

Iris Recognition I

CSE 40537/60537 Biometrics

Daniel Moreira
Spring 2020

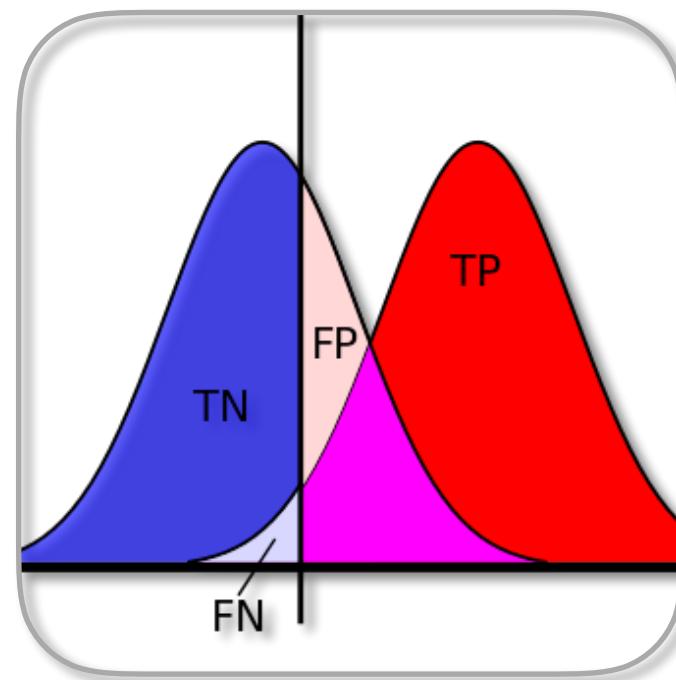


Today you will...

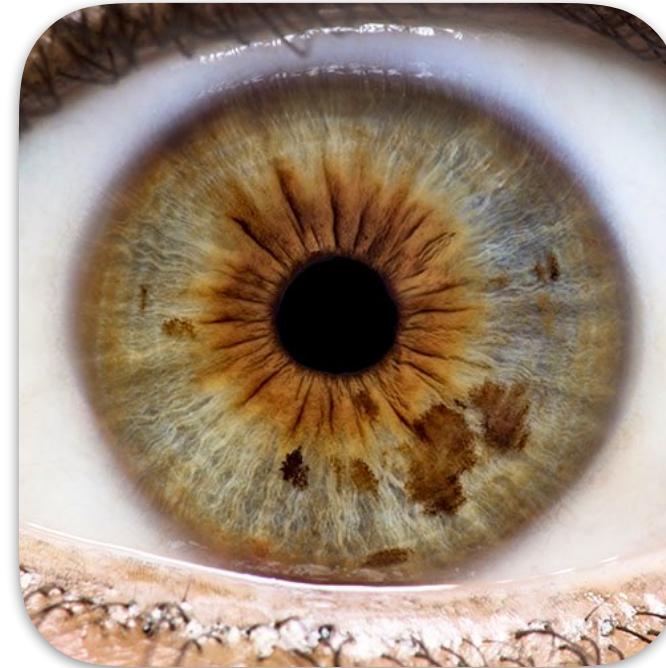
Get to know
Reasons to use irises for recognition.
How irises compare to fingerprints
and to faces.

Course Overview

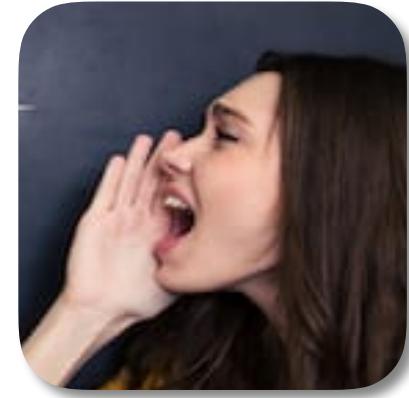
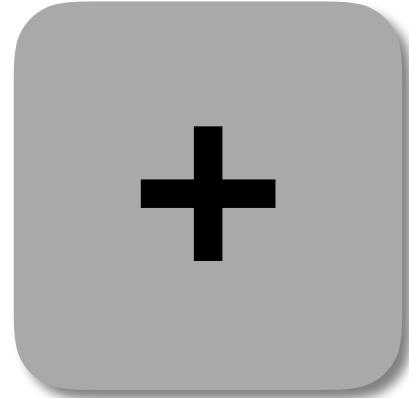
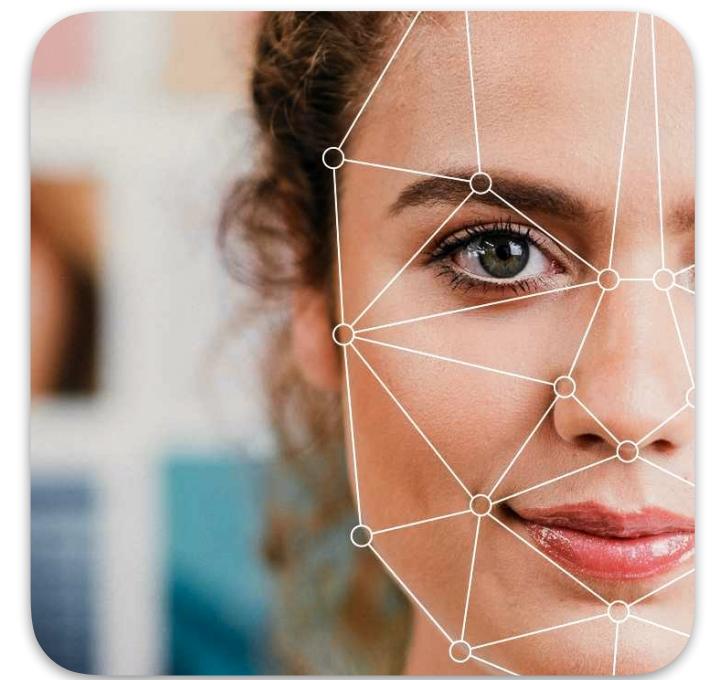
Content



Basics
Concepts
Metrics
Metric implementation



Core Traits (3)
Concepts
Baseline implementation
Evaluation
Assignments



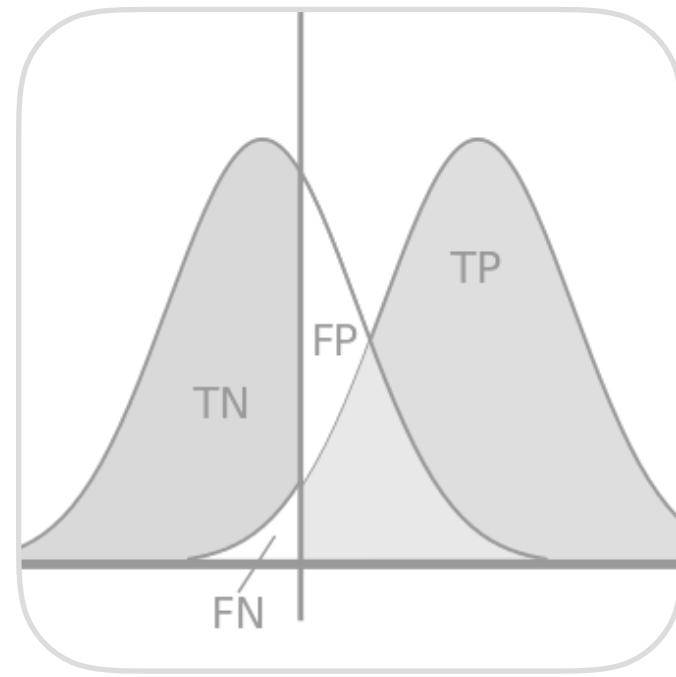
Alternative Traits and Fusion Concepts



Invited Talks (2)
State of the art
Future work

Course Overview

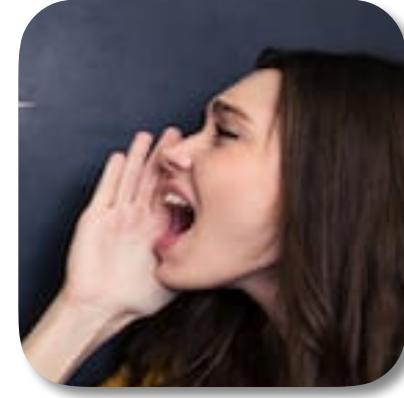
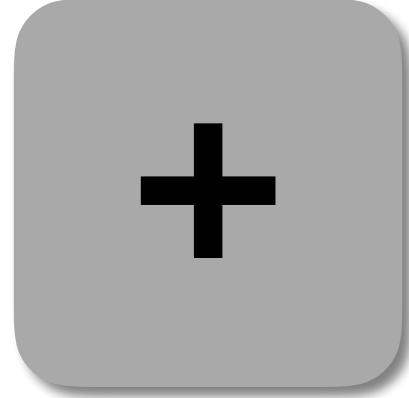
Content



Basics
Concepts
Metrics
Metric implementation



Core Traits (3)
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Baseline implementation
Evaluation
Assignments



Alternative Traits and Fusion Concepts



Invited Talks (2)
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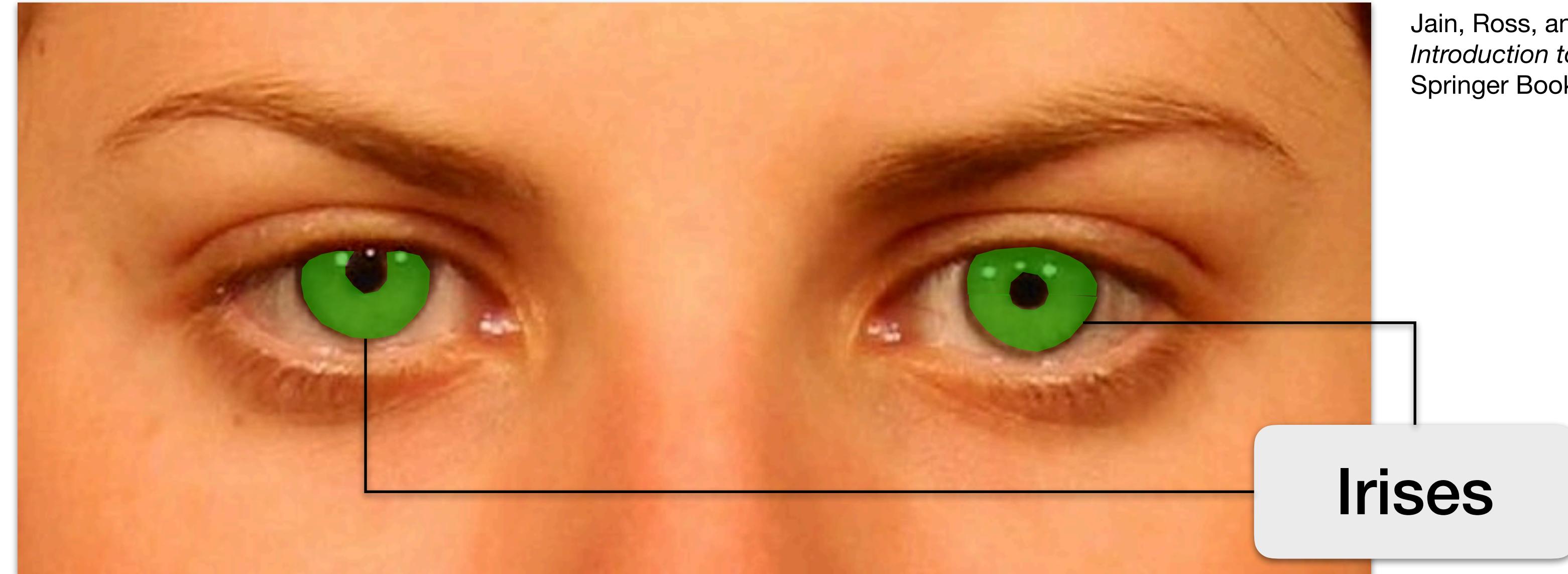
Irides



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

Ocular Region

Irides



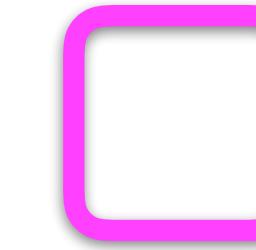
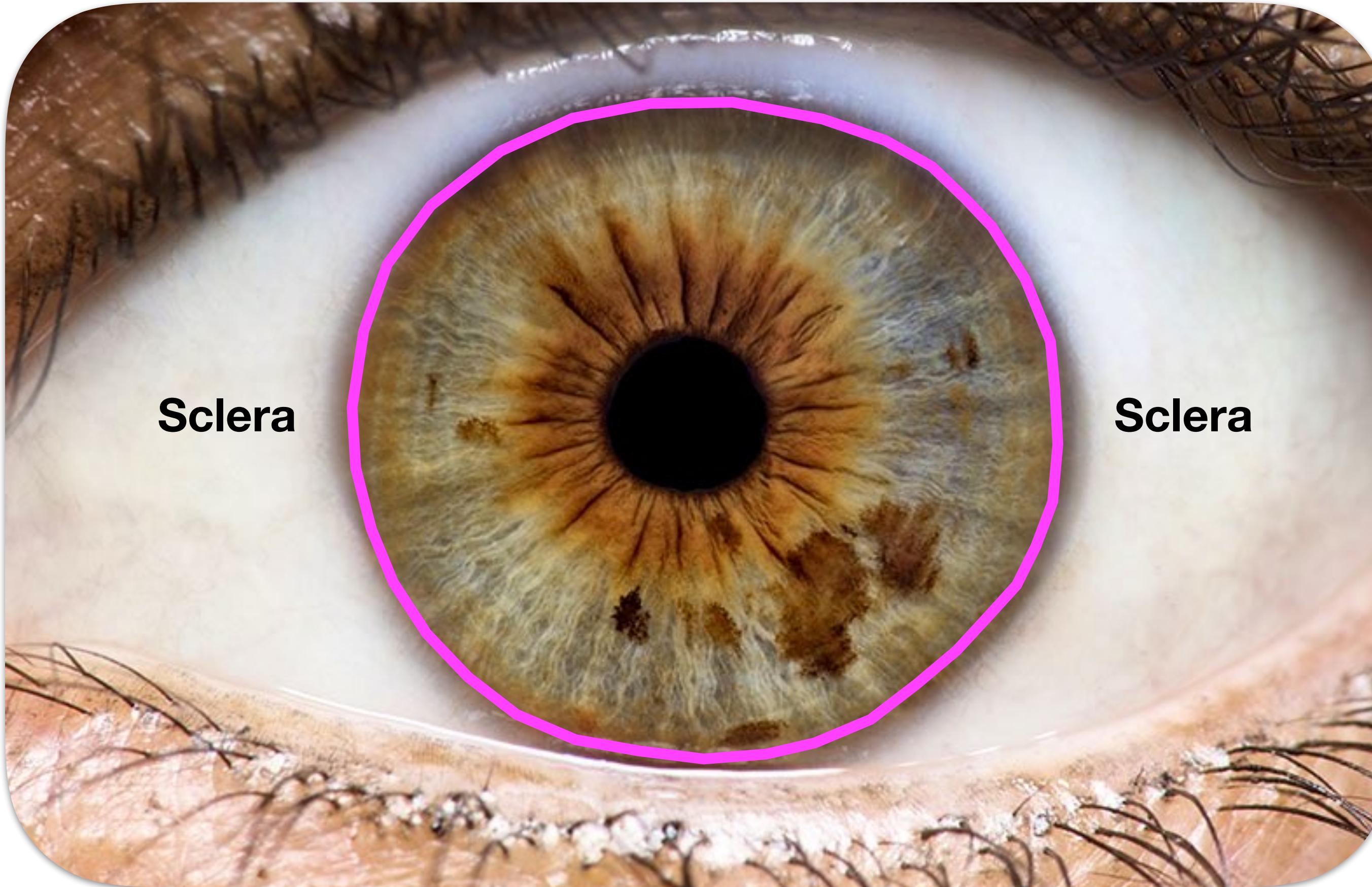
Jain, Ross, and Nandakumar
Introduction to Biometrics
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Ocular Region

Anatomy



Anatomy

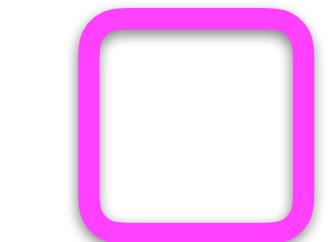
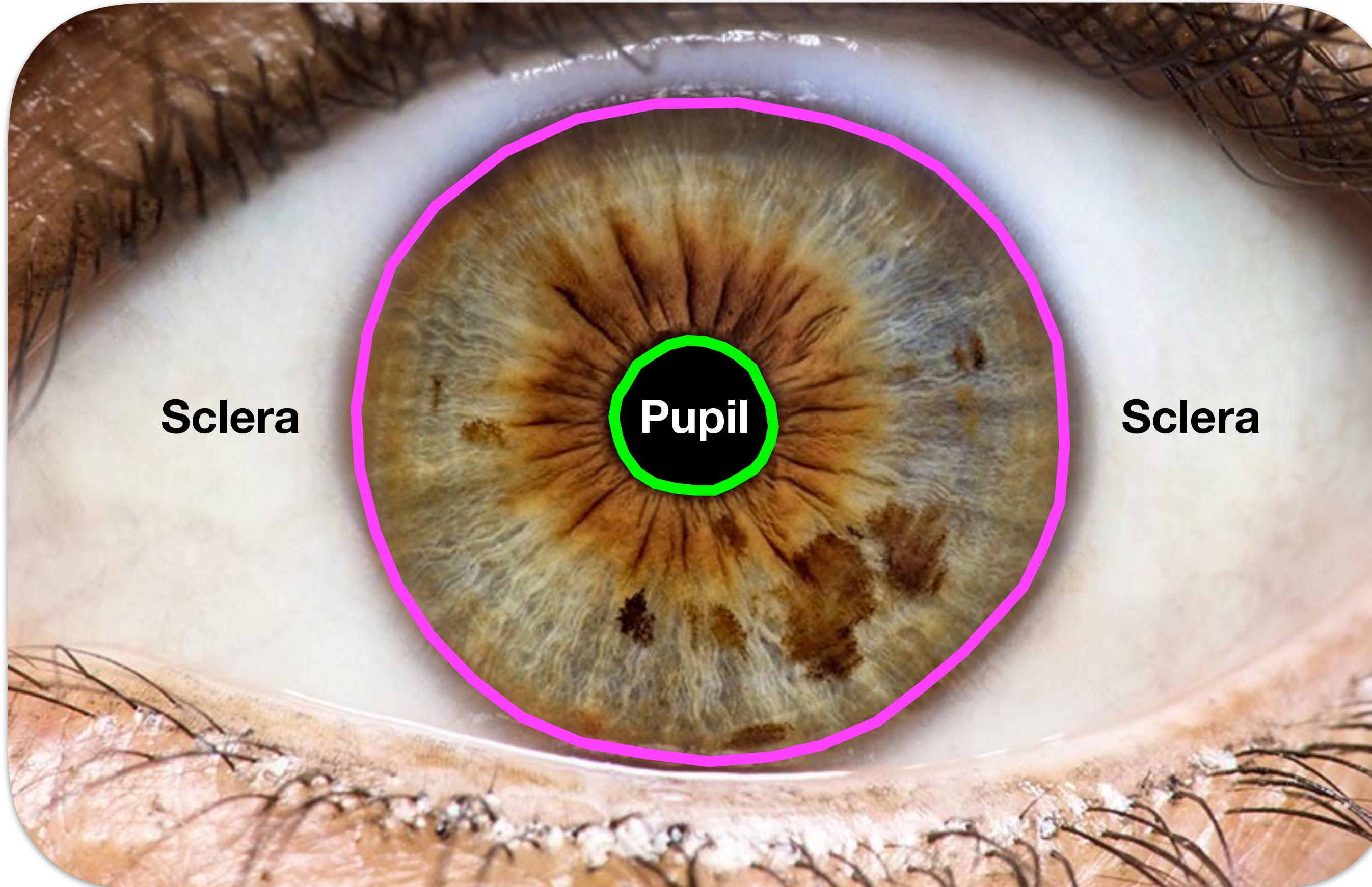


Limbus boundary

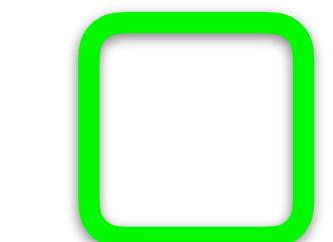
Sclera

Sclera

Anatomy

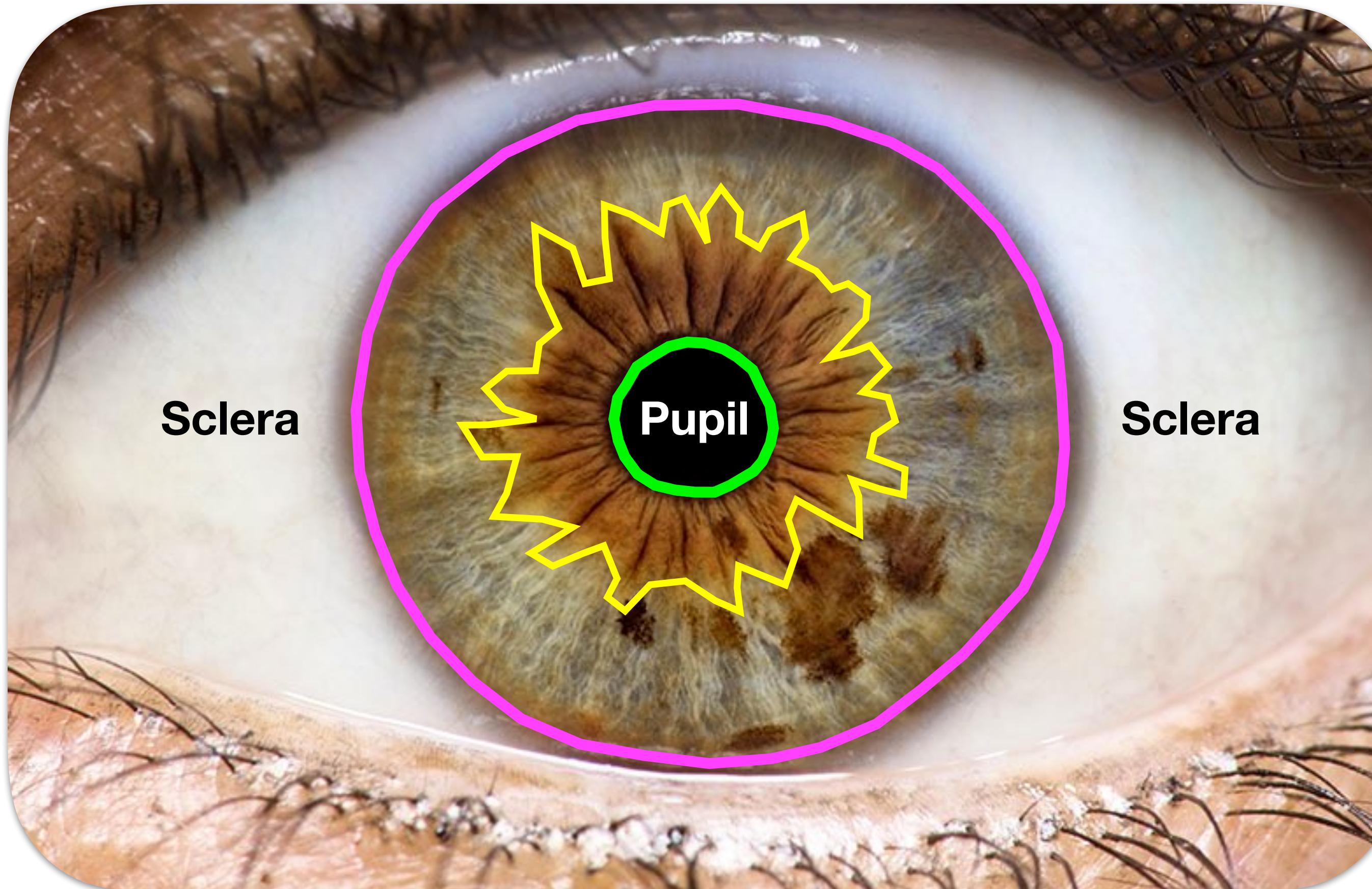


Limbus boundary



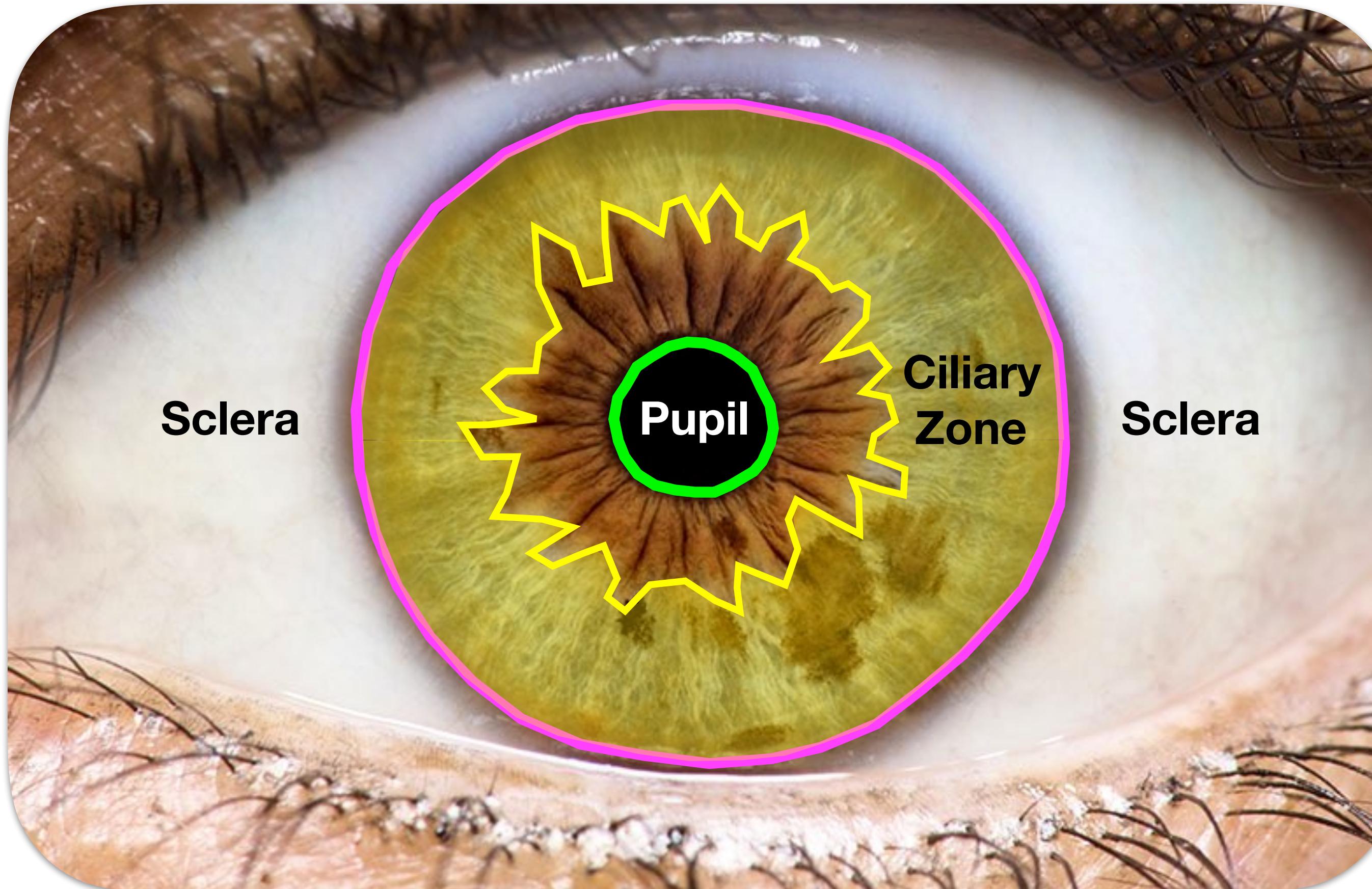
Pupillary boundary

Anatomy



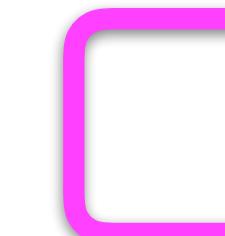
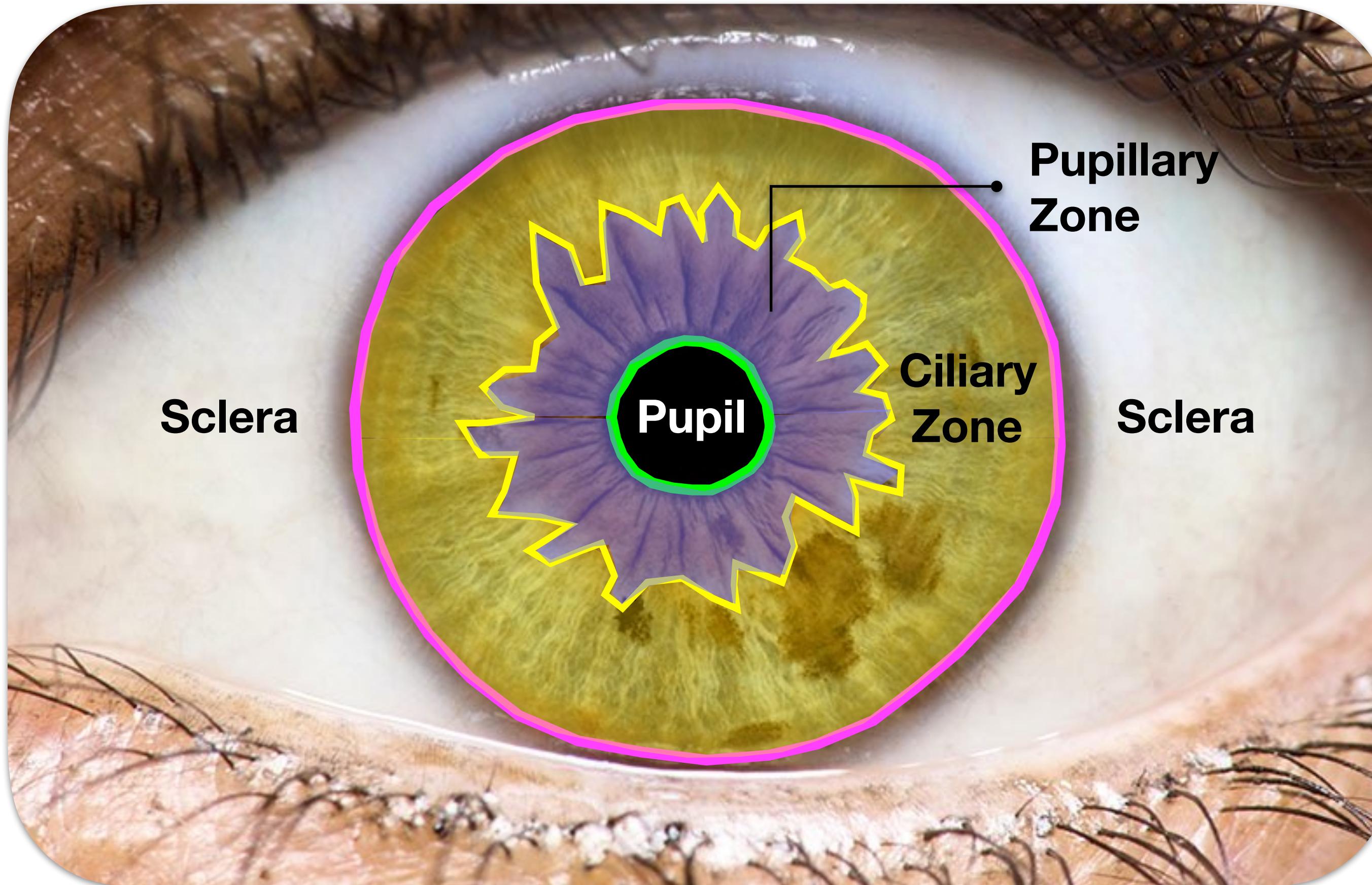
- Limbus boundary
- Pupillary boundary
- Collarette

Anatomy

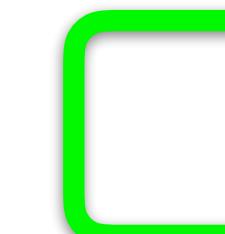


- Limbus boundary
- Pupillary boundary
- Collarette

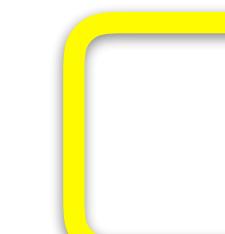
Anatomy



Limbus boundary

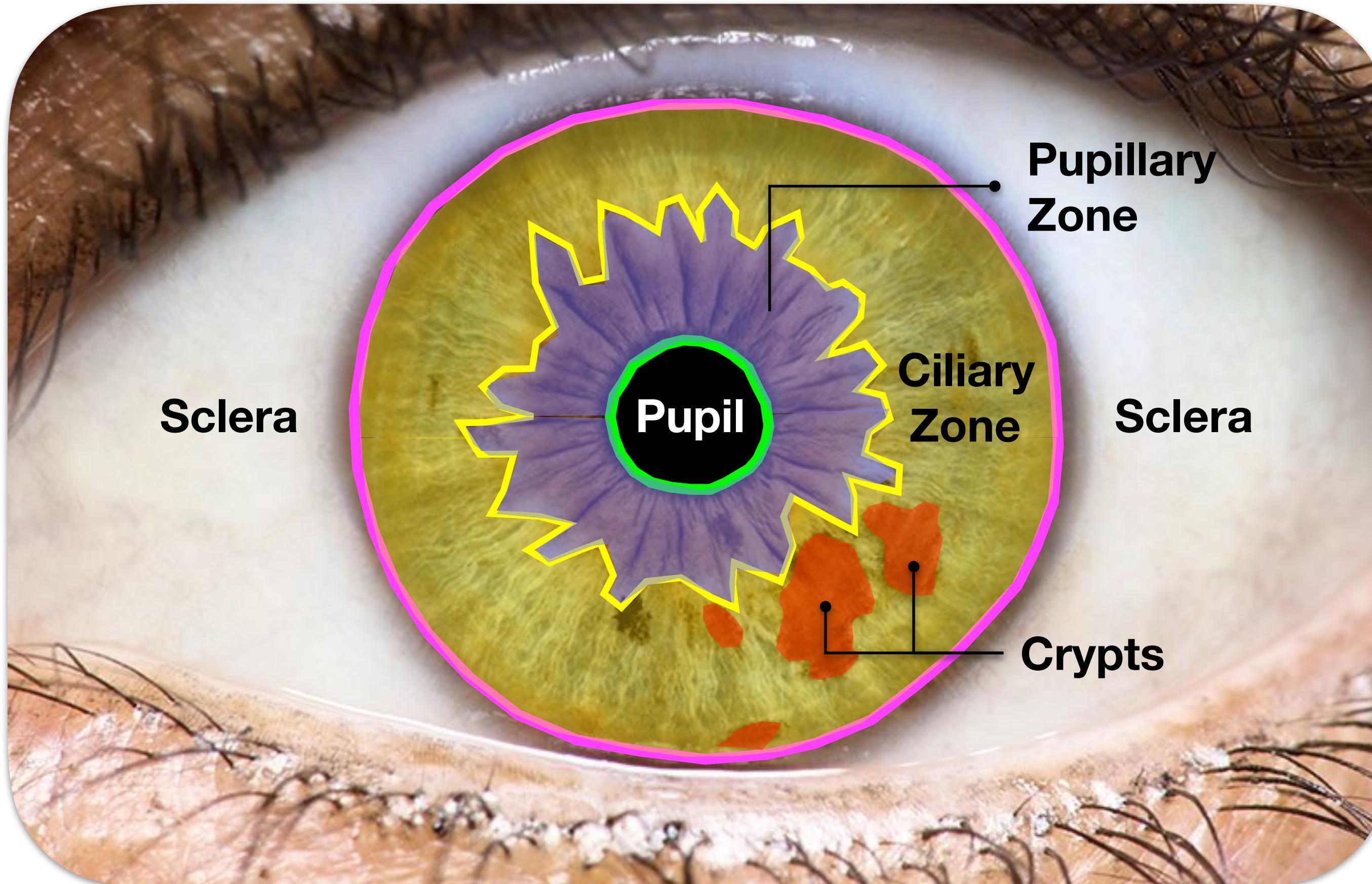


Pupillary boundary



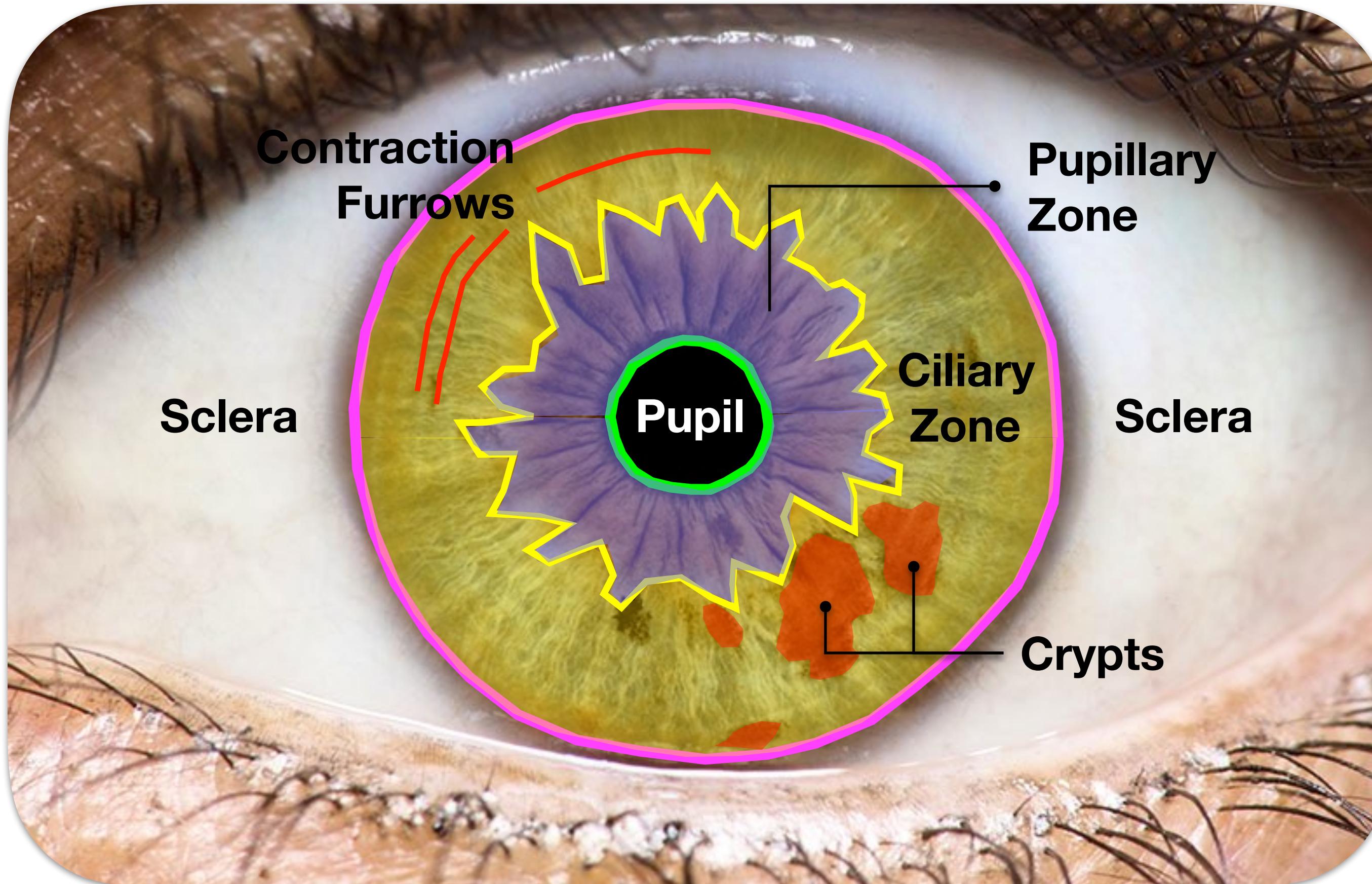
Collarette

Anatomy



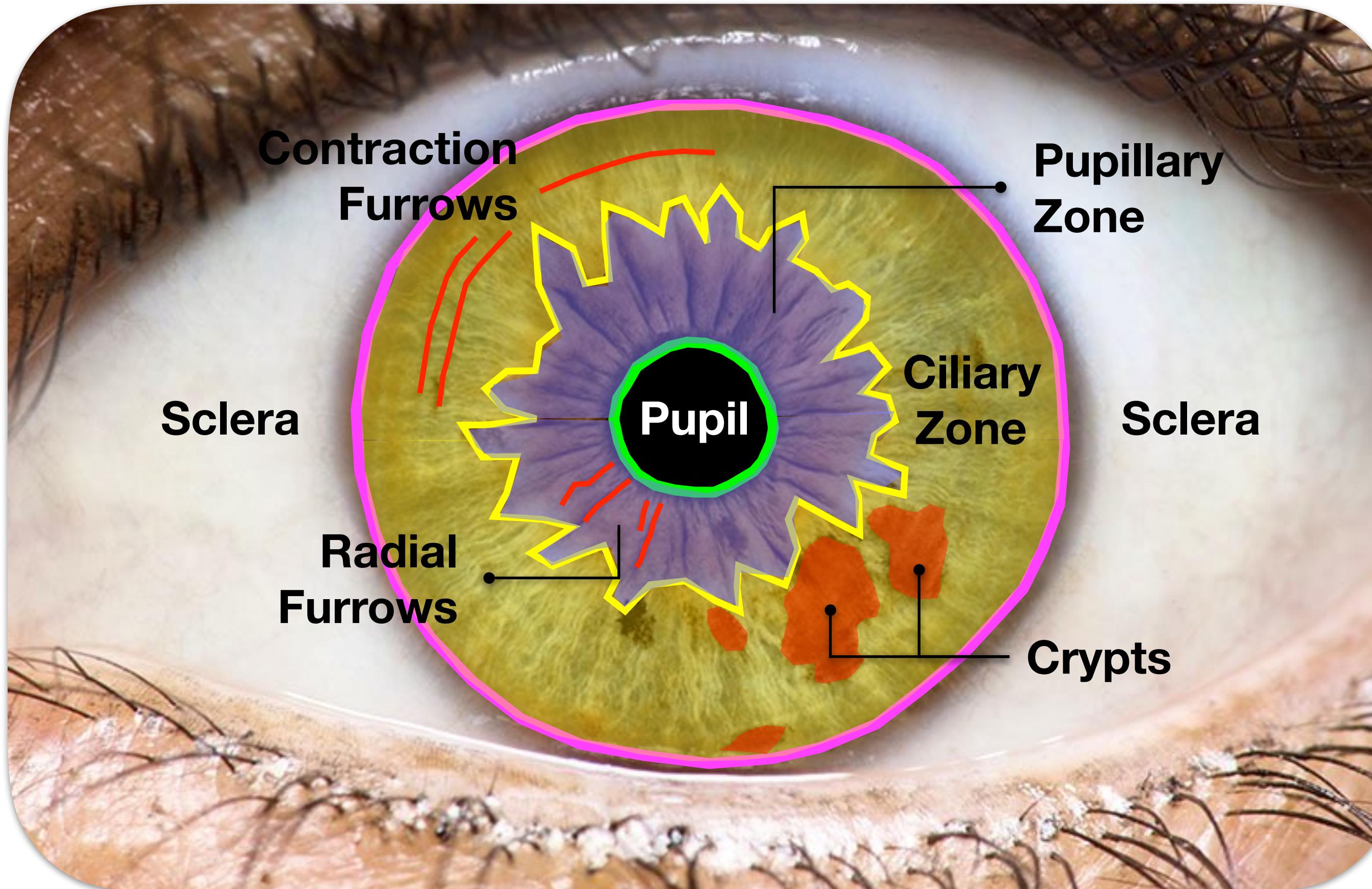
- Limbus boundary
- Pupillary boundary
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Anatomy



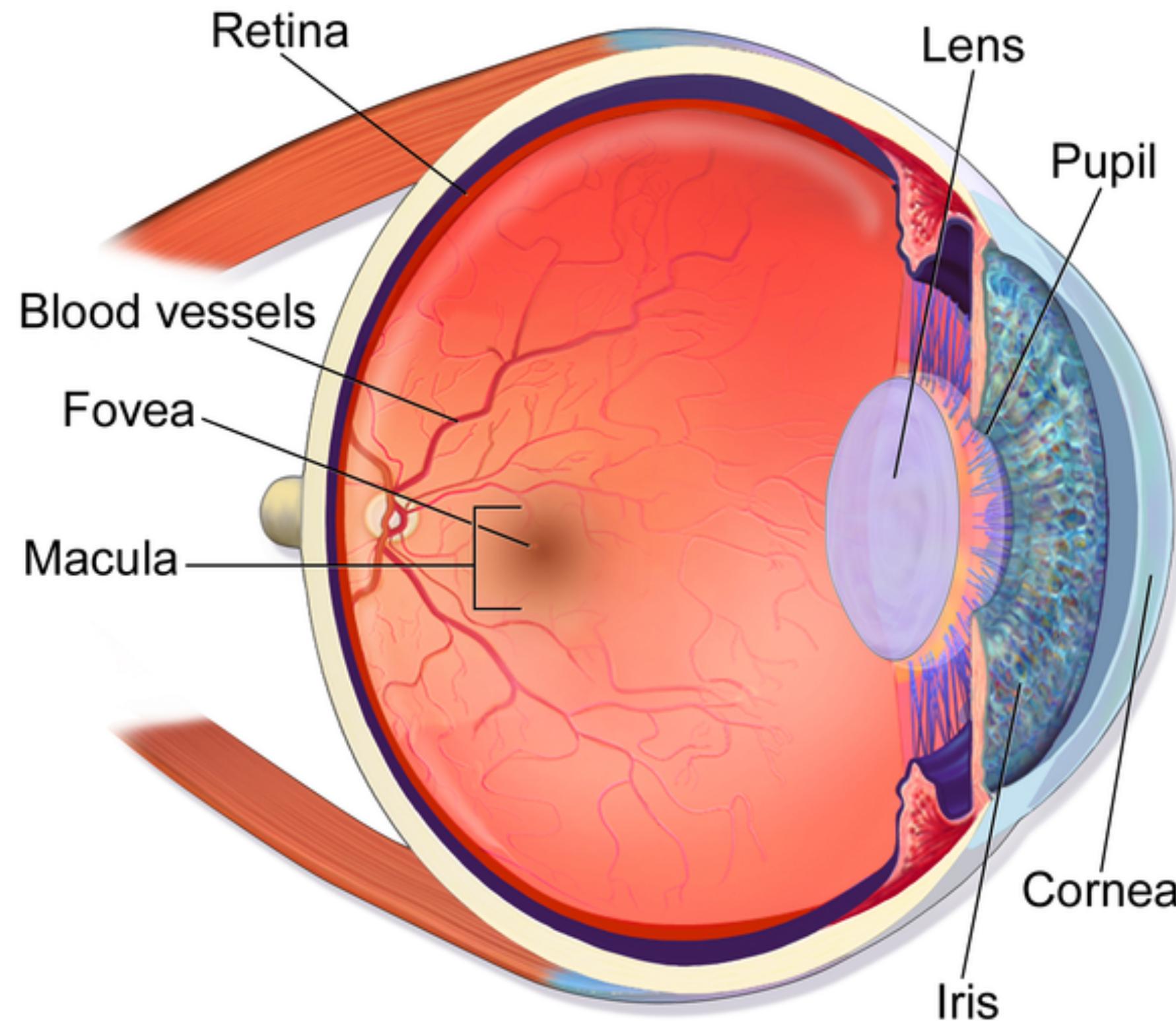
- Limbus boundary
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Anatomy



- Limbus boundary
- Pupillary boundary
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Anatomy

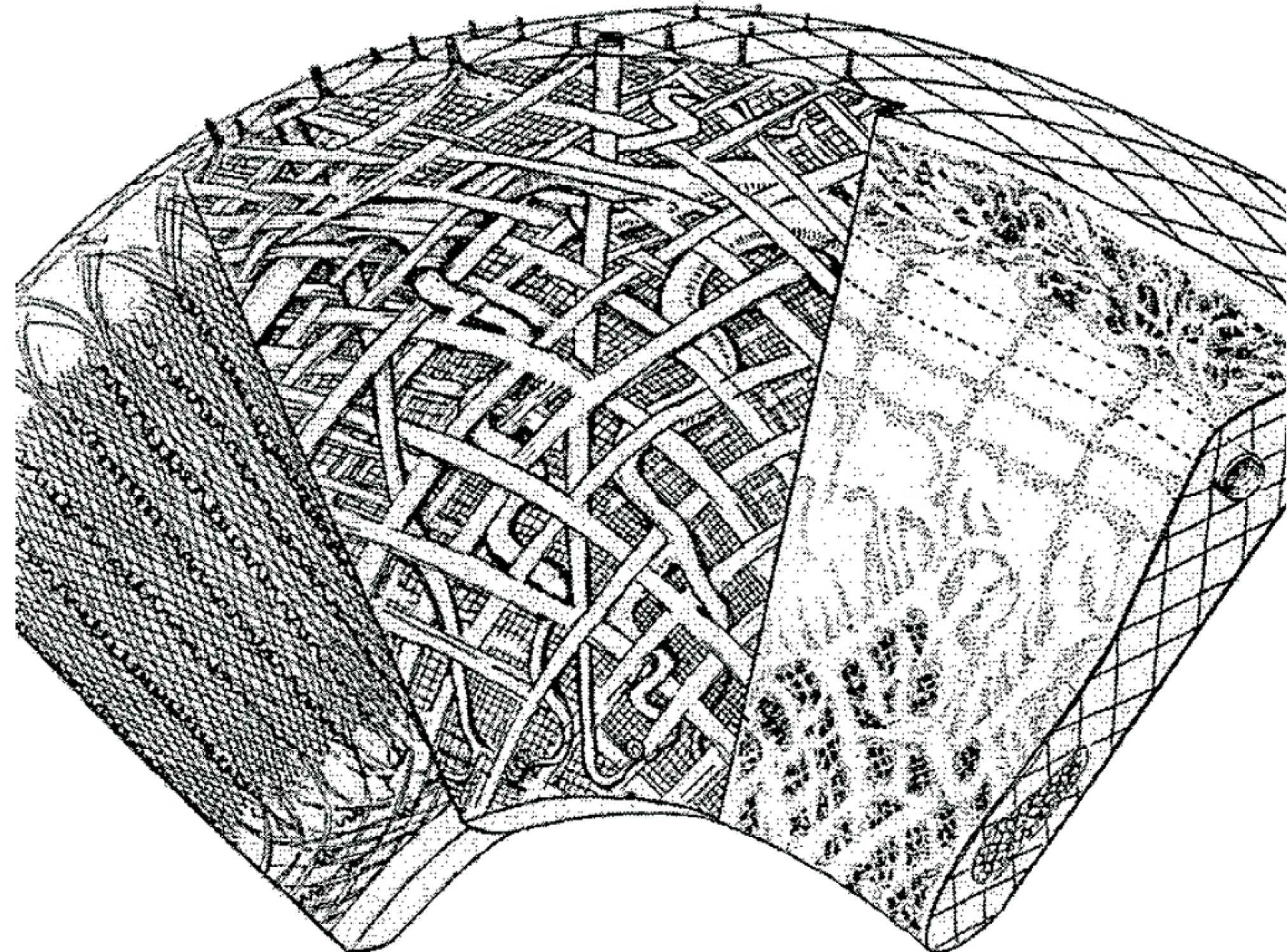


commons.wikimedia.org

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.

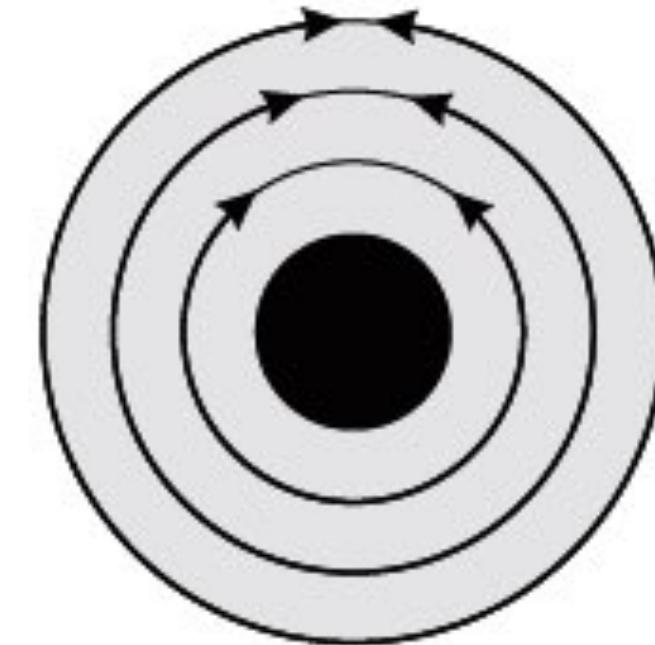
Anatomy



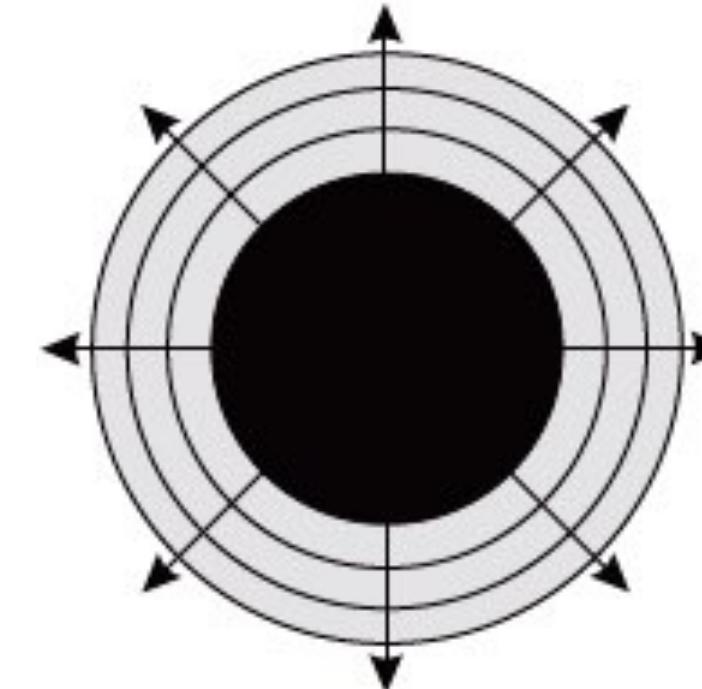
Suren Manvelyan

Anatomy

Adam Czajka

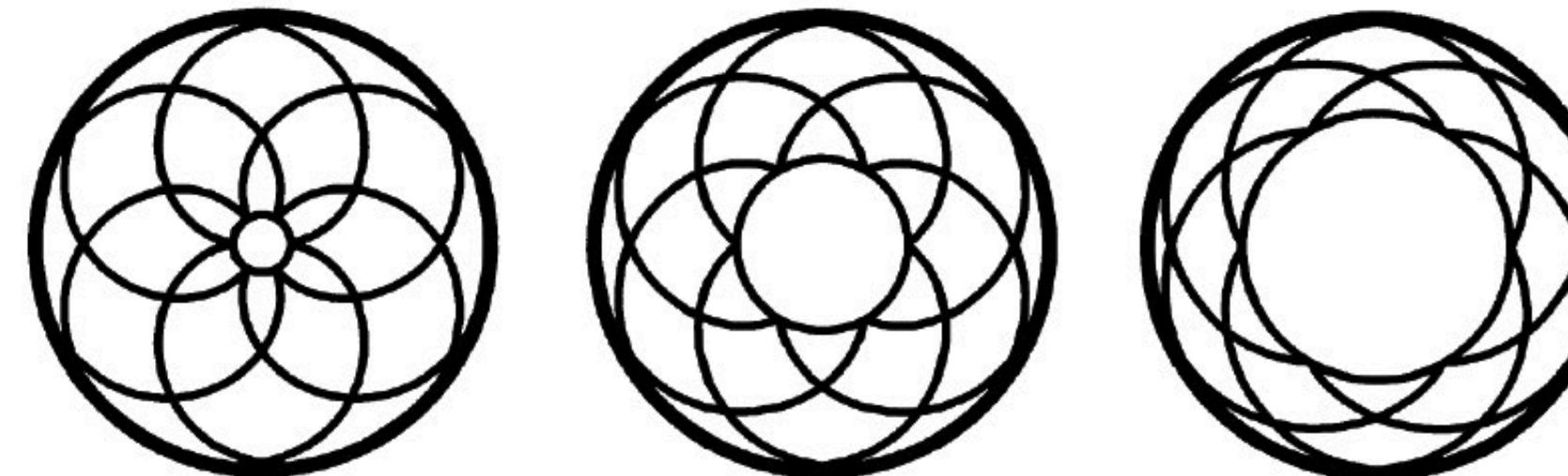


Sphincter Muscles



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.

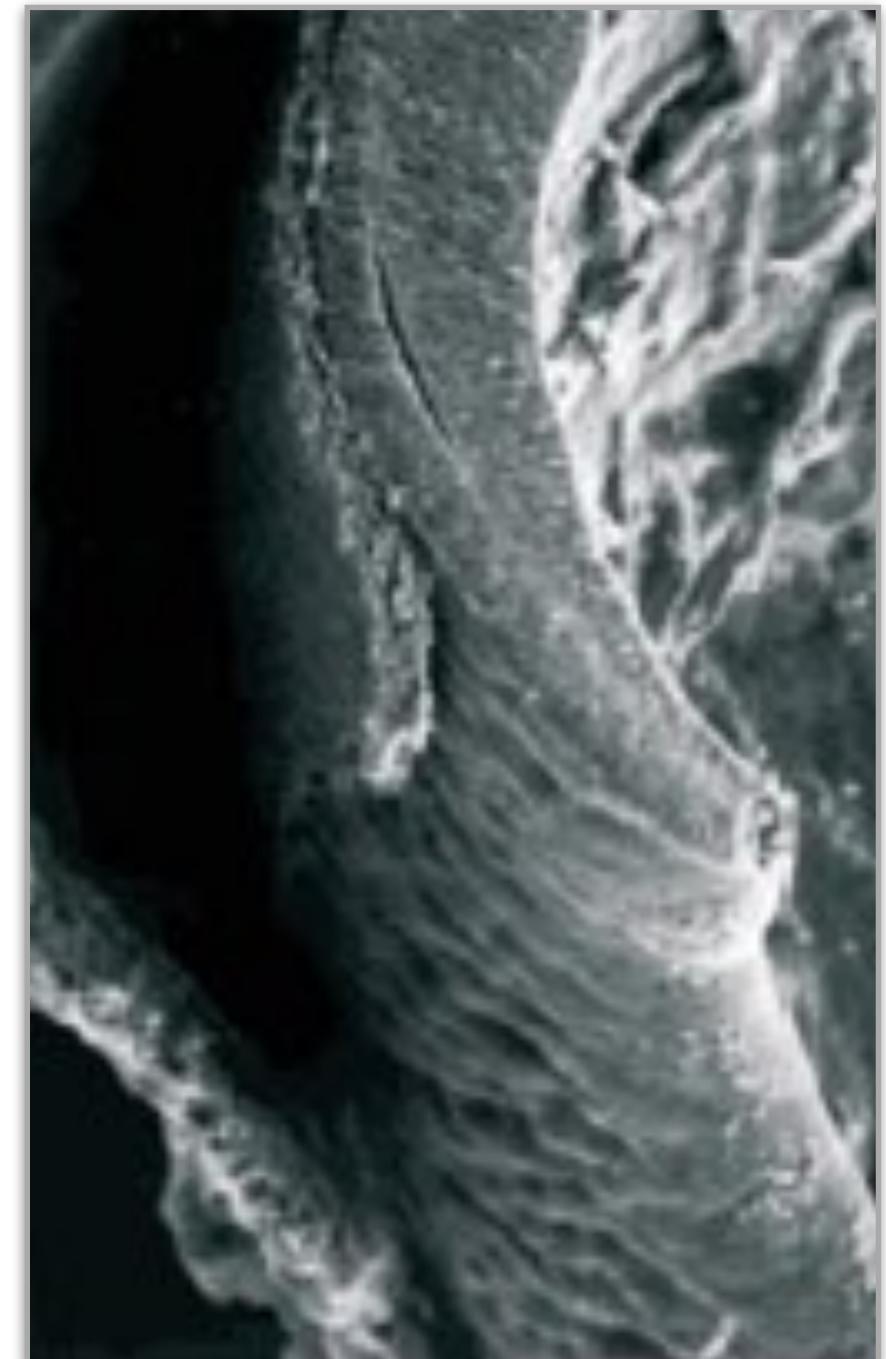
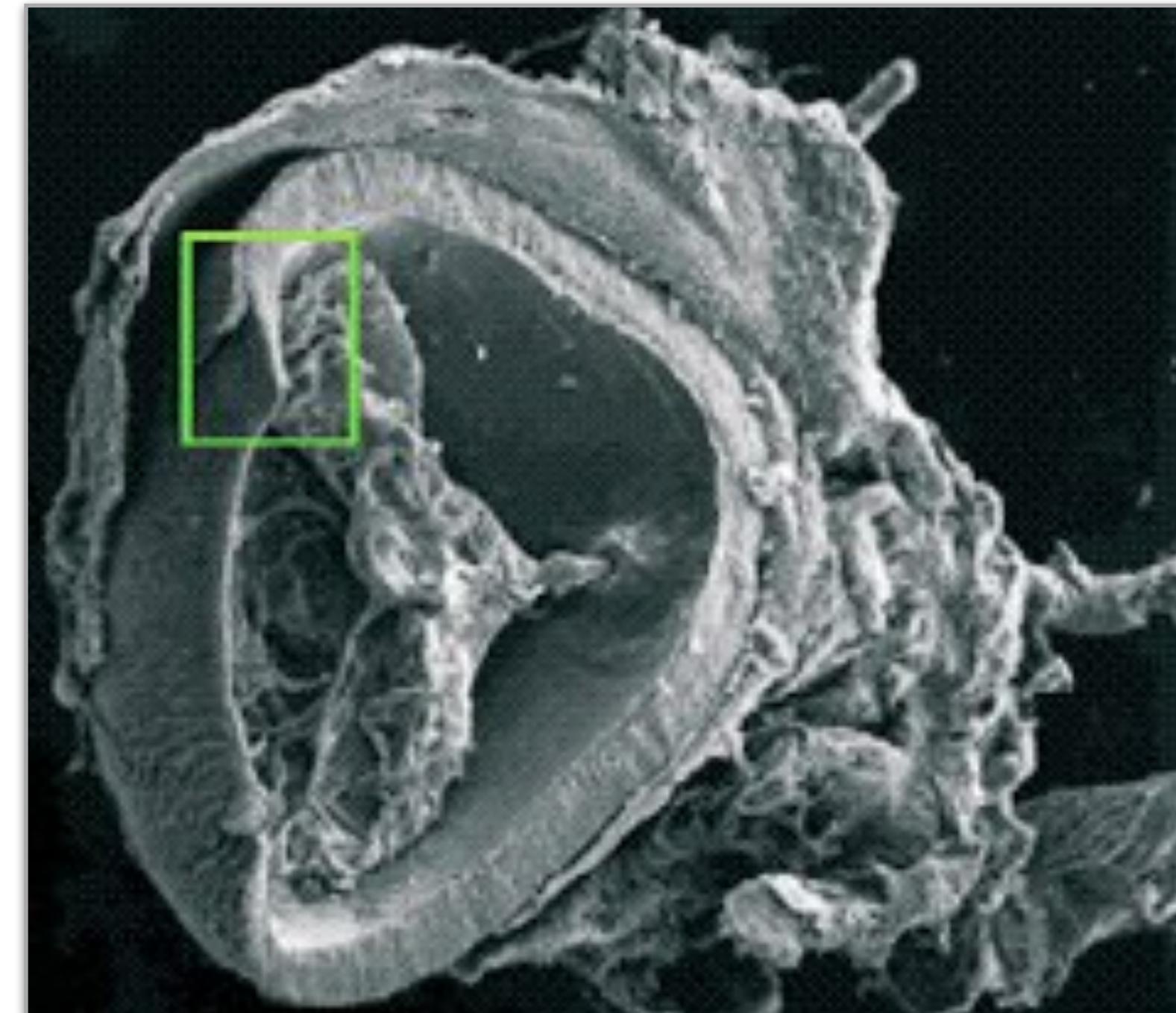
Function: regulate the amount of light entering the eye by dilating or contracting the pupil.

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.

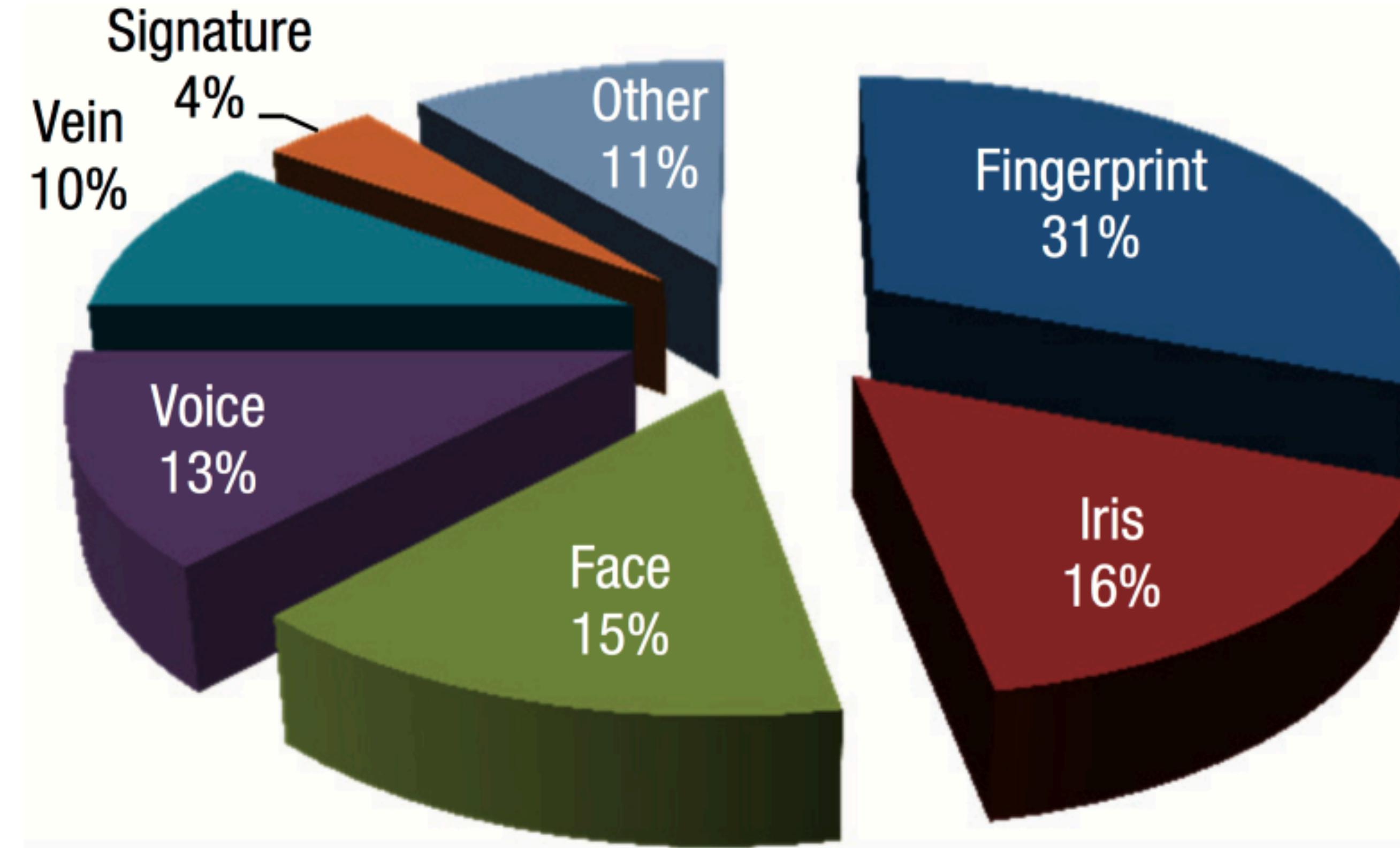
Right and left irises are different.

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?

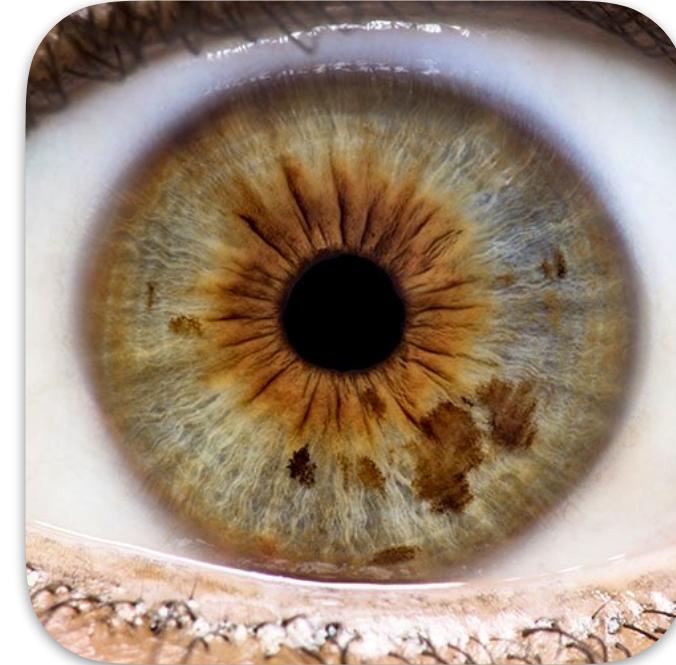


Probably

better than



>

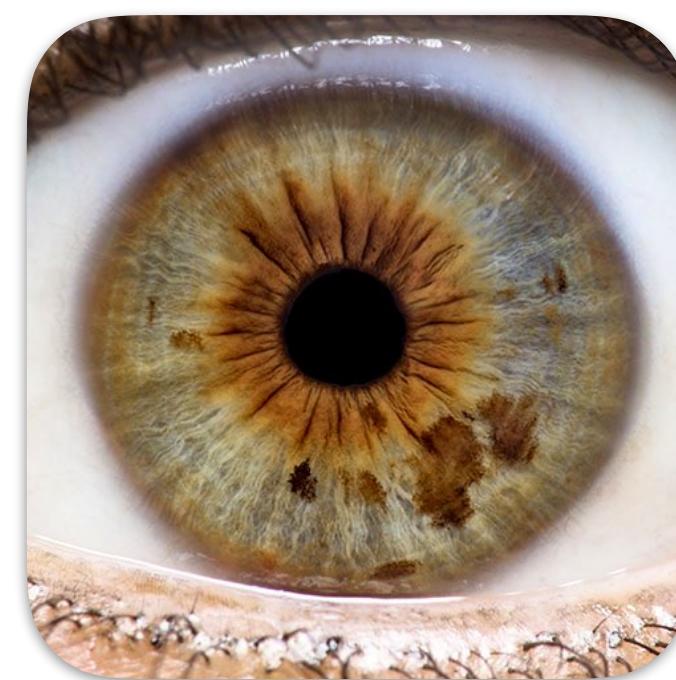


Why Irises?

Uniqueness (2/8)

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

Probably



>



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.



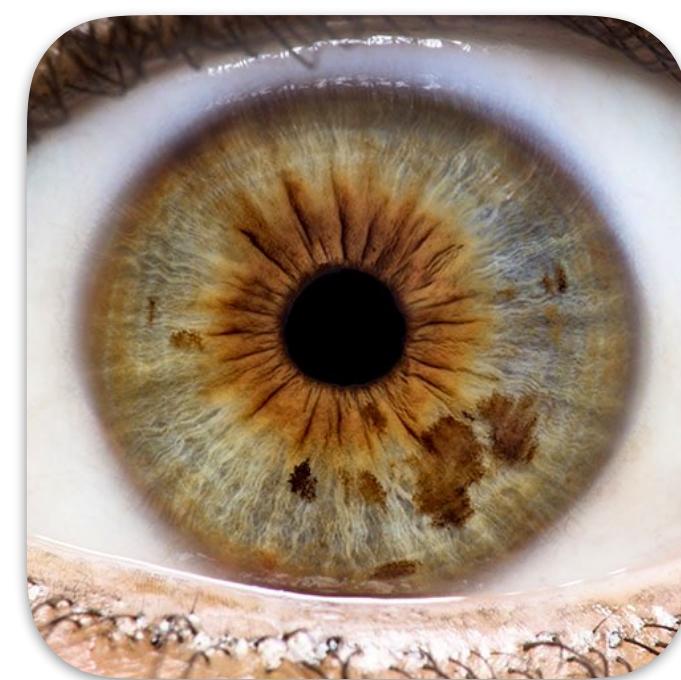
Source: John Daugman
Lecture Notes, 2018

Why Irises?

Permanence (3/8)

How easily does the trait change?

Probably



>



Why Irises?



Permanence (3/8)

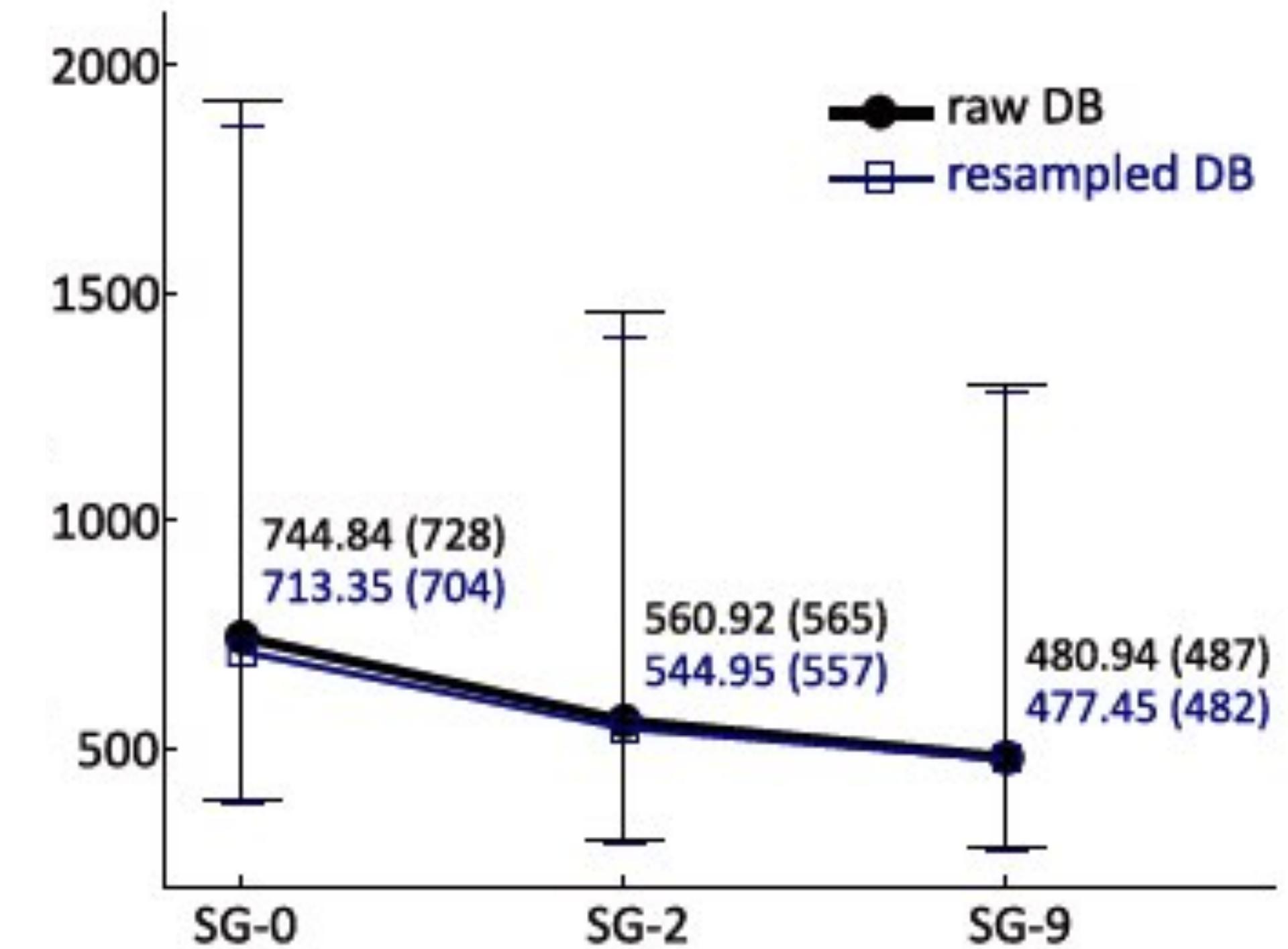
How easily does the trait change?

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?

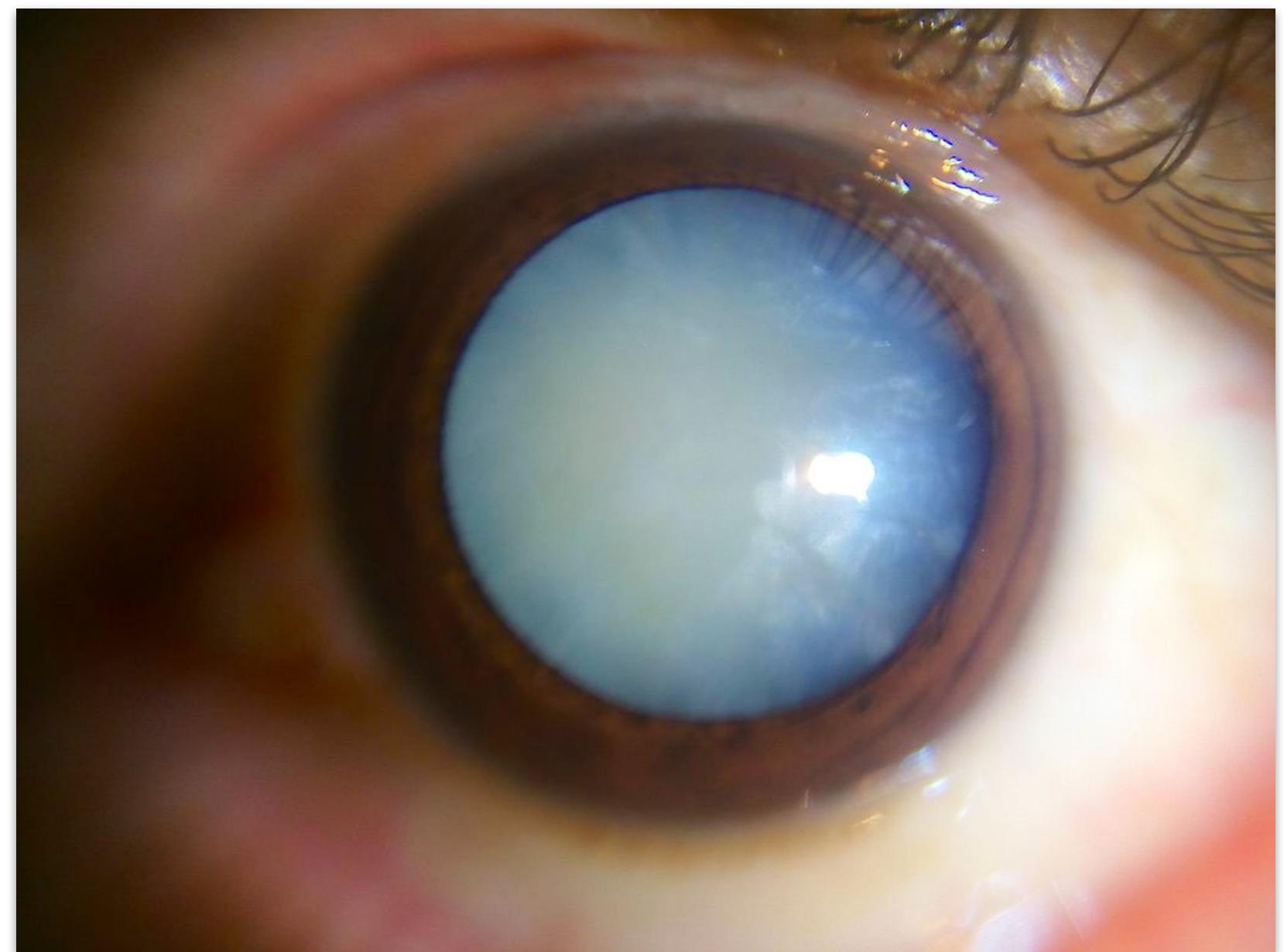
Permanence (3/8)

How easily does the trait change?

Traumas and Diseases

Some traumas and diseases might degrade/change the iris.

commons.wikimedia.org



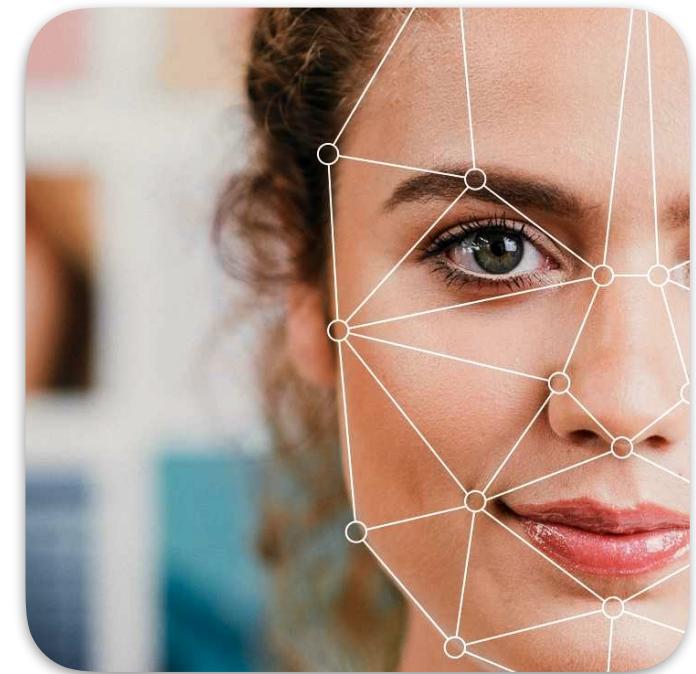
E.g., cataracts.

Why Irises?

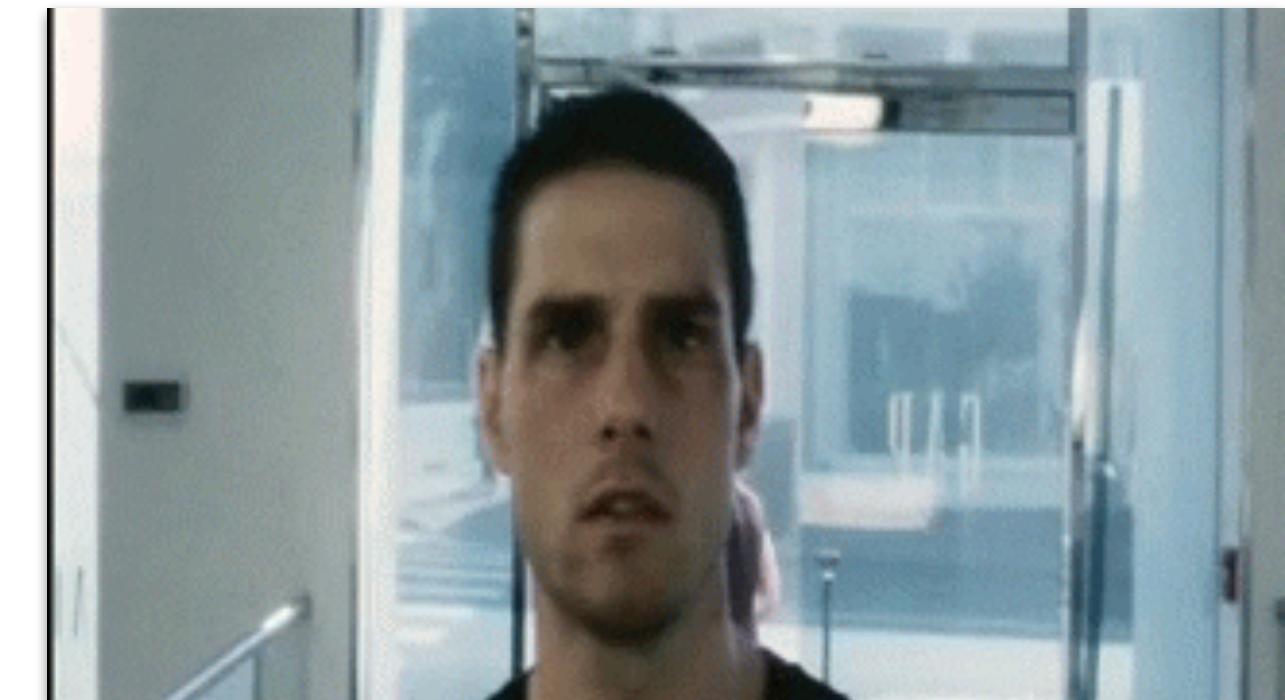
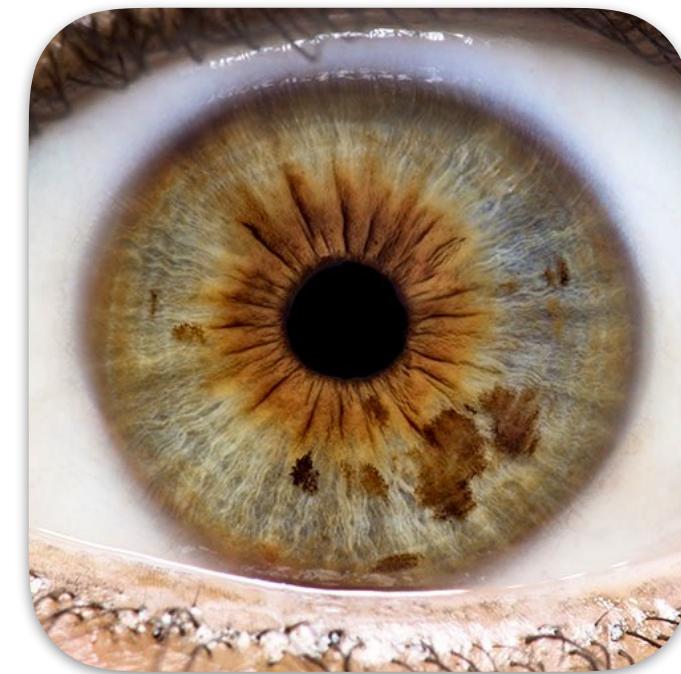
Measurability (4/8)

How easy is it to acquire and digitize the trait?

Probably



∨



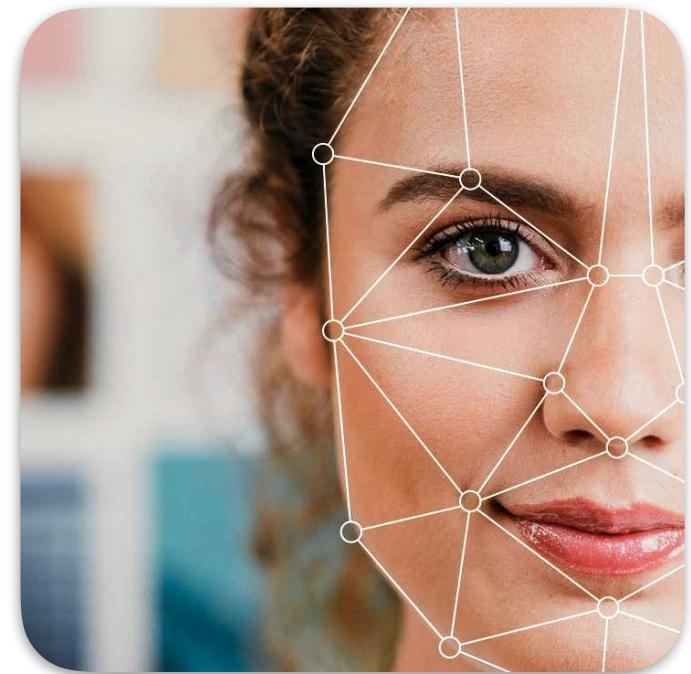
Not there yet.

Why Irises?

Acceptability (5/8)

Will individuals collaborate during data collection?

Probably



∨



Why Irises?

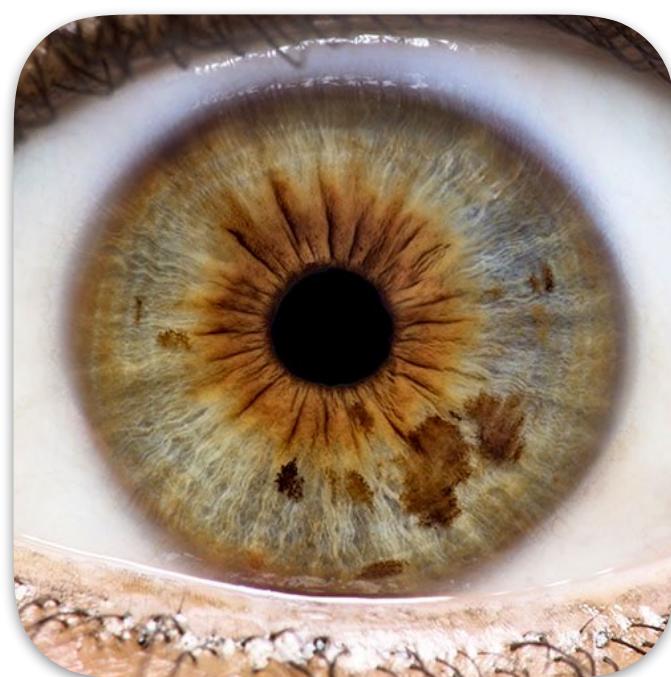
Acceptability (5/8)

Will individuals collaborate during data collection?

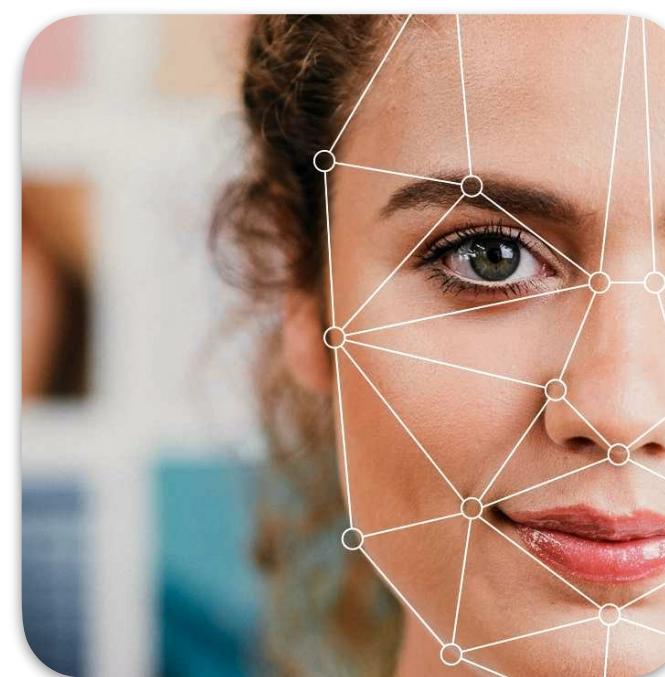
Privacy Concerns



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?



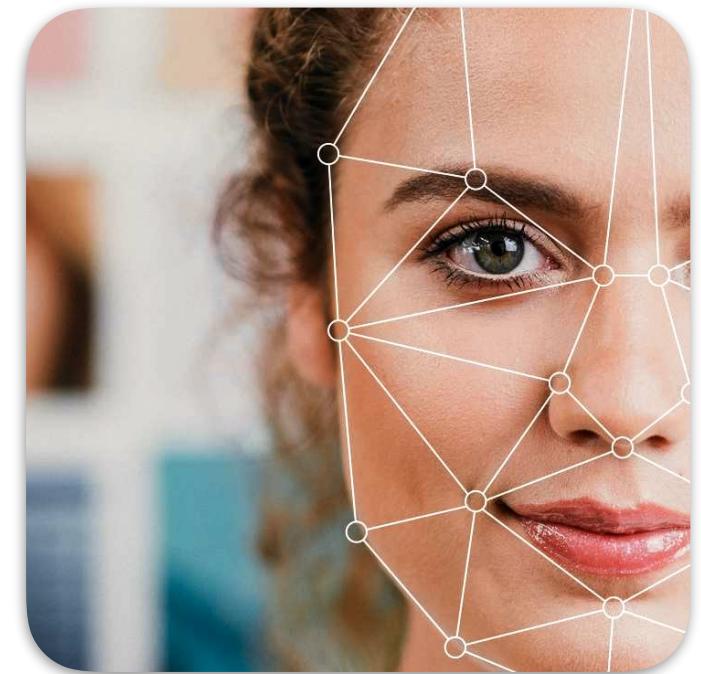
Jain, Ross, and Nandakumar
Introduction to Biometrics
Springer Books, 2011

Why Irises?

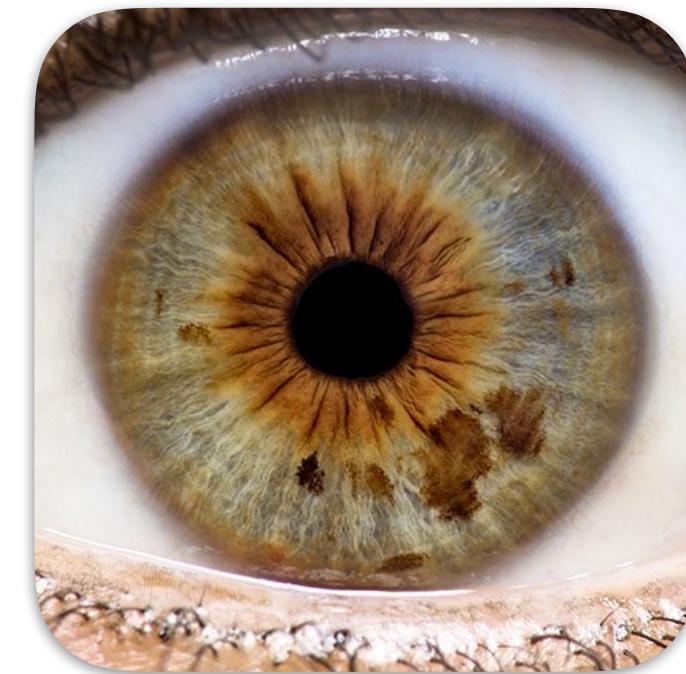
Circumvention (6/8)

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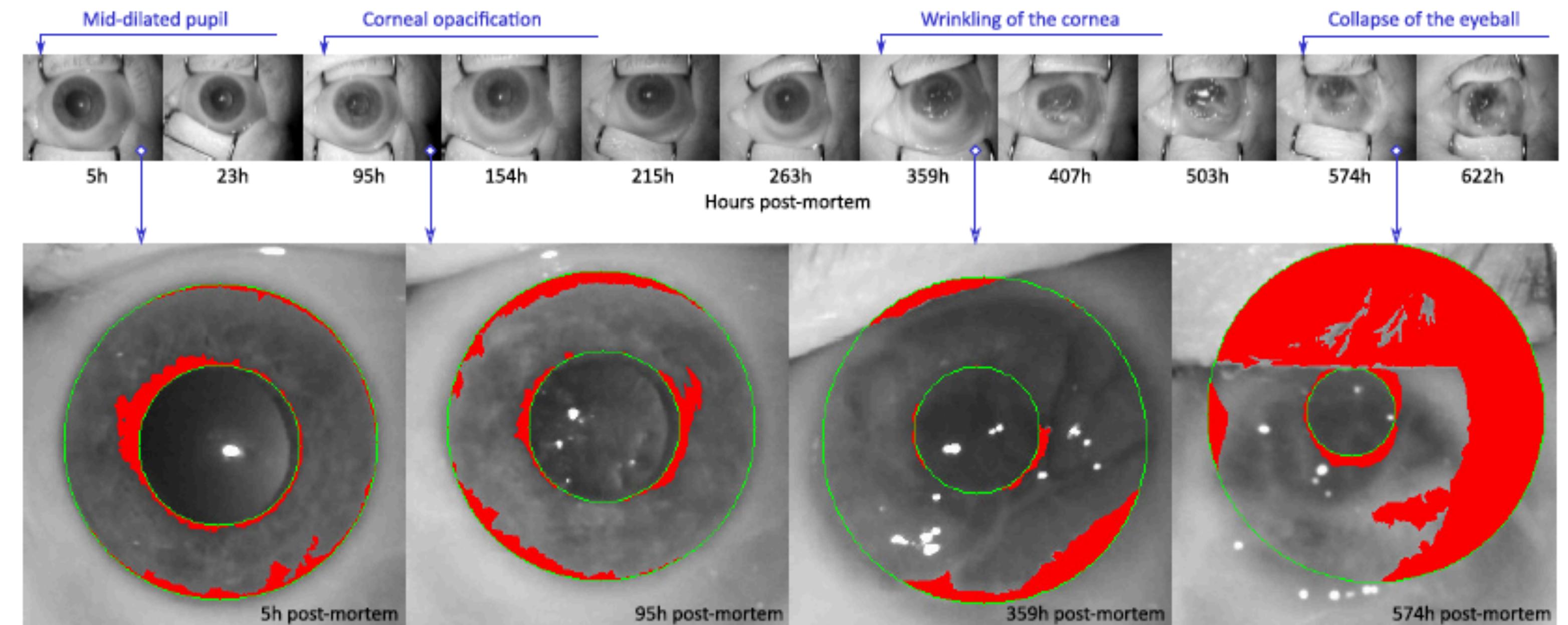
Egad, would it work?

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



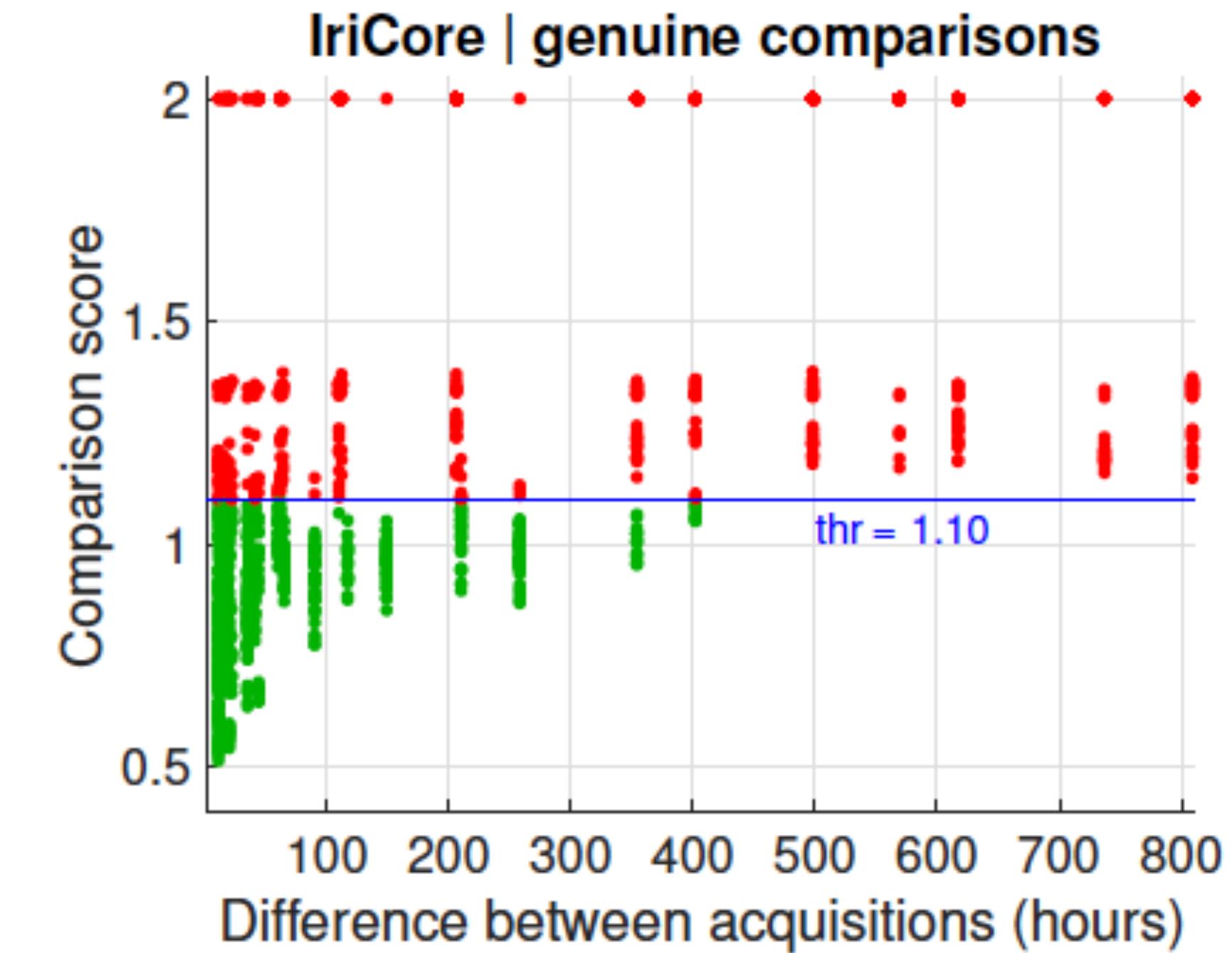
Why Irises?

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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!

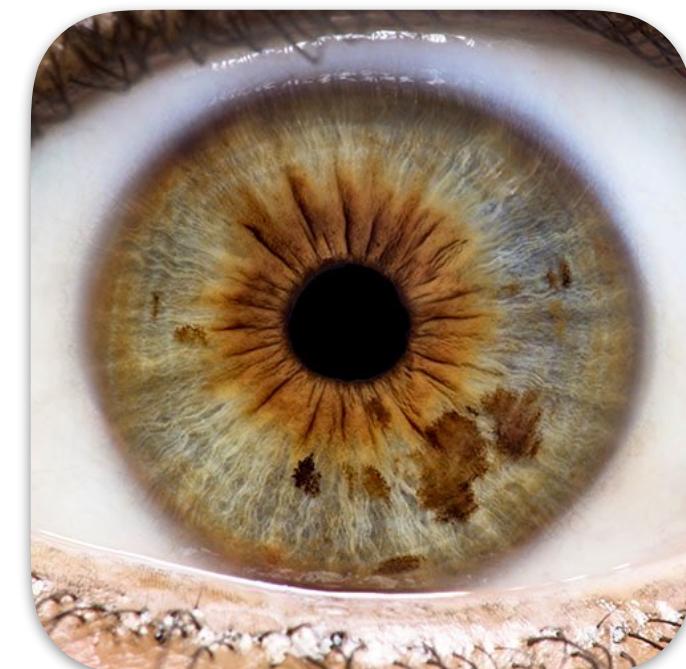
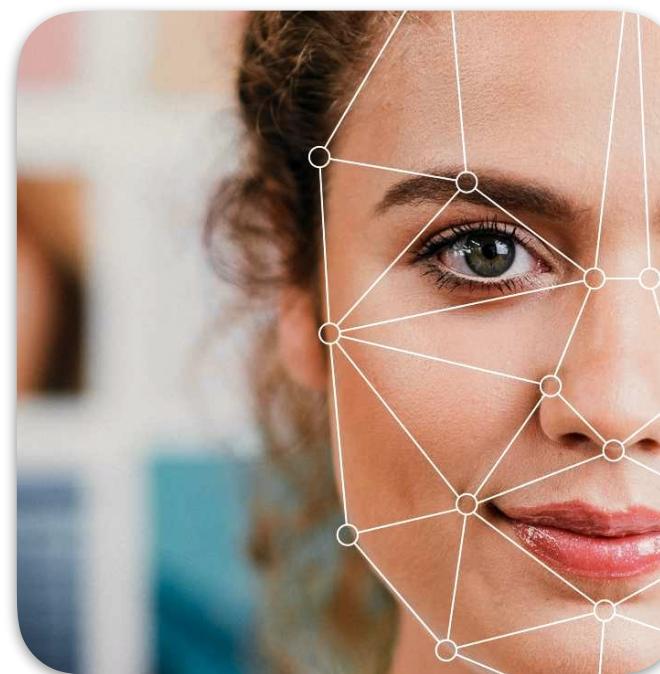


Why Irises

Performance (7/8)

How good is the trait quantitatively according to objective metrics?

Probably
(Needed investigation)



v



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?

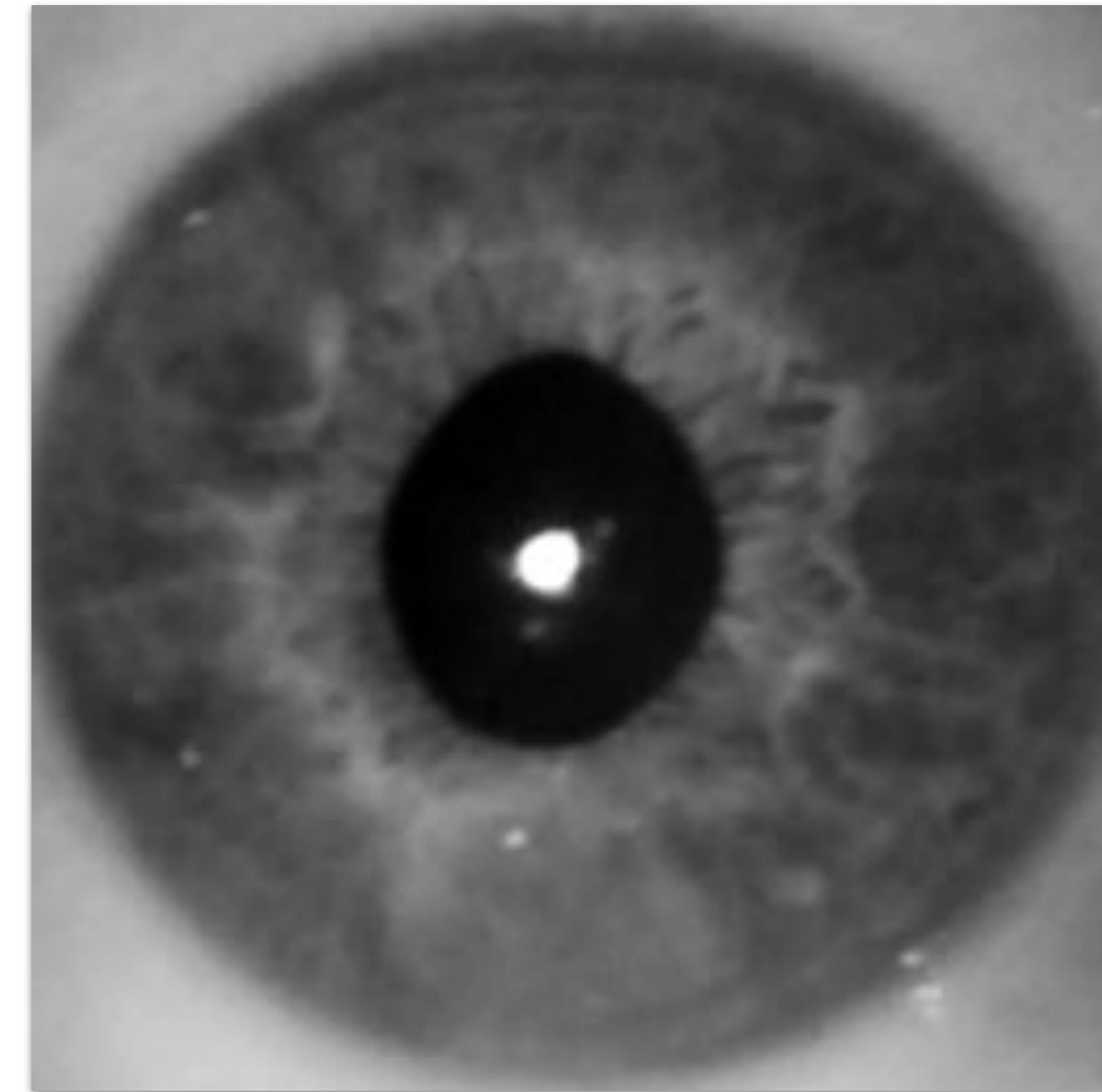
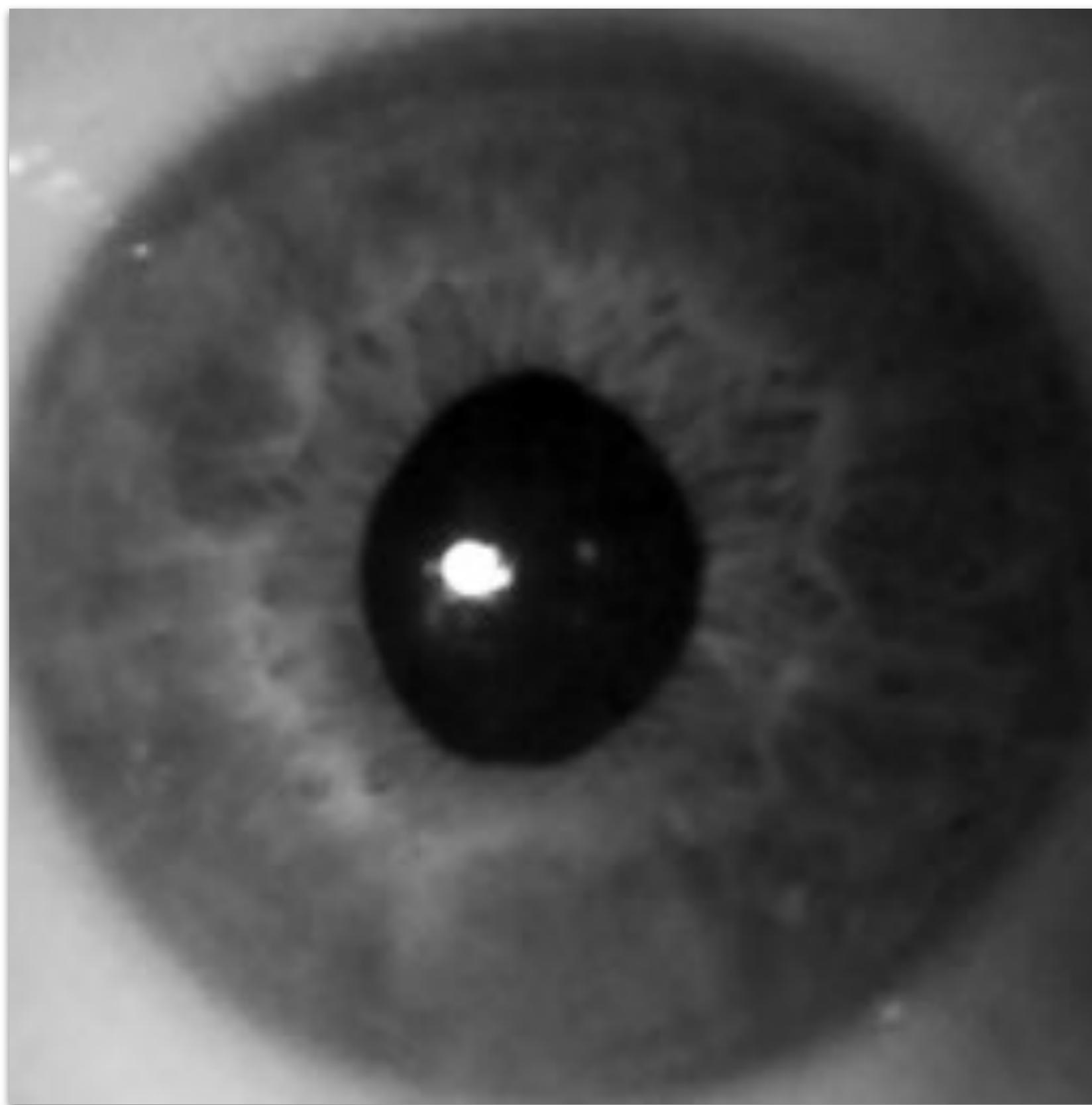
Accountability (8/8)

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

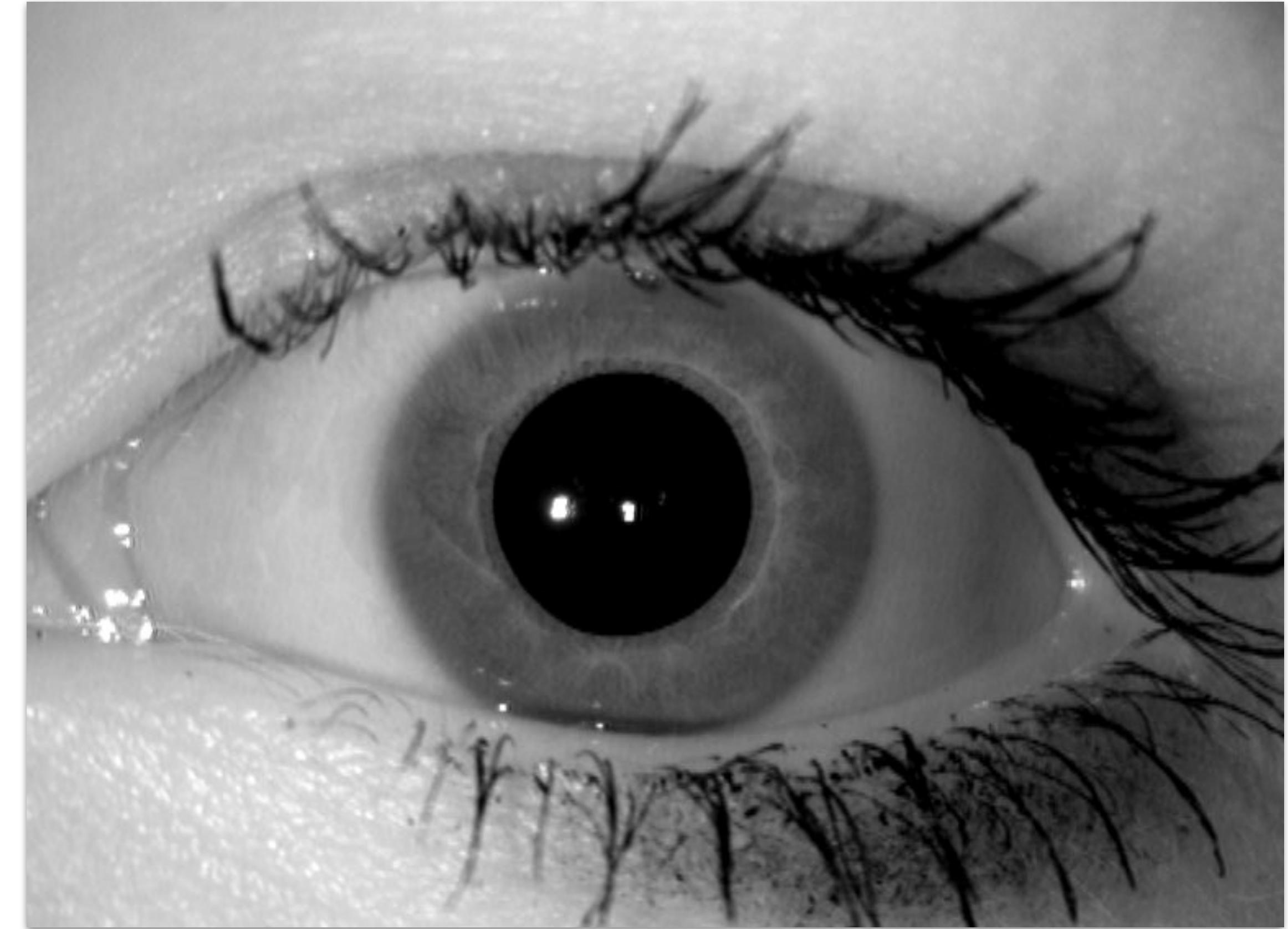
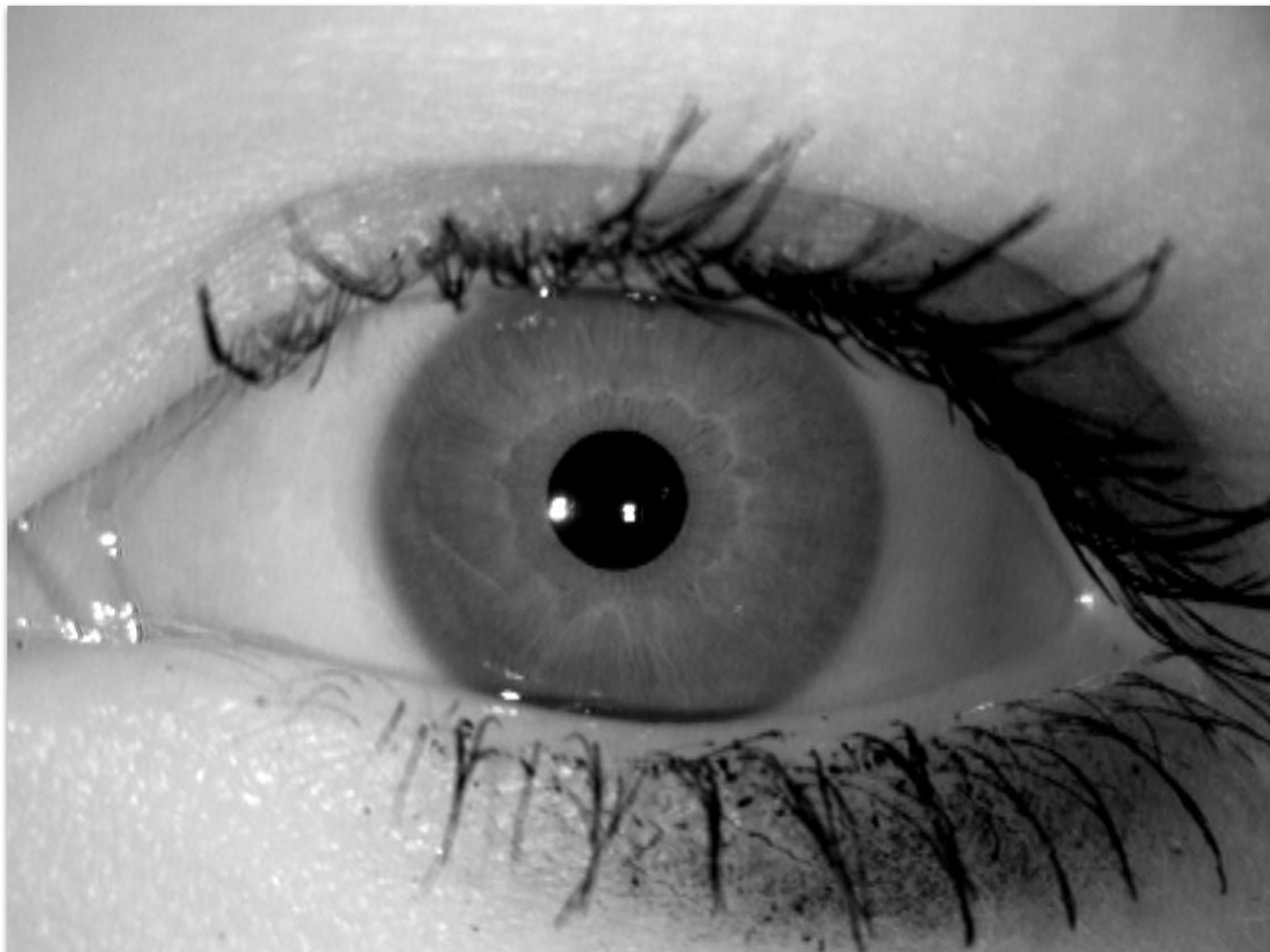
Probably



Same Person?

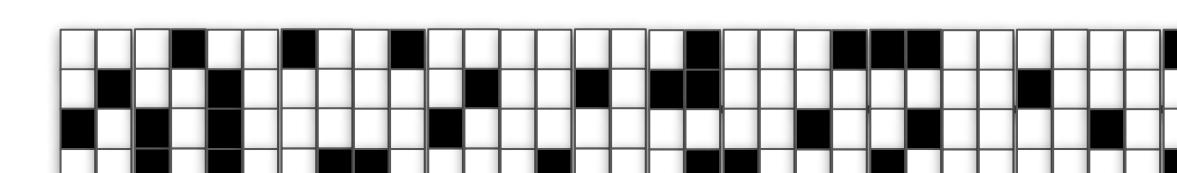
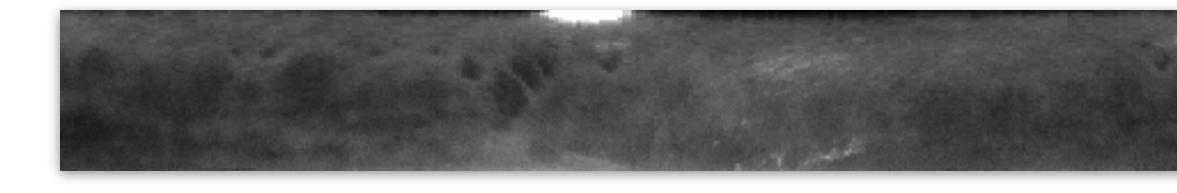
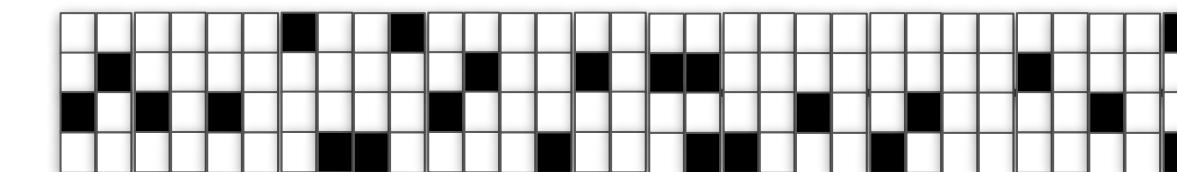
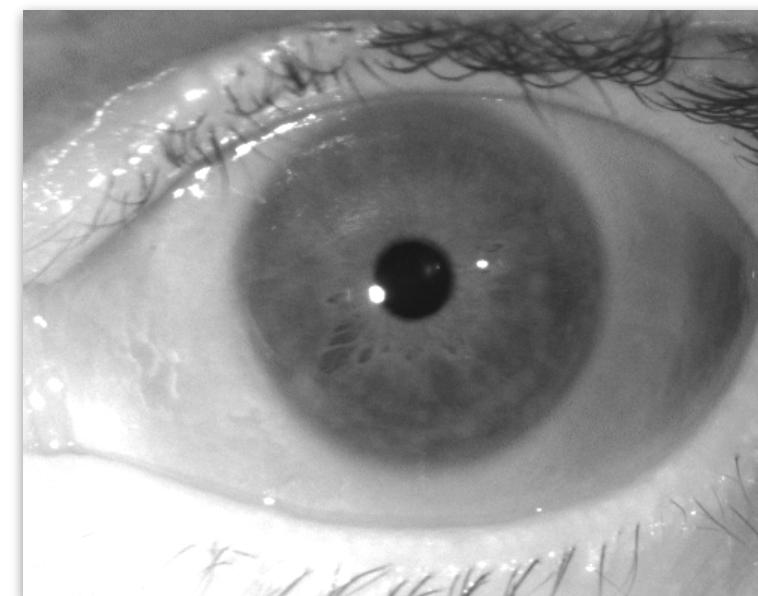
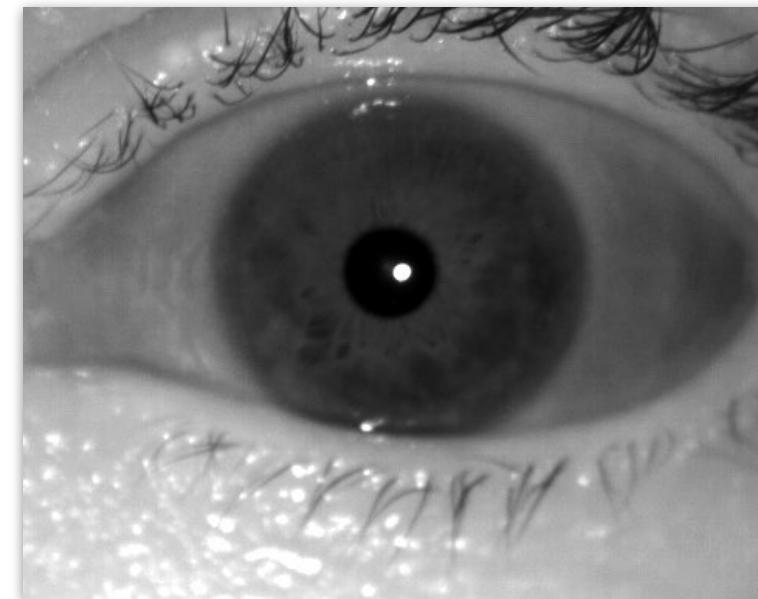


Same Person?



Iris Recognition

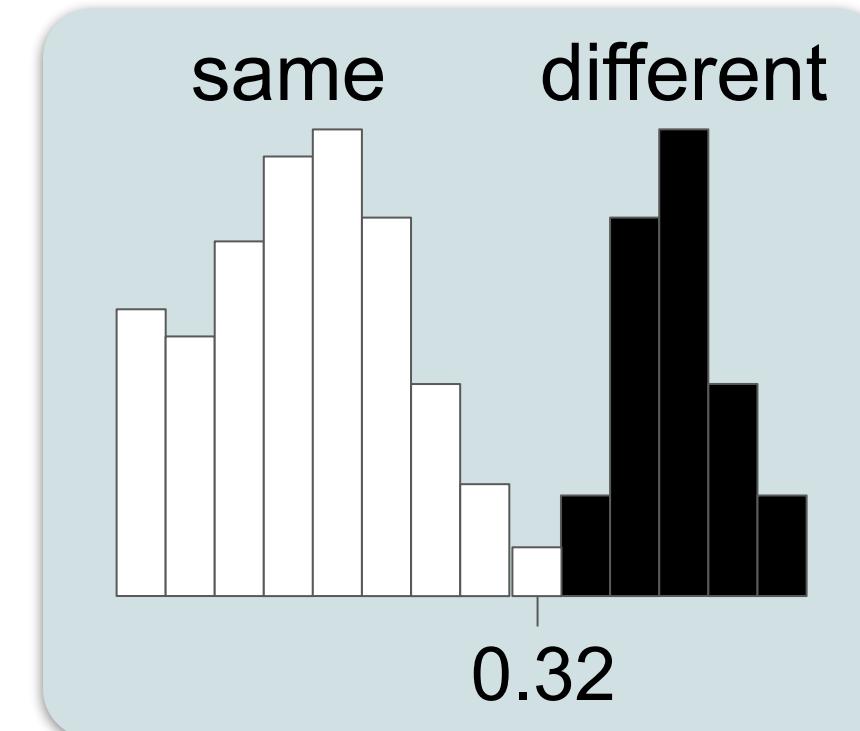
In a Nutshell



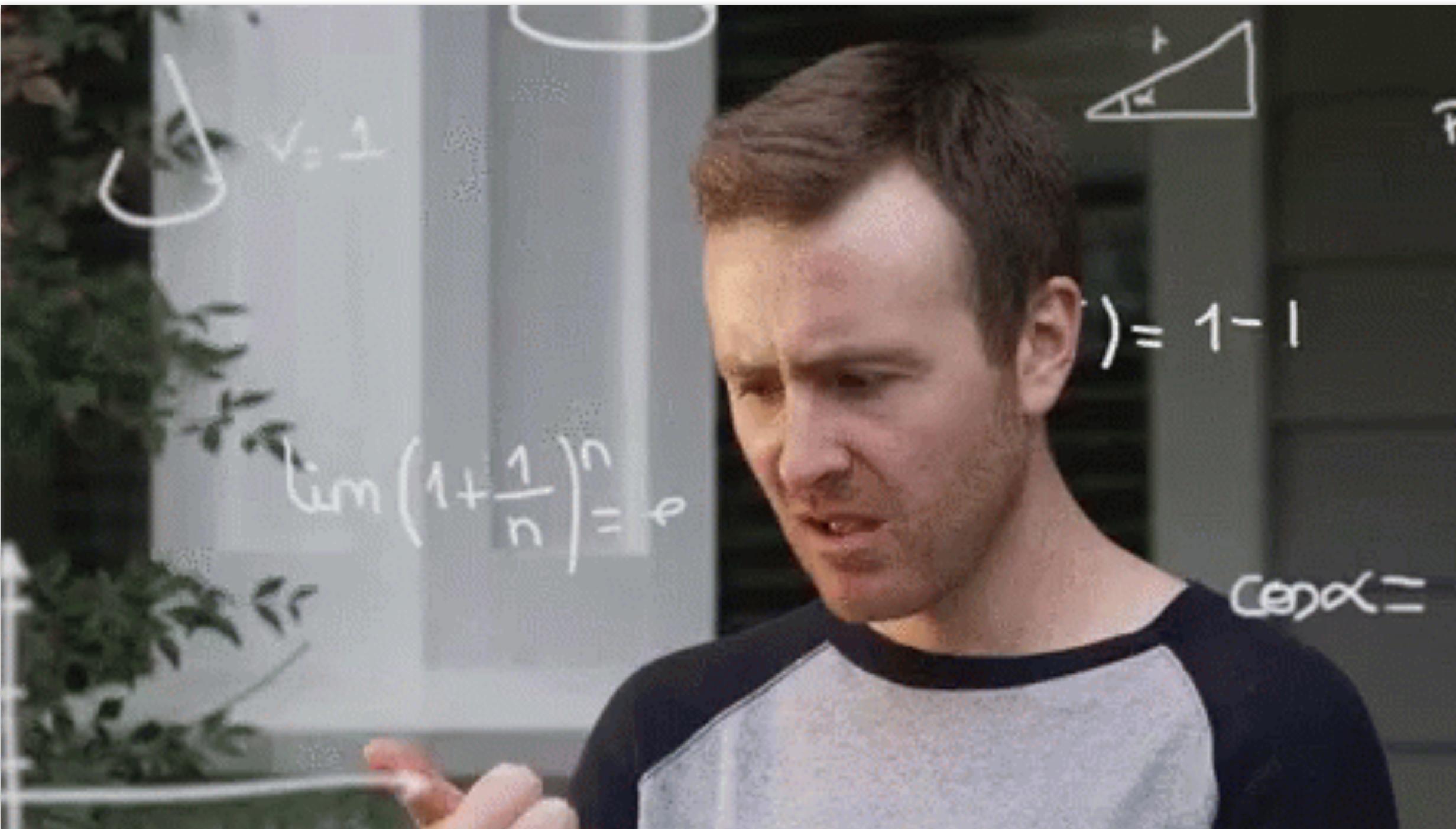
Hamming
Distance

0.25

Yes



Easy, right?



Accountable Iris Recognition



How can we make it
meaningful to the
everyman?

Accountable Iris Recognition



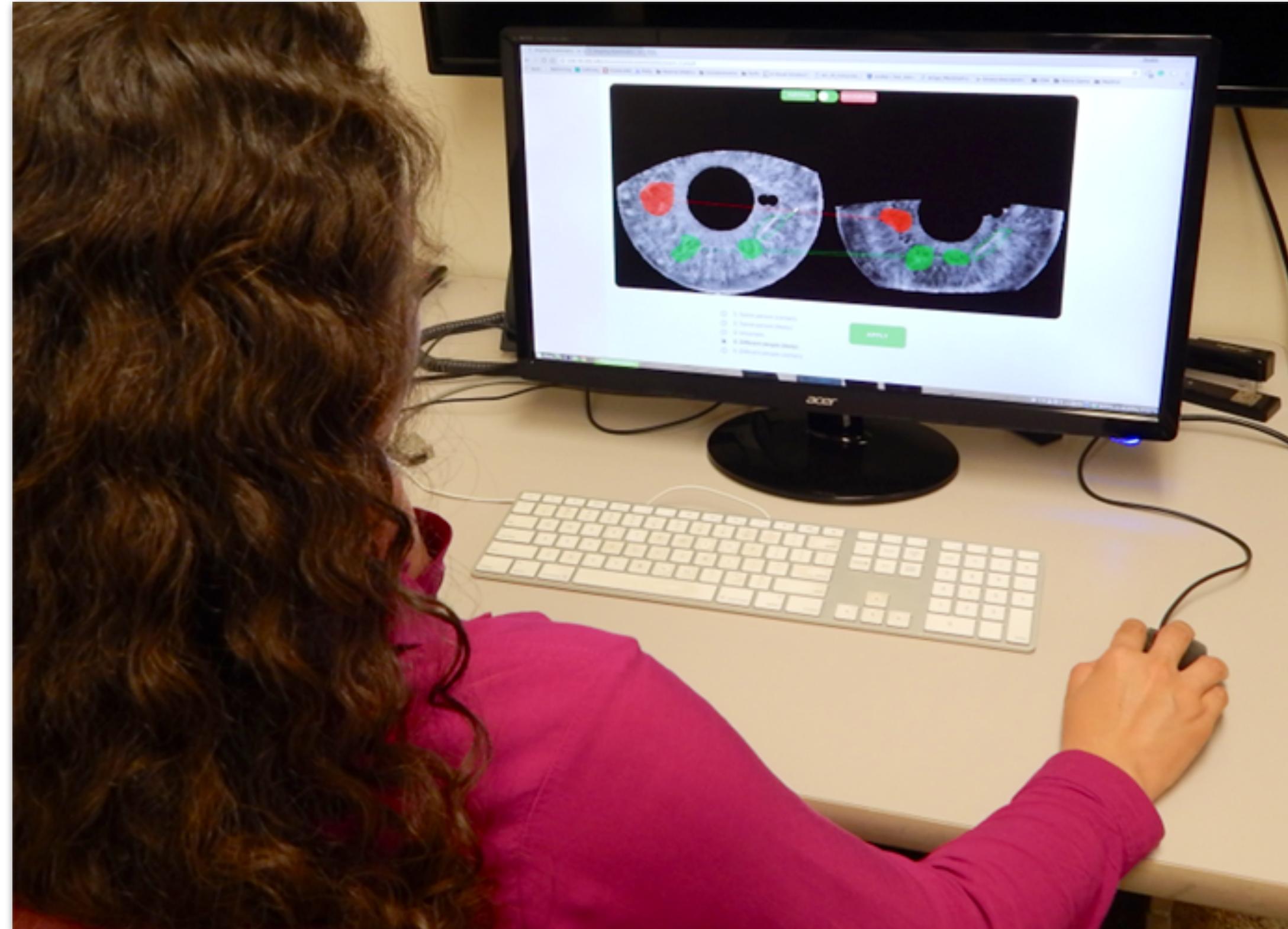
People have the right to obtain **an explanation of decisions** made about them by algorithms.

Accountable Iris Recognition



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

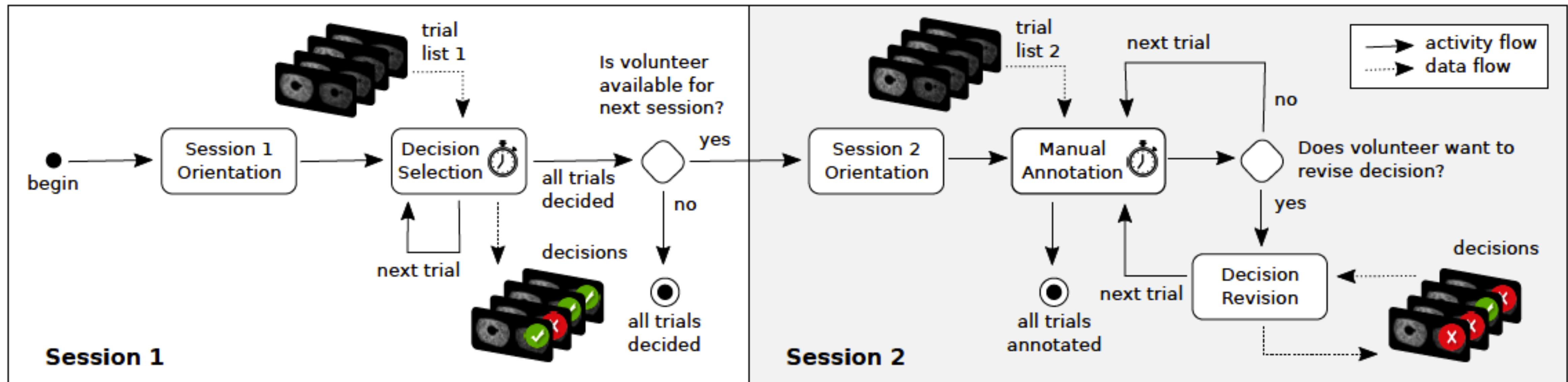
Accountable Iris Recognition



How should we start?

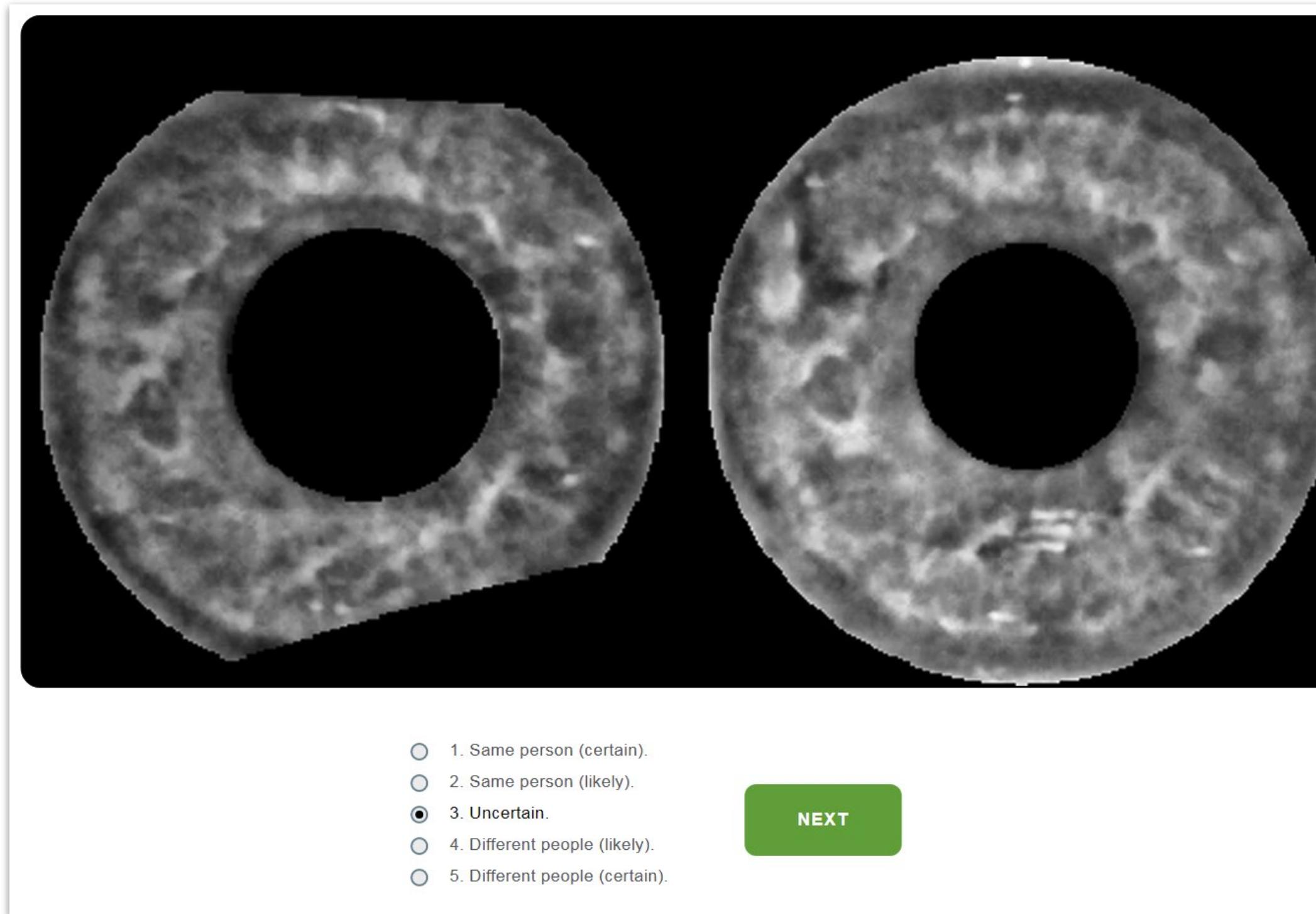
Ask a human:
**How do people perform
iris recognition?**

Human Experiments



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

Human Experiments



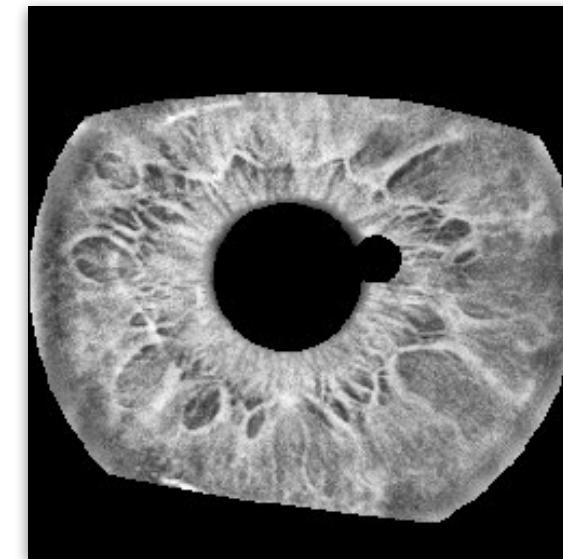
Section 1: annotation-less



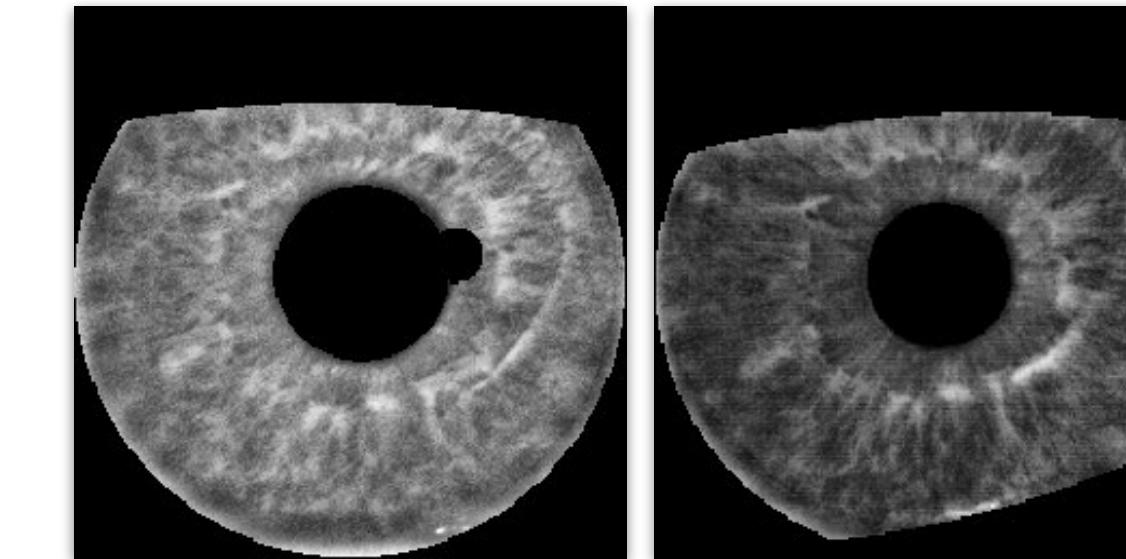
Section 2: annotation-driven

Human Experiments

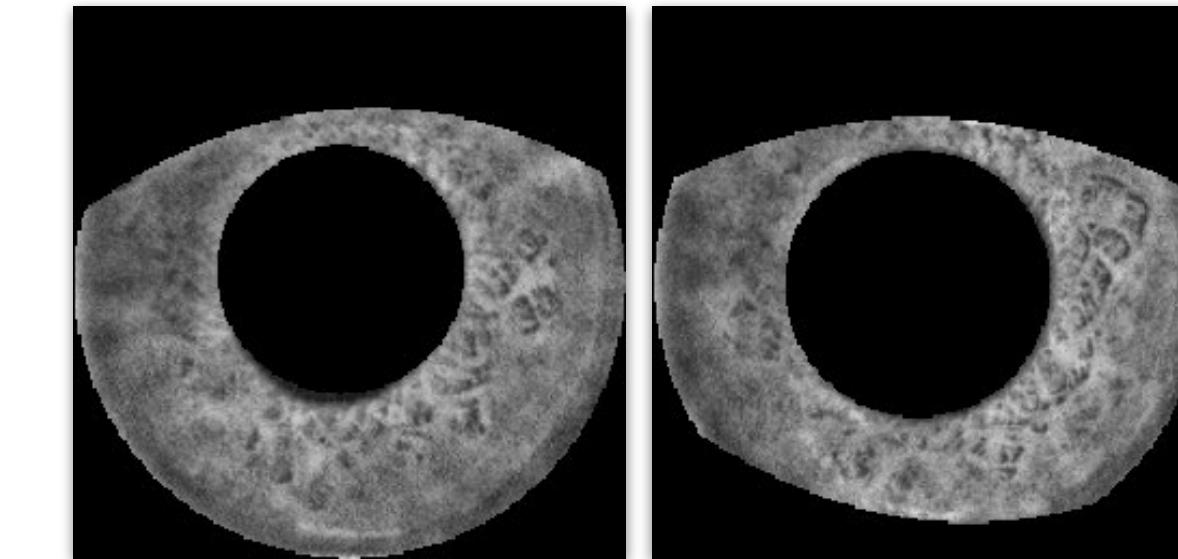
Dataset



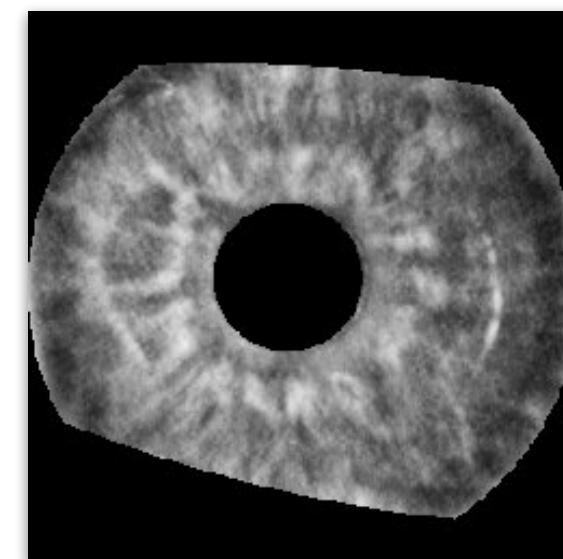
Easy for an automated solution



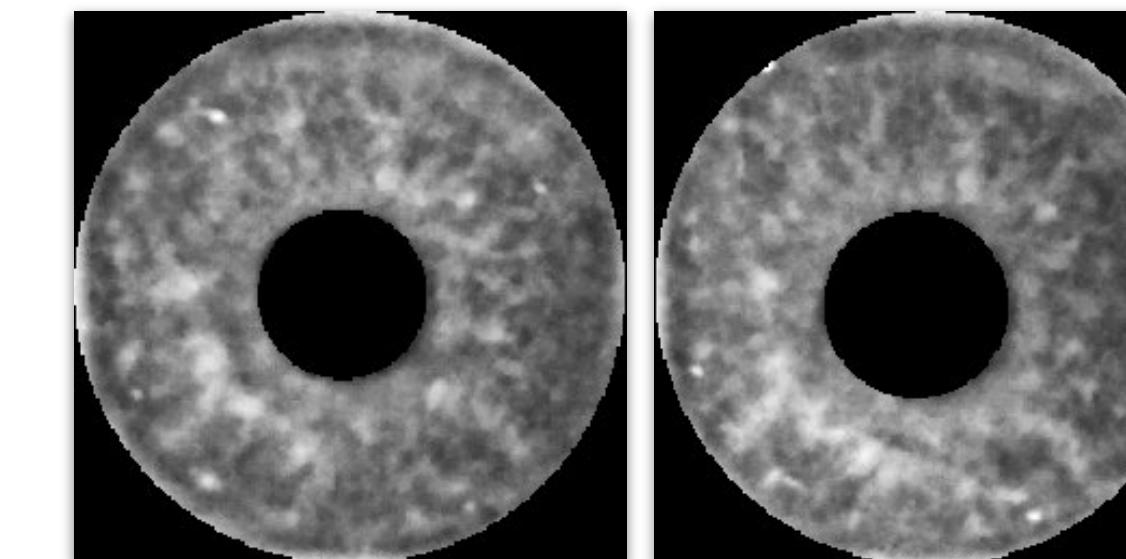
Hard for an automated solution



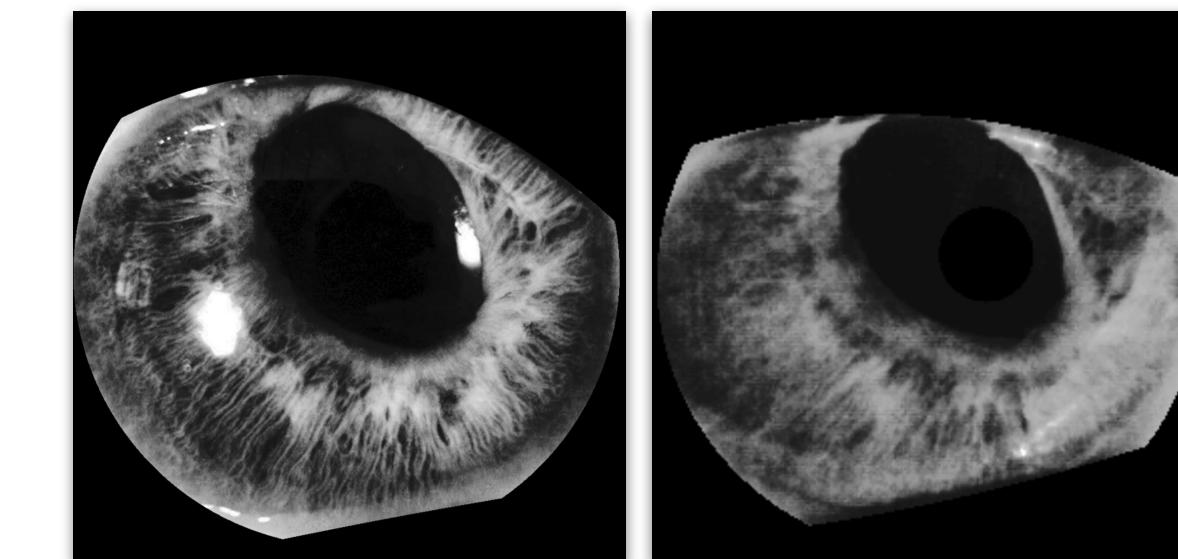
Twins'



Pupil dynamic



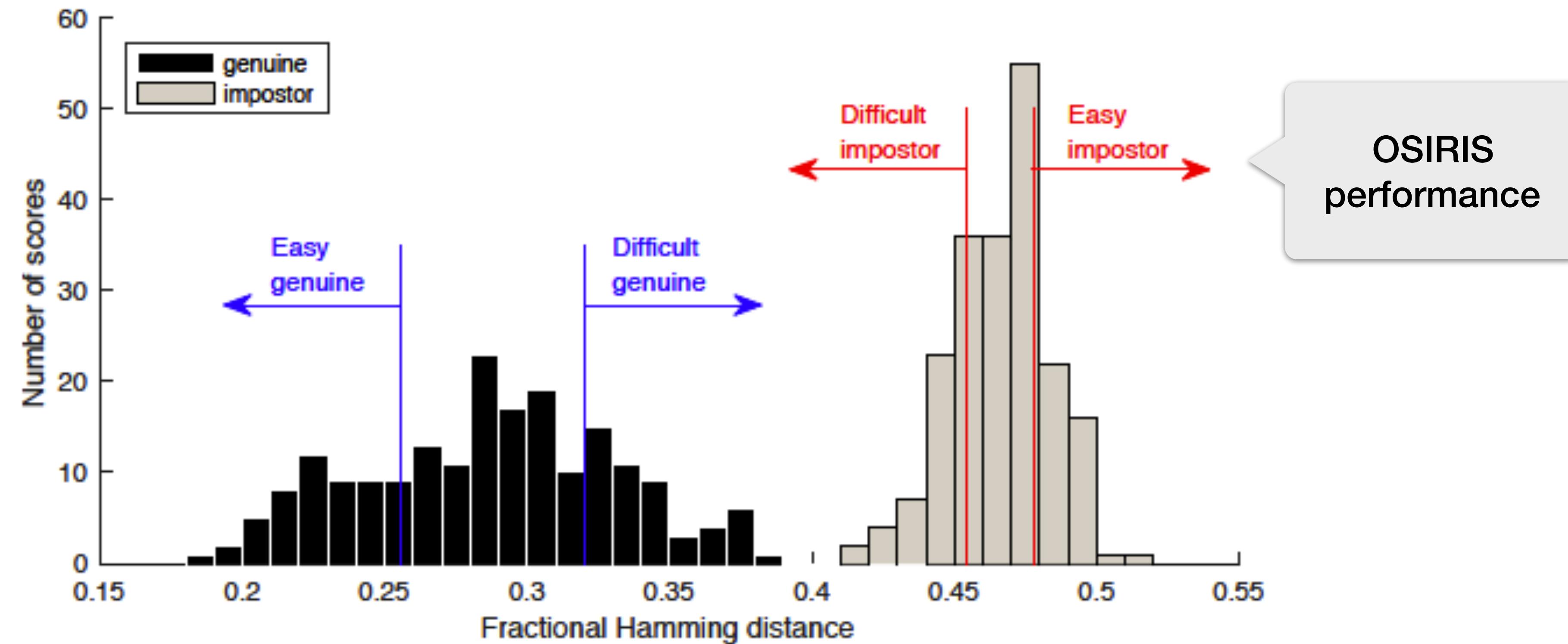
Deceased



Disease-affected

Human Experiments

What is “hard” for a computer?

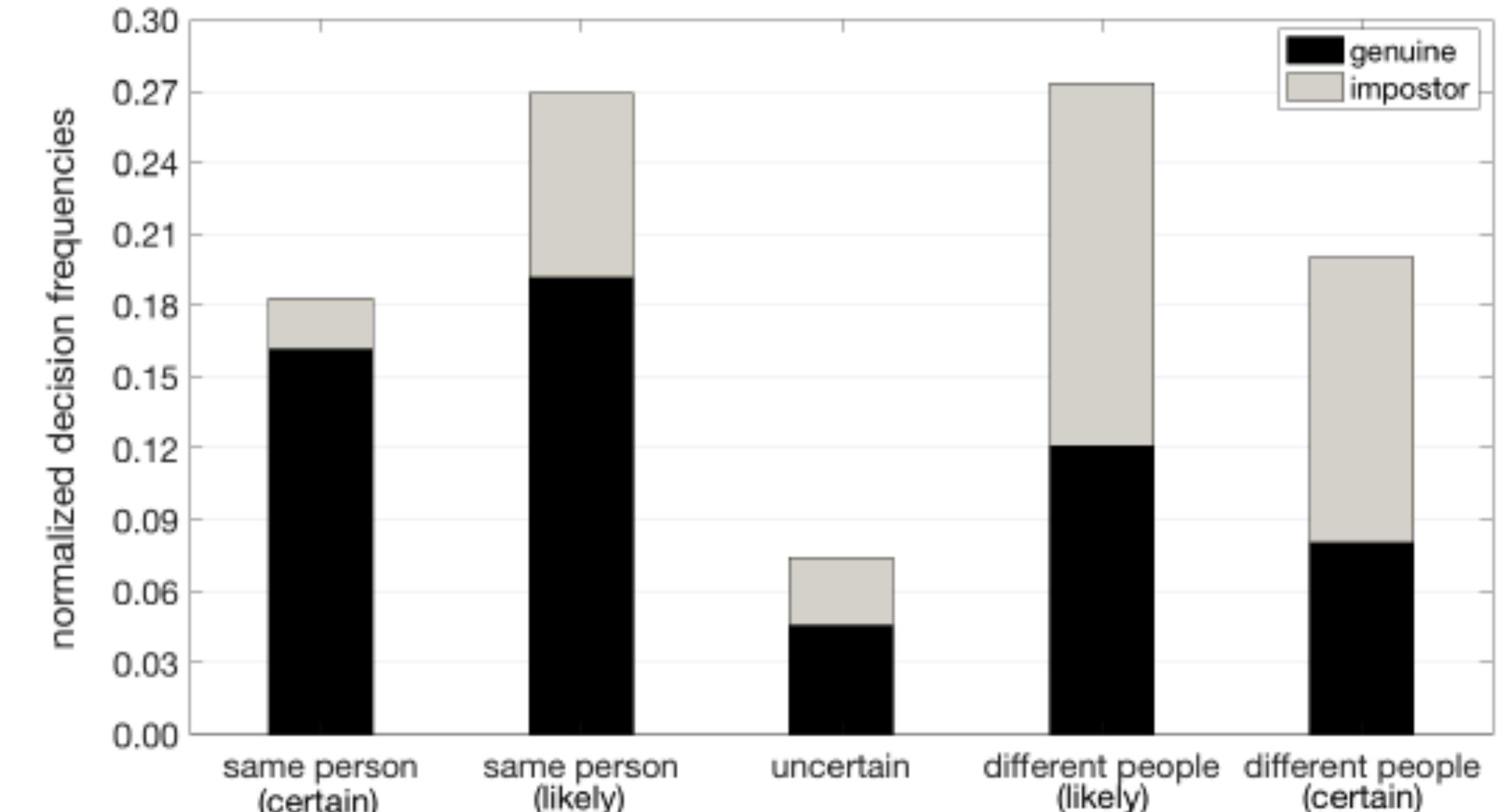


Human Experiments

Results

		Accuracy (%)			
		Humans	OSIRIS	IriCore	MIRLIN
Genuine pairs	Healthy easy	91.28	95.00	100.00	97.50
	Healthy difficult	79.07	90.00	97.50	97.50
	Pupil-dynamic	43.90	61.25	95.00	97.50
	Post-mortem	51.95	33.57	73.57	47.14
	Disease-affected	70.80	25.00	53.33	25.00
Impostor pairs	Combined	60.60	58.86	80.56	65.83
	Healthy easy	84.30	100.00	100.00	100.00
	Healthy difficult	76.16	100.00	100.00	100.00
	Twins	55.81	100.00	100.00	100.00
	Post-mortem	83.90	100.00	100.00	100.00
	Disease-affected	91.00	100.00	100.00	100.00
Combined		74.41	100.00	100.00	100.00
Overall		70.11	79.43	89.06	80.78

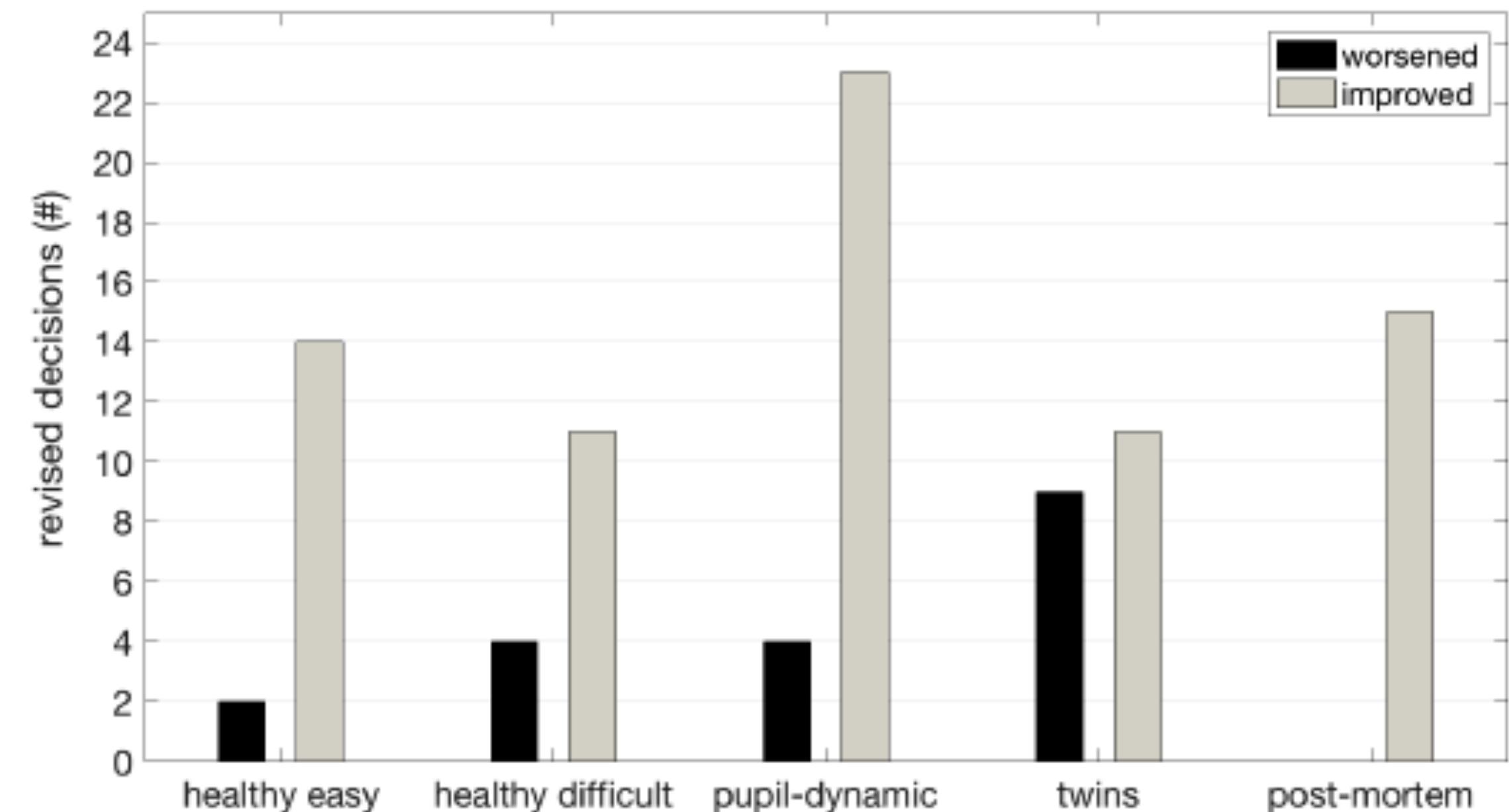
How confident were people?



Human Experiments

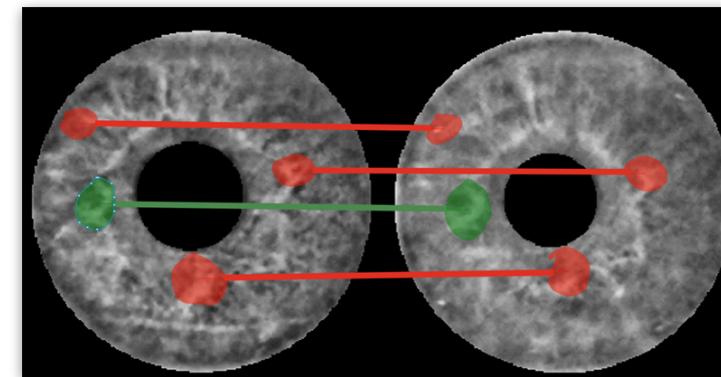
Did annotations help?

Pair class	Iris category	Accuracy (%)	
		without annotations	with annotations
Genuine	Healthy easy	87.06	96.47
	Healthy difficult	75.29	84.71
	Pupil-dynamic	41.18	52.35
	Post-mortem	45.29	54.12
Impostor	Combined	55.88	65.69
	Healthy easy	85.88	90.59
	Healthy difficult	80.00	78.82
	Twins	59.41	60.59
Overall	Combined	71.18	72.65
		62.00	68.47



Human Experiments

Findings



People performed better when they annotated the irises.



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



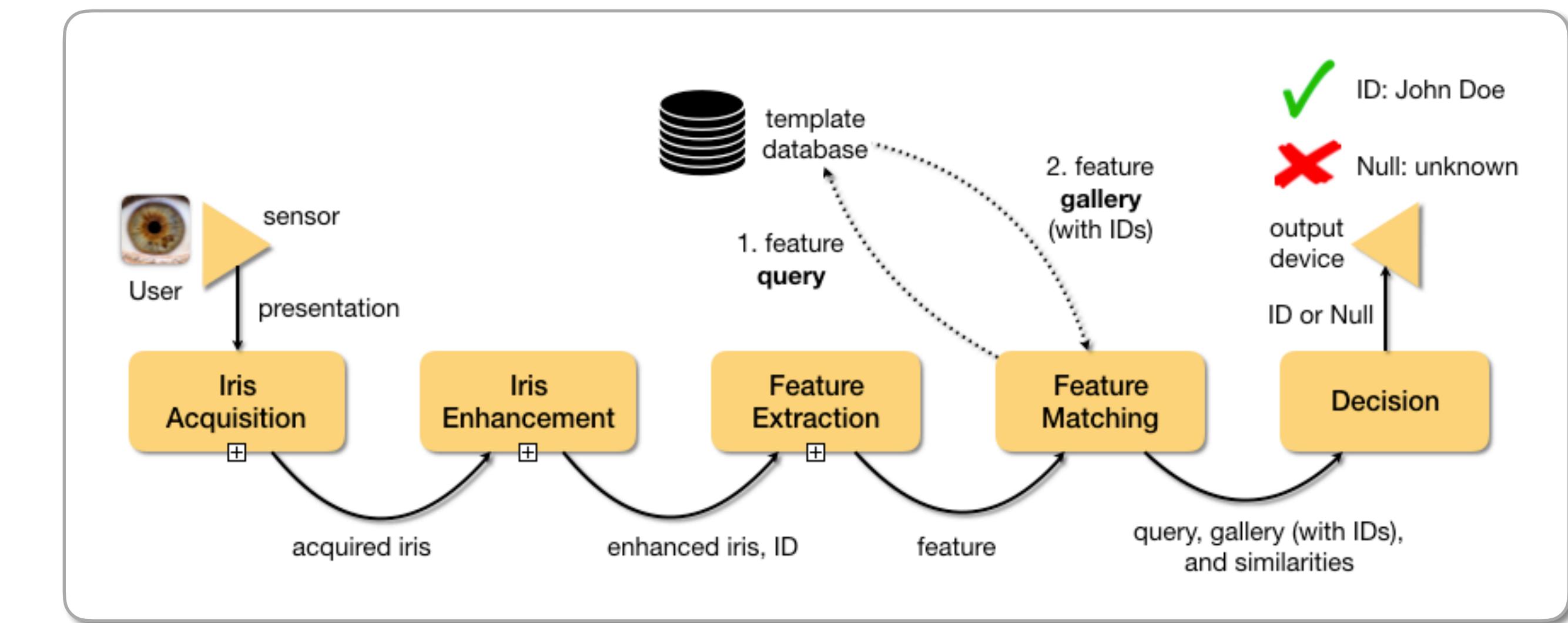
Most challenging cases to people: with **pupil dilation** and **twins**.

Annotating pupil dilation helps.

Annotating twins' doesn't.

S'up Next?

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



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