

Iris Recognition I

COMP 388-002/488-002 Biometrics

Daniel Moreira
Fall 2025



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Today we will...

Get to know

Reasons to use irises for recognition.

How irises compare to fingerprints
and to faces.

Today's Attendance

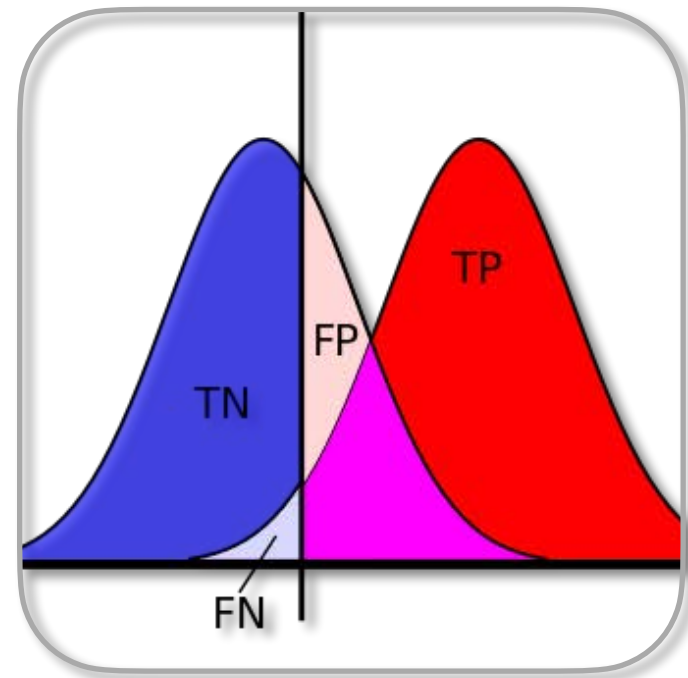
Please fill out the form

forms.gle/Lp4kXKWgGBRwPsJE7



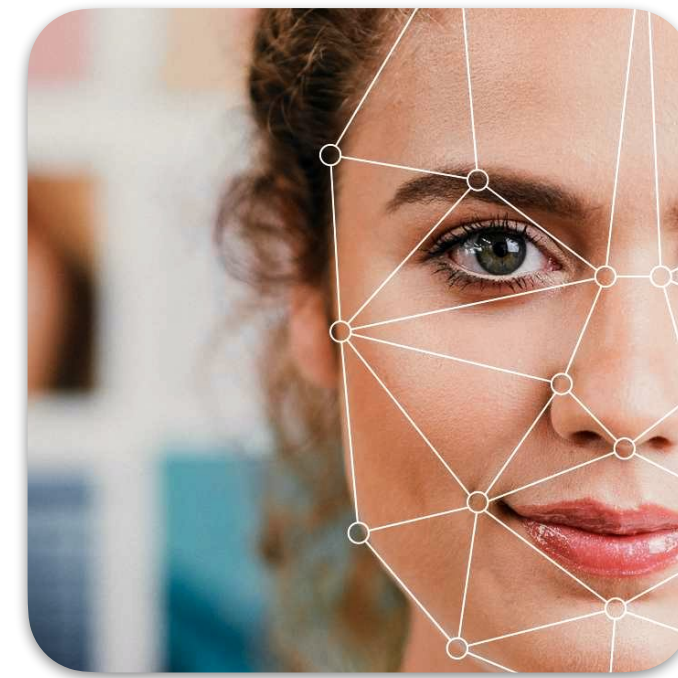
Course Overview

Content



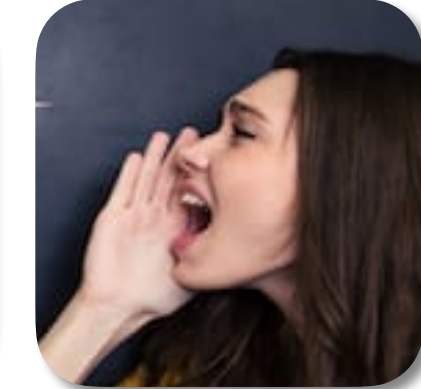
Basics

Concepts
Metrics
Metric
implementation



Core Traits (3)

Concepts
Baseline implementation
Data collection
Evaluation
Attacks
Assignments



**Alternative Traits and
Fusion
Concepts**



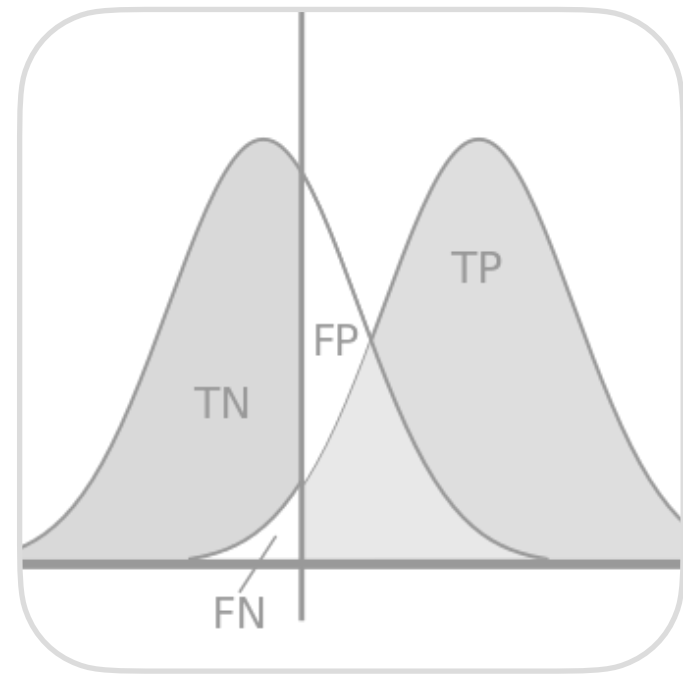
Invited Talks (2)
State of the art
Future work



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Course Overview

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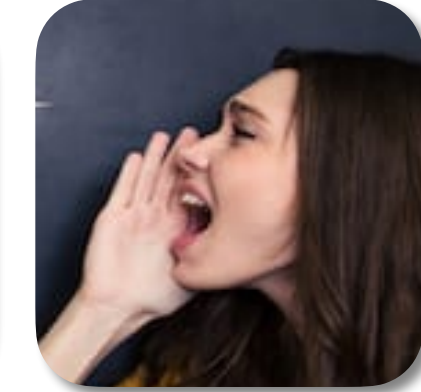
Basics

Concepts
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Core Traits (3)

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Baseline implementation
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Alternative Traits and Fusion Concepts



Invited Talks (2)
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Future work



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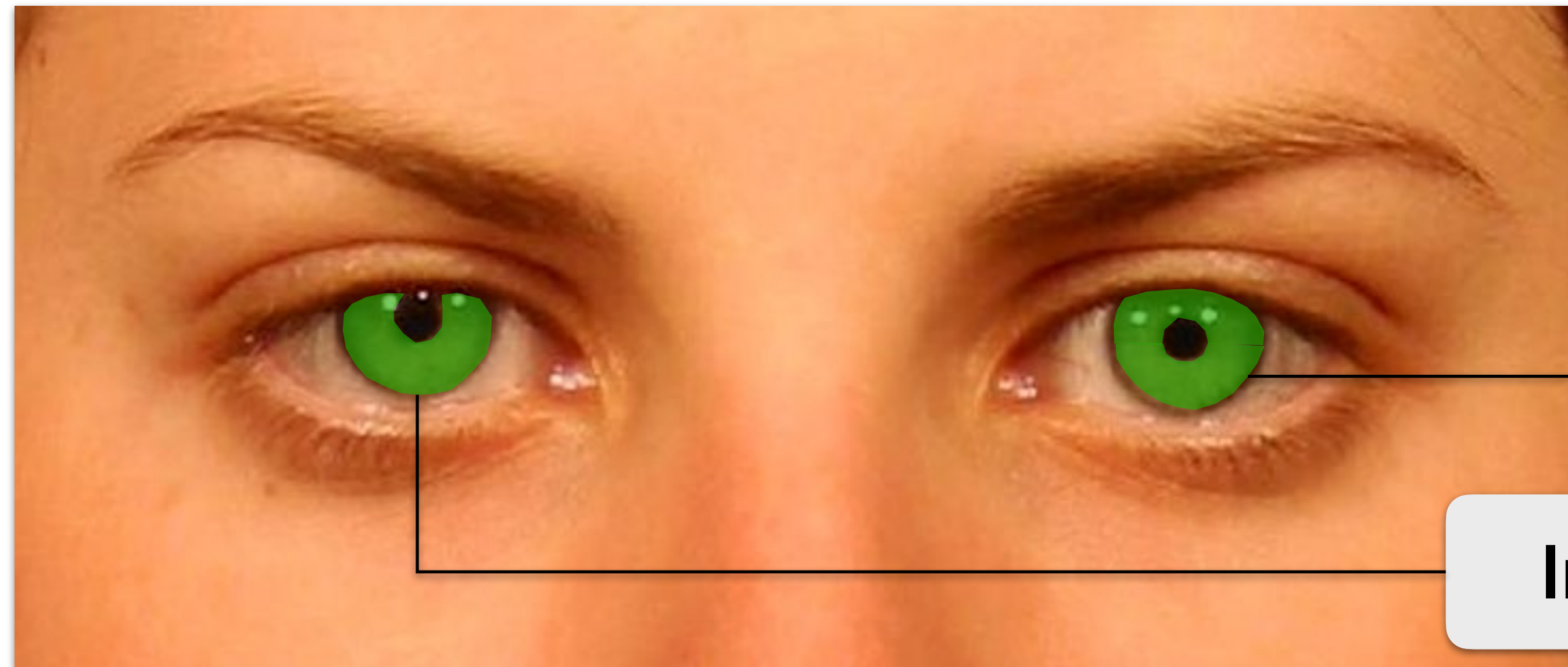
Irides



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

Ocular Region

Iris



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

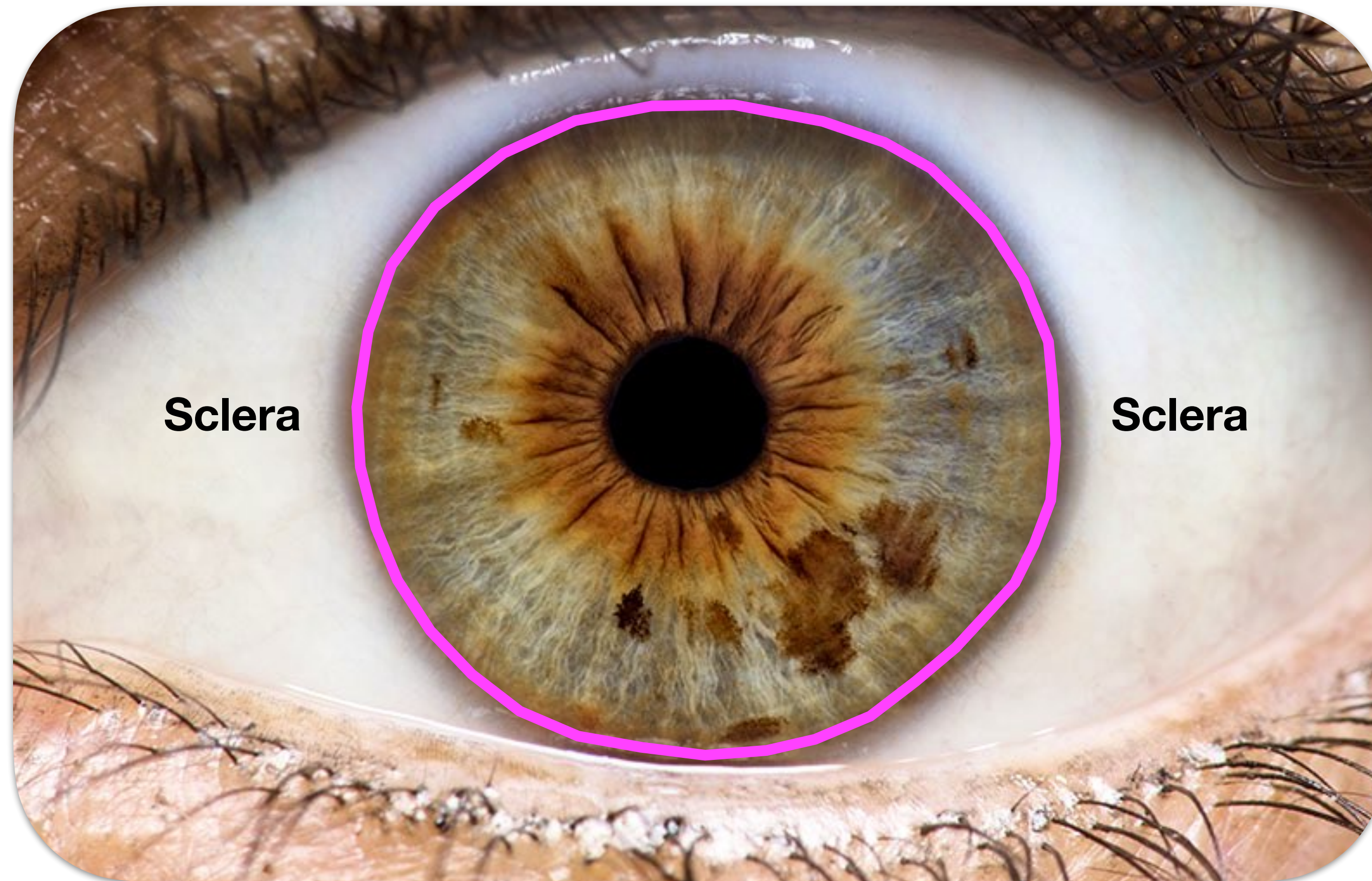
Iris

Ocular Region

Anatomy

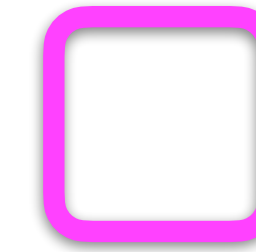


Anatomy



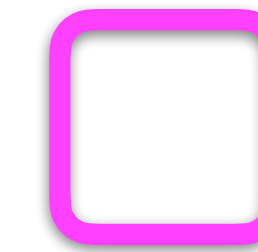
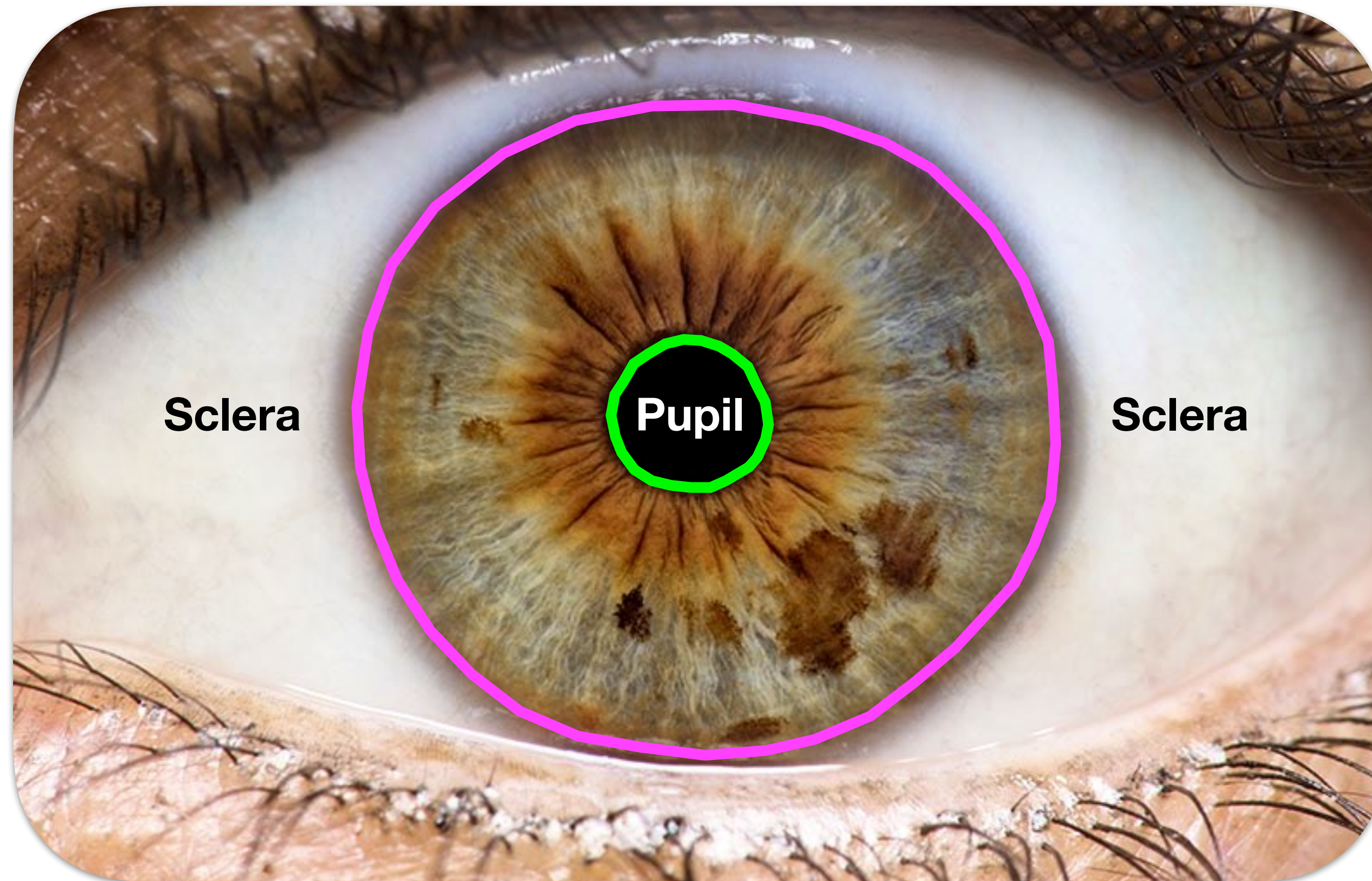
Sclera

Sclera

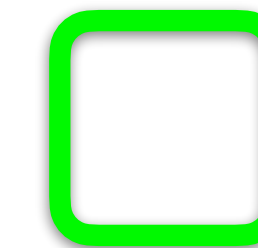


Limbus boundary

Anatomy

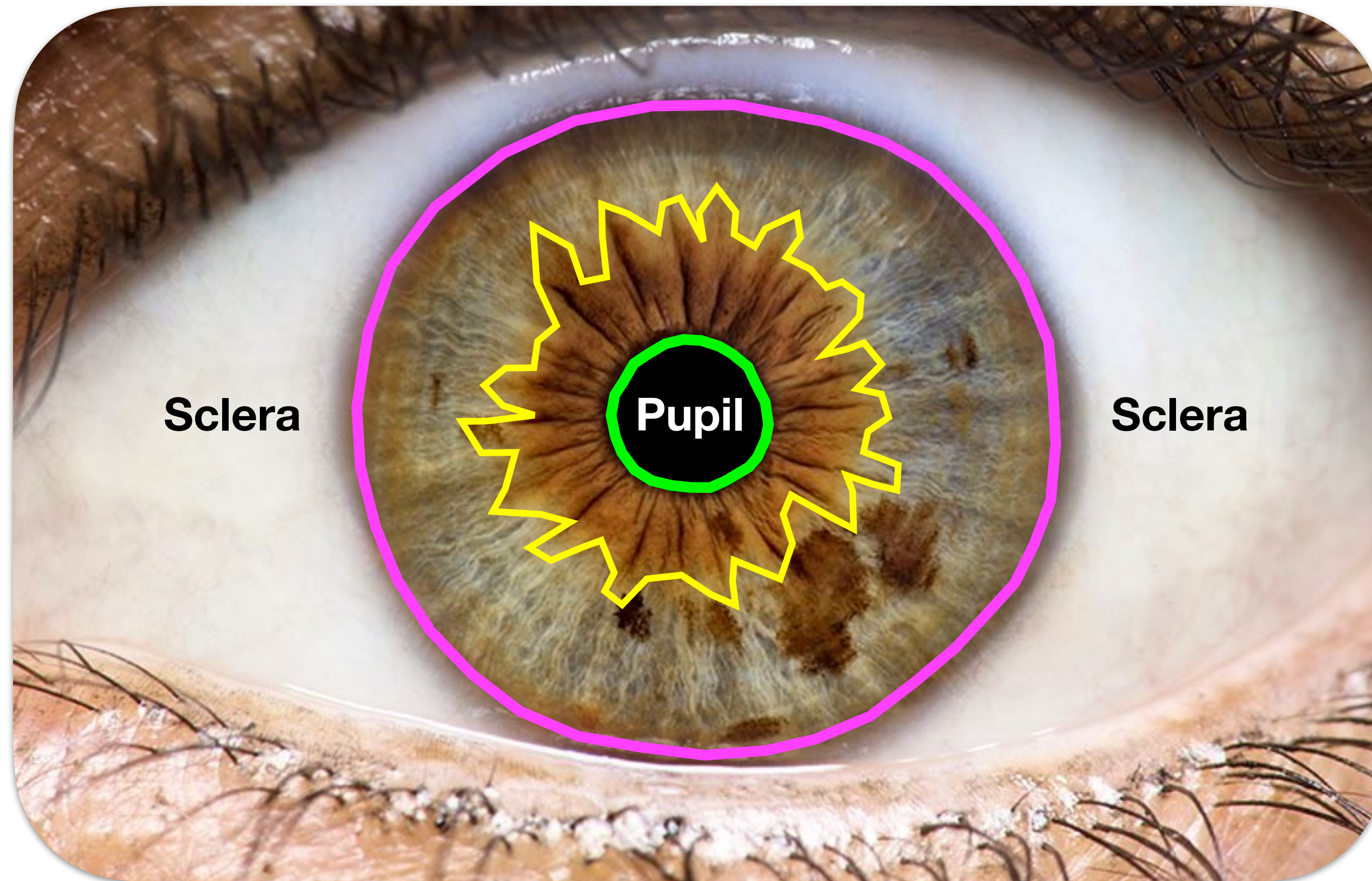


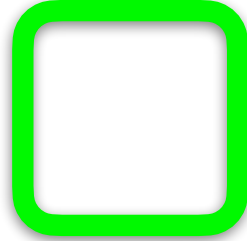
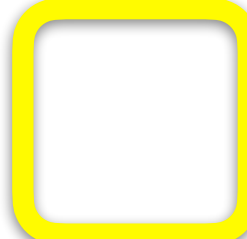
Limbus boundary



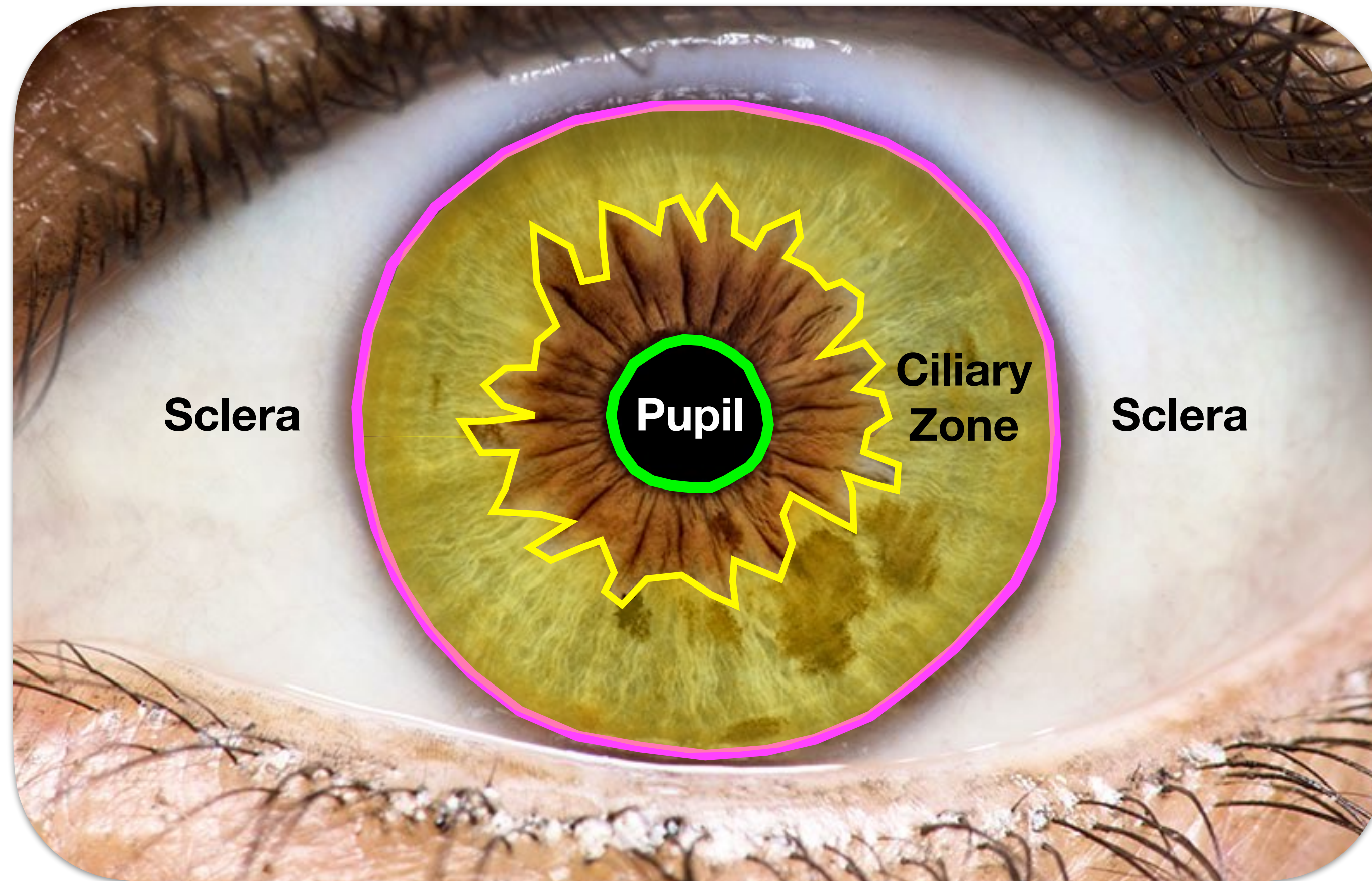
Pupillary boundary

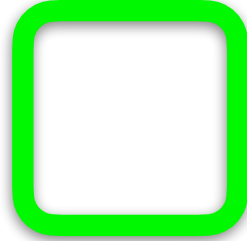
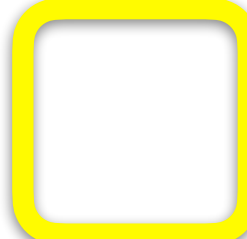
Anatomy



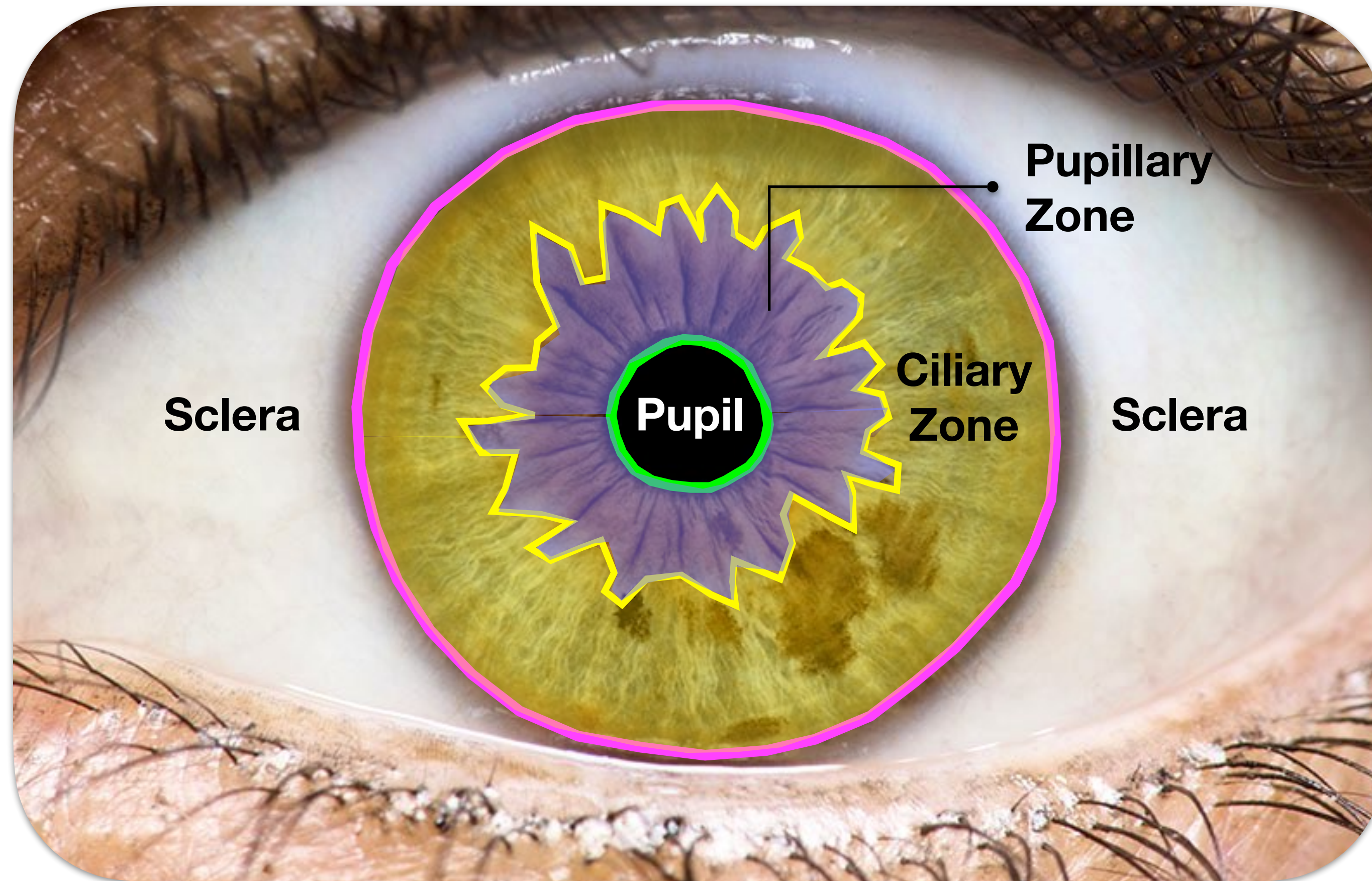
-  Limbus boundary
-  Pupillary boundary
-  Collarette

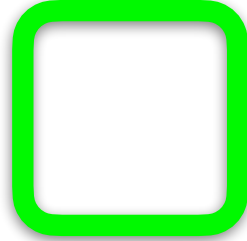
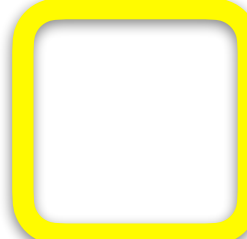
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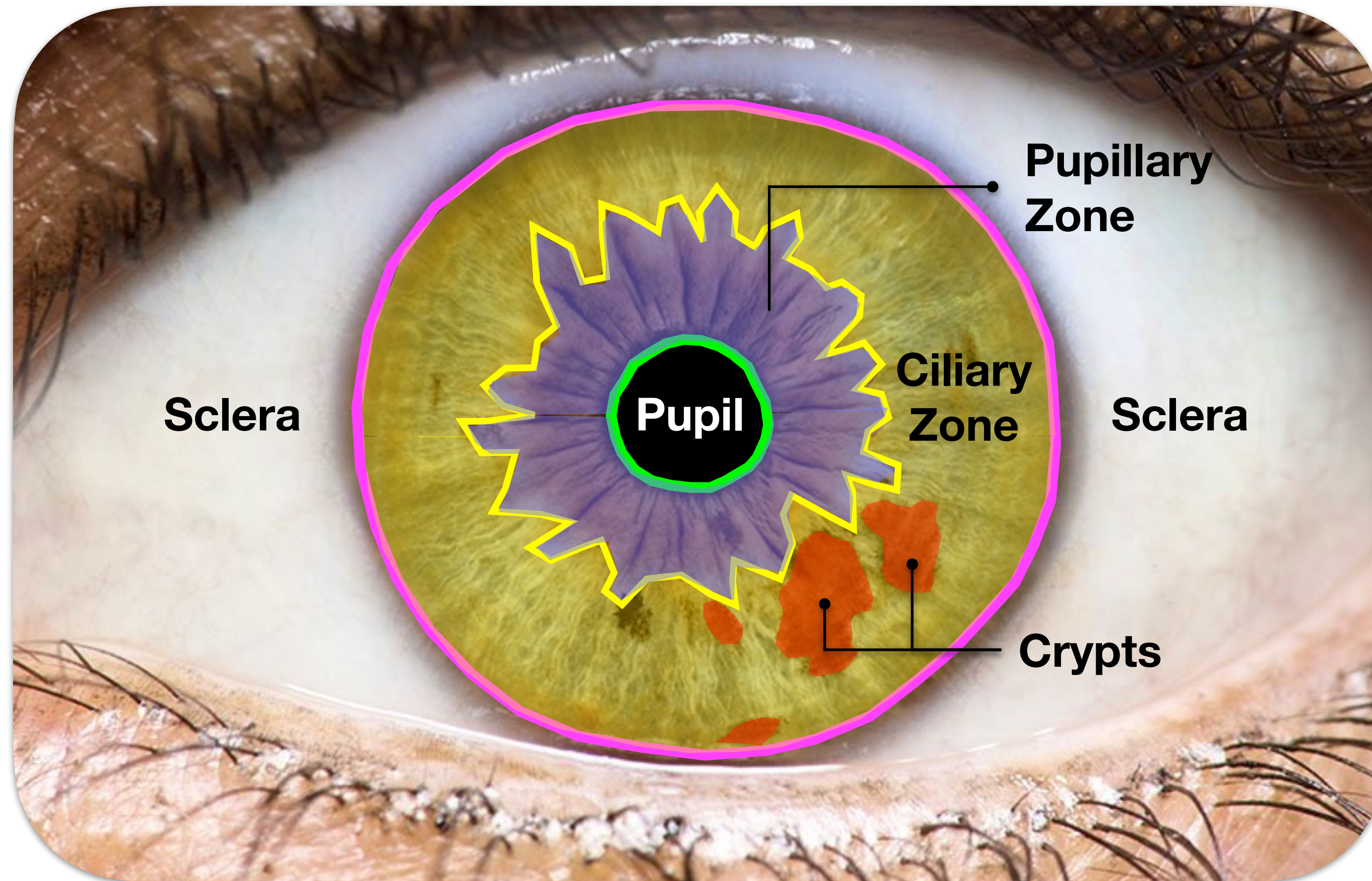
-  Limbus boundary
-  Pupillary boundary
-  Collarette

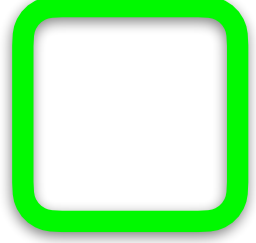
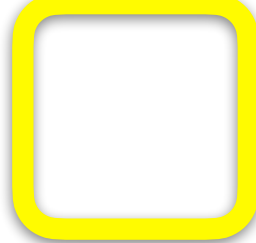
Anatomy



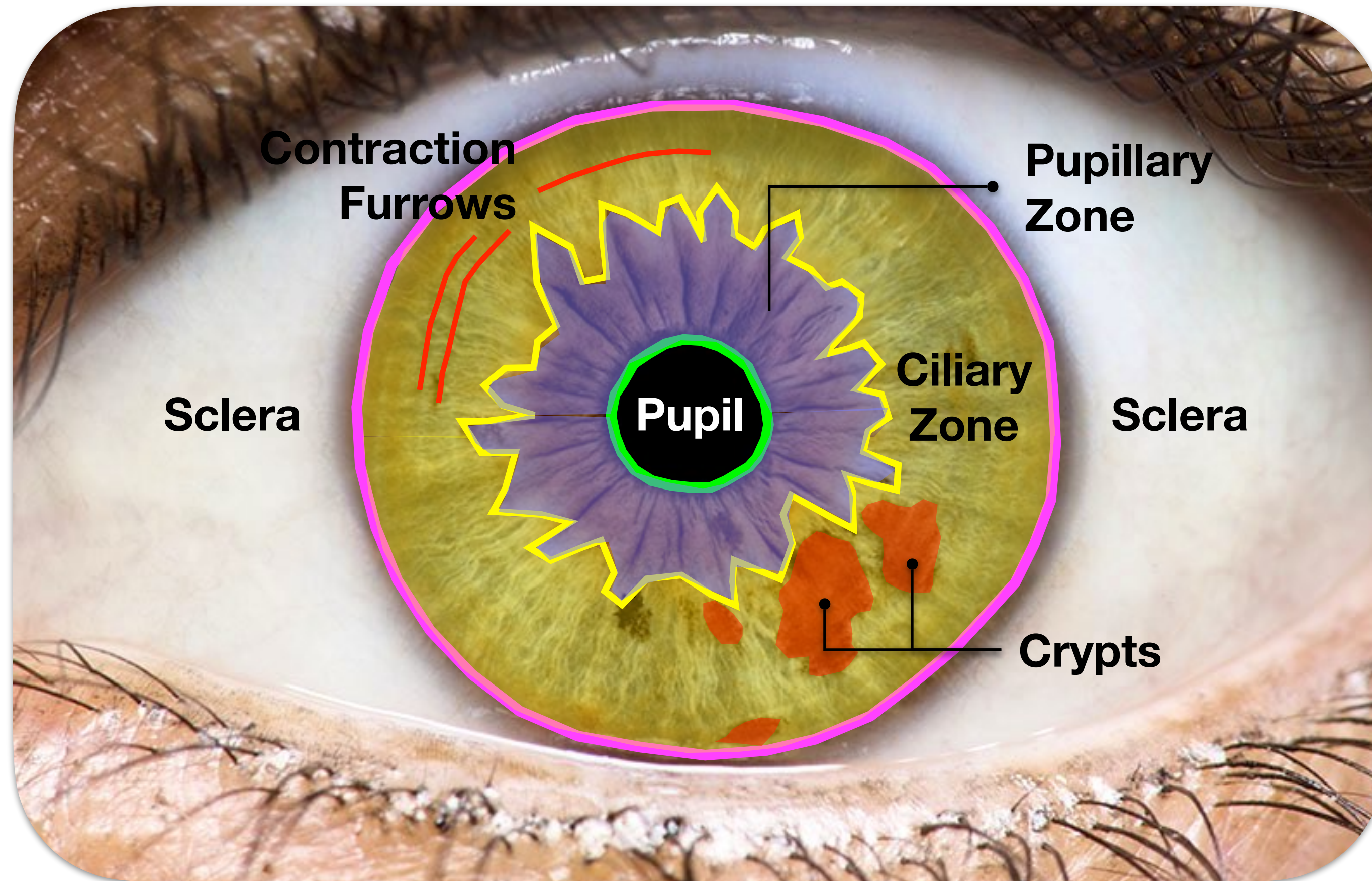
-  Limbus boundary
-  Pupilary boundary
-  Collarette

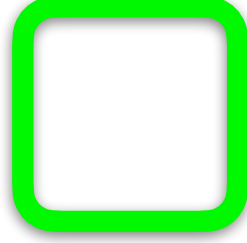
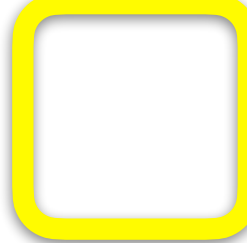
Anatomy



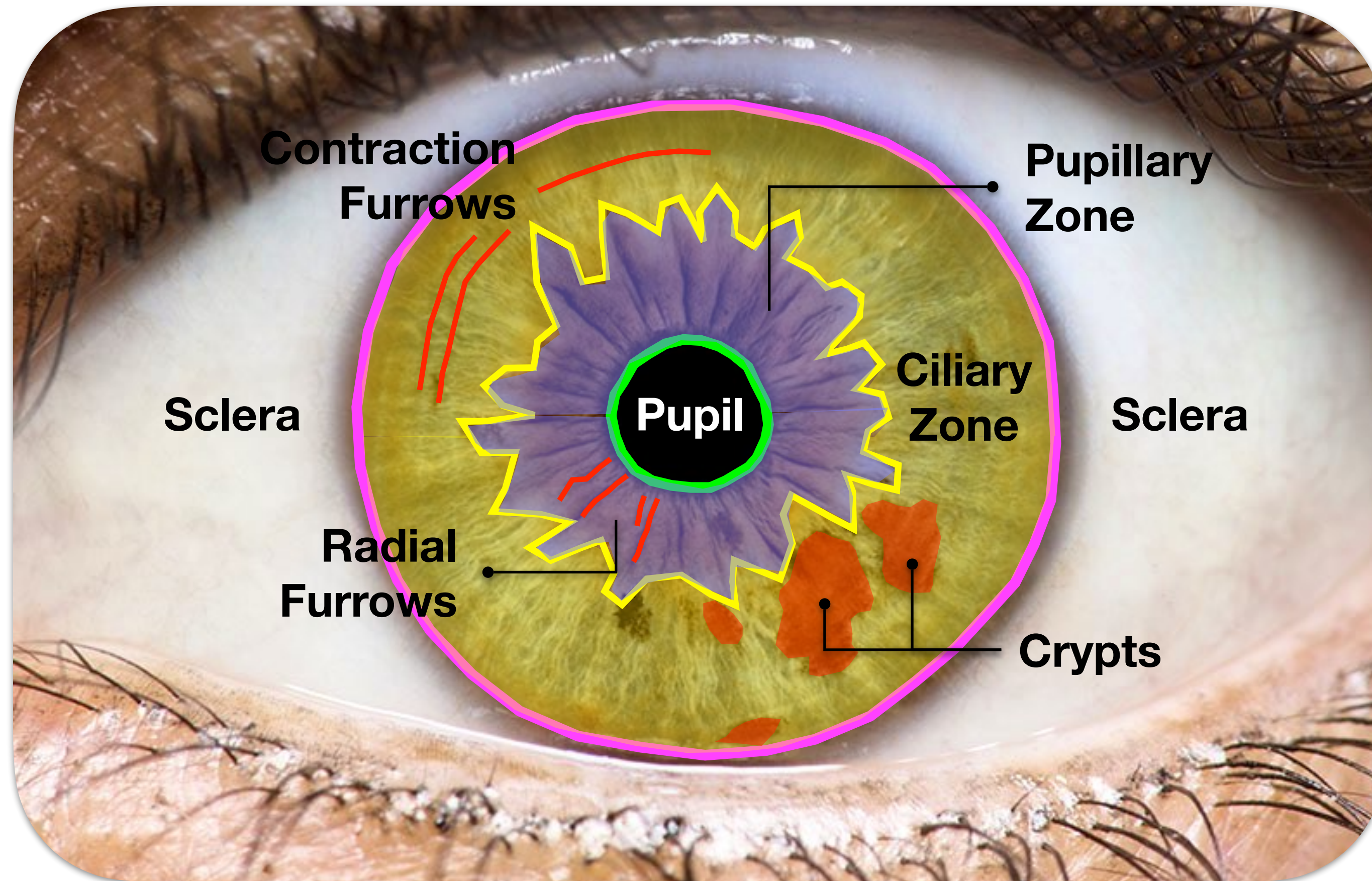
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-  Pupillary boundary
-  Collarette

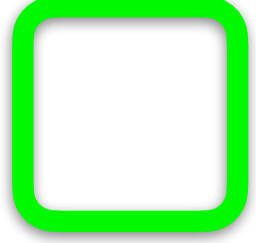
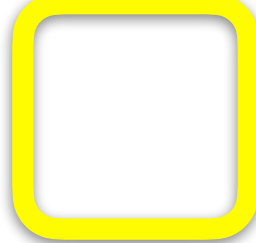
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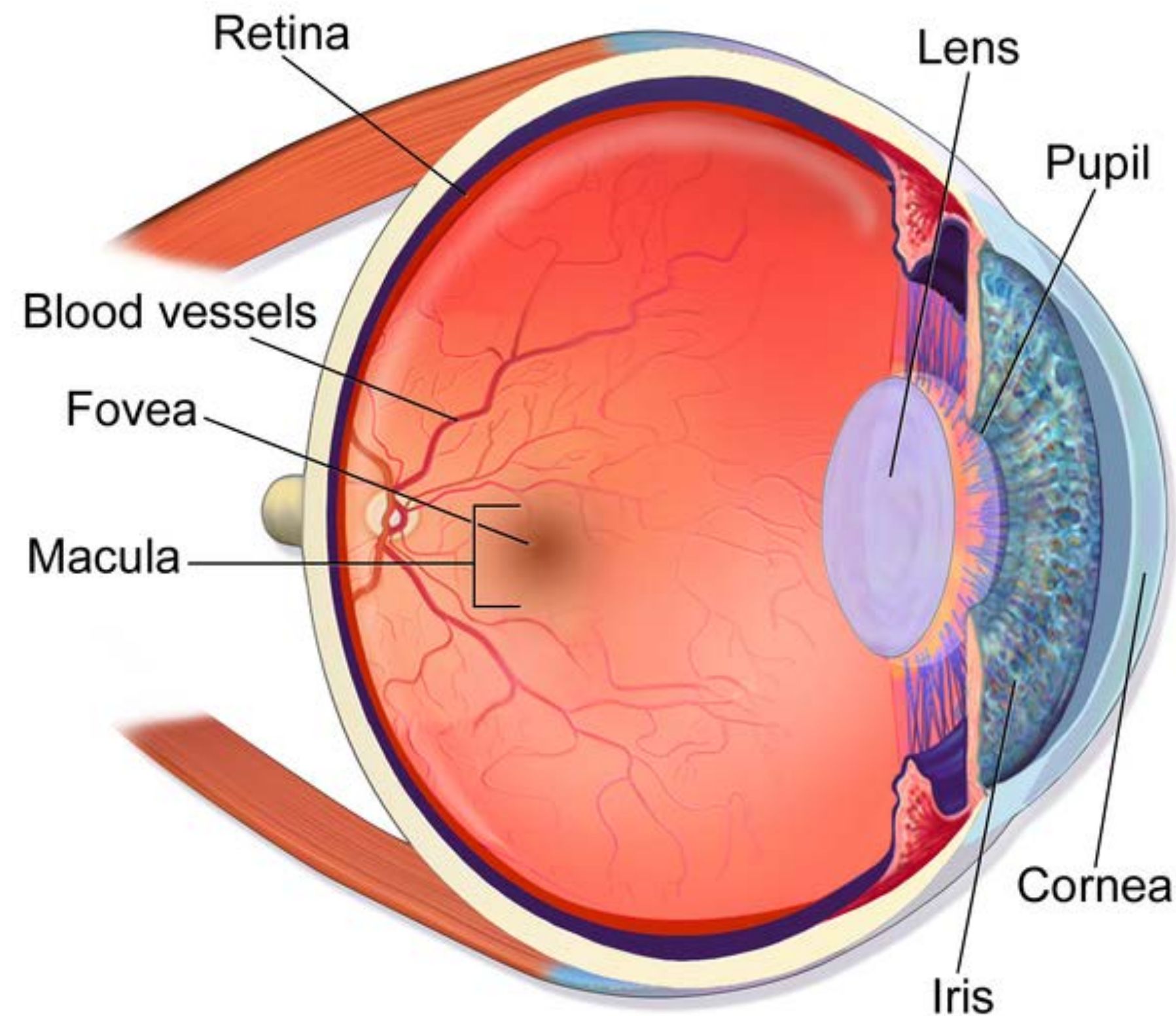
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Anatomy



-  Limbus boundary
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Anatomy

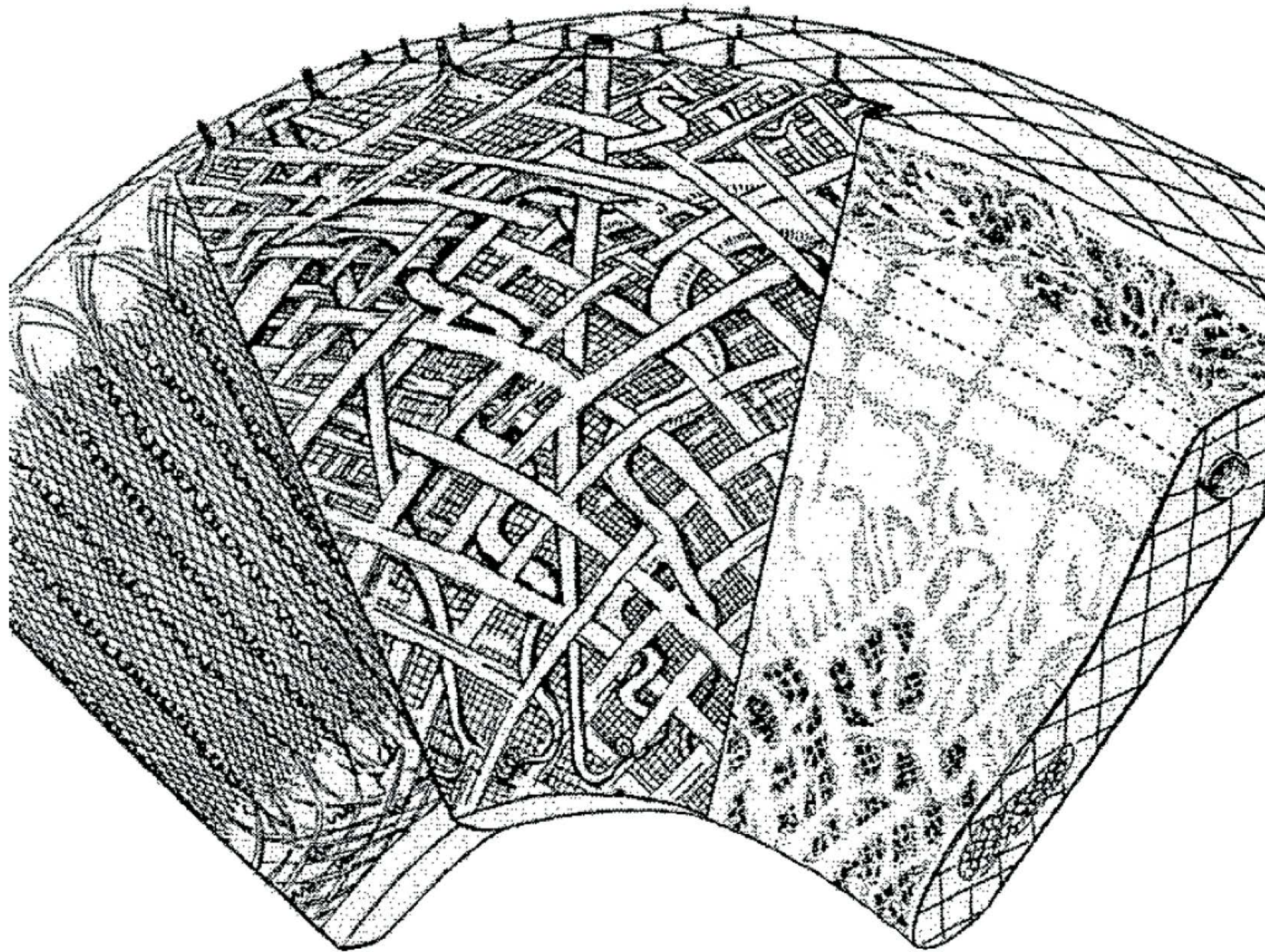


commons.wikimedia.org

Iris

Located behind the cornea and in front of the lens.

Anatomy



Iris

Located behind the cornea and in front of the lens.

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

Hans Rohen
*Der bau der regenbogenhaut beim
menschen und einigen Saugern*
Gegenbaur Morphology Journal, 1951

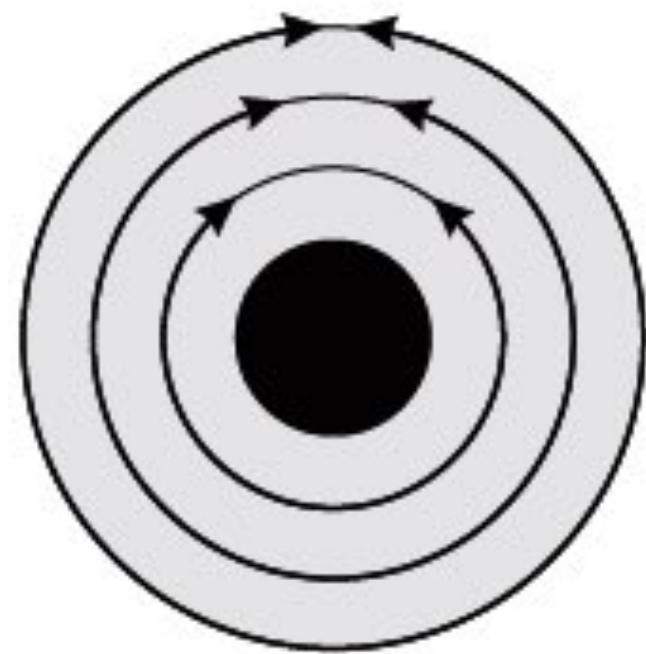
Anatomy



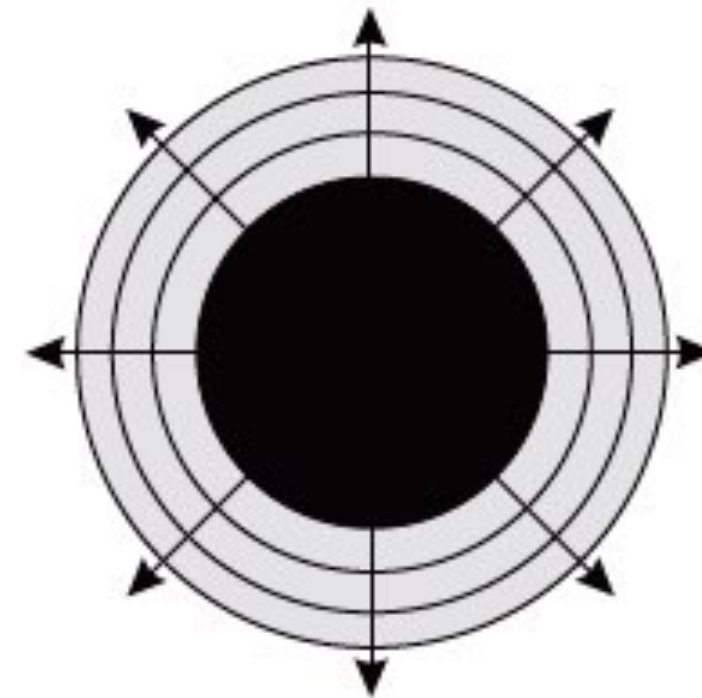
Suren Manvelyan

Anatomy

Adam Czajka



Sphincter Muscles



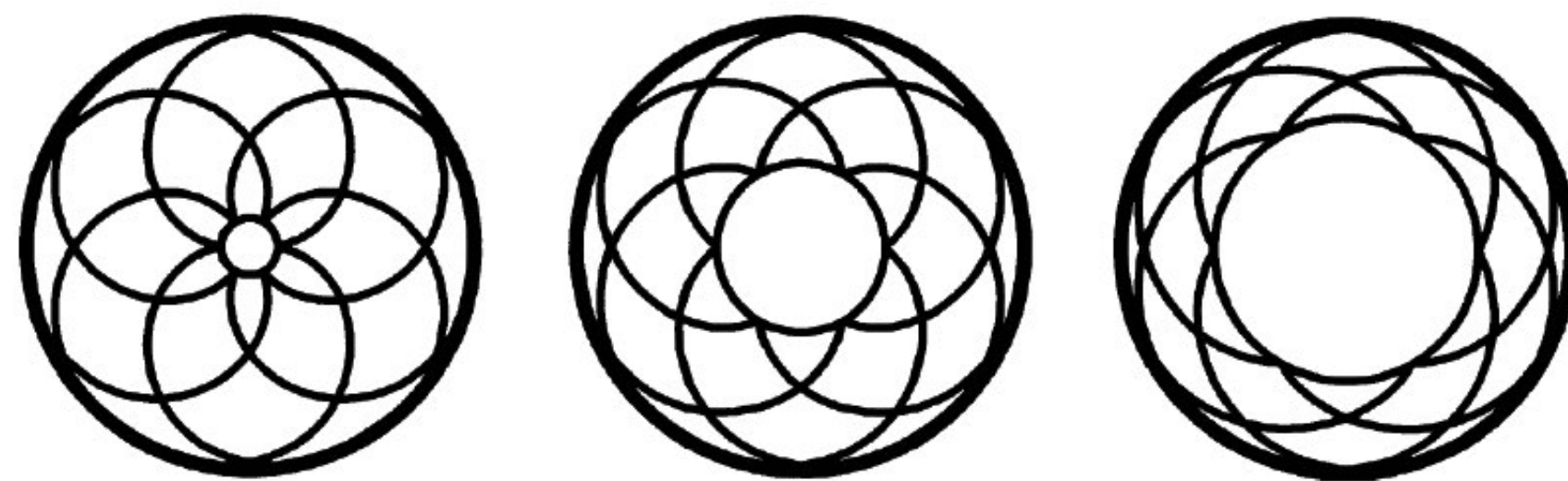
Dilator Muscles

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.



Non-linear constrictions and dilations.

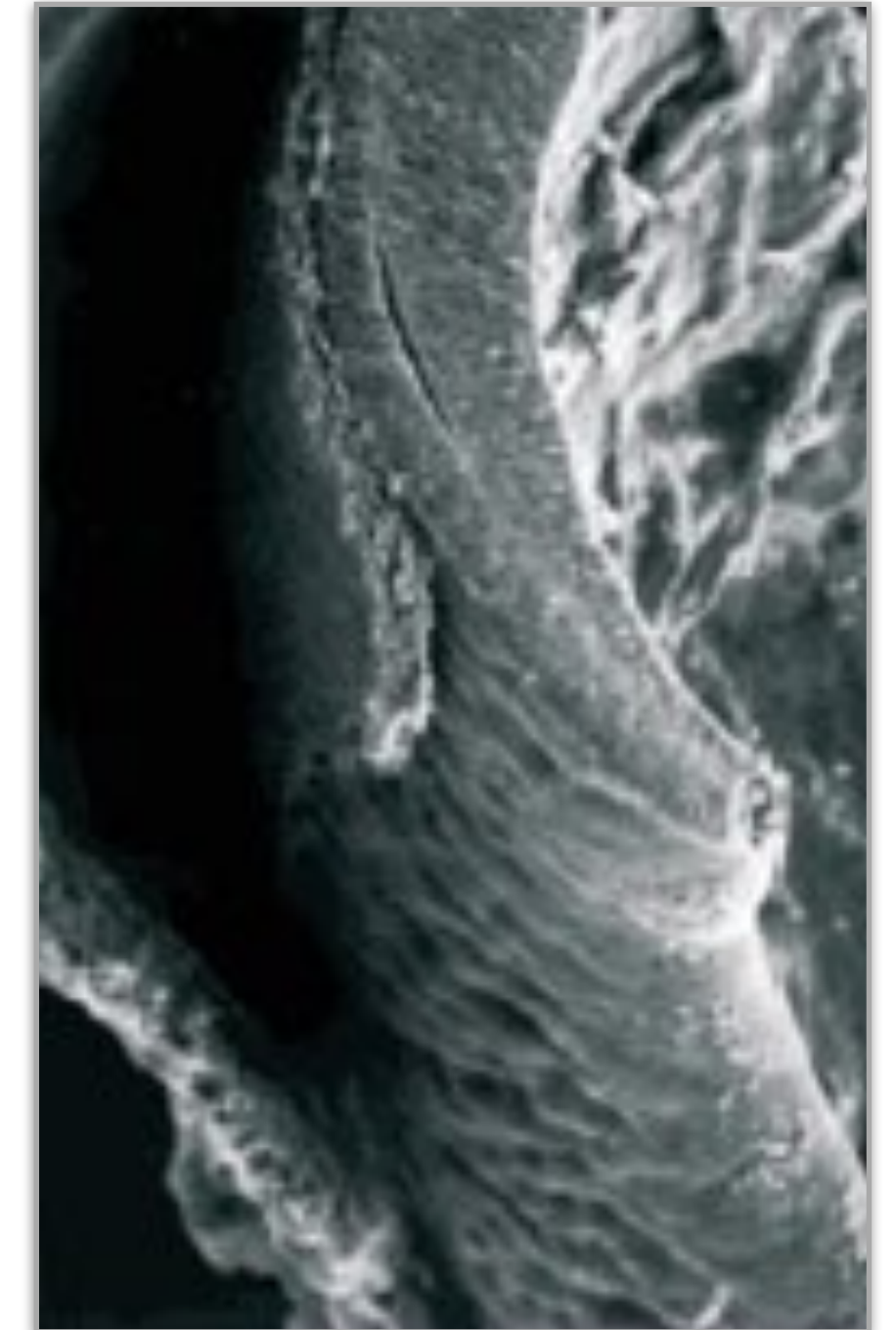
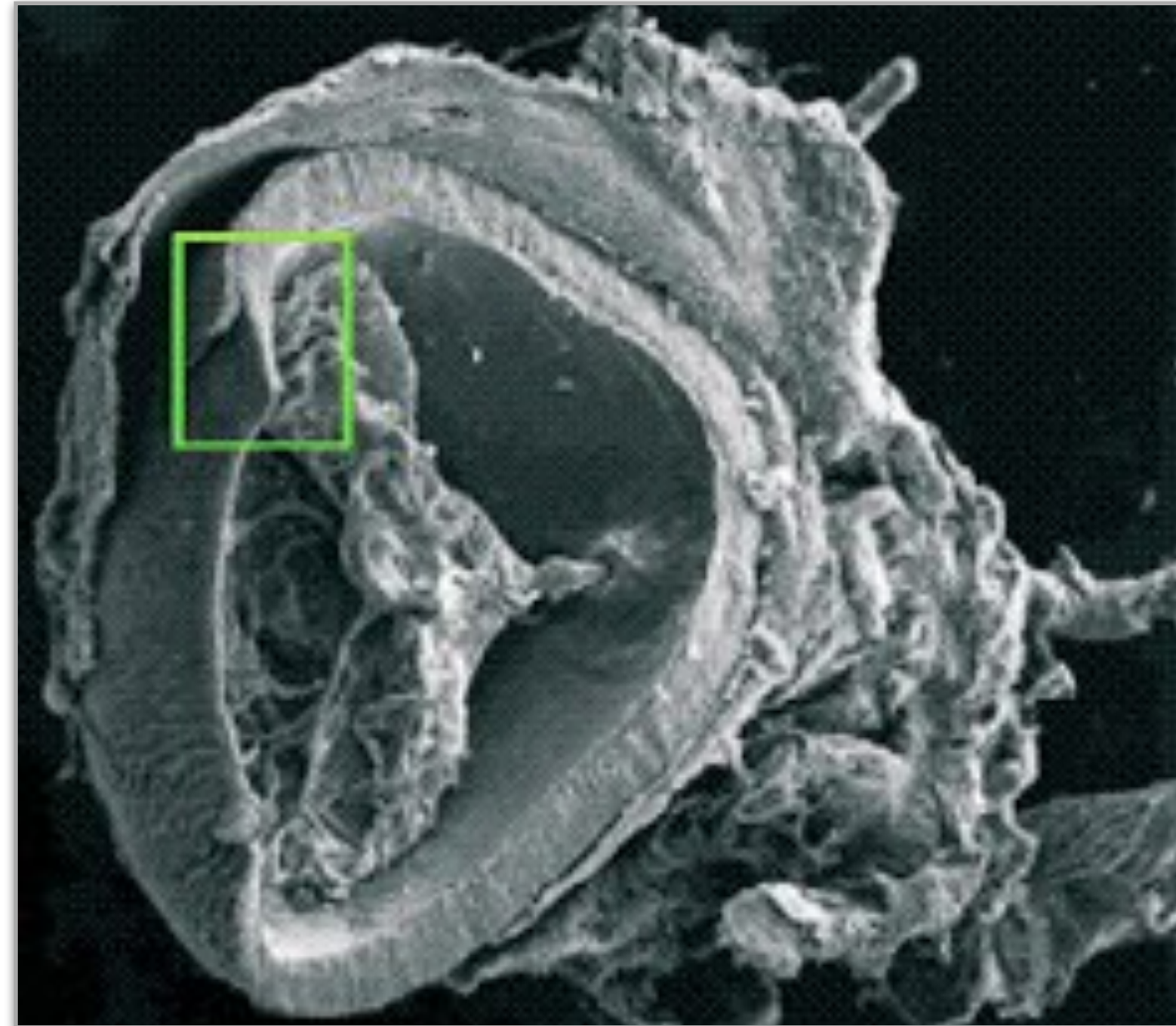
H. J. Wyatt
*A minimum wear-and-tear
meshwork for the iris.*
Vision Research, 2000

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.

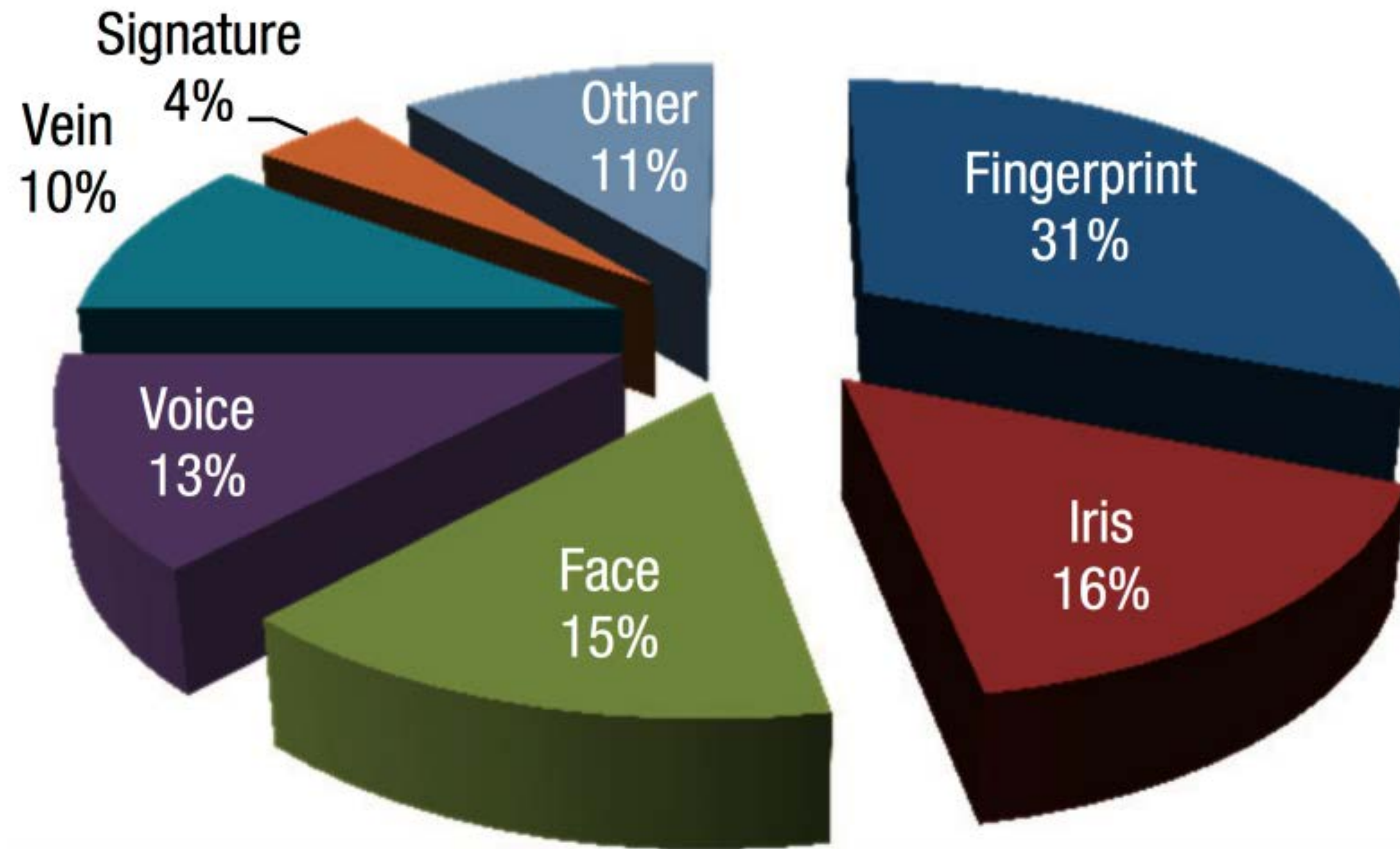
Right and left irises are different.

Identical twins have different irises.



Why Irises?

Market



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

Why Irises?

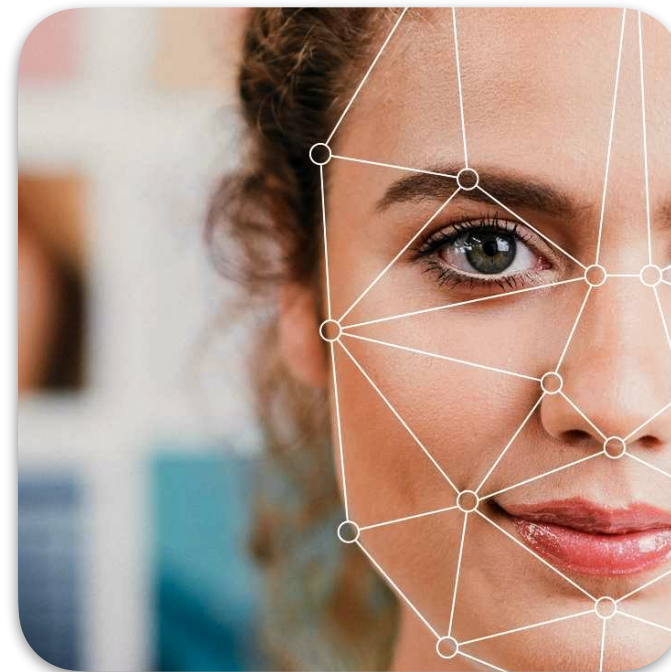
Universality (1/8)

Does everybody have the trait?



Probably

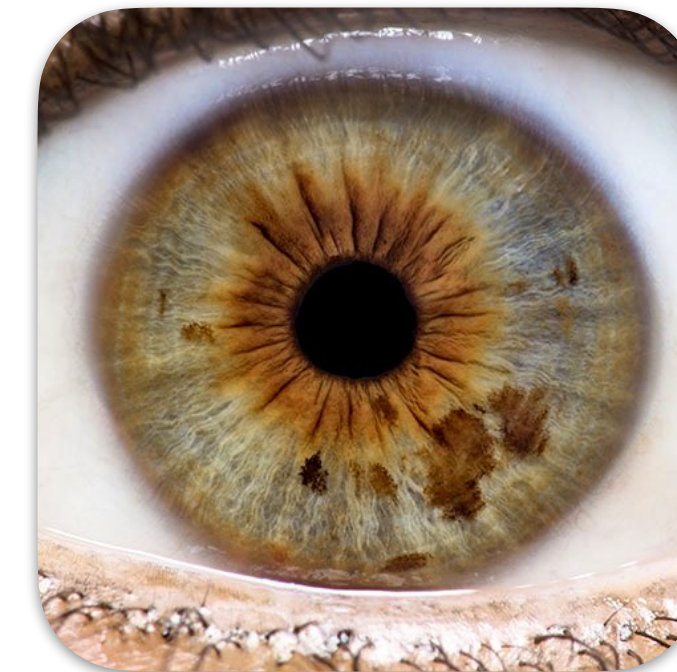
better than



>



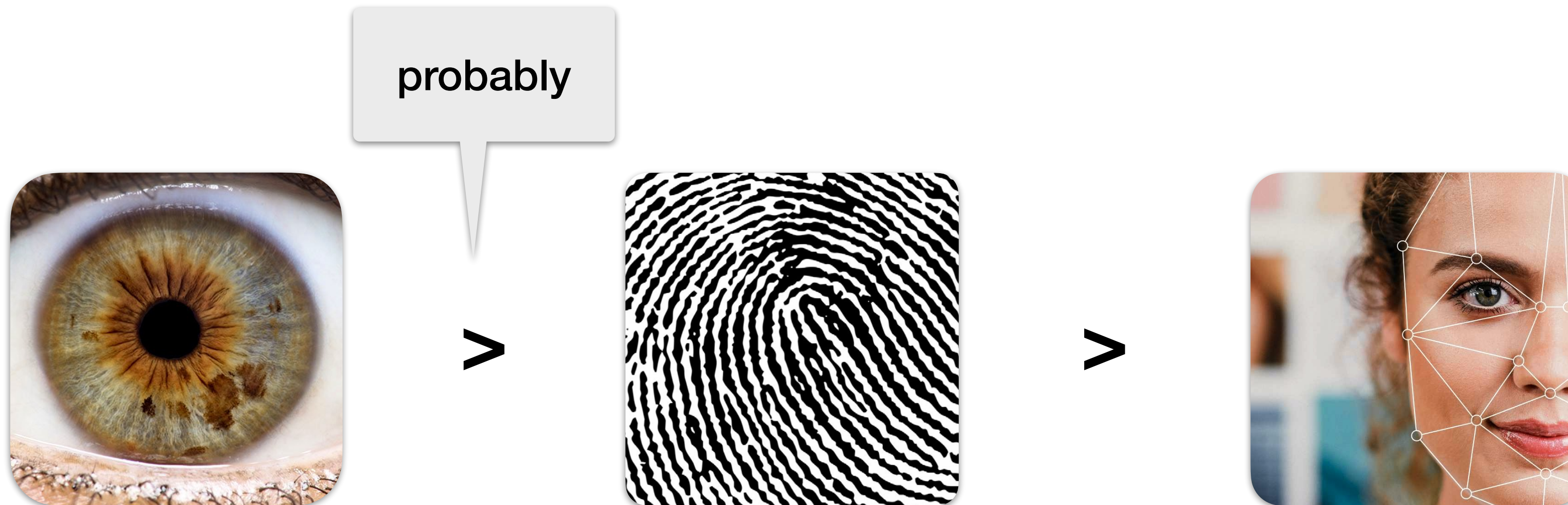
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Why Irises?

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.

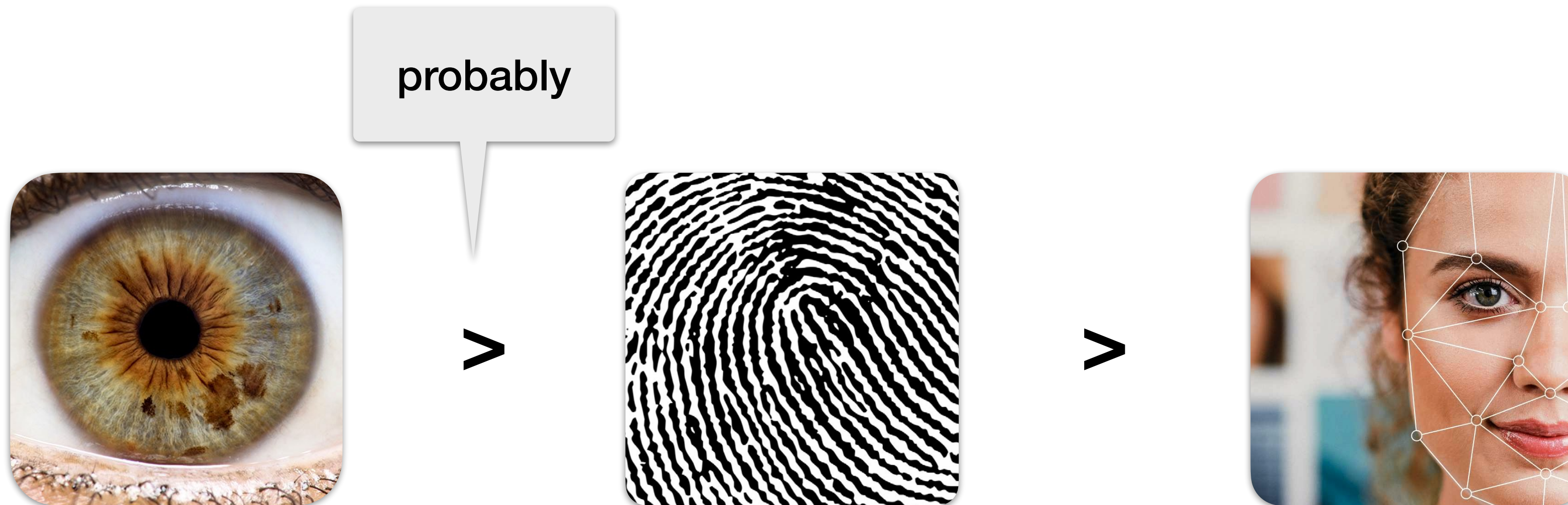


Source: John Daugman
Lecture Notes, 2018

Why Irises?

Permanence (3/8)

How easily does the trait change?



Why Irises?



Permanence (3/8)

How easily does the trait change?

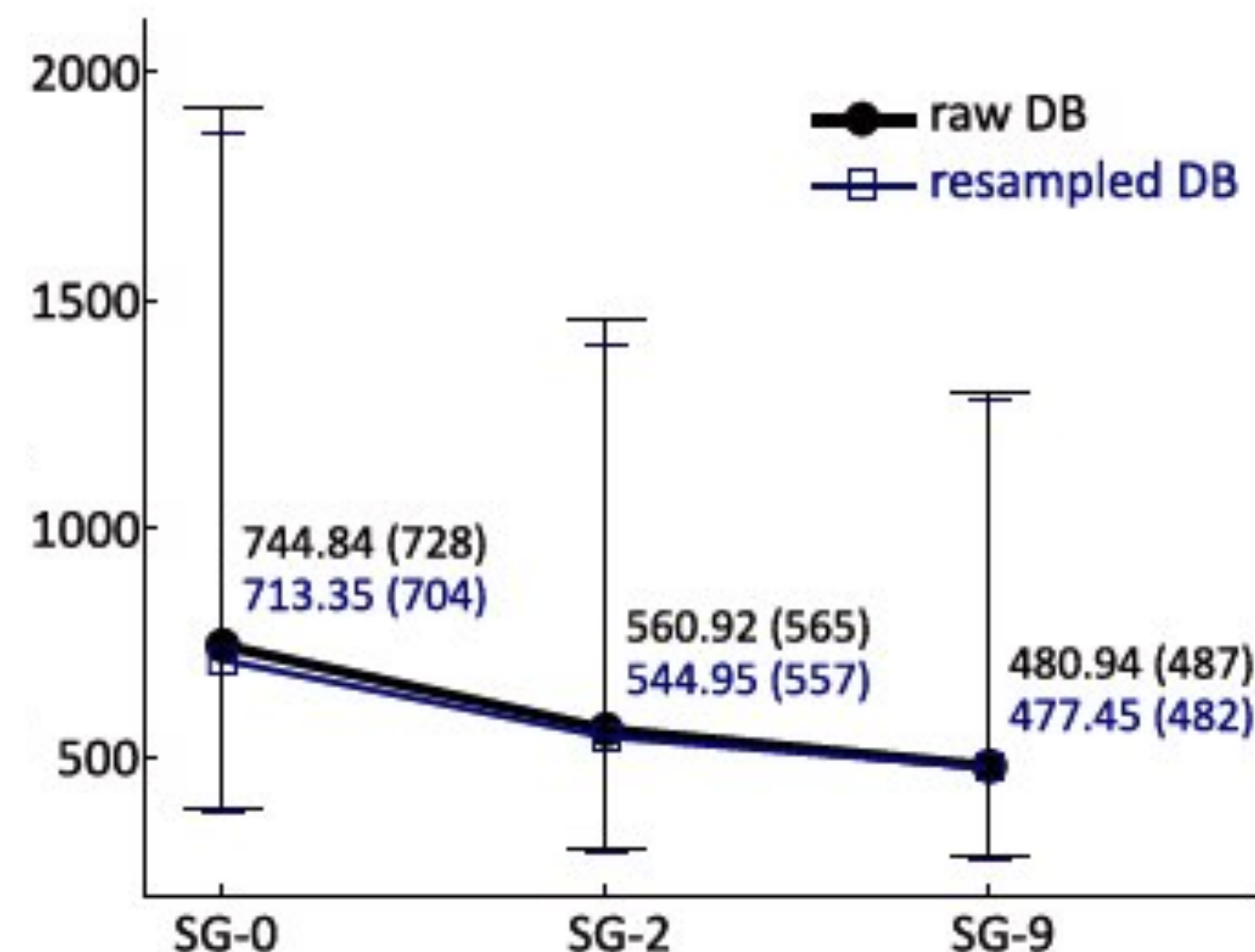
Needed Research

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?

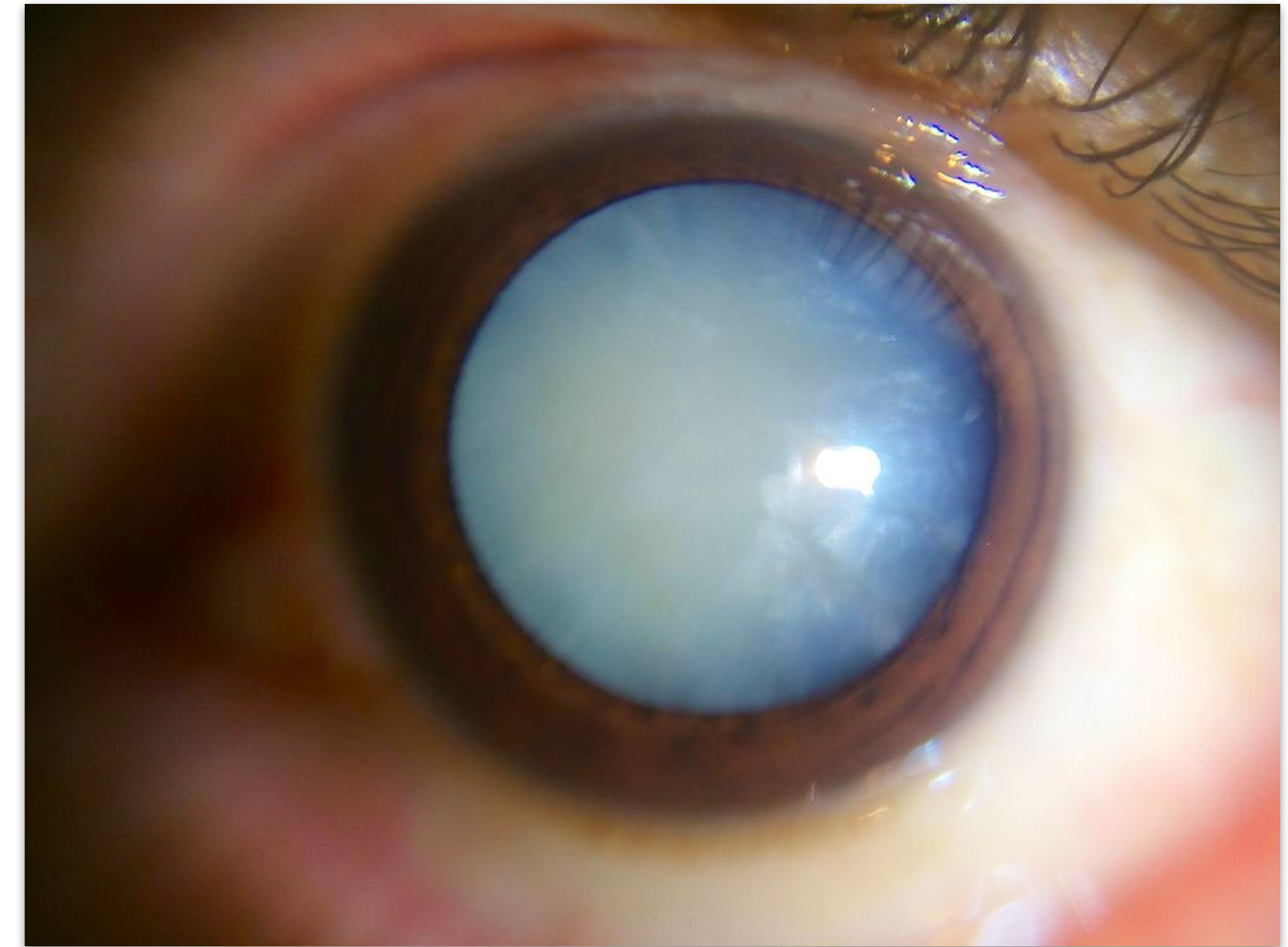
Permanence (3/8)

How easily does the trait change?

Traumas and Diseases

Some traumas and diseases might degrade/change the iris.

commons.wikimedia.org

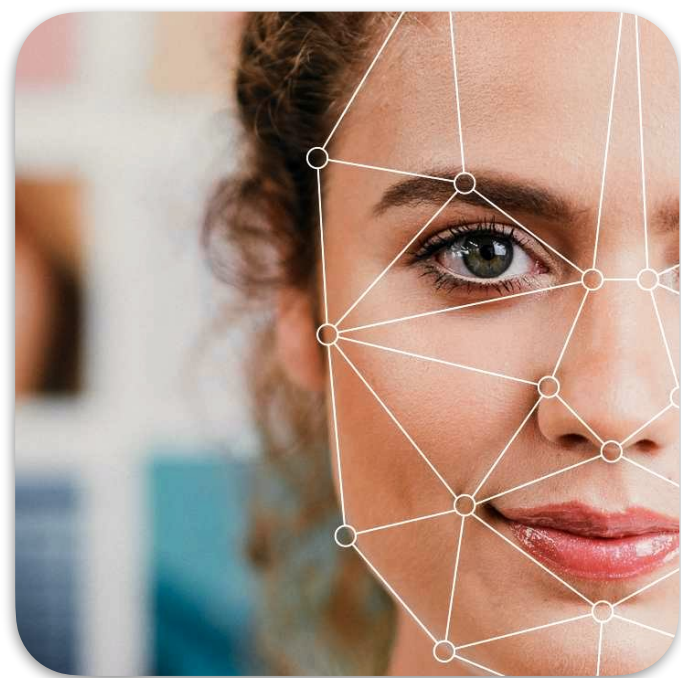


E.g., cataracts.

Why Irises?

Measurability (4/8)

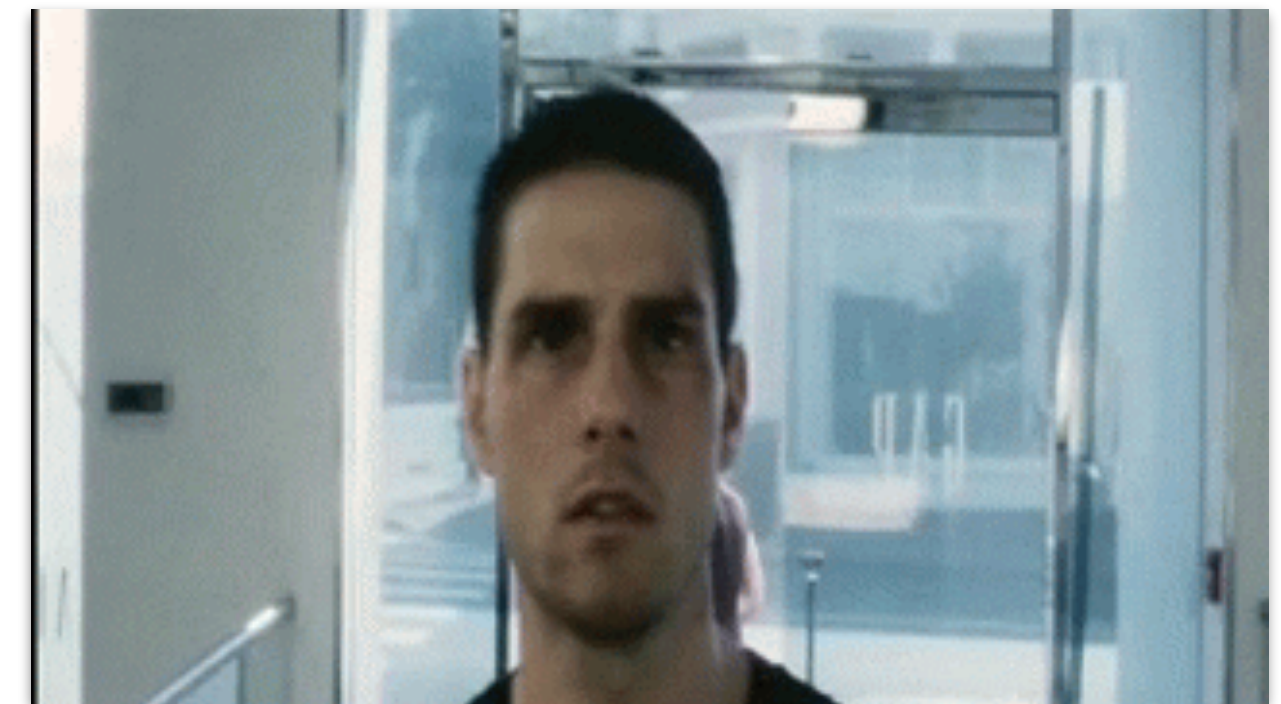
How easy is it to acquire and digitize the trait?



>



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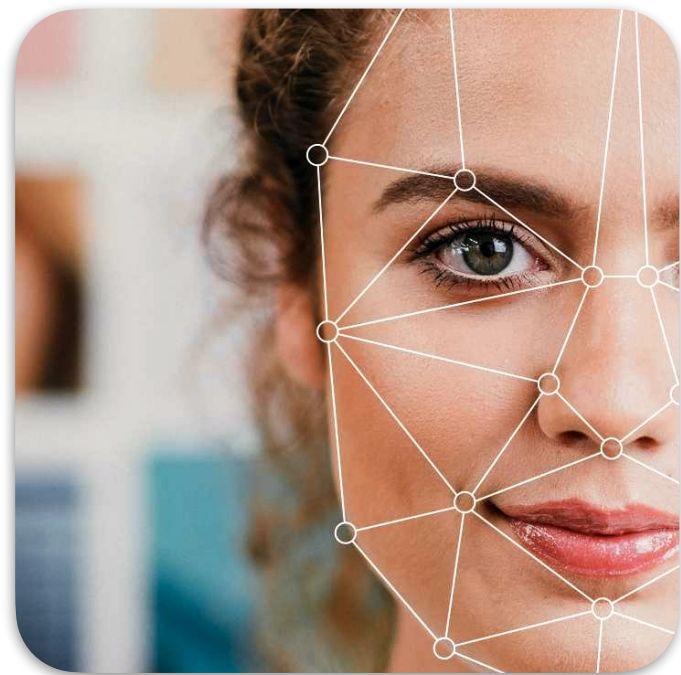


Not there yet.

Why Irises?

Acceptability (5/8)

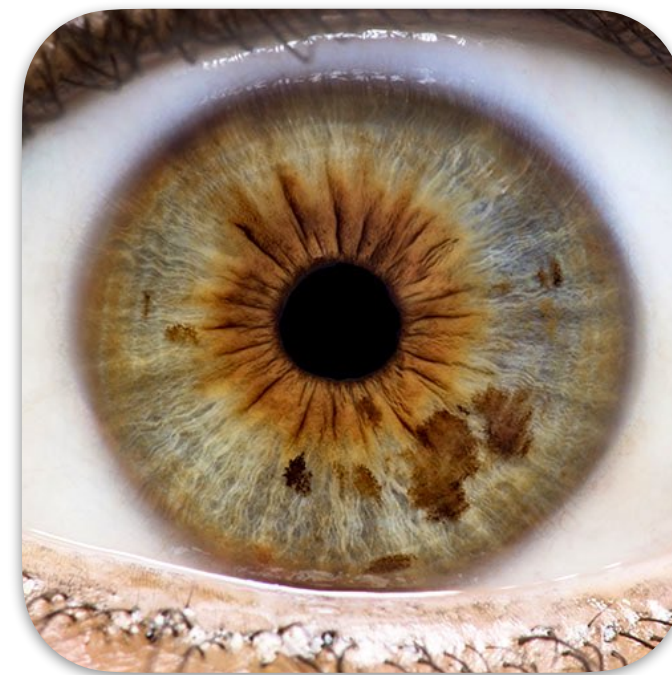
Will individuals collaborate during data collection?



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Why Irises?

Acceptability (5/8)

Will individuals collaborate during data collection?

Privacy Concerns

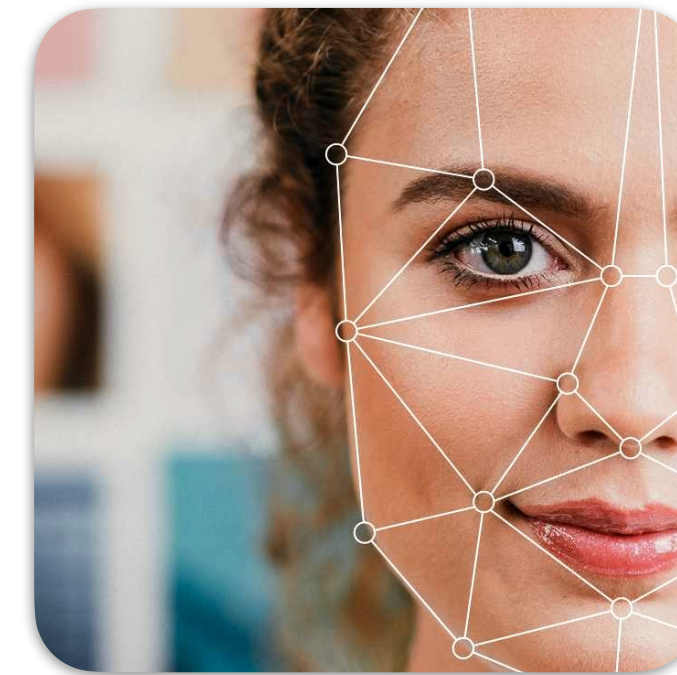


Whose fingerprint is this?



Whose iris is this?

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Whose face is this?

Why Irises?

Circumvention (6/8)

How hard can the trait be forged or imitated?



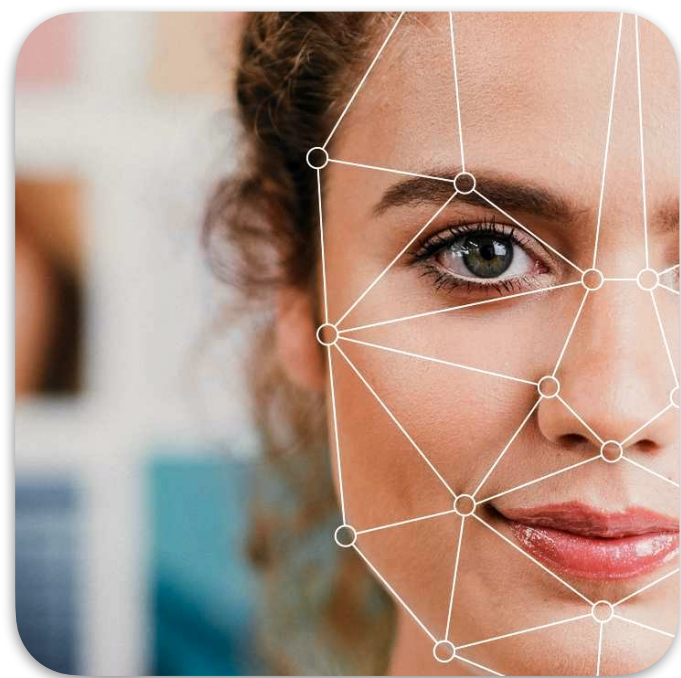
Jain, Ross, and Nadakumar
Introduction to Biometrics
Springer Books, 2011



Why Irises?

Circumvention (6/8)

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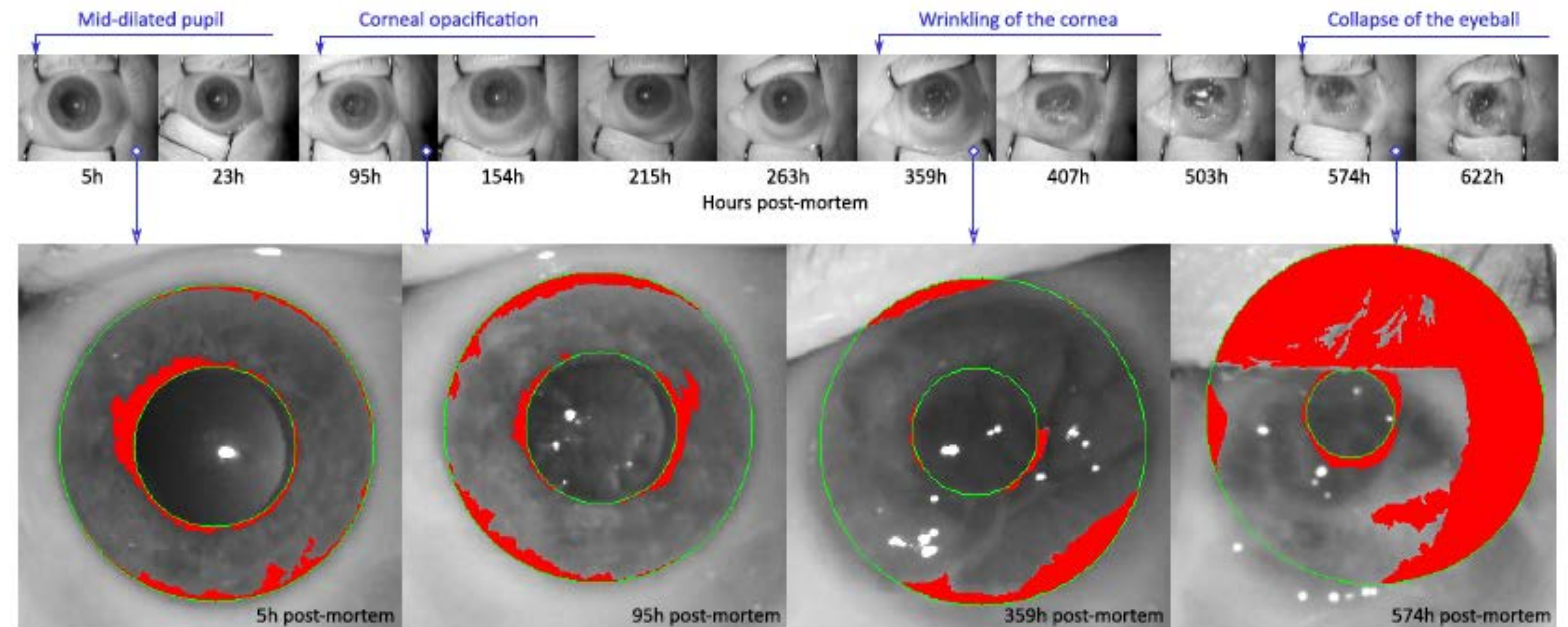
Egad, would it work?

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



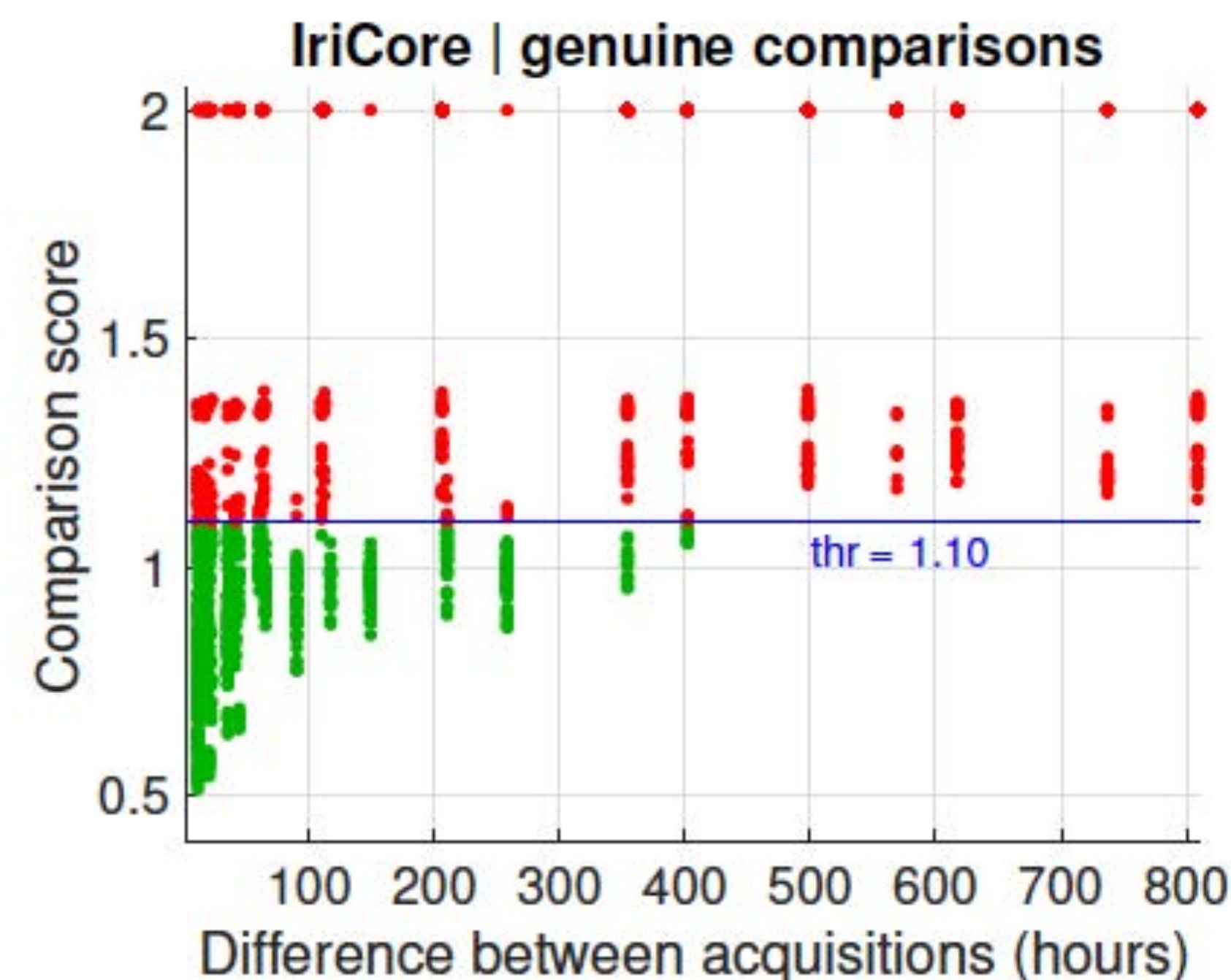
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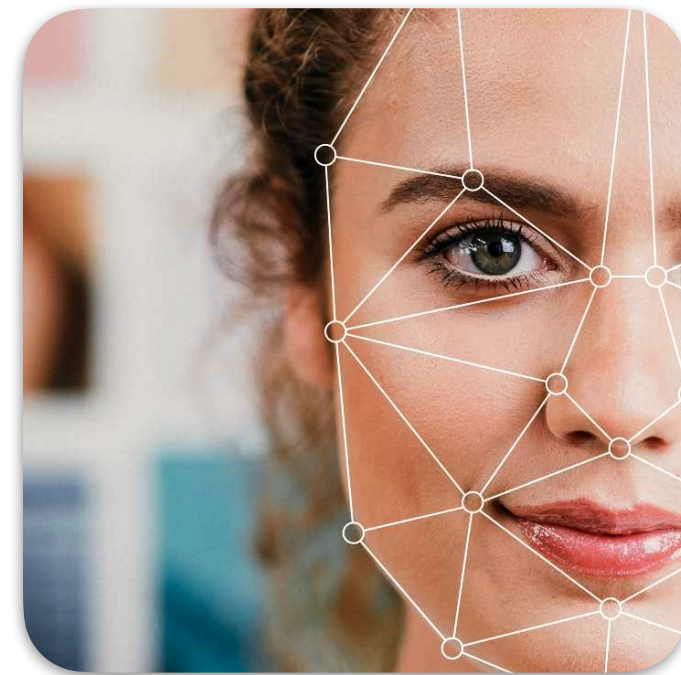
If body is kept in a mortuary,
iris recognition is successful even
17 days after death!



Why Irises?

Performance (7/8)

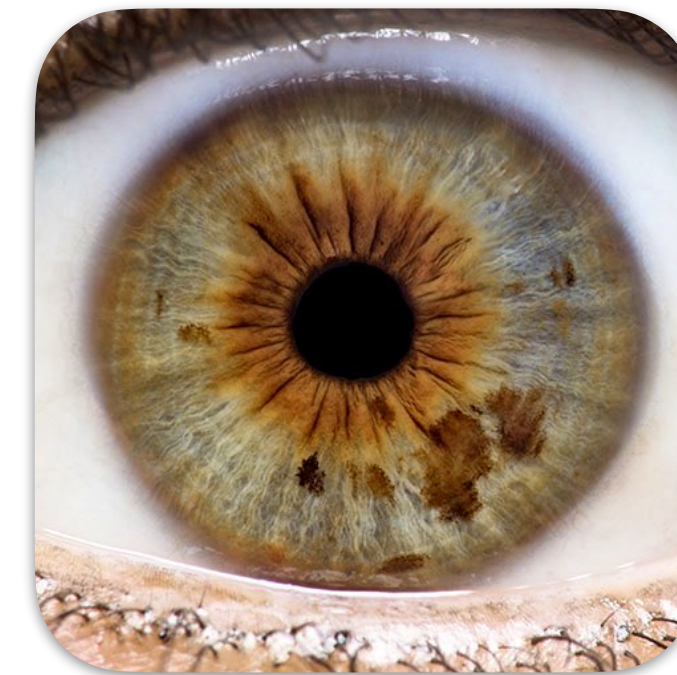
How good is the trait quantitatively according to objective metrics?



>



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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

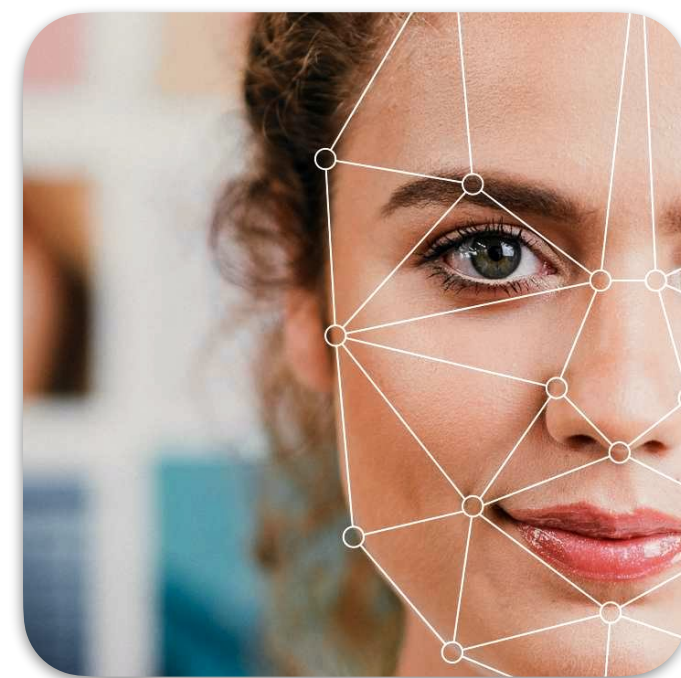


Nearly perfect
match rates

Why Irises?

Explainability (8/8)

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



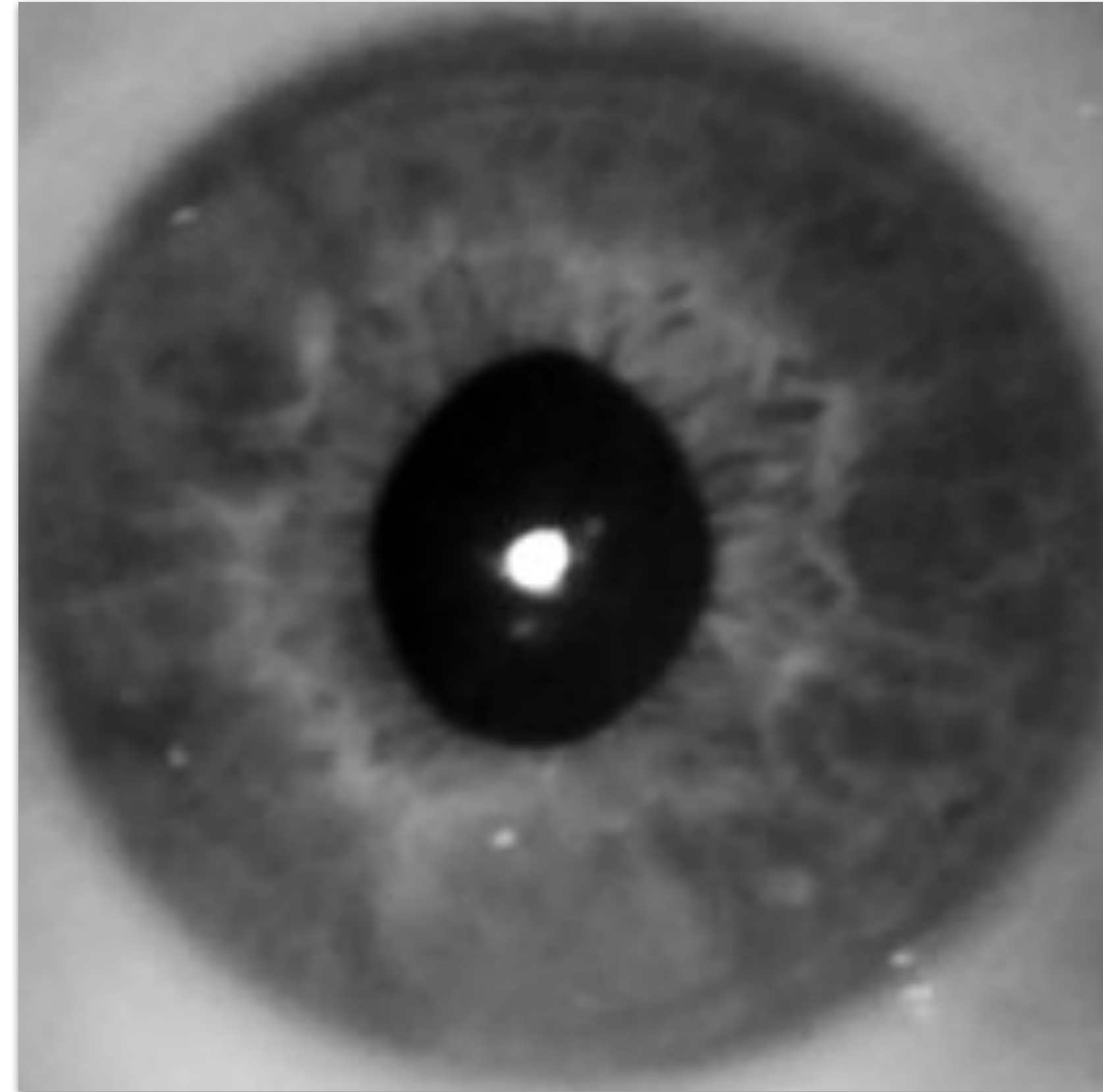
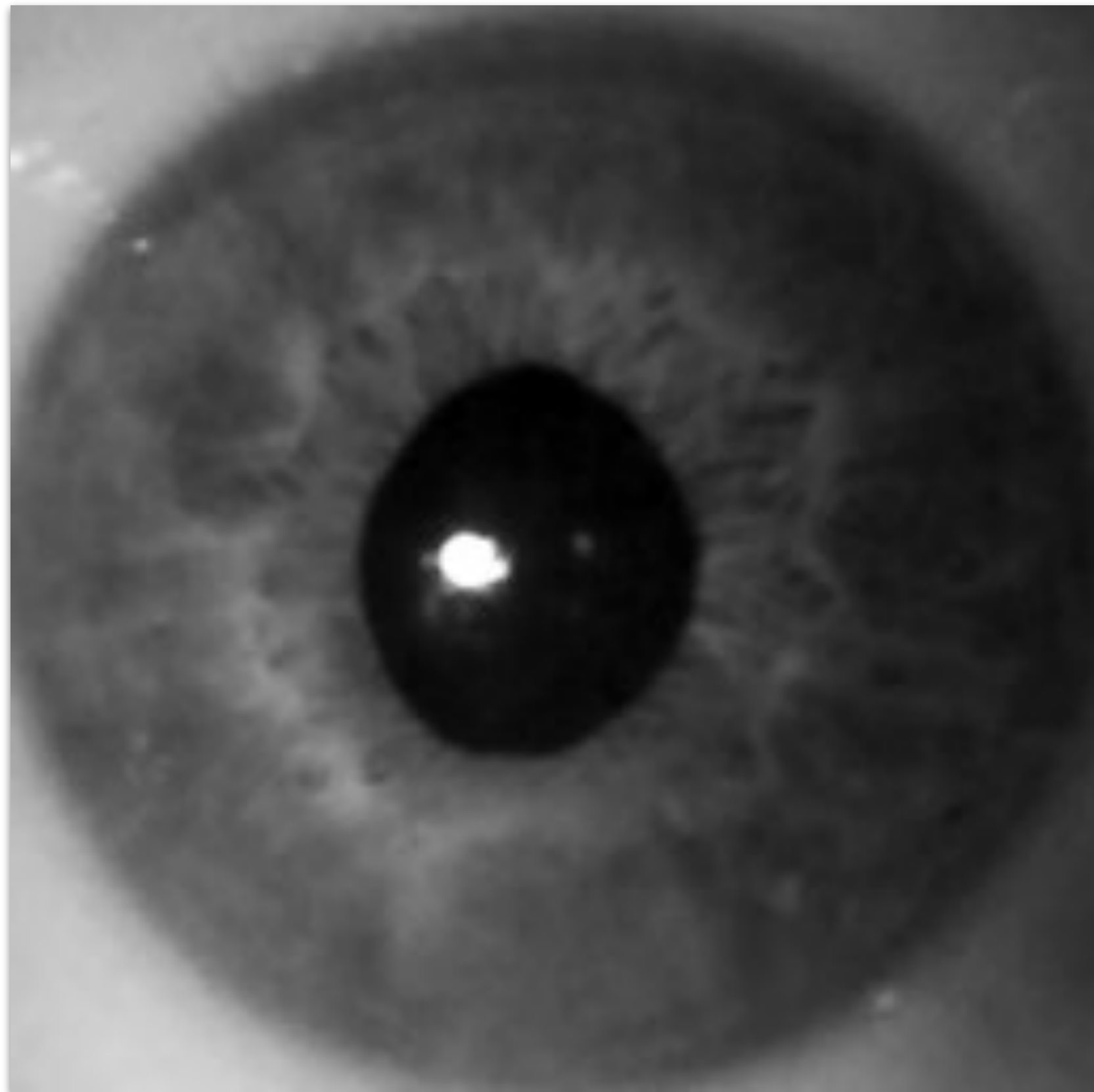
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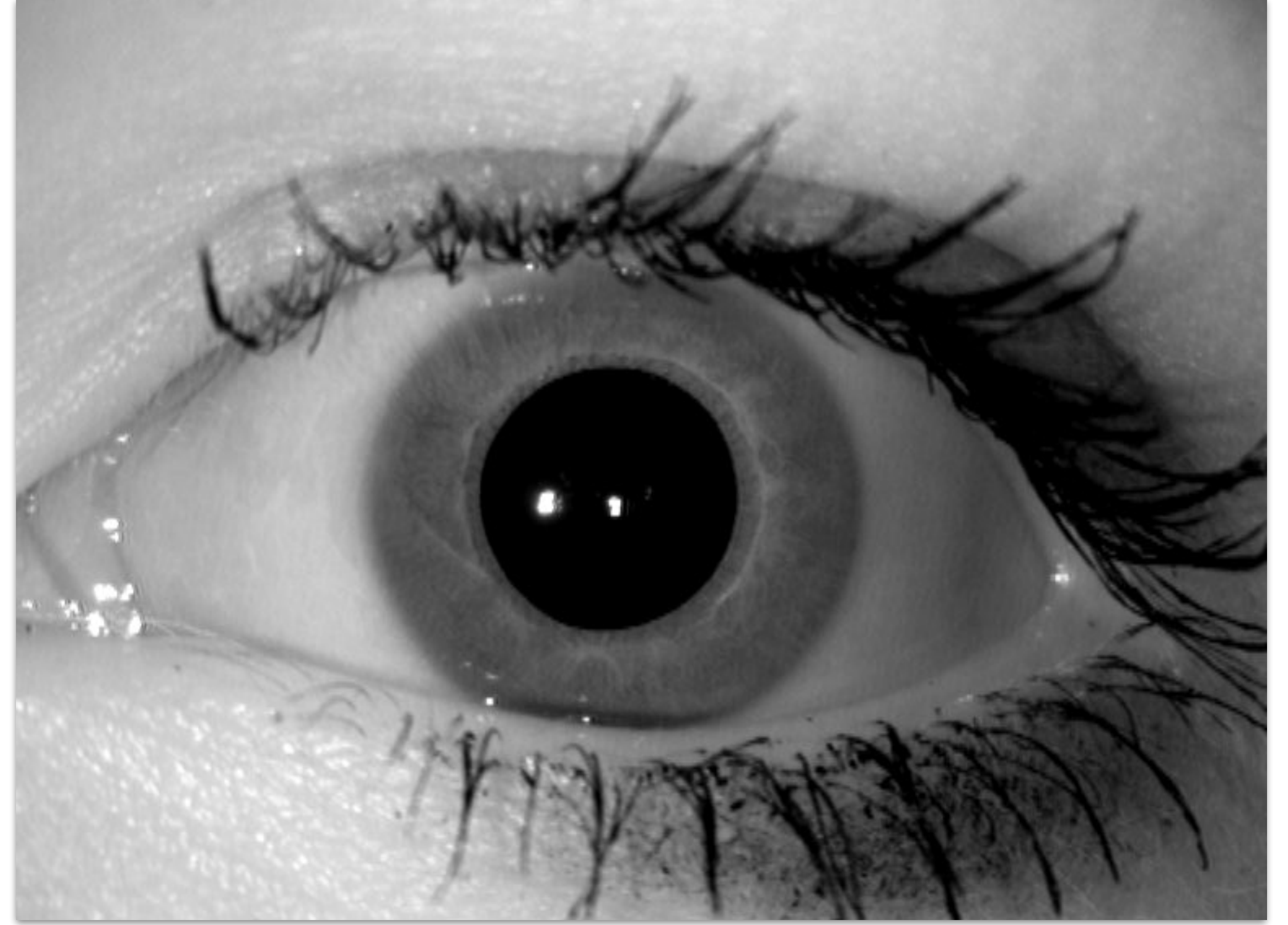
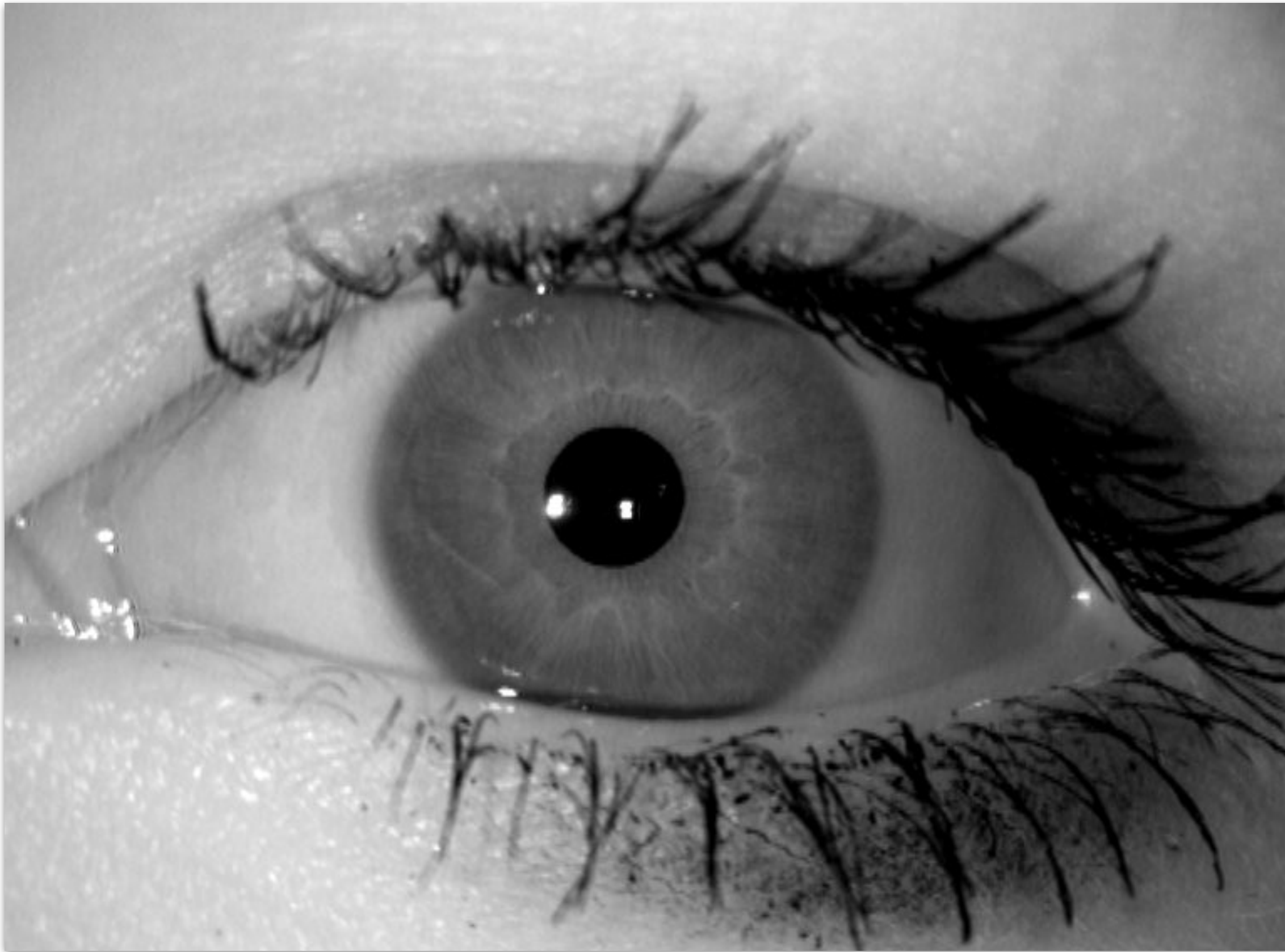
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Same Person?

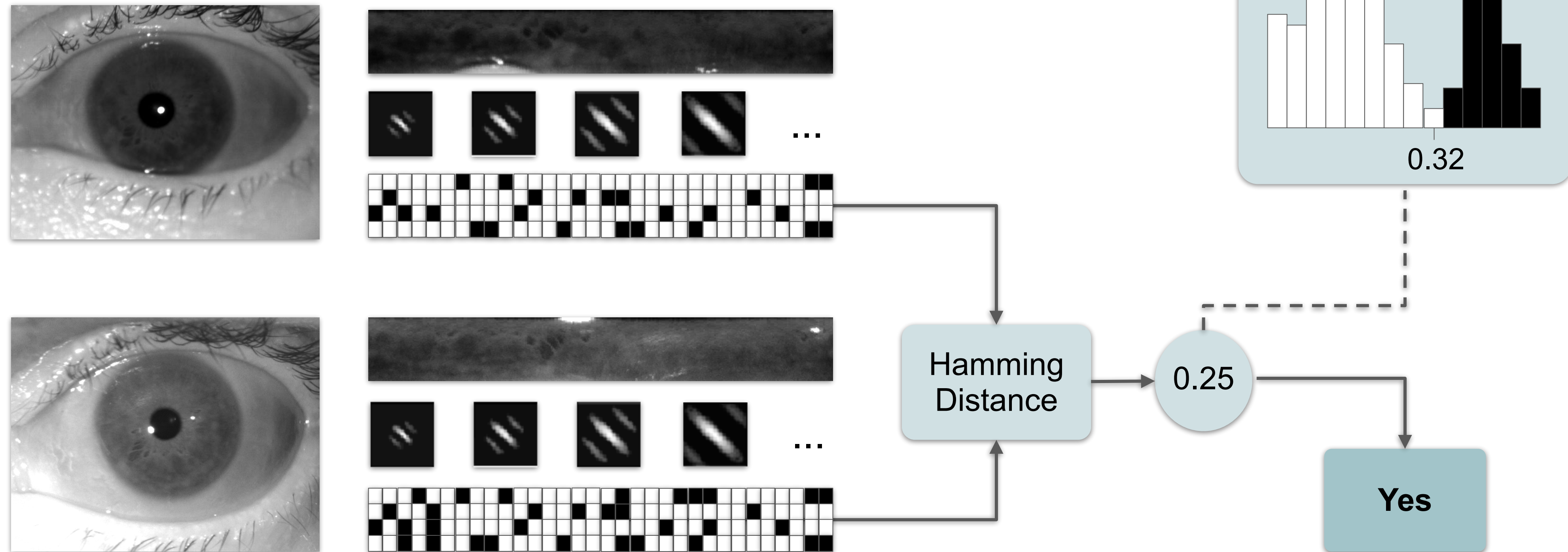


Same Person?

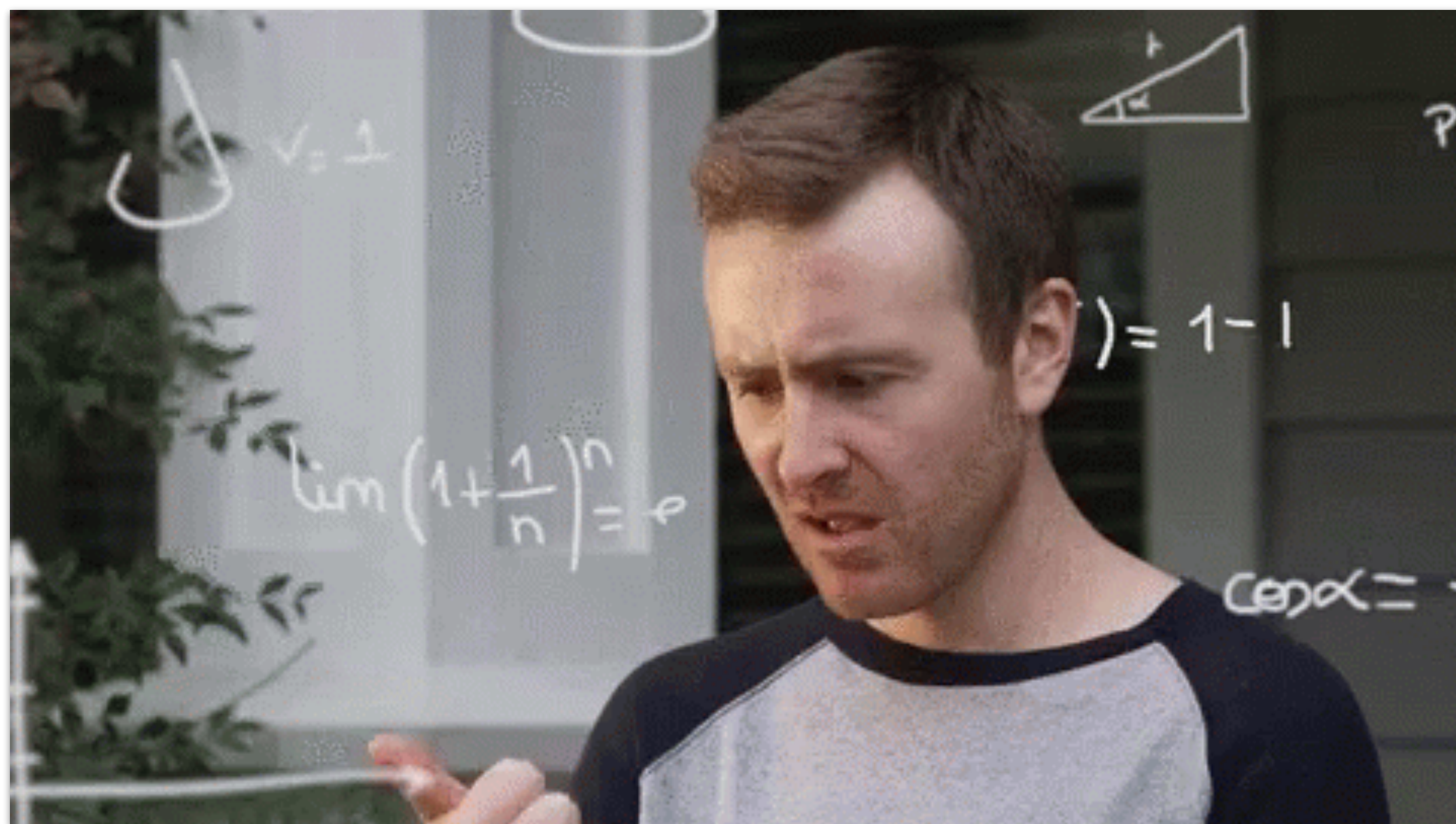


Iris Recognition

In a Nutshell



Easy, right?



Explainable Iris Recognition



How can we make it
meaningful to the
everyman?

Explainable Iris Recognition



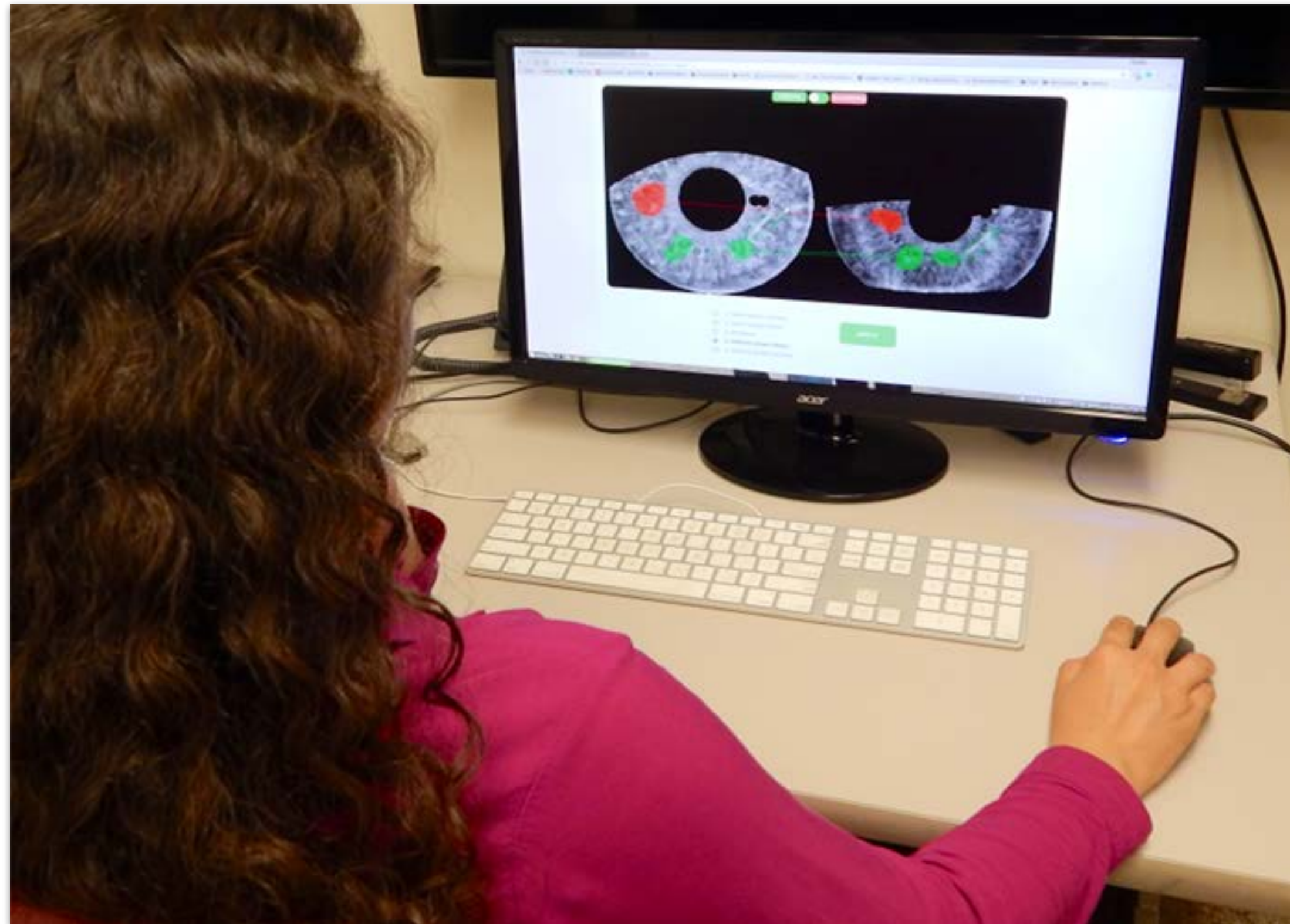
People have the right to obtain **an explanation of decisions** made about them by algorithms.

Explainable Iris Recognition



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

Explainable Iris Recognition

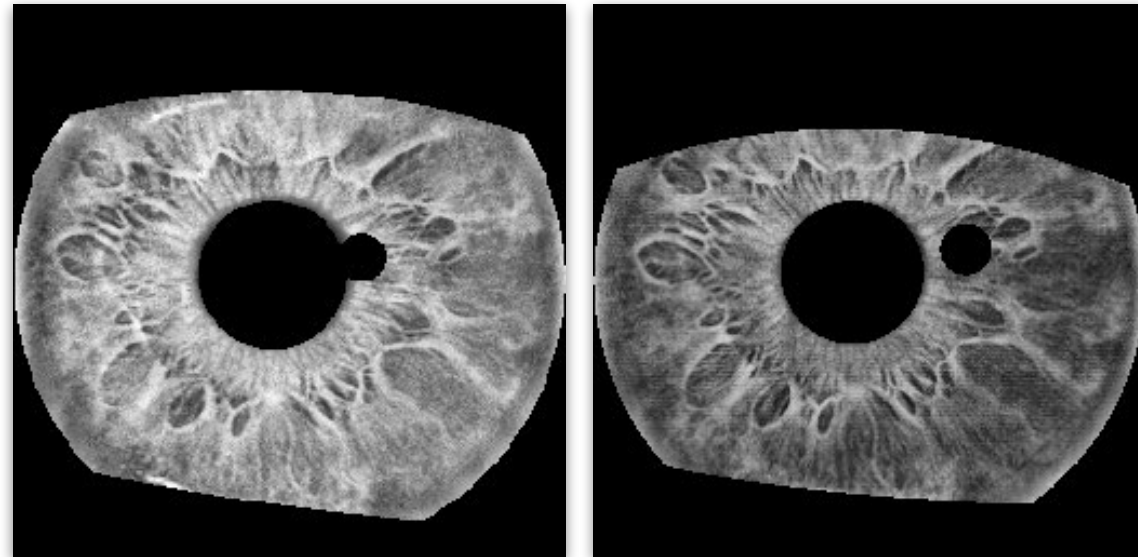


How should we start?

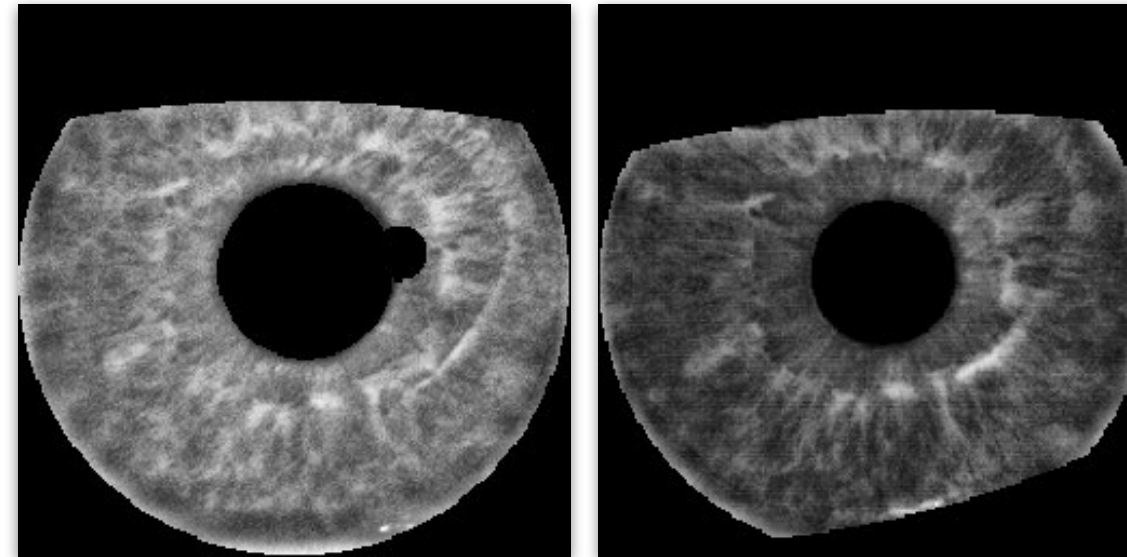
Ask a human:
**How do people perform
iris recognition?**

Human Experiments

Dataset



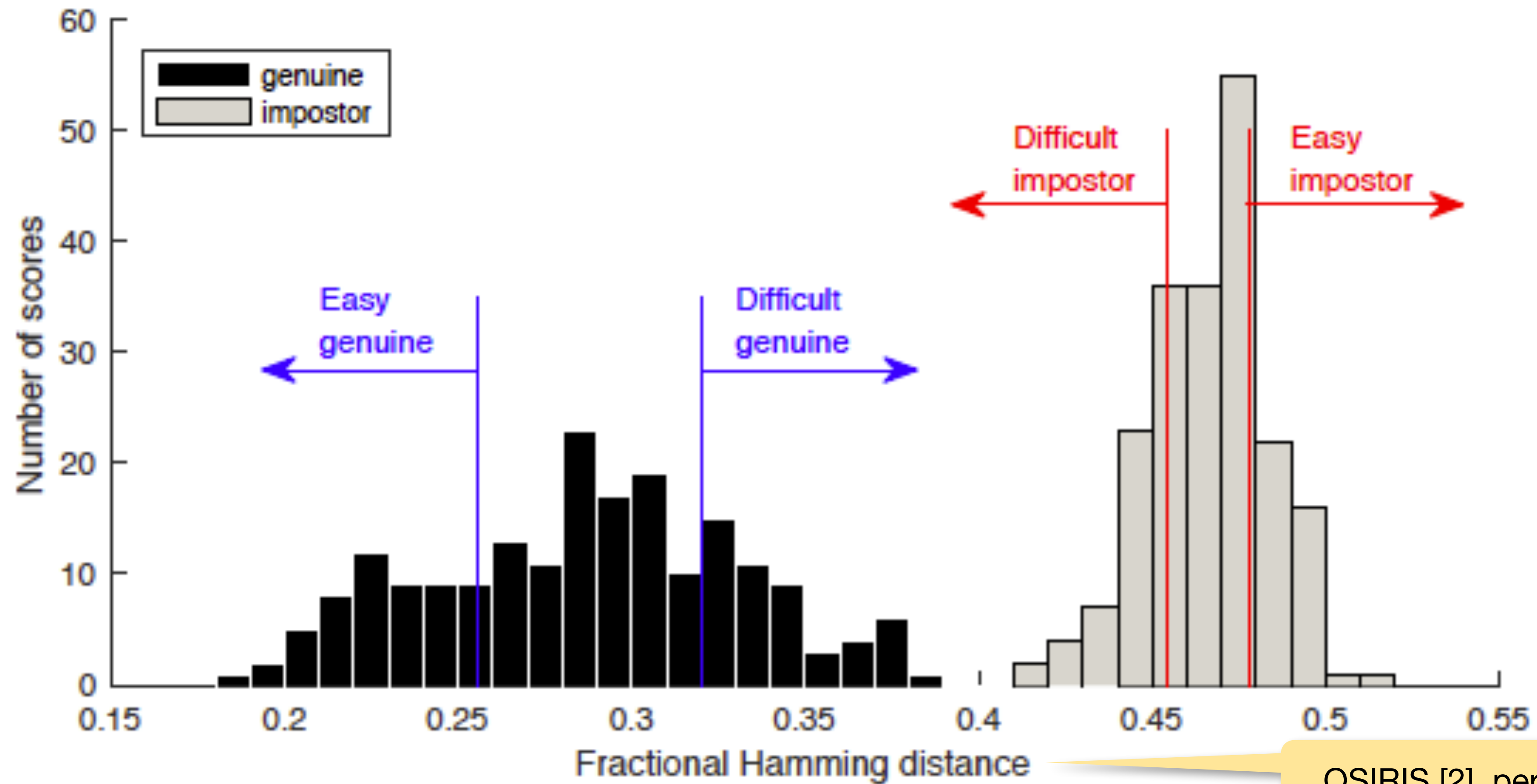
Easy for an automated solution



Hard for an automated solution

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

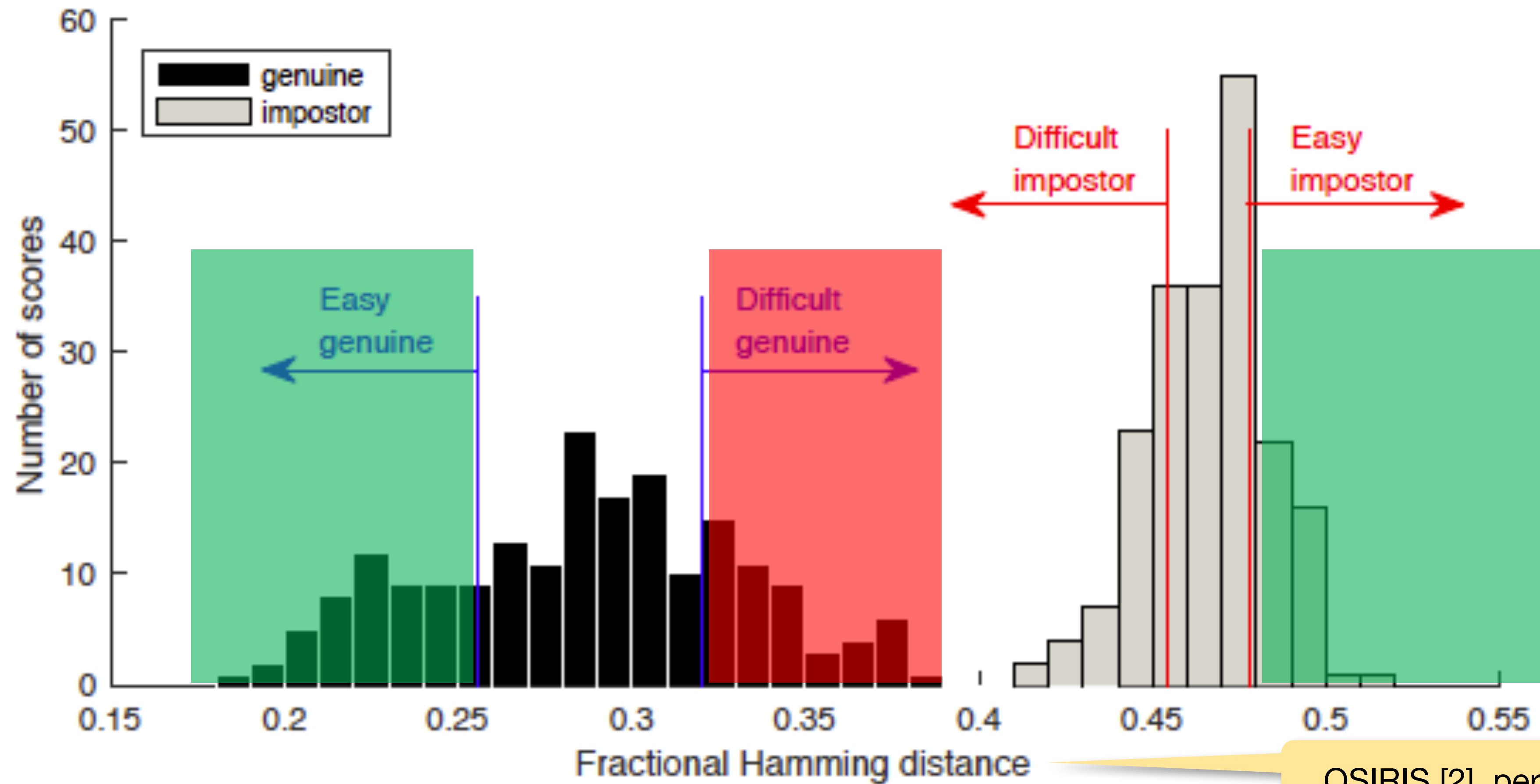
[1] Collection ND-CrossSensor-Iris-2013
Computer Vision Research Laboratory at the University of Notre Dame, 2013.



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



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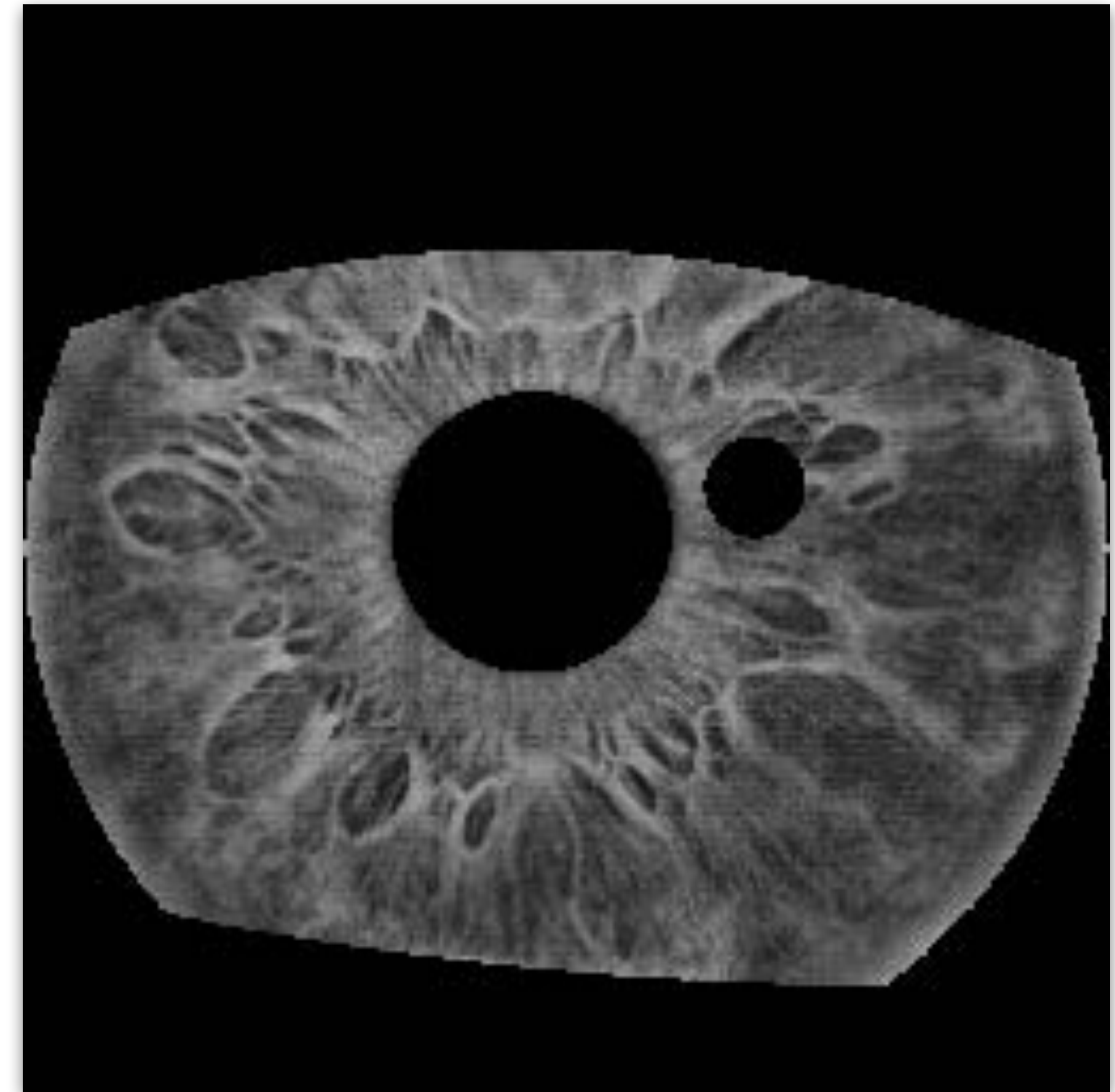
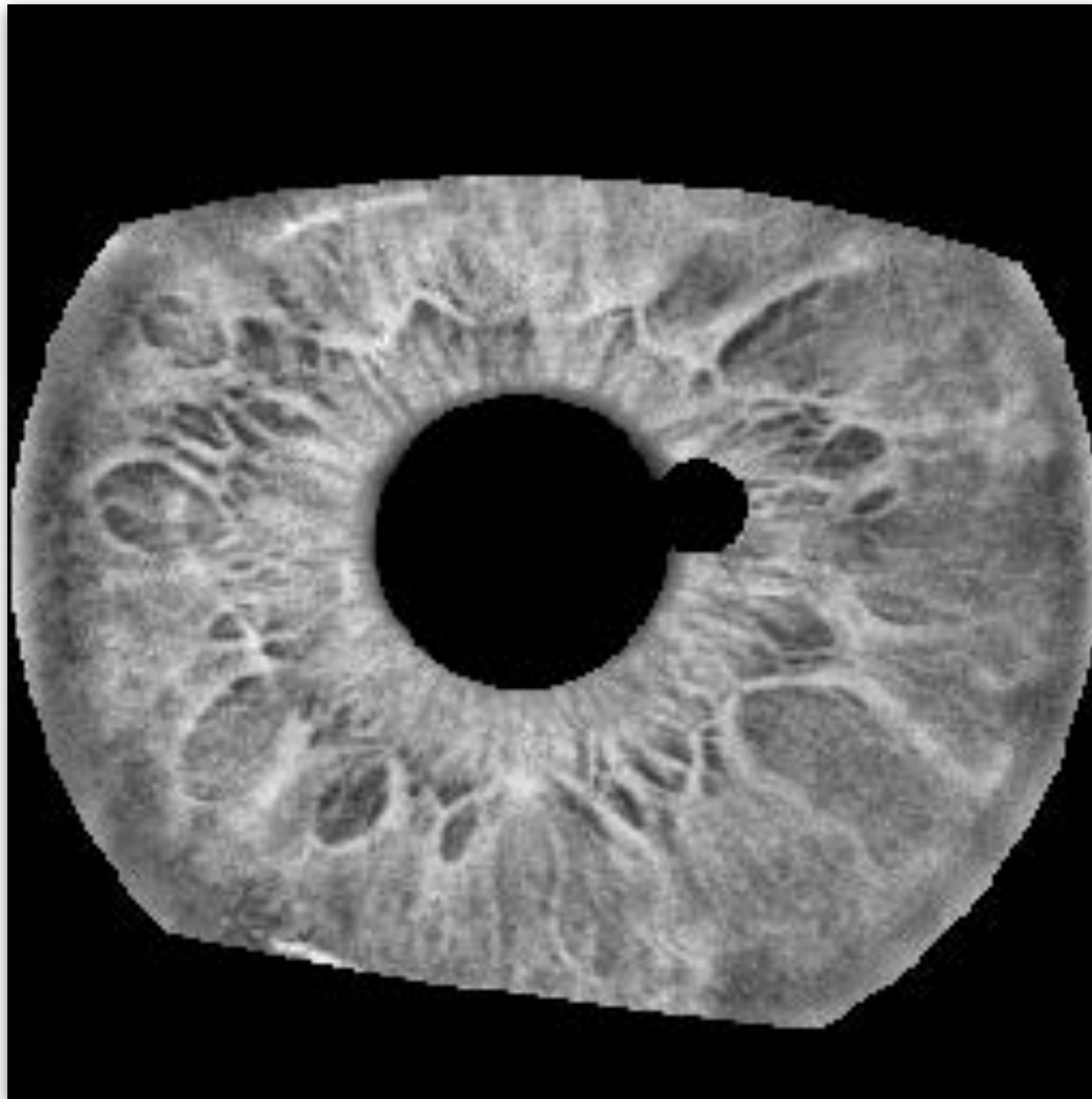


OSIRIS [2] performance.

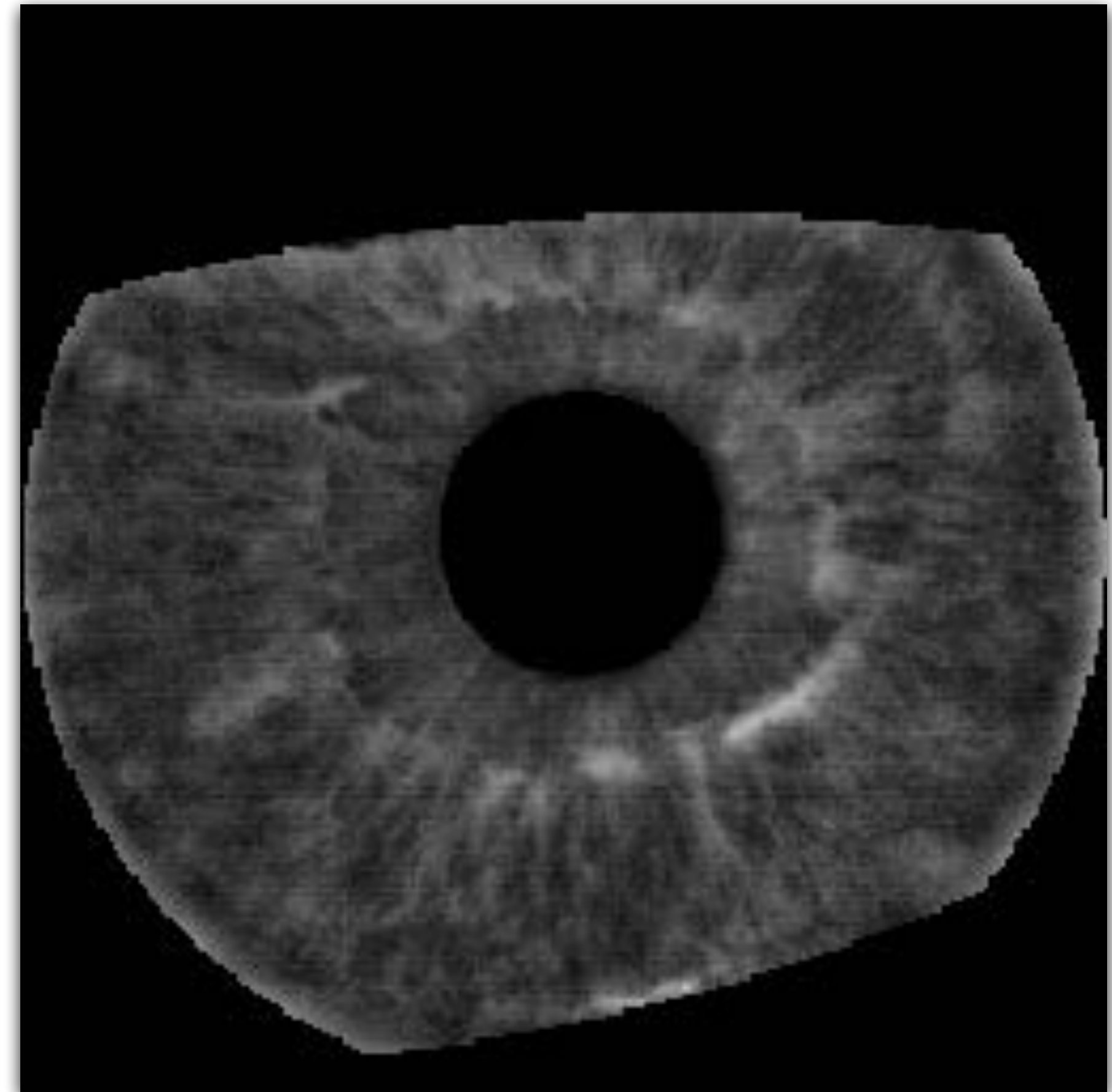
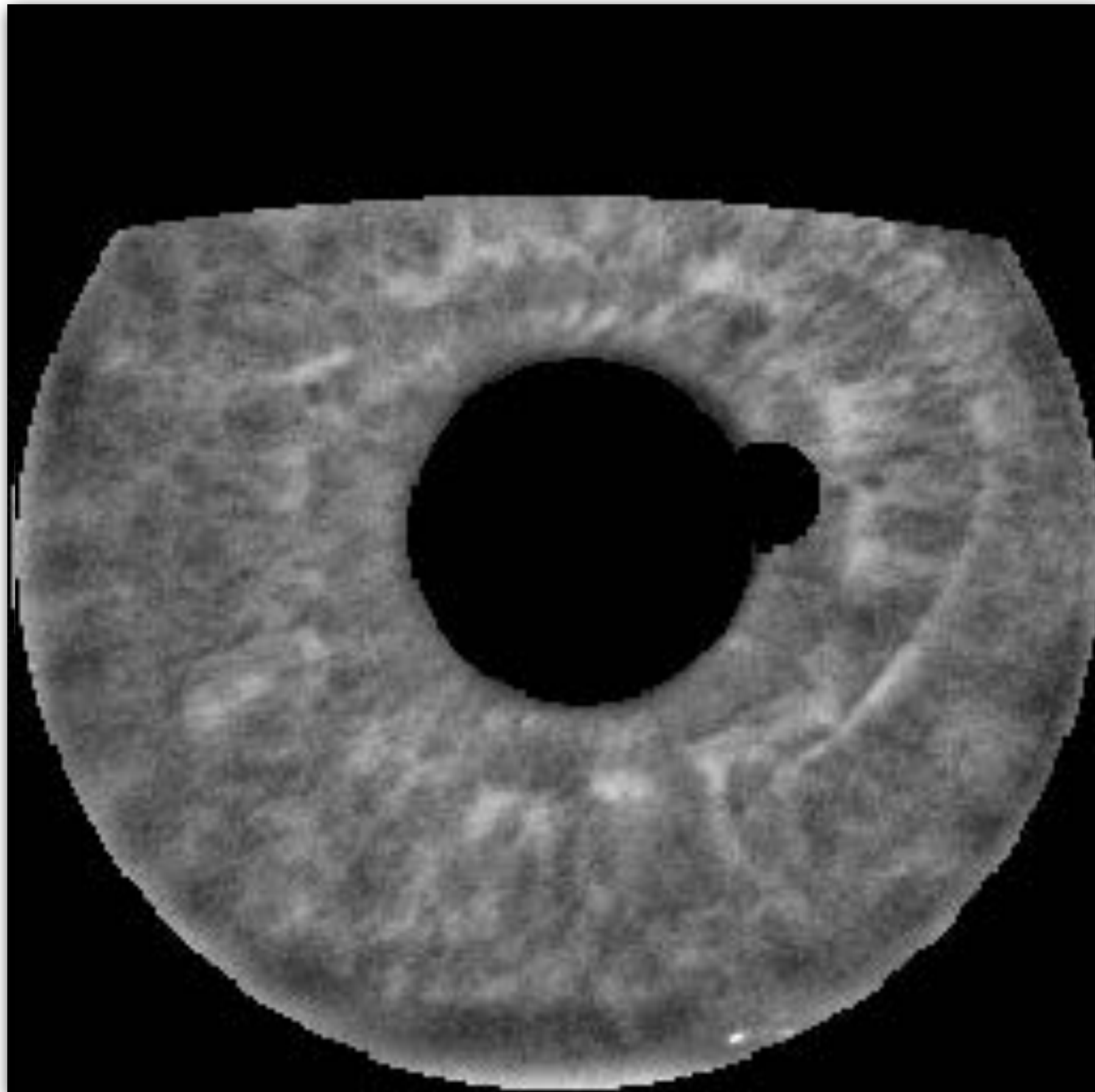
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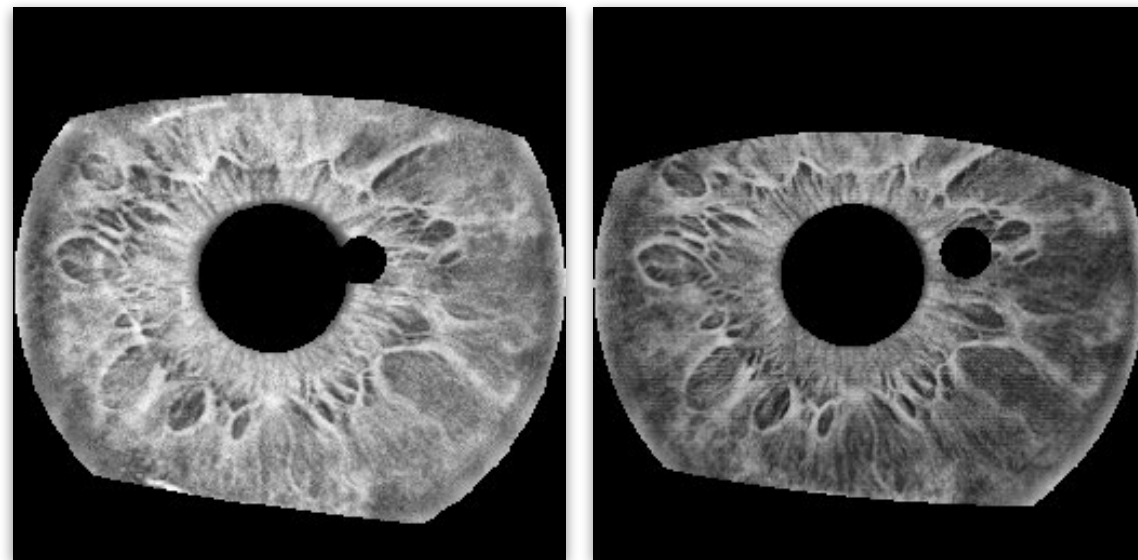
Easy for an automated solution



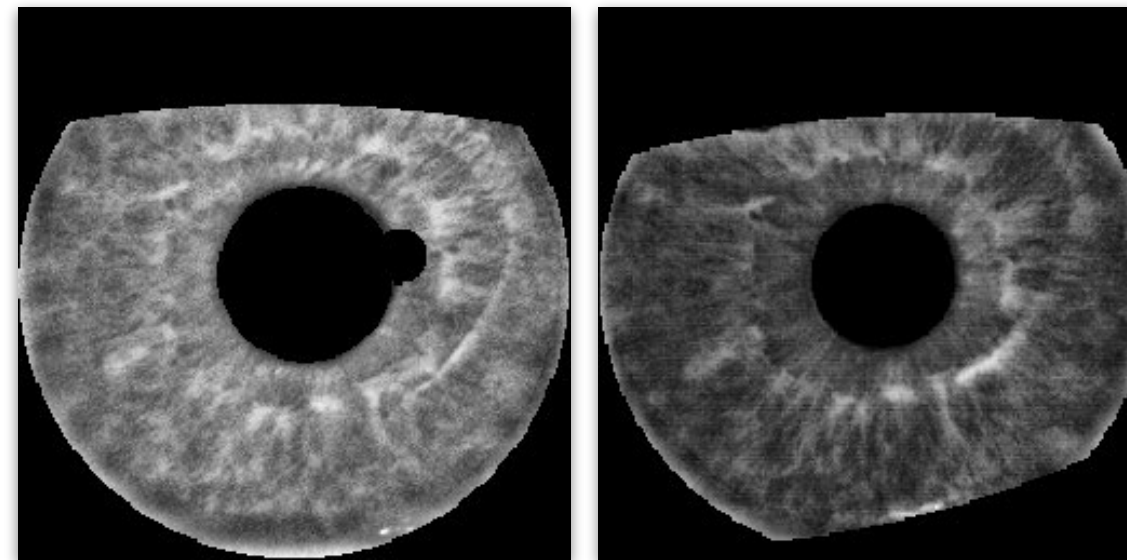
Hard for an automated solution

Human Experiments

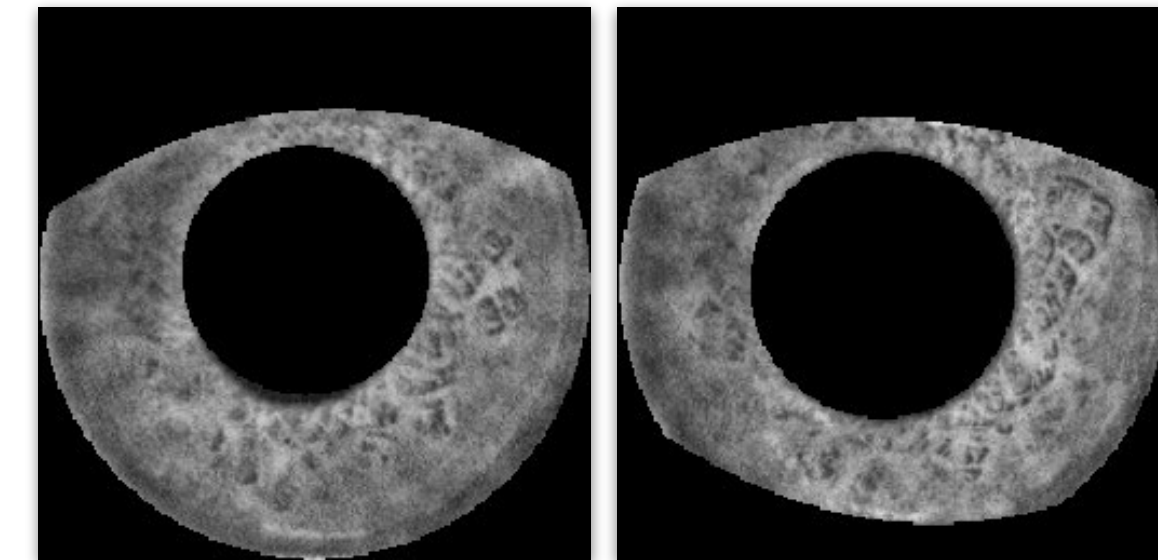
Dataset



Easy for an automated solution



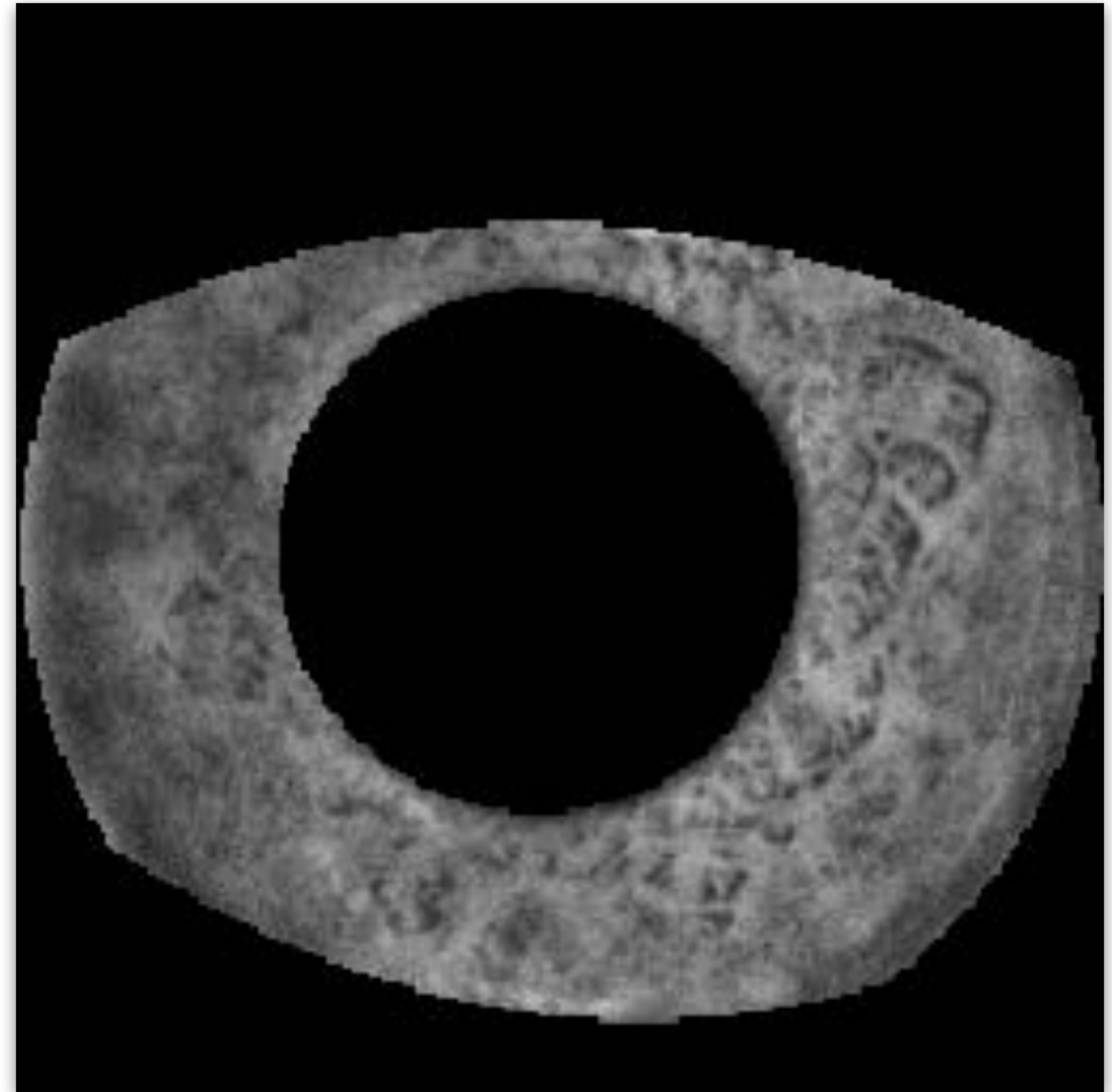
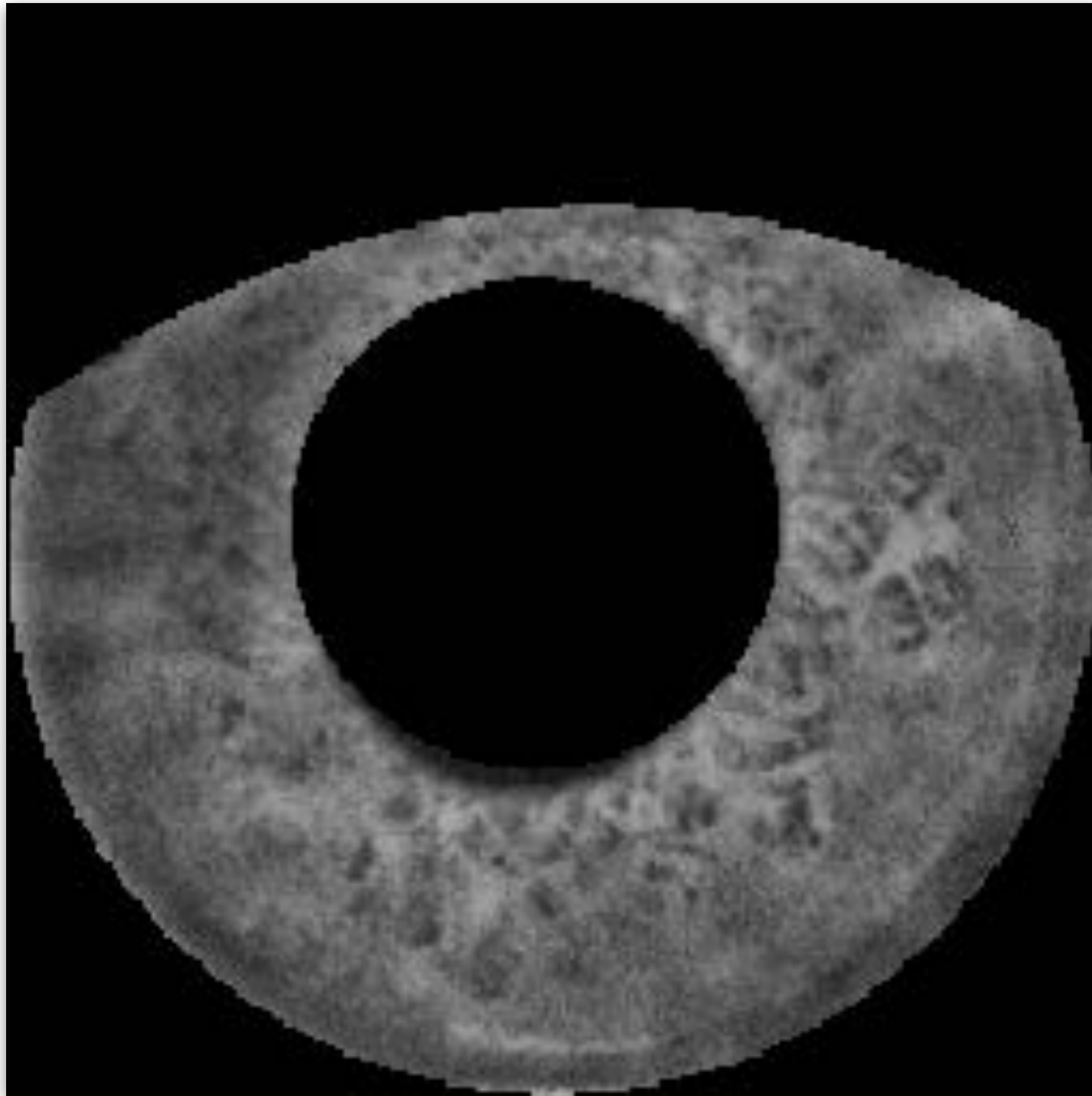
Hard for an automated solution



Twins'

Source:
Hollingsworth et al. [3]

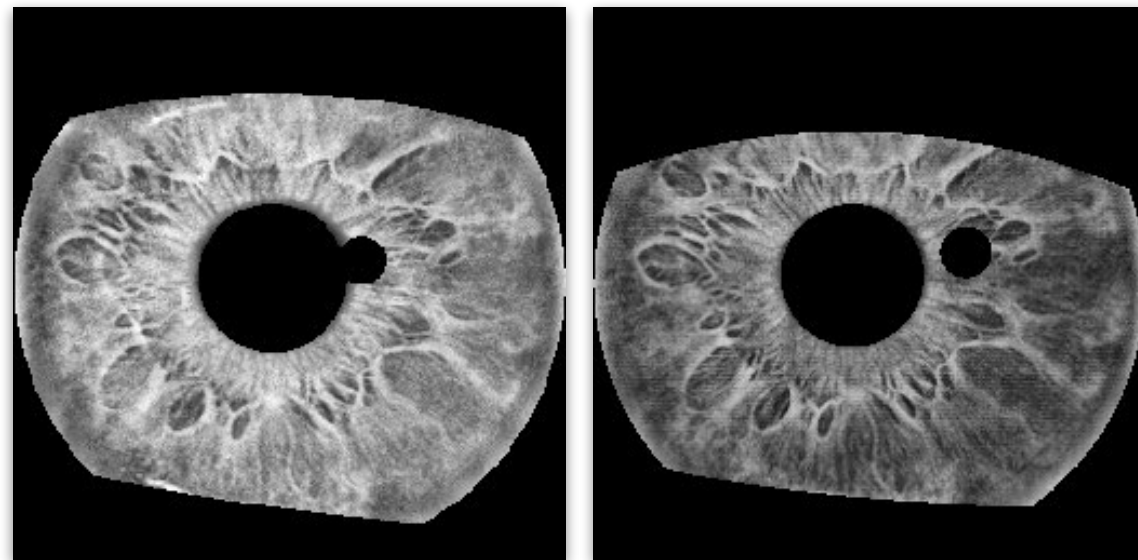
[3] Genetically identical irises have texture similarity that is not detected by iris biometrics.
Hollingsworth et al. Elsevier Computer Vision and Image Understanding, 115(11):1493–1502, 2011.



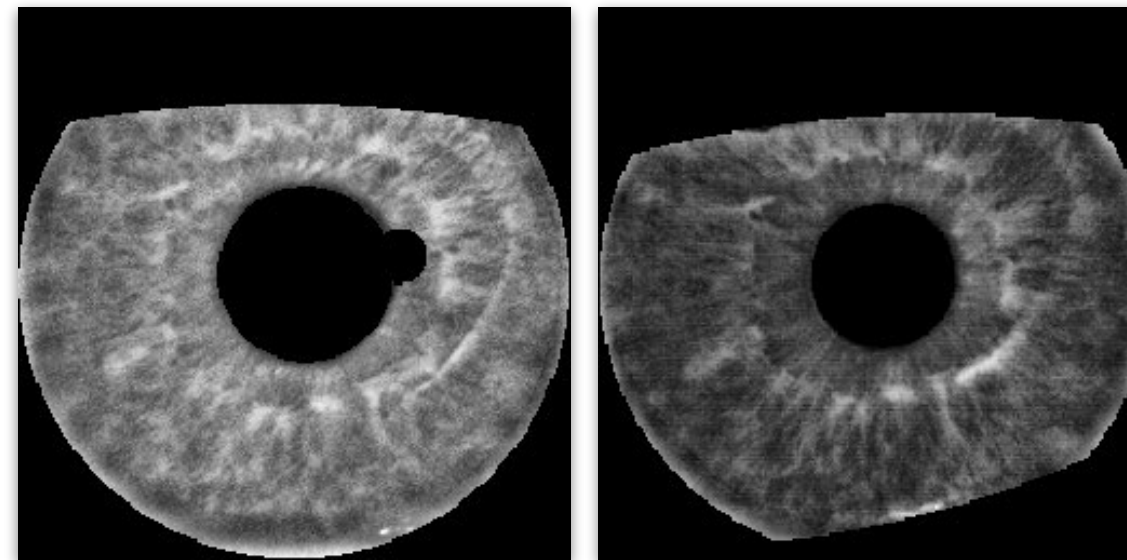
Twins'

Human Experiments

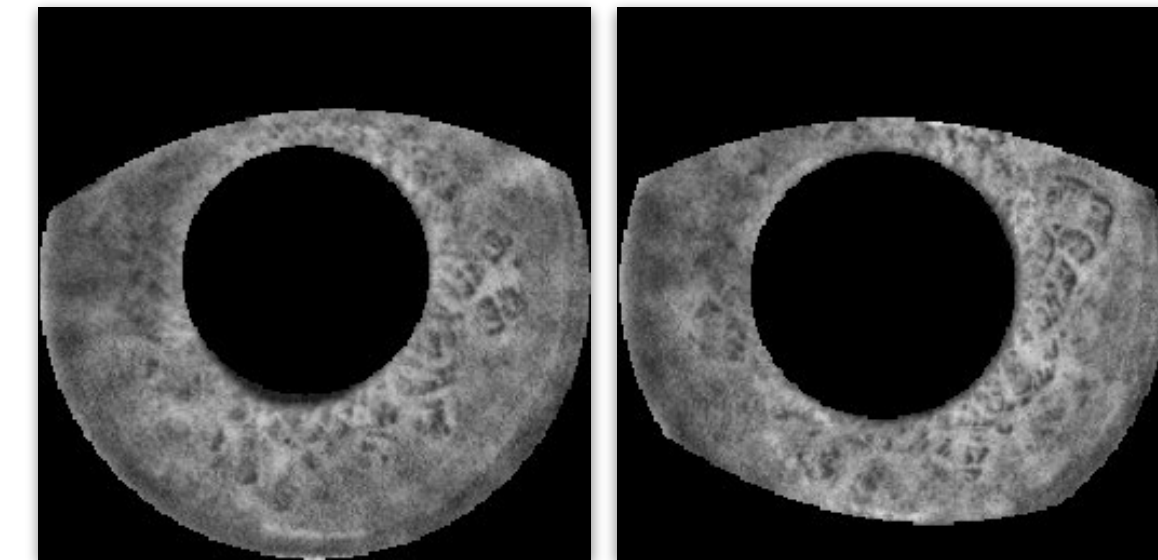
Dataset



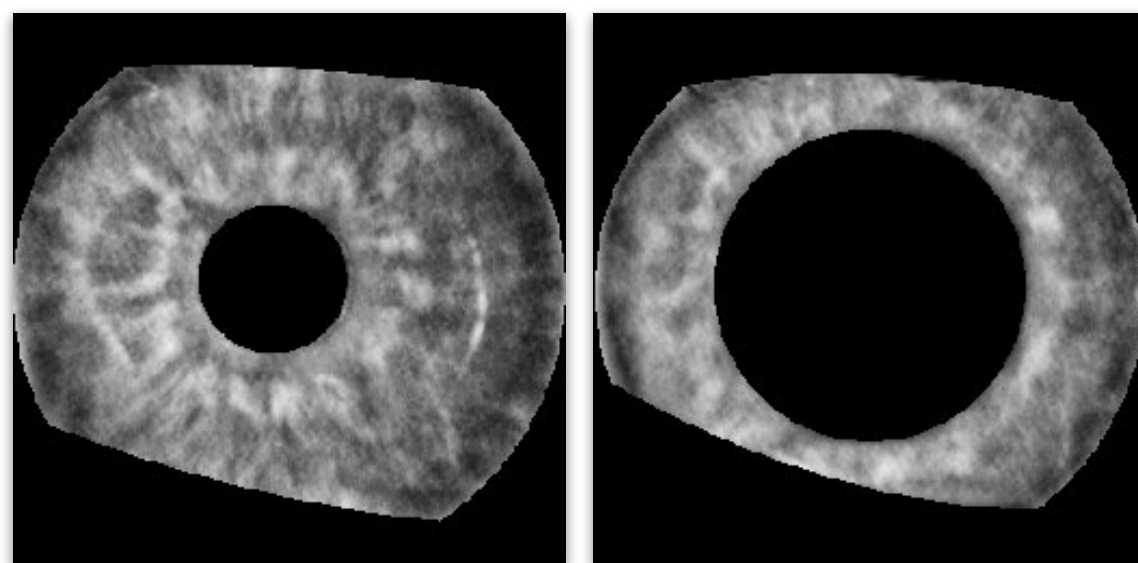
Easy for an automated solution



Hard for an automated solution



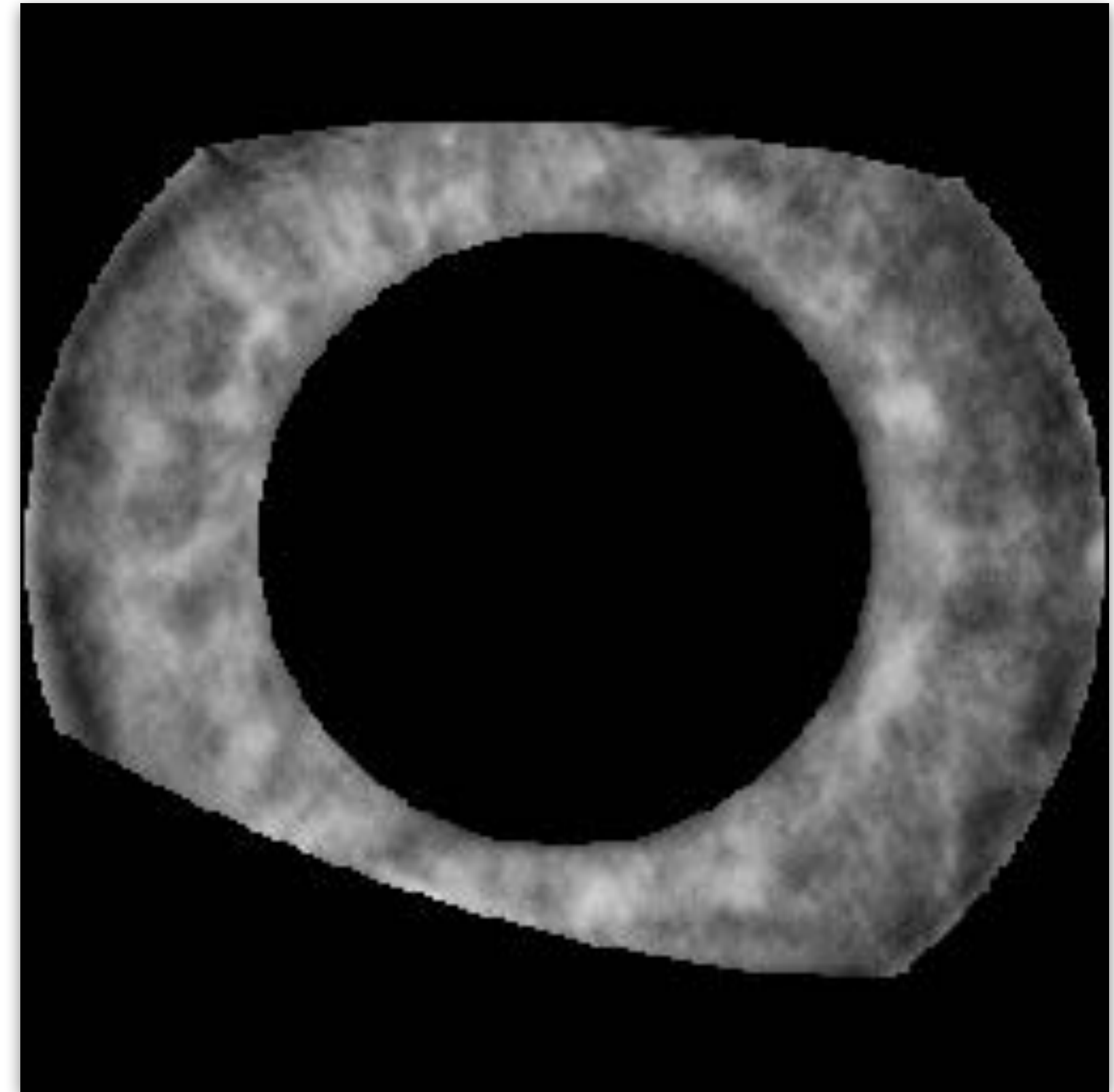
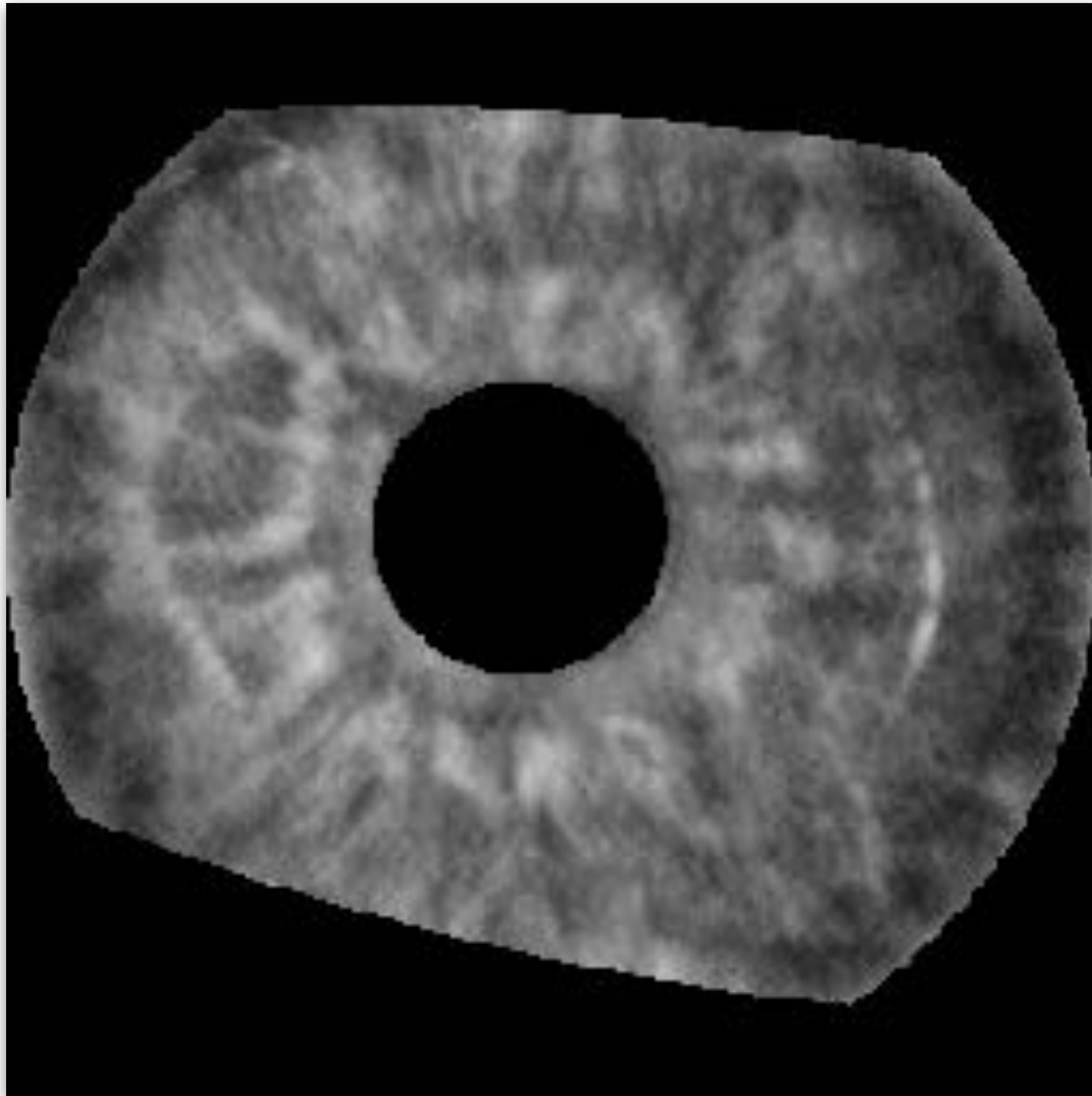
Twins'



Pupil dynamic

Source:
Hollingsworth et al. [3]

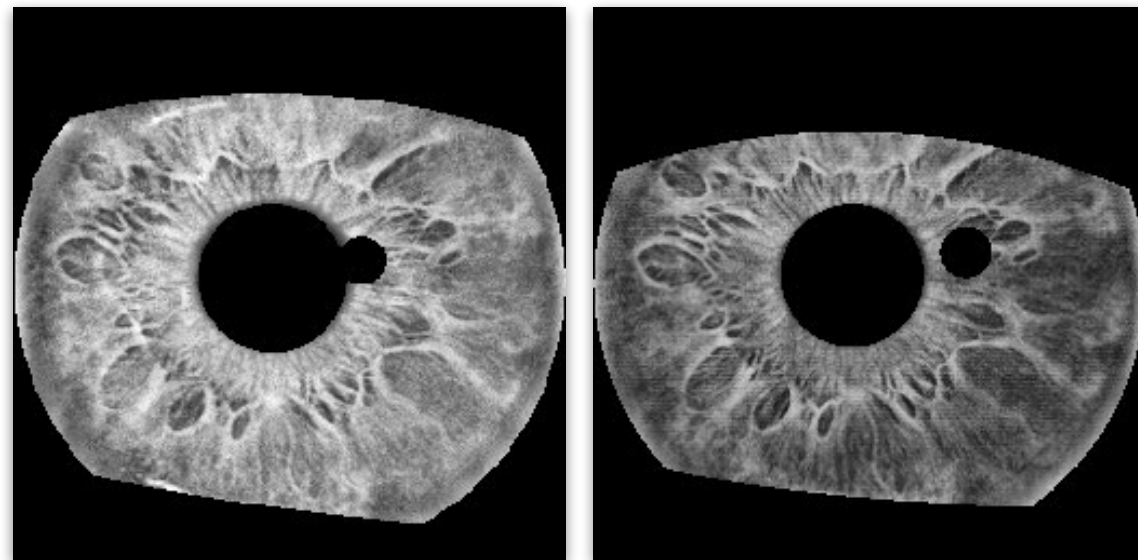
[3] Genetically identical irises have texture similarity that is not detected by iris biometrics. Hollingsworth et al.
Elsevier Computer Vision and Image Understanding, 115(11):1493–1502, 2011.



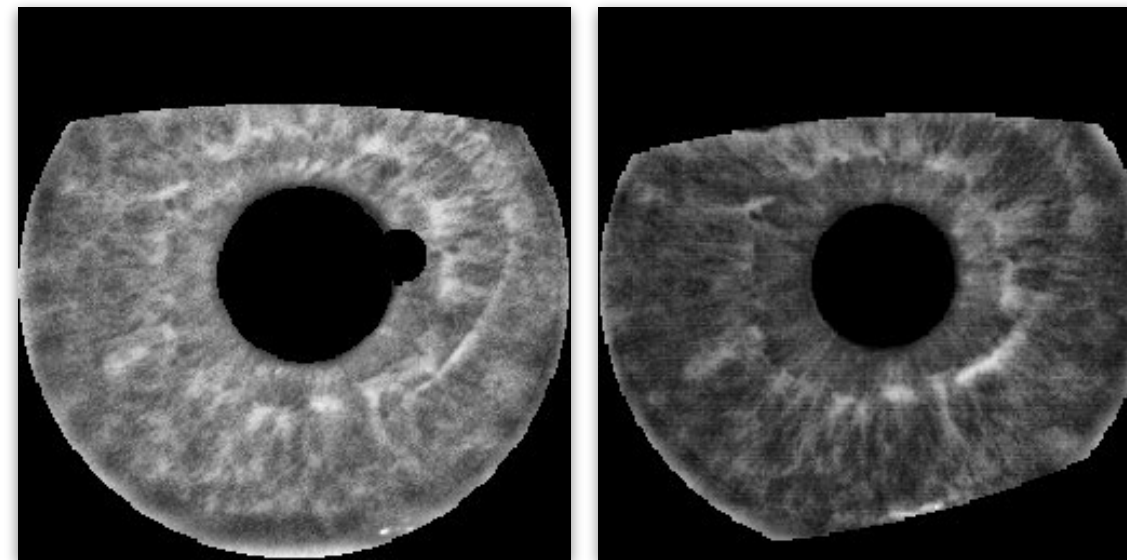
Pupil-dynamic

Human Experiments

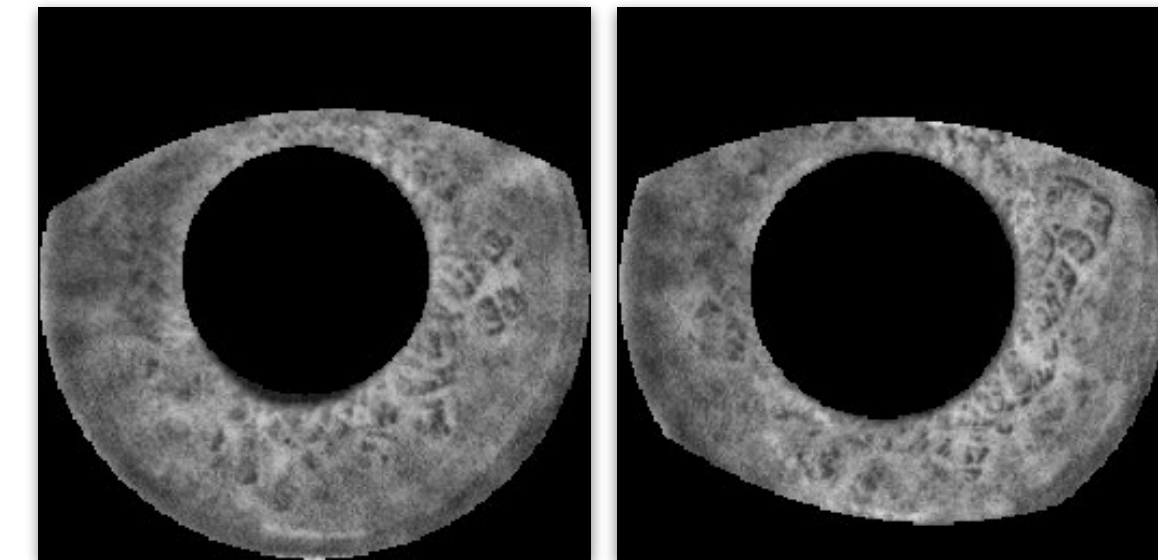
Dataset



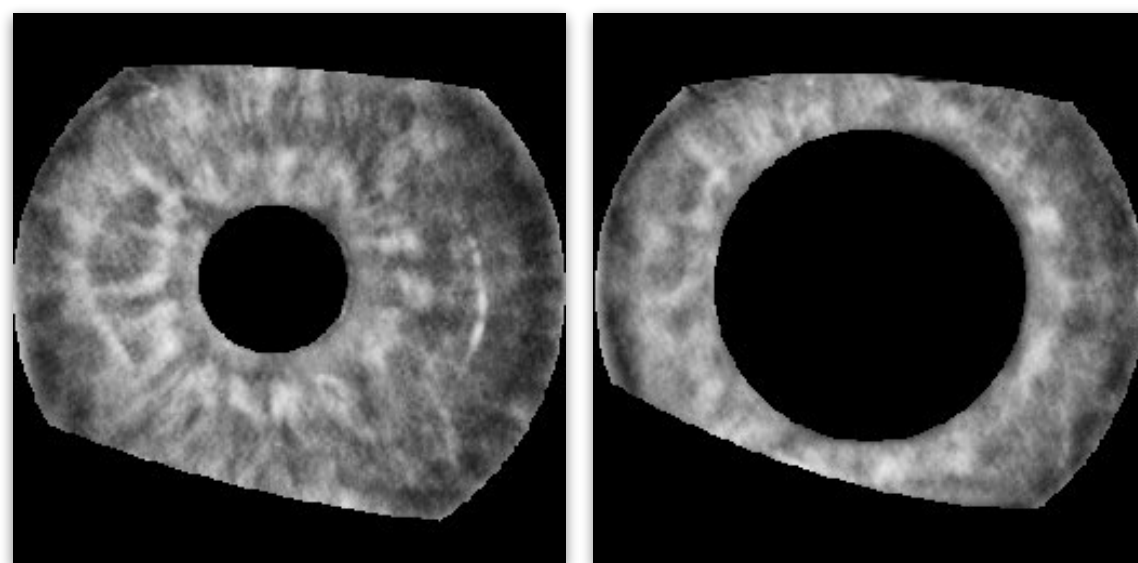
Easy for an automated solution



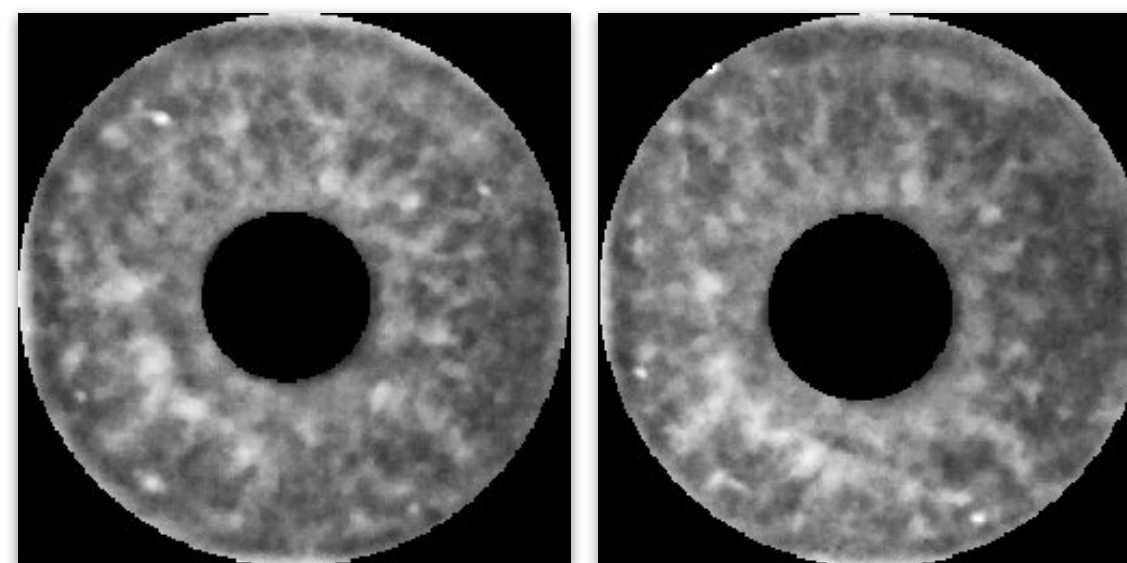
Hard for an automated solution



Twins'



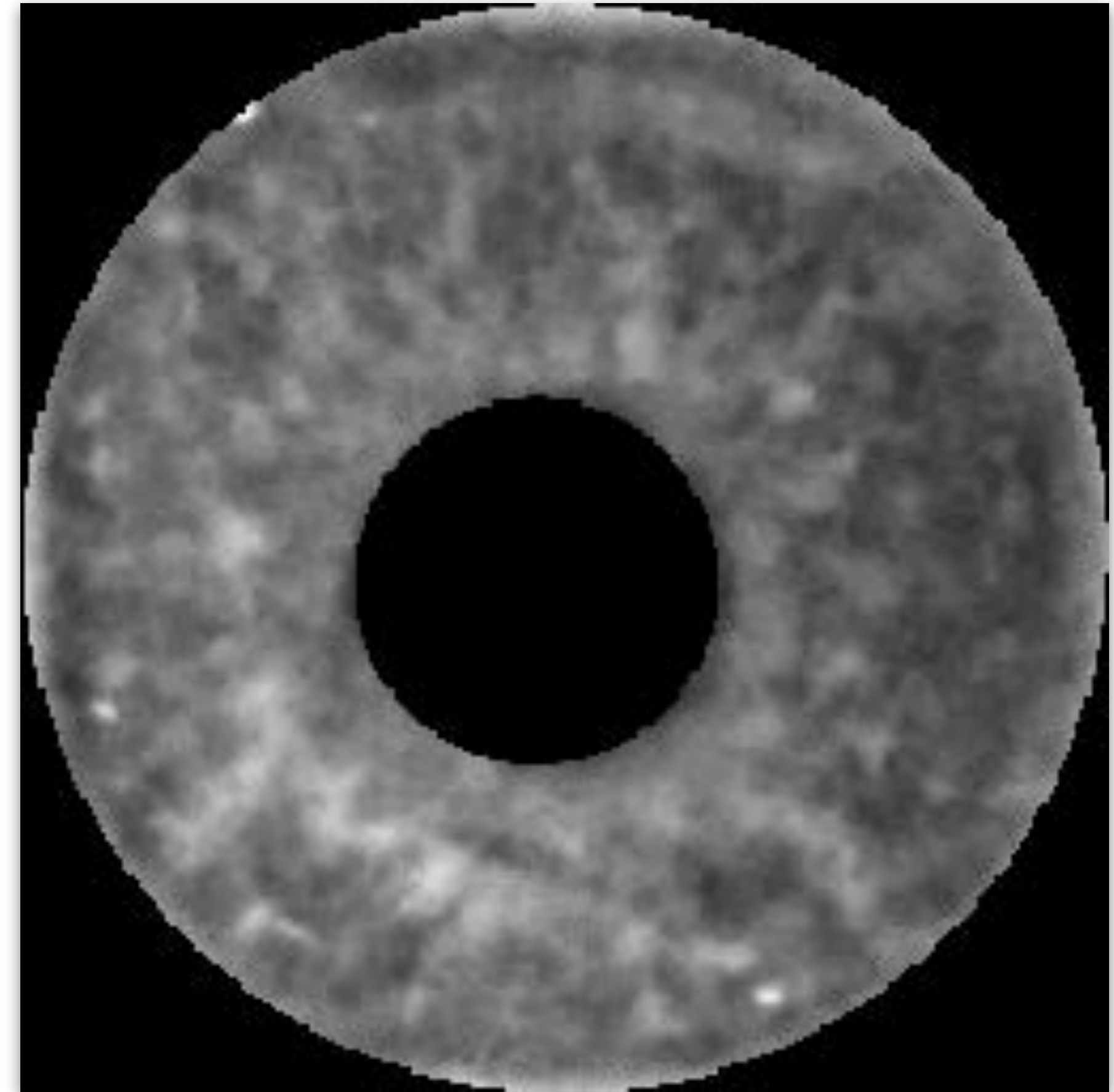
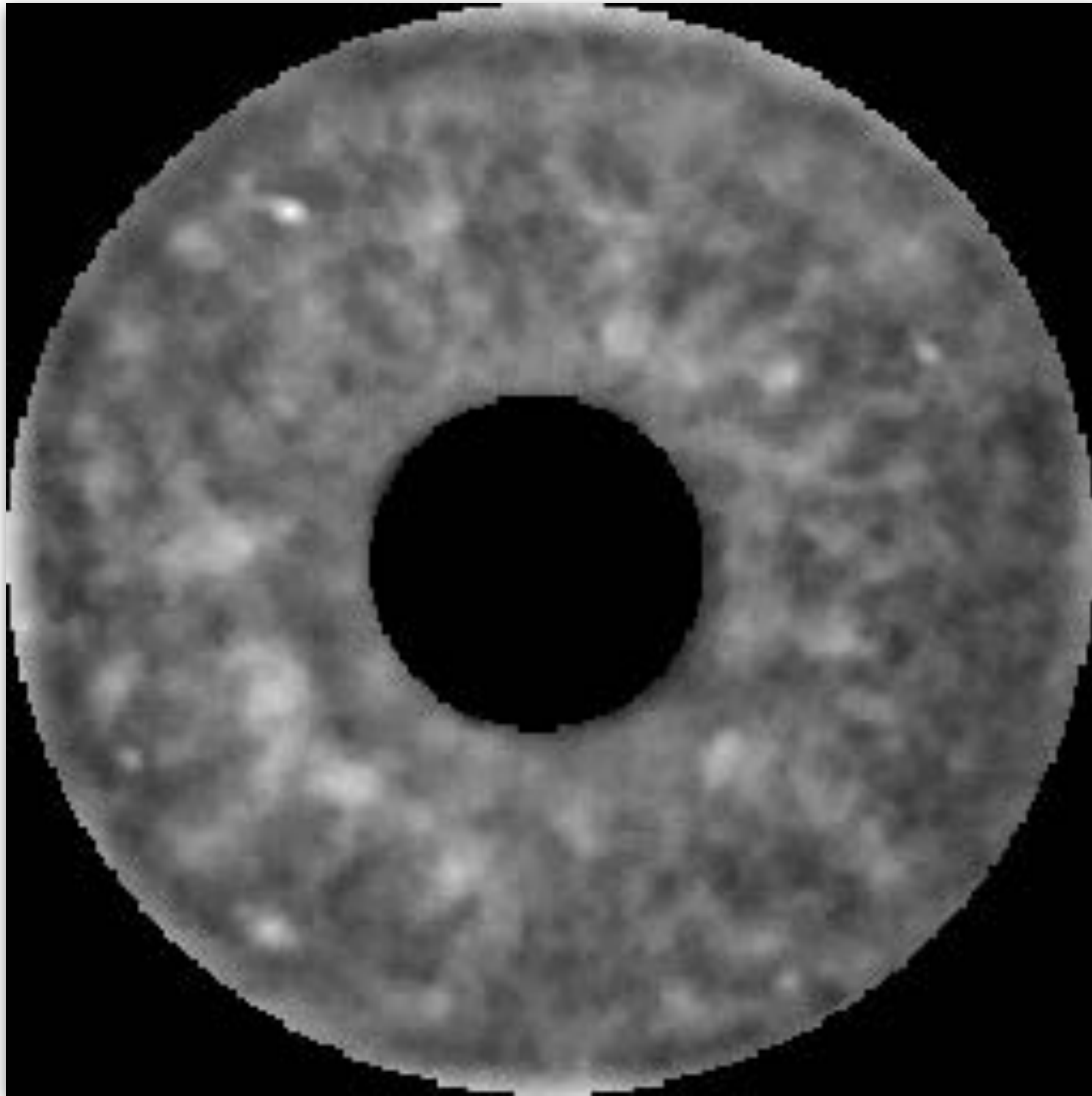
Pupil dynamic



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.

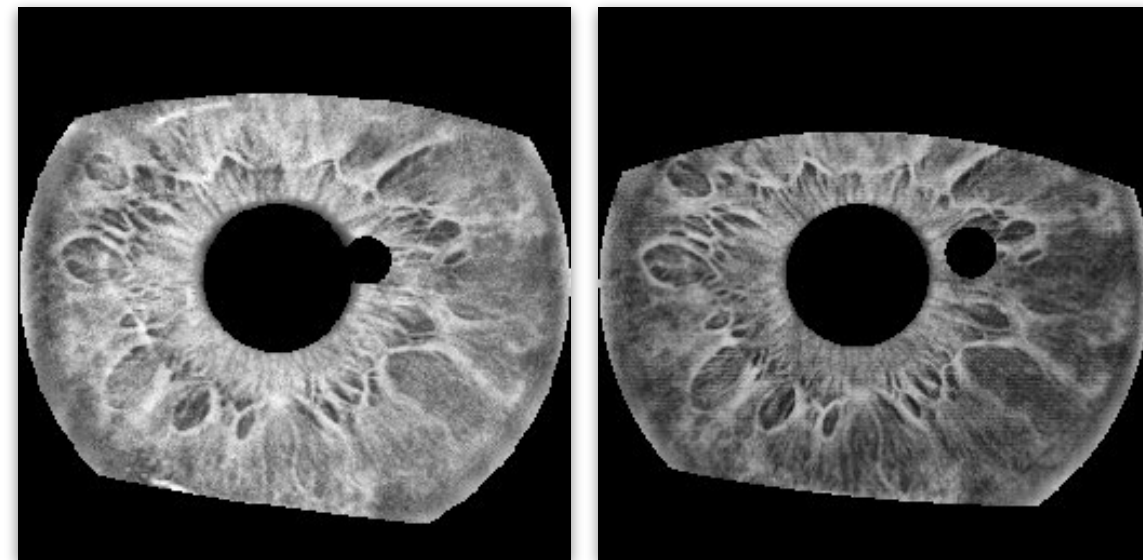


Deceased

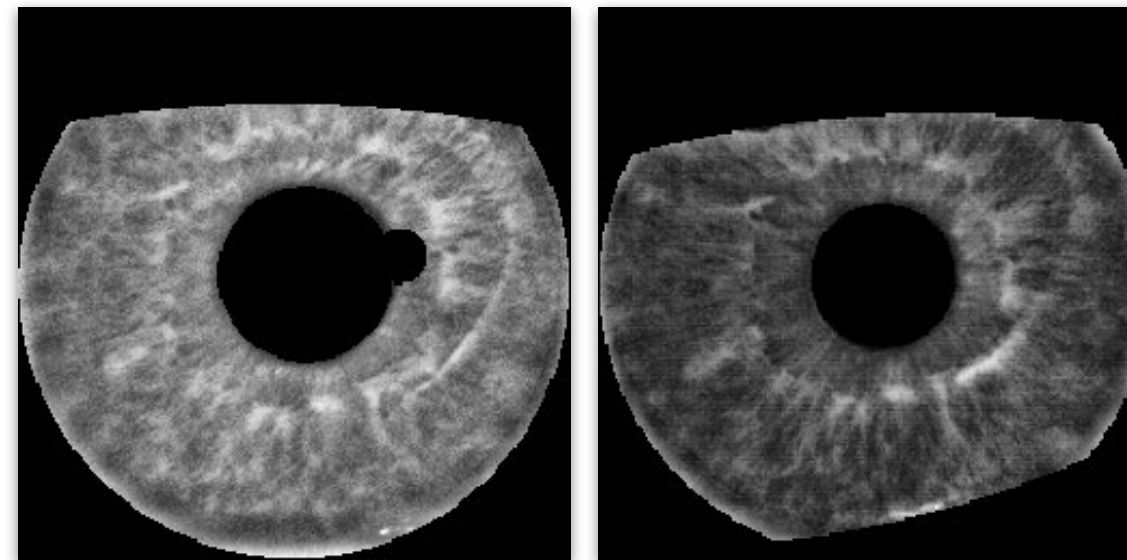
Human Experiments

Dataset

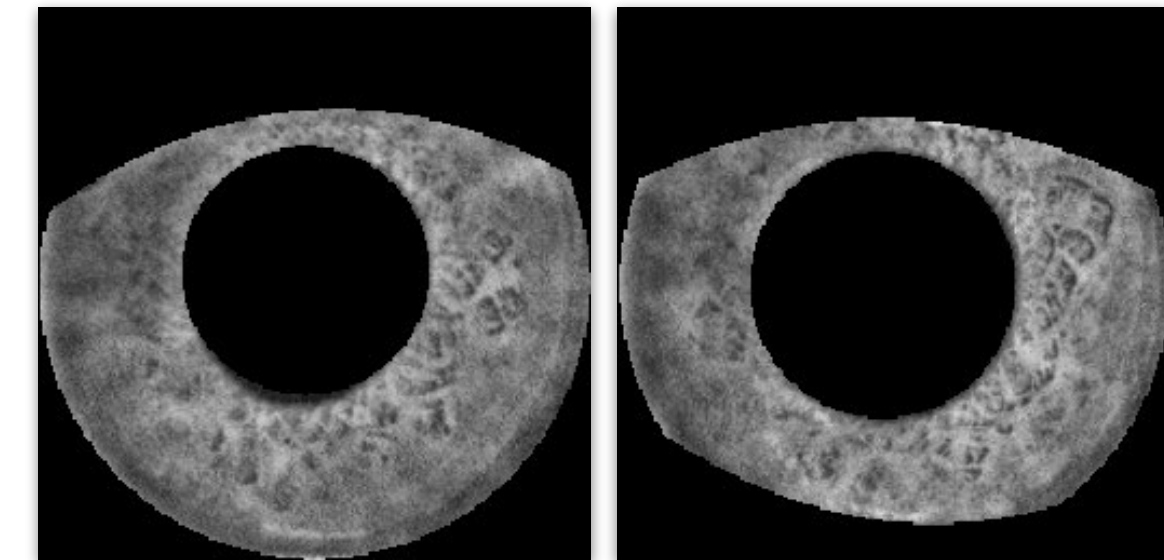
[5] Human iris recognition in post-mortem subjects: Study and database.
Trokielewicz et al. IEEE Intl. Conference on Biometrics: Theory, Applications and Systems, 2016.



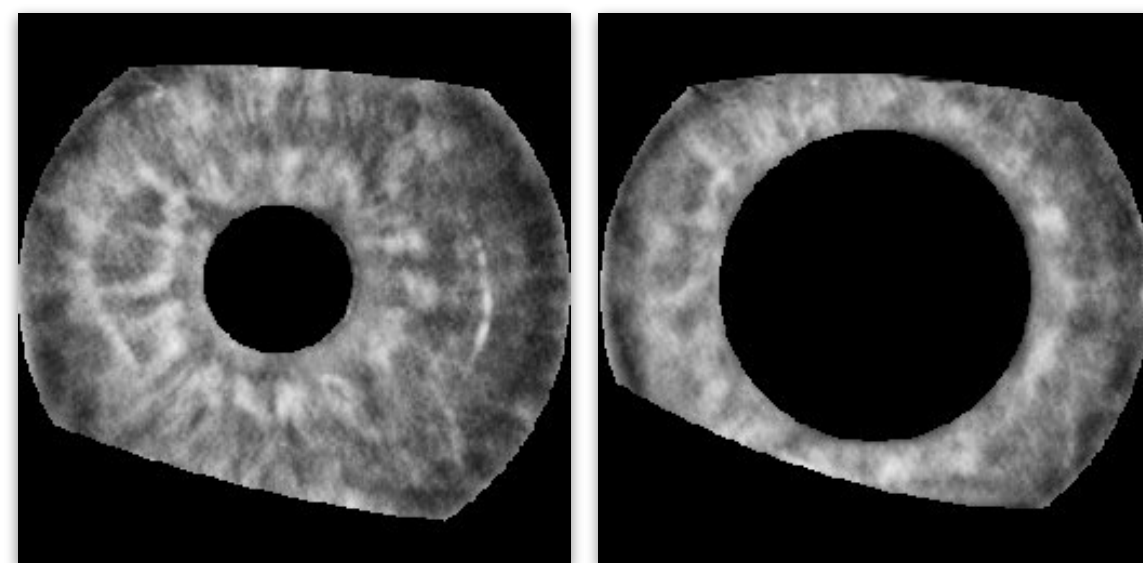
Easy for an automated solution



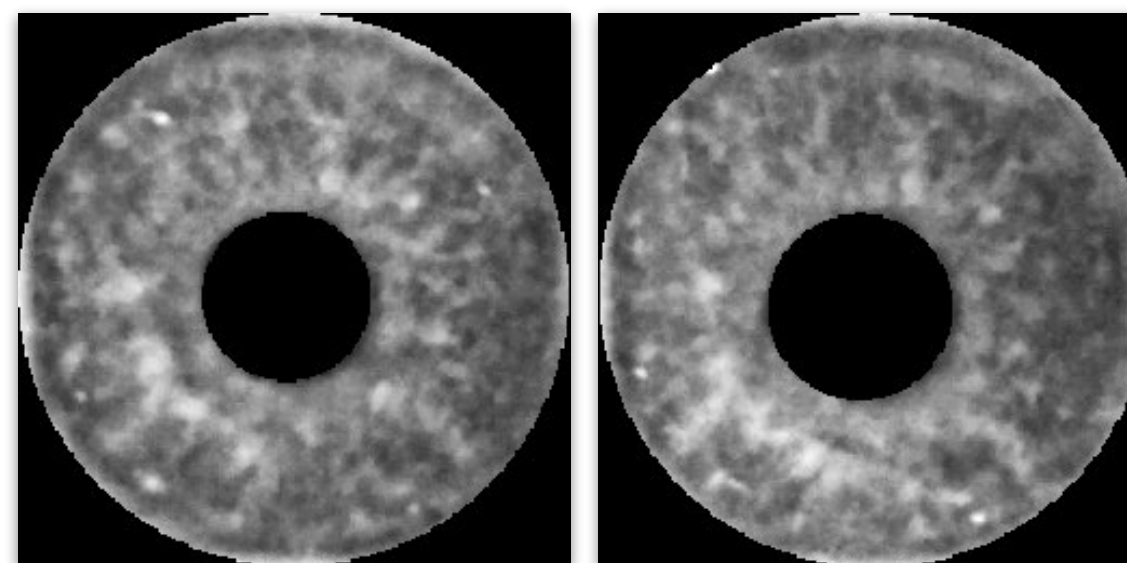
Hard for an automated solution



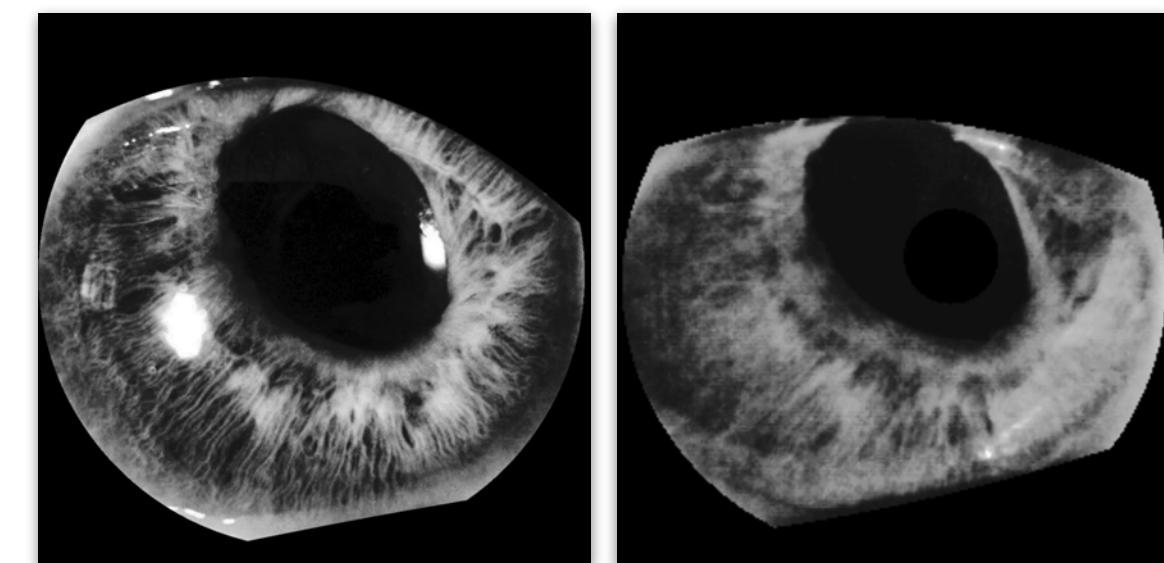
Twins'



Pupil dynamic



Deceased

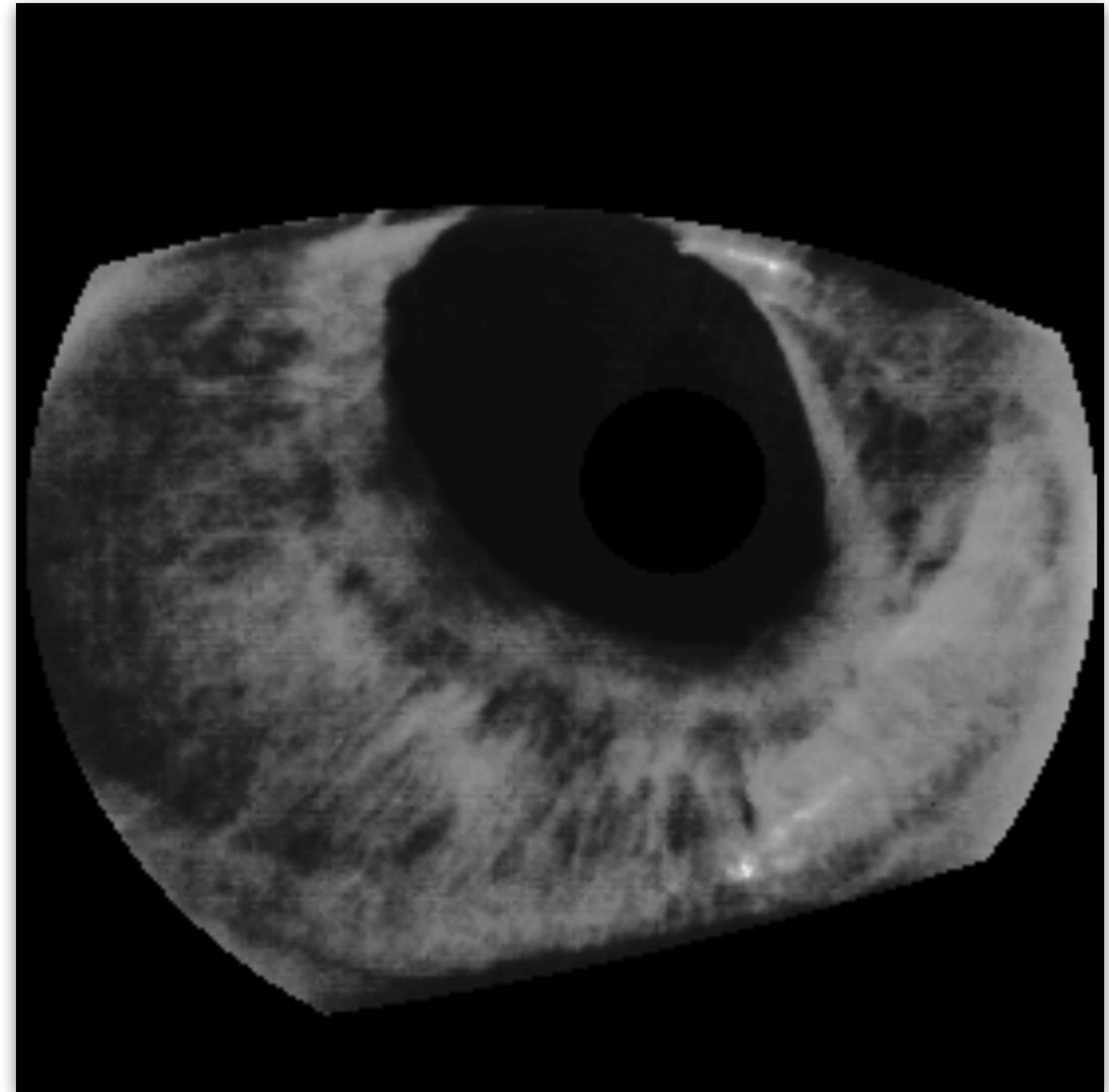
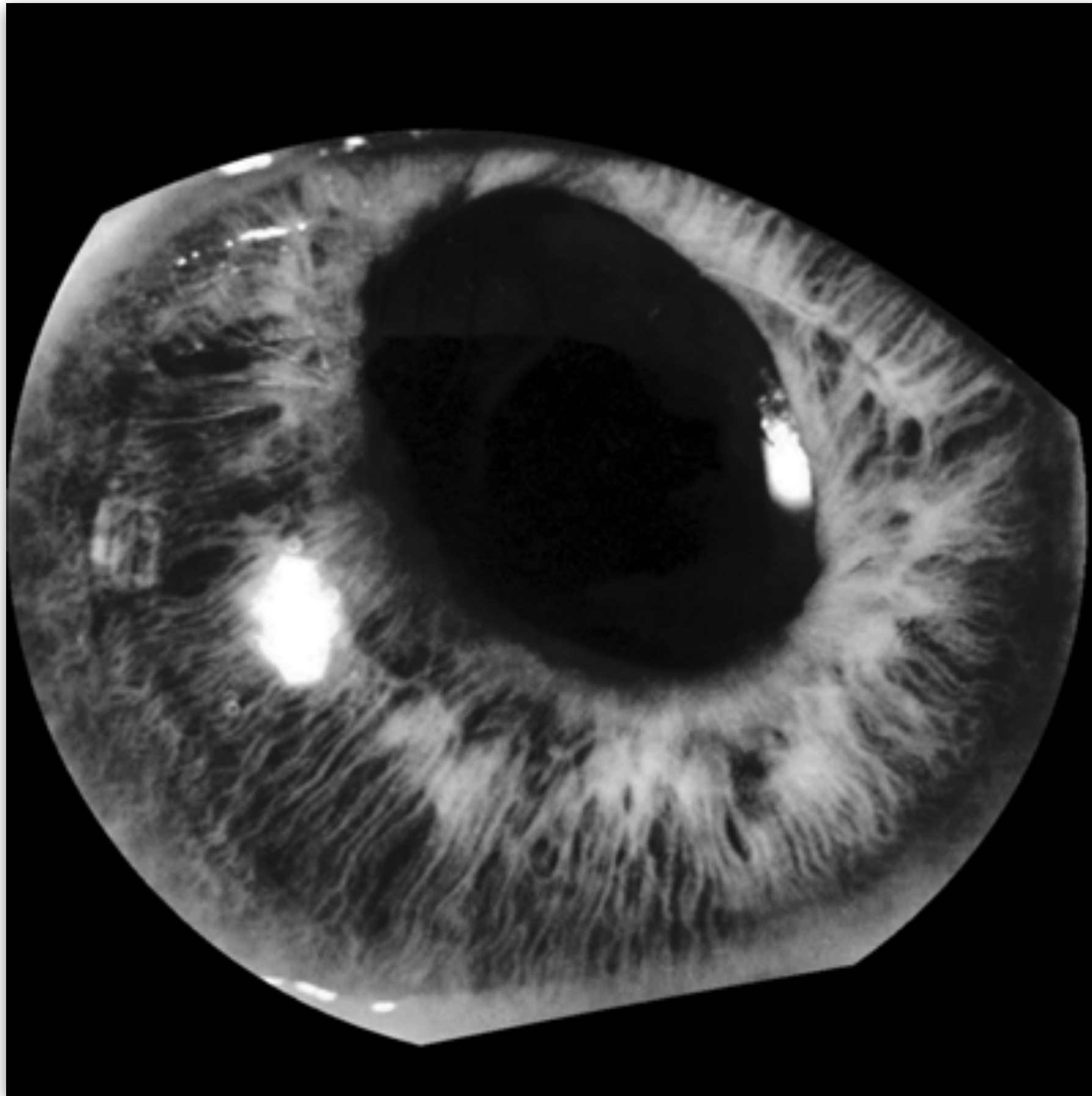


Disease-affected

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



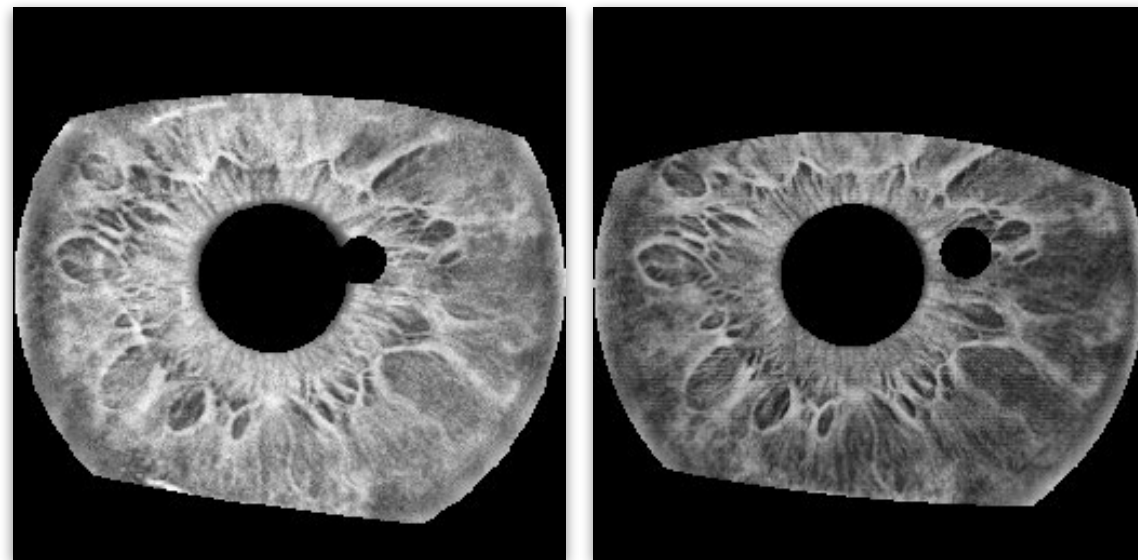
LOYOLA
UNIVERSITY CHICAGO



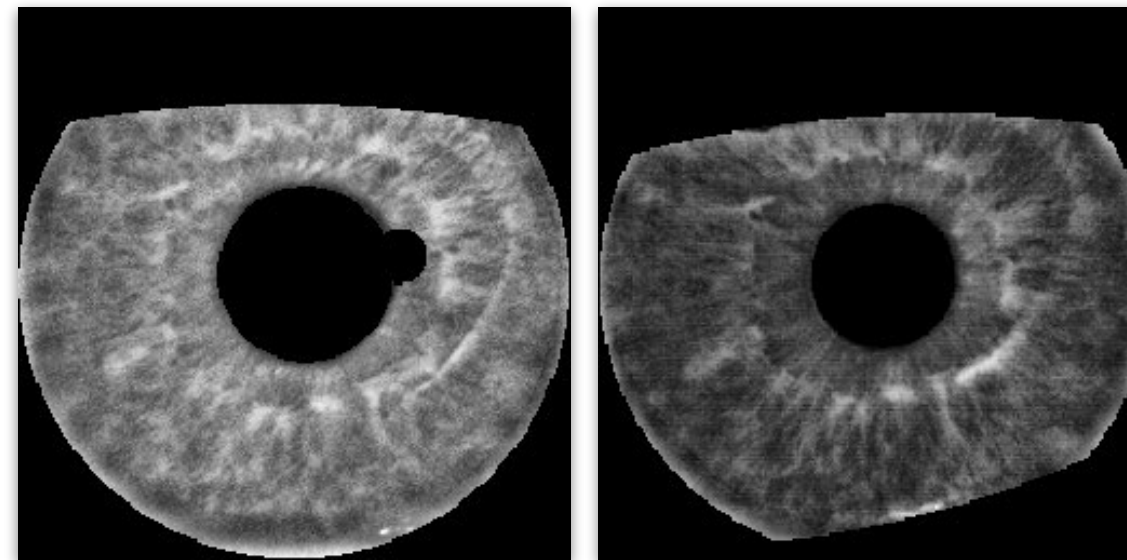
Disease-affected

Human Experiments

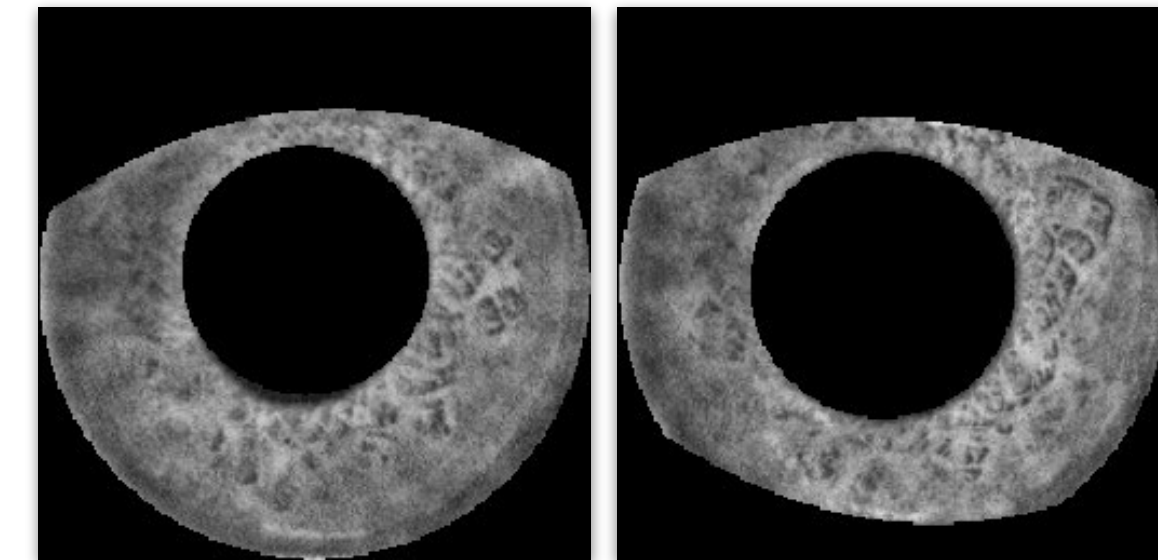
Dataset



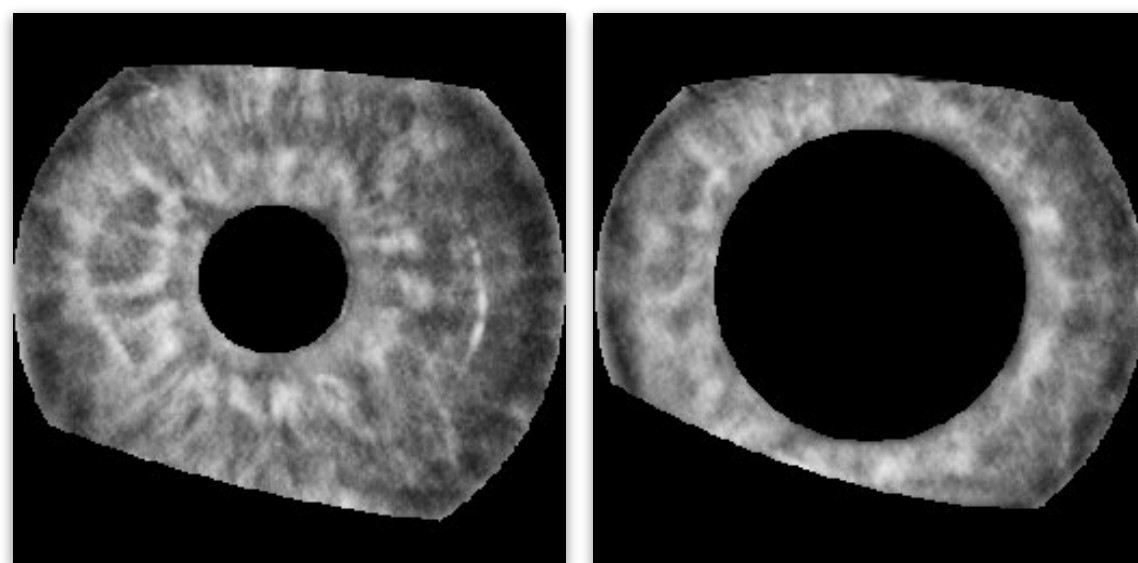
Easy for an automated solution



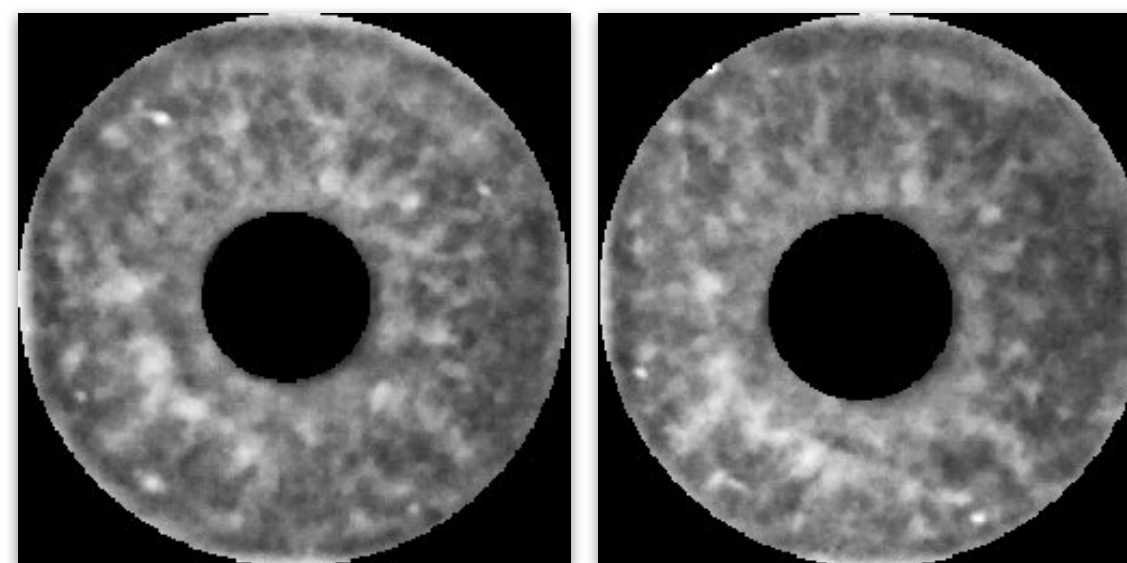
Hard for an automated solution



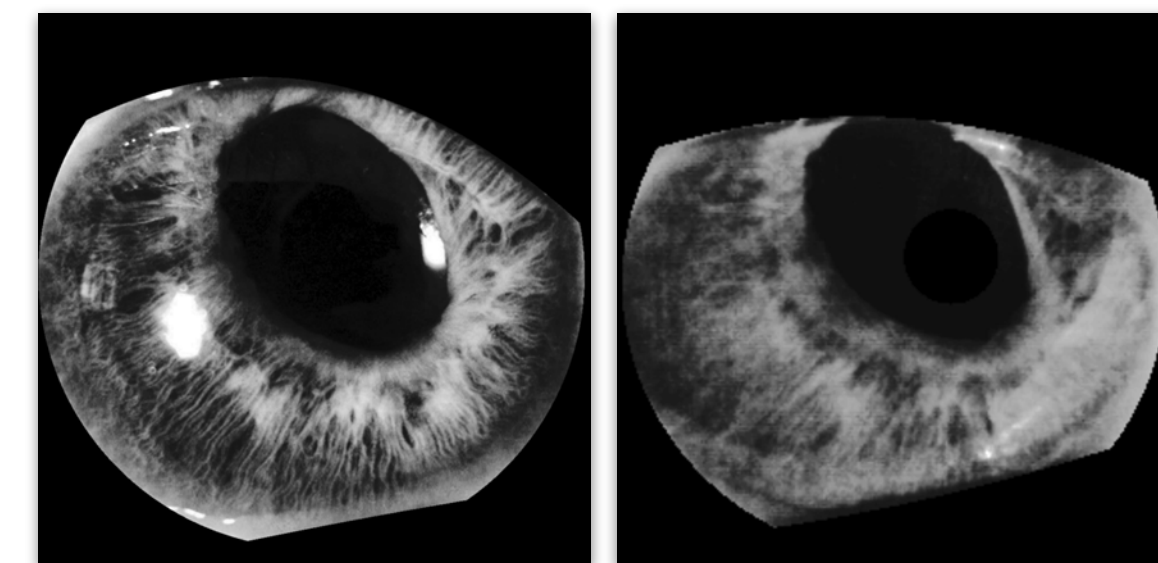
Twins'



Pupil dynamic

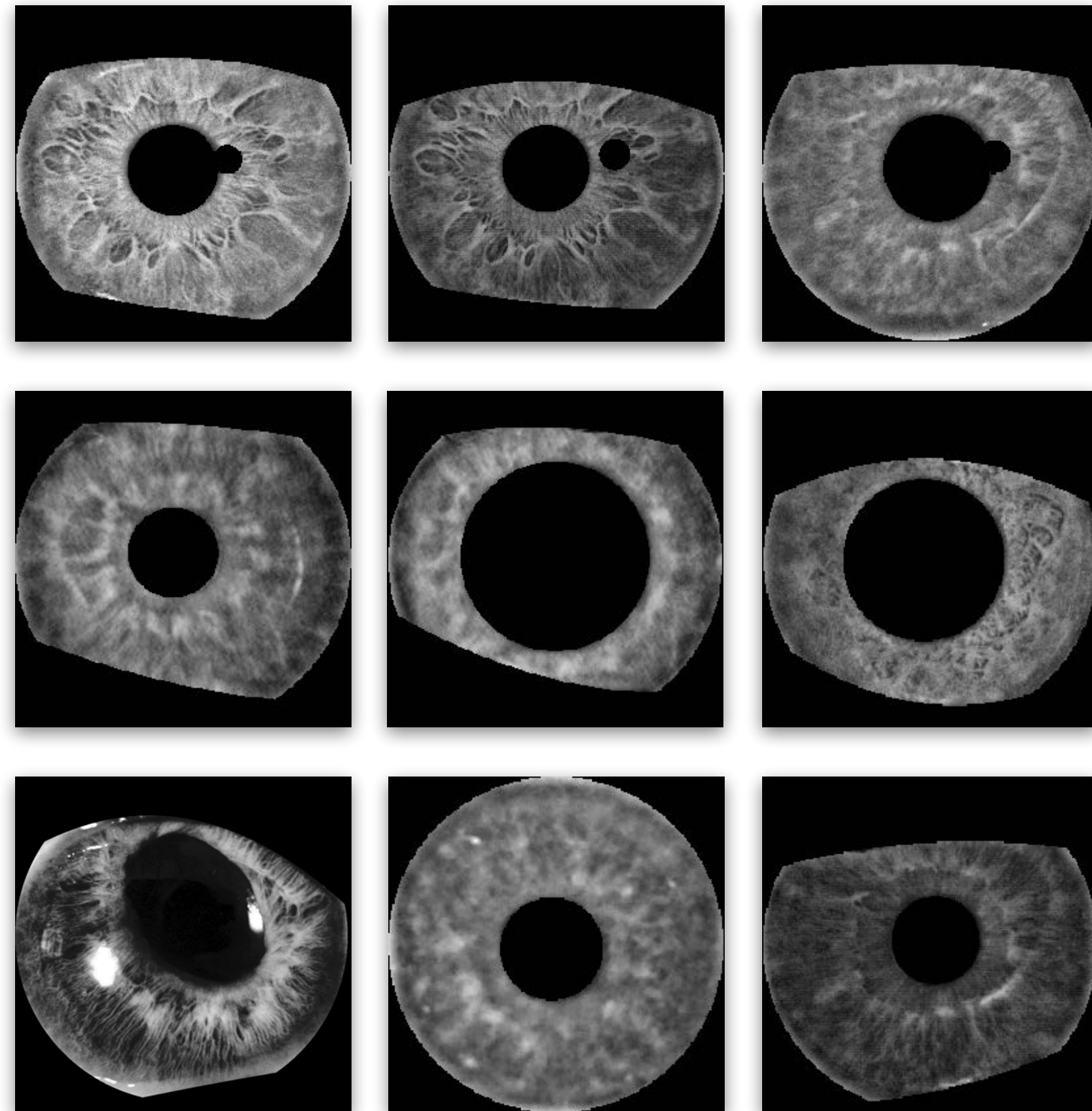


Deceased



Disease-affected

Human Experiments



1360 iris images
(NIR and manually segmented)

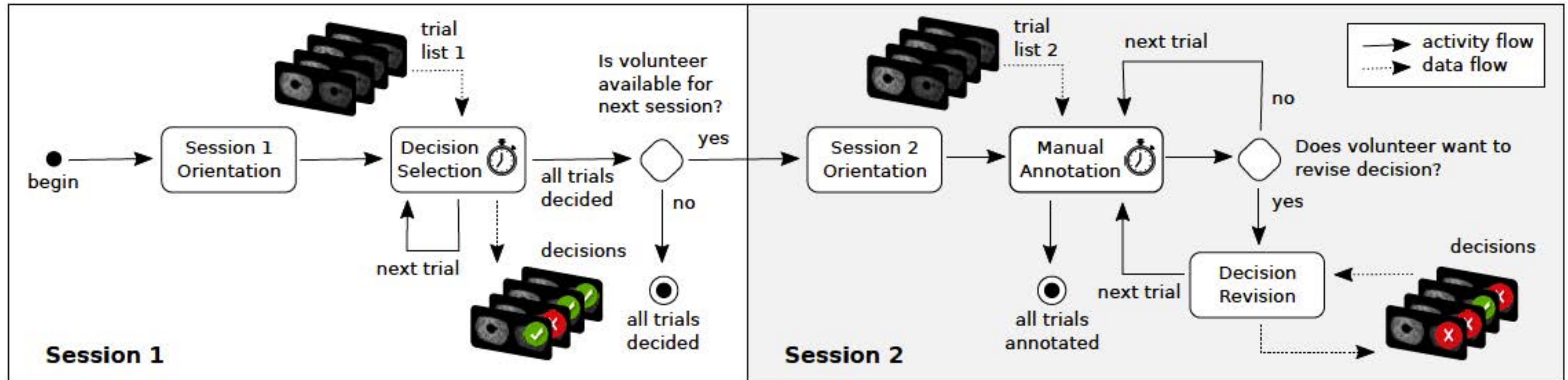
512 distinct irises
512 individuals

Iris-pair types

Genuine (not taken at the same day)

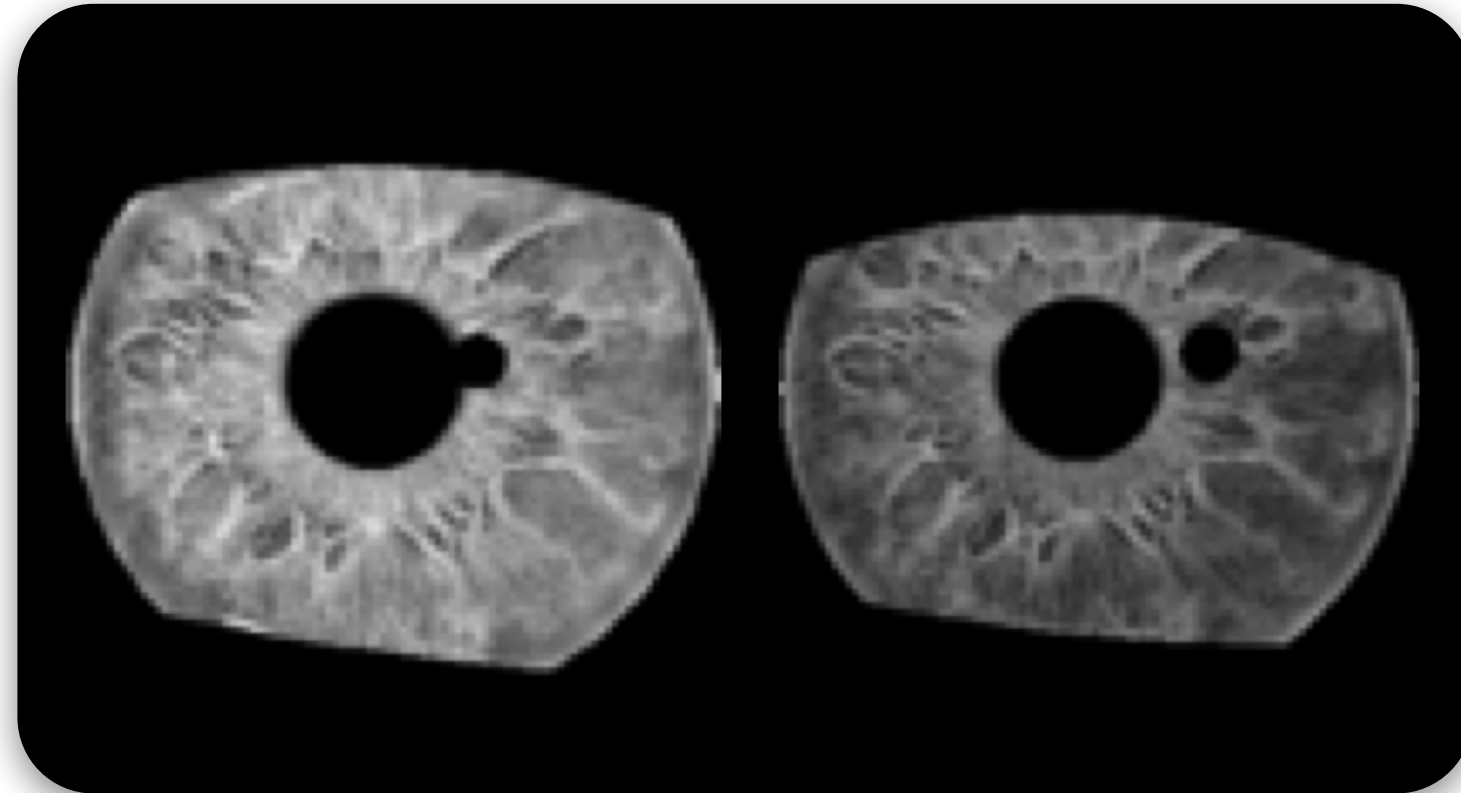
Impostor (not mixing different categories)

Human Experiments



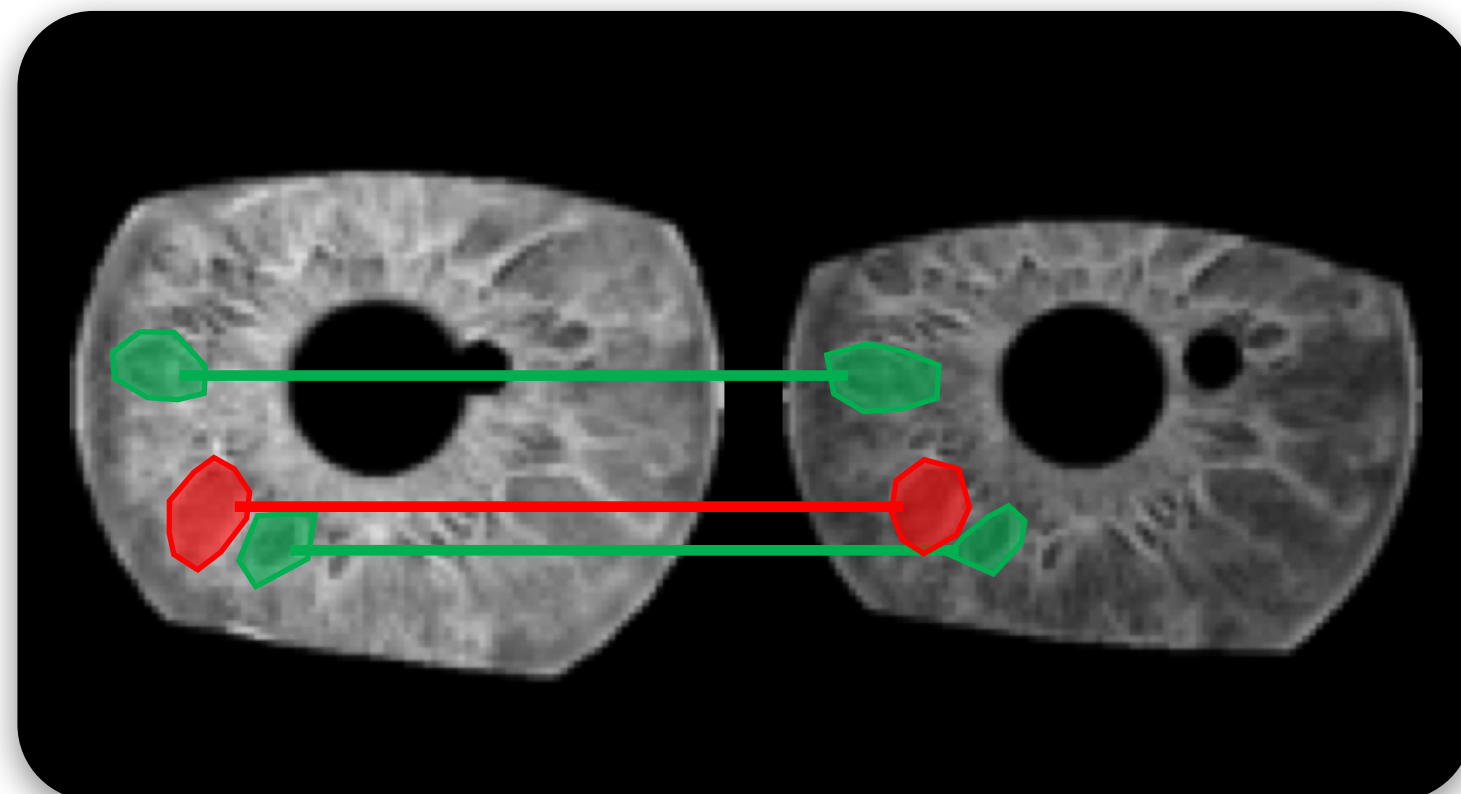
Moreira et al.,
Performance of Humans in Iris Recognition: The Impact of Iris Condition and Annotation-driven Verification
WACV 2019

Human Experiments



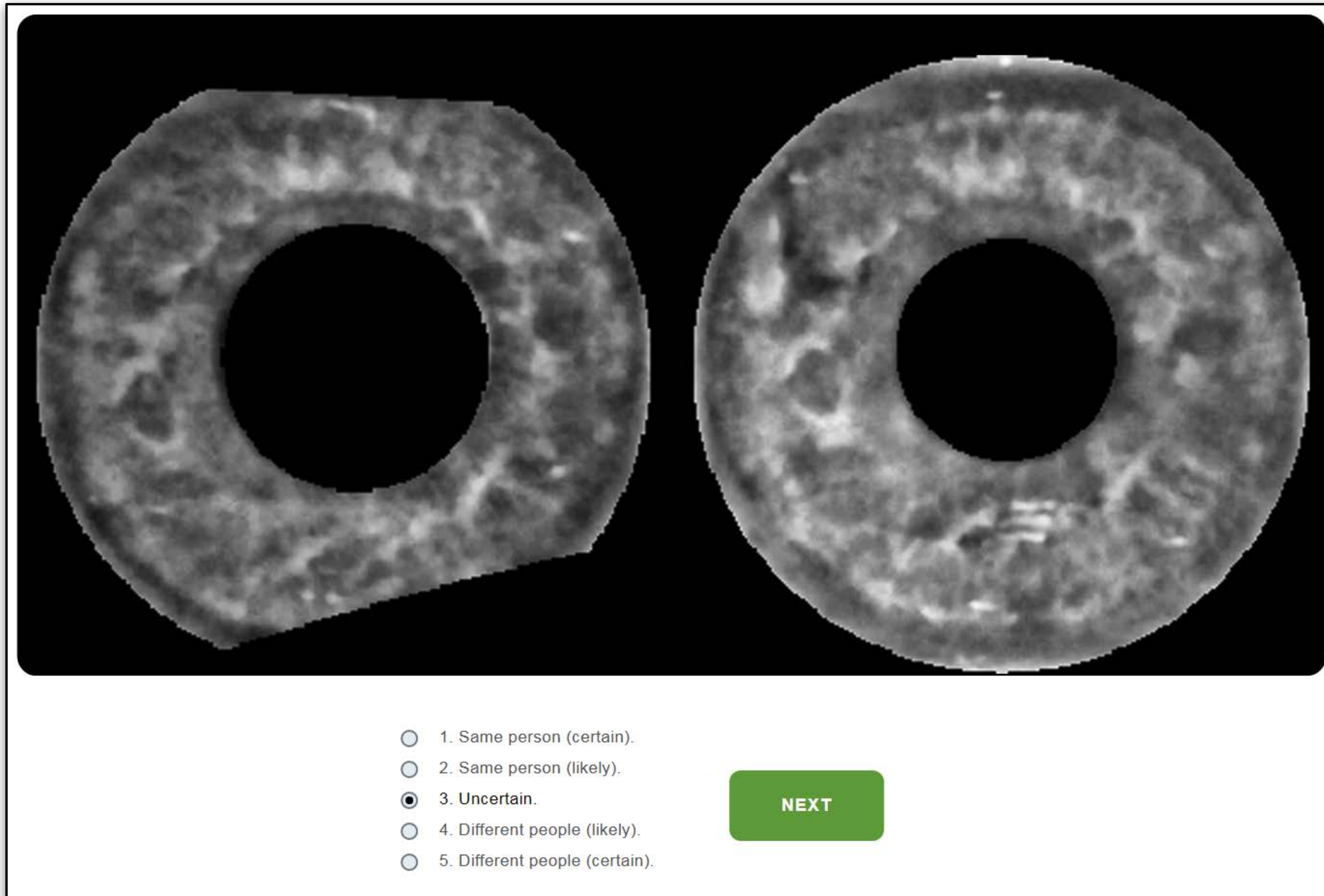
Session 1

- ☐ 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

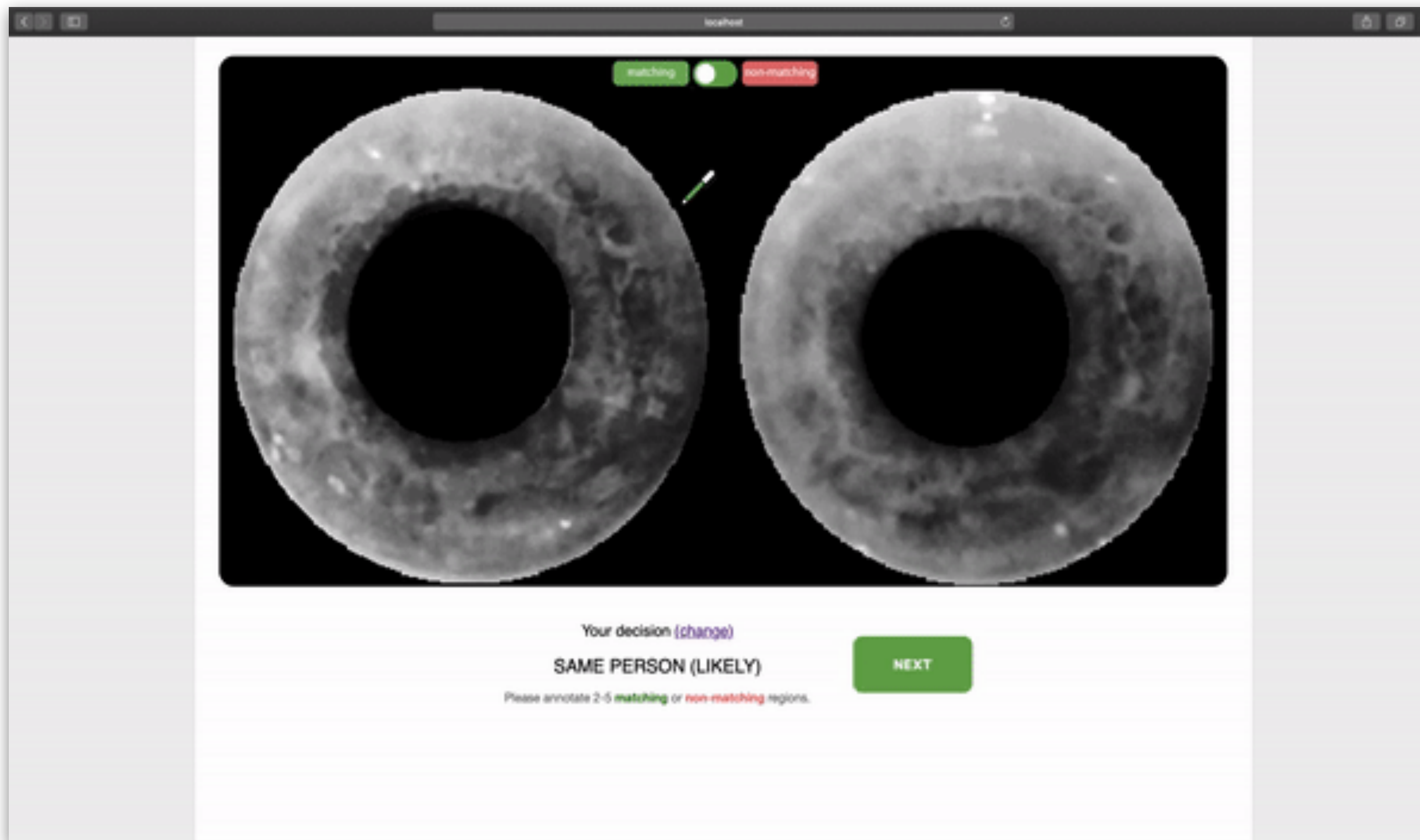


114 people
(age 18 to 65)

For each person
20 trials

Average session time
7 min

Balanced distribution
Category wise
Pair-type wise
Random presentation



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>

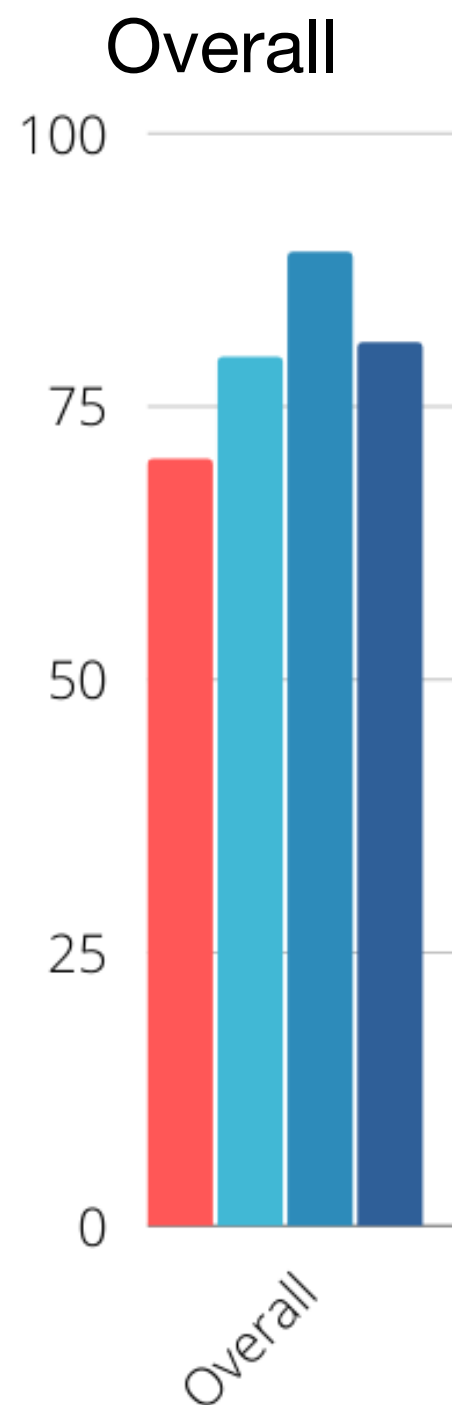


Paper.js
Web-browser drawing
library.



Human Experiments

Accuracy (%)



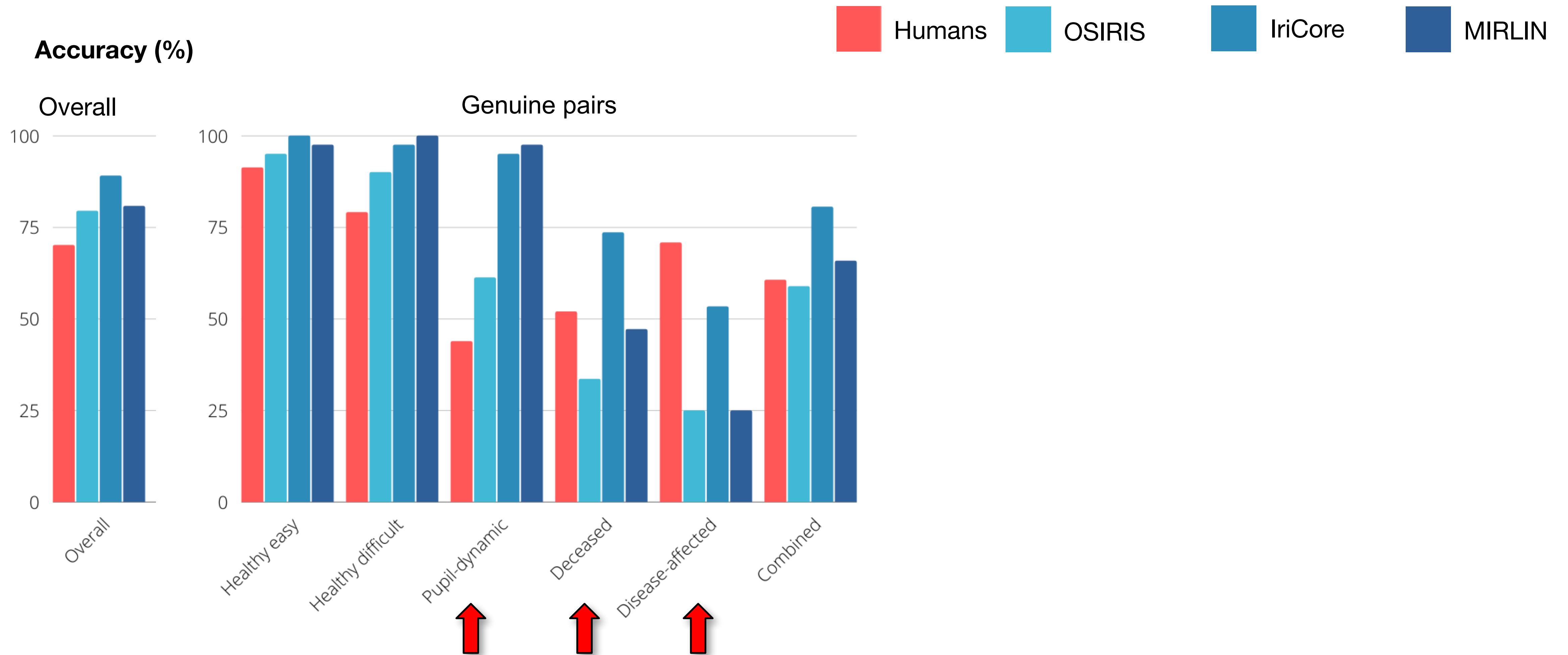
Humans OSIRIS [2] IriCore [6] MIRLIN [7]

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

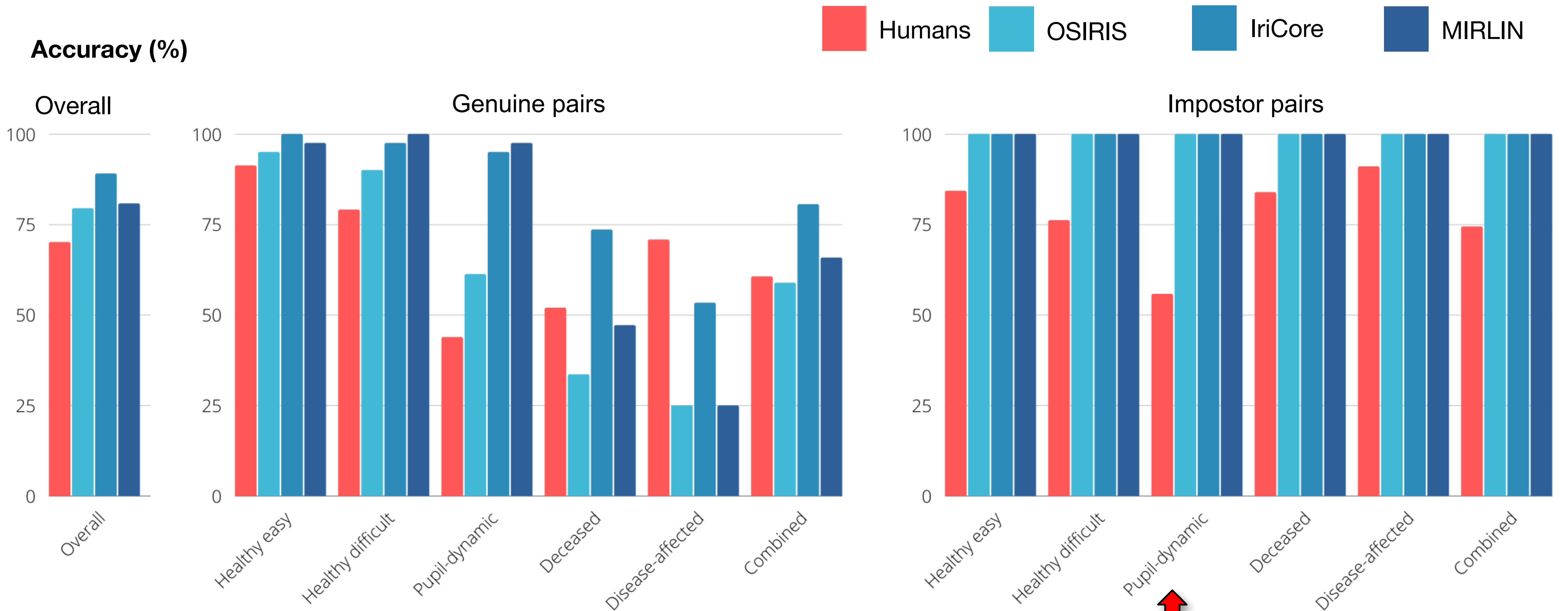
[6] IriCore.
Iritech, Inc. Available at <http://www.iritech.com>, 2018.

[7] MIRLIN Iris Recognition.
FotoNation. Available at <https://www.fotonation.com>, 2018.

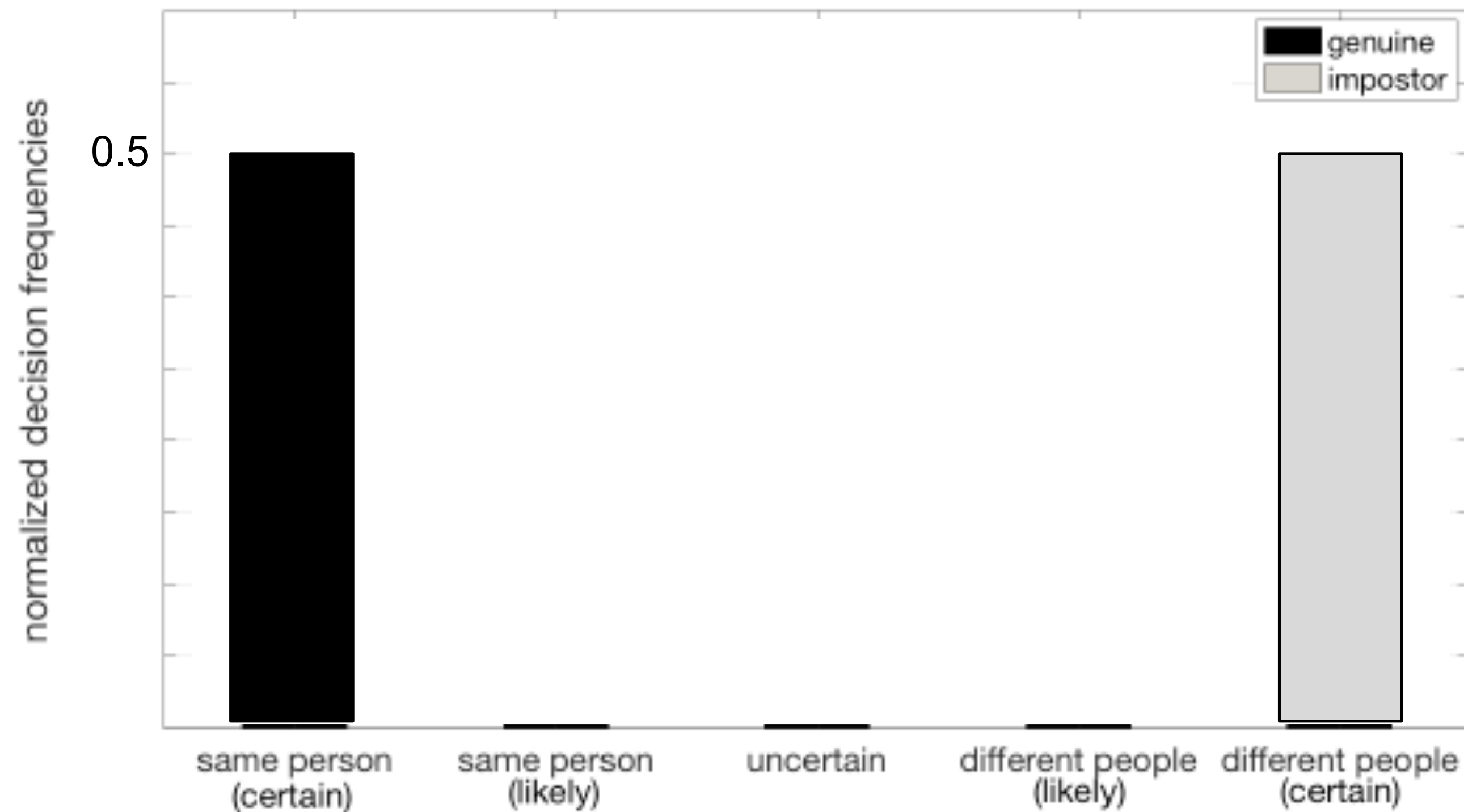
Human Experiments



Human Experiments



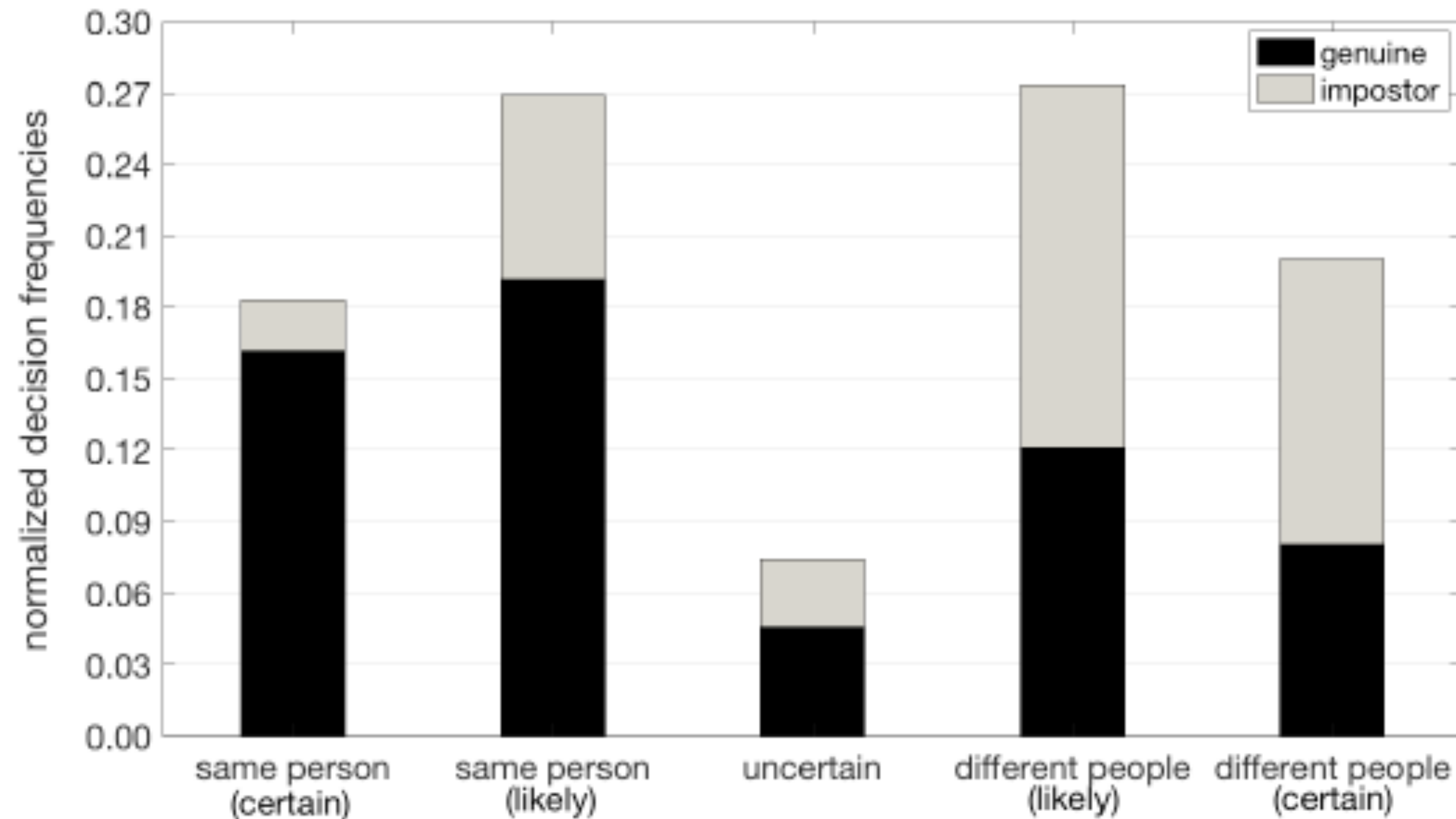
Human Experiments



How confident were people?

Ideal graph

Human Experiments

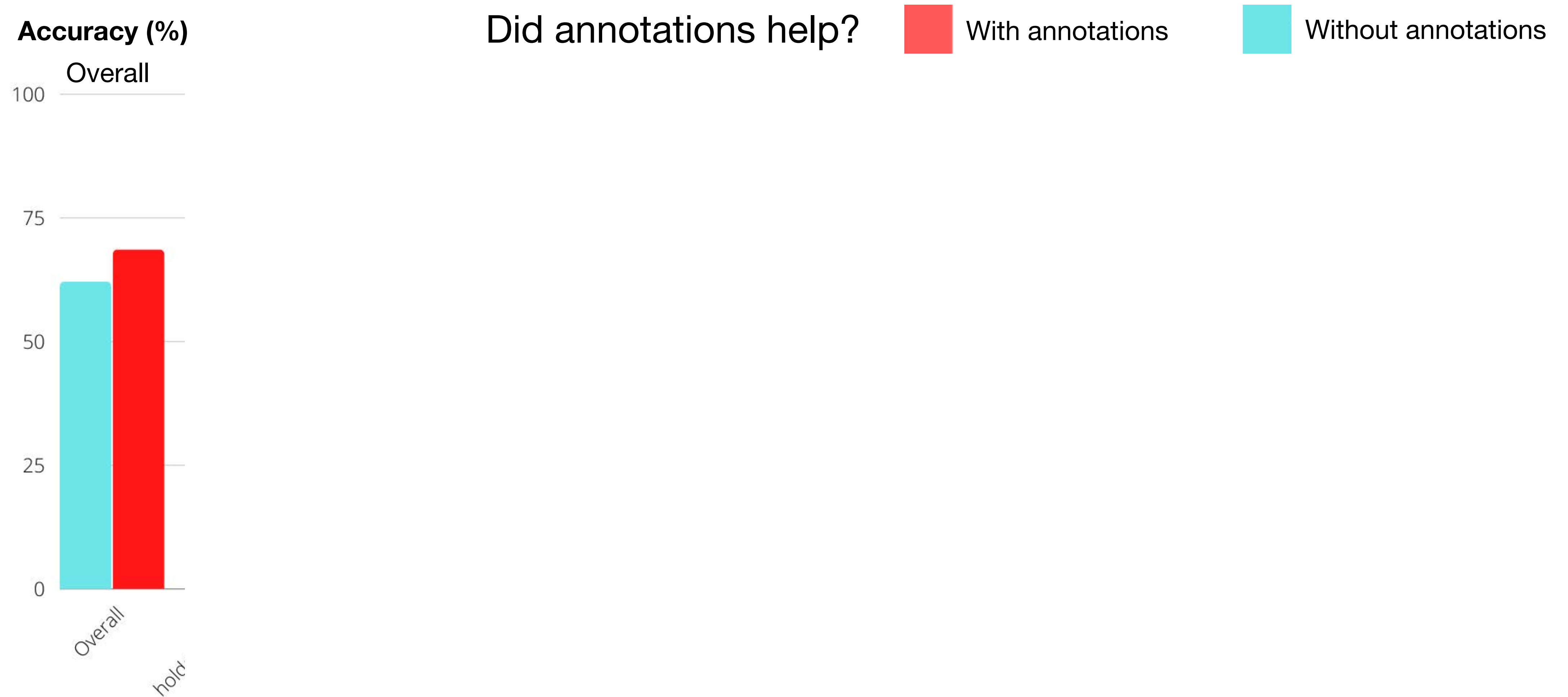


How confident were people?

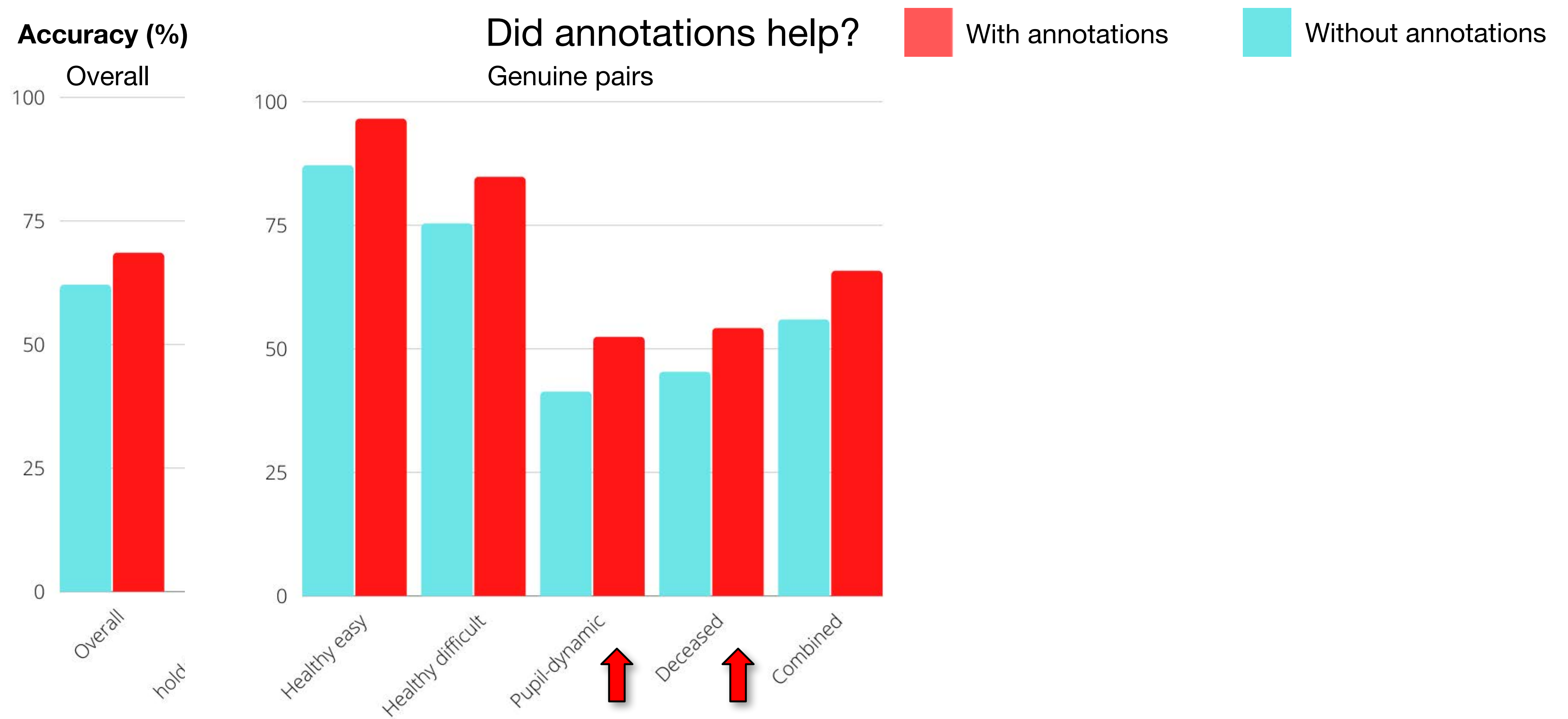
Obtained graph



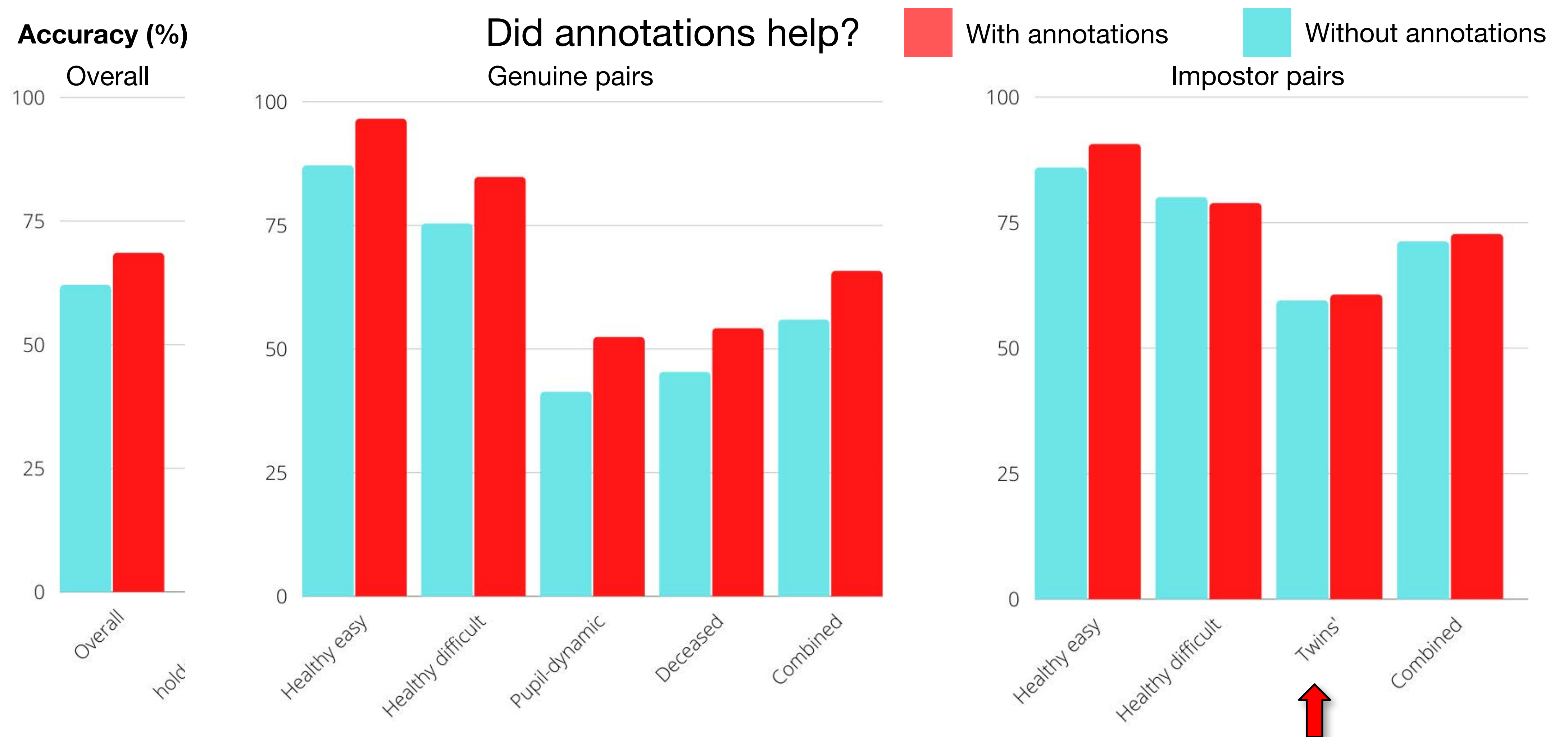
Human Experiments



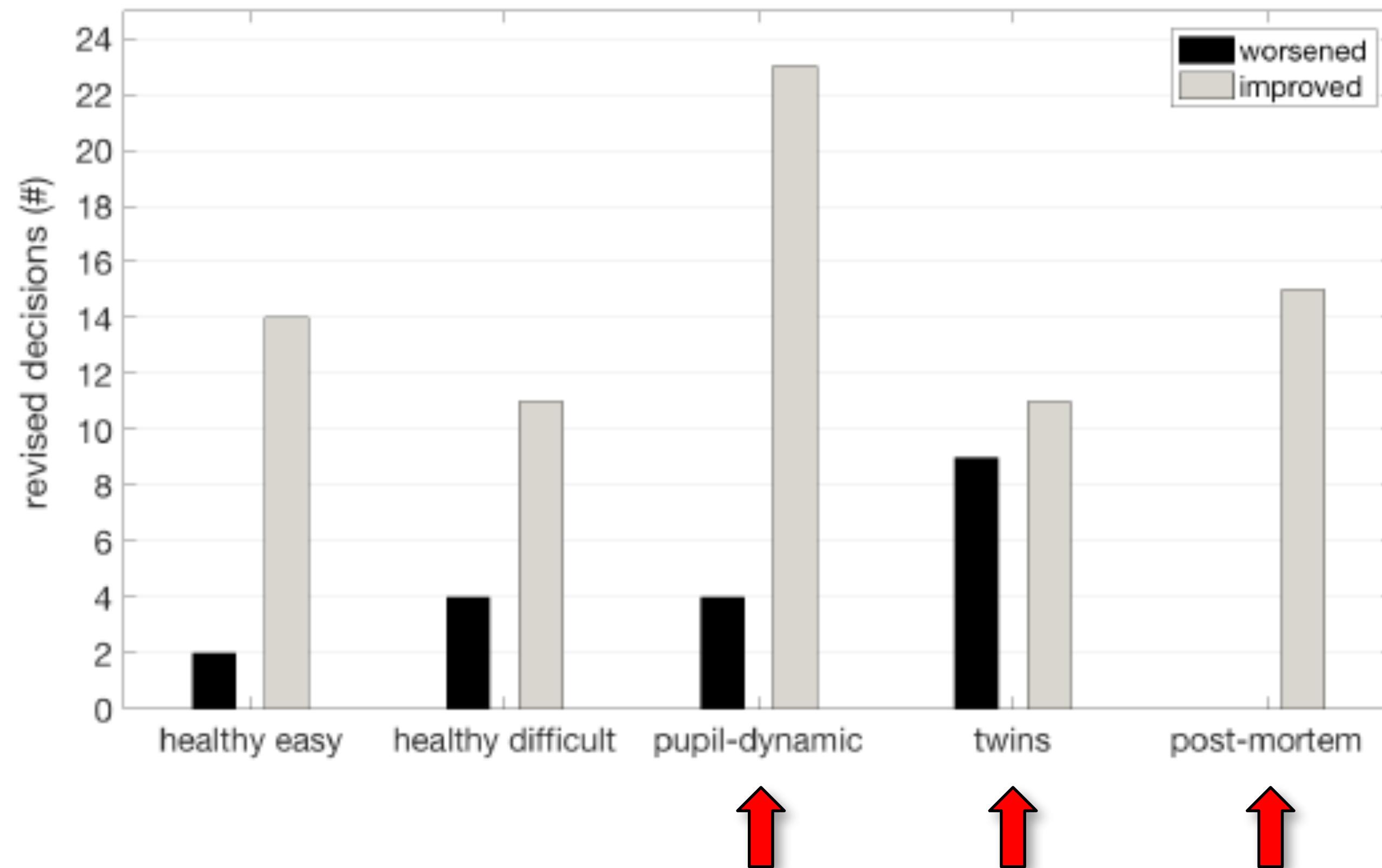
Human Experiments



Human Experiments

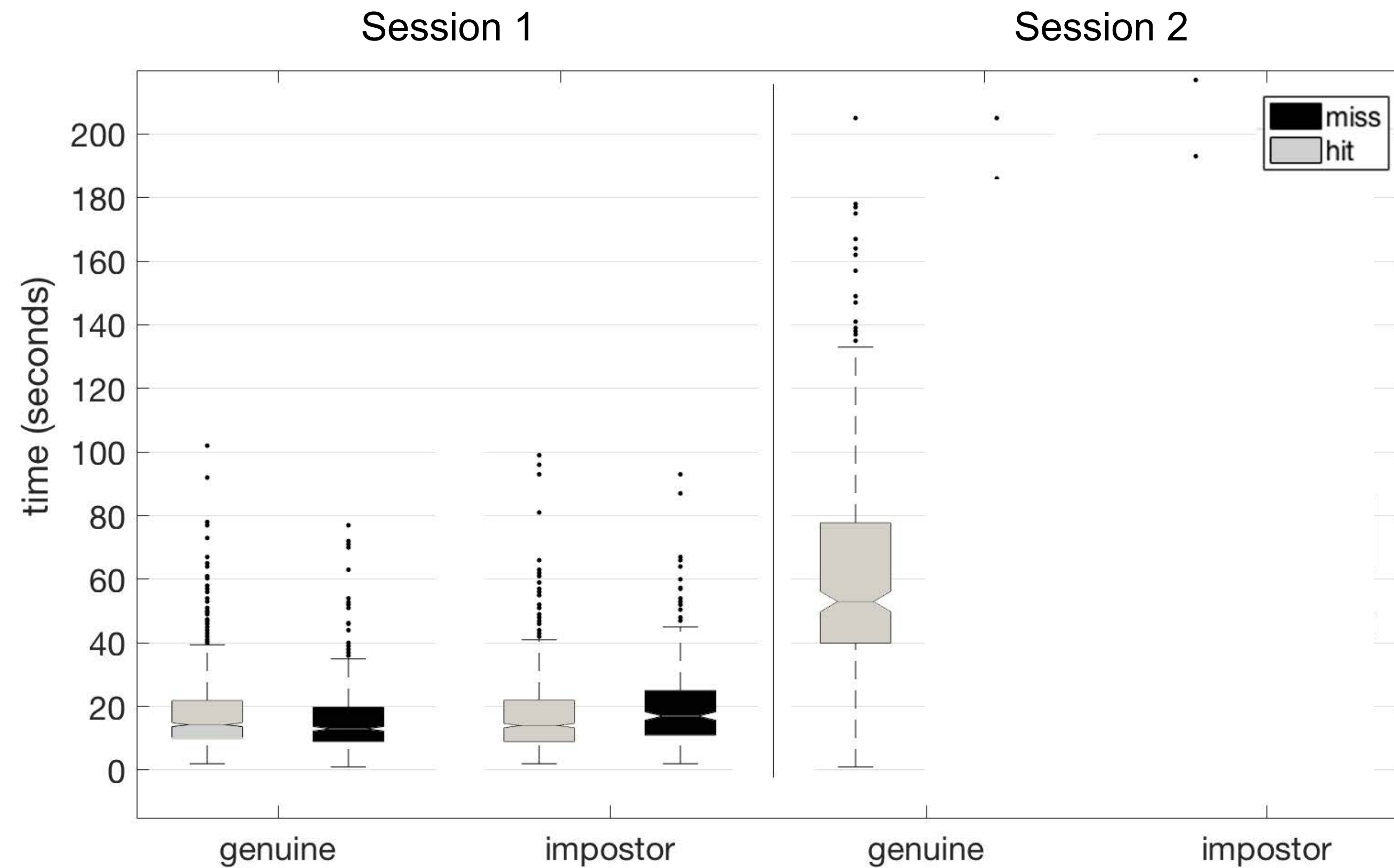


Human Experiments



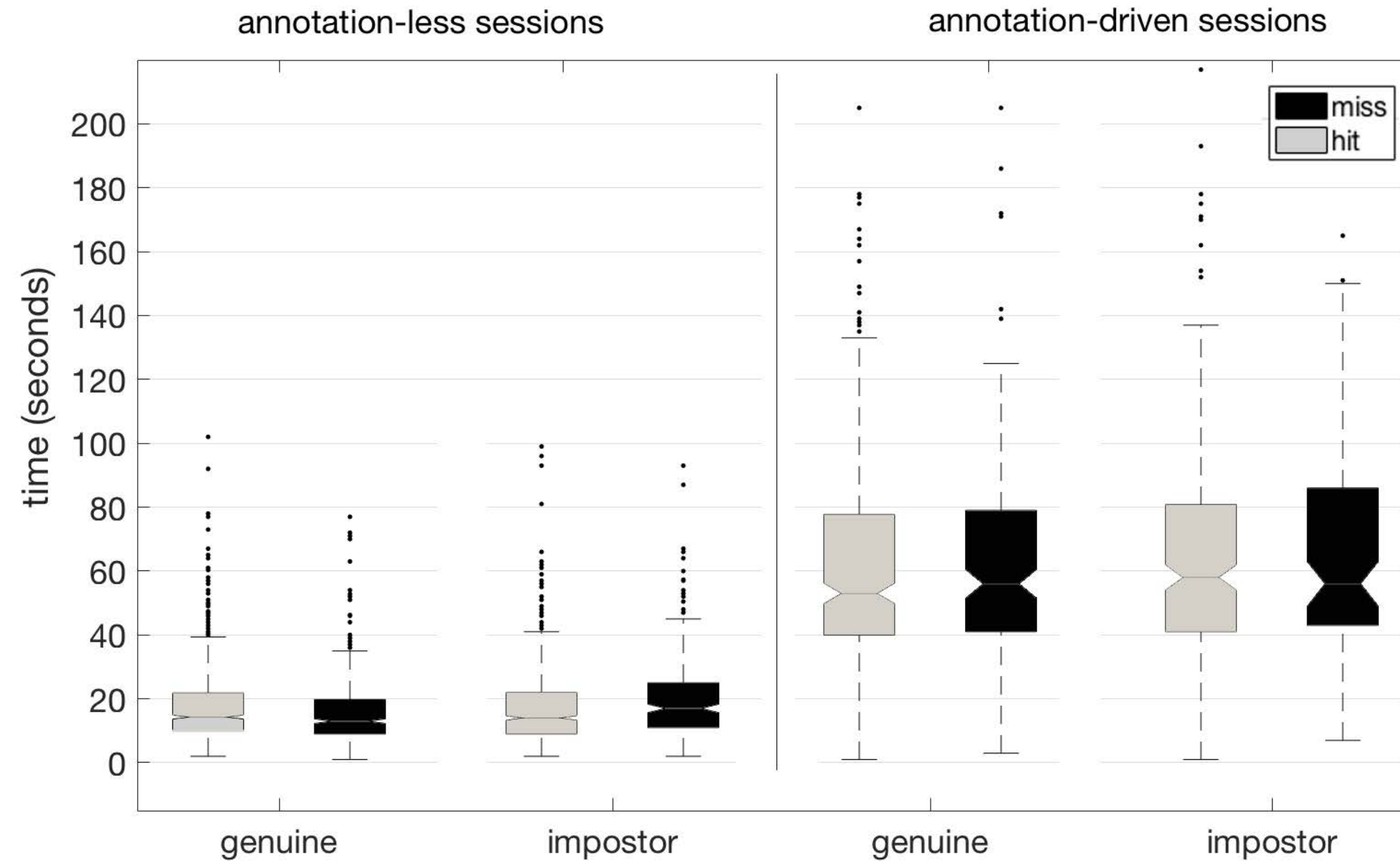
Did annotations help?

Human Experiments



Was time important?

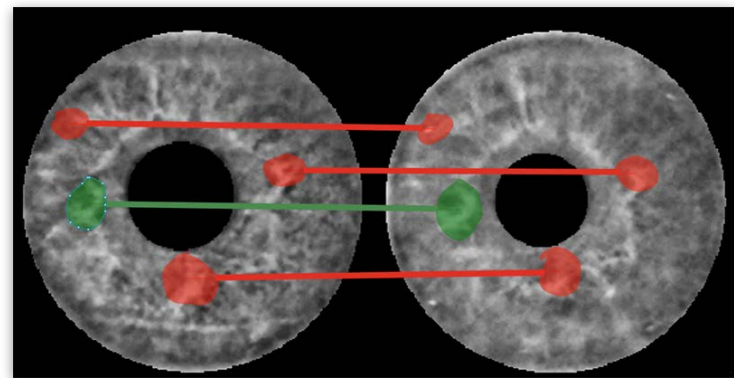
Human Experiments



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**.

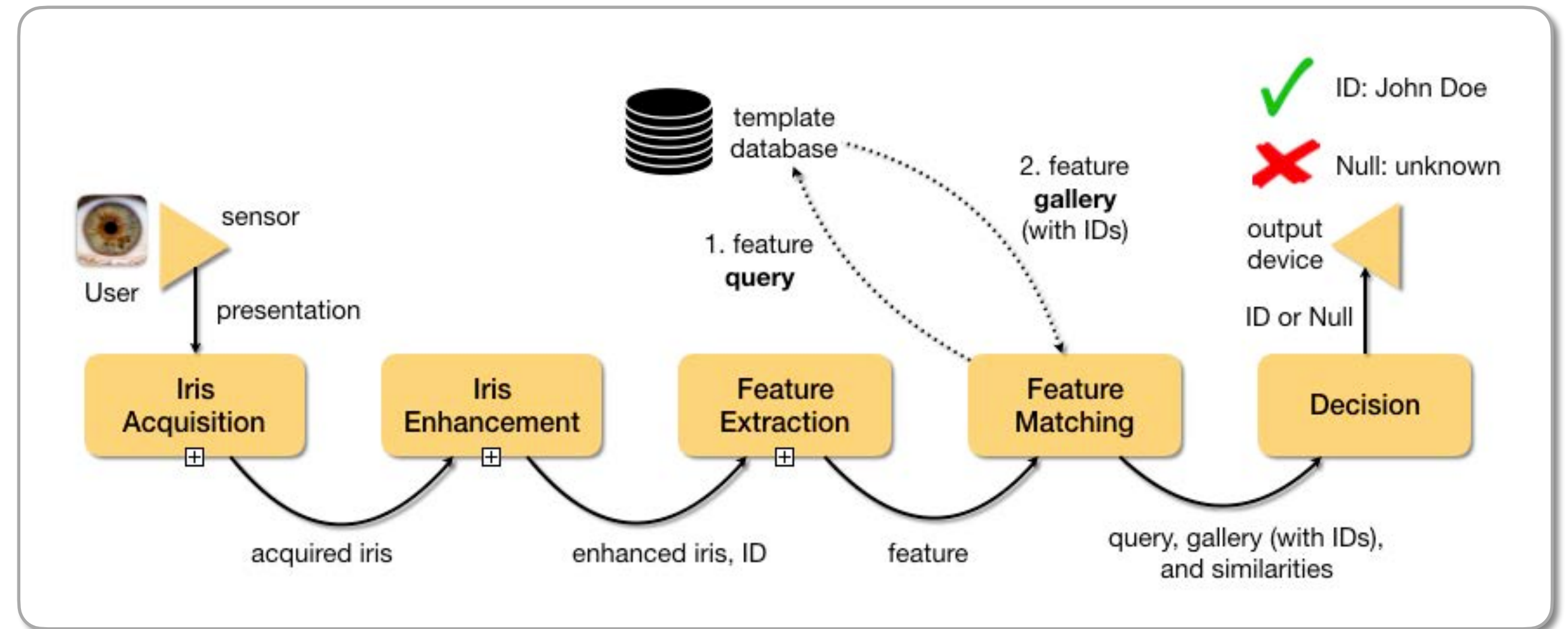
Annotating pupil dilation helps.

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 sakai.luc.edu/x/BCJs8K.