Basics I

COMP 388-002/488-002 Biometrics

Daniel Moreira

Fall 2023

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Today we will…

Discuss
What Biometrics is.
Reasons to use Biometrics.
Biometric traits.
How Biometric systems should look like.

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Today’s attendance

Please fill out the form

bit.ly/3EgXf6S

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What is Biometrics?

7 billion people
Who is this person? *(Identification)*
Is this person Jane Doe? *(Verification)*

Biometrics aims at ***identifying*** or ***verifying*** the claimed or denied identity of an individual based on their *physical*, *chemical* or *behavioral* traits.

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What is Biometrics?

In this course, we aim at **computer-aided Biometrics**.

We'll focus on **software solutions** rather than hardware.

But we'll get to use some **devices**, I promise.

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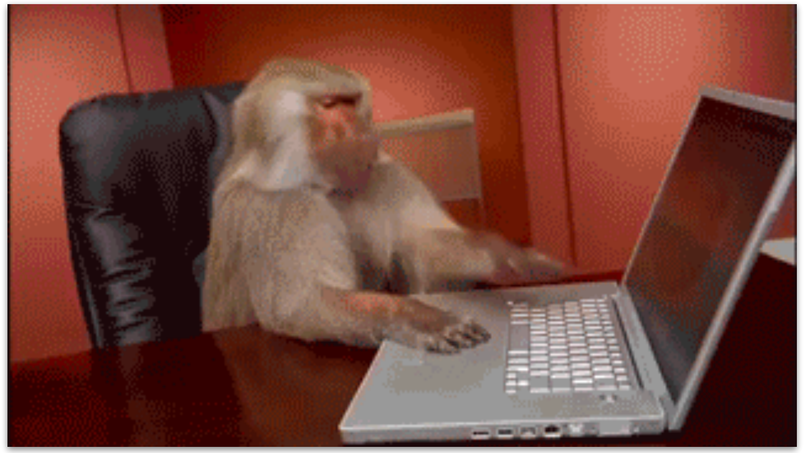
What is Biometrics?

Why computers?



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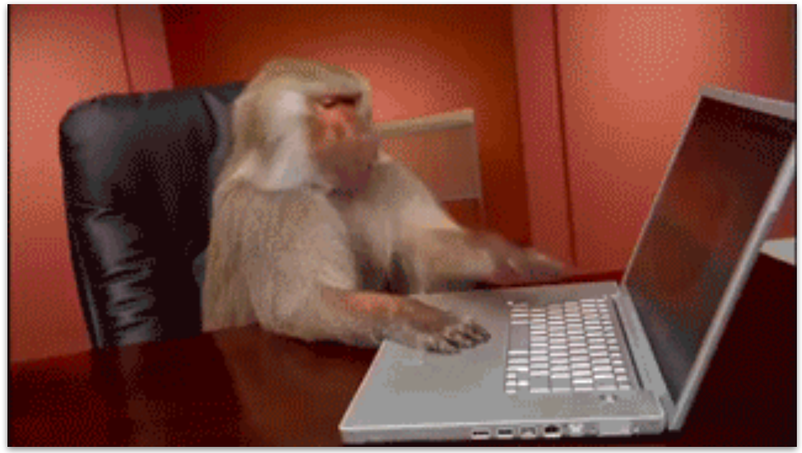
What is Biometrics?

Why computers?
High throughput
Repeatability
Predictability
Accountability



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What is Biometrics?

Identity verification through:

✓ A unique trait of yours.

physical

chemical

behavioral

✗ Not something you **have**.

✗ Not something you **know**.

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Why use Biometrics?

Consumers prefer biometric authentication to traditional passwords, Visa says

Jan 6, 2020 | Chris Burt

CATEGORIES Biometrics News | Financial Services

Almost 70 percent of U.S. shoppers did not go through with an online purchase because they either forgot the password, couldn't log in or couldn't receive a one-time passcode, according to research conducted by Visa, while another report from Verizon found that as many as 80 percent of data breaches are caused by compromised and weak passwords.

https://www.biometricupdate.com/202001/consumers-prefer-biometric-authentication-to-traditional-passwords-visa-says

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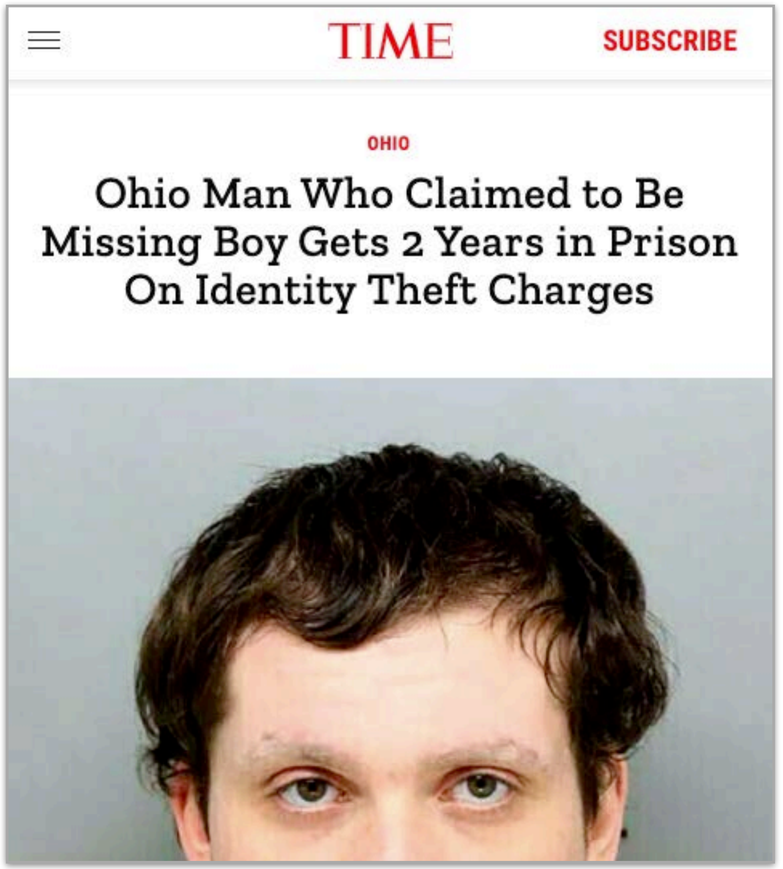
Why use Biometrics?



TIME SUBSCRIBE

OHIO

Ohio Man Who Claimed to Be Missing Boy Gets 2 Years in Prison On Identity Theft Charges

(CINCINNATI) — An Ohio man who claimed to be a child who disappeared at age 6 pleaded guilty Wednesday to aggravated identity theft and will serve two years in prison, minus time served.

Federal authorities said they were suspicious after he refused to be fingerprinted. DNA testing quickly revealed his true identity.

https://time.com/5762223/brian-rini-missing-child-pleads-guilty/

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Why use Biometrics?

Biometrics is safer
But not absolutely safe!

https://www.bbc.com/news/world-latin-america-21756709

A Brazilian doctor faces charges of fraud after being caught on camera using silicone fingers to sign in for work for absent colleagues, police say.

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Why use Biometrics?

Biometrics is safer
But not absolutely safe!

https://www.wired.com/story/10-year-old-face-id-unlocks-mothers-iphone-x/

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Why use Biometrics?

Biometrics is safer
But not absolutely safe!
Even humans fail.

latent
fingerprint

collected
fingerprint

The New York Times

Report Faults F.B.I.'s Fingerprint Scrutiny in Arrest of Lawyer

By David Stout

Nov. 17, 2004

https://www.nytimes.com/2004/11/17/politics/report-faults-fbis-fingerprint-scrutiny-in-arrest-of-lawyer.html

WASHINGTON, Nov. 16 - The Federal Bureau of Investigation wrongly implicated an Oregon lawyer in a deadly train bombing in Madrid because the F.B.I. culture discouraged fingerprint examiners from disagreeing with their superiors, a panel of forensic experts has concluded.

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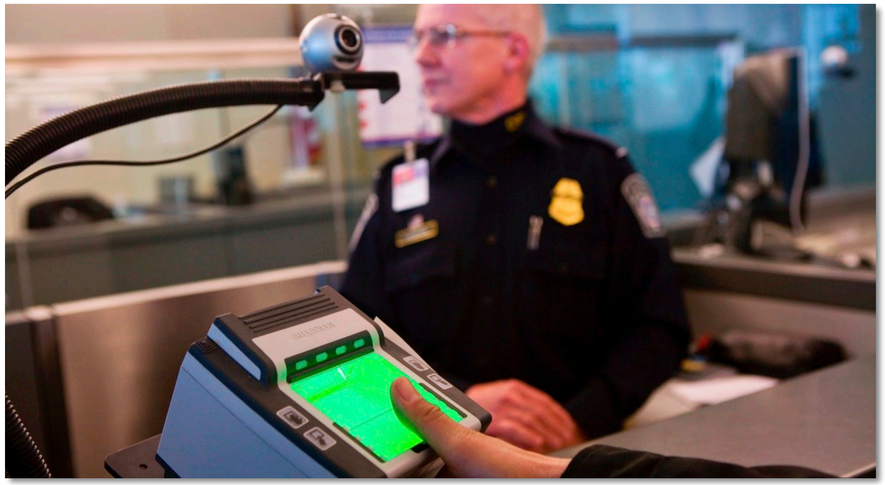
Biometrics Use

Biometrics is a reality



border patrol

entertainment

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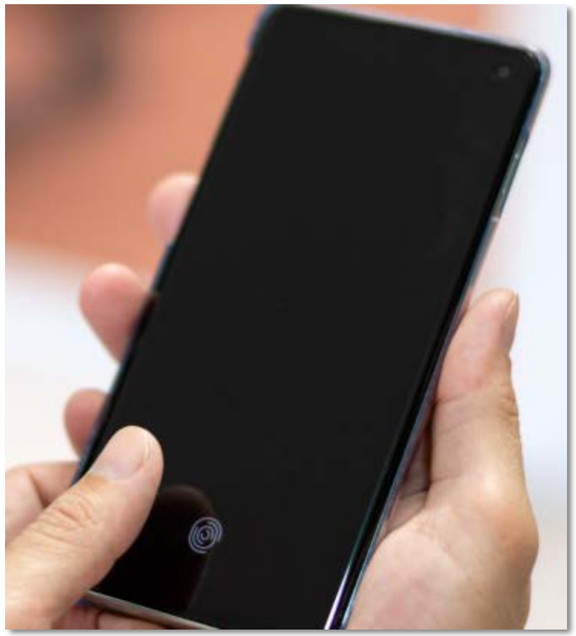
Biometrics Use

Biometrics is a reality



personal devices

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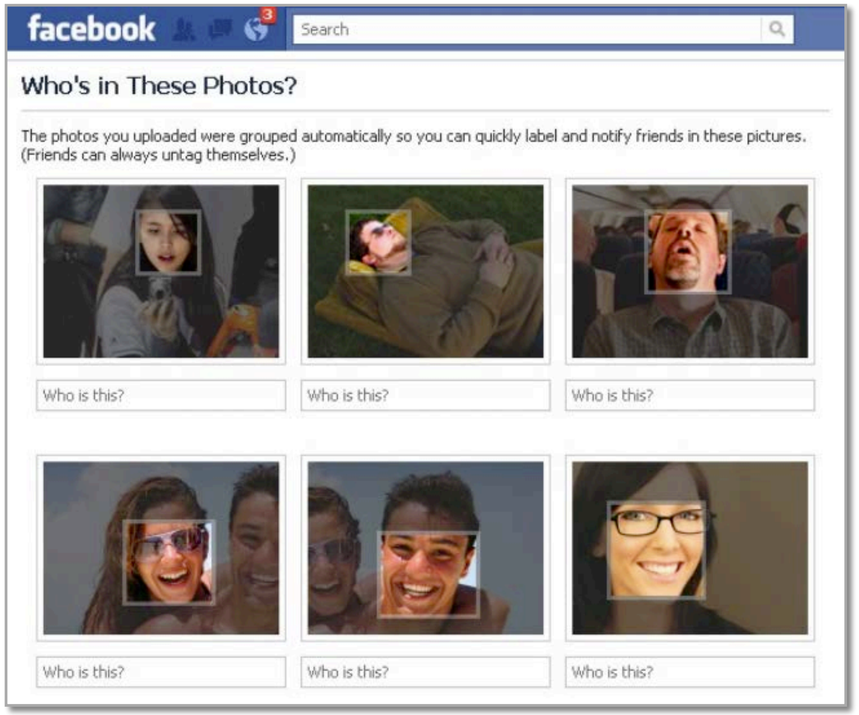
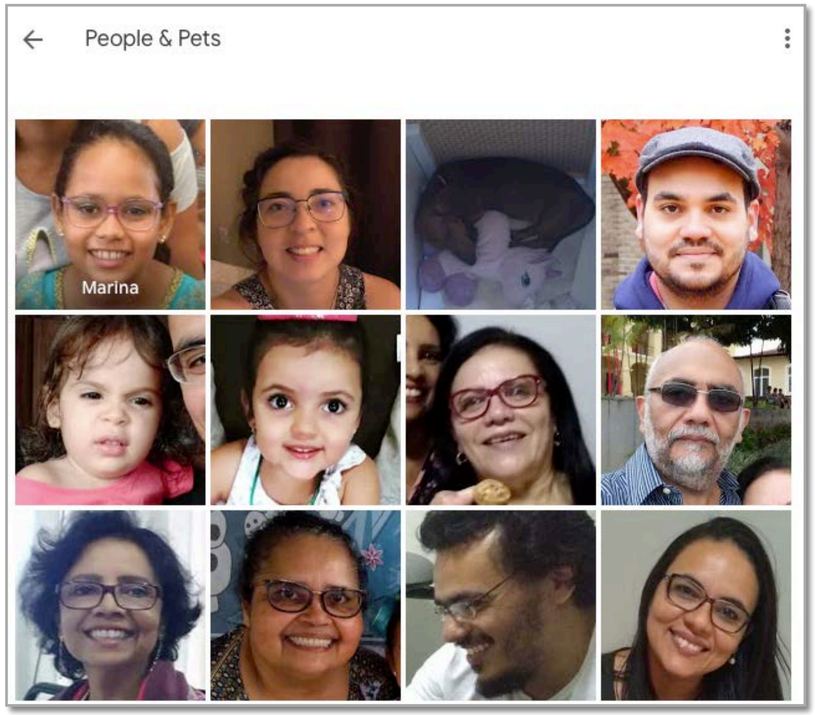
Biometrics Use

Biometrics is a reality



Facebook



Google Photos

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Biometrics Use

Biometrics is a reality

Indian AADHAAR program
10-year initiative.
1.2 billion people enrolled
(99% of adult population).
Iris scans, faces, and fingerprints.
Claimed to have saved the
Indian government $12.4 billion.

civil rights

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Biometrics Abuse

Function Creep
Widening of the use of a technology
beyond the purpose for which
it was originally intended.

US typical example: SSN

The same may happen with Biometric systems.

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Biometrics Abuse

Function Creep

In 2001, Colorado state was caught selling its DMV* face and fingerprint databases to corporations.

*Department of Motor Vehicles
Source: https://i2i.org/wp-content/uploads/2011/02/IP-8-2001-1.pdf

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Biometrics Abuse

Segregating Profiling

hindustantimes

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Home / Bhopal / Linking benefits for AIDS patients to Aadhaar triggers privacy concerns

Linking benefits for AIDS patients to Aadhaar triggers privacy concerns

Many patients are avoiding going to hospitals and ATR centres fearing mandatory submission of their Aadhaar number could lead to disclosure of their identity, inviting social stigma.

BHOPAL Updated: Apr 03, 2017 12:34 IST

https://www.hindustantimes.com/bhopal/linking-benefits-for-aids-patients-to-aadhaar-triggers-privacy-concerns/story-iR6HB8RmqPDaNwkX2Oj5EJ.html

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Biometrics Abuse

Segregating Profiling

The New York Times

China Uses DNA to Map Faces, With Help From the West

Beijing's pursuit of control over a Muslim ethnic group pushes the rules of science and raises questions about consent.

By Sui-Lee Wee and Paul Mozur

Published Dec. 3, 2019 Updated Dec. 10, 2019

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https://www.nytimes.com/2019/12/03/business/china-dna-uighurs-xinjiang.html

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Biometrics Abuse

Data Leakage

NATION

TRIBUNE INVESTIGATION — SECURITY BREACH

Rs 500, 10 minutes, and you have access to billion Aadhaar details

JALANDHAR:It was only last November that the UIDAI asserted that “Aadhaar data is fully safe and secure and there has been no data leak or breach at UIDAI.

Posted: Jan 04, 2018 02:07 AM (IST) **Updated :** 2 years ago

103612 0 0 0

https://www.tribuneindia.com/news/archive/rs-500-10-minutes-and-you-have-access-to-billion-aadhaar-details-523361

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Biometrics Abuse

Compromised biometric data
People cannot change their biometric data in response to a leak. Irreversible for whole lifetime.

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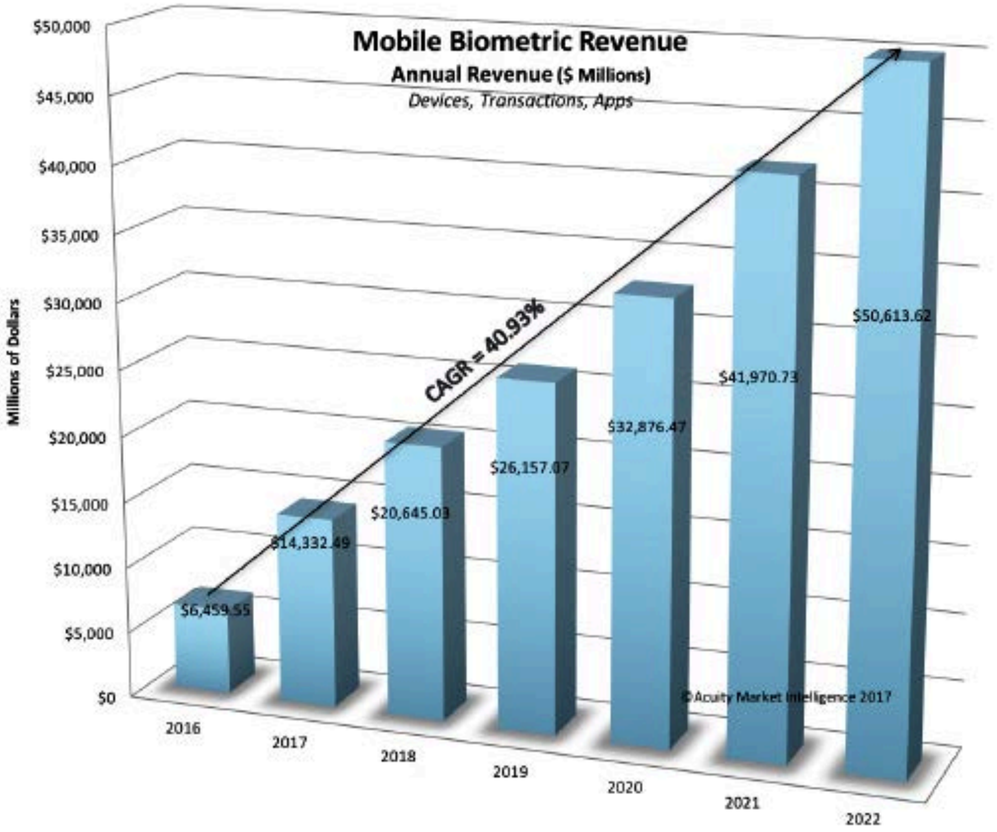
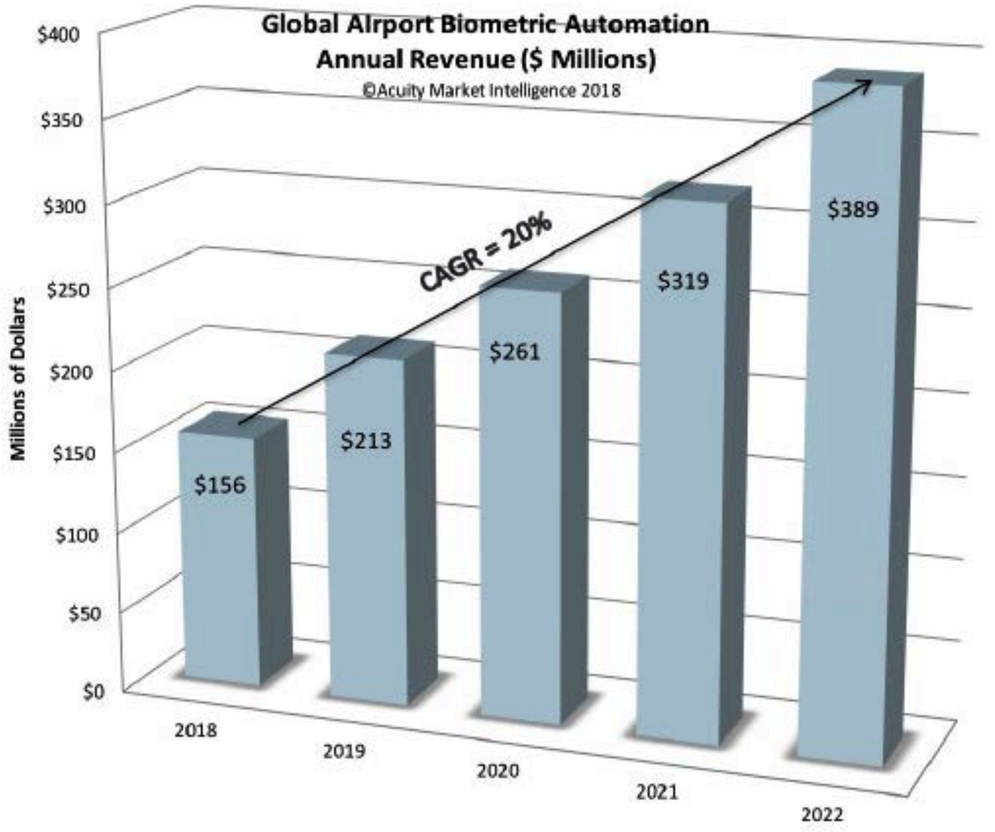
Biometrics Appeal

2017 Forecast



2019 Forecast



Source: Acuity Market Intelligence (https://www.acuitymi.com/)
CAGR: Compound Annual Growth Rate

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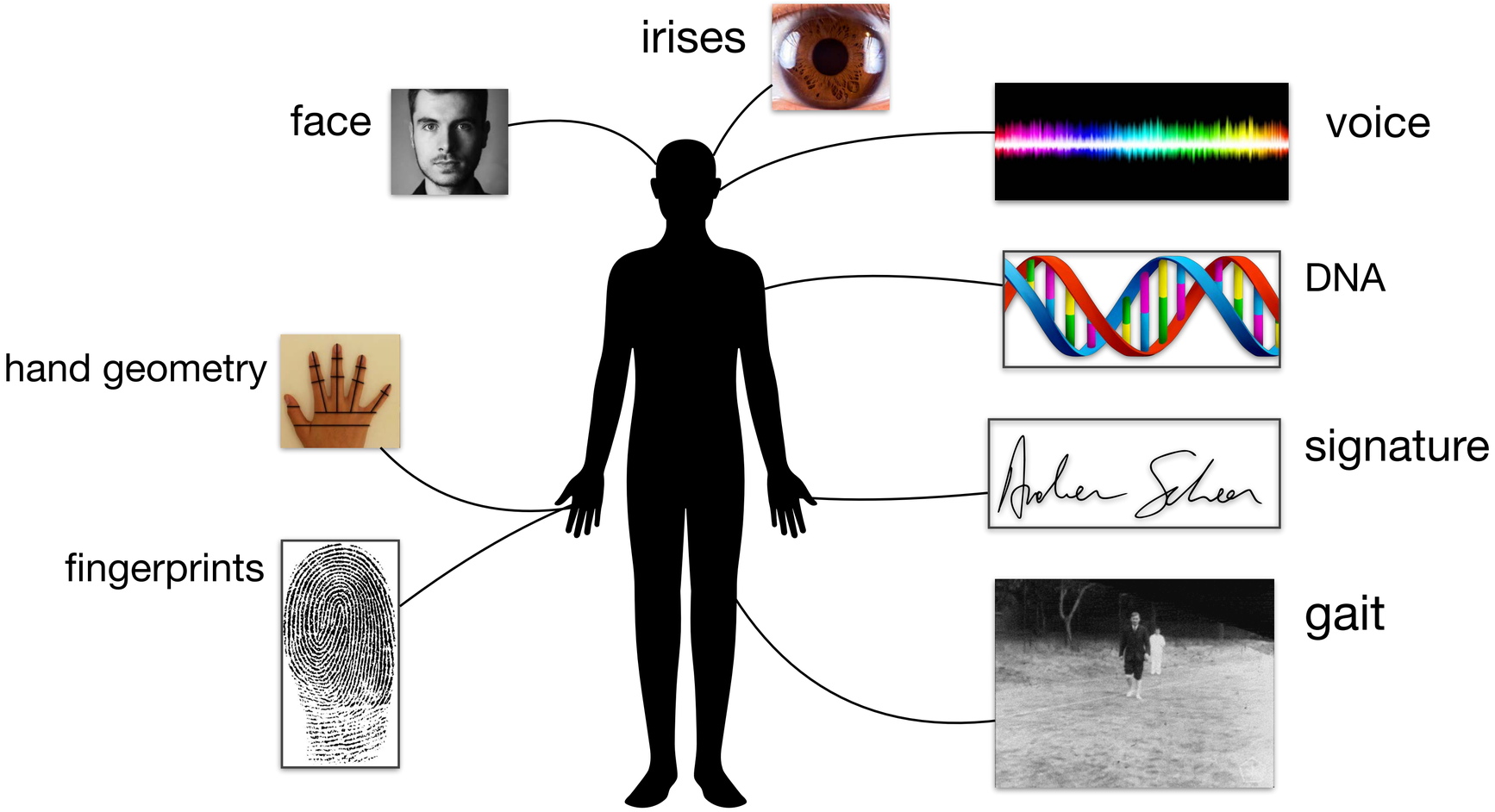
Biometric Traits



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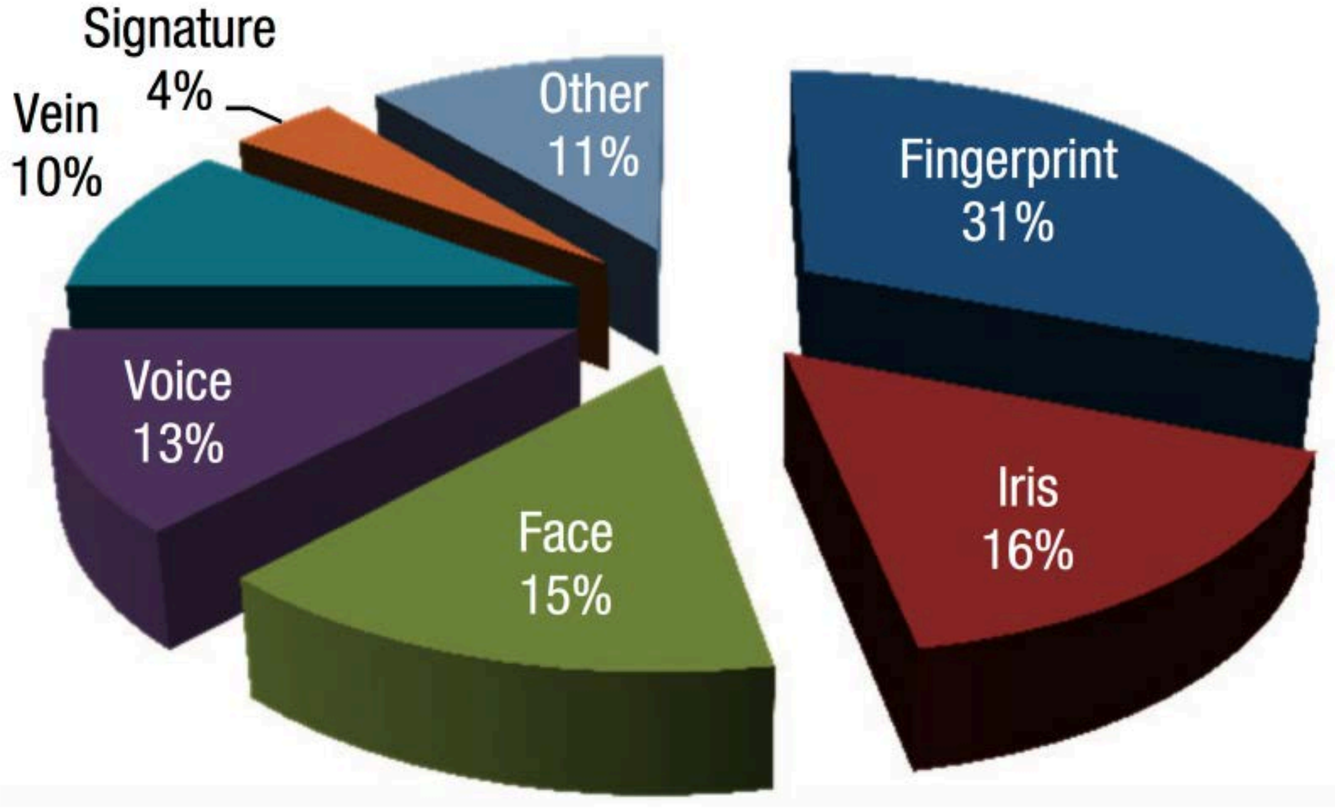
Biometric Traits

Market



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

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Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

Universality (1/8)

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Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

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

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Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

Uniqueness (2/8)

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Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

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

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Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

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

The New York Times

Who's the Daddy? Neither Twin Would Say. But They Both Will Pay.

By Ernesto Londoño and Lis Moriconi

April 3, 2019

RIO DE JANEIRO — The judge was stumped.

He had ordered a pair of identical twins to take DNA tests in a paternity case in the central Brazilian state of Goiás. Both came back positive.

https://www.nytimes.com/2019/04/03/world/americas/brazil-paternity-dna.html

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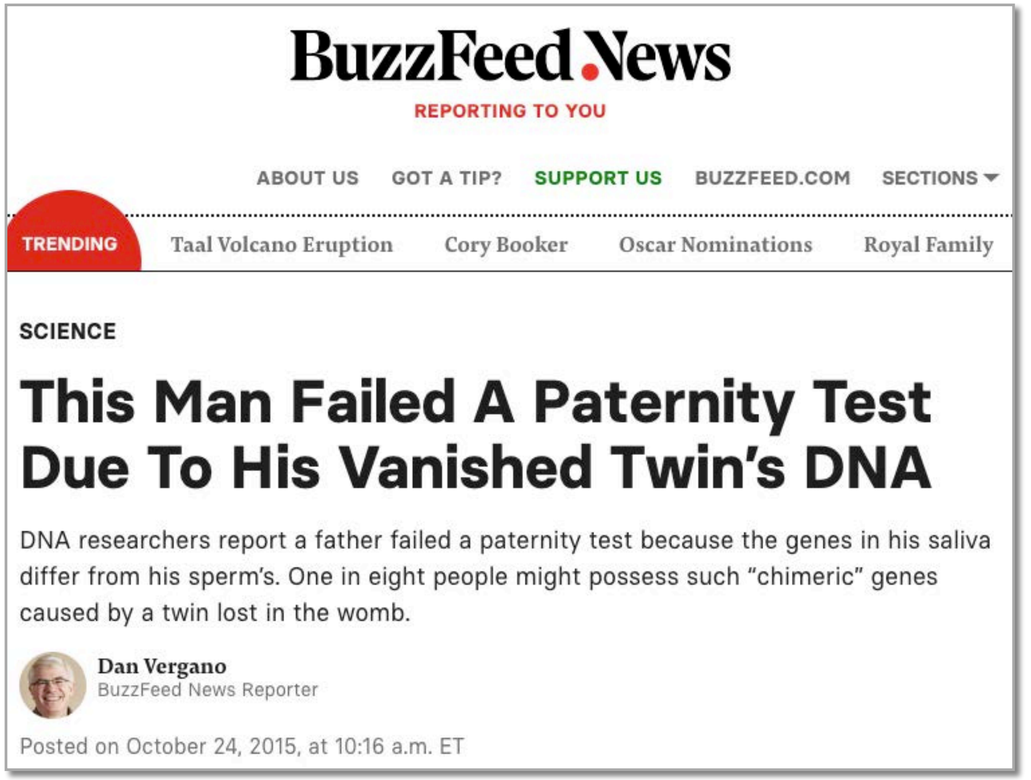
Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

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



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SCIENCE

This Man Failed A Paternity Test Due To His Vanished Twin's DNA

DNA researchers report a father failed a paternity test because the genes in his saliva differ from his sperm's. One in eight people might possess such "chimeric" genes caused by a twin lost in the womb.

Dan Vergano
BuzzFeed News Reporter

Posted on October 24, 2015, at 10:16 a.m. ET

https://www.buzzfeednews.com/article/danvergano/failed-paternity-test-vanished-twin

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Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

Permanence (3/8)

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Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

Permanence (3/8)
How does the trait change
over time?
How can diseases affect the trait?

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Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

Measurability (4/8)

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Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

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

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Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

Acceptability (5/8)

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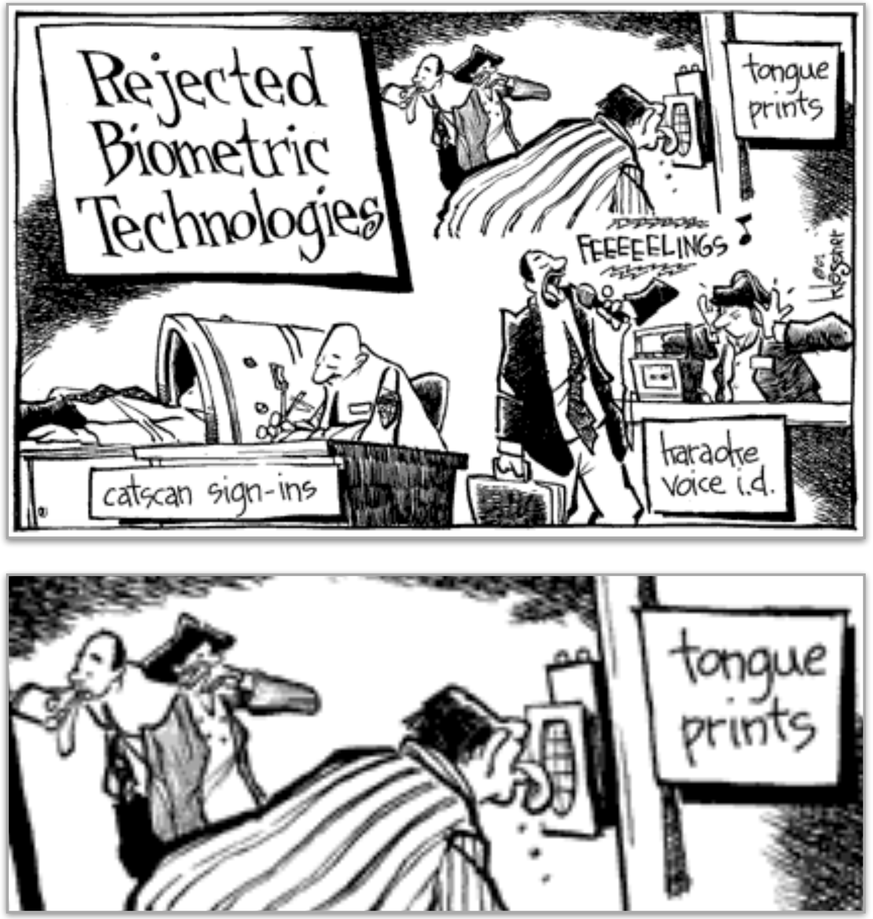
Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

Acceptability (5/8)
Will individuals collaborate during data collection?



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Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

Circumvention (6/8)

https://www.youtube.com/watch?v=SIII8L43nng

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Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

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

https://www.youtube.com/watch?v=SIII8L43nng

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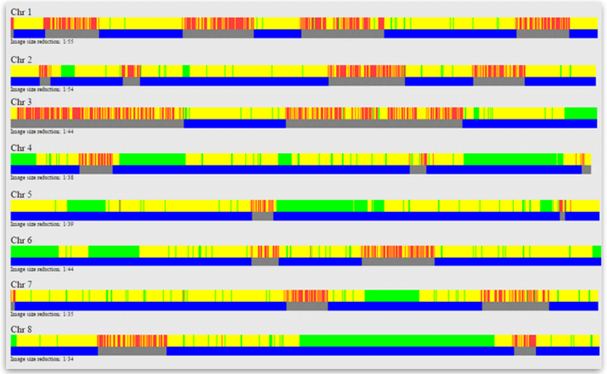
Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

Explainability (7/8)



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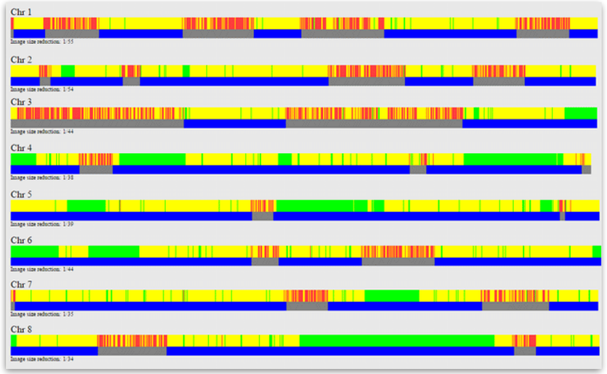
Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

Explainability (7/8)
How easy is it for the everyman to understand the trait comparison?



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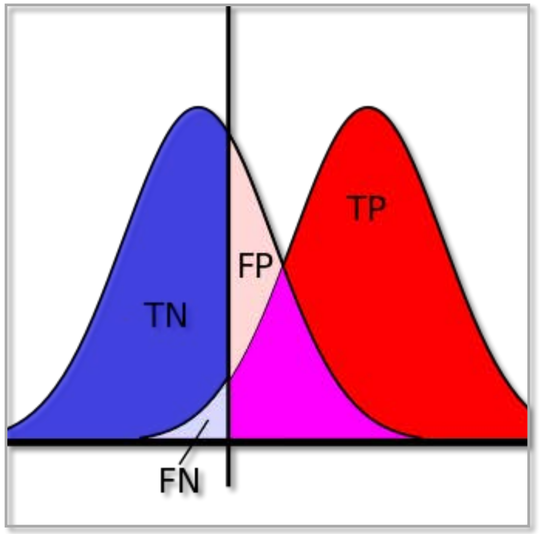
Biometric Traits

What do we want to consider?
Some traits might be more suitable than others.

Performance (8/8)
How good is the trait quantitatively according to objective **metrics**?
(we'll see them soon)



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Activity

Please go to **bit.ly/3Rj4xiz** and answer the questions.

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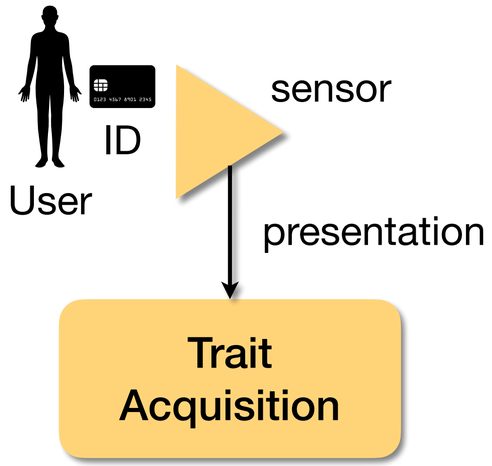
Biometric Systems

Enrollment



Trait Acquisition
We'll have data-collection classes.
We'll use real-world sensors.

What to observe?
Sensors have different **quality**
(in terms of precision, resolution,
presence of noise, and usability)

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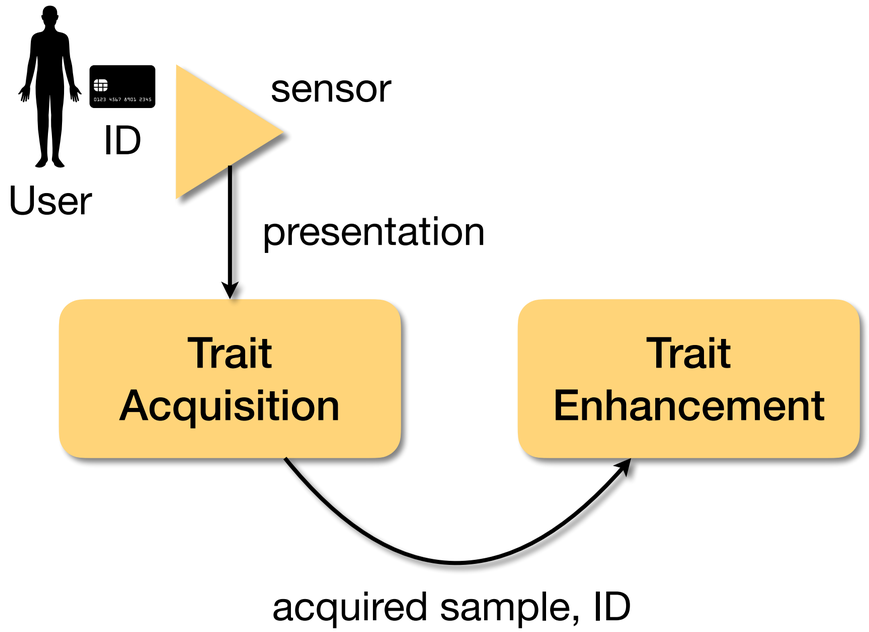
Biometric Systems

Enrollment



Trait Enhancement
Noise removal.
Operations to keep only **essential** information (consider universality, uniqueness, permanence, circumvention, accountability, and performance).

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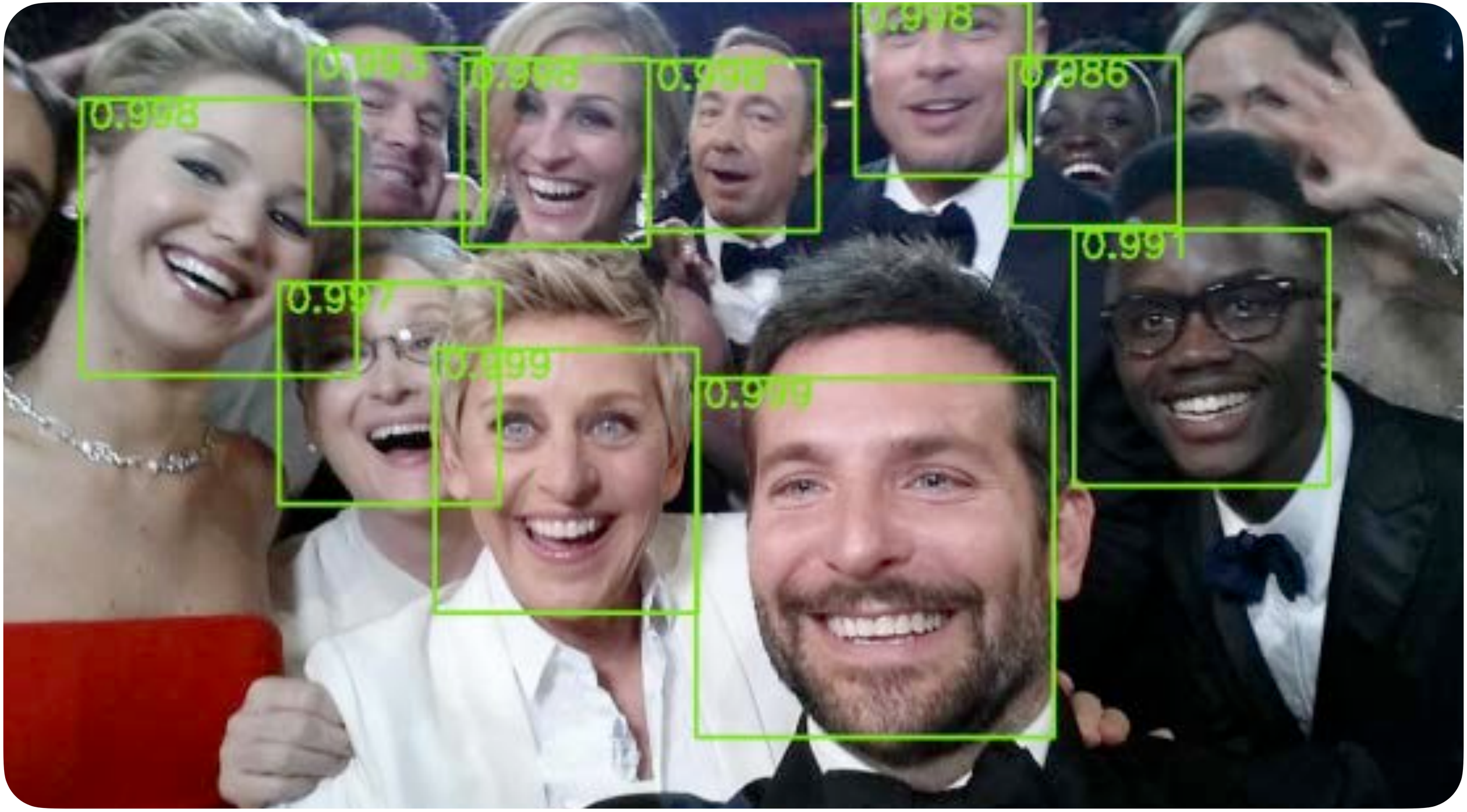
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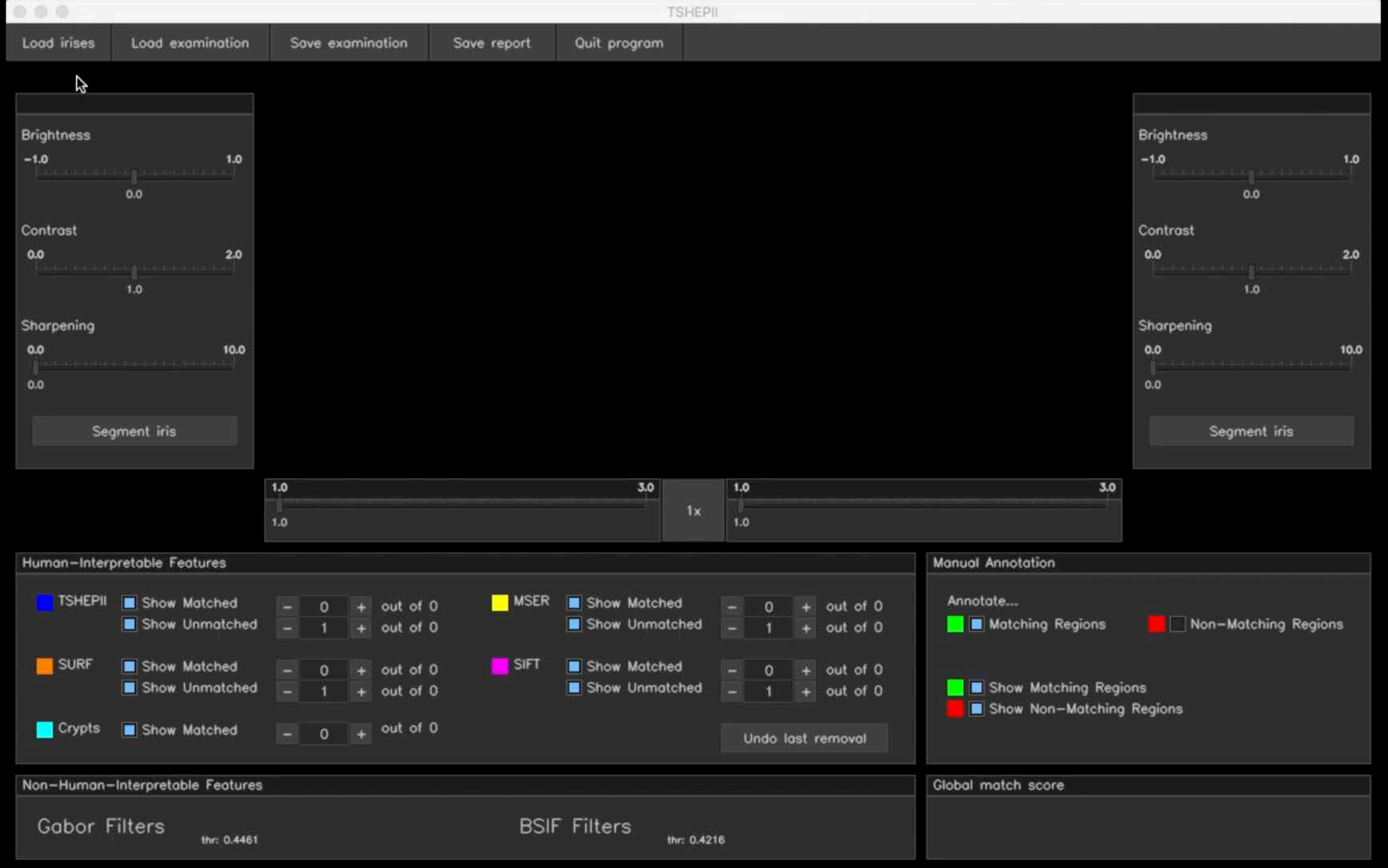
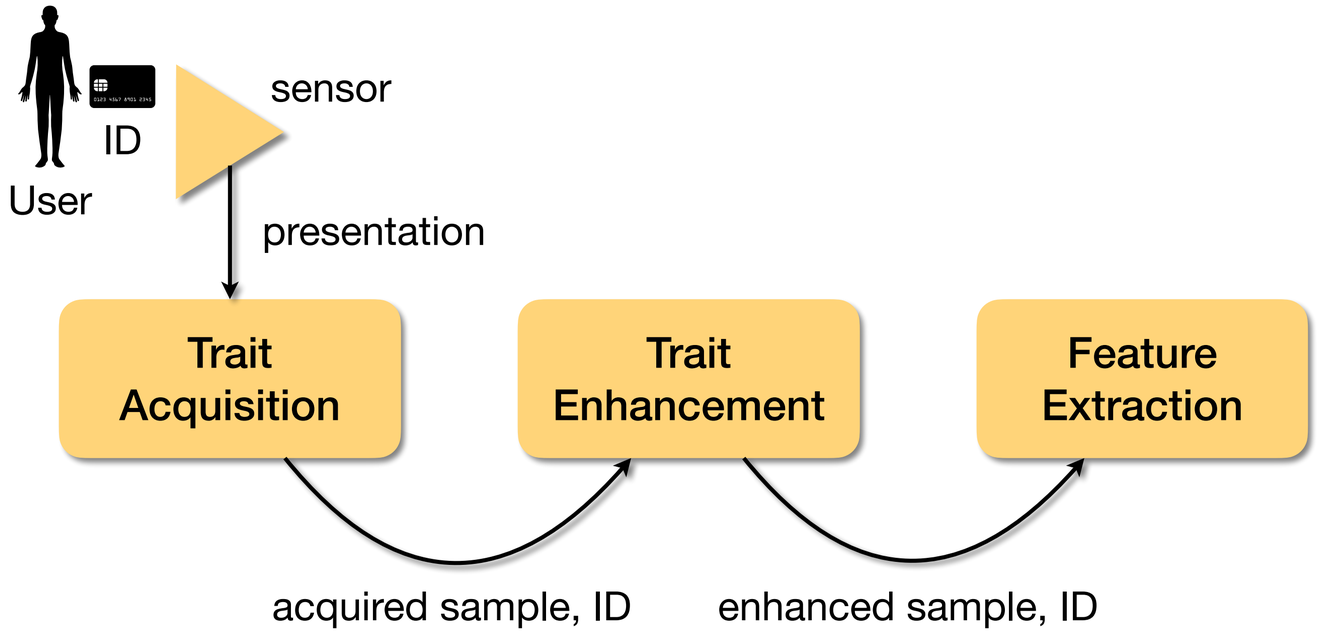

TSHEPII
Load irises
Load examination
Save examination
Save report
Quit program
Brightness
-1.0
1.0
0.0
Contrast
0.0
2.0
1.0
Sharpening
0.0
10.0
0.0
Segment iris
Brightness
-1.0
1.0
0.0
Contrast
0.0
2.0
1.0
Sharpening
0.0
10.0
0.0
Segment iris
1.0
3.0
1.0
1x
1.0
3.0
1.0
Human-Interpretable Features
TSHEPII
Show Matched
Show Unmatched
0
out of 0
1
out of 0
SURF
Show Matched
Show Unmatched
0
out of 0
1
out of 0
Crypts
Show Matched
0
out of 0
MSER
Show Matched
Show Unmatched
0
out of 0
1
out of 0
SIFT
Show Matched
Show Unmatched
0
out of 0
1
out of 0
Undo last removal
Manual Annotation
Annotate...
Matching Regions
Non-Matching Regions
Show Matching Regions
Show Non-Matching Regions
Non-Human-Interpretable Features
Gabor Filters
thr: 0.4461
BSIF Filters
thr: 0.4216
Global match score

Biometric Systems

Enrollment Modules



Feature Extraction
Compact but expressive digital representation of the trait.

Types
Handcrafted or **learned** with machine learning.
We'll see both cases.

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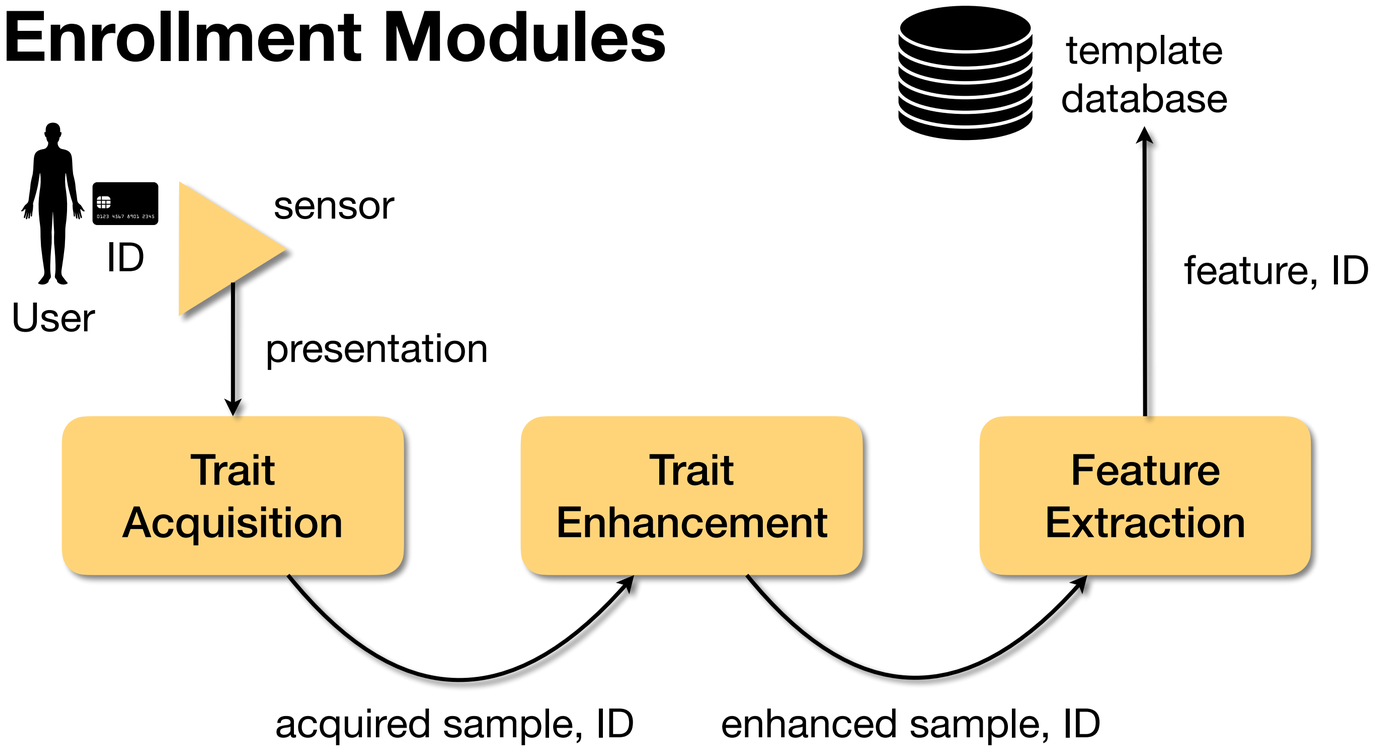
Biometric Systems

Enrollment Modules



Template Database
It inherits all the security and privacy issues from database systems.
Be careful with invasions, leaks, etc.

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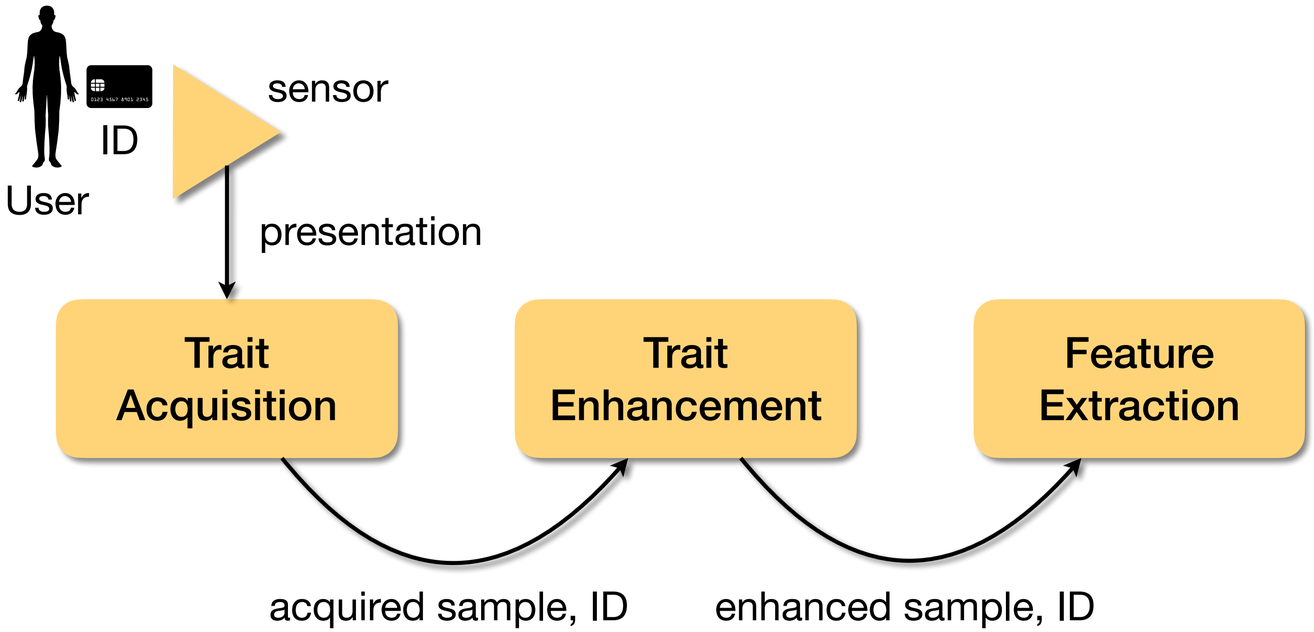
Biometric Systems

Verification Modules



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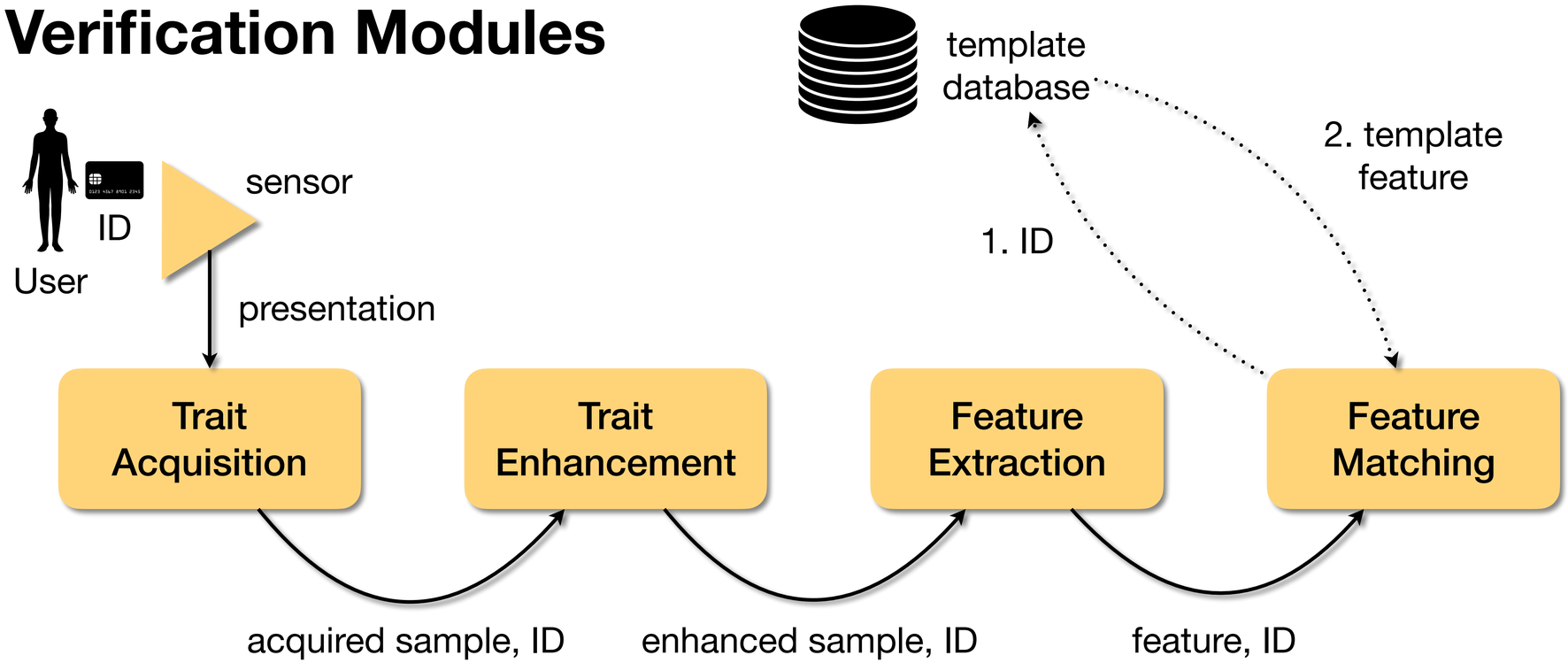
Biometric Systems

Verification Modules



Feature Matching Comparison of **acquired** and **template** features.

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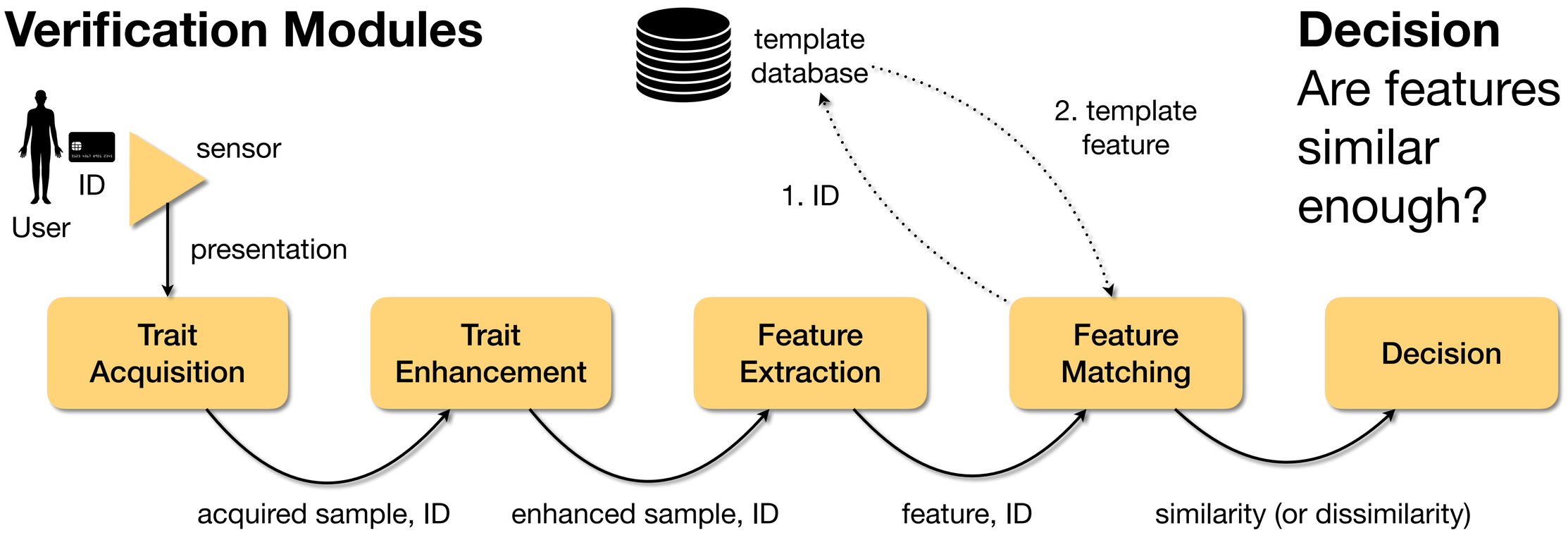
Biometric Systems



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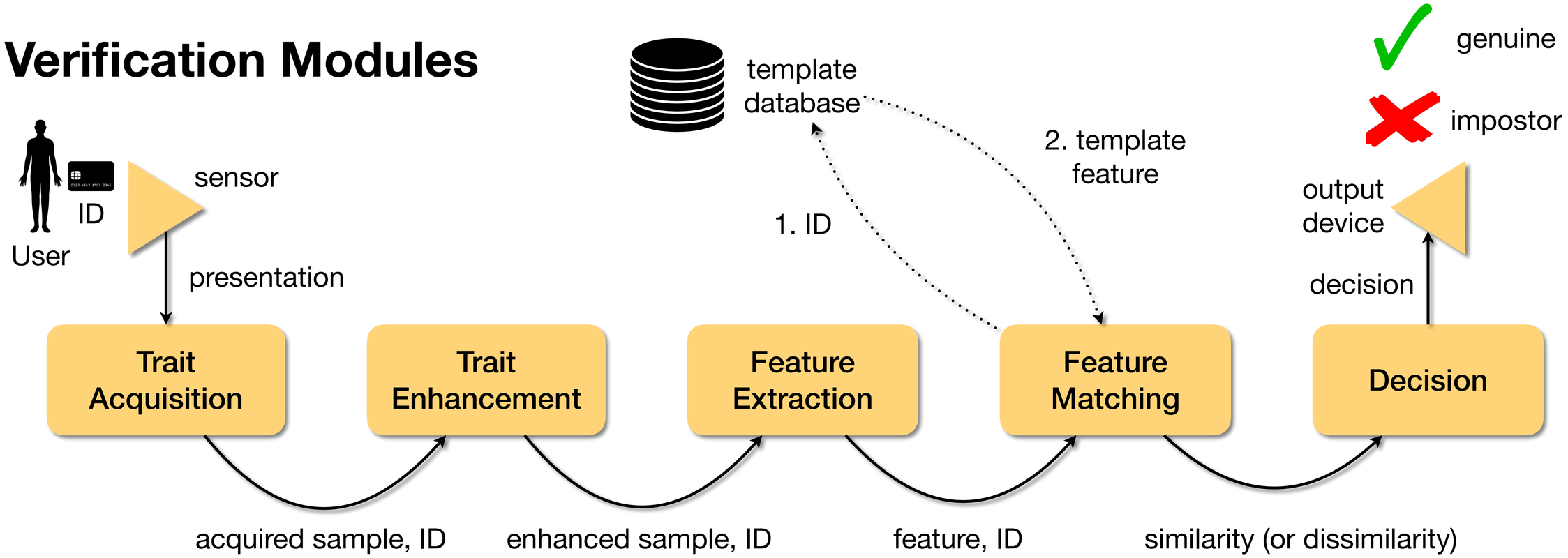
Biometric Systems



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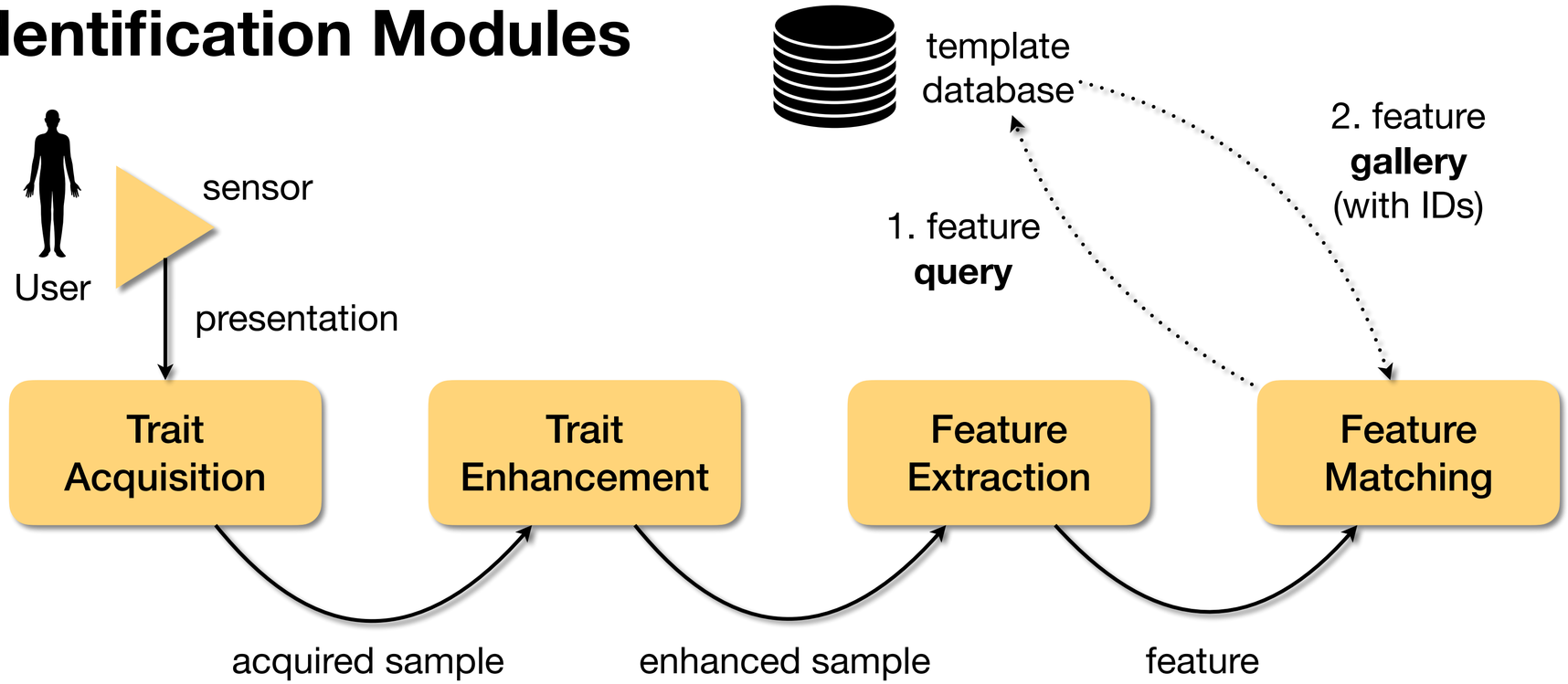
Biometric Systems

Identification Modules



Gallery
Closest template features to query.

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Biometric Systems

Query and Gallery Example

query

gallery

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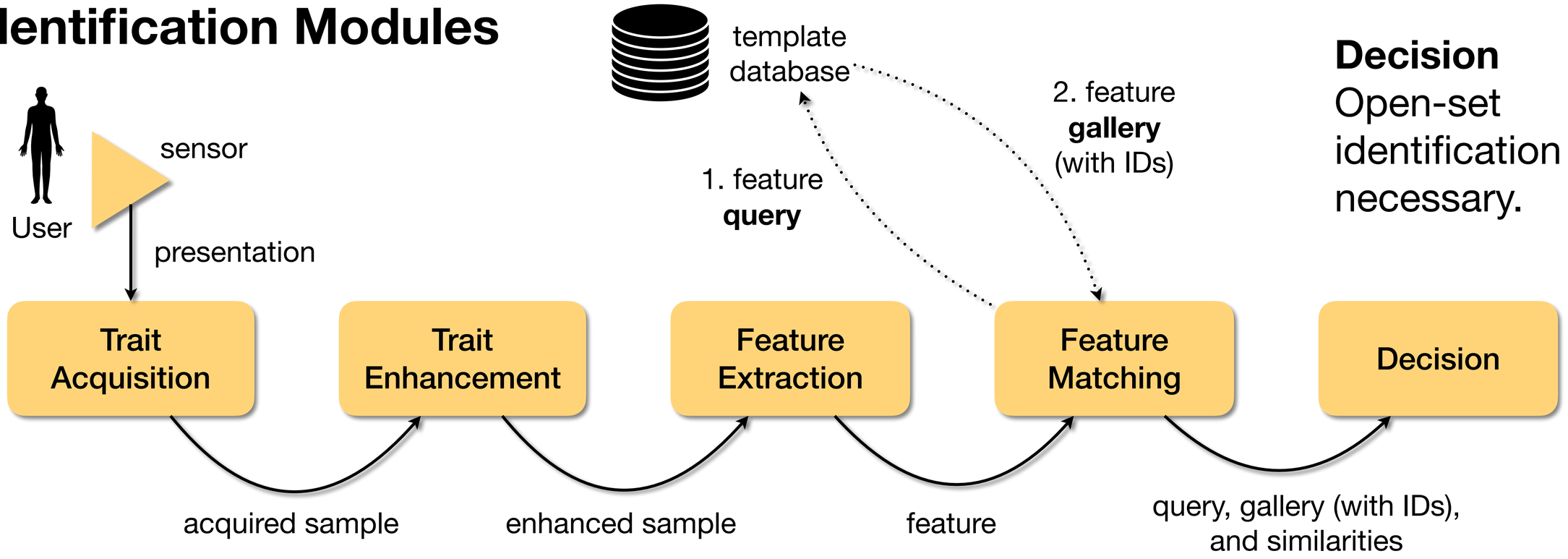
Biometric Systems

Identification Modules



Decision
Open-set identification is necessary.

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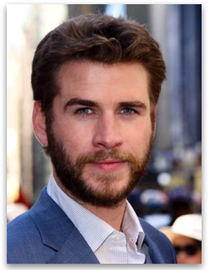
Biometric Systems

Open-set vs. Closed-set Identification

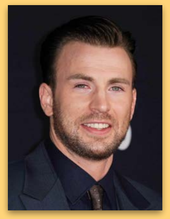


Query
(Liam Hemsworth)

Dataset

Robert Downey Jr.

Scarlet Johansson



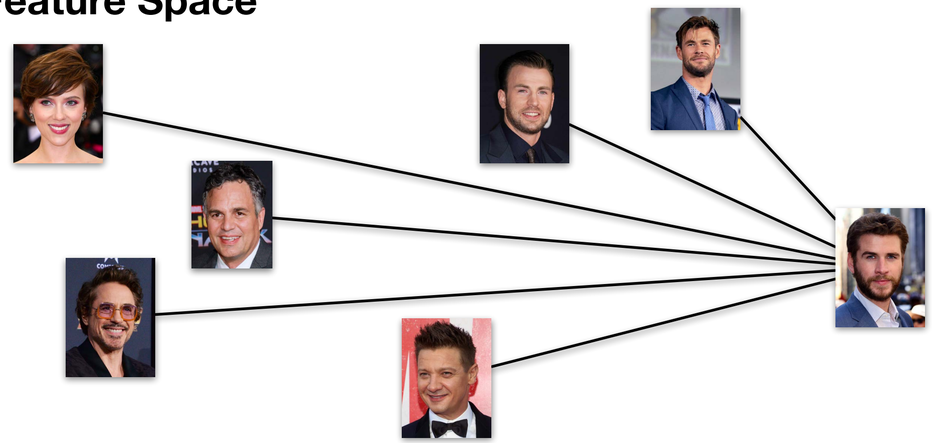
Chris Evans

Mark Ruffalo

Chris Hemsworth

Jeremy Renner

Feature Space



Closed Set

Output
This is Chris Hemsworth!

Open Set

Output
I don't know this person!

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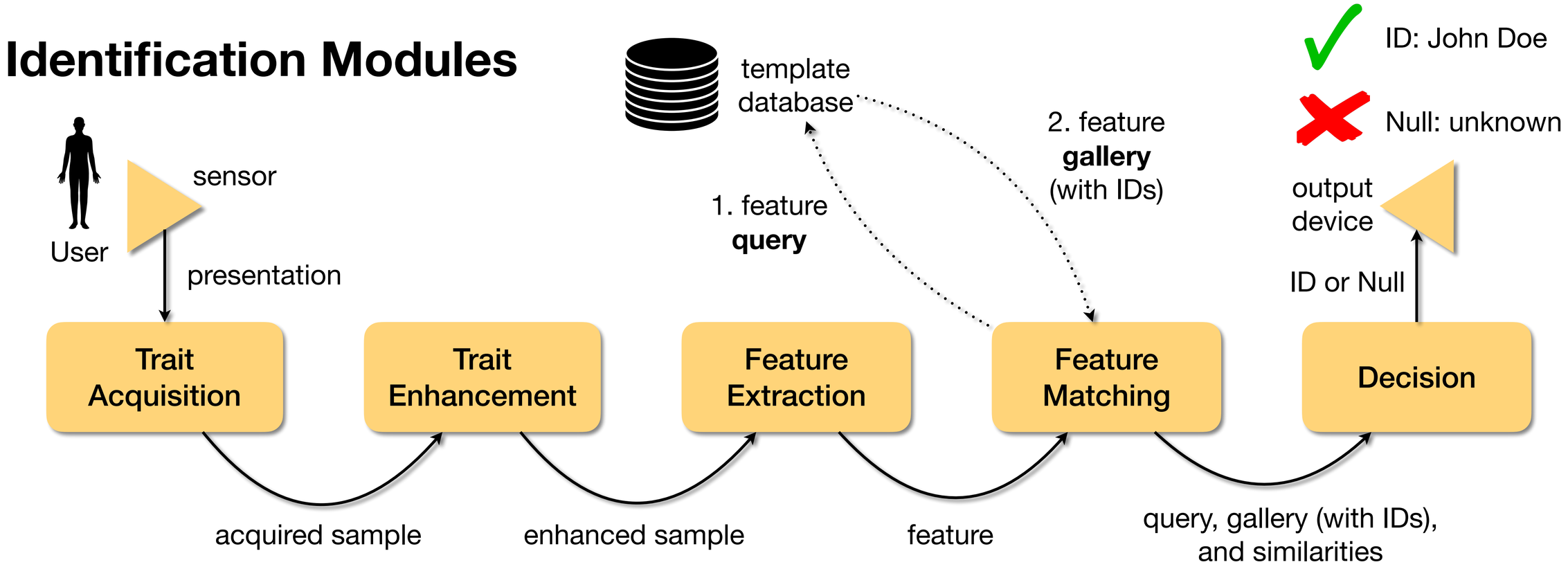
Biometric Systems



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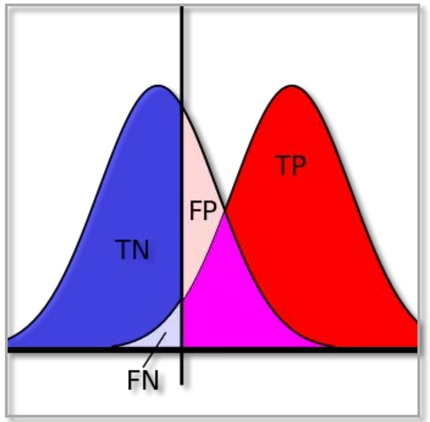
What's Next?

Keep relaxed
Any issues? Please come and talk to me.
Enjoy Labor Day!



More basics
Biometric system errors and metrics.

Fill out your *Today-I-missed* Statement
https://sakai.luc.edu/x/PnQvIG

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