

Basics I

COMP 388-002/488-002 Biometrics

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Fall 2025



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UNIVERSITY CHICAGO

Today we will...

Discuss

What Biometrics is

Reasons to use Biometrics

Biometric traits

Biometric system modules

Today's Attendance

Please fill out the form

forms.gle/R9S6J4QaQntLHupU8



What is Biometrics?



8.2 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.

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.

What is Biometrics?

Why computers?



[tinyurl.com/
4yu228t6](https://tinyurl.com/4yu228t6)



What is Biometrics?

Why computers?

High throughput
Repeatability
Predictability
Accountability

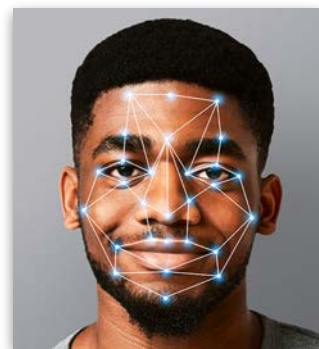


What is Biometrics?

Identity verification through:



A unique trait
of yours.



physical



chemical



behavioral



Not something
you **have**.



Not something
you **know**.



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>

Why use Biometrics?



A federal judge Tuesday sentenced an apologetic Ohio man to two years behind bars and one year of probation for falsely claiming to be a long-missing Illinois child.

Confronted with **DNA** results proving he wasn't Pitzen, Rini said he had watched a story about the missing boy on ABC's "20/20" and wanted to get away from his own family, the FBI said.

[cbsnews.com/news/brian-rini-timothy-pitzen-man-who-claimed-to-be-long-missing-boy-gets-two-year-sentence-apologizes-to-boys-family/](https://www.cbsnews.com/news/brian-rini-timothy-pitzen-man-who-claimed-to-be-long-missing-boy-gets-two-year-sentence-apologizes-to-boys-family/)

Why use Biometrics?

Biometrics is safer
But not absolutely safe!



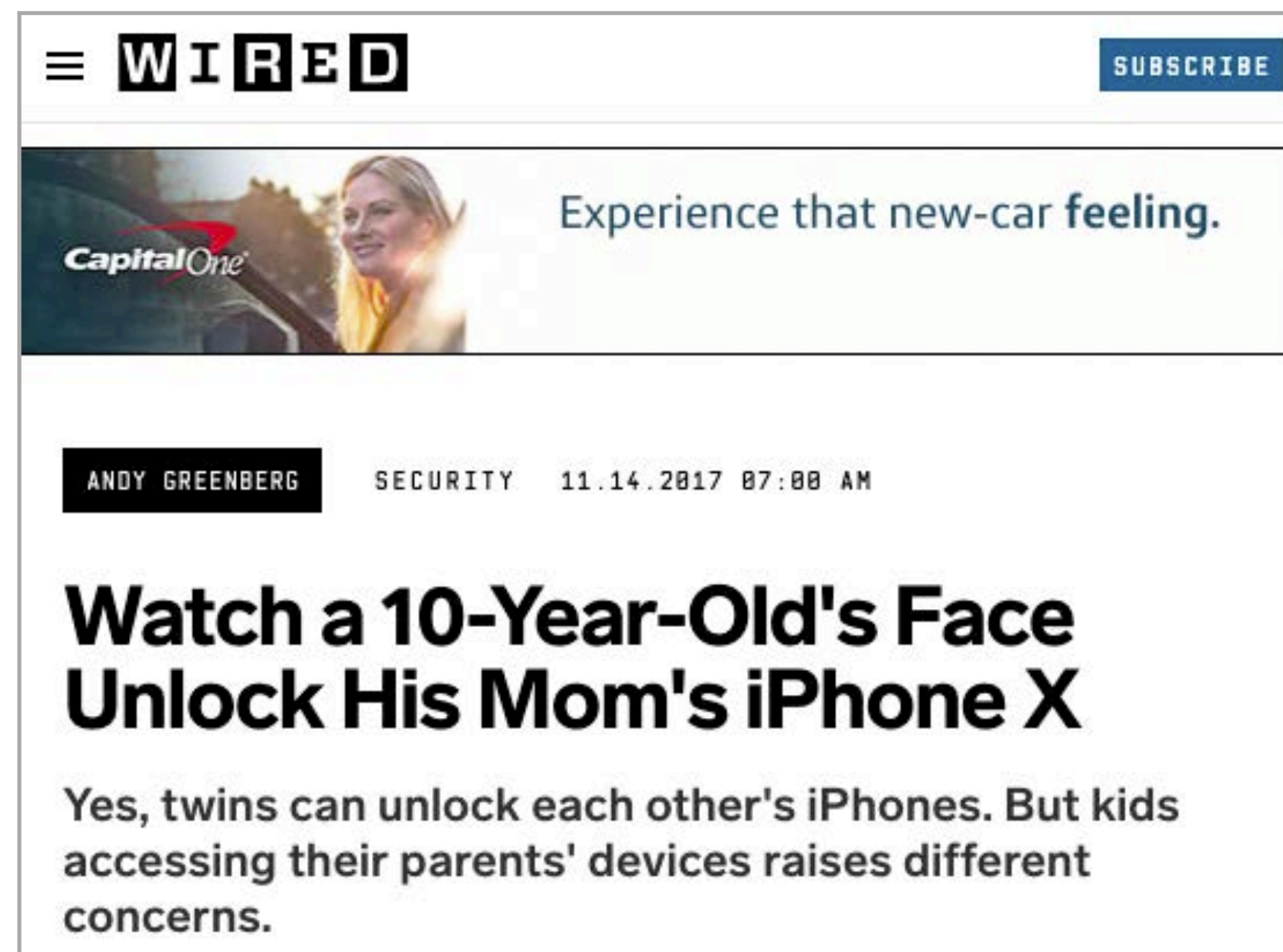
<https://www.bbc.com/news/world-latin-america-21756709>



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.

Why use Biometrics?

Biometrics is safer
But not absolutely safe!



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

Why use Biometrics?

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



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



latent
fingerprint

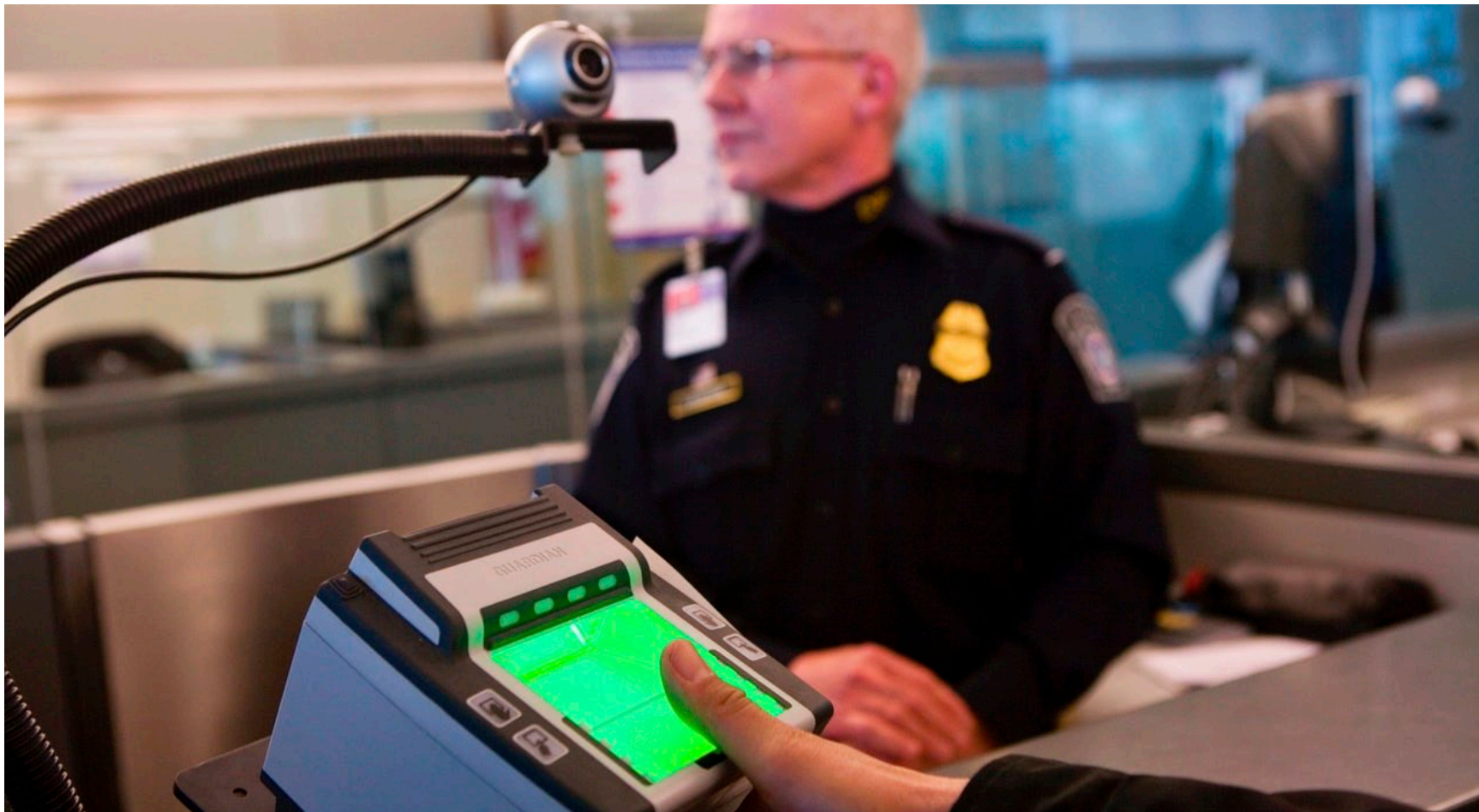


collected
fingerprint

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.

Biometrics Use

Biometrics is a reality



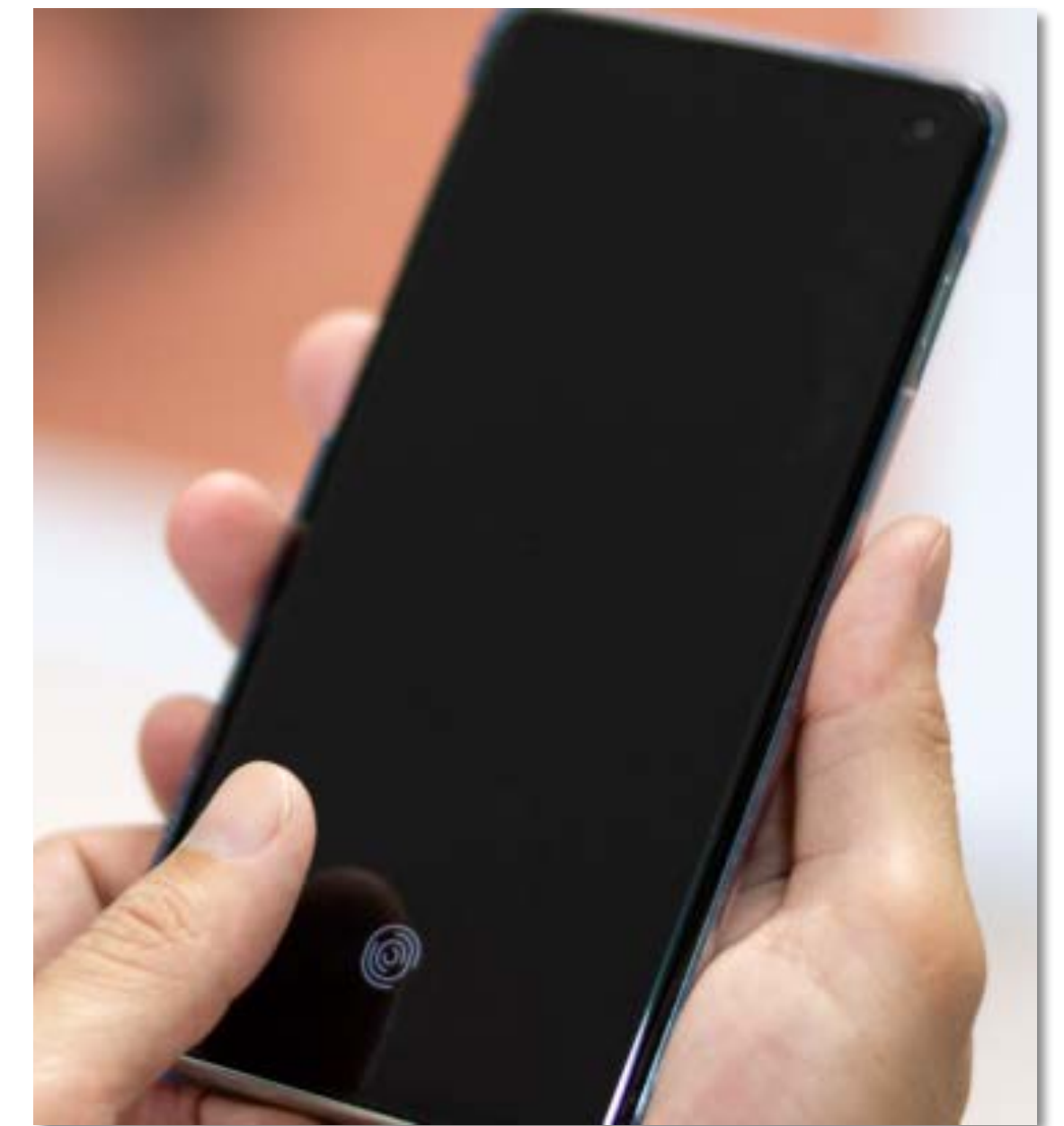
border patrol



entertainment

Biometrics Use

Biometrics is a reality



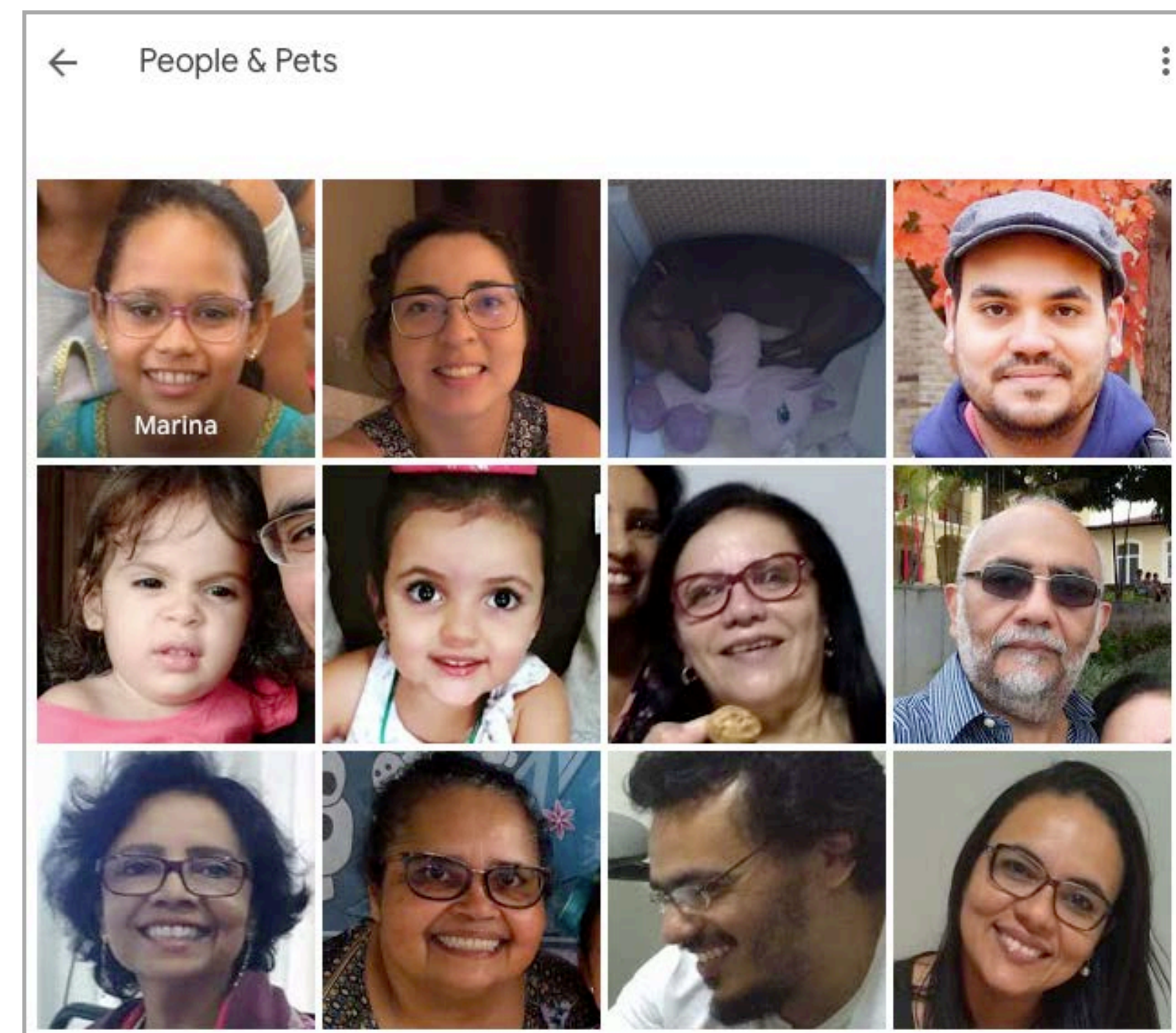
personal devices

Biometrics Use

Biometrics is a reality



Facebook



Google Photos

Biometrics Use

Biometrics is a reality

Indian AADHAAR program

16-year initiative.

1.38 billion people enrolled
(99% of adult population).

Iris scans, faces, and fingerprints.

Claimed to have saved the
Indian government \$10 billion per year.



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.

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>

Biometrics Abuse

Segregating Profiling



The screenshot shows the Hindustan Times website interface. At the top, the logo "hindustantimes" is on the left, and "Sign In" is on the right. Below the logo, the date "Saturday, Jan 11, 2020" and location "New Delhi 16°C" are displayed, along with a link to the "e-paper". A navigation bar includes "discover" and various categories like "india cities opinion world cricket entertainment election trending videos tech". A search bar is on the right. The main content area shows a breadcrumb trail: "Home / Bhopal / Linking benefits for AIDS patients to Aadhaar triggers privacy concerns". The article title "Linking benefits for AIDS patients to Aadhaar triggers privacy concerns" is prominently displayed. Below the title, a summary states: "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." At the bottom left of the article, a box labeled "BHOPAL" indicates the location, and a timestamp "Updated: Apr 03, 2017 12:34 IST" is shown.

hindustantimes Sign In
Saturday, Jan 11, 2020 | New Delhi 16°C | e-paper

discover india cities opinion world cricket entertainment election trending videos tech ... Search

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>

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

      341

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

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>

Biometrics Abuse

Compromised biometric data

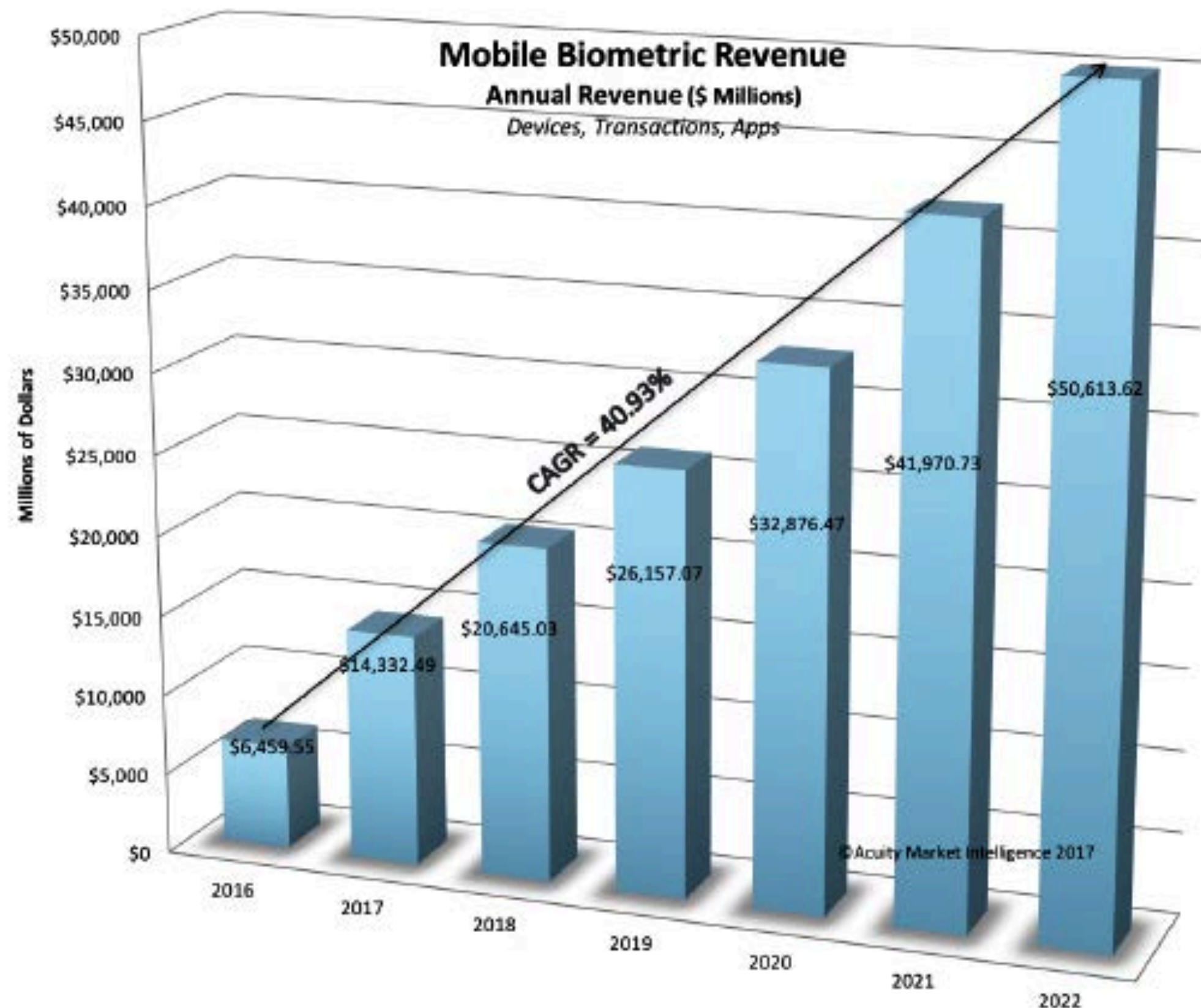
People cannot change their biometric data in response to a leak. Irreversible for whole lifetime.



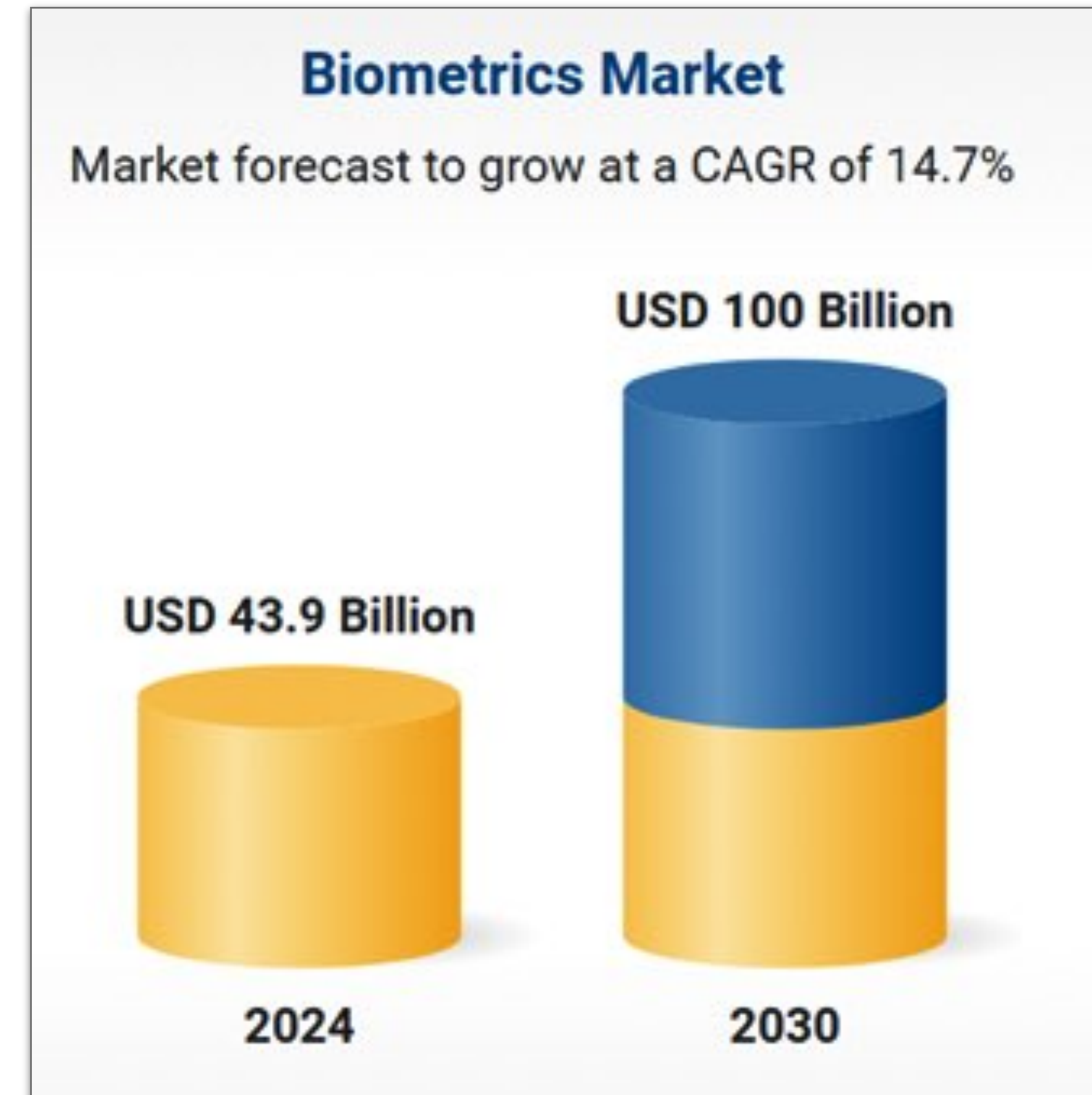
Please, don't.

Biometrics Appeal

2017 Forecast

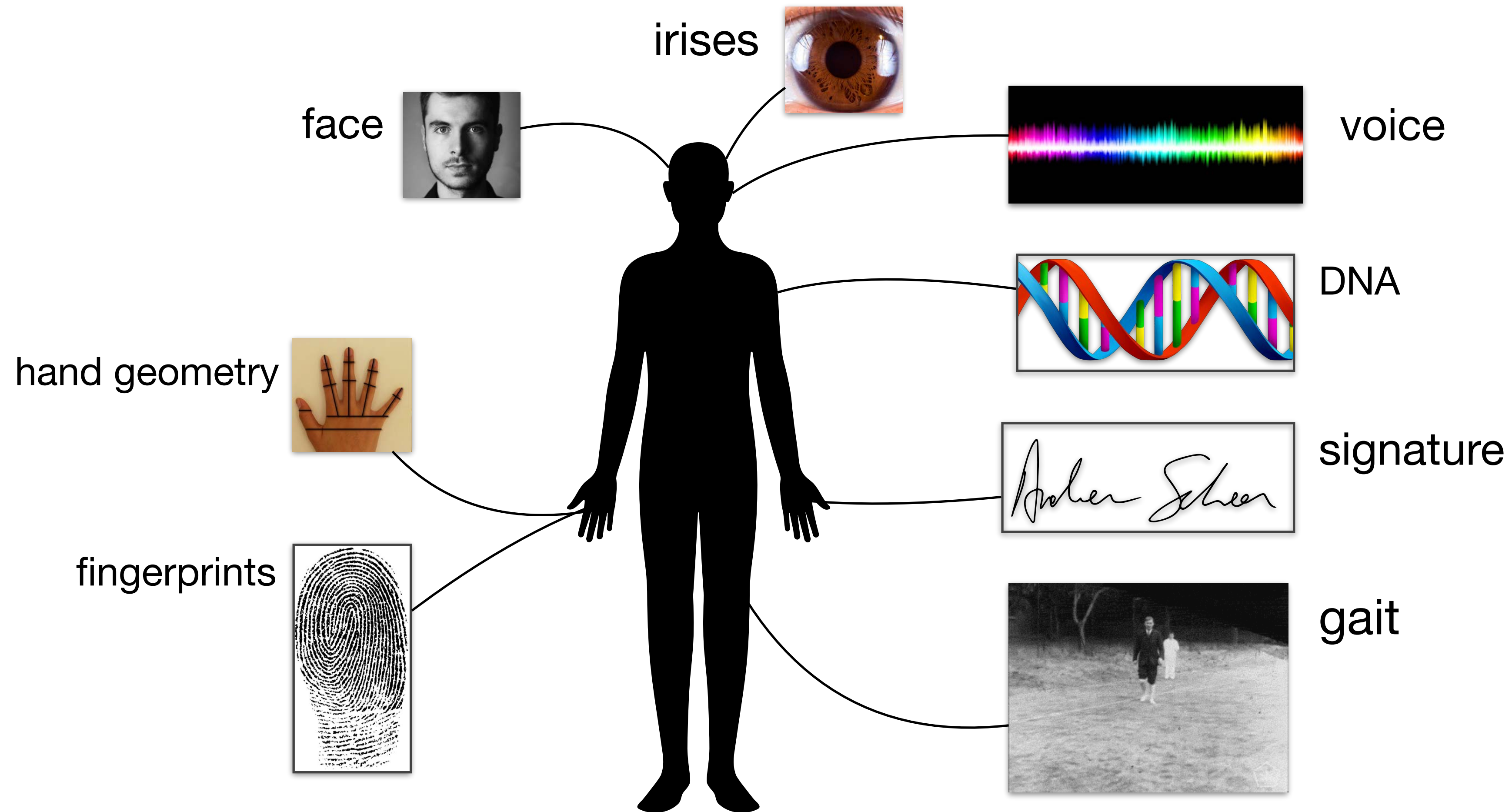


Source: acuitymi.com
CAGR: Compound Annual Growth Rate



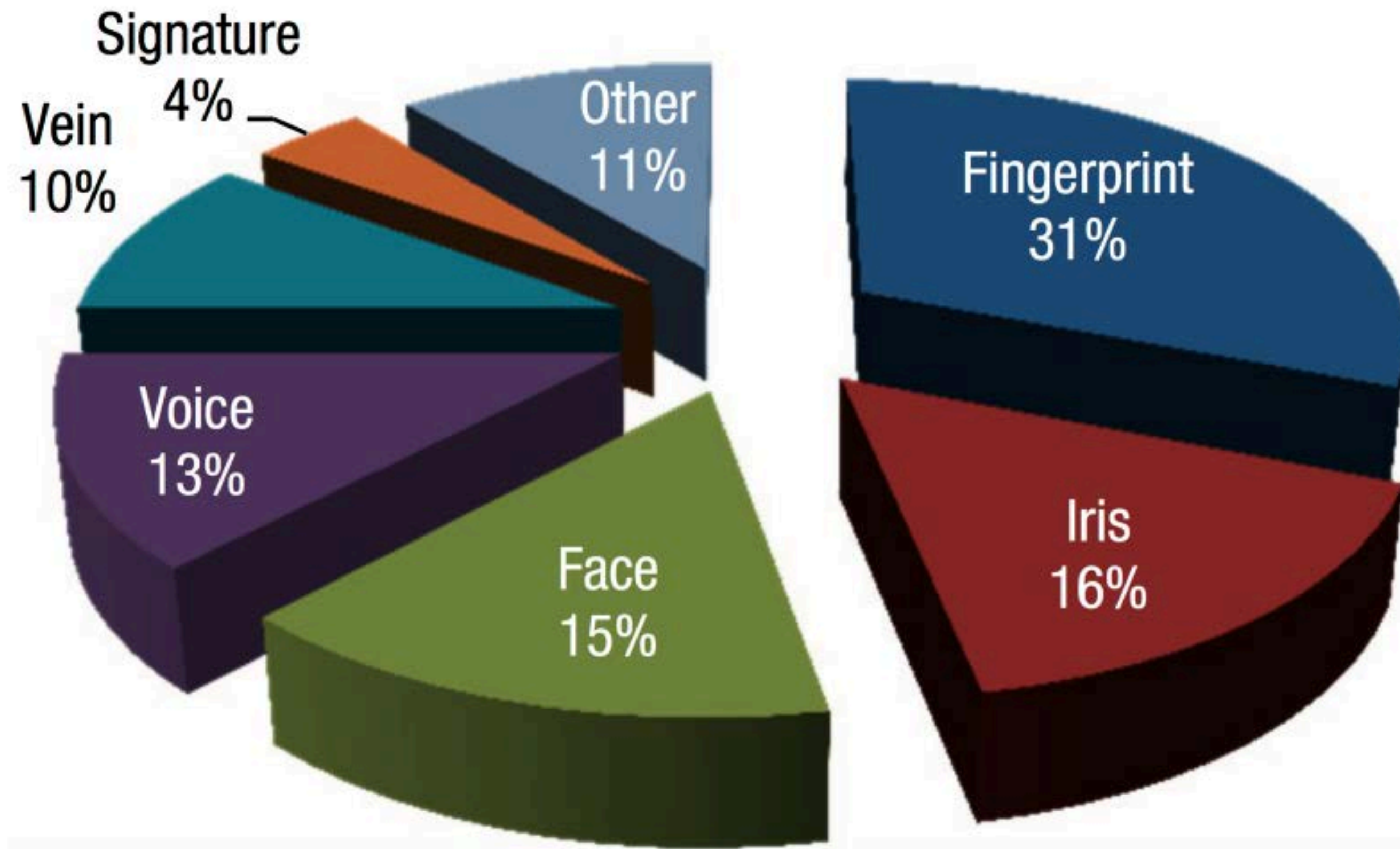
Source: researchandmarkets.com/reports/6064810/biometrics-global-market-overview

Biometric Traits



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)



Biometric Traits

What do we want to consider?

Some traits might be more suitable than others.

Universality (1/8)

Does everybody have the trait?



Biometric Traits

What do we want to consider?

Some traits might be more suitable than others.

Uniqueness (2/8)



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?



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?



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

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?



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

Biometric Traits

What do we want to consider?

Some traits might be more suitable than others.

Permanence (3/8)



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?



Biometric Traits

What do we want to consider?

Some traits might be more suitable than others.

Measurability (4/8)



Biometric Traits

What do we want to consider?

Some traits might be more suitable than others.

Measurability (4/8)

How convenient is it to acquire and digitize the trait?



Biometric Traits

What do we want to consider?

Some traits might be more suitable than others.

Acceptability (5/8)



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?



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>

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?



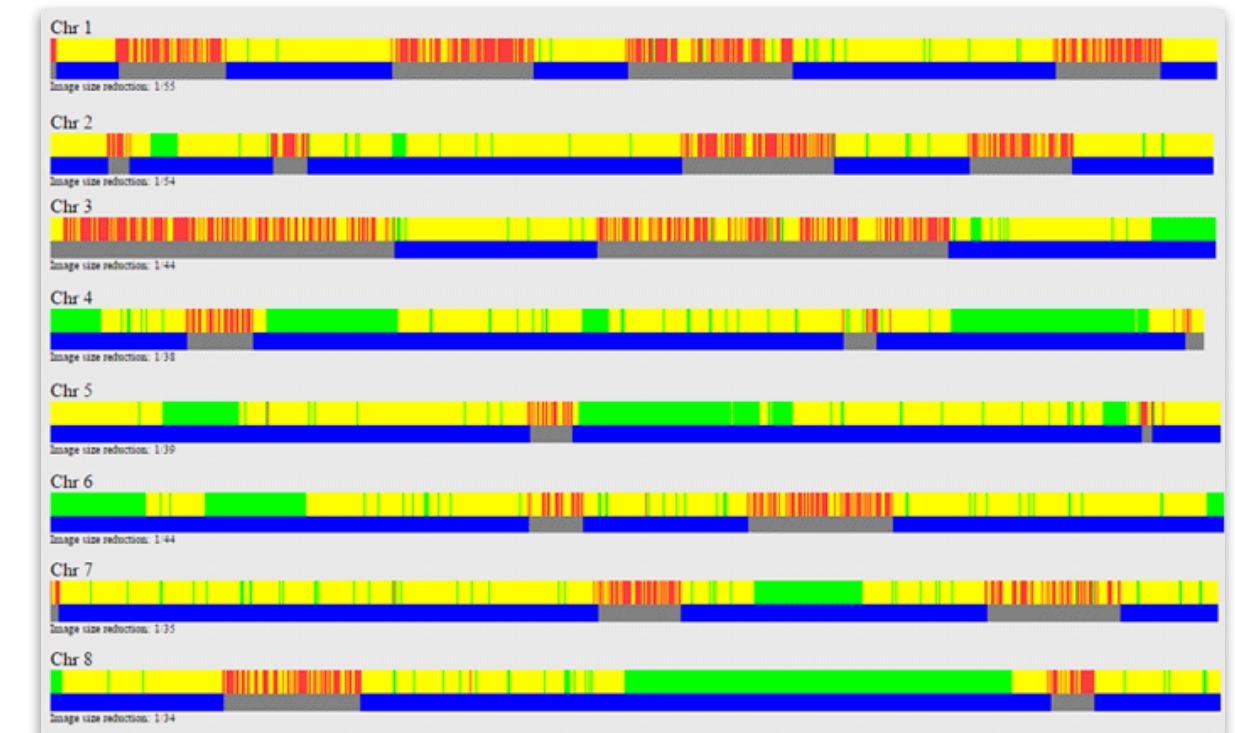
<https://www.youtube.com/watch?v=SIII8L43nng>

Biometric Traits

What do we want to consider?

Some traits might be more suitable than others.

Explainability (7/8)



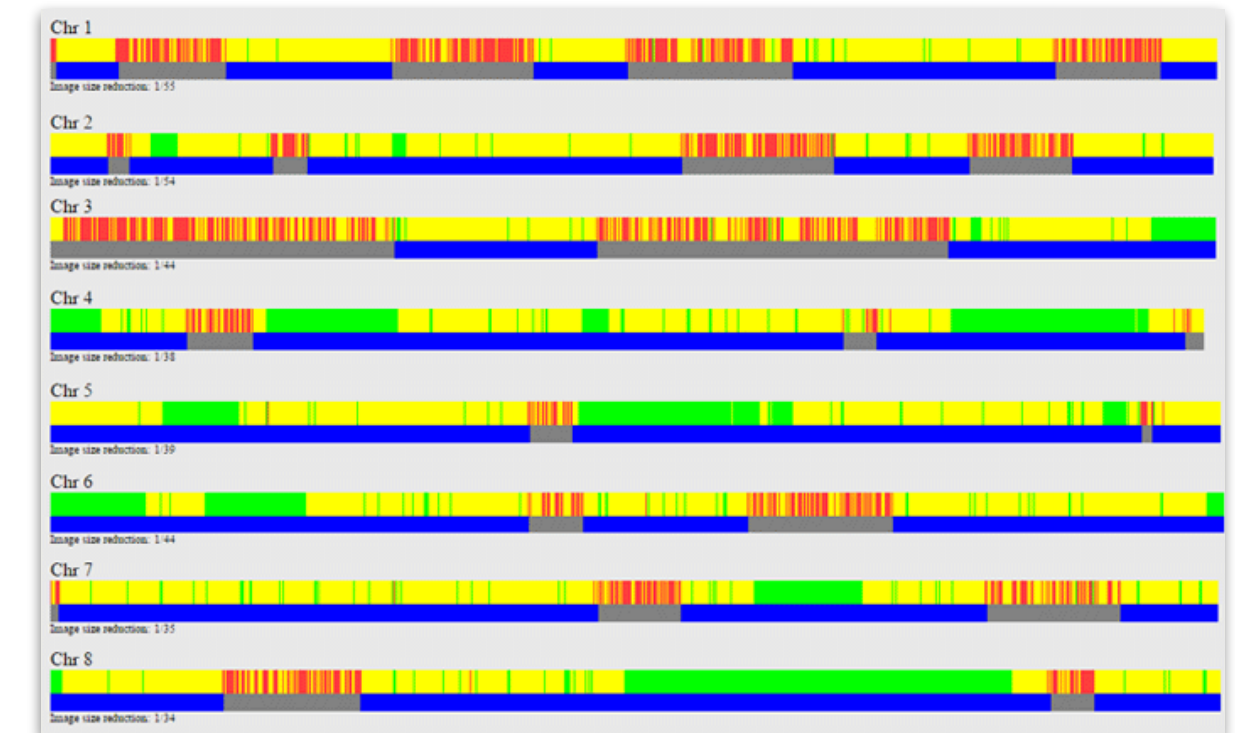
Biometric Traits

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?

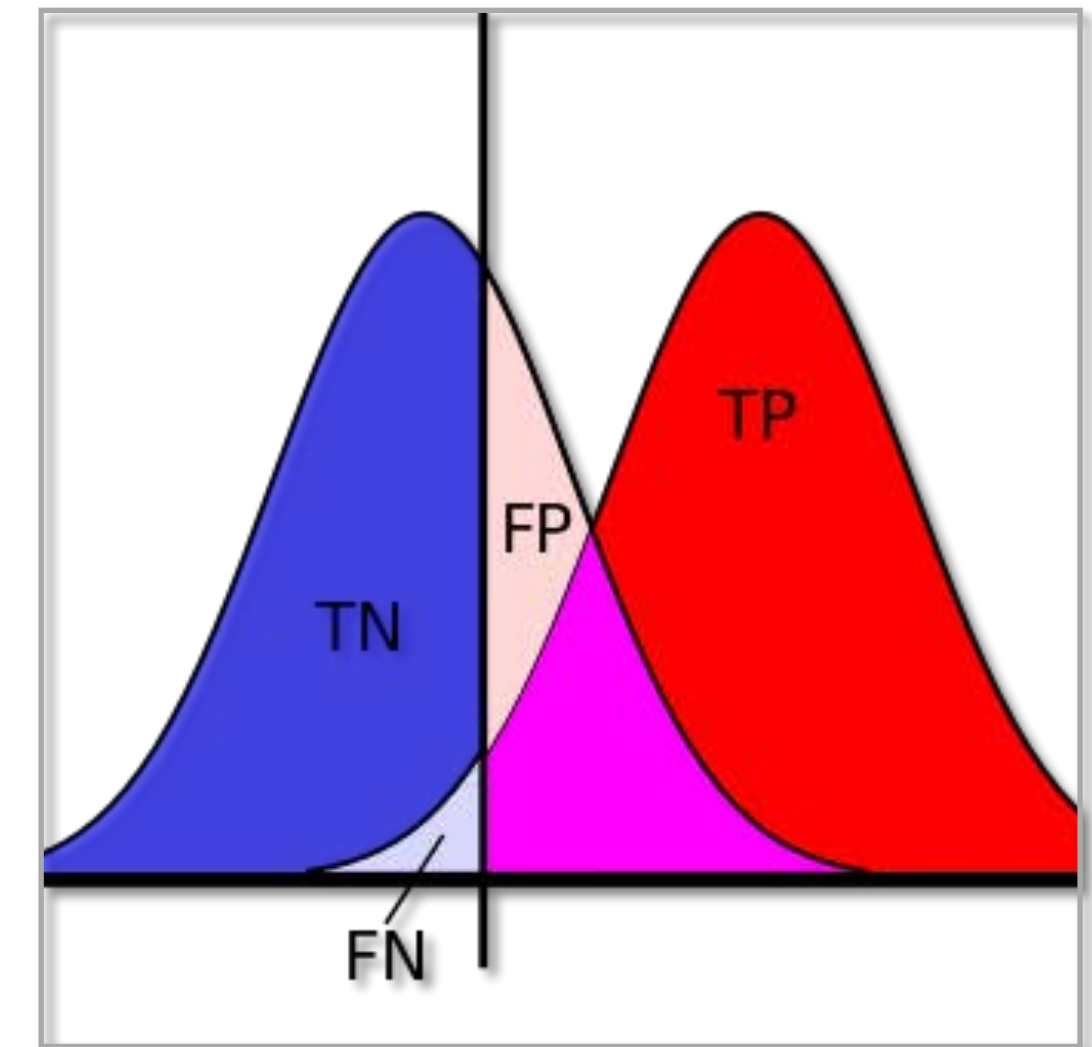


Biometric Traits

What do we want to consider?

Some traits might be more suitable than others.

Performance (8/8)



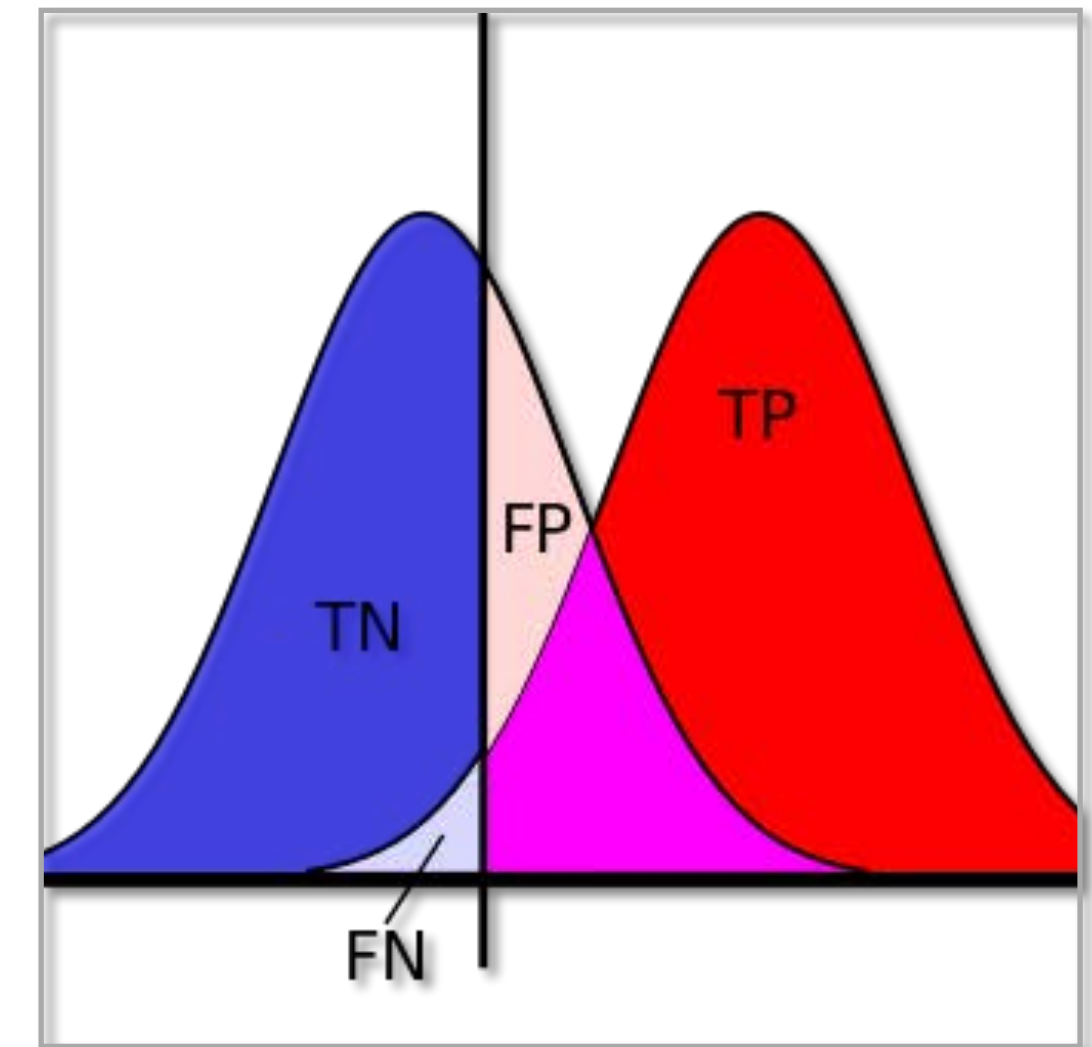
Biometric Traits

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)



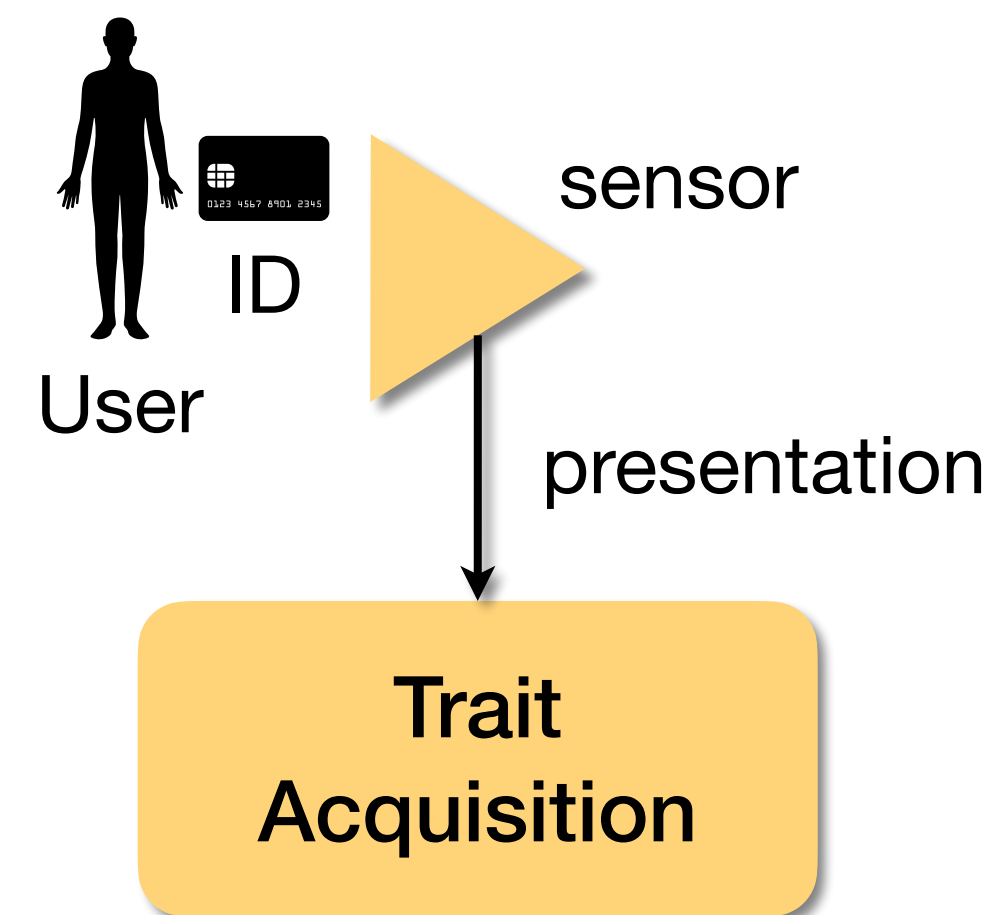
Activity

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



Biometric Systems

Enrollment



Trait Acquisition

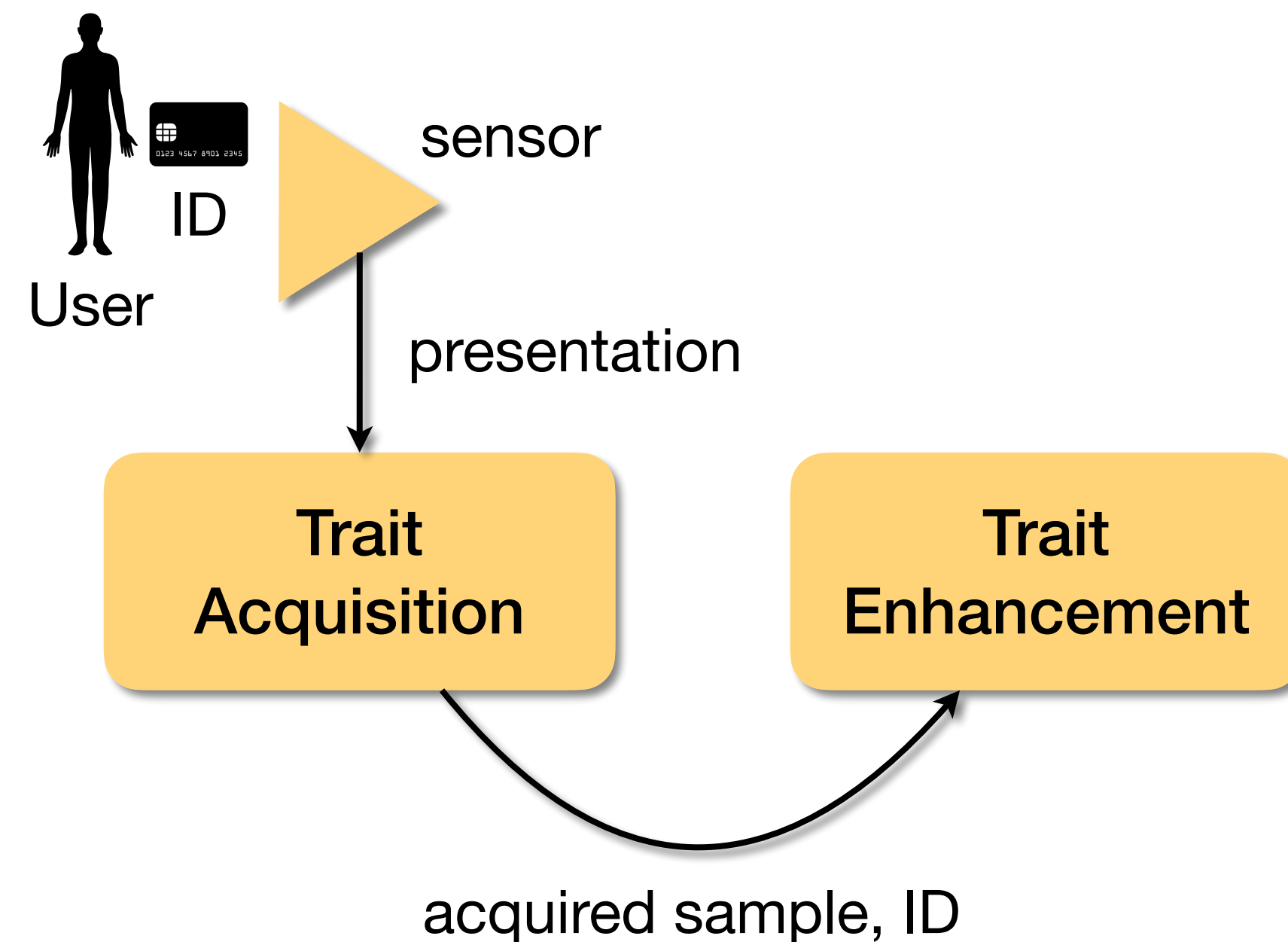
We'll have data-collection classes.
We'll use real-world sensors.

What to observe?

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

Biometric Systems

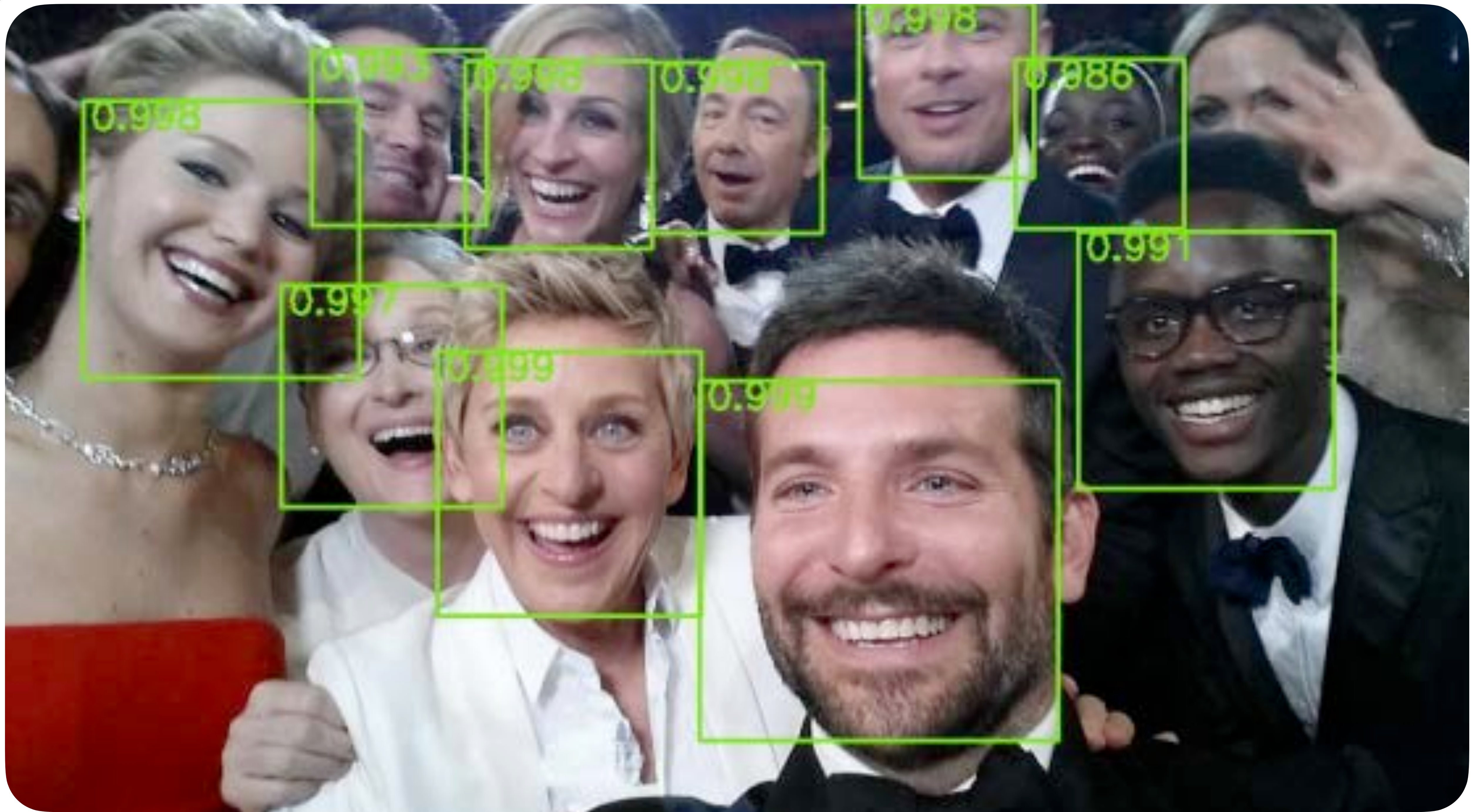
Enrollment



Trait Enhancement

Noise removal.

Operations to keep only **essential** information (consider universality, uniqueness, permanence, circumvention, and performance).



0.998

0.995

0.998

0.998

0.998

0.986

0.997

0.999

0.999

0.991

Load irises Load examination Save examination Save report Quit program

Brightness

-1.0 0.0 1.0

Contrast

0.0 1.0 2.0

Sharpening

0.0 0.0 10.0

Segment iris

Brightness

-1.0 0.0 1.0

Contrast

0.0 1.0 2.0

Sharpening

0.0 0.0 10.0

Segment iris

1.0 3.0 1.0 3.0

1.0 1.0 1x 1.0 3.0

Human-Interpretable Features

☒ TSHEPII	☐ Show Matched	- 0 + out of 0	☒ MSER	☐ Show Matched	- 0 + out of 0
	☐ Show Unmatched	- 1 + out of 0		☐ Show Unmatched	- 1 + out of 0
☒ SURF	☐ Show Matched	- 0 + out of 0	☒ SIFT	☐ Show Matched	- 0 + out of 0
	☐ Show Unmatched	- 1 + out of 0		☐ Show Unmatched	- 1 + out of 0
☒ Crypts	☐ Show Matched	- 0 + 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

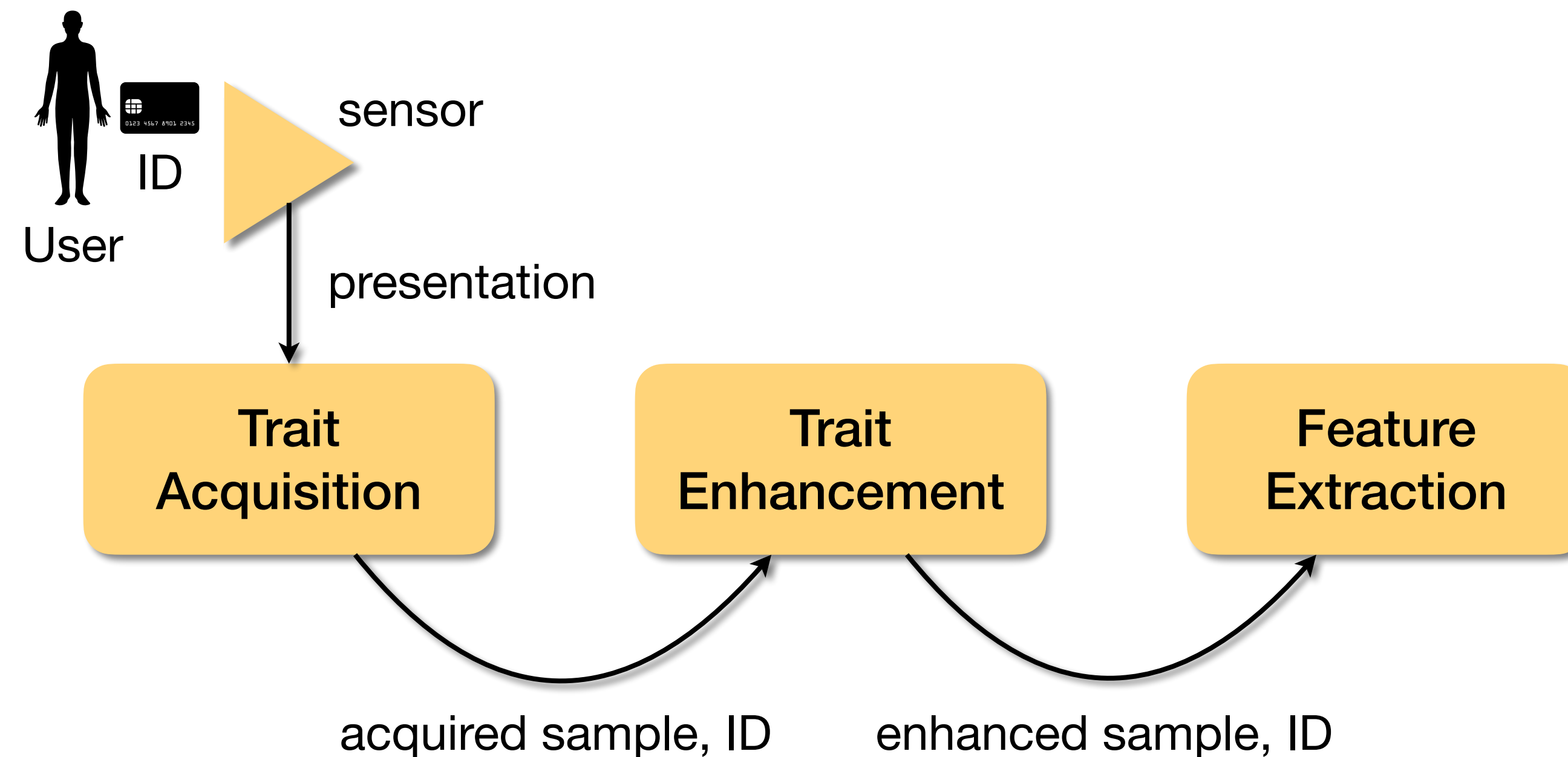
Gabor Filters thr: 0.4461

BSIF Filters thr: 0.4216

Global match score

Biometric Systems

Enrollment Modules



Feature Extraction

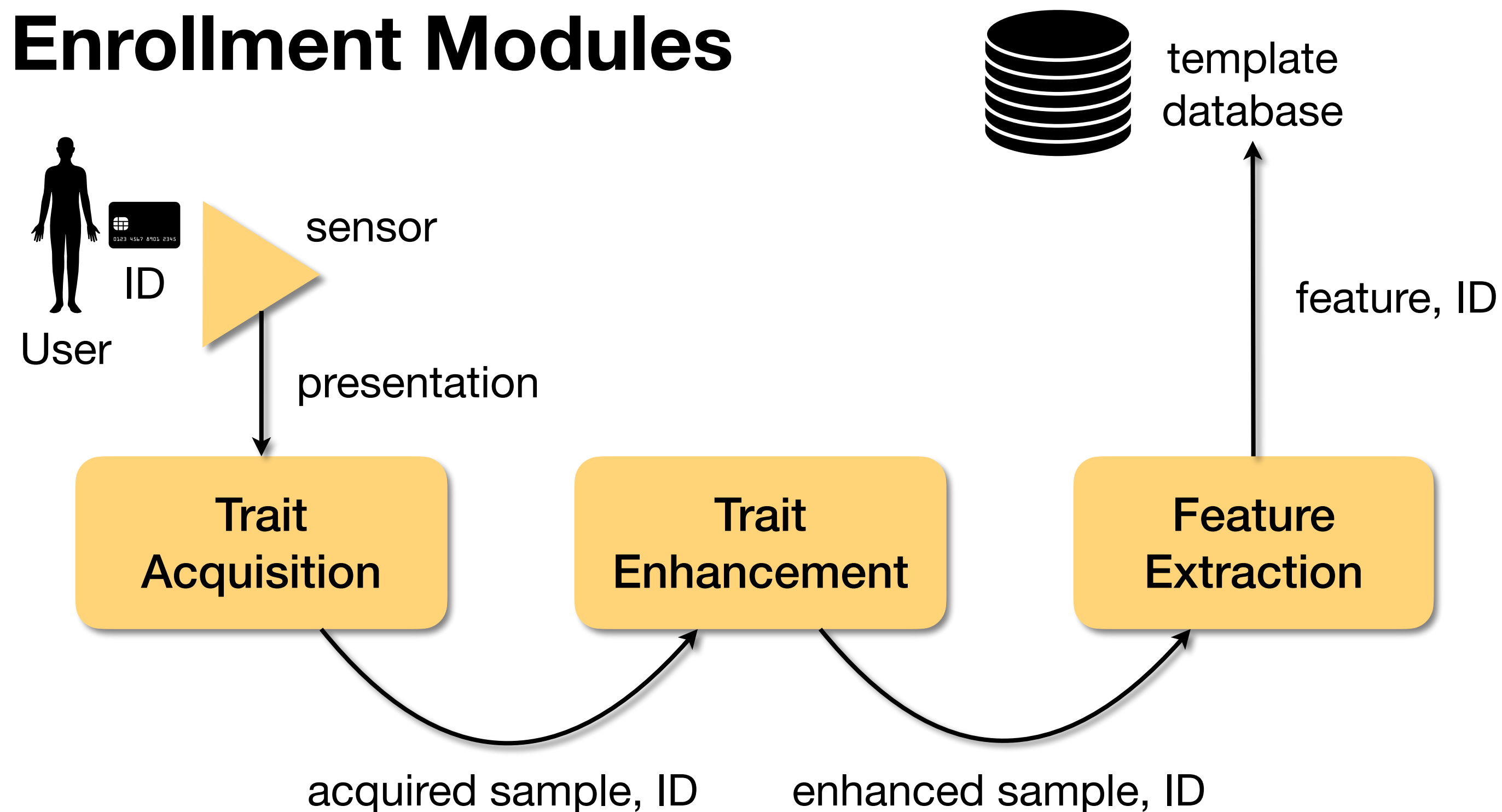
Compact but expressive digital representation of the trait.

Types

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

Biometric Systems

Enrollment Modules

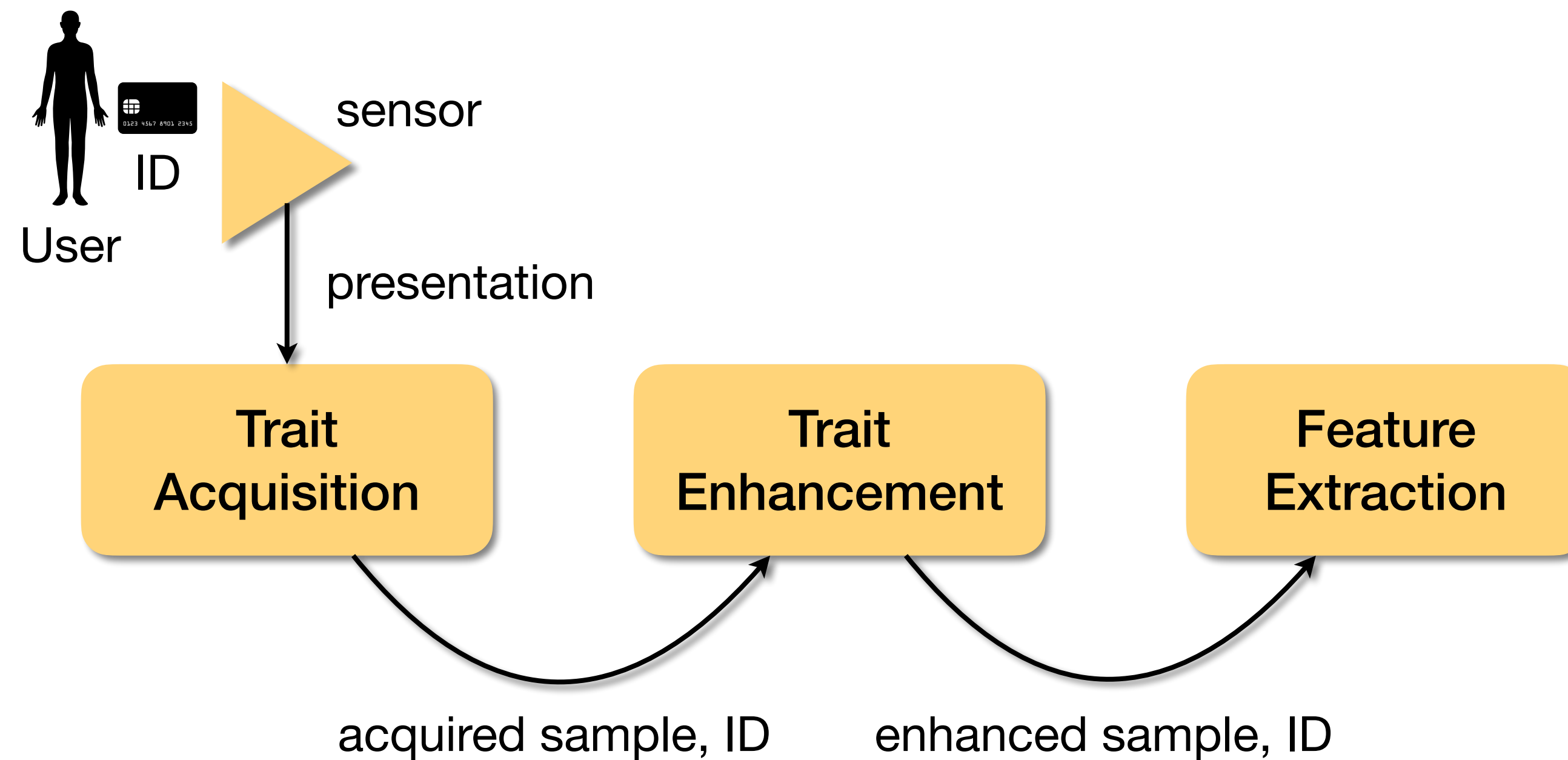


Template Database

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

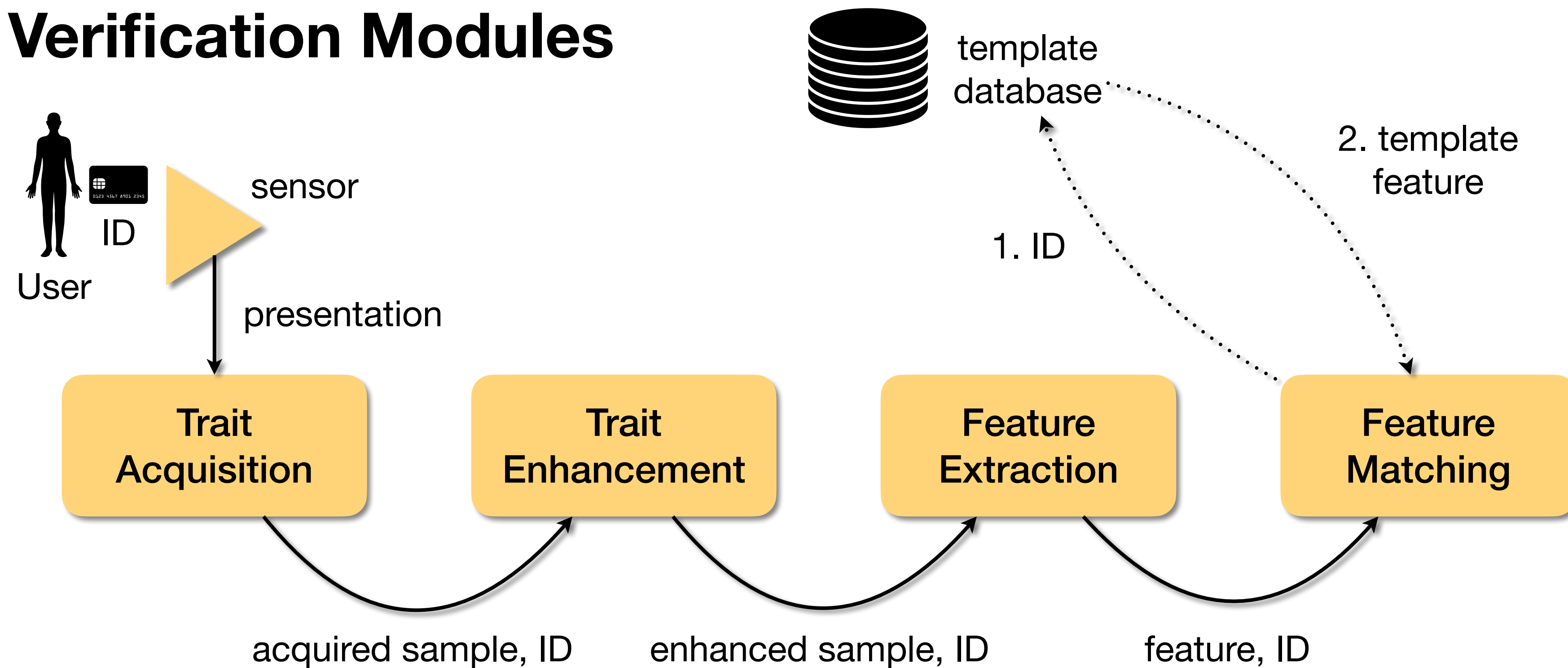
Biometric Systems

Verification Modules



Biometric Systems

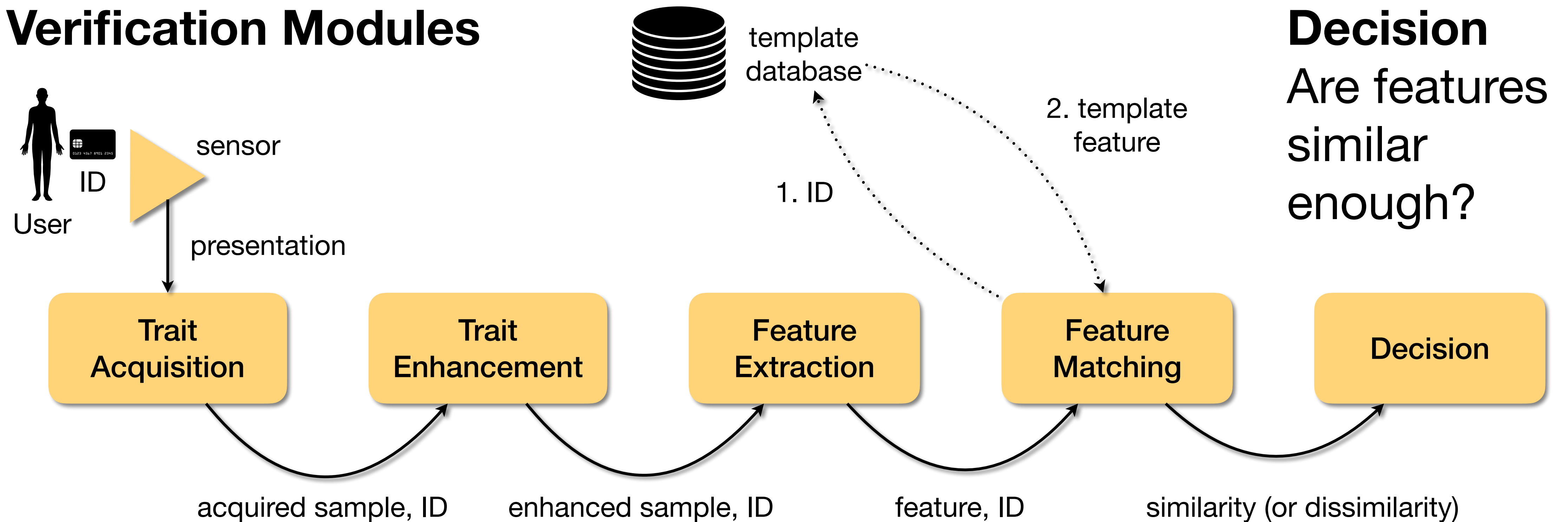
Verification Modules



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

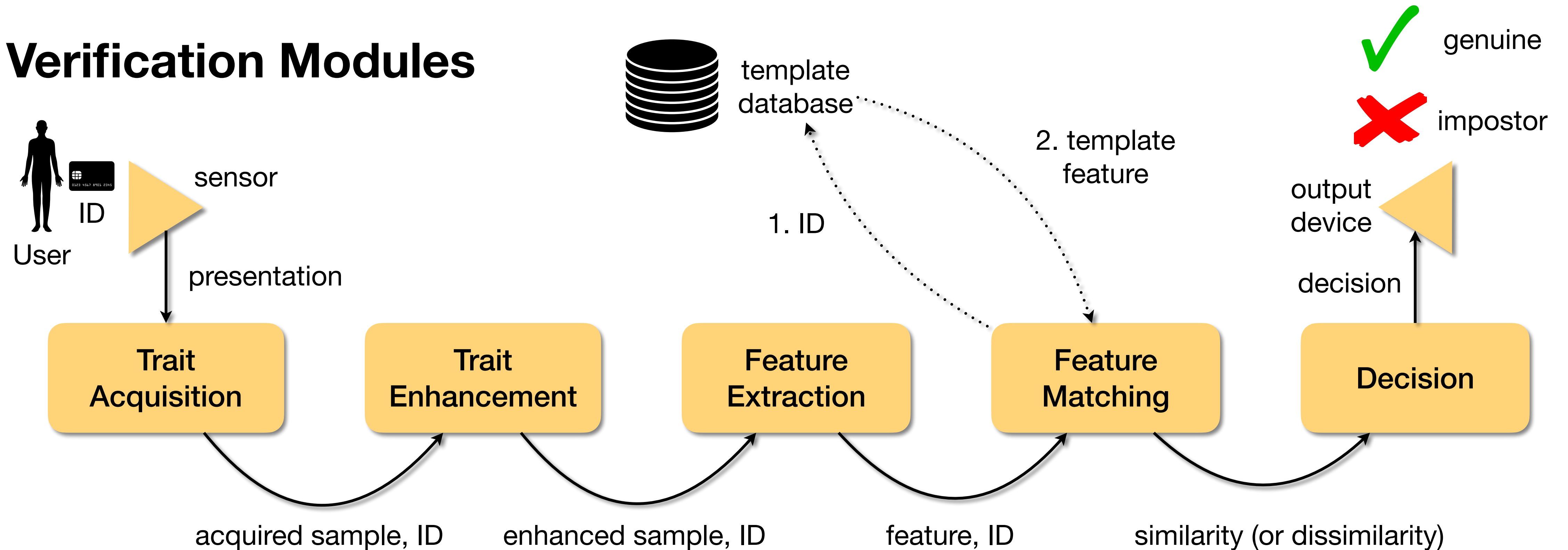
Biometric Systems

Verification Modules



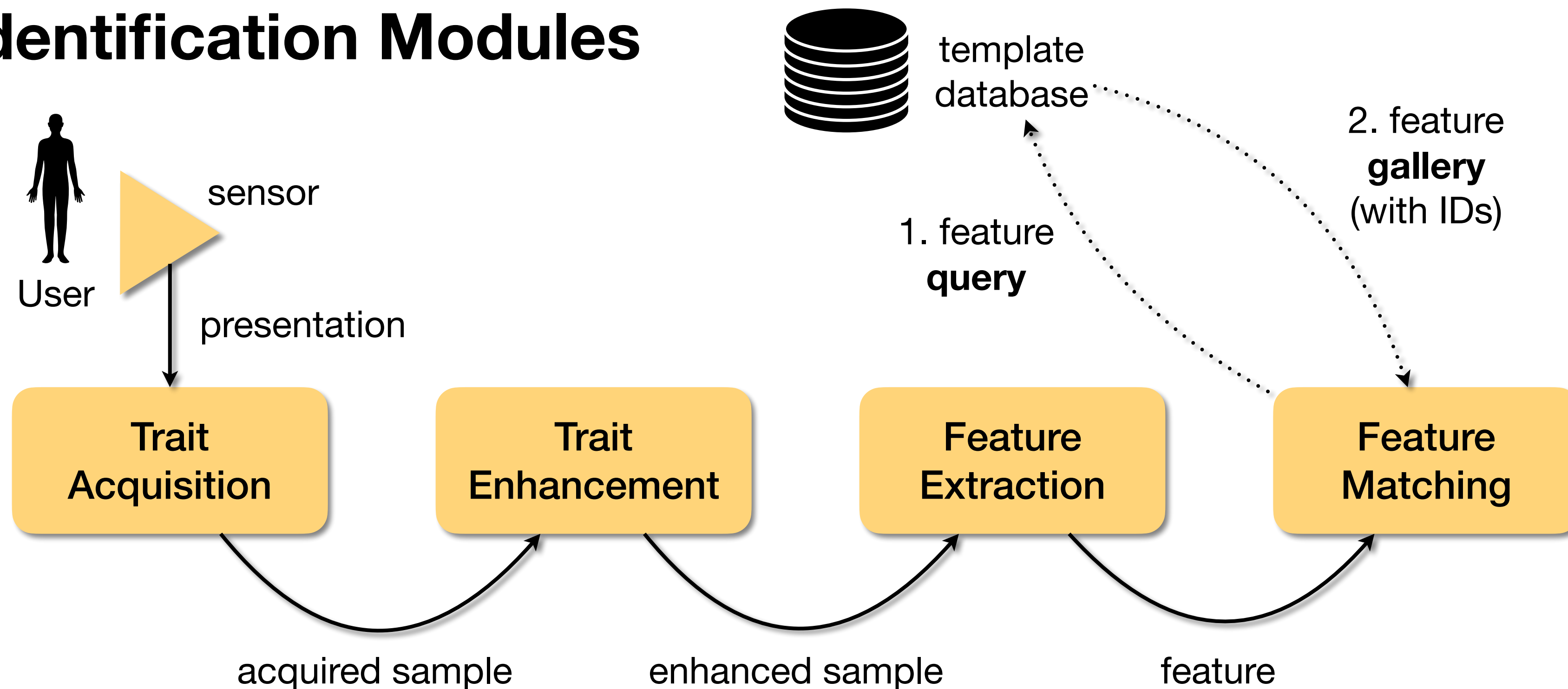
Biometric Systems

Verification Modules



Biometric Systems

Identification Modules



Gallery
Closest
template
features to
query.

Biometric Systems

Query and Gallery Example



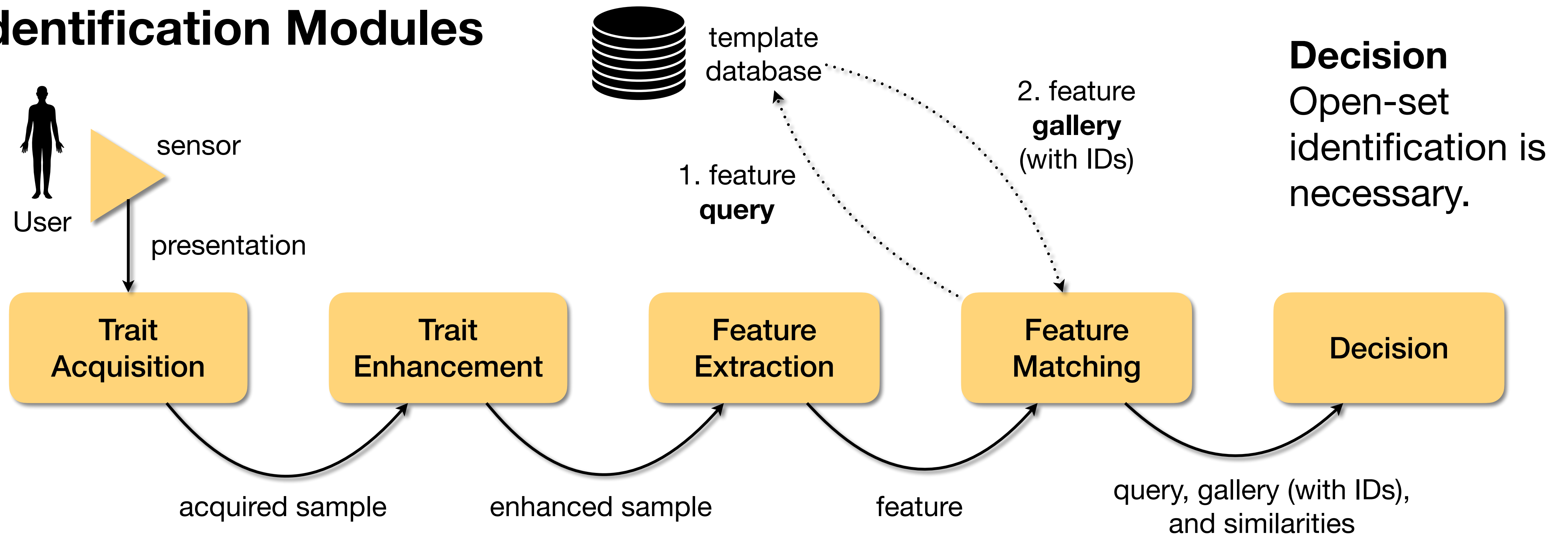
query



gallery

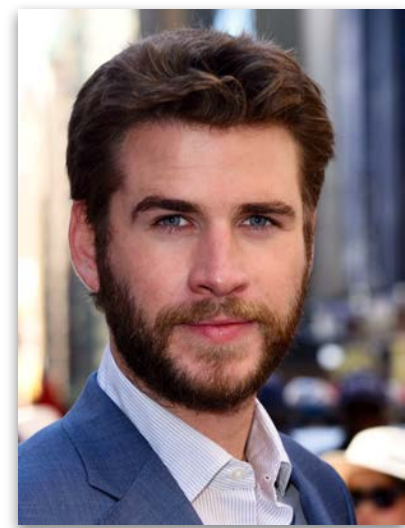
Biometric Systems

Identification Modules



Biometric Systems

Open-set vs. Closed-set Identification



Query
(Liam Hemsworth)

Dataset



Robert
Downey Jr.



Scarlet
Johansson



Chris
Evans



Mark
Ruffalo

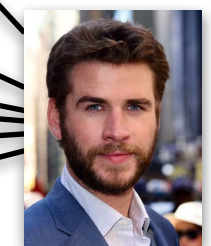


Chris
Hemsworth



Jeremy
Renner

Feature Space



Closed Set

Output
This is
Chris Hemsworth!



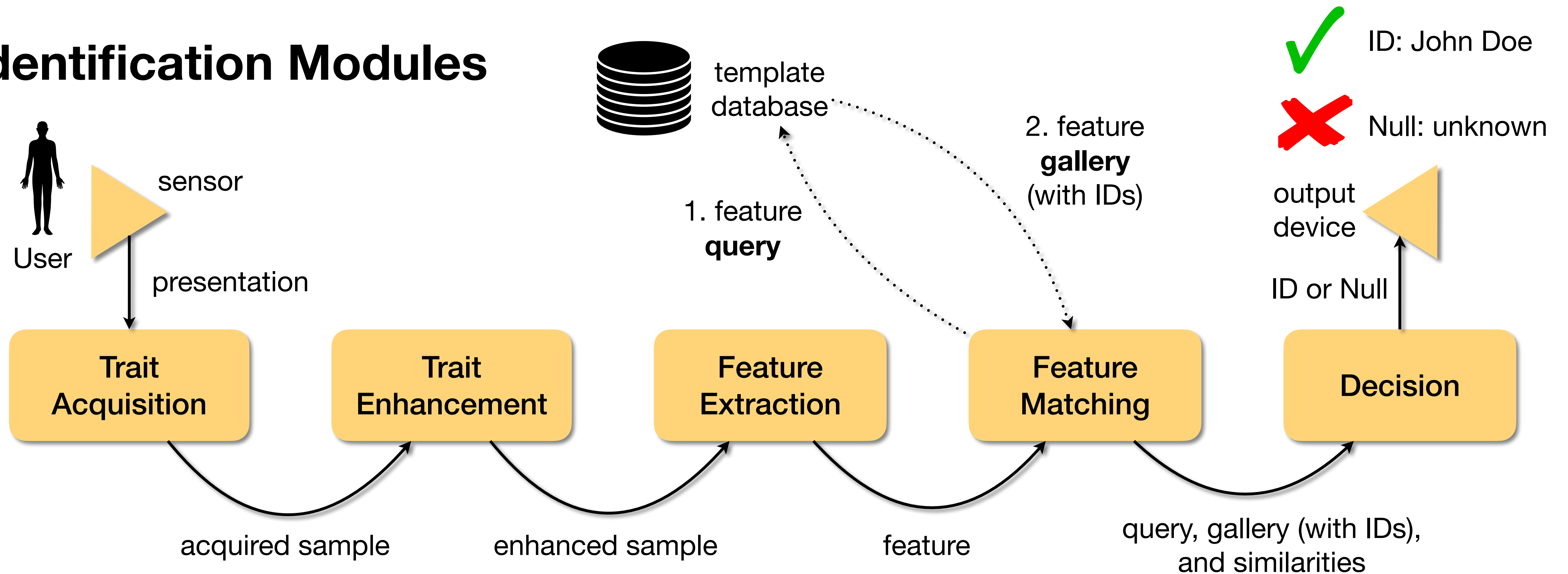
Open Set

Output
I don't know
this person!



Biometric Systems

Identification Modules



What's Next?

Relax

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

Please visit sakai.luc.edu/x/BCJs8K.

