Iris Recognition I

COMP 388-002/488-002 Biometrics

Daniel Moreira

Fall 2026



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UNIVERSITY CHICAGO

Today we will…

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

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Today's Attendance

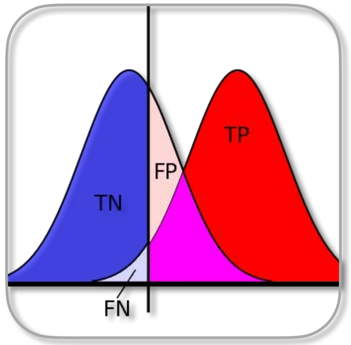
Please fill out the form

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Course Overview

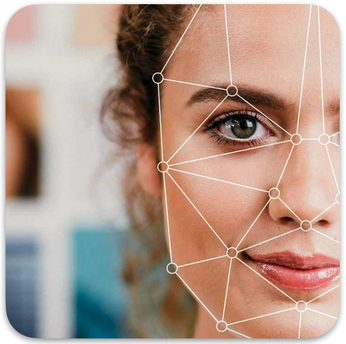
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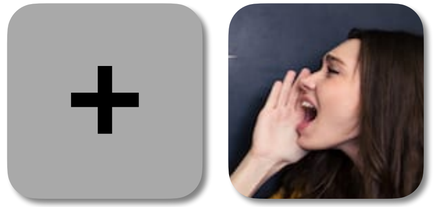
Basics
Concepts
Metrics
Metric implementation







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



Alternative Traits and Fusion
Concepts

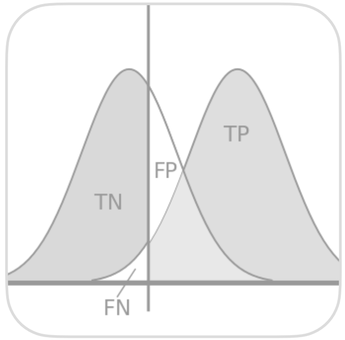


Invited Talks (2)
State of the art
Future work

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Course Overview

Content



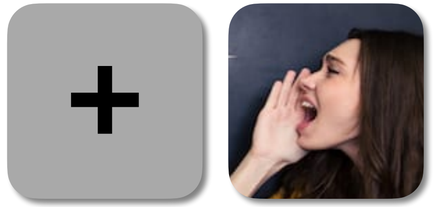
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Core Traits (3)
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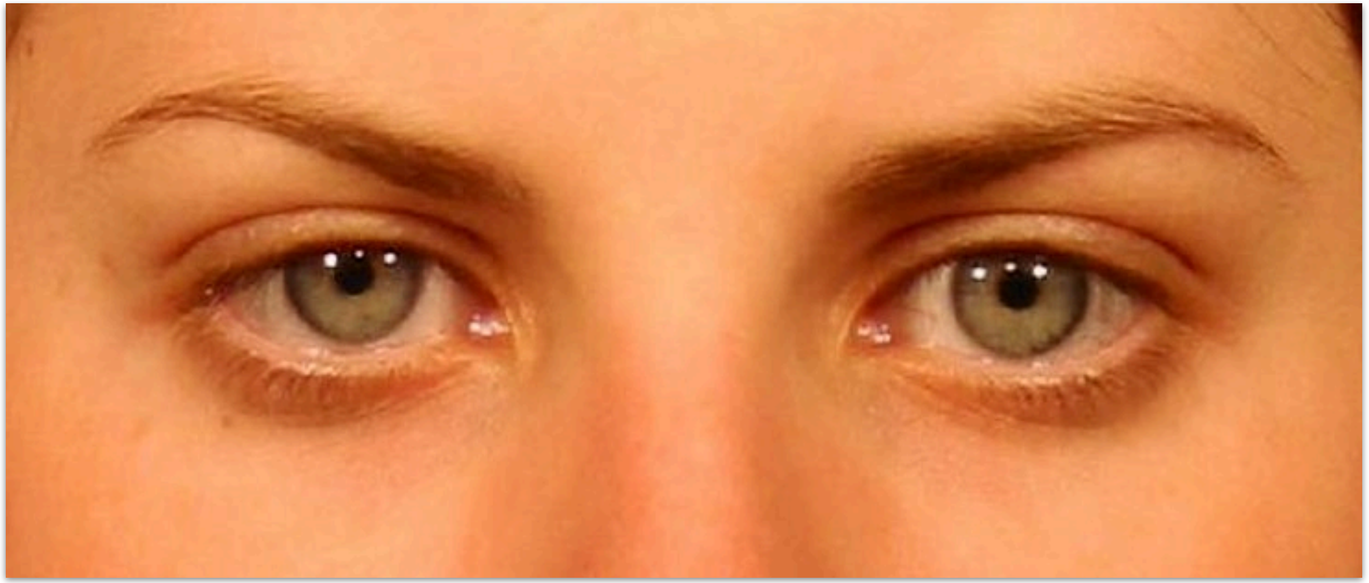
Alternative Traits and Fusion
Concepts



Invited Talks (2)
State of the art
Future work

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Irises

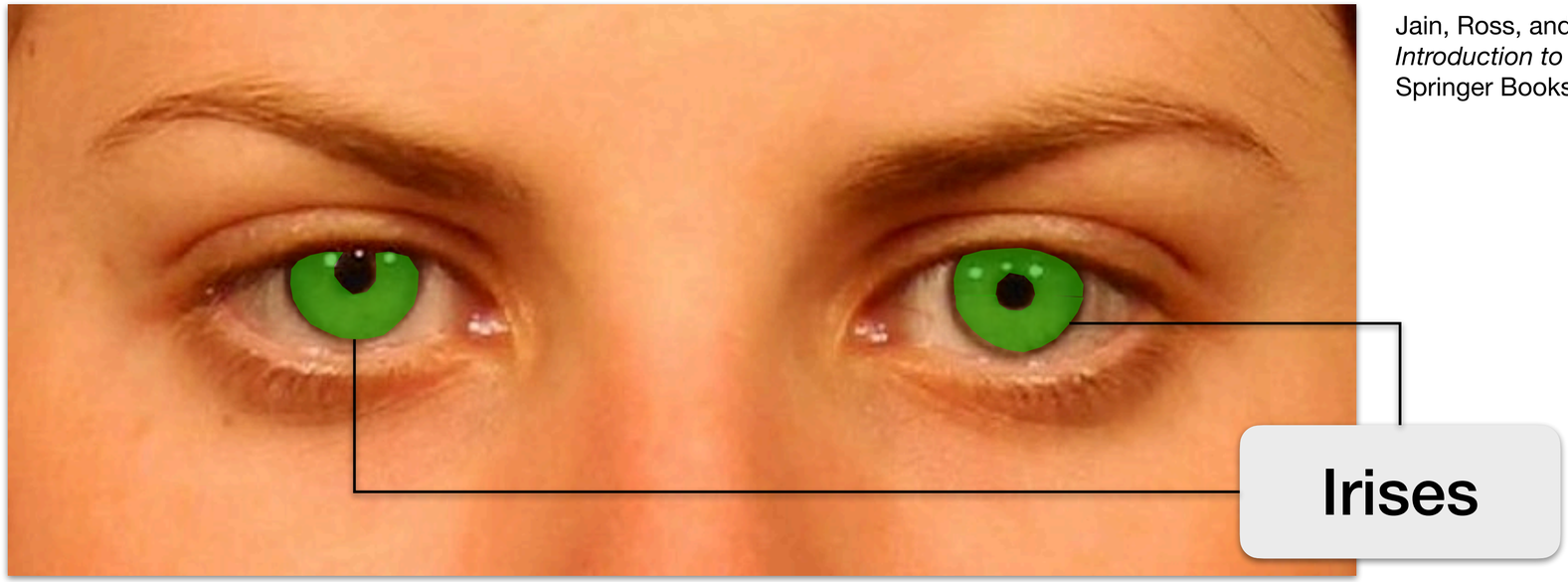


Jain, Ross, and Nadakumar
Introduction to Biometrics
Springer Books, 2011

Ocular Region

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Irises



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

Ocular Region

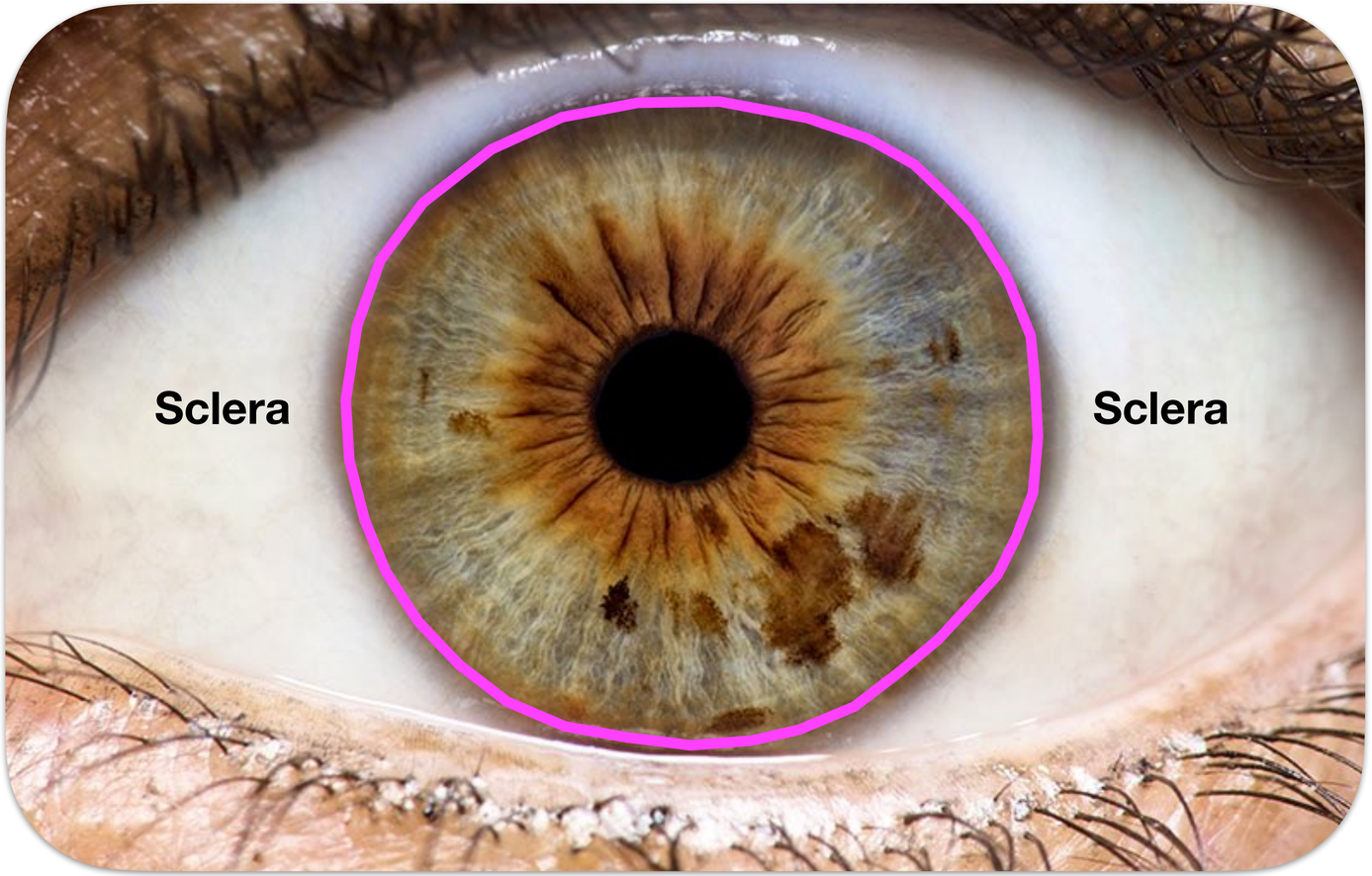
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Anatomy



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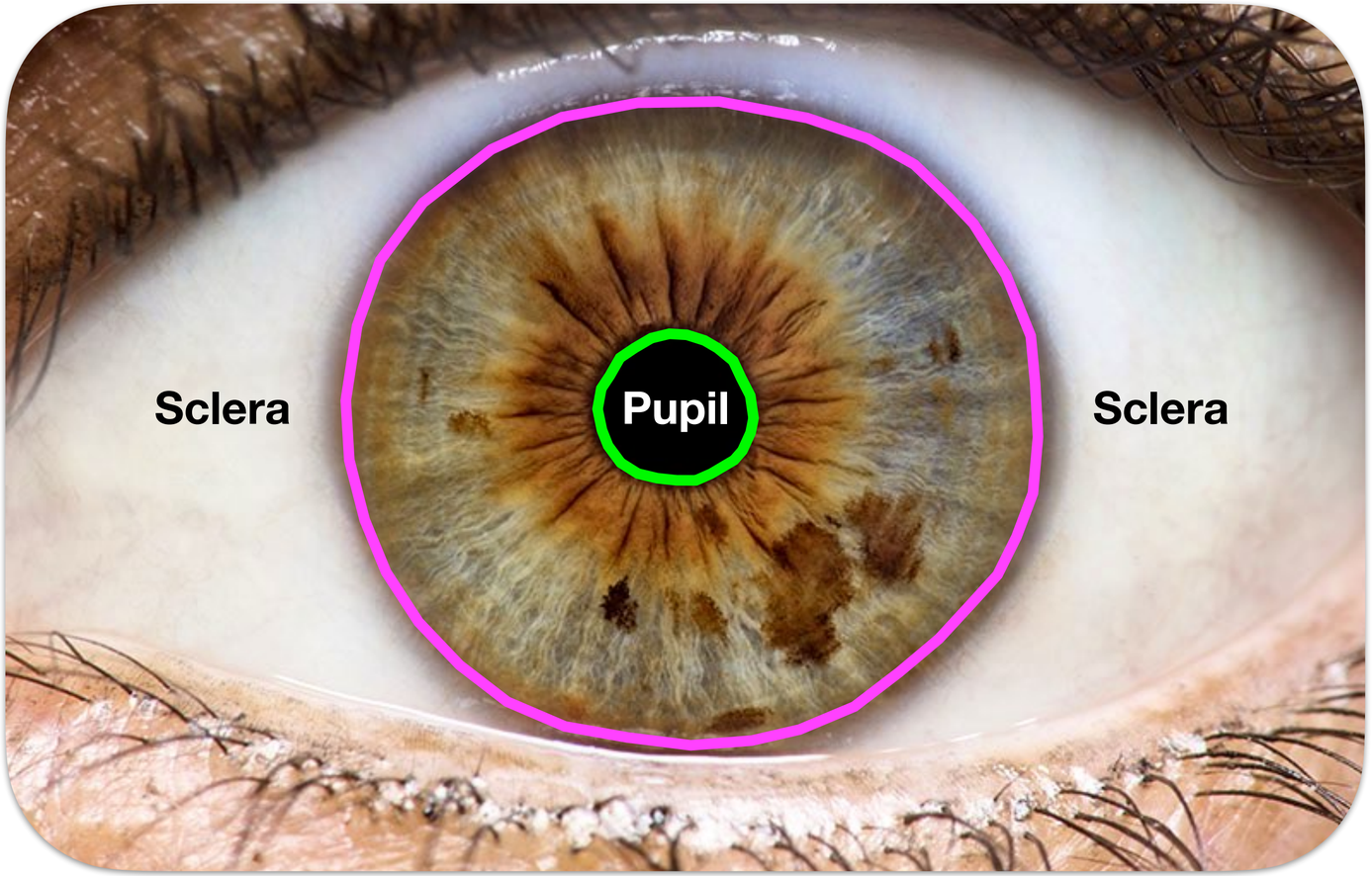
Anatomy



Limbus boundary

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Anatomy

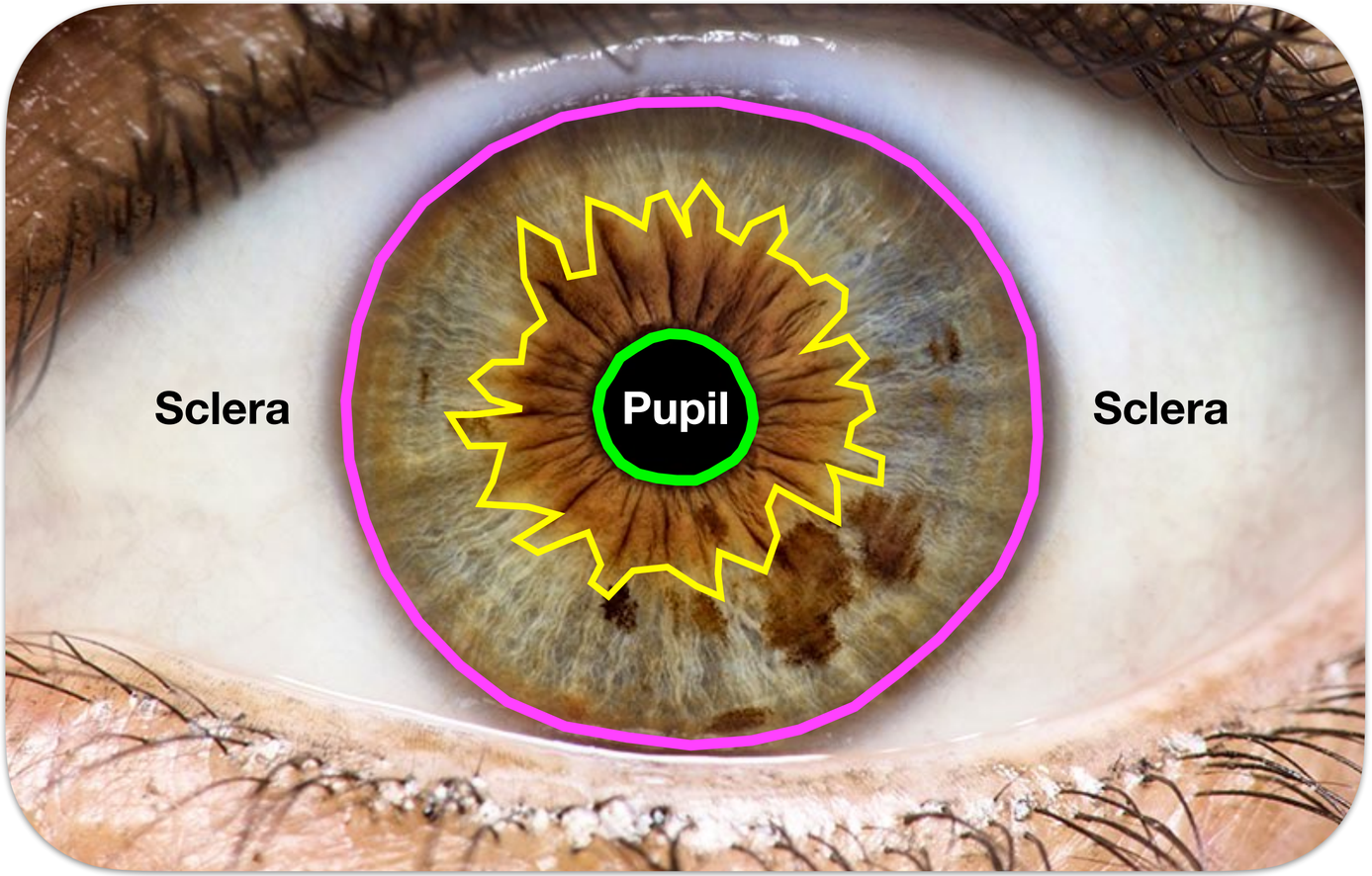


Limbus boundary

Pupillary boundary

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Anatomy



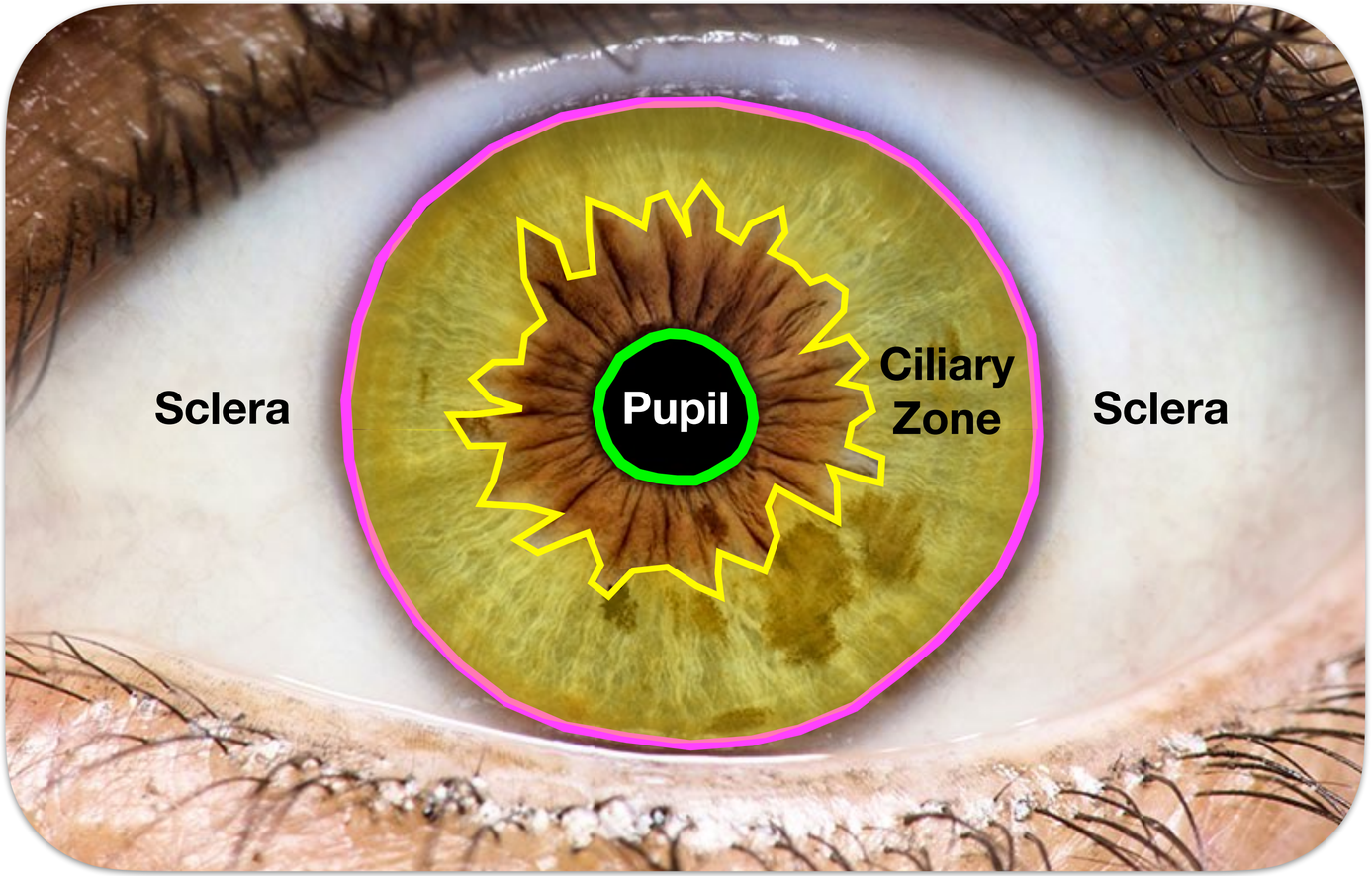
Limbus boundary

Pupillary boundary

Collarette

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Anatomy



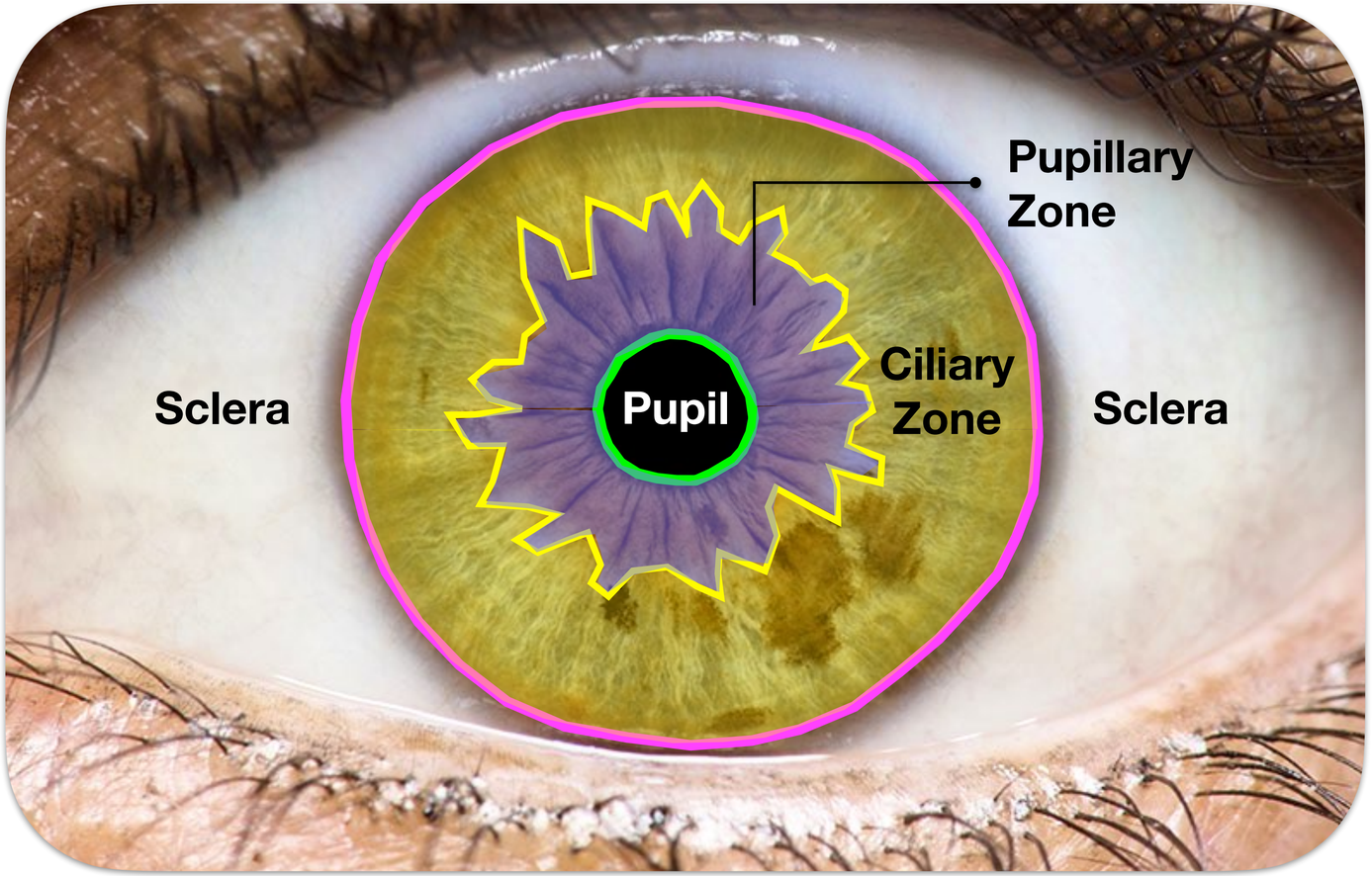
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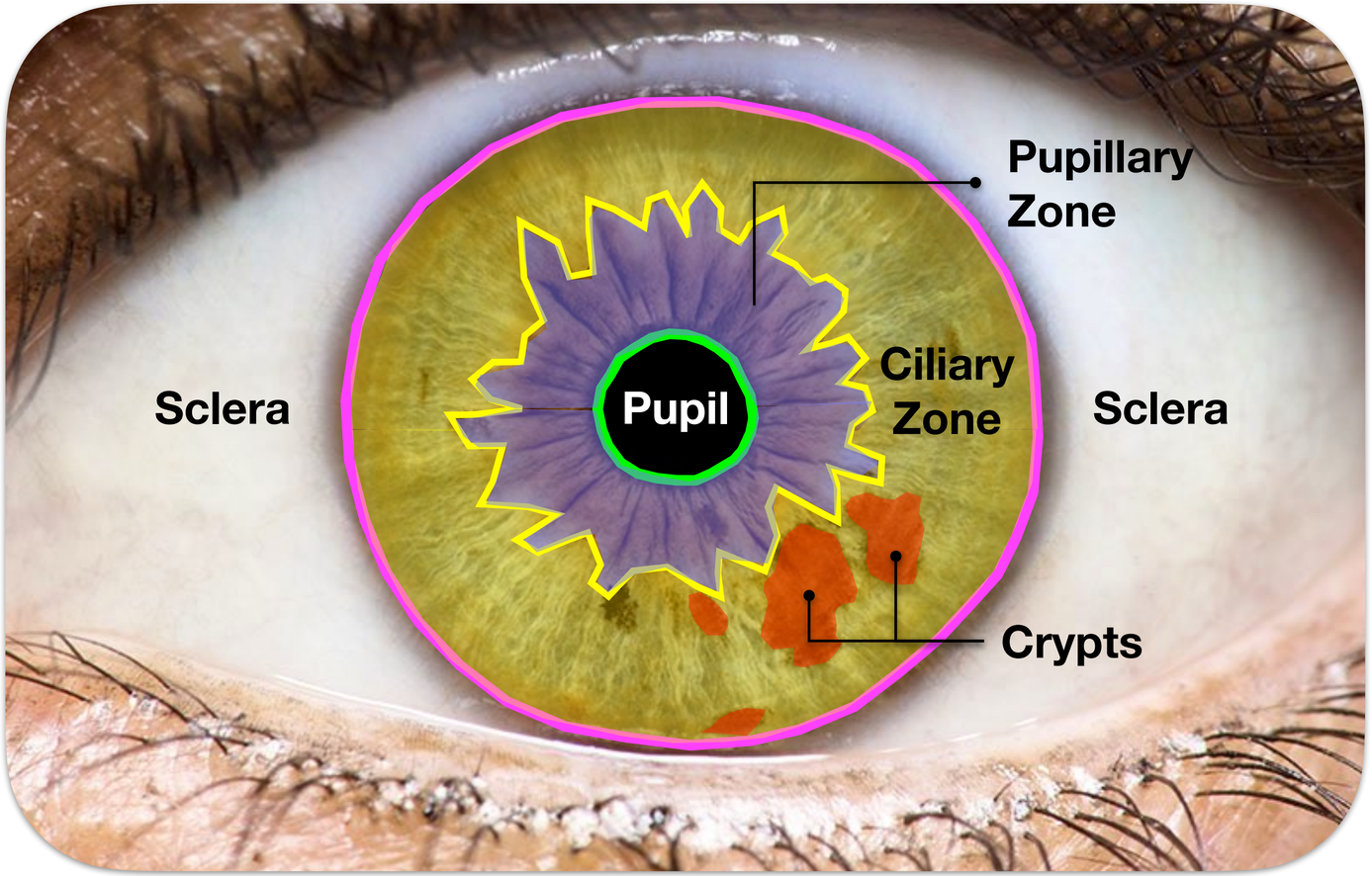
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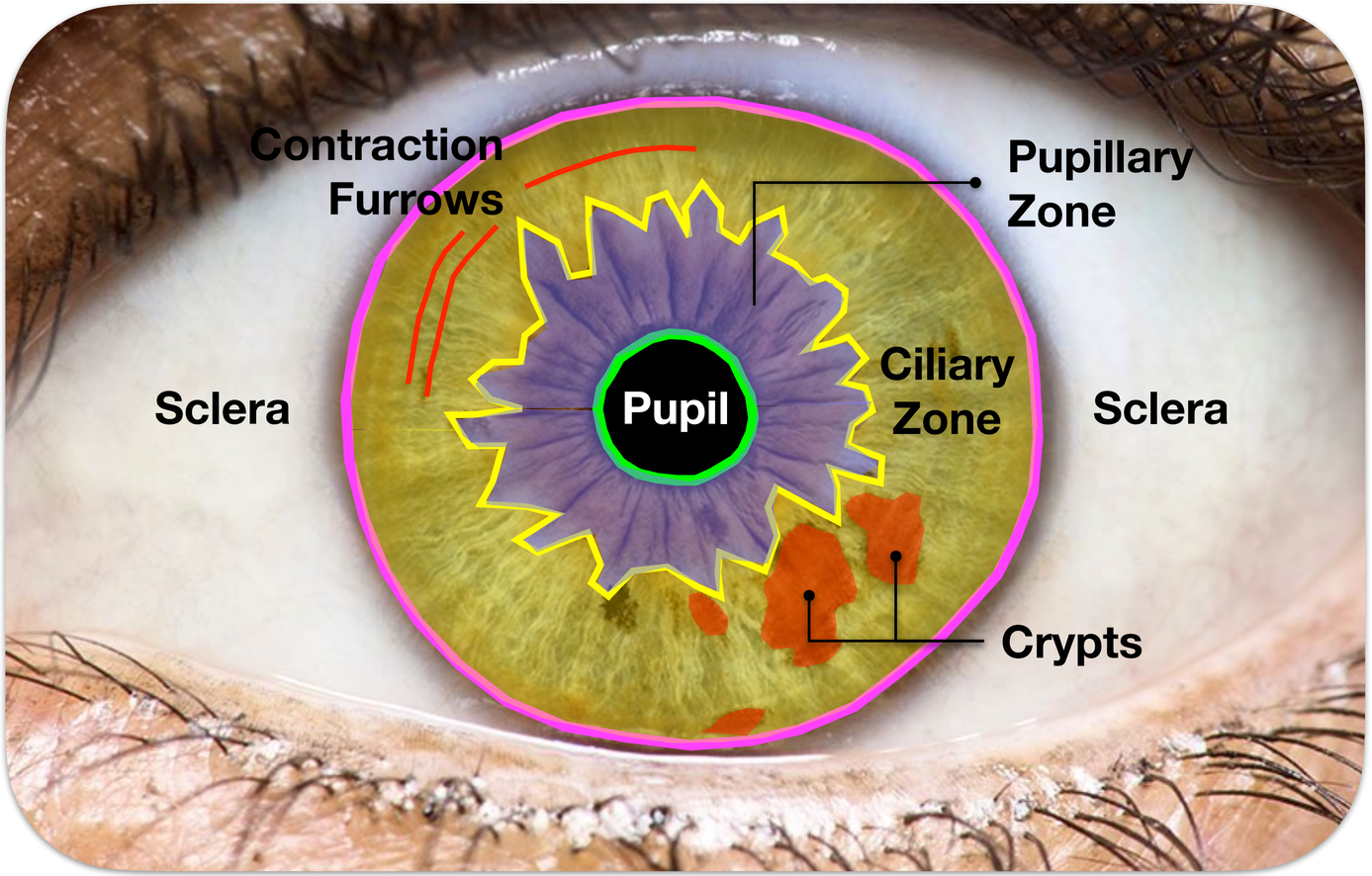
Limbus boundary

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Anatomy



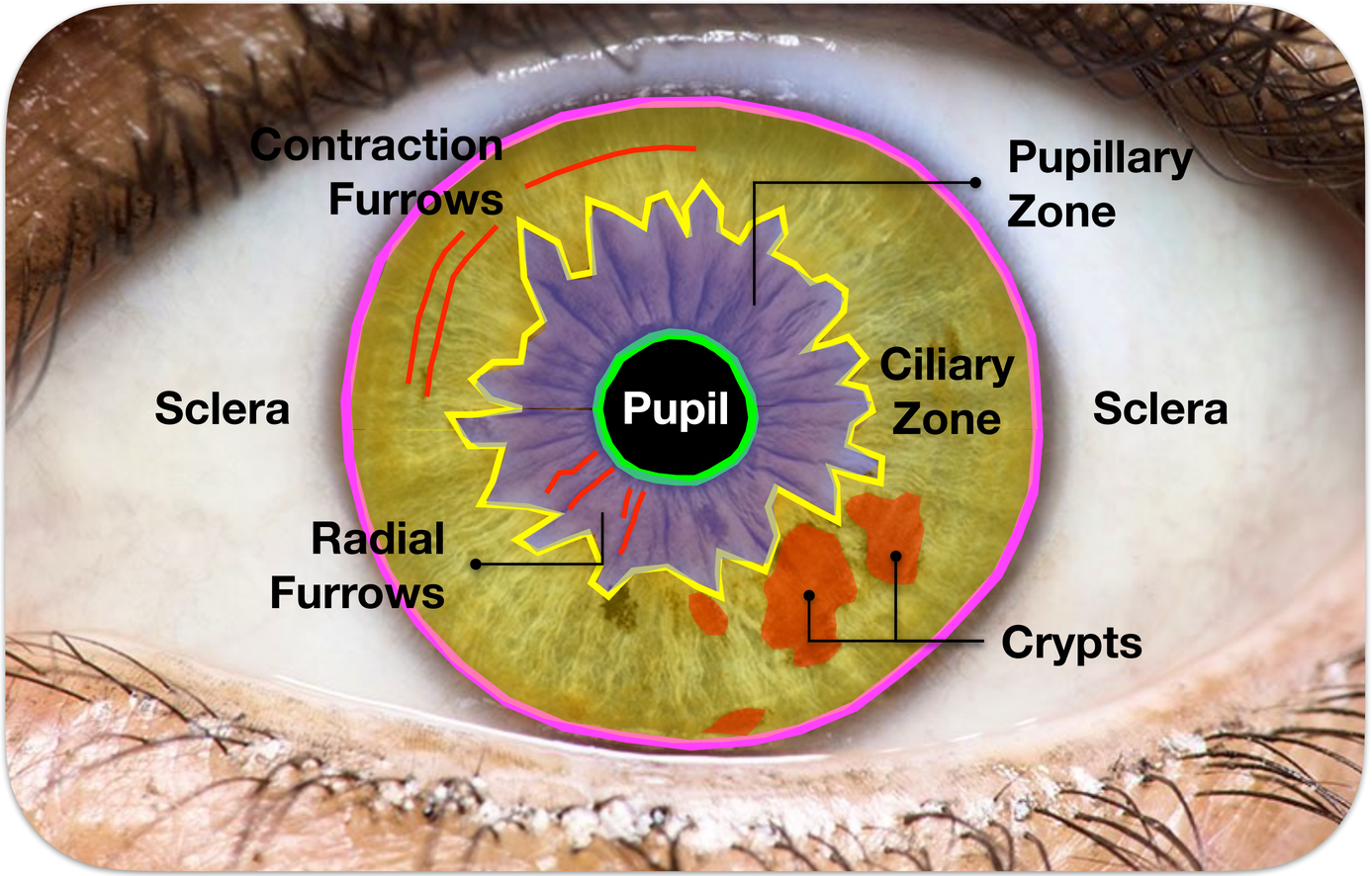
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Anatomy



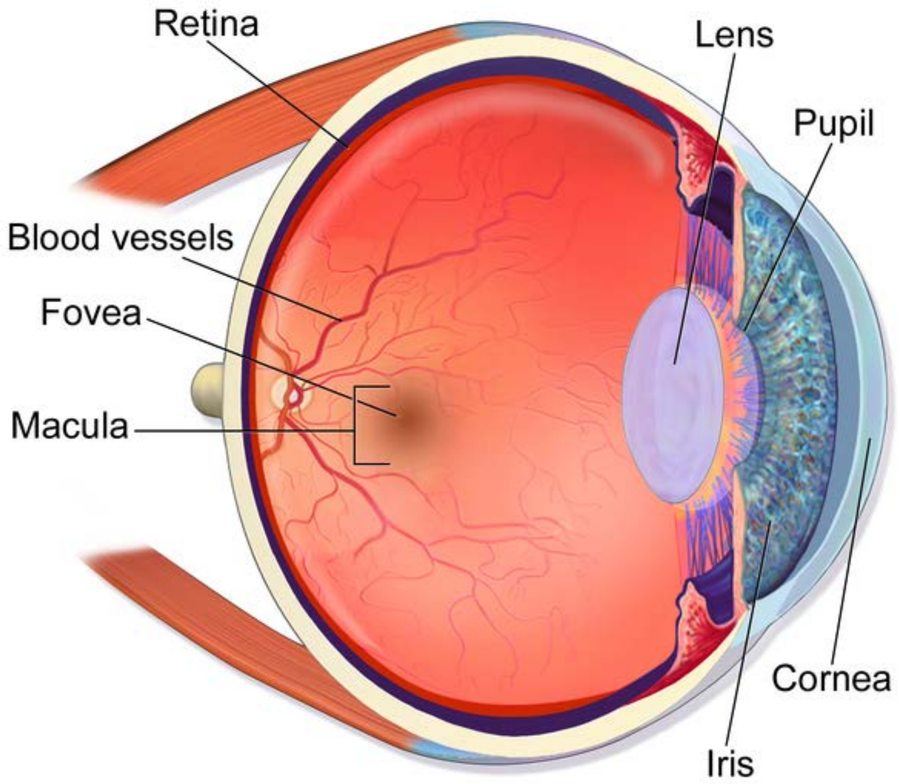
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Anatomy

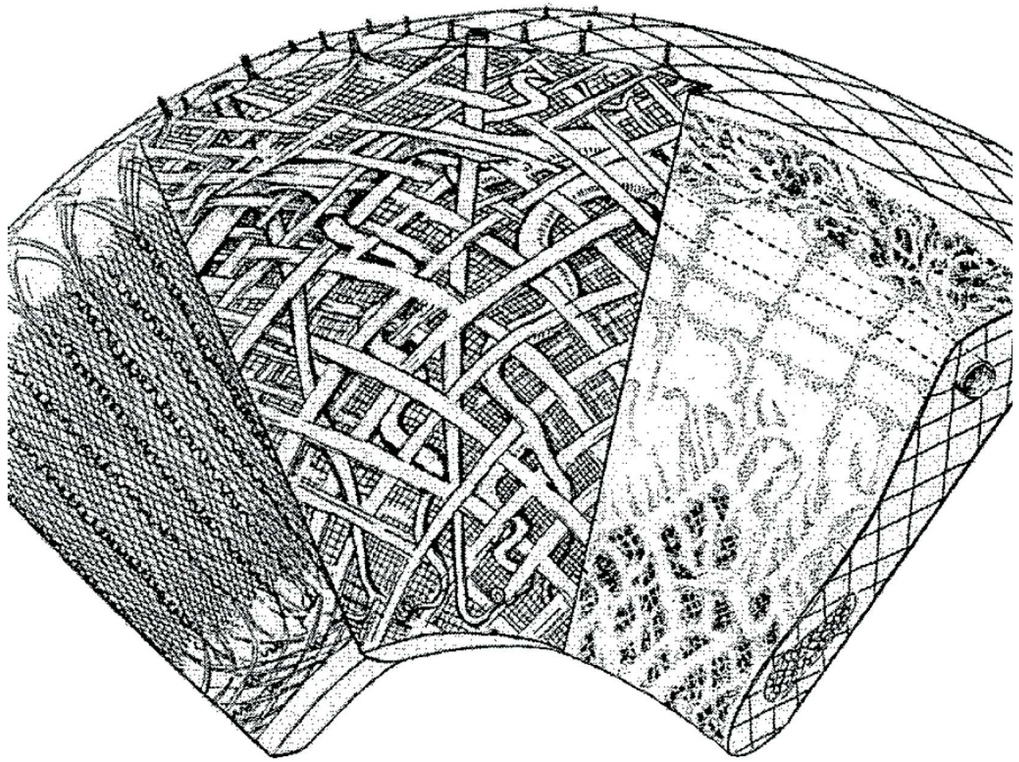


commons.wikimedia.org

Iris
Located behind the cornea and in front of the lens.

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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





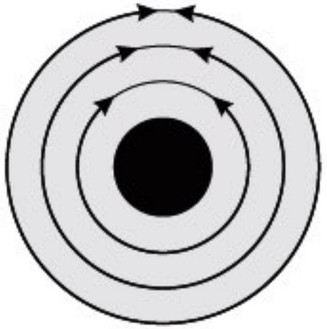


Suren Manvelyan

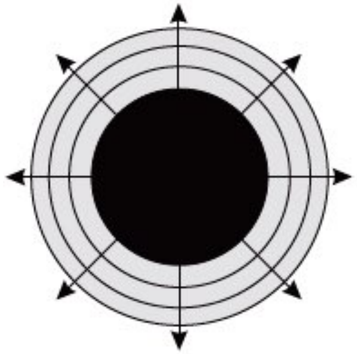
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Anatomy

Adam Czajka

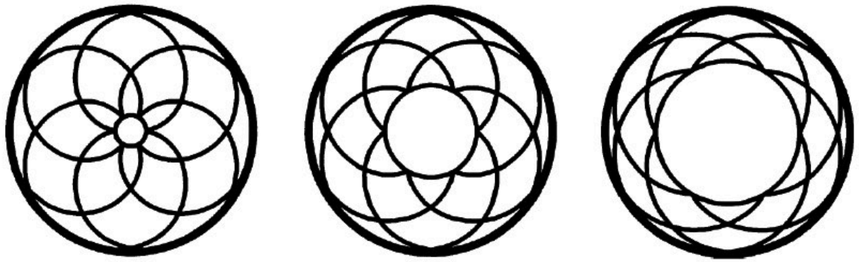


Sphincter Muscles



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.

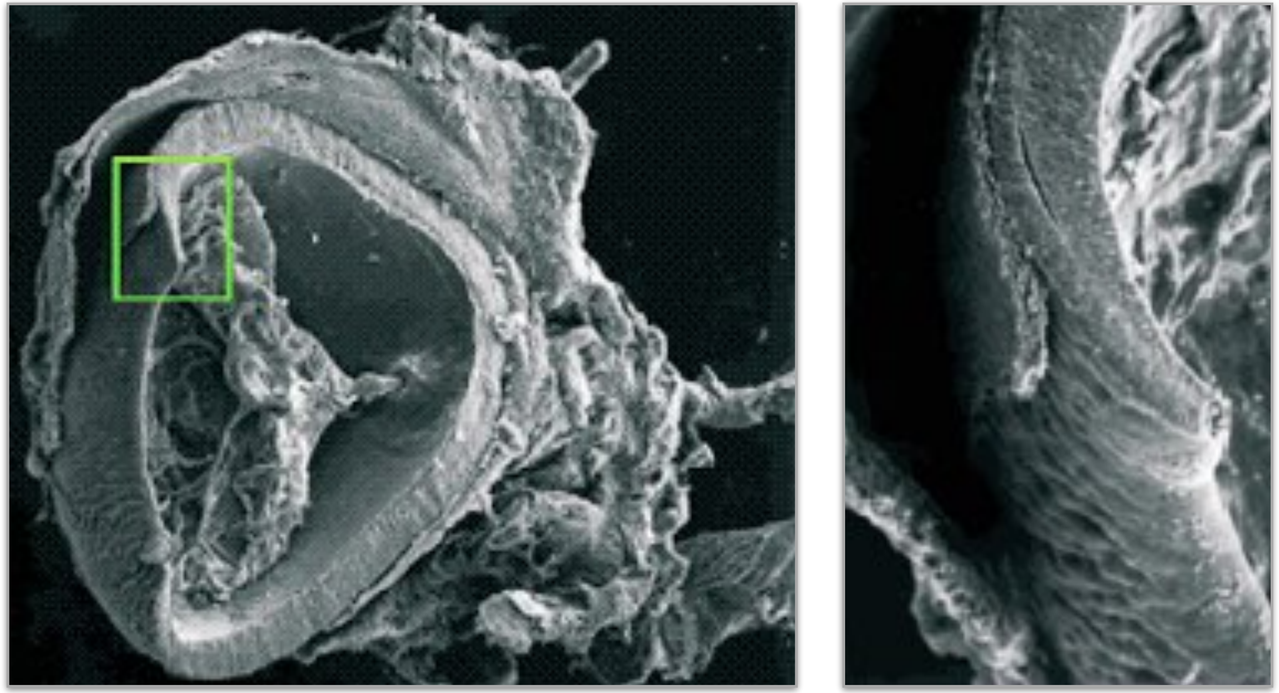
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Genesis

Epigenetic Trait

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

Fully developed by the 8th month of gestation.



Adam Czajka

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Genesis

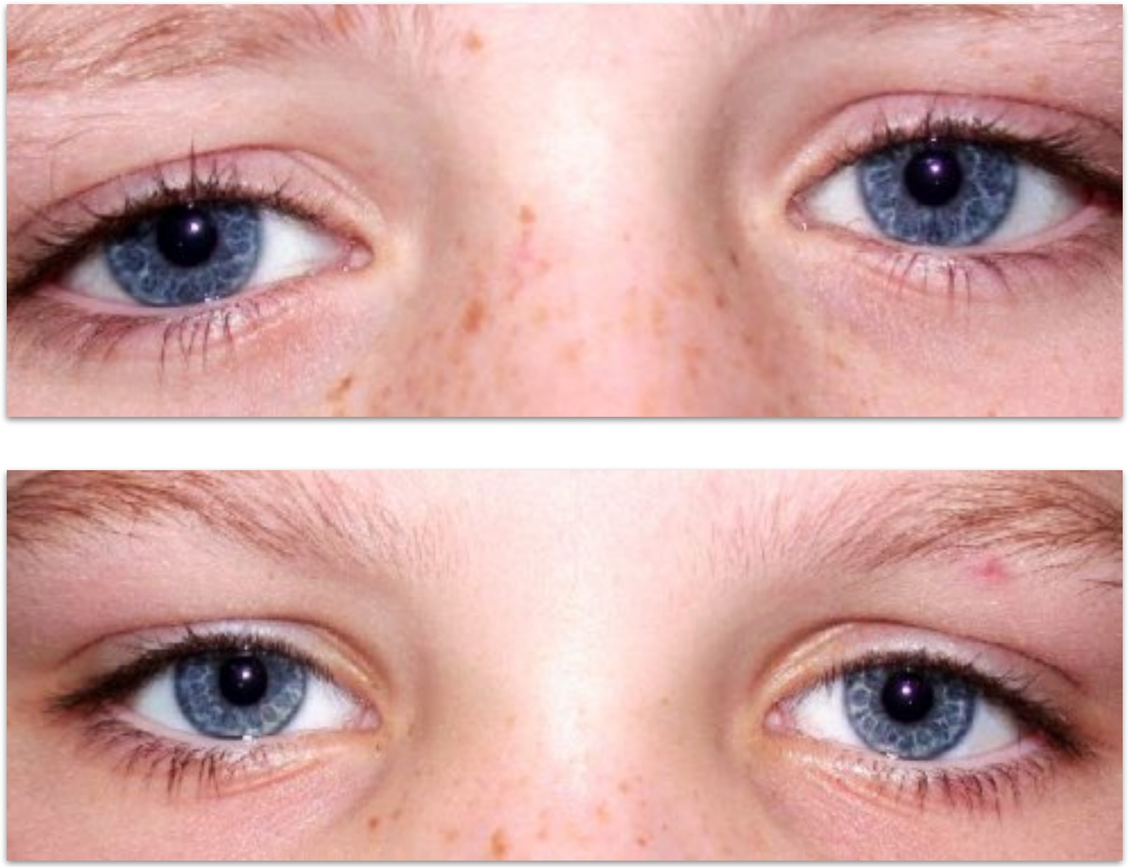
J. Daugman
Evolving Methods in Iris Recognition
BTAS, 2012

Epigenetic Trait

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

Right and left irises are different.

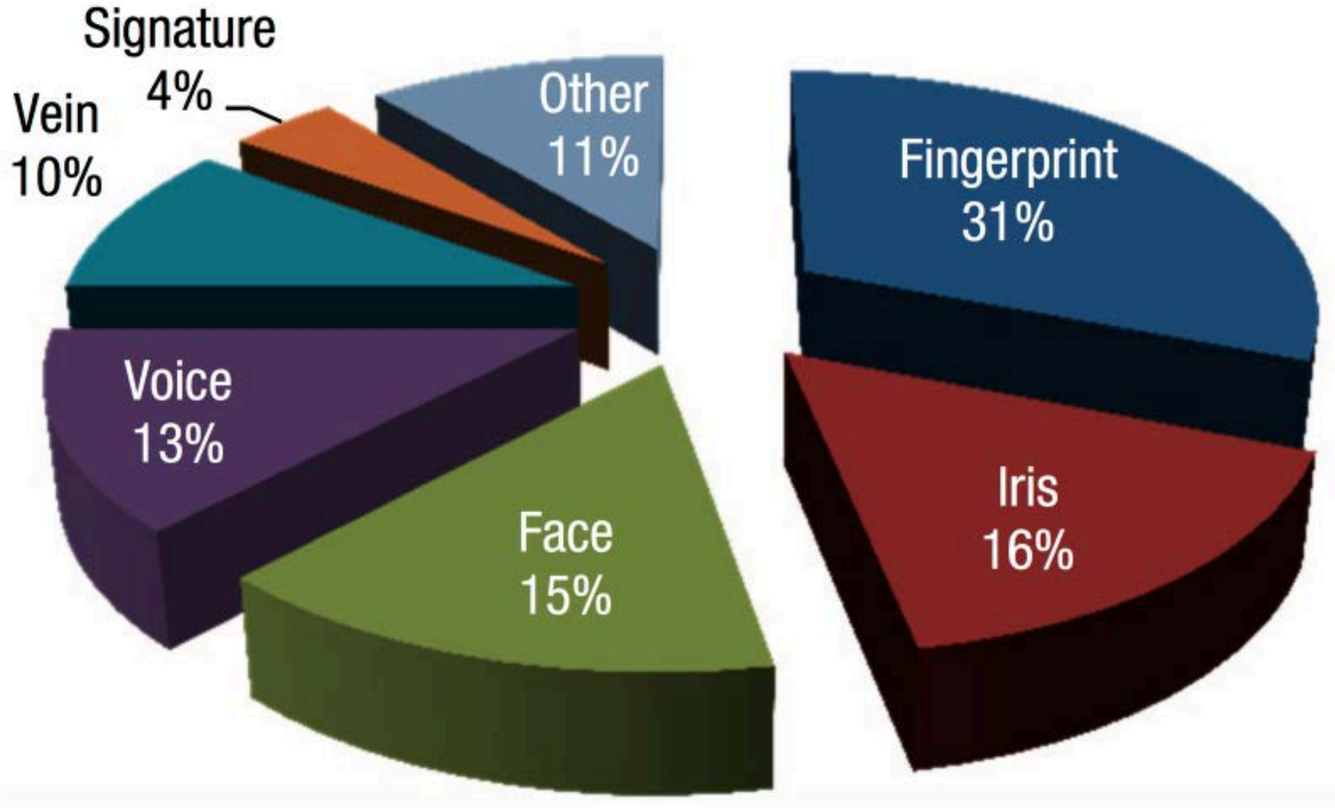
Identical twins have different irises.



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Why Irises?

Market



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

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Why Irises?

Universality (1/8)
Does everybody have the trait?



Probably



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Why Irises?

Uniqueness (2/8)
How likely two or more individuals will present the same trait?



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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

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Why Irises?

Permanence (3/8)
How easily does the trait change?



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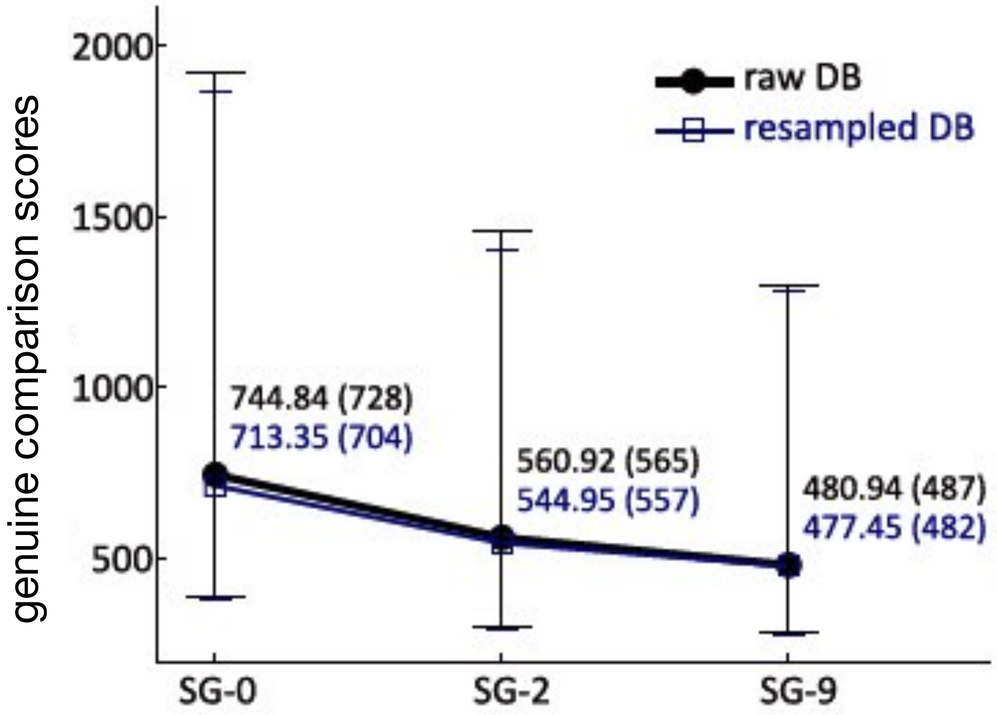
Why Irises?



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



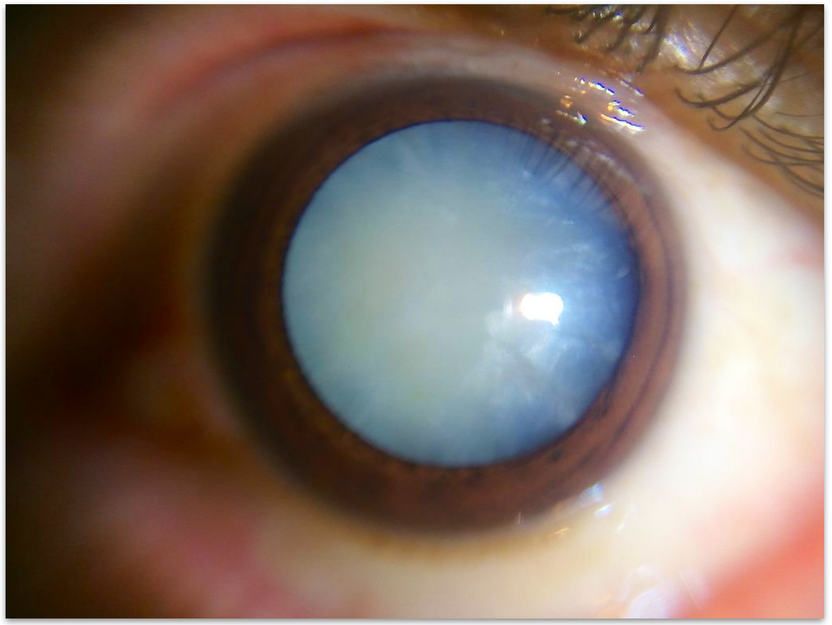
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Why Irises?

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.

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Why Irises?

Measurability (4/8)
How easy is it to acquire and digitize the trait?



>



?





Not there yet.

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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

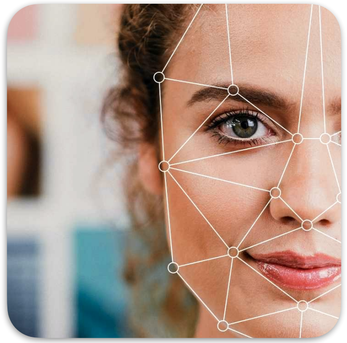


Whose fingerprint is this?



Whose iris is this?

>



Whose face is this?

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Why Irises?

Circumvention (6/8)
How hard can the trait be forged or imitated?





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

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Why Irises?

Circumvention (6/8)
How hard can the trait be forged or imitated?



>



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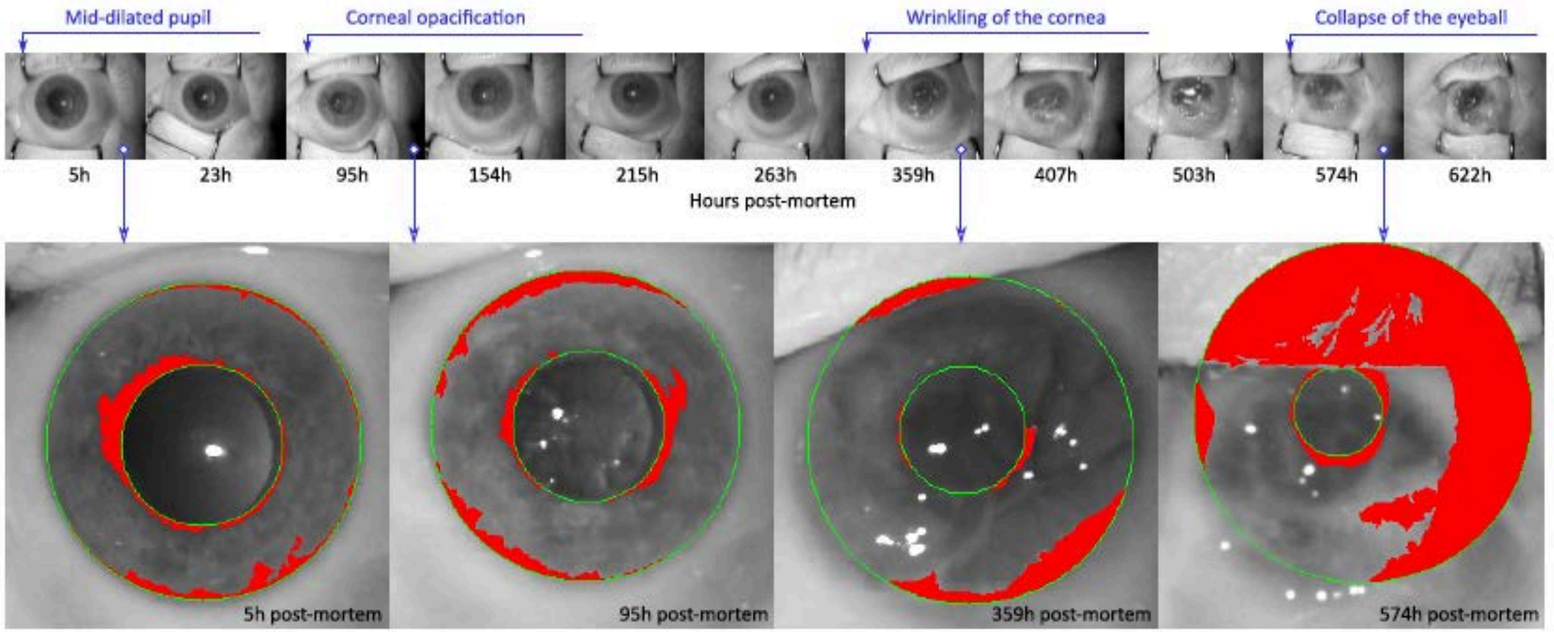
Egad, would it work?

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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



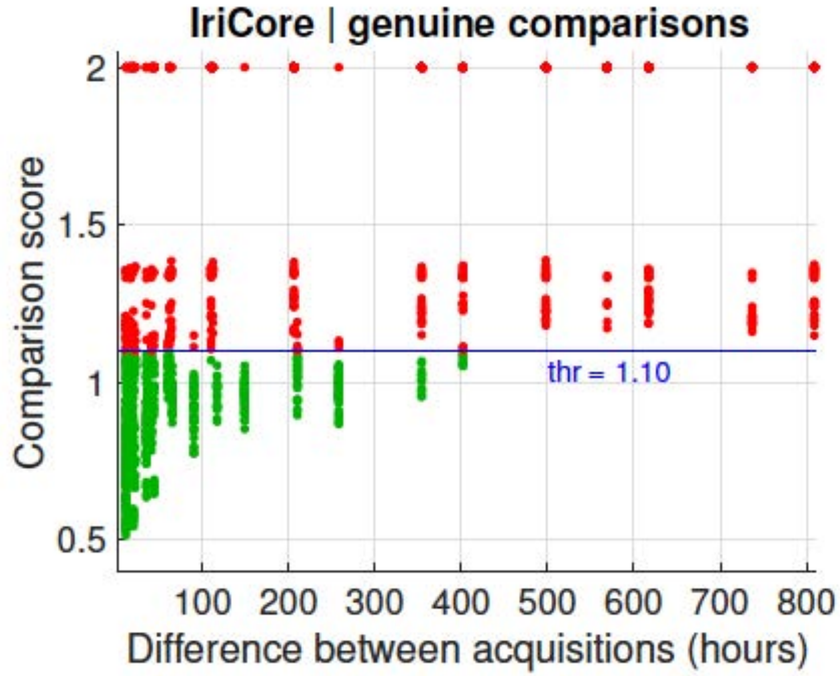
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Why Irises?

Circumvention (6/8)
Irises can be used in identification soon after death.

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

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



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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

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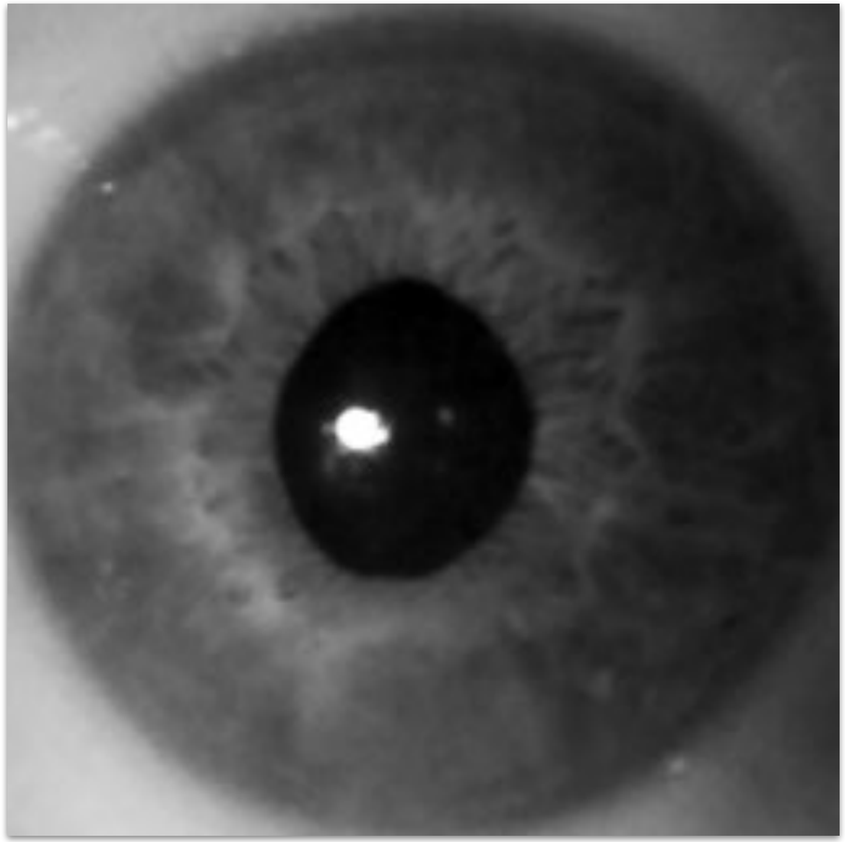
Why Irises?

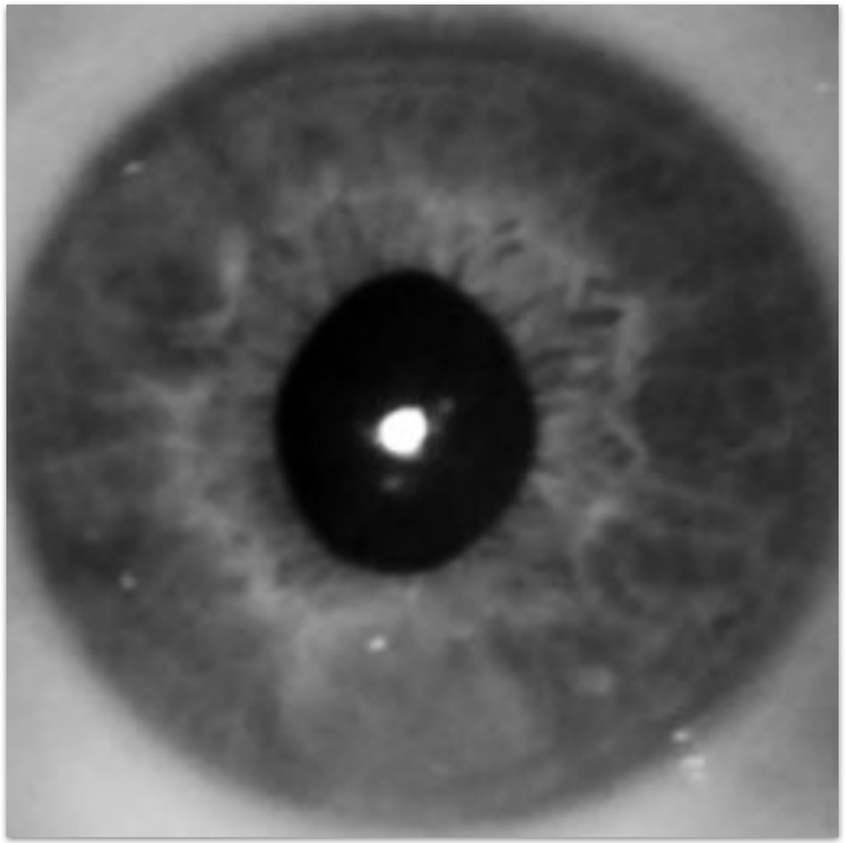
Explainability (8/8)
How easy is it for the everyman to understand the trait comparison?



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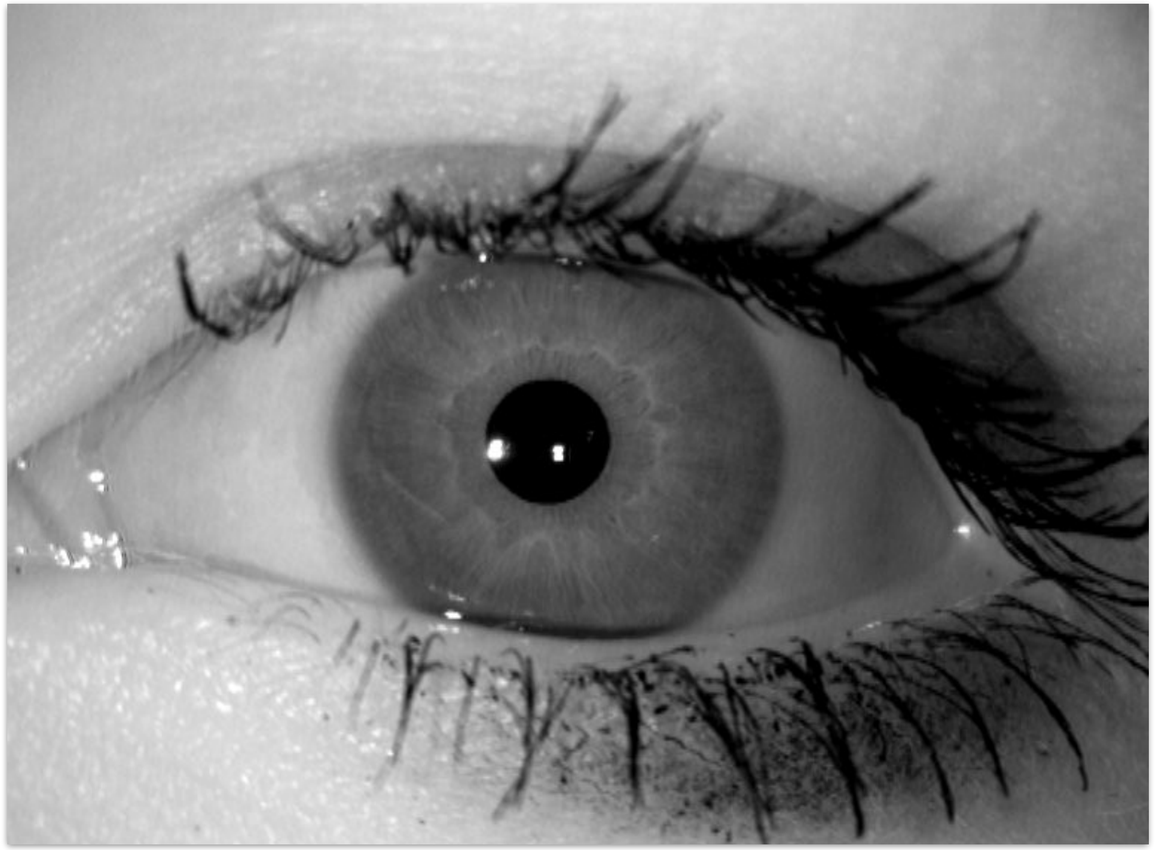
Same Person?

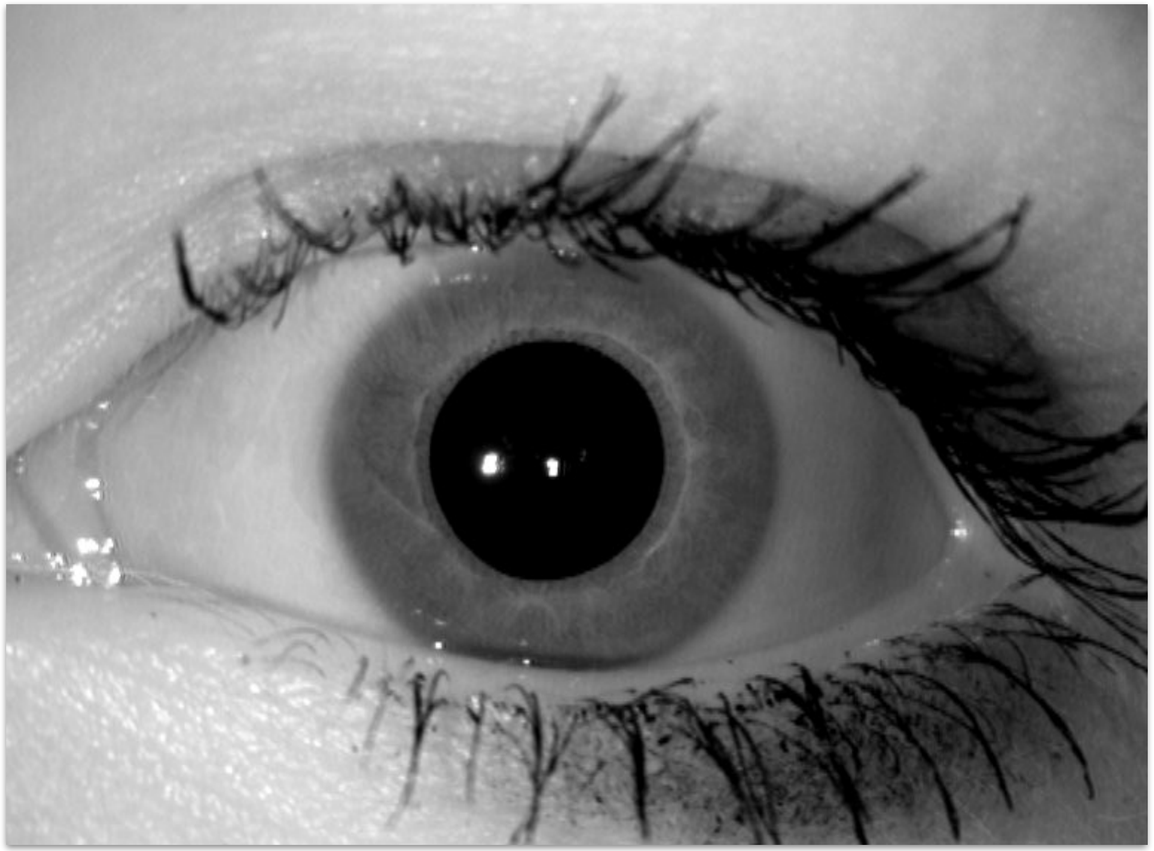




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Same Person?

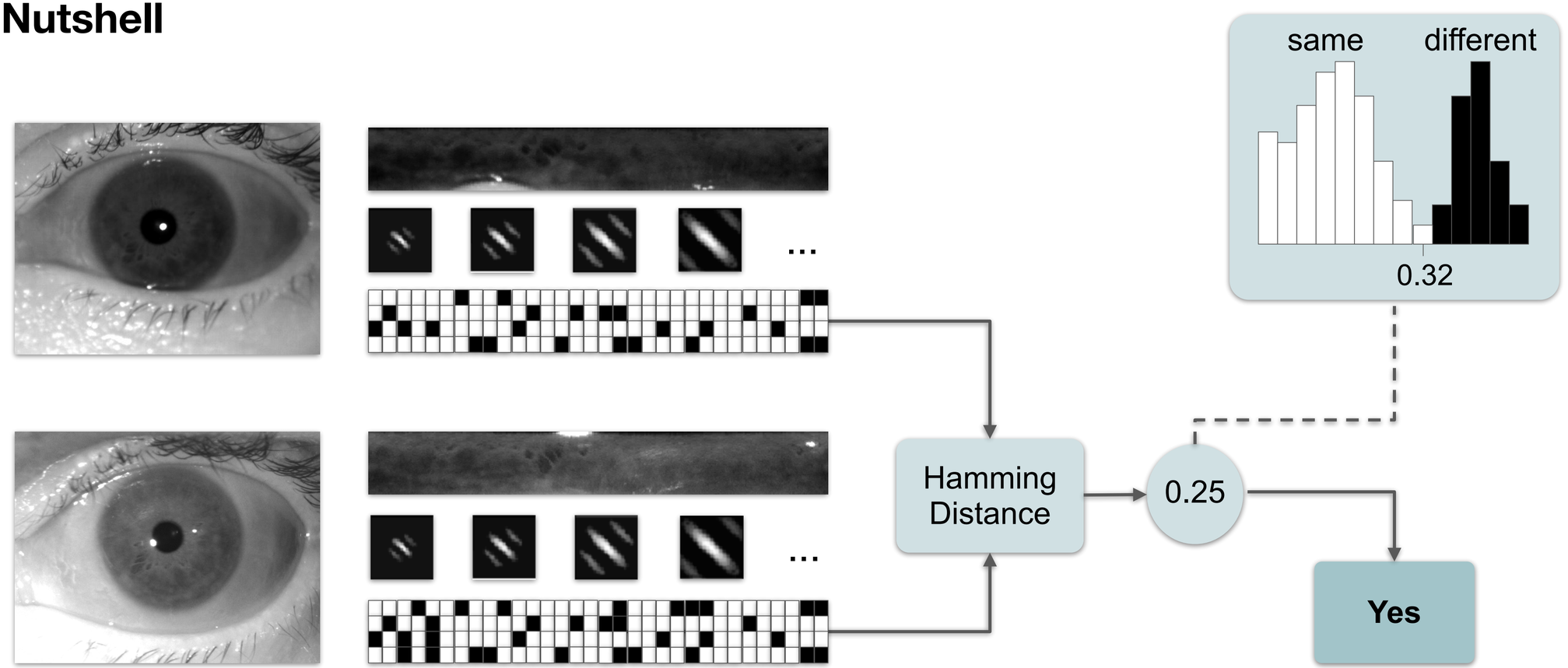




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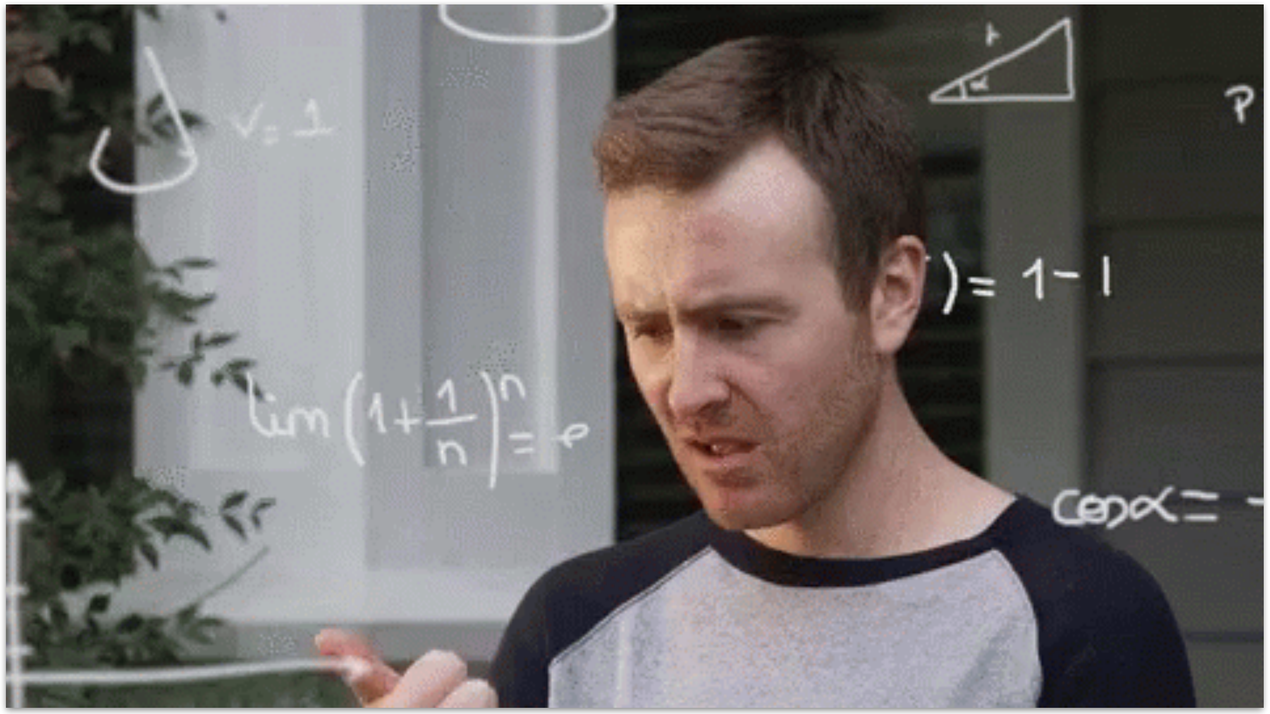
Iris Recognition

In a Nutshell



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Easy, right?





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Explainable Iris Recognition



How can we make it meaningful to the everyman?

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Explainable Iris Recognition



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

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Explainable Iris Recognition

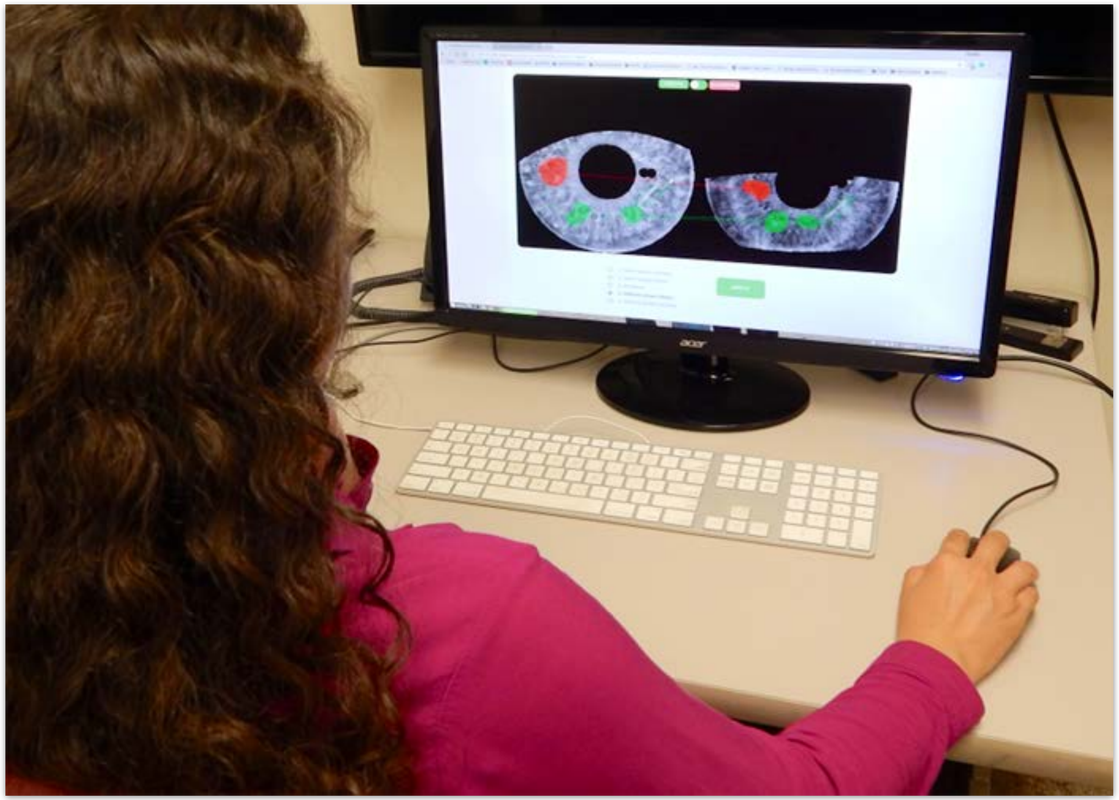


General Data Protection Regulation

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

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Explainable Iris Recognition



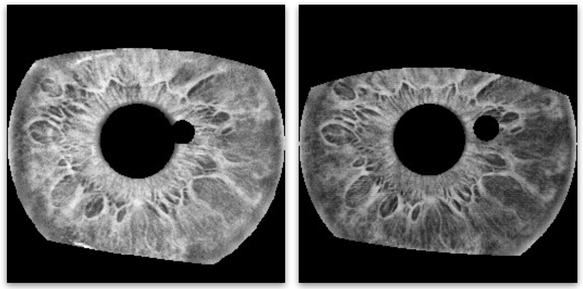
How should we start?

Ask a human:
How do people perform iris recognition?

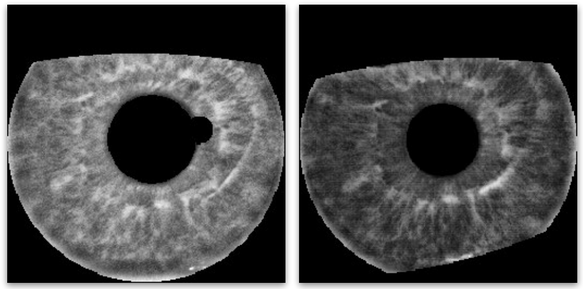
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Human Experiments

Dataset



Easy for an automated solution

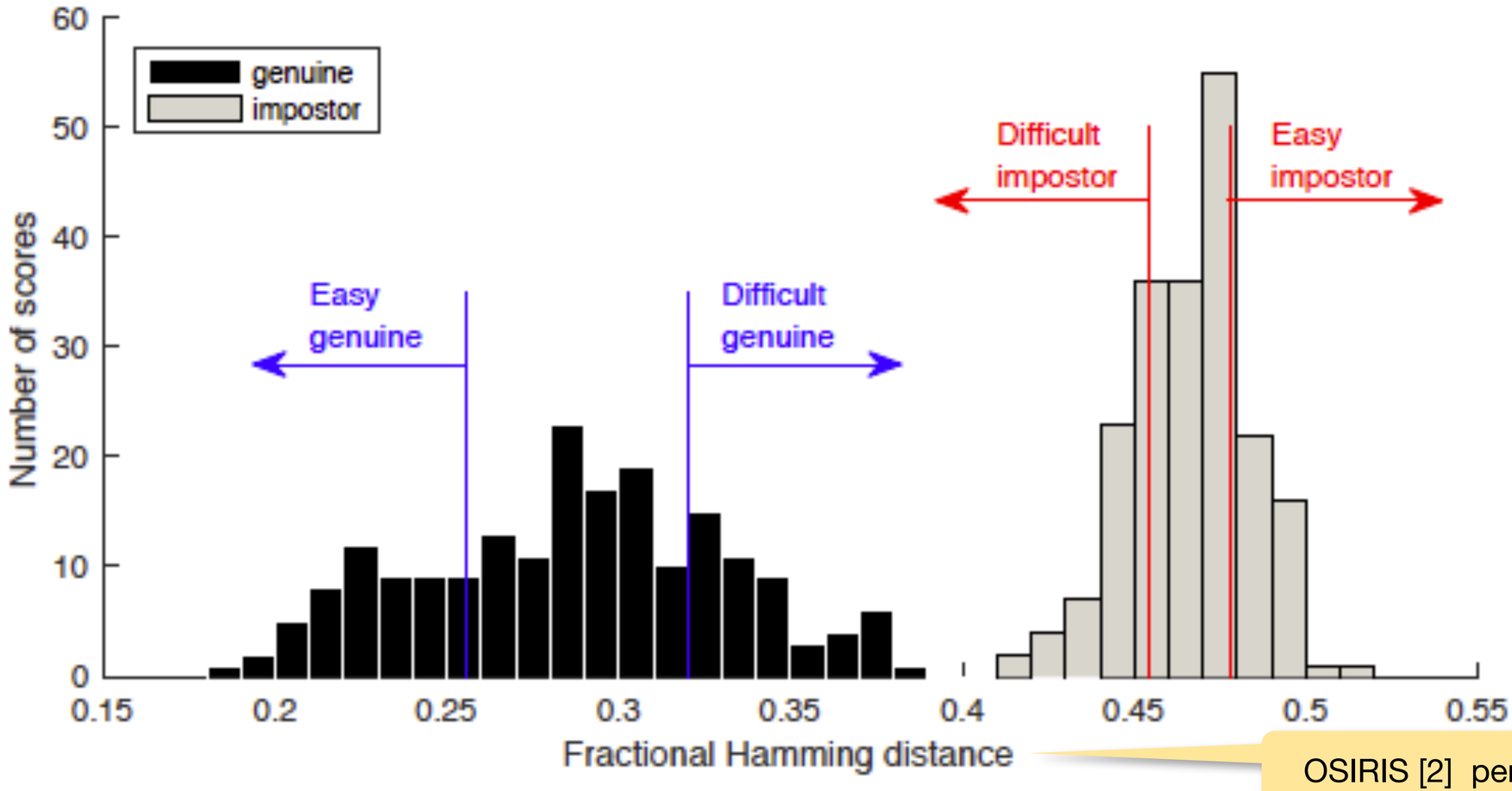


Hard for an automated solution

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

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

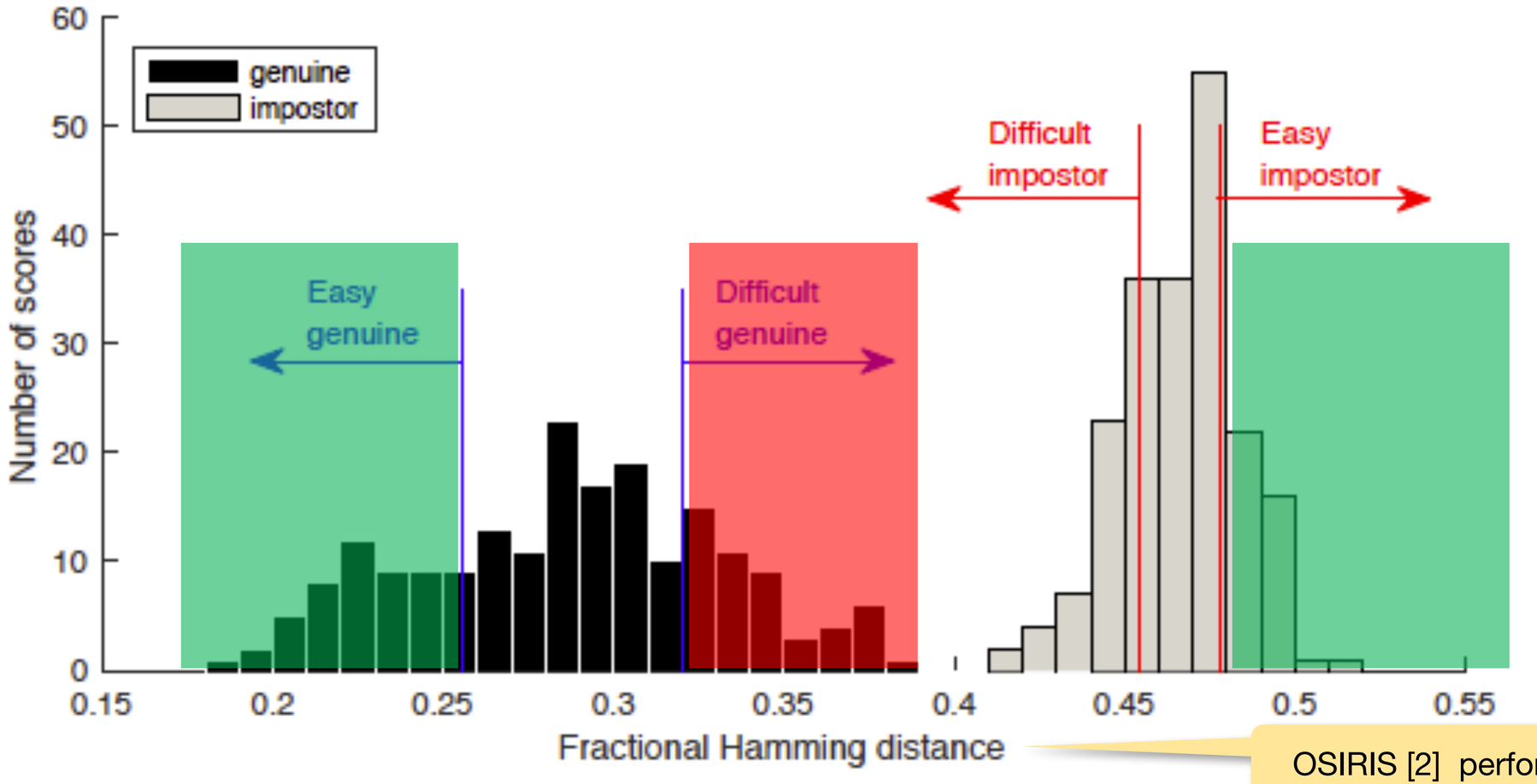
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OSIRIS [2] performance.

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

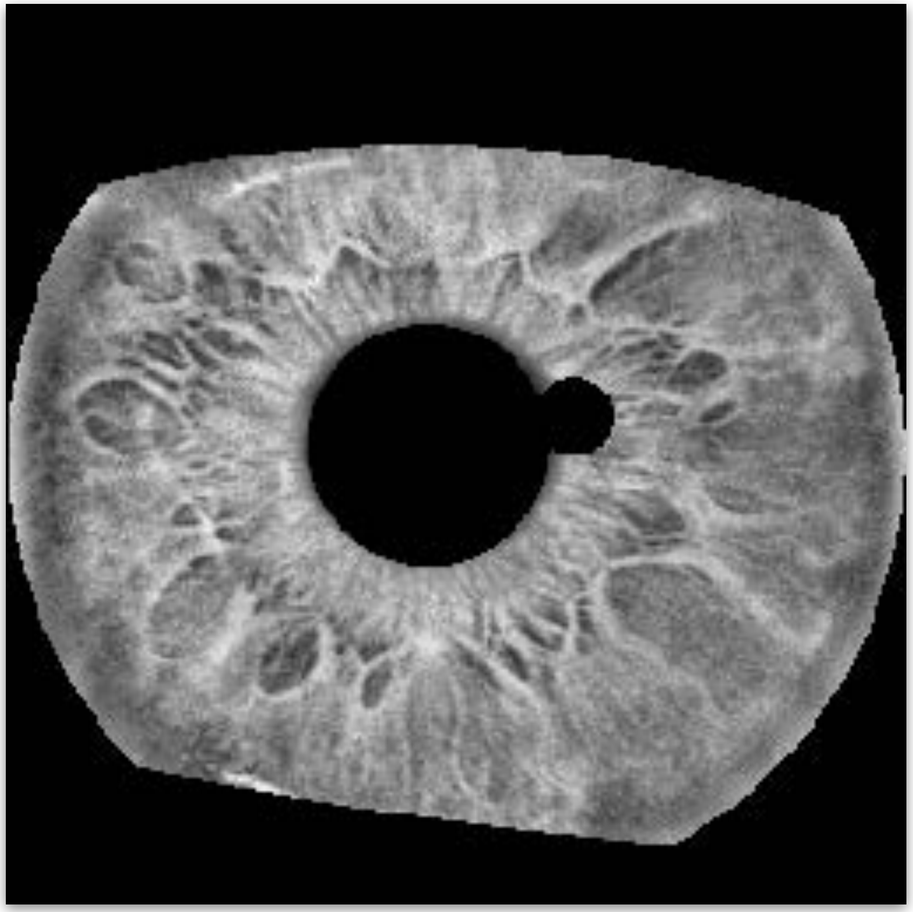
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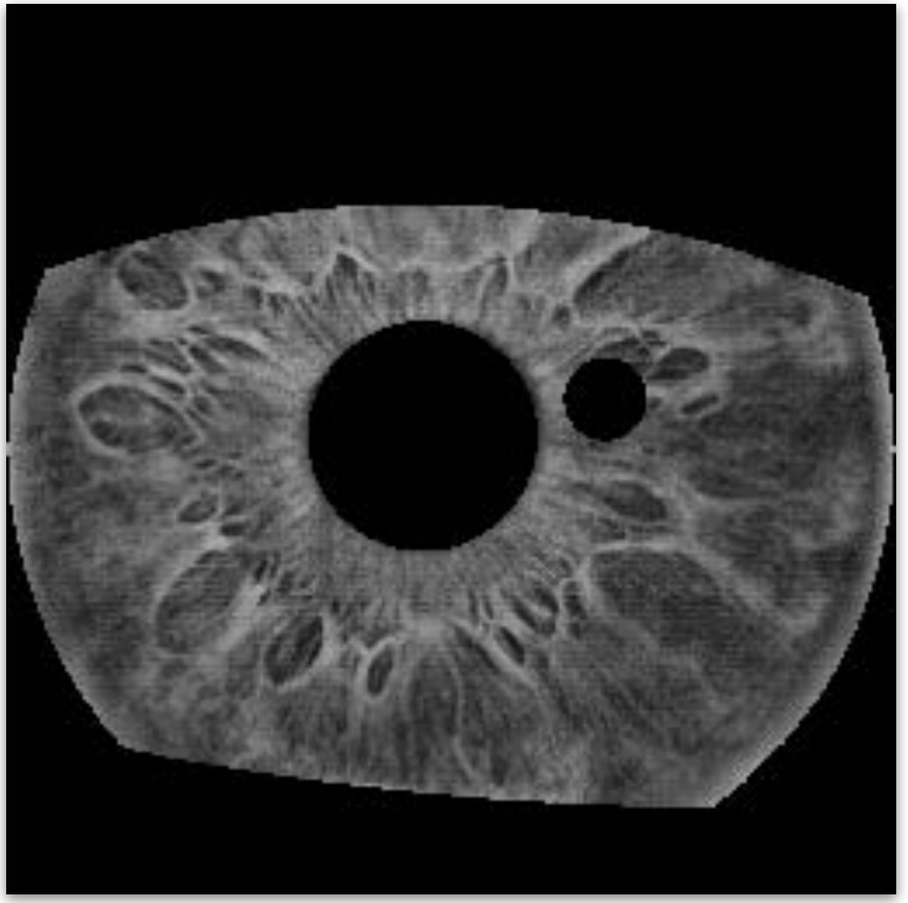


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Othman et al. Elsevier Pattern Recognition Letters, 82(2):124–131, 2016

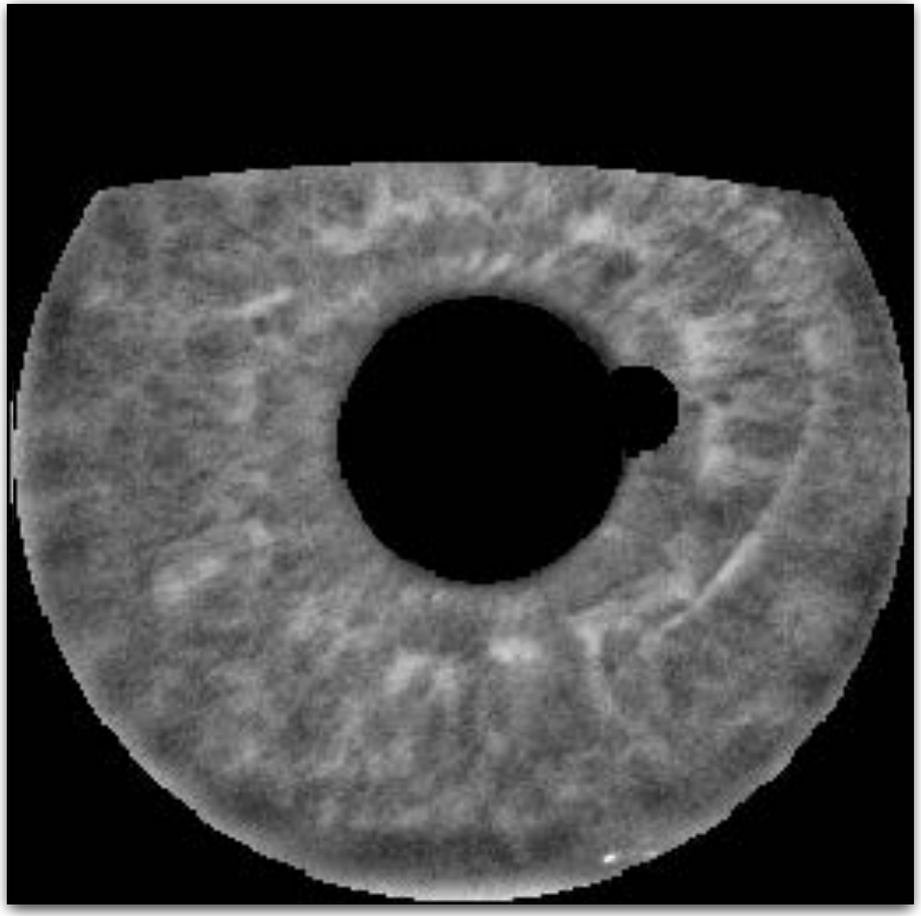
LOYOLA UNIVERSITY CHICAGO

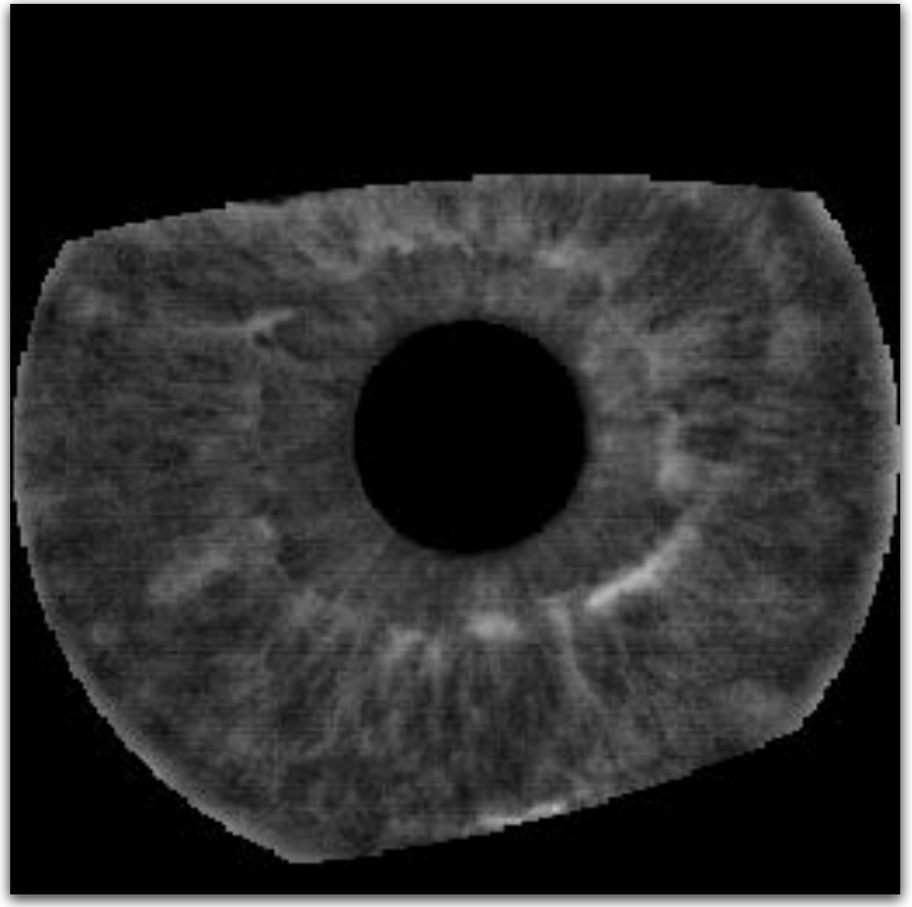




Easy for an automated solution

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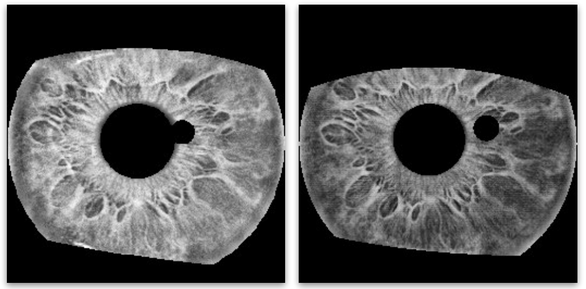


Hard for an automated solution

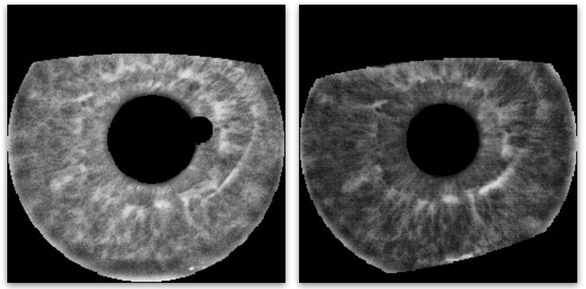
LOYOLA UNIVERSITY CHICAGO

Human Experiments

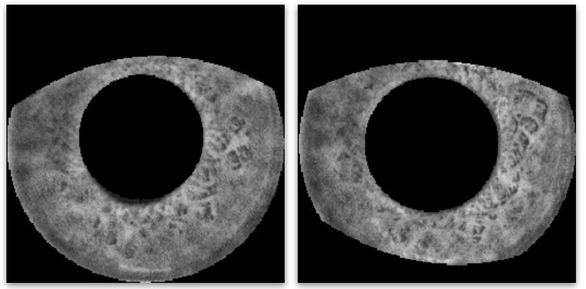
Dataset



Easy for an automated solution



Hard for an automated solution

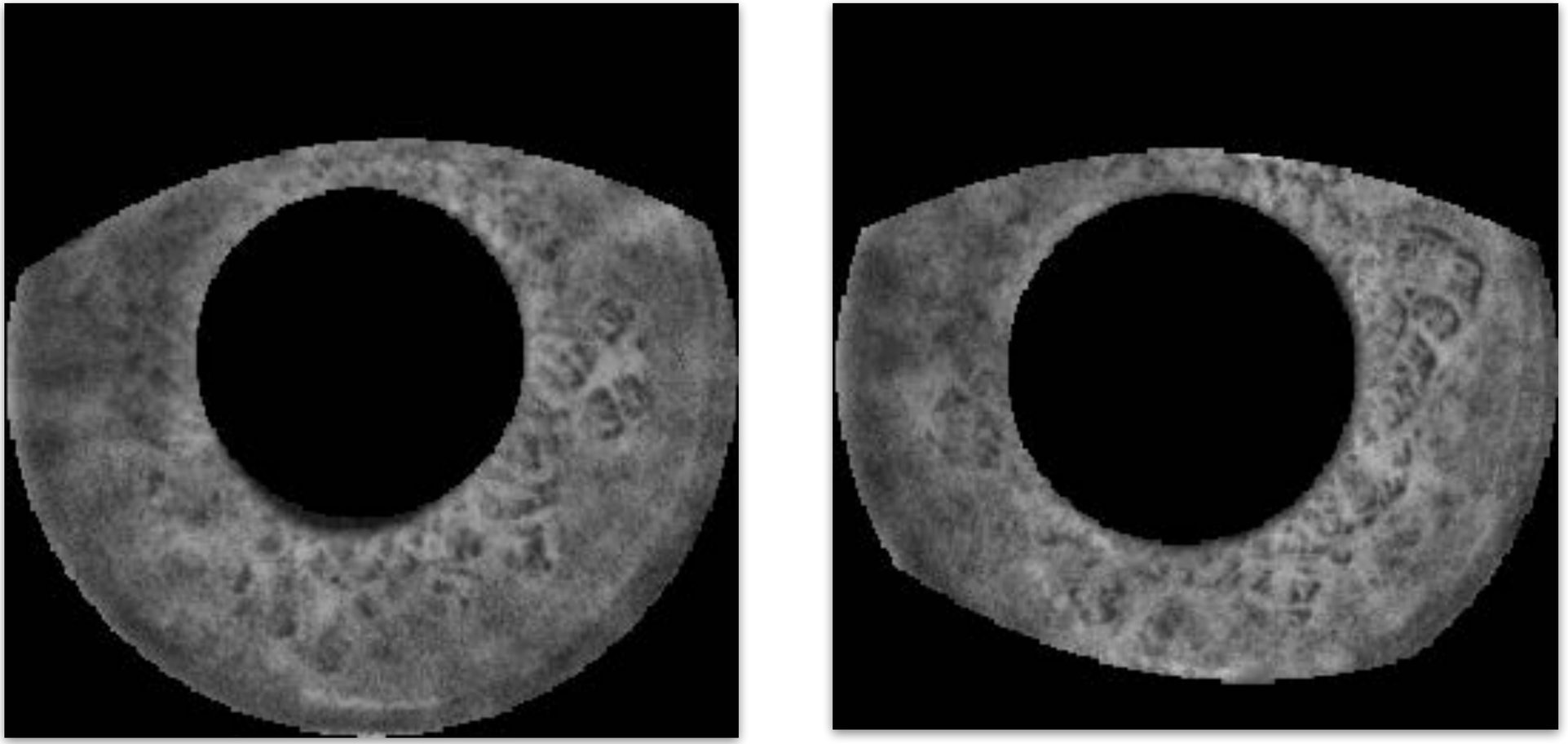


Twins'

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.

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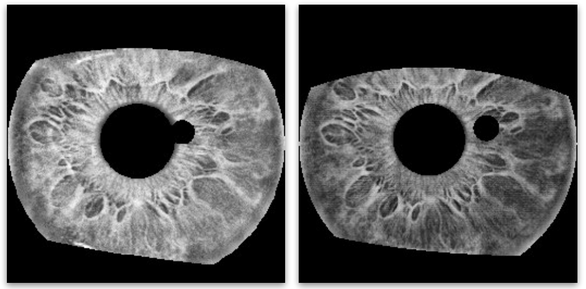


Twins’

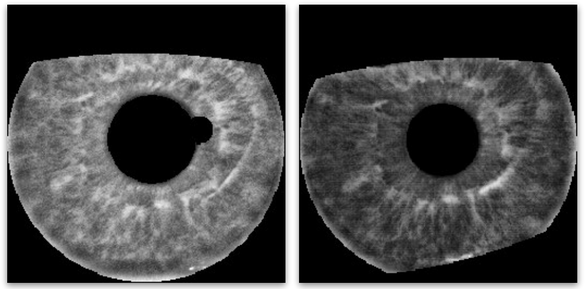
LOYOLA UNIVERSITY CHICAGO

Human Experiments

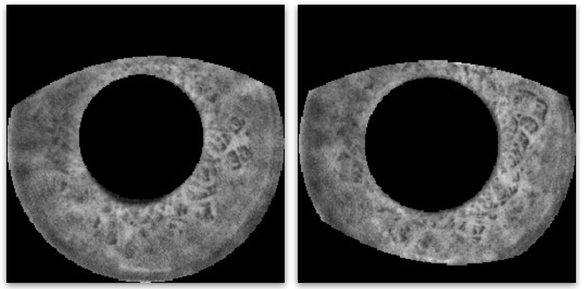
Dataset



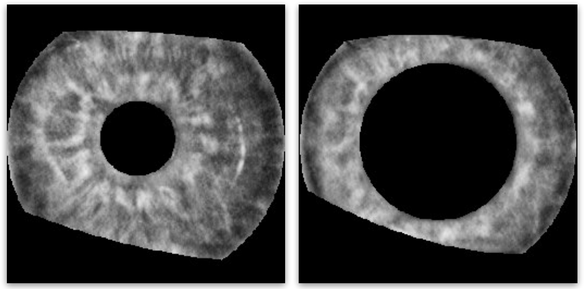
Easy for an automated solution



Hard for an automated solution



Twins'

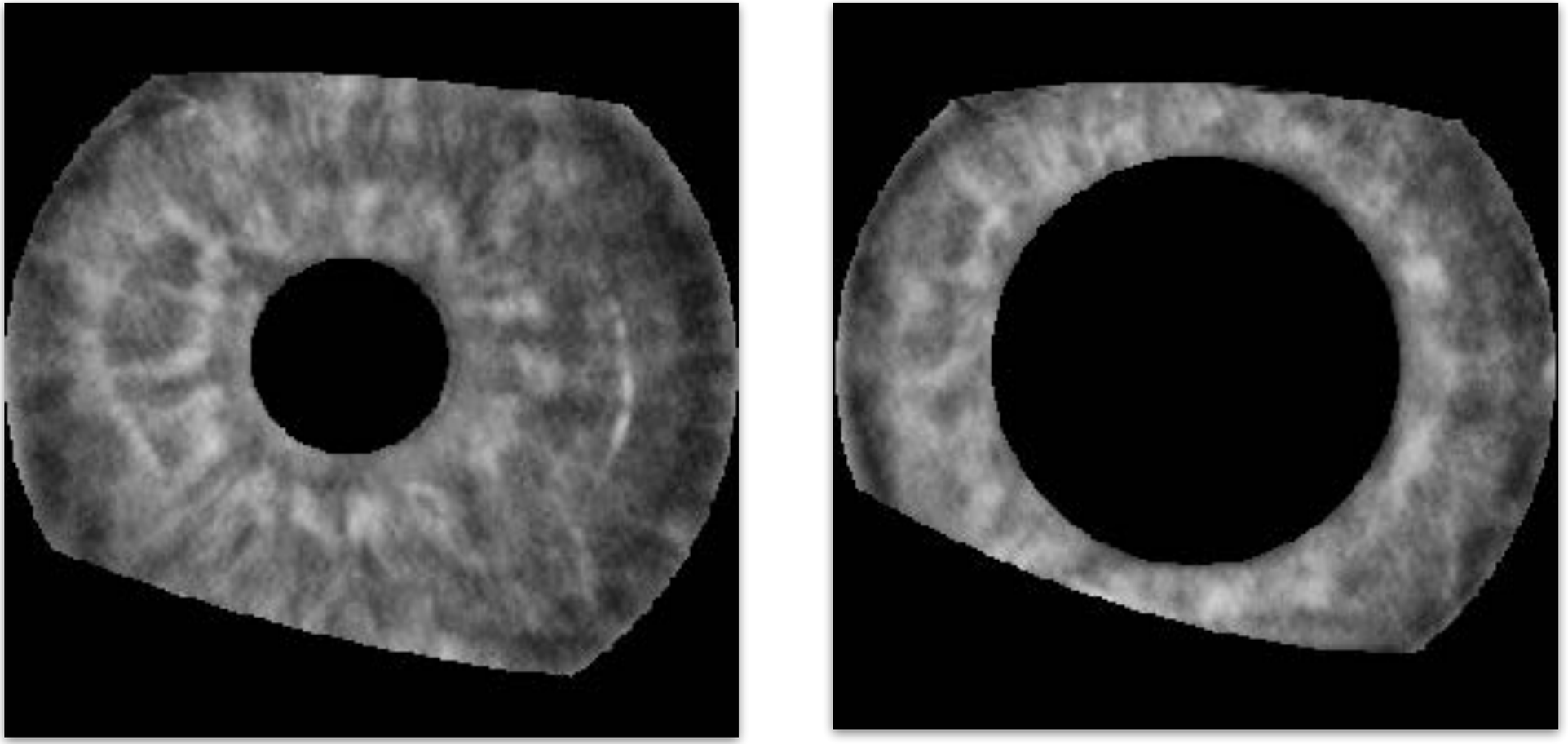


Pupil dynamic

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.

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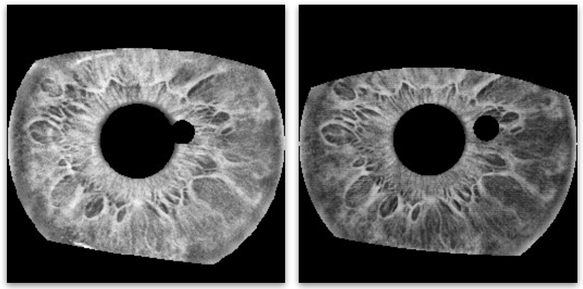


Pupil-dynamic

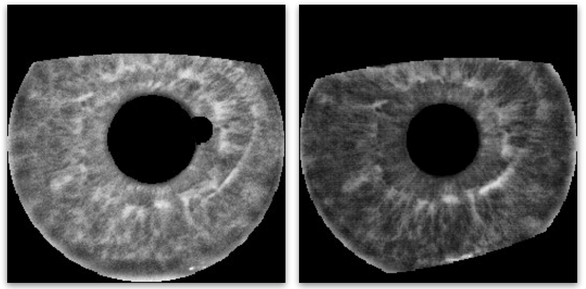
LOYOLA UNIVERSITY CHICAGO

Human Experiments

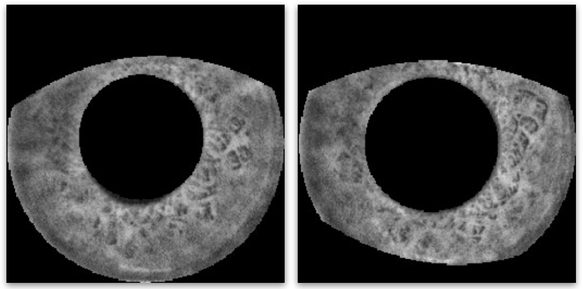
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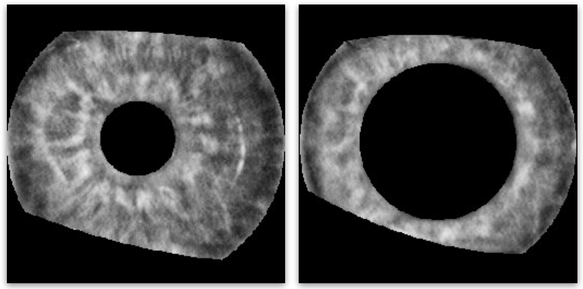
Easy for an automated solution



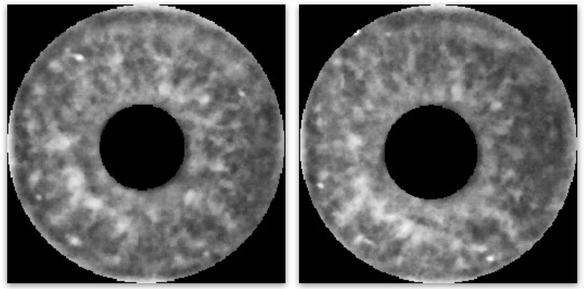
Hard for an automated solution



Twins'



Pupil dynamic

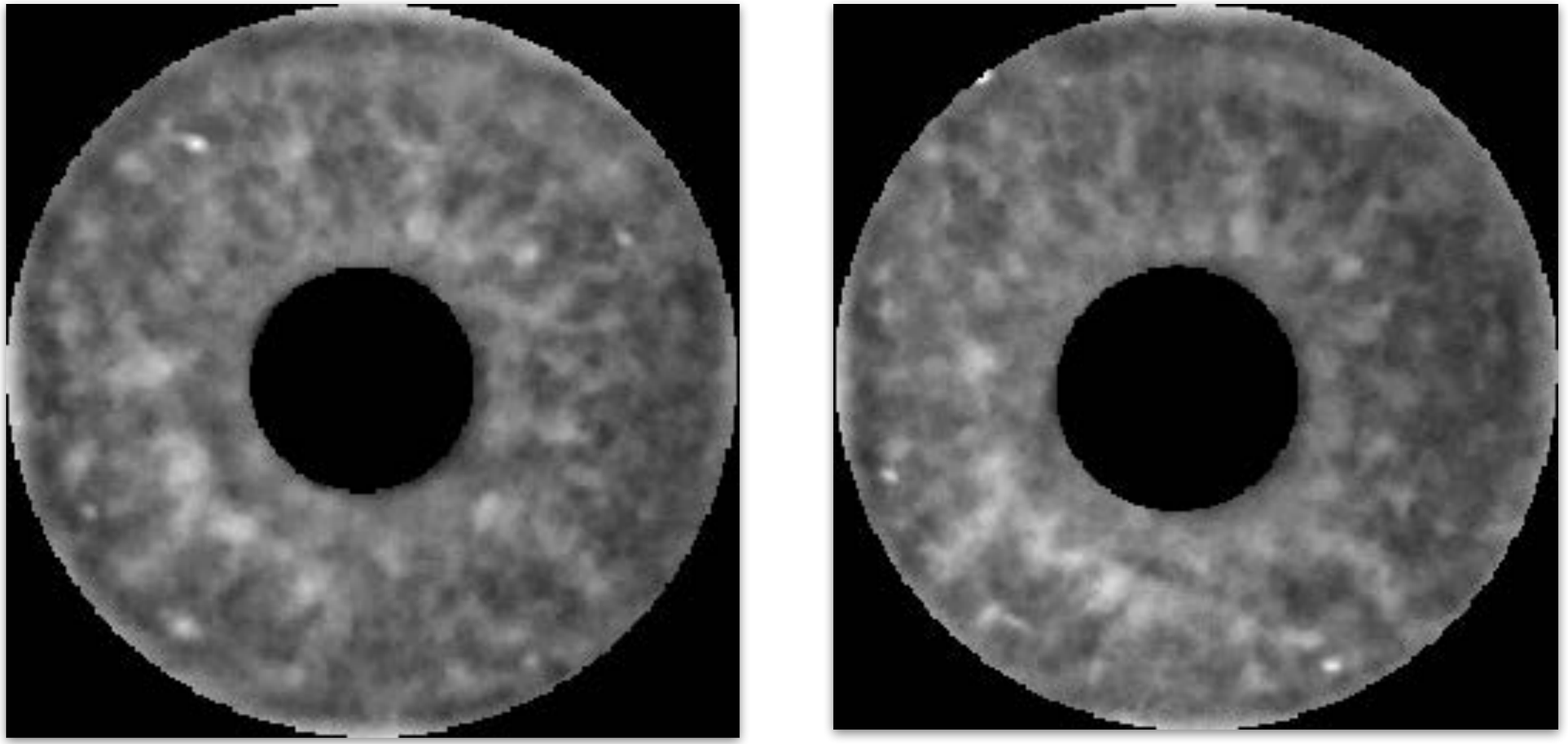


Deceased

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.

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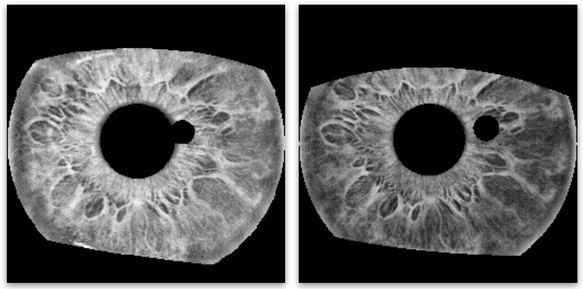
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LOYOLA UNIVERSITY CHICAGO

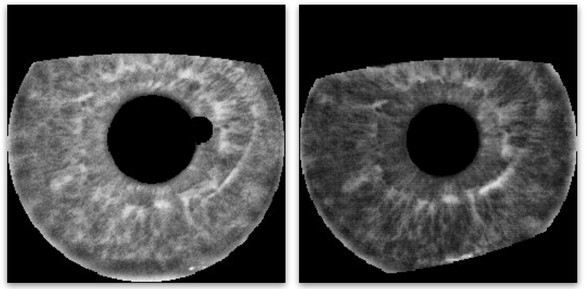
Human Experiments

Dataset

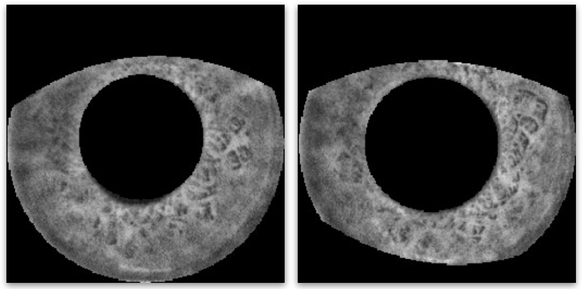
[5] Human iris recognition in post-mortem subjects: Study and database.
Trokielewicz et al. IEEE Intl. Conference on Biometrics: Theory, Applications and Systems, 2016.



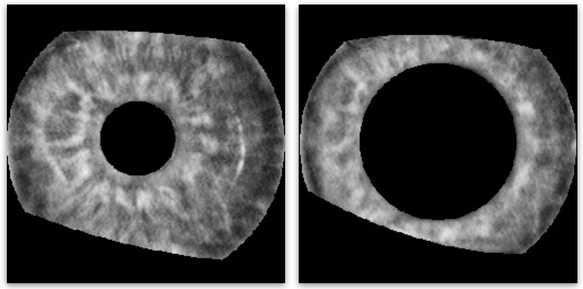
Easy for an automated solution



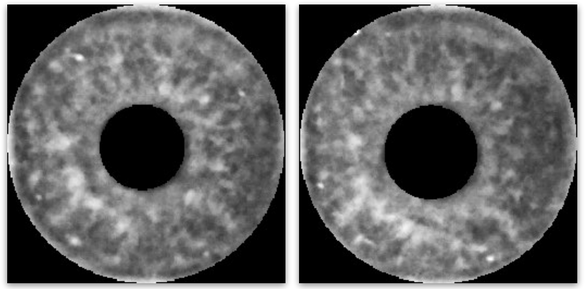
Hard for an automated solution



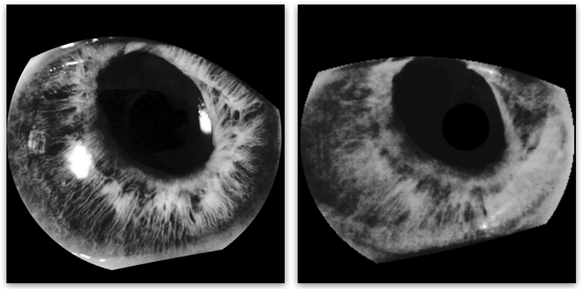
Twins'



Pupil dynamic



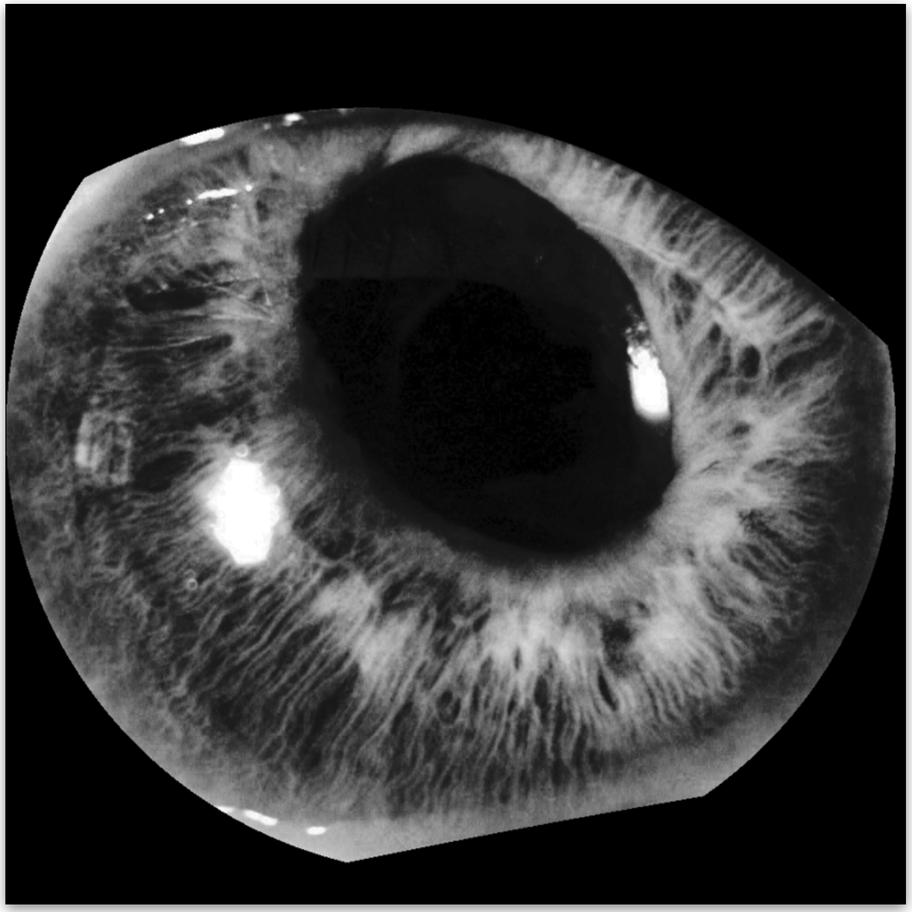
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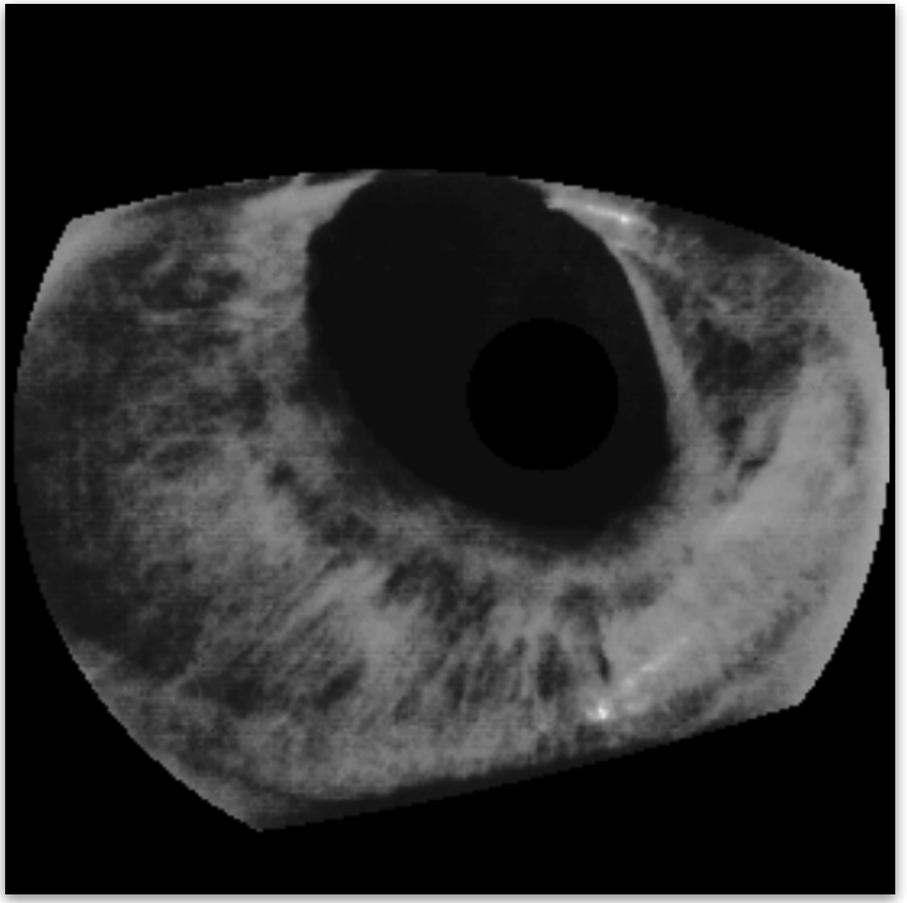


Disease-affected

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

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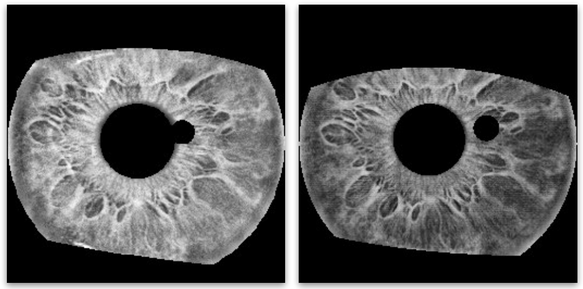


Disease-affected

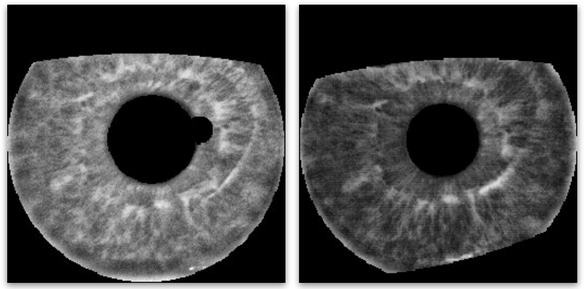
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Human Experiments

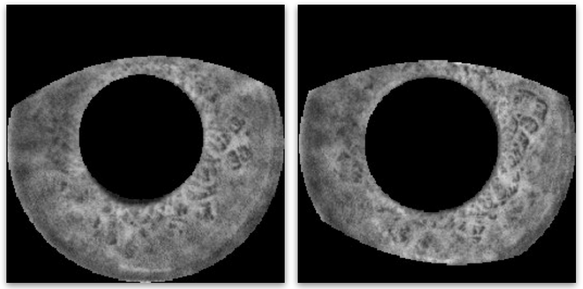
Dataset



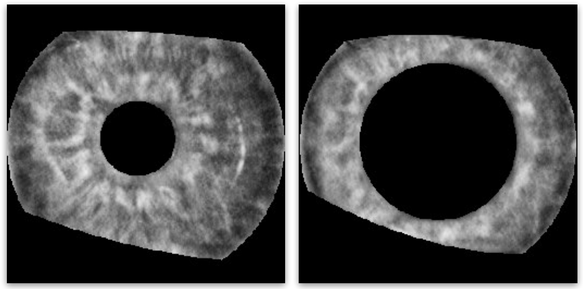
Easy for an automated solution



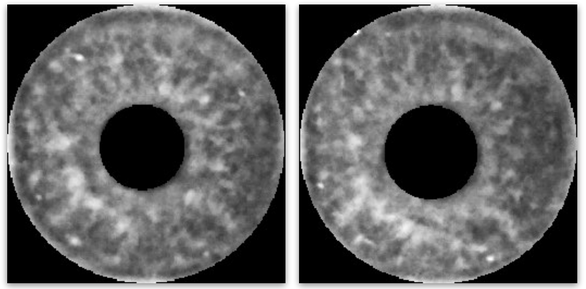
Hard for an automated solution



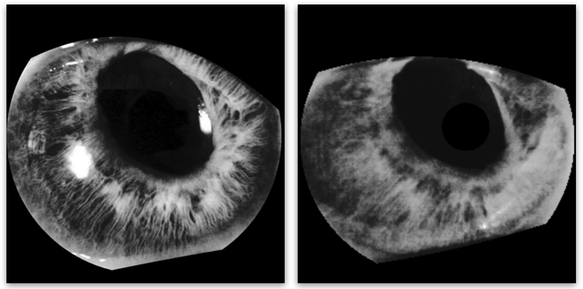
Twins’



Pupil dynamic



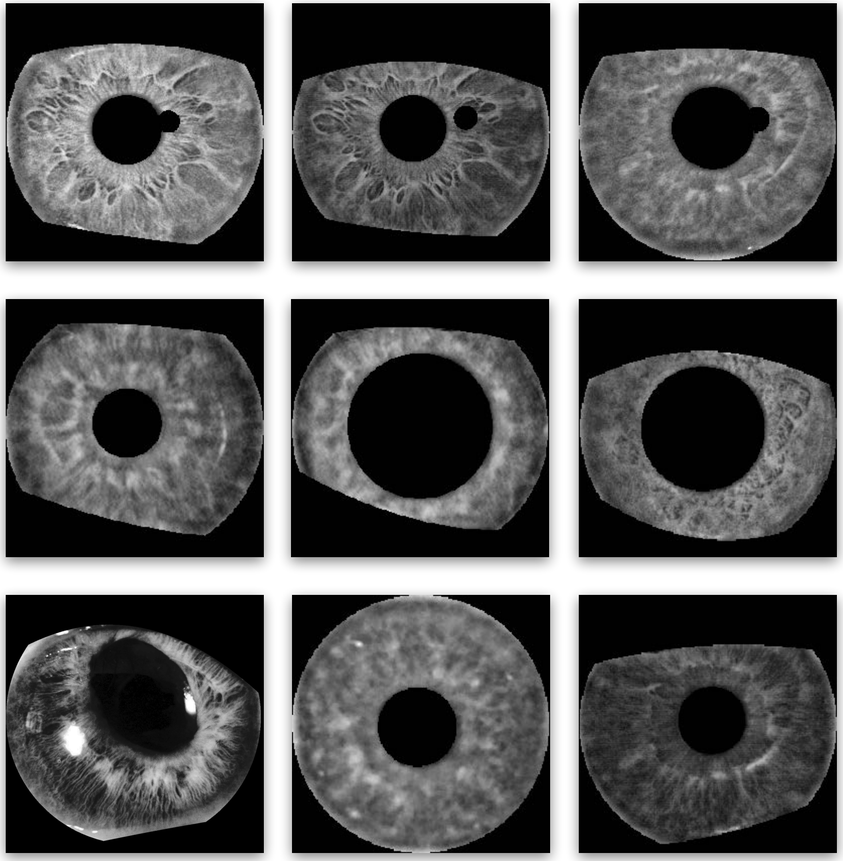
Deceased



Disease-affected

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Human Experiments



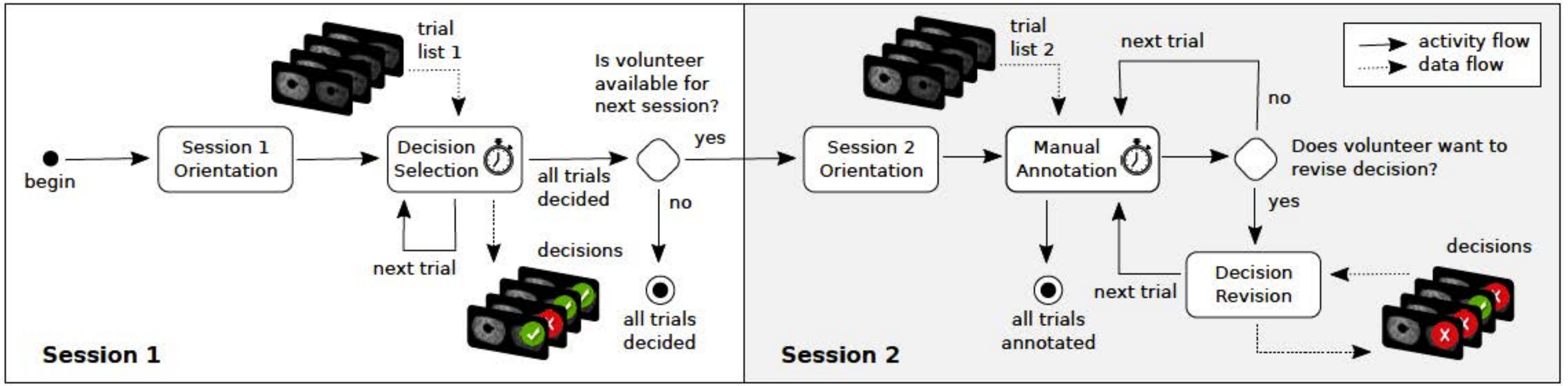
1360 iris images
(NIR and manually segmented)

512 distinct irises
512 individuals

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

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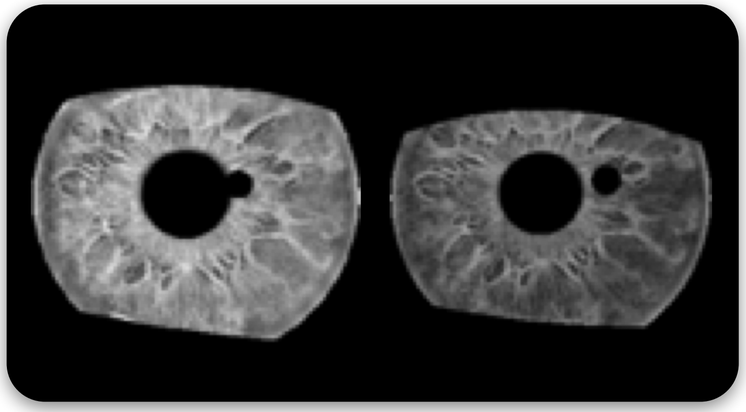
Human Experiments



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

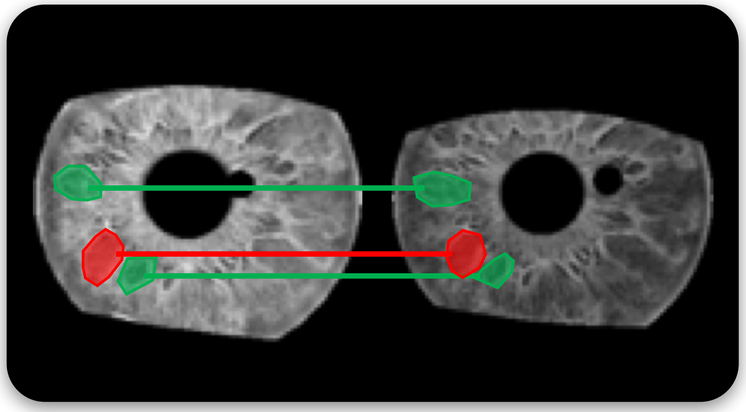
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Human Experiments



Session 1

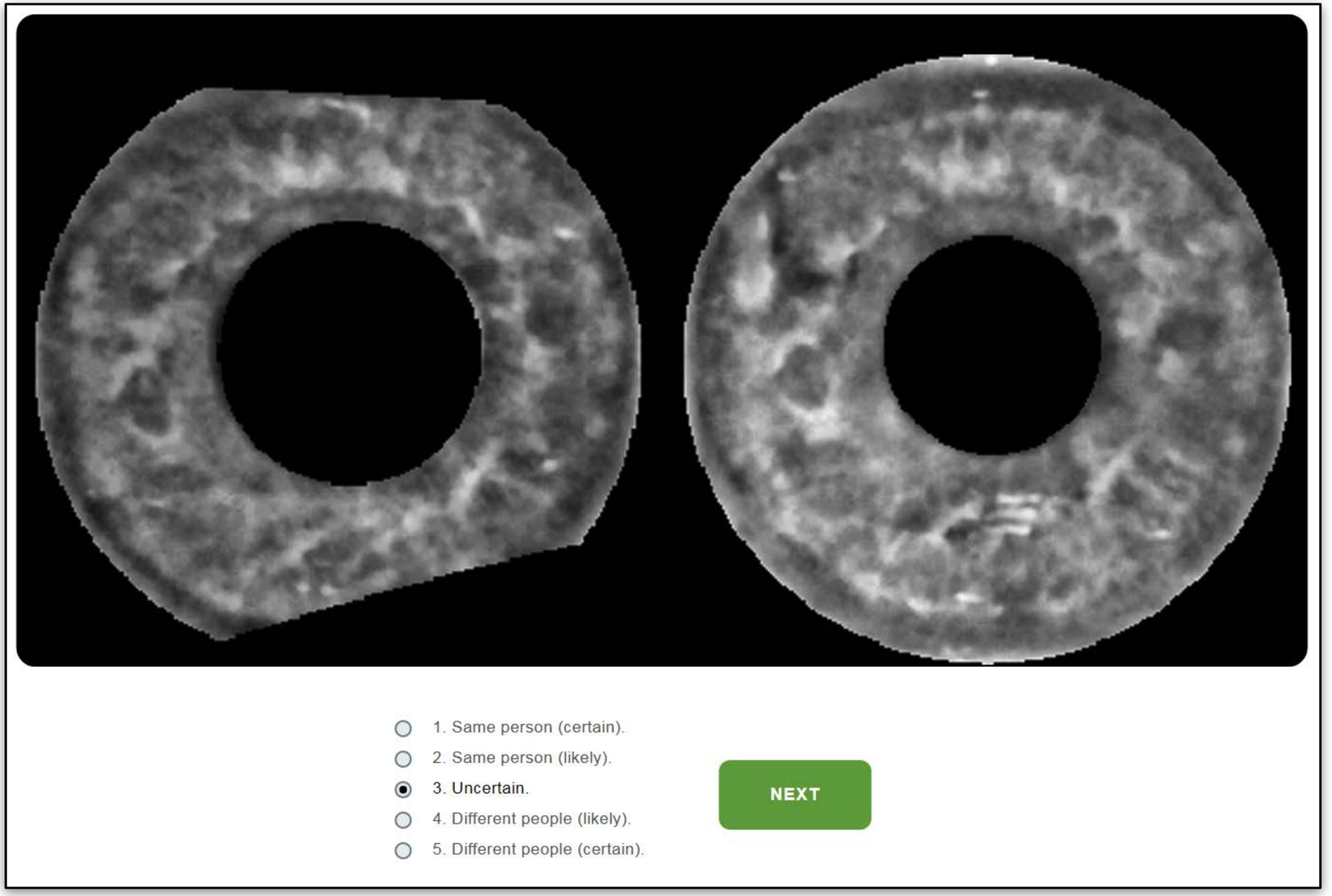
- ○ 1. Same person (certain).
- ○ 2. Same person (likely).
- ◉ 3. Uncertain.
- ○ 4. Different person (likely).
- ○ 5. Different person (certain).



Session 2

Manual annotation of **matching** and **missing** features

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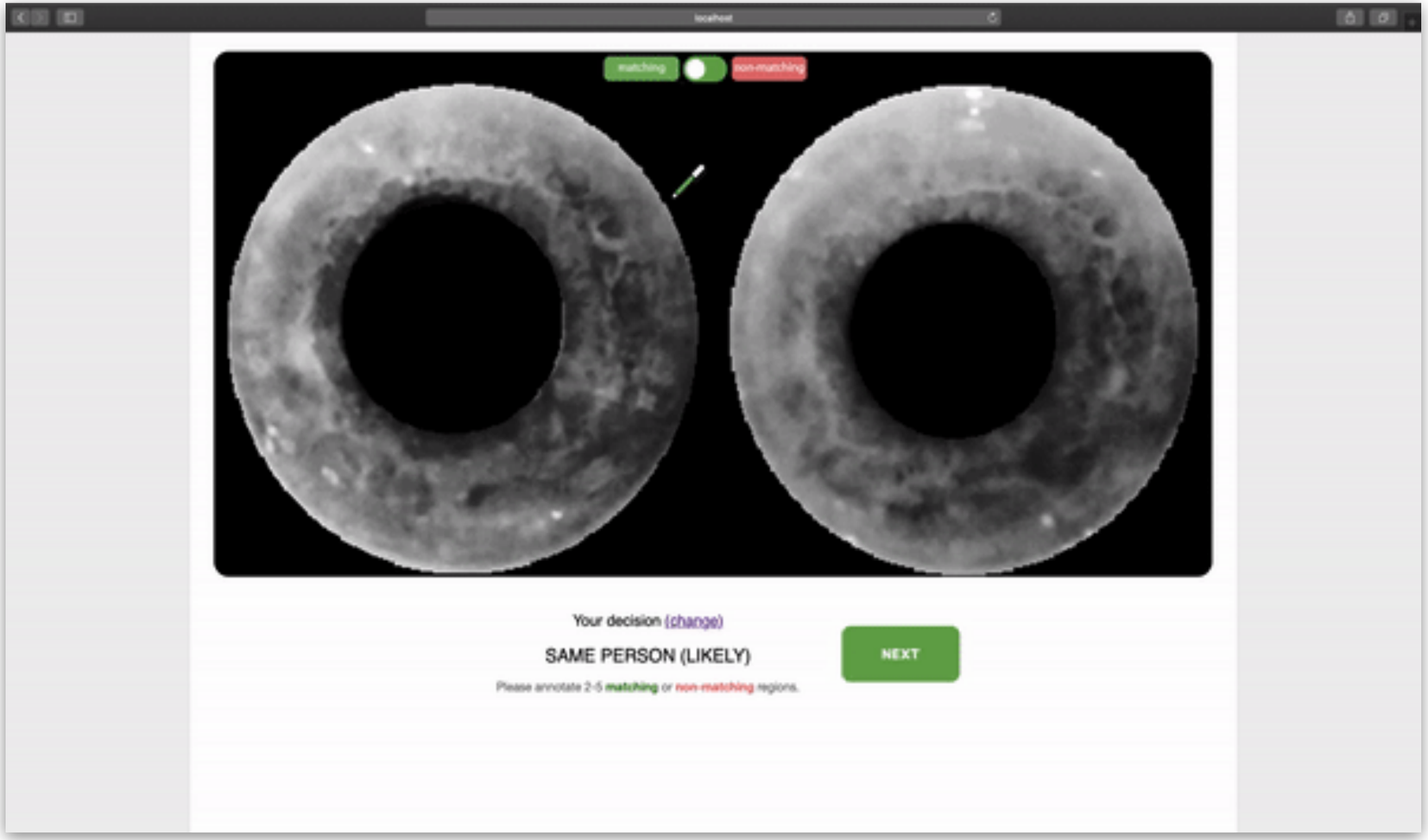
114 people
(age 18 to 65)

For each person
20 trials

Average session time
7 min

Balanced distribution
Category wise
Pair-type wise
Random presentation

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85 people

For each person
10 trials

Average session time
10 min

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

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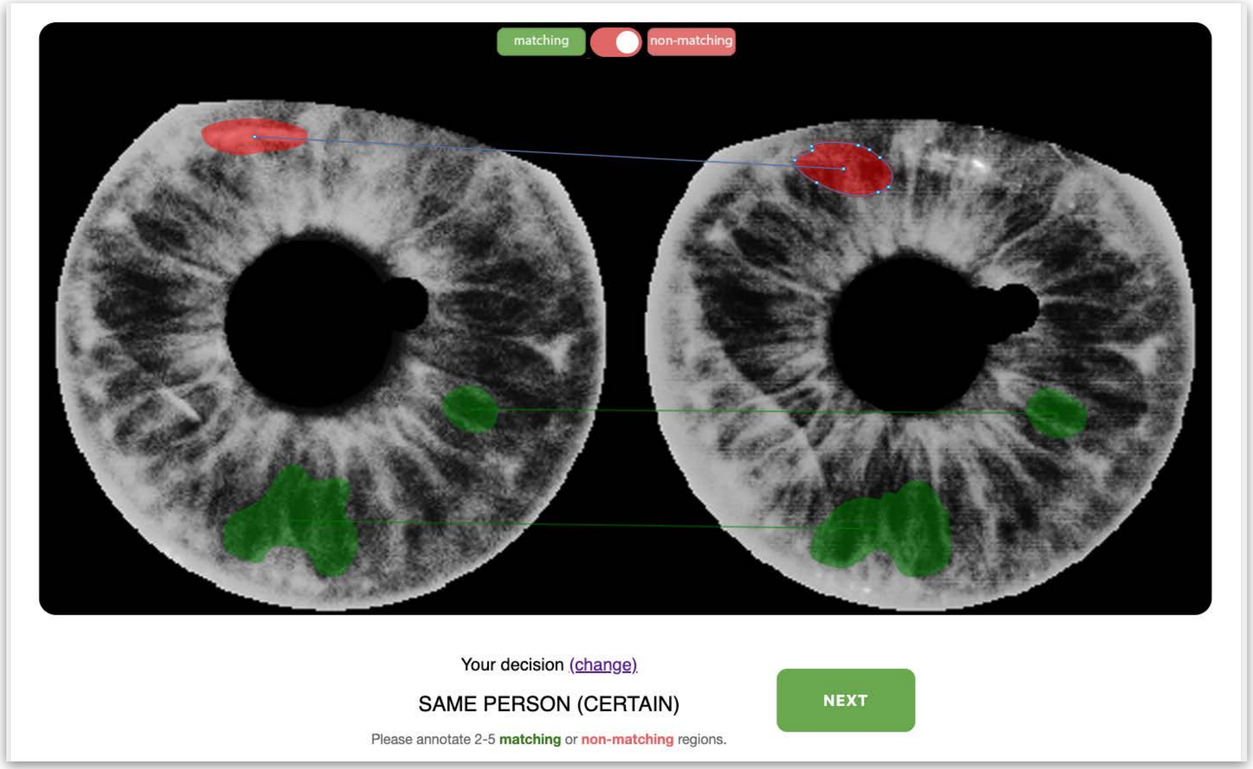
Annotation Tool



Available at
https://github.com/
danielmoreira/iris-examination

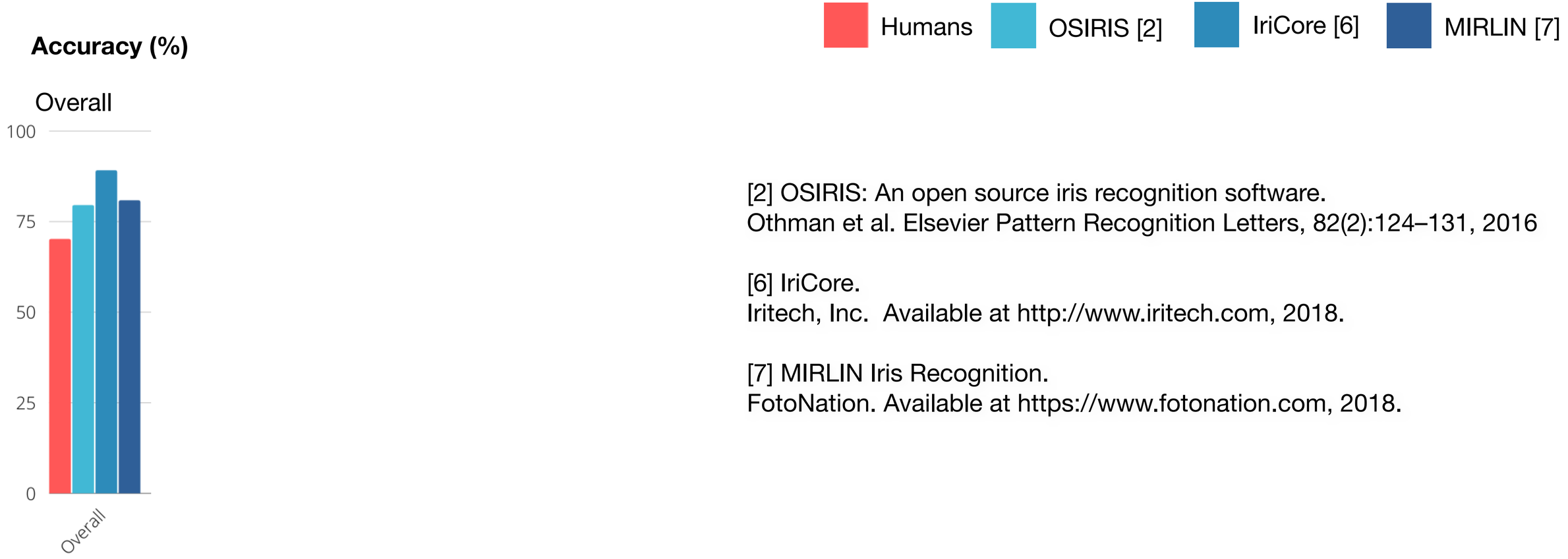


Paper.js
Web-browser drawing
library.



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Human Experiments



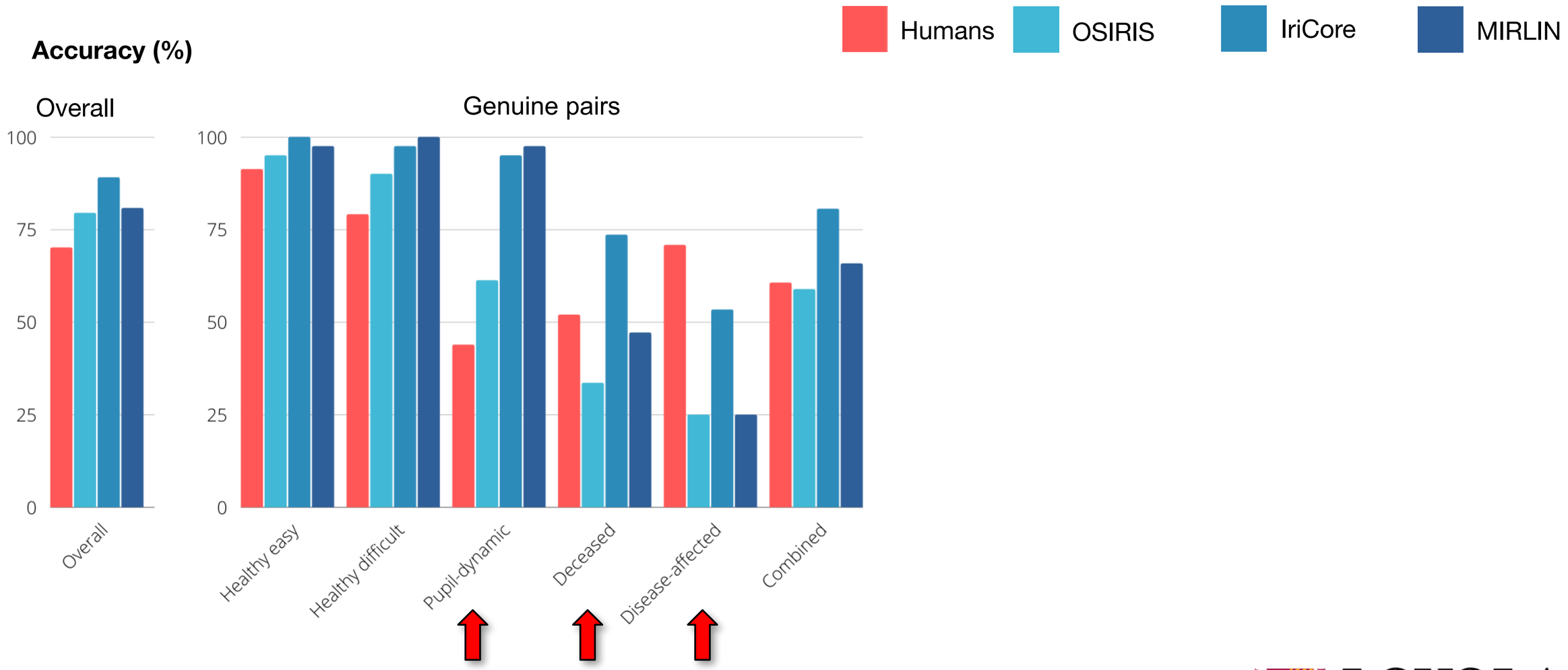
[2] OSIRIS: An open source iris recognition software.
Othman et al. Elsevier Pattern Recognition Letters, 82(2):124–131, 2016

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

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

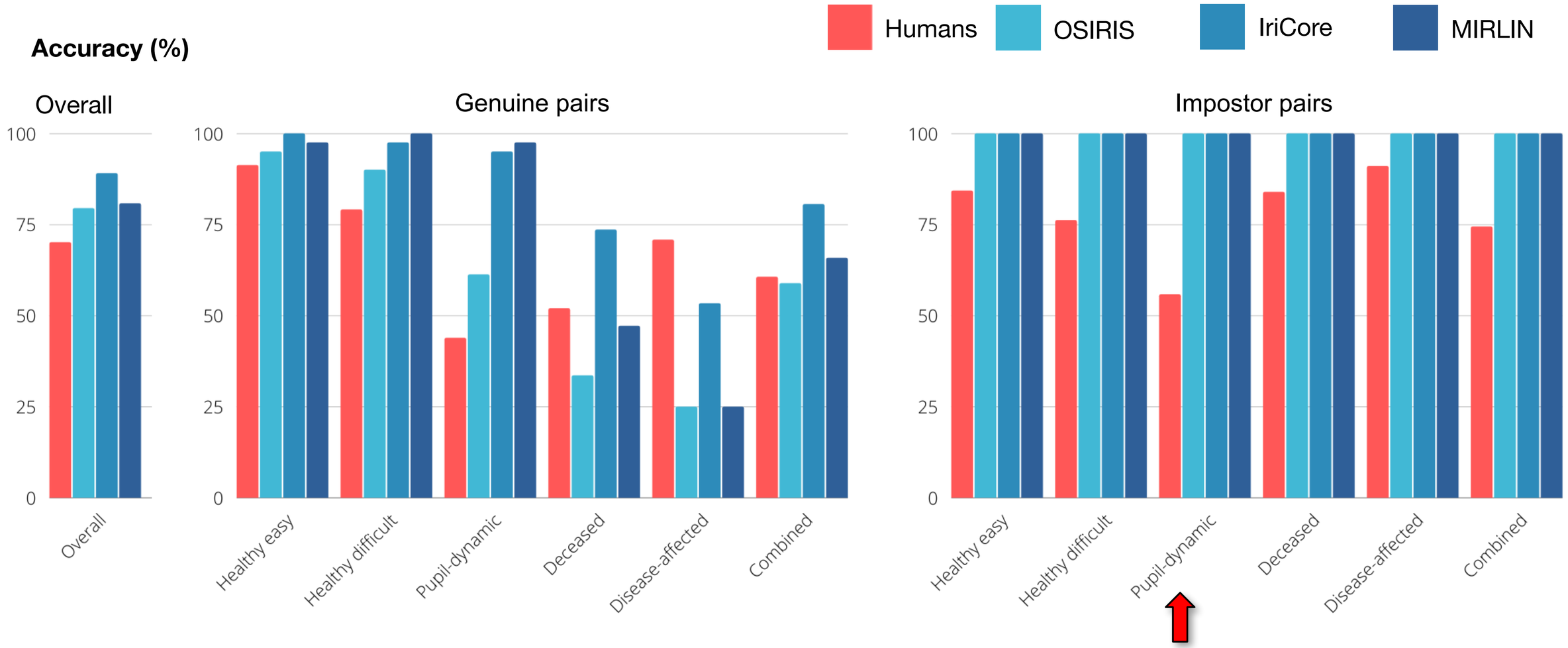
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Human Experiments



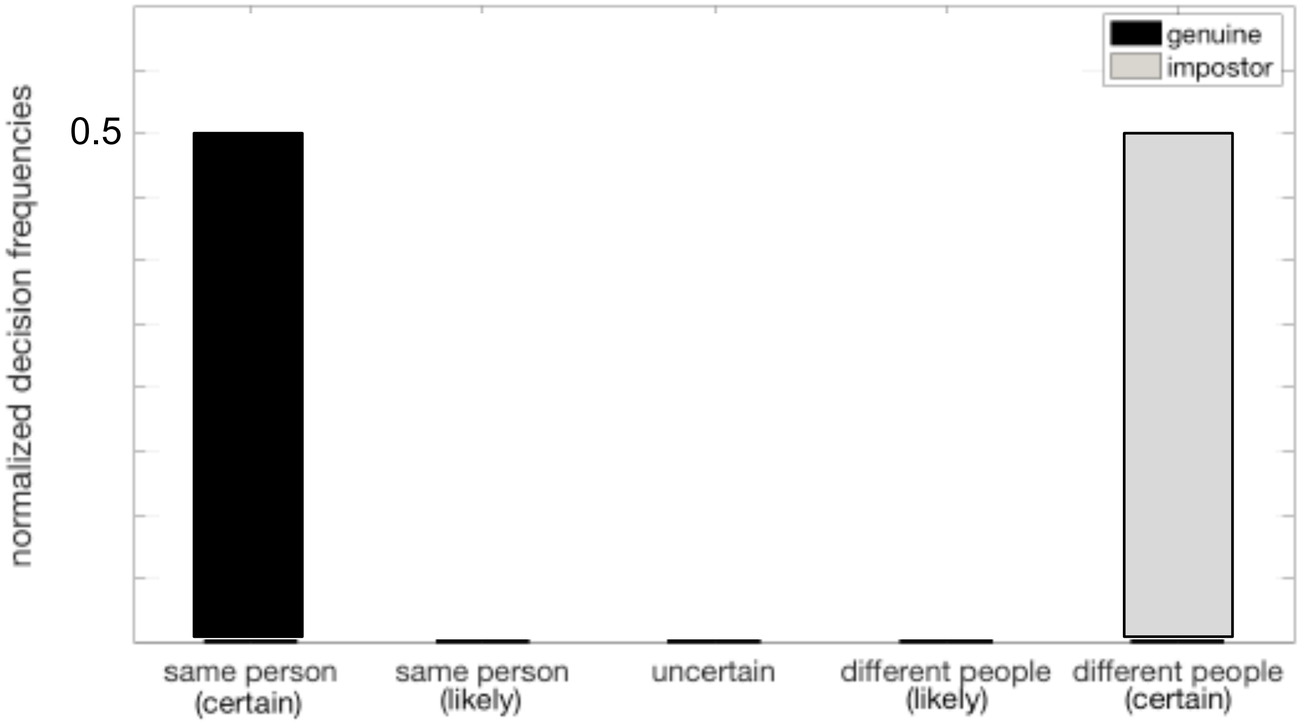
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Human Experiments



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Human Experiments

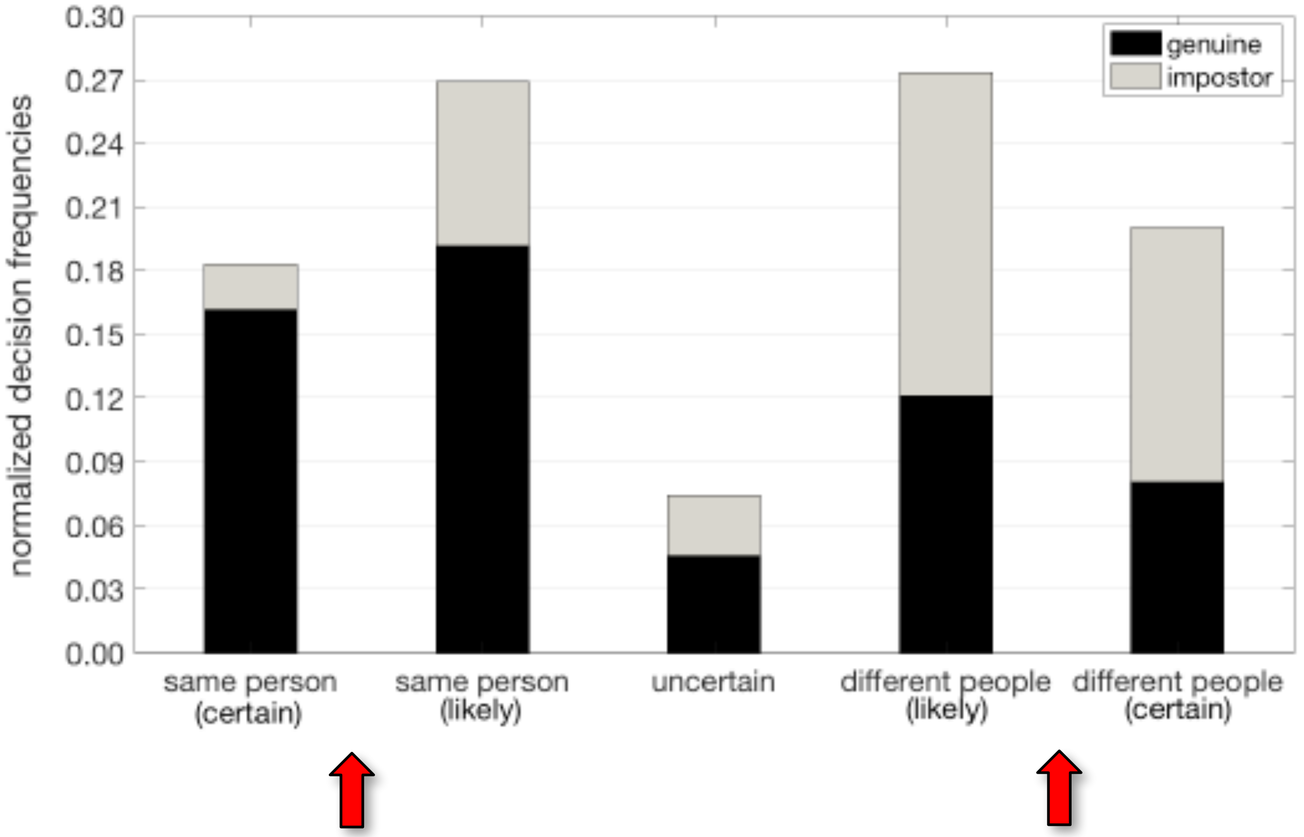


How confident were people?

Ideal graph

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Human Experiments

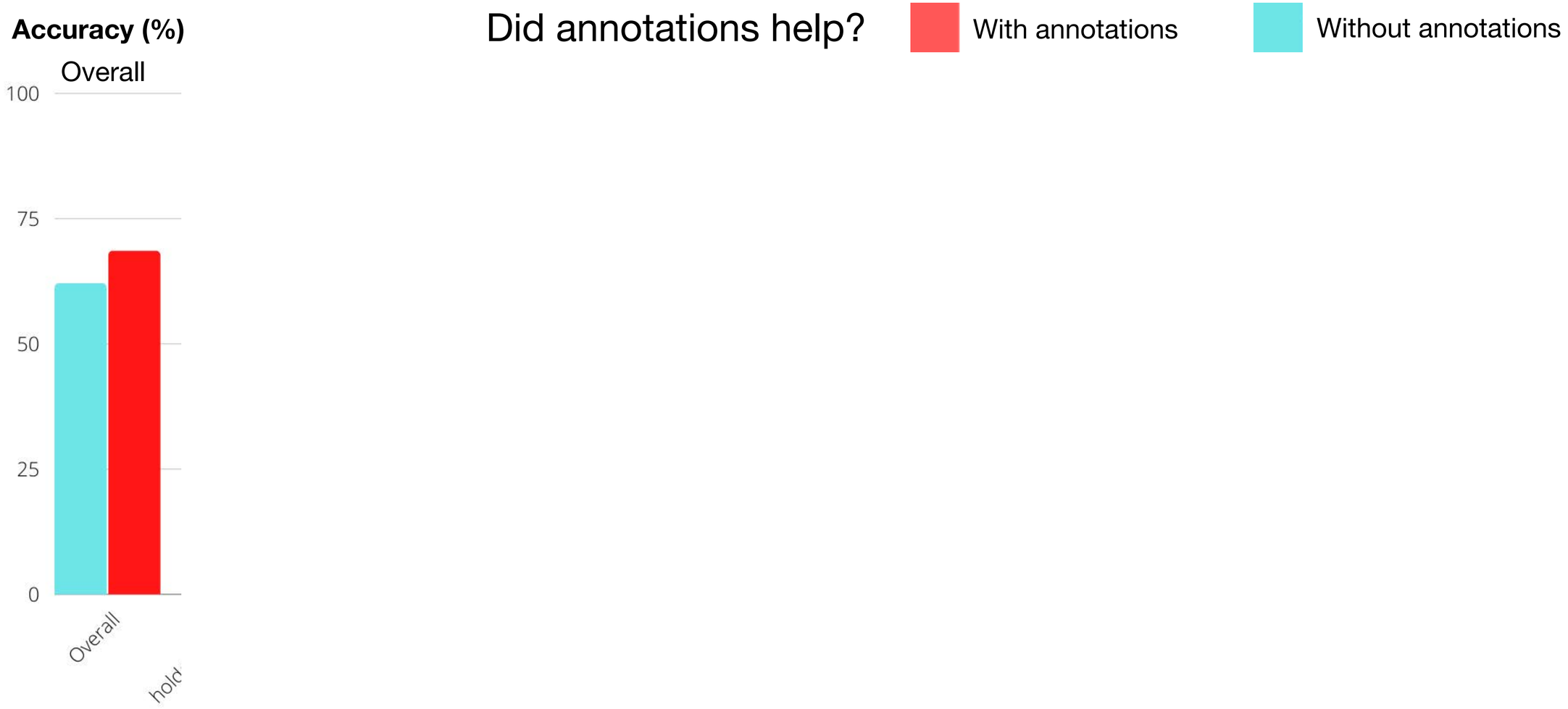


How confident were people?

Obtained graph

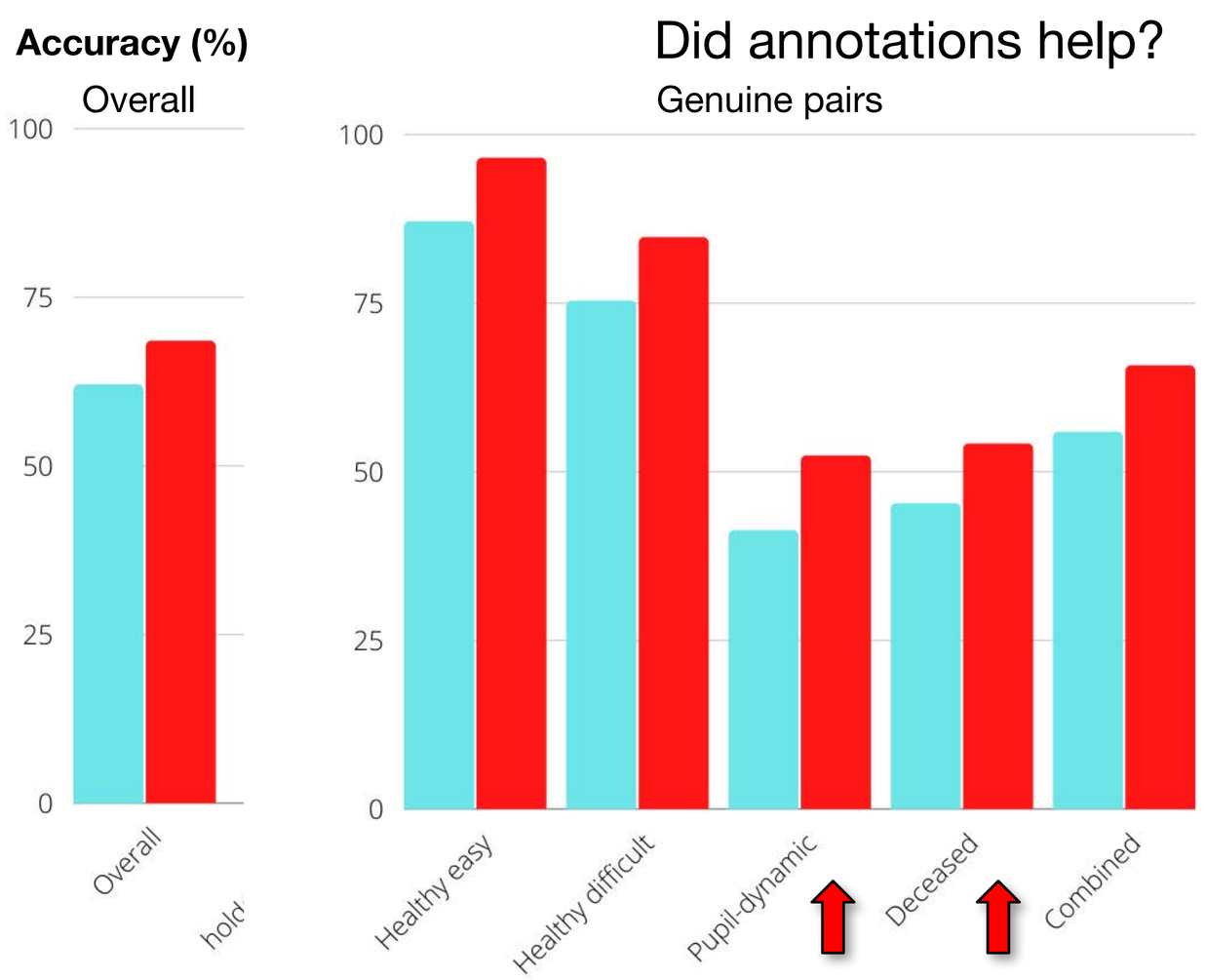
LOYOLA UNIVERSITY CHICAGO

Human Experiments



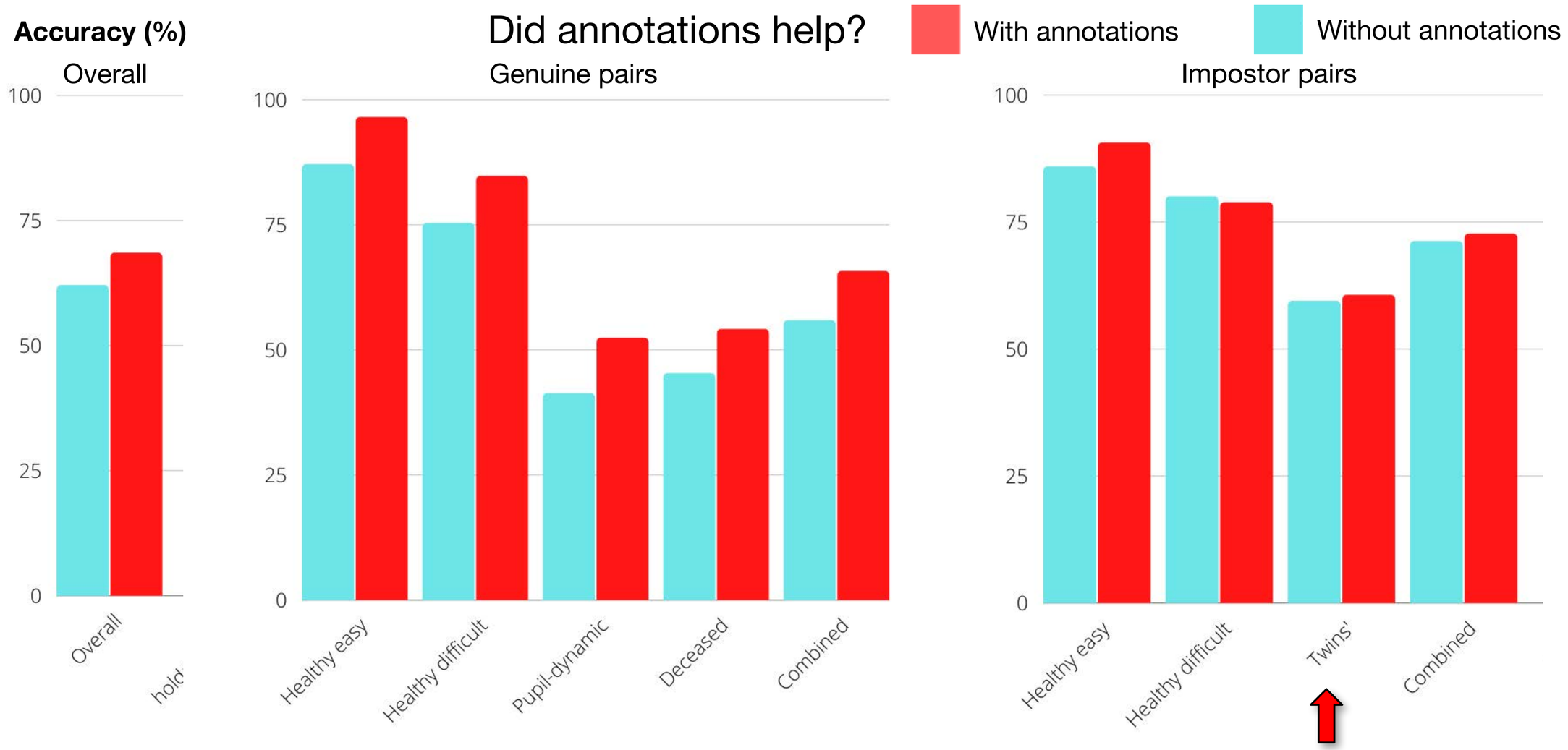
LOYOLA UNIVERSITY CHICAGO

Human Experiments

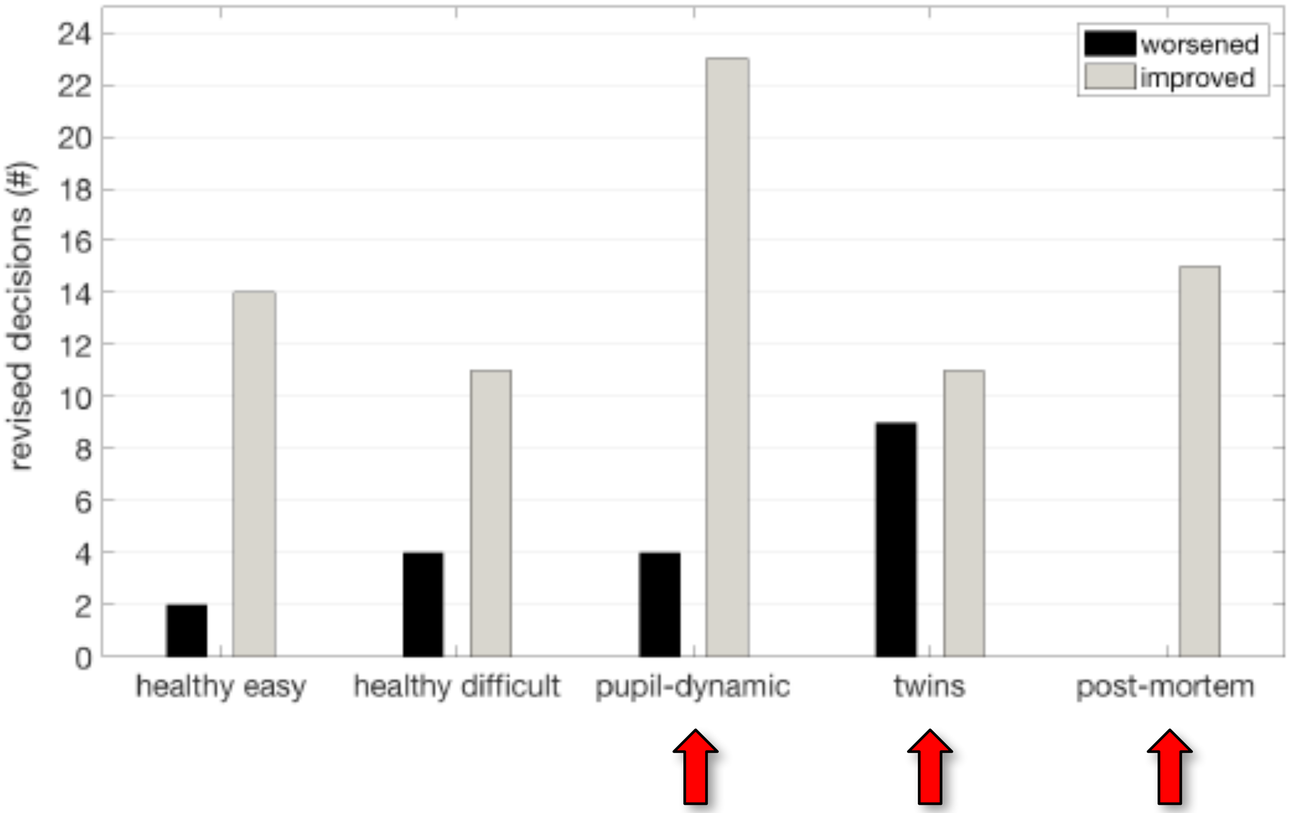


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Human Experiments



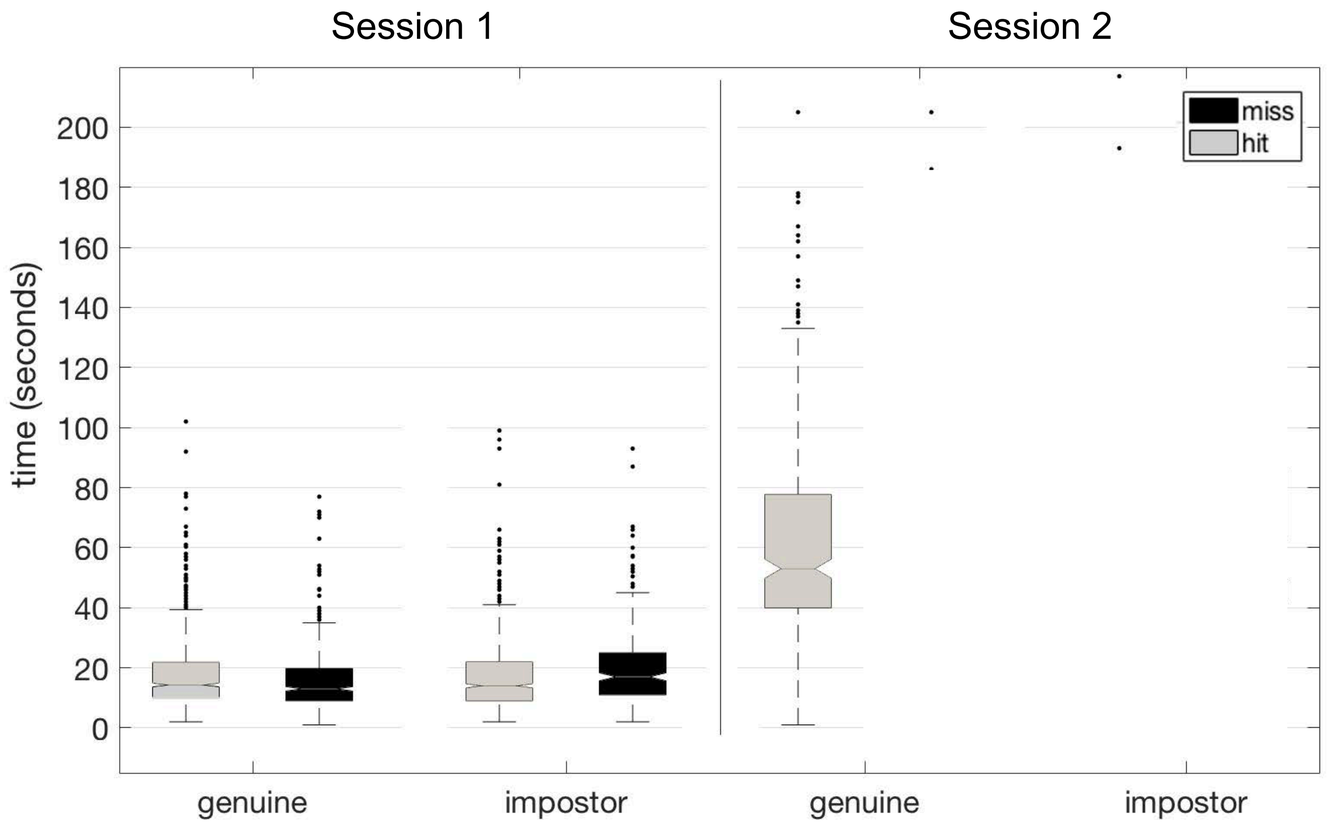
Human Experiments



Did annotations help?

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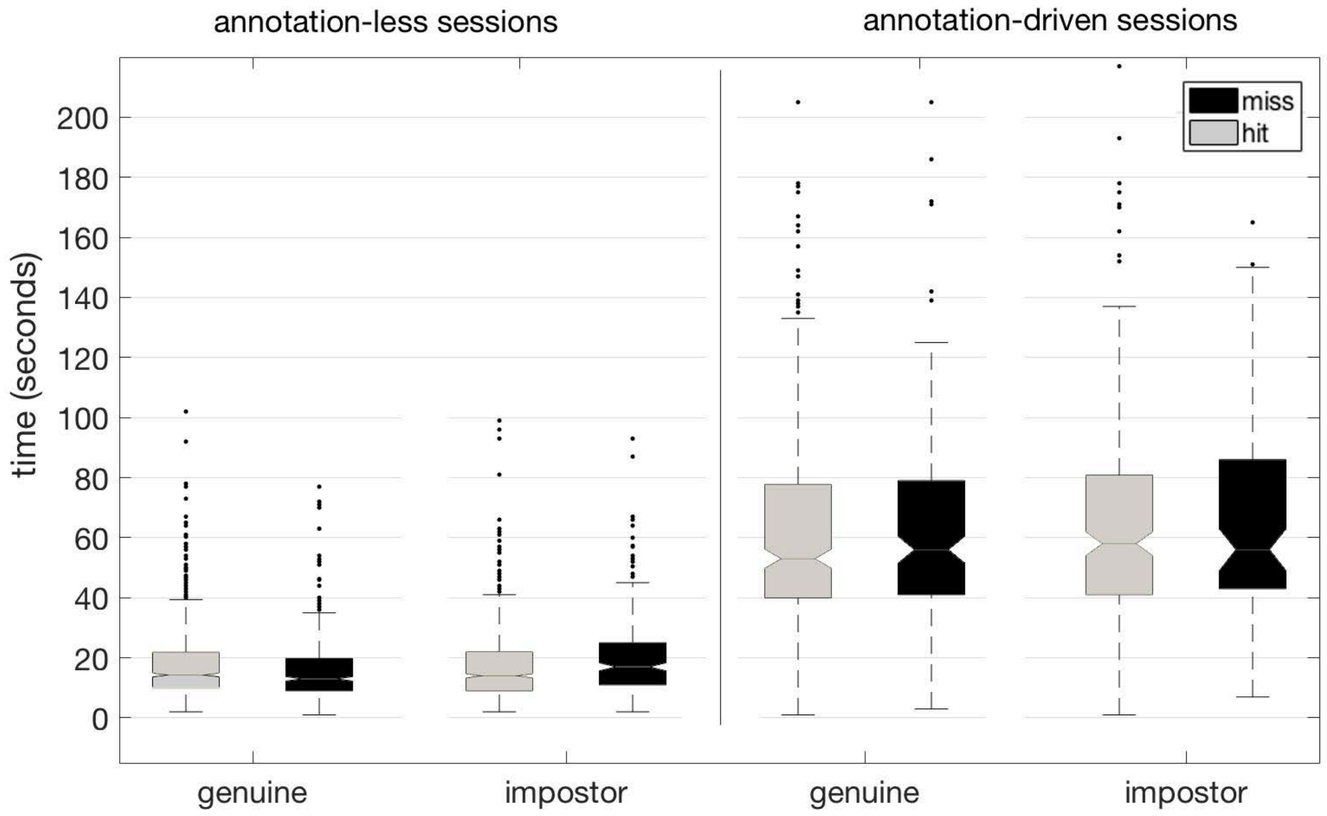
Human Experiments



Was time important?

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Human Experiments

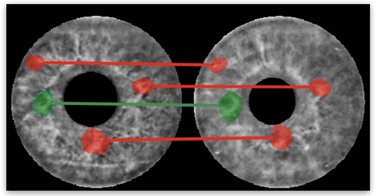


Was time important?

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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.**

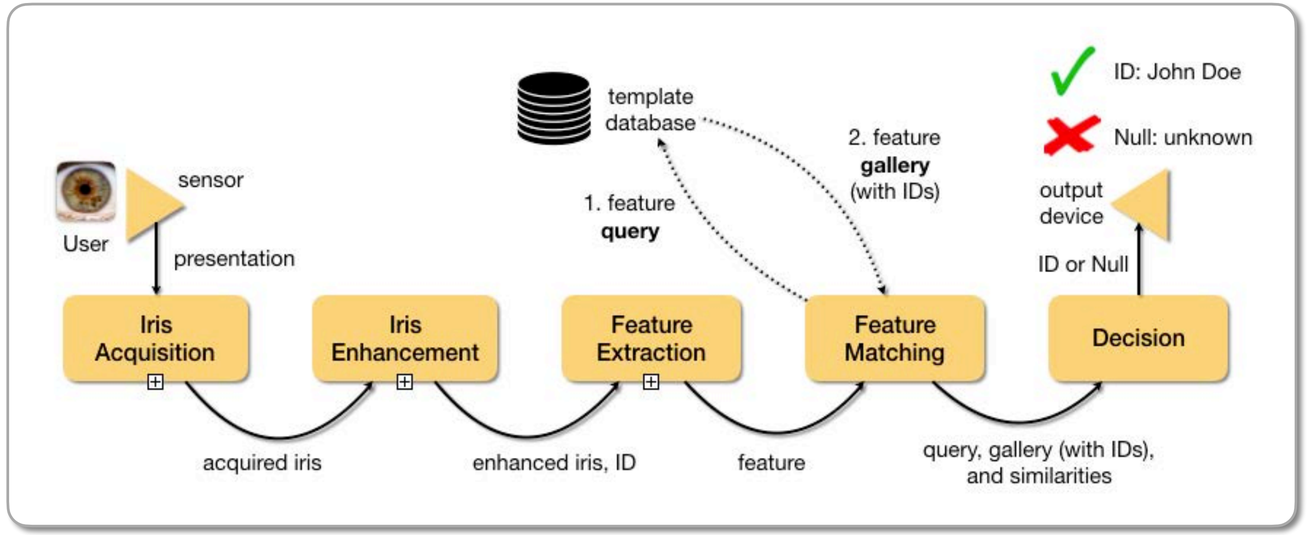
Annotating pupil dilation helps.

Annotating twins' doesn't.

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What's Next?

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



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