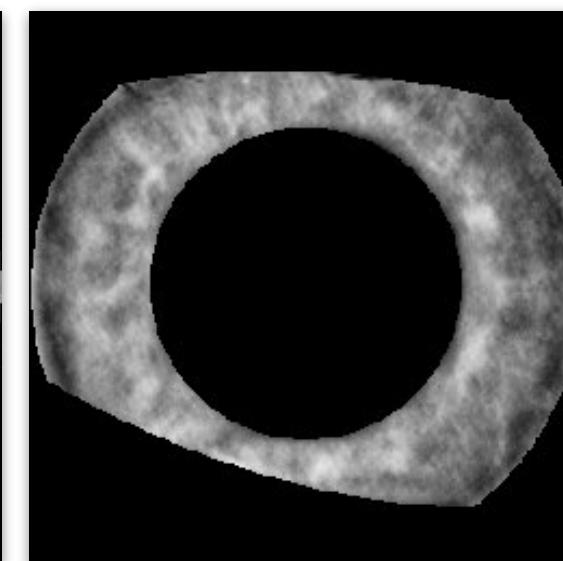
Hard for an automated solution



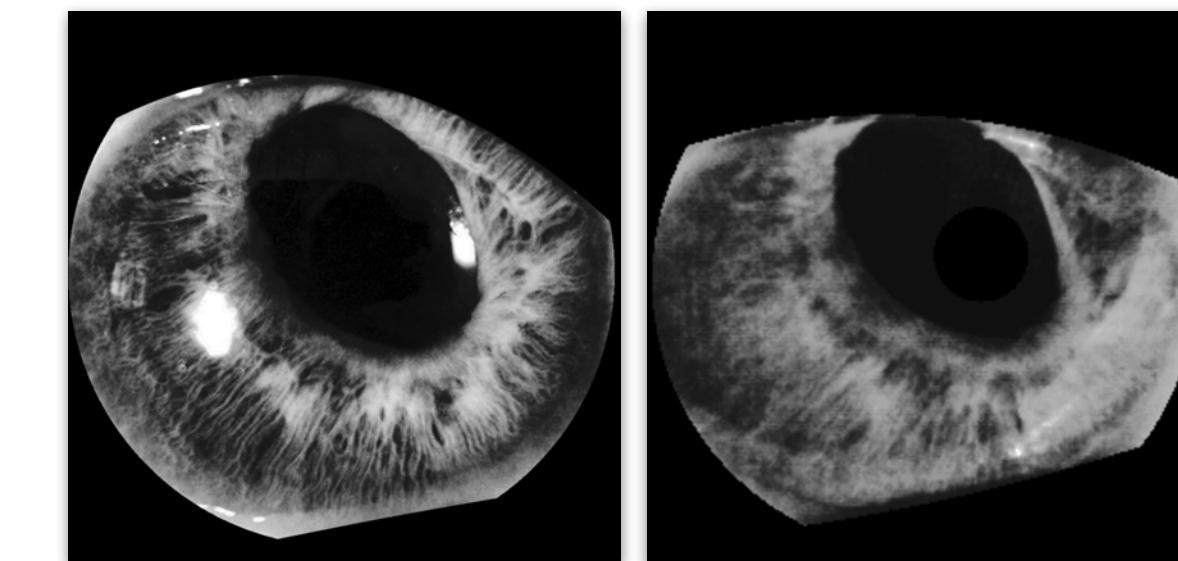
Twins'



Pupil dynamic

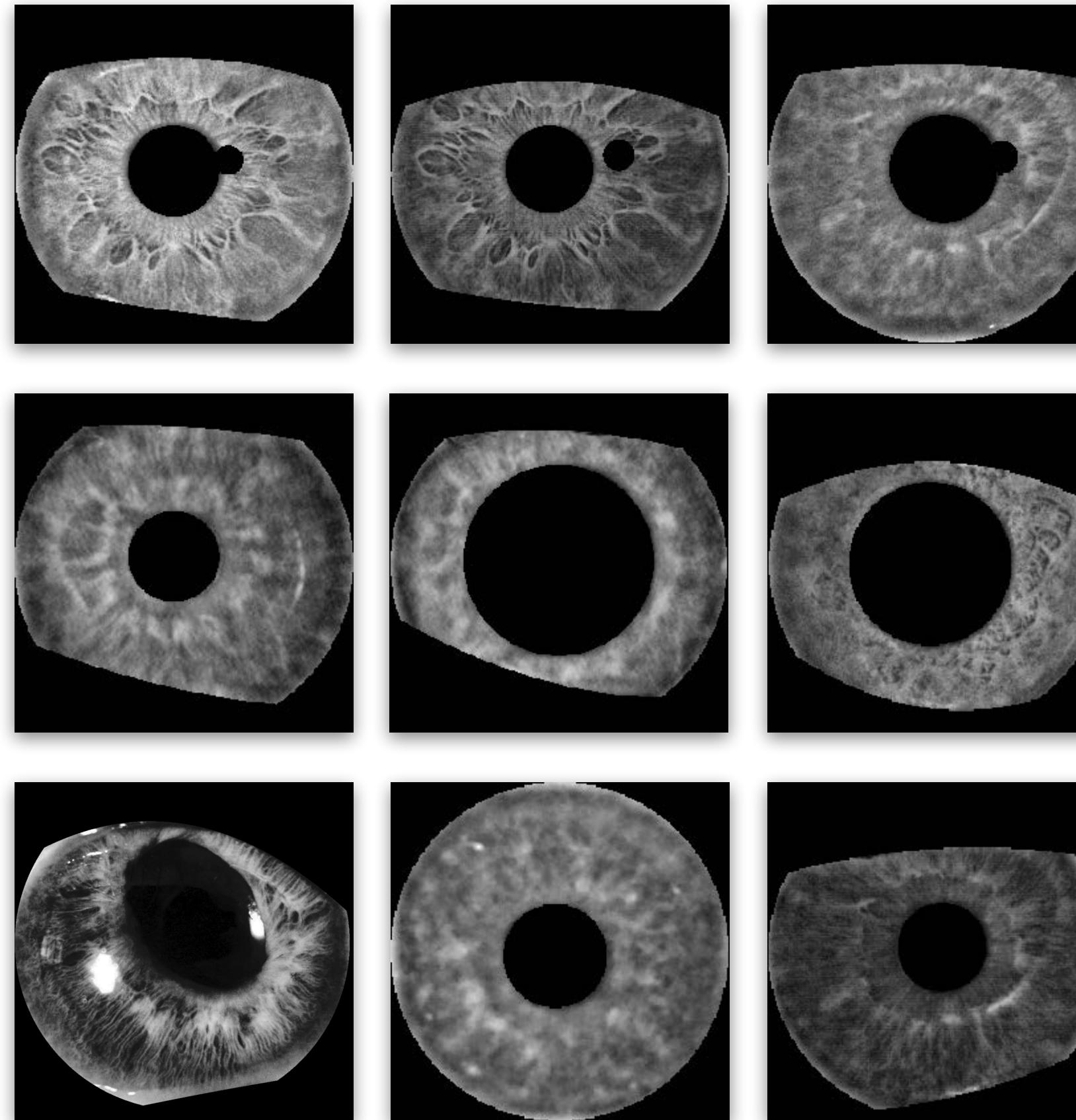


Deceased



Disease-affected

Human Experiments

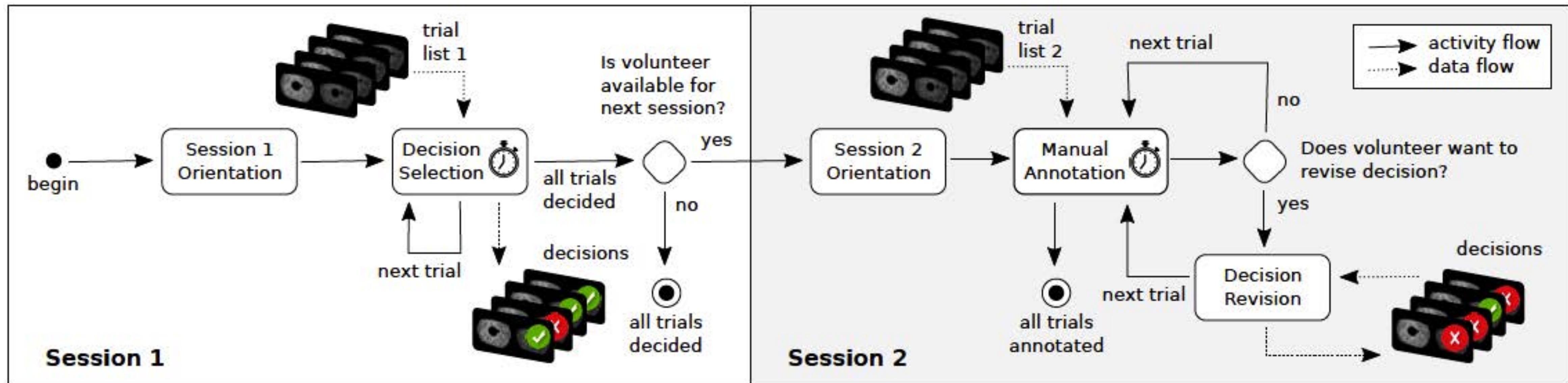


1360 iris images
(NIR and manually segmented)

512 distinct irises
512 individuals

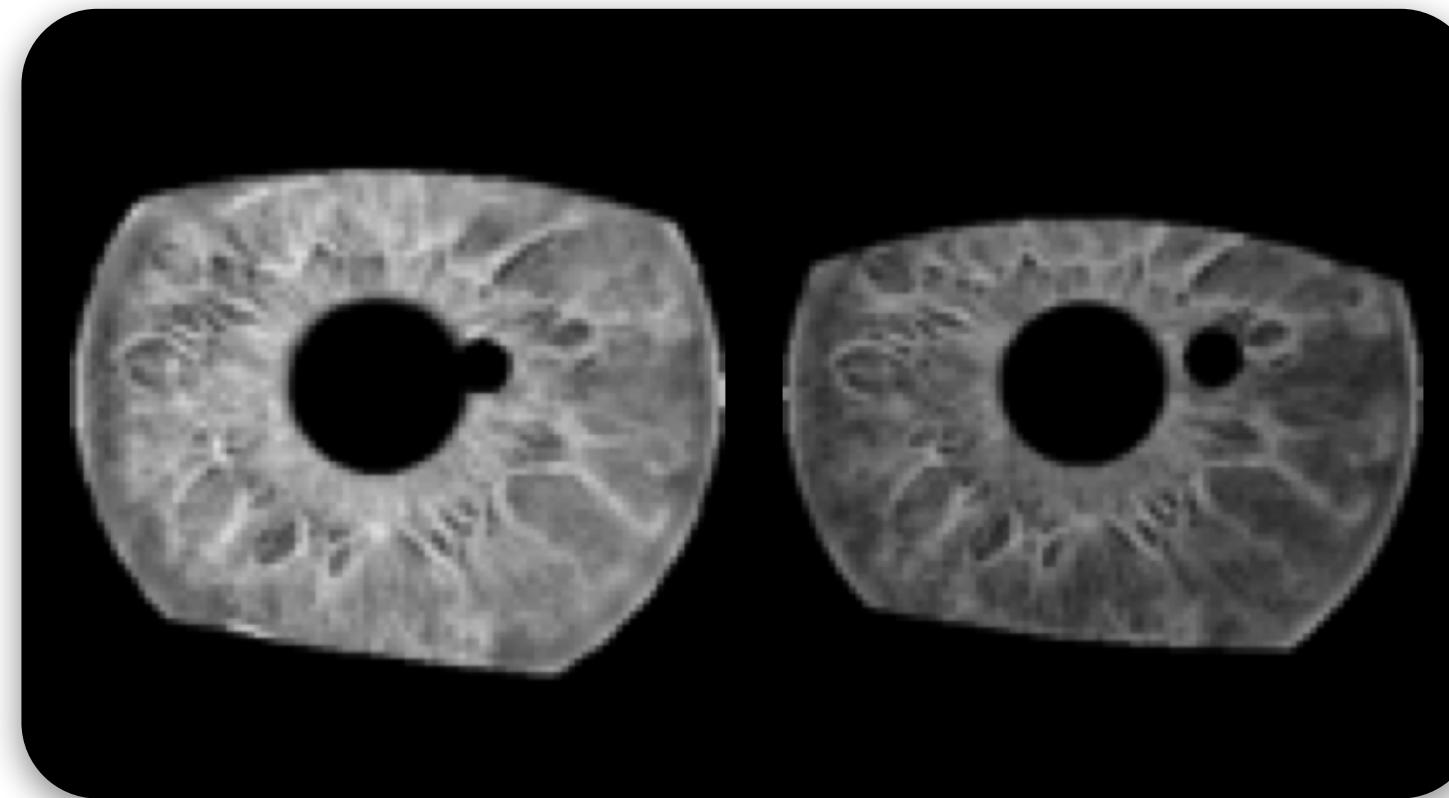
Iris-pair types
Genuine (not taken at the same day)
Impostor (not mixing different categories)

Human Experiments



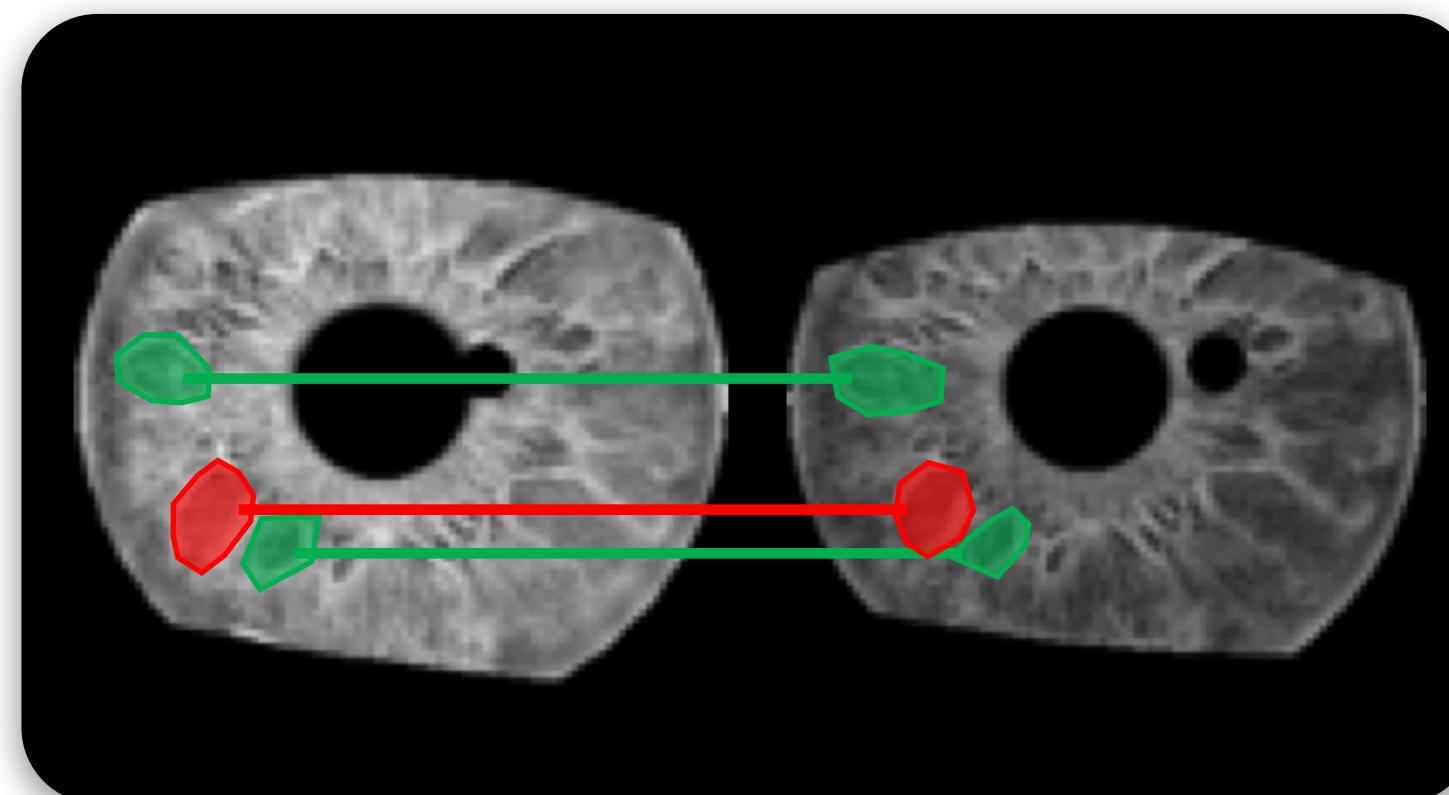
Moreira et al.,
Performance of Humans in Iris Recognition: The Impact of Iris Condition and Annotation-driven Verification
WACV 2019

Human Experiments



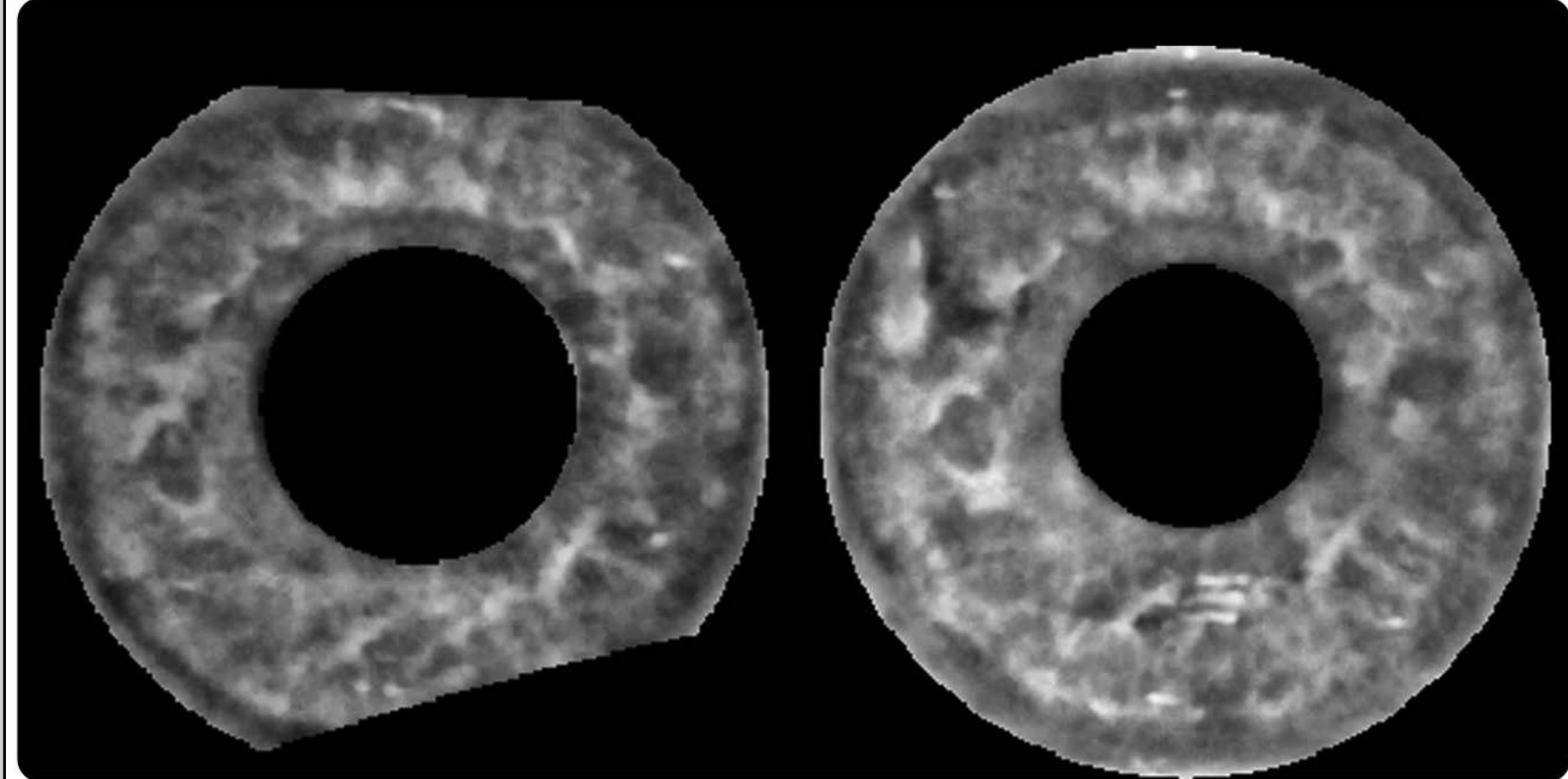
Session 1

- 1. Same person (certain).
- 2. Same person (likely).
- 3. Uncertain.
- 4. Different person (likely).
- 5. Different person (certain).



Session 2

Manual annotation of **matching** and
missing features



1. Same person (certain).

2. Same person (likely).

3. Uncertain.

4. Different people (likely).

5. Different people (certain).

NEXT

114 people
(age 18 to 65)

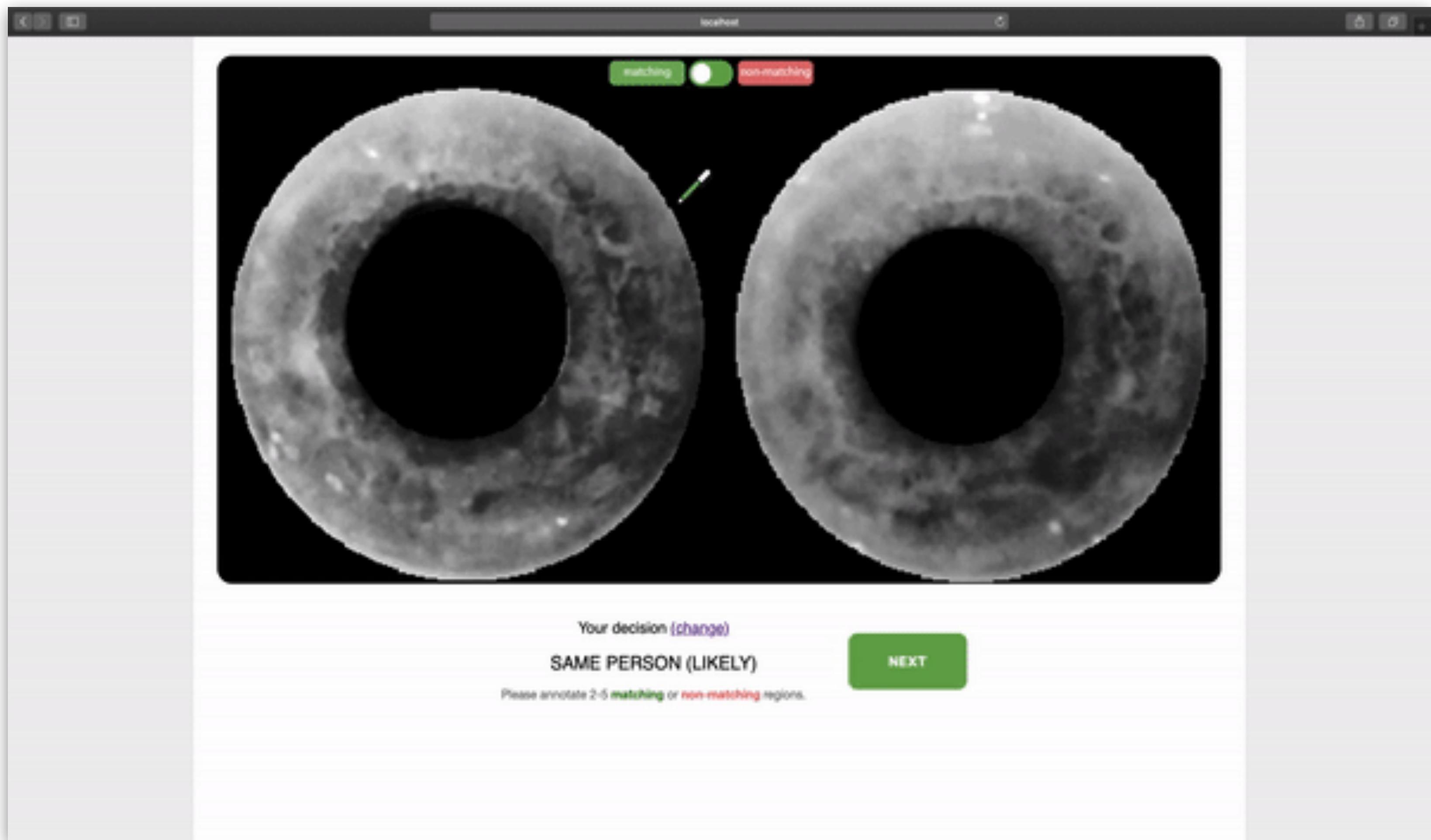
For each person
20 trials

Average session time
7 min

Balanced distribution
Category wise
Pair-type wise
Random presentation



LOYOLA
UNIVERSITY CHICAGO



85 people

For each person
10 trials

Average session time
10 min

Balanced distribution
Category wise
Pair-type wise
Session-1 answer wise

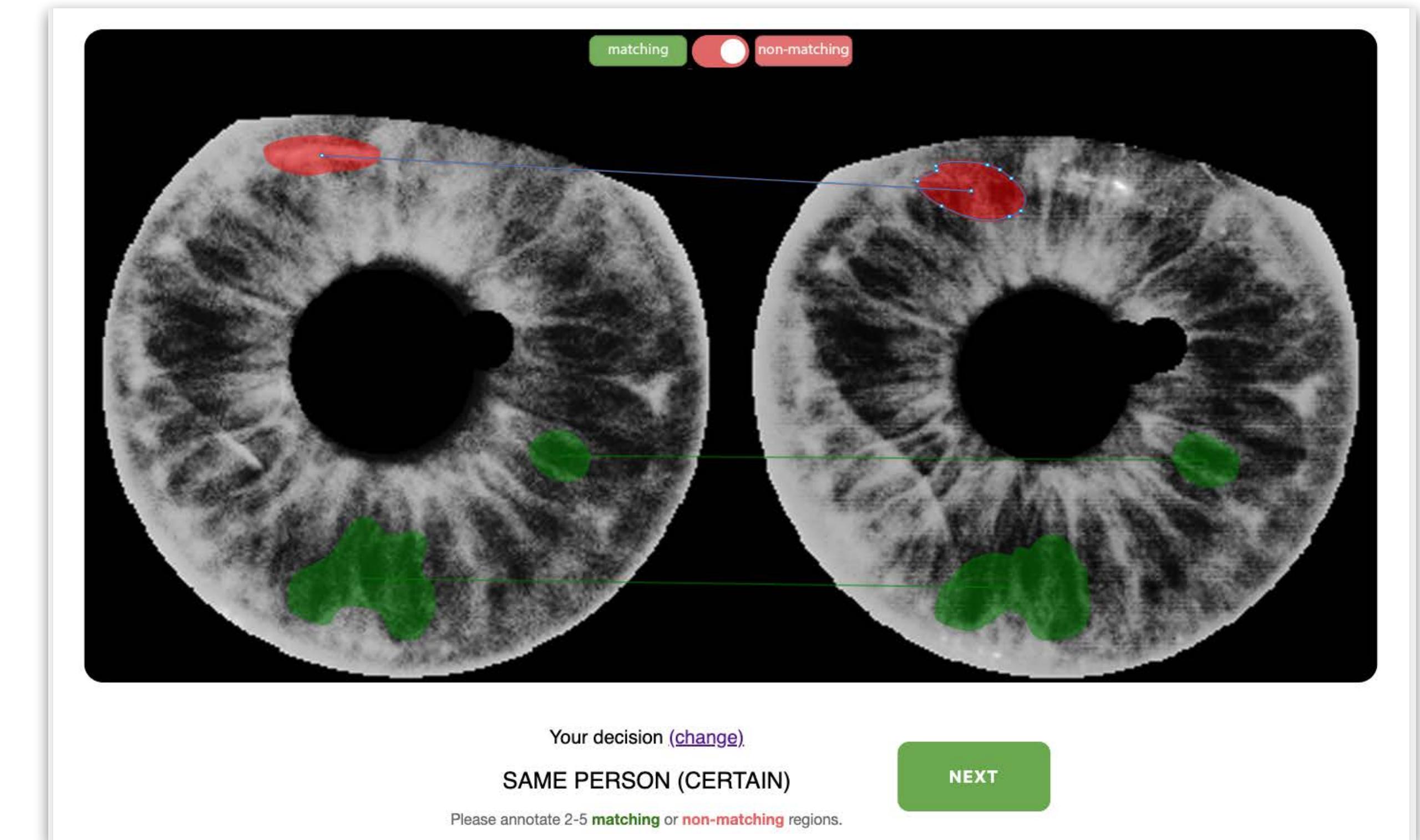
Annotation Tool



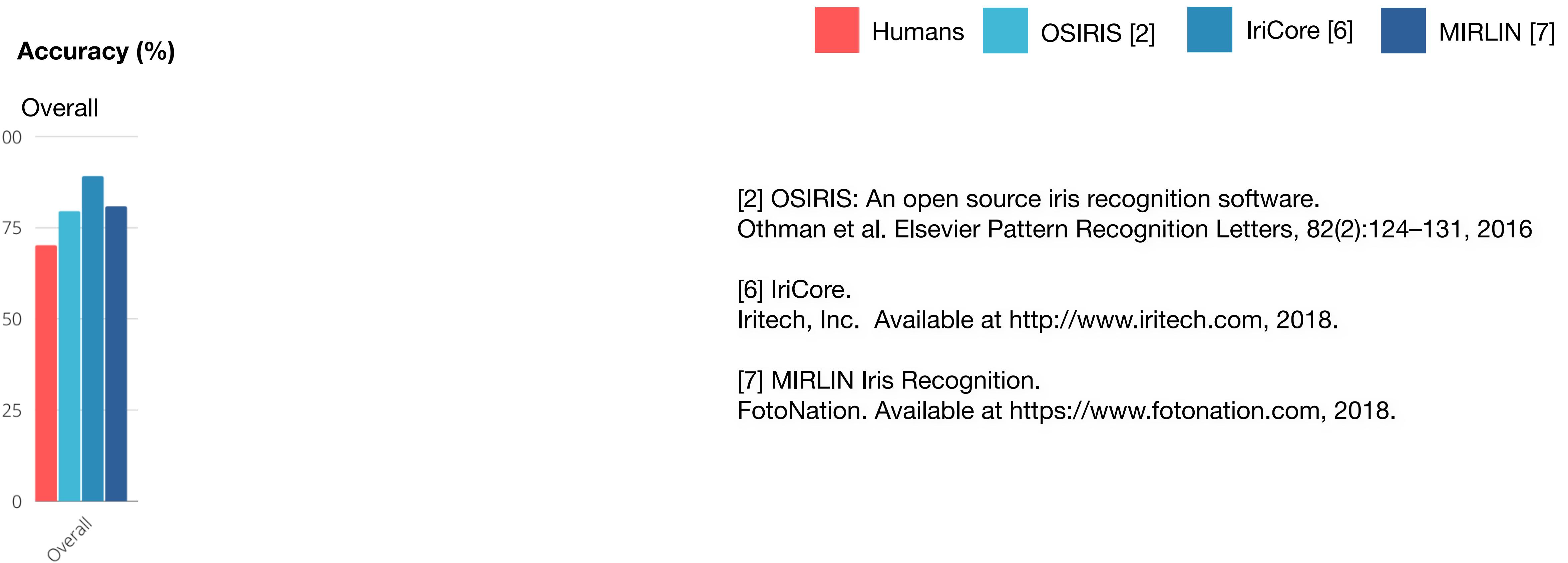
Available at
[https://github.com/
danielmoreira/iris-examination](https://github.com/danielmoreira/iris-examination)



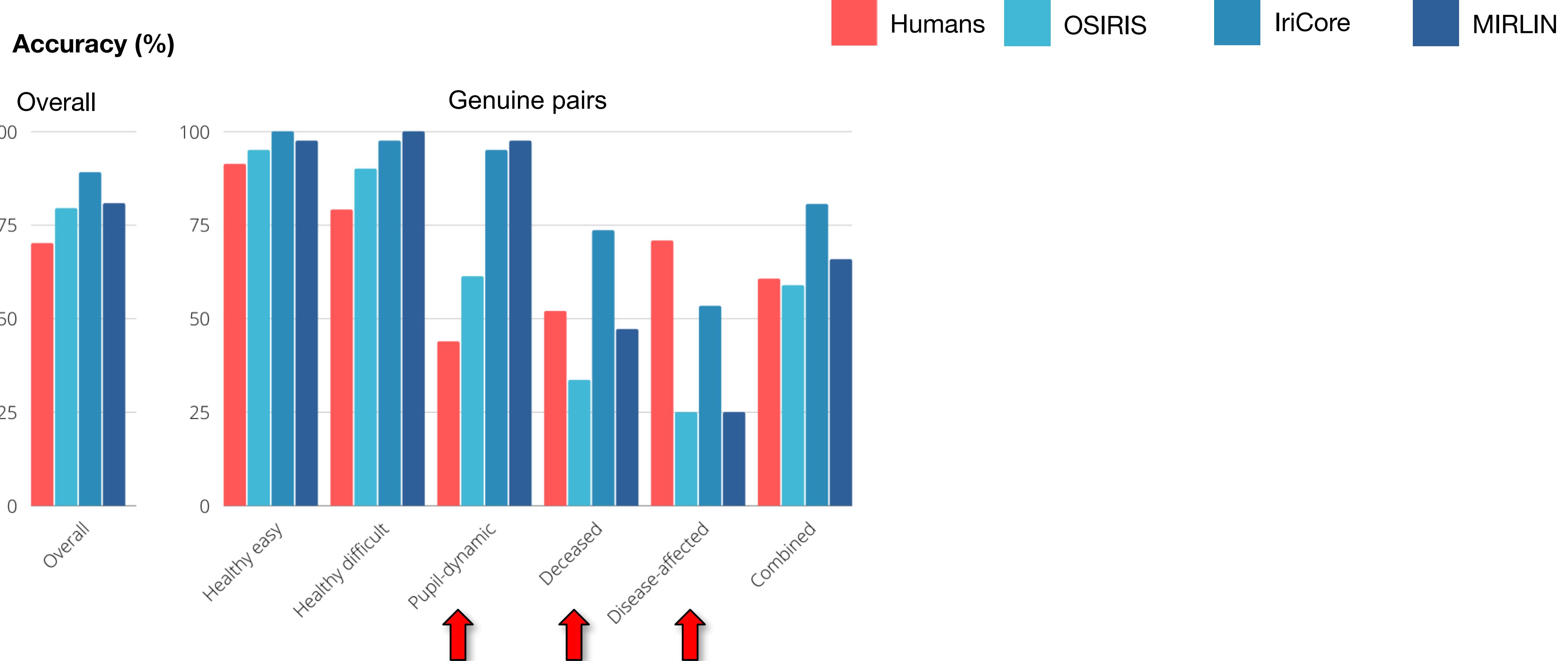
Paper.js
Web-browser drawing
library.



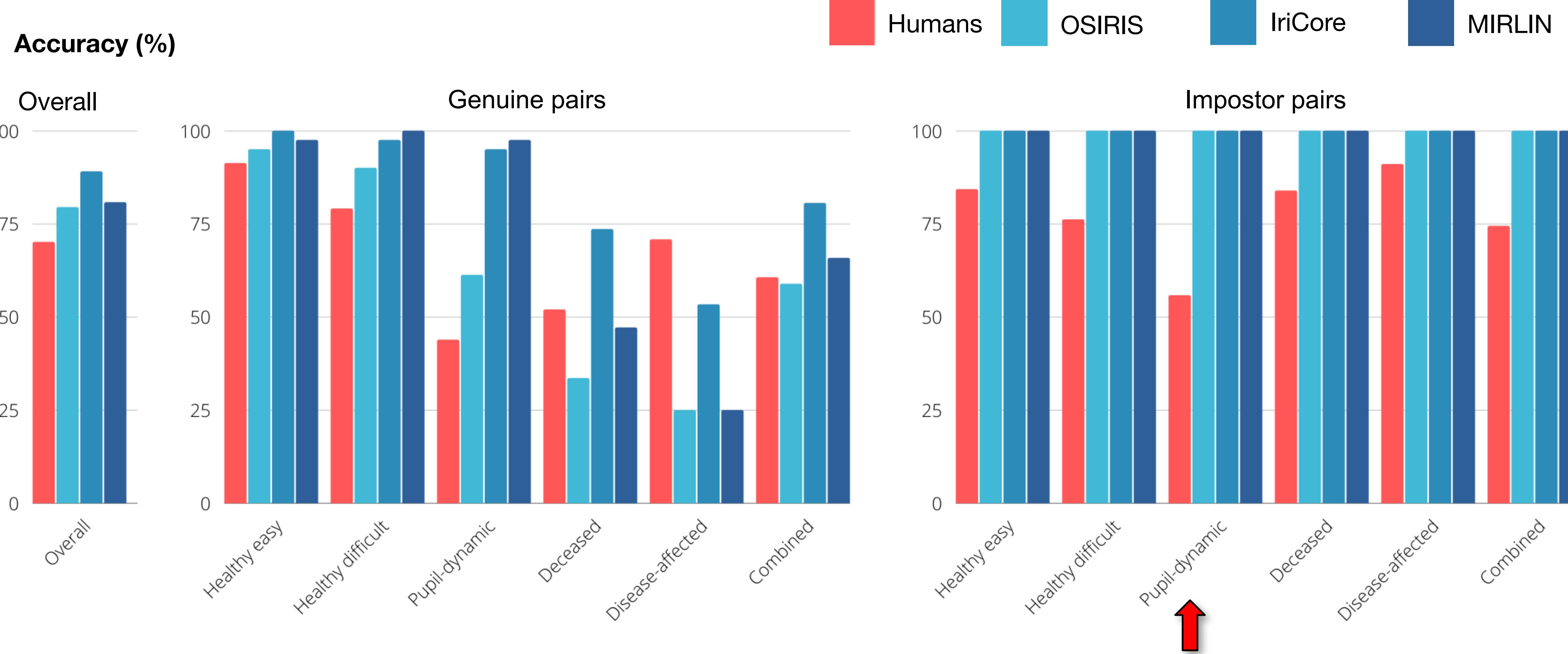
Human Experiments



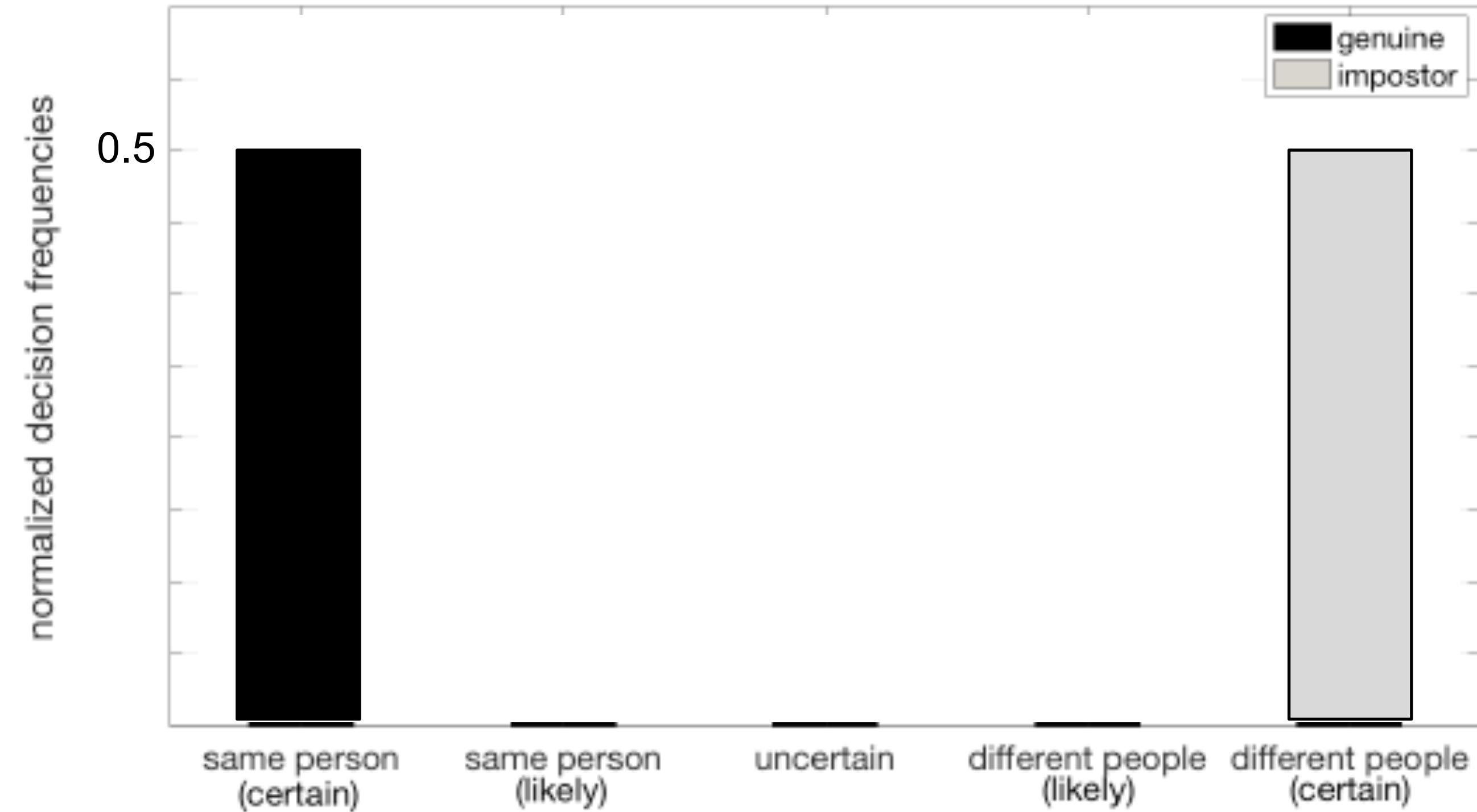
Human Experiments



Human Experiments



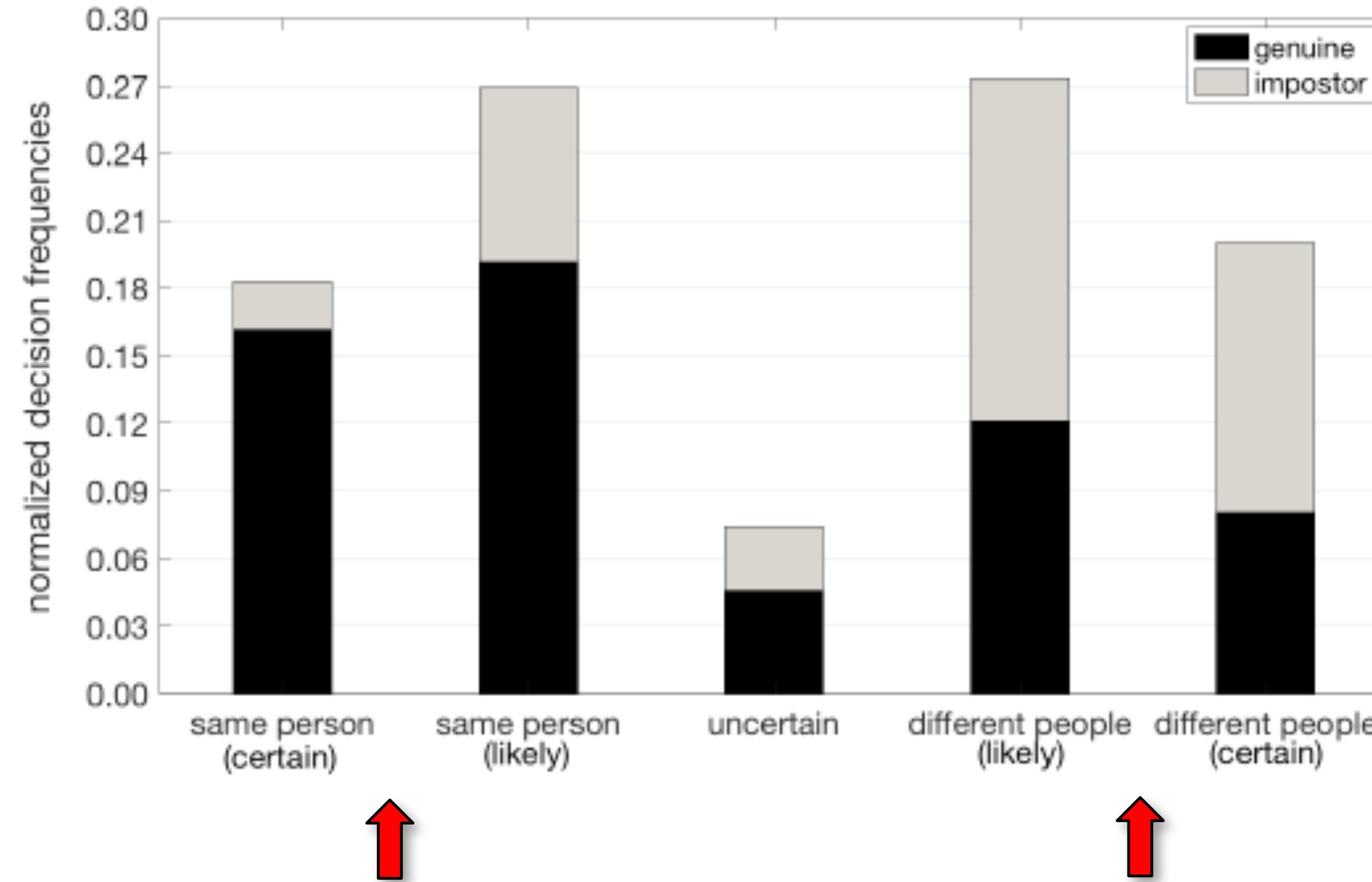
Human Experiments



How confident were people?

Ideal graph

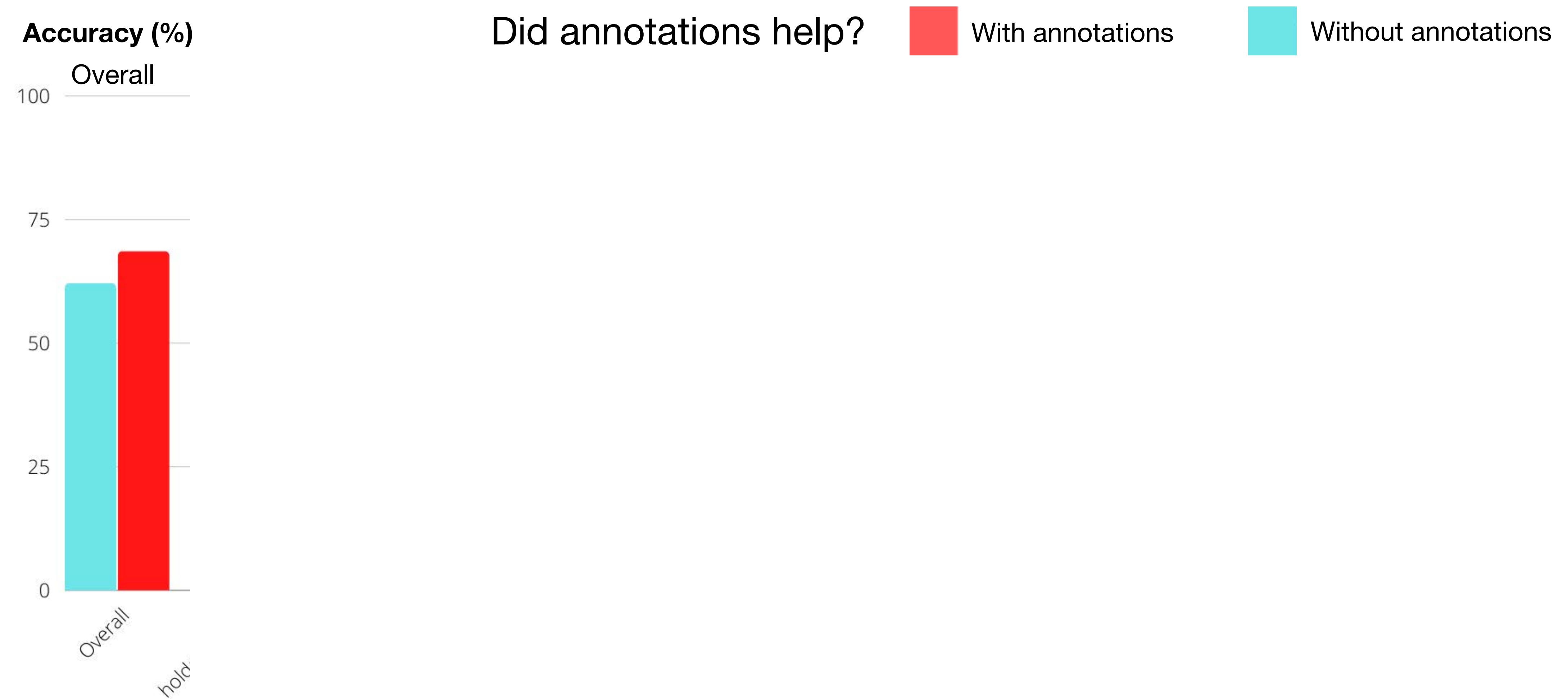
Human Experiments



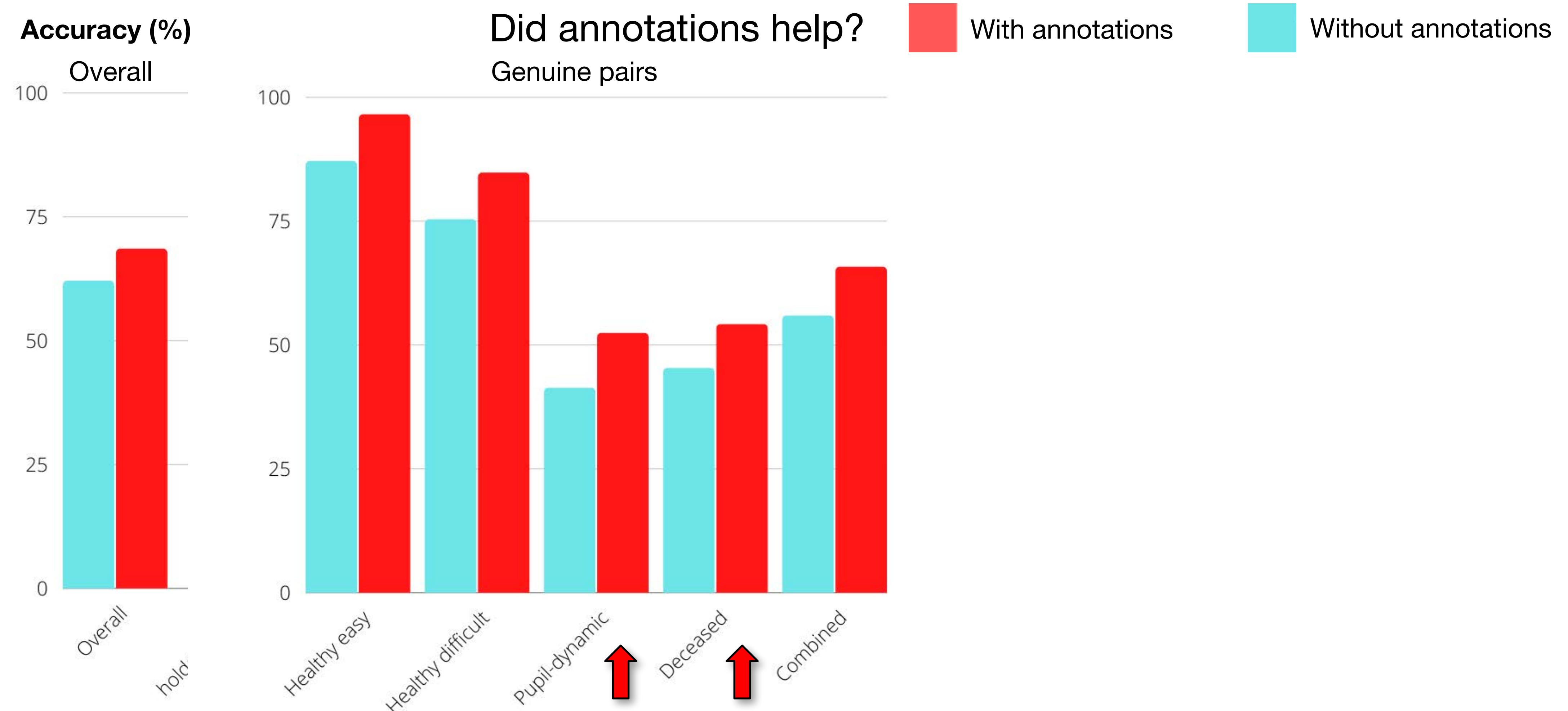
How confident were people?

Obtained graph

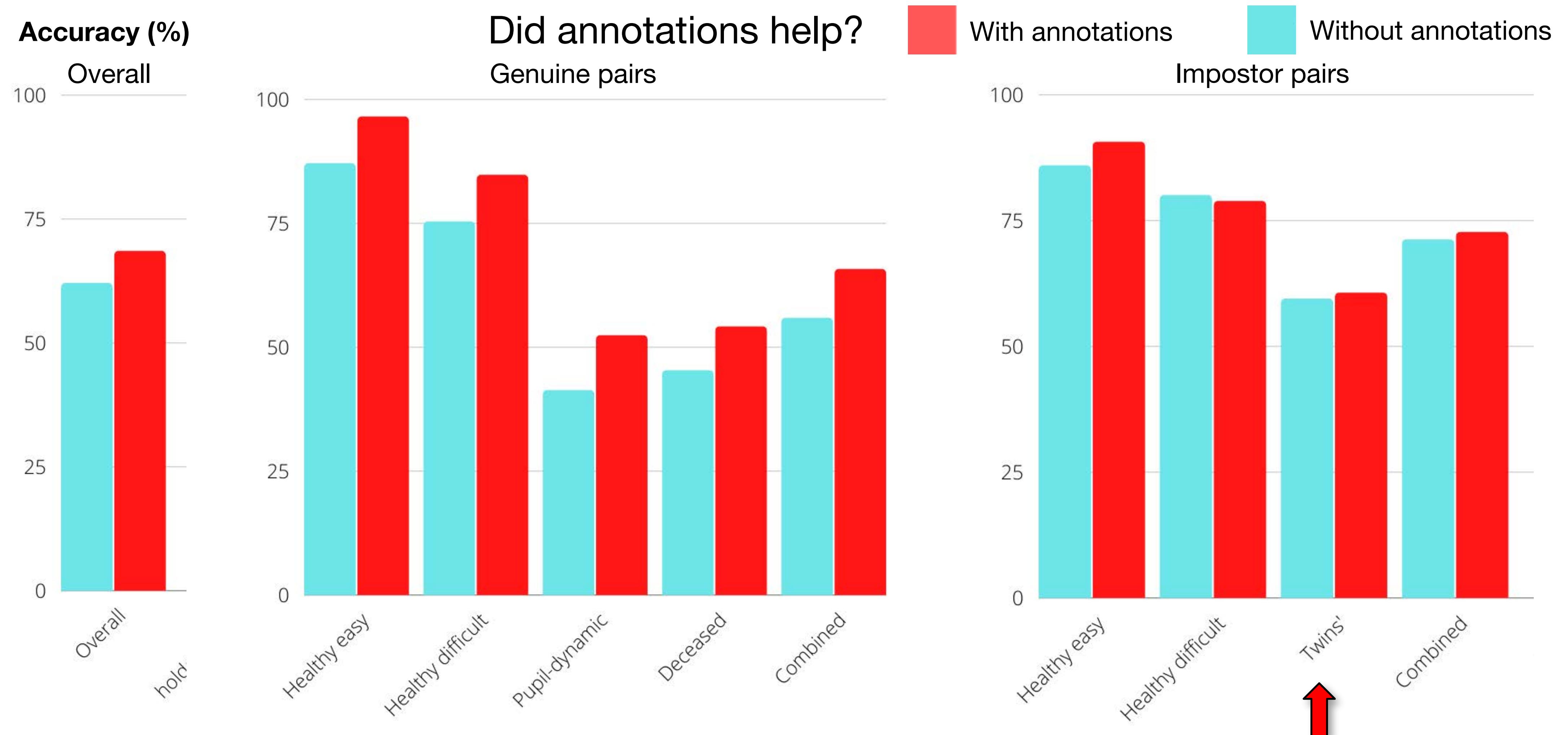
Human Experiments



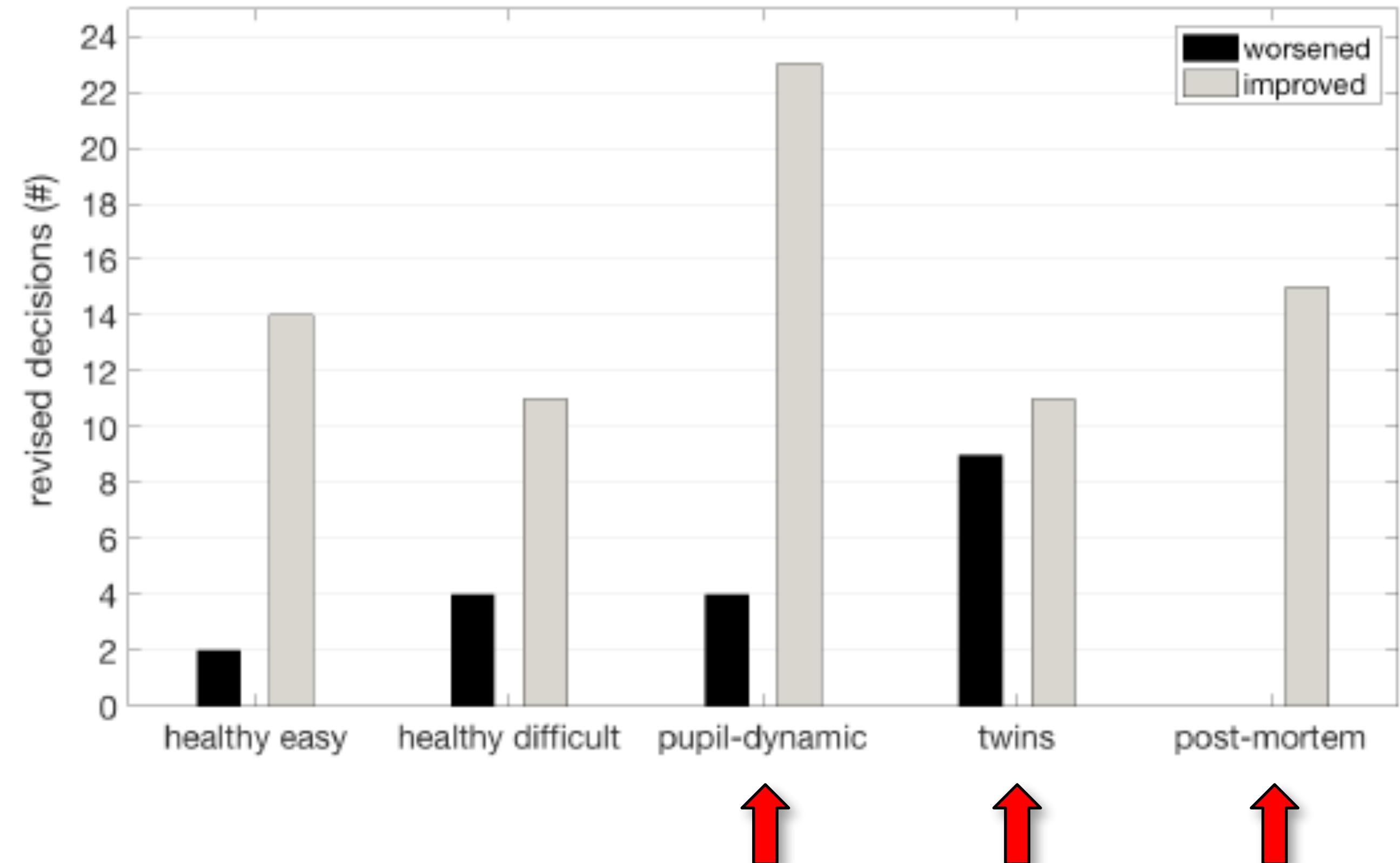
Human Experiments



Human Experiments

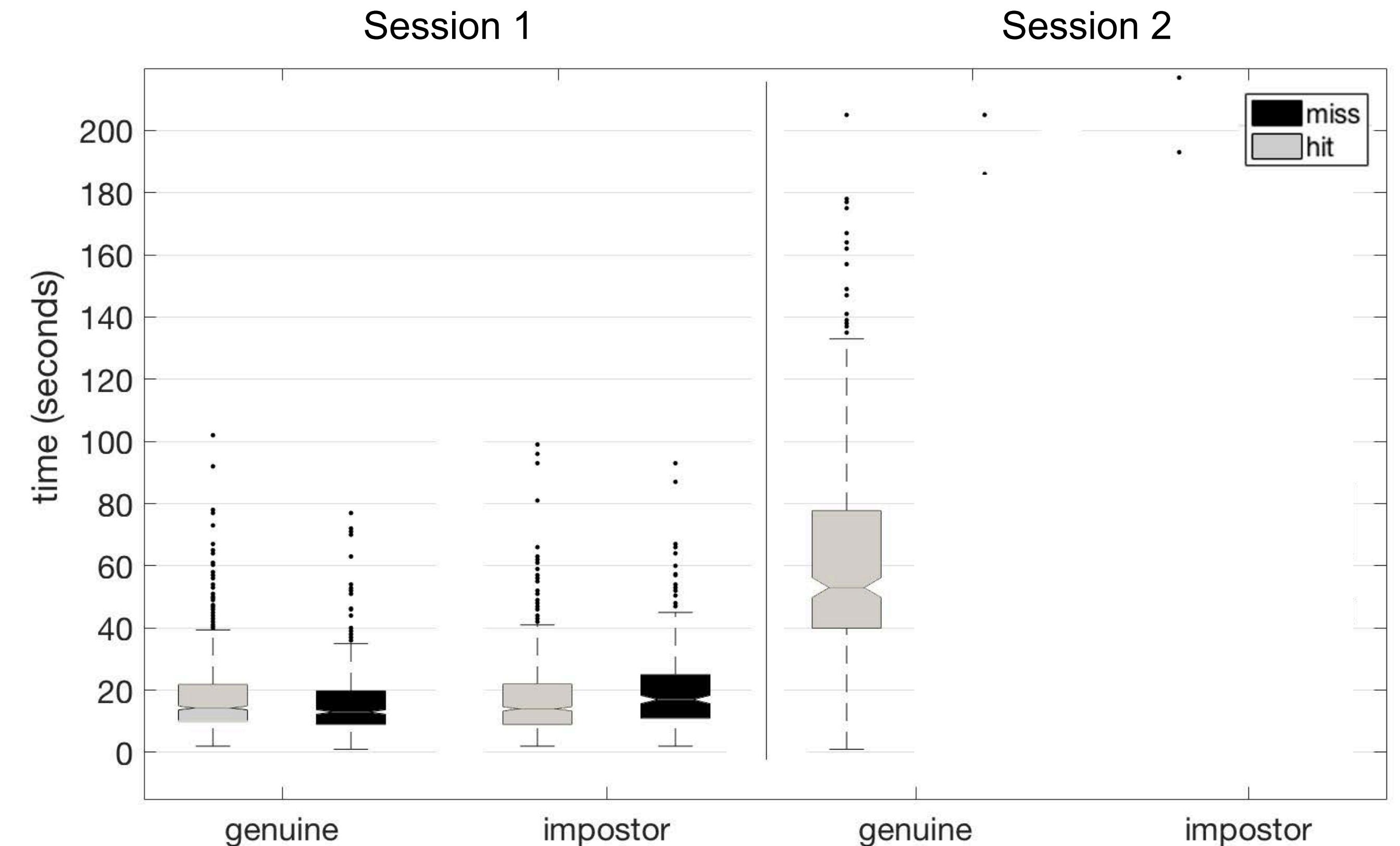


Human Experiments



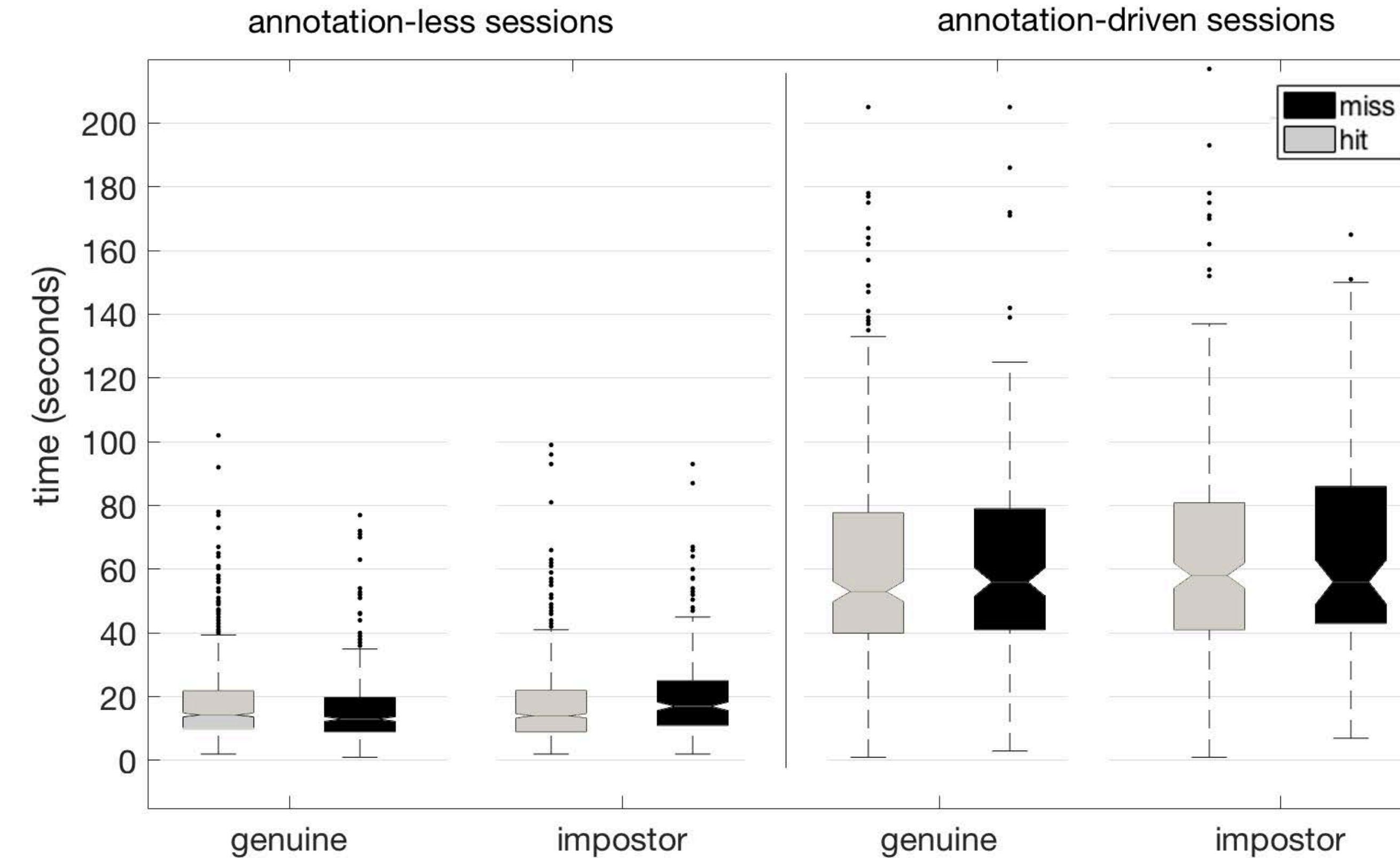
Did annotations help?

Human Experiments



Was time important?

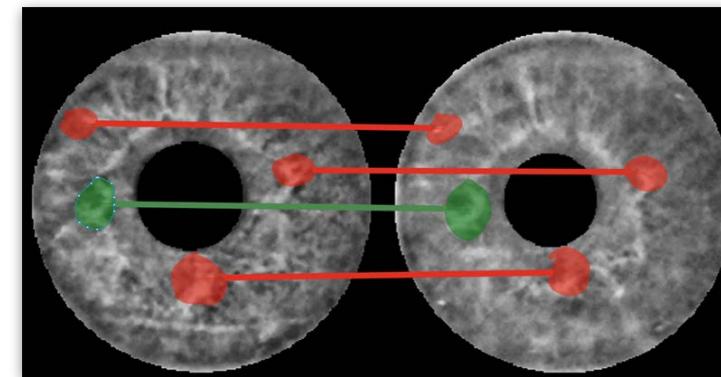
Human Experiments



Was time important?

Human Experiments

Findings



People performed better when they annotated the irises.



People were better than machines in deceased and disease-affected cases.



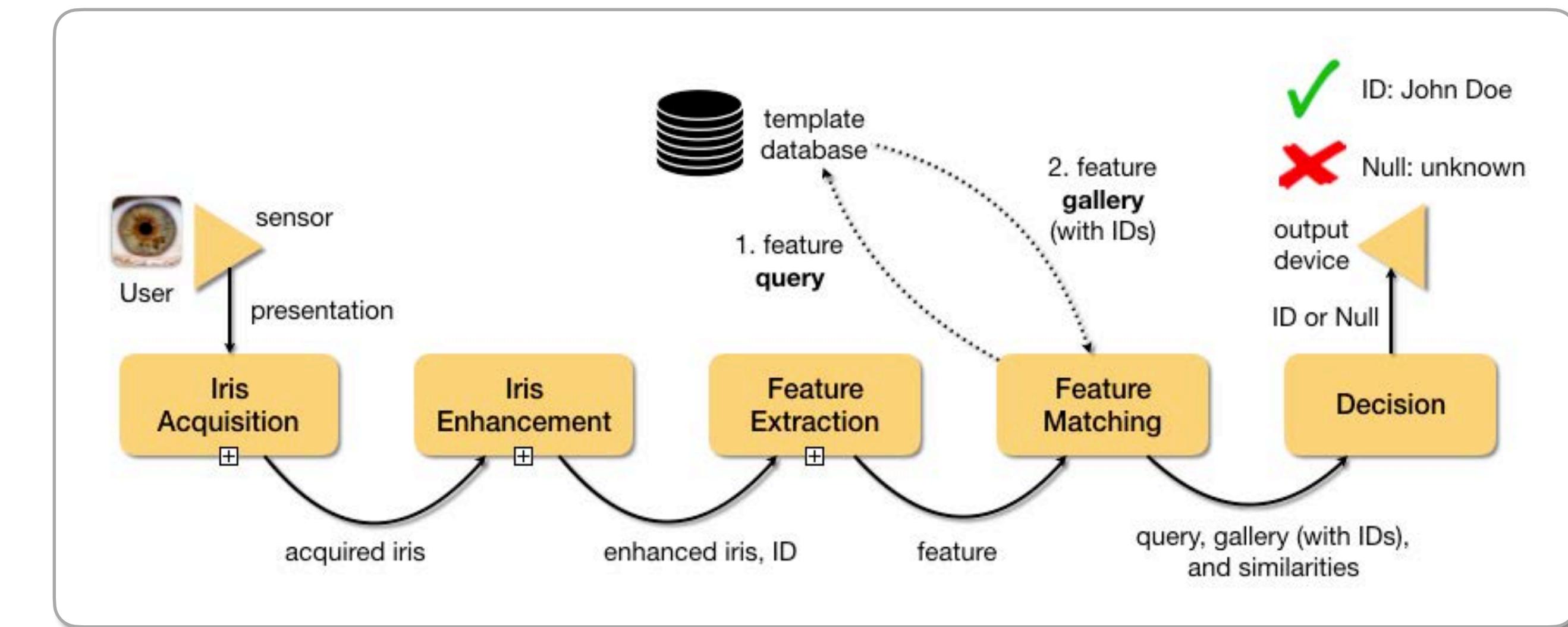
Most challenging cases to people: with **pupil dilation** and **twins**.

Annotating pupil dilation helps.

Annotating twins' doesn't.

What's Next?

Iris Recognition Pipeline
Acquisition, enhancement,
feature extraction, matching,
and decision.



Fill out your
Today-I-missed Statement
Please visit <https://sakai.luc.edu/x/HAZC1P>.