

Basics I

COMP 388-002/488-002 Biometrics

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Fall 2025



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Today we will...

Discuss

What Biometrics is

Reasons to use Biometrics

Biometric traits

Biometric system modules

Today's Attendance

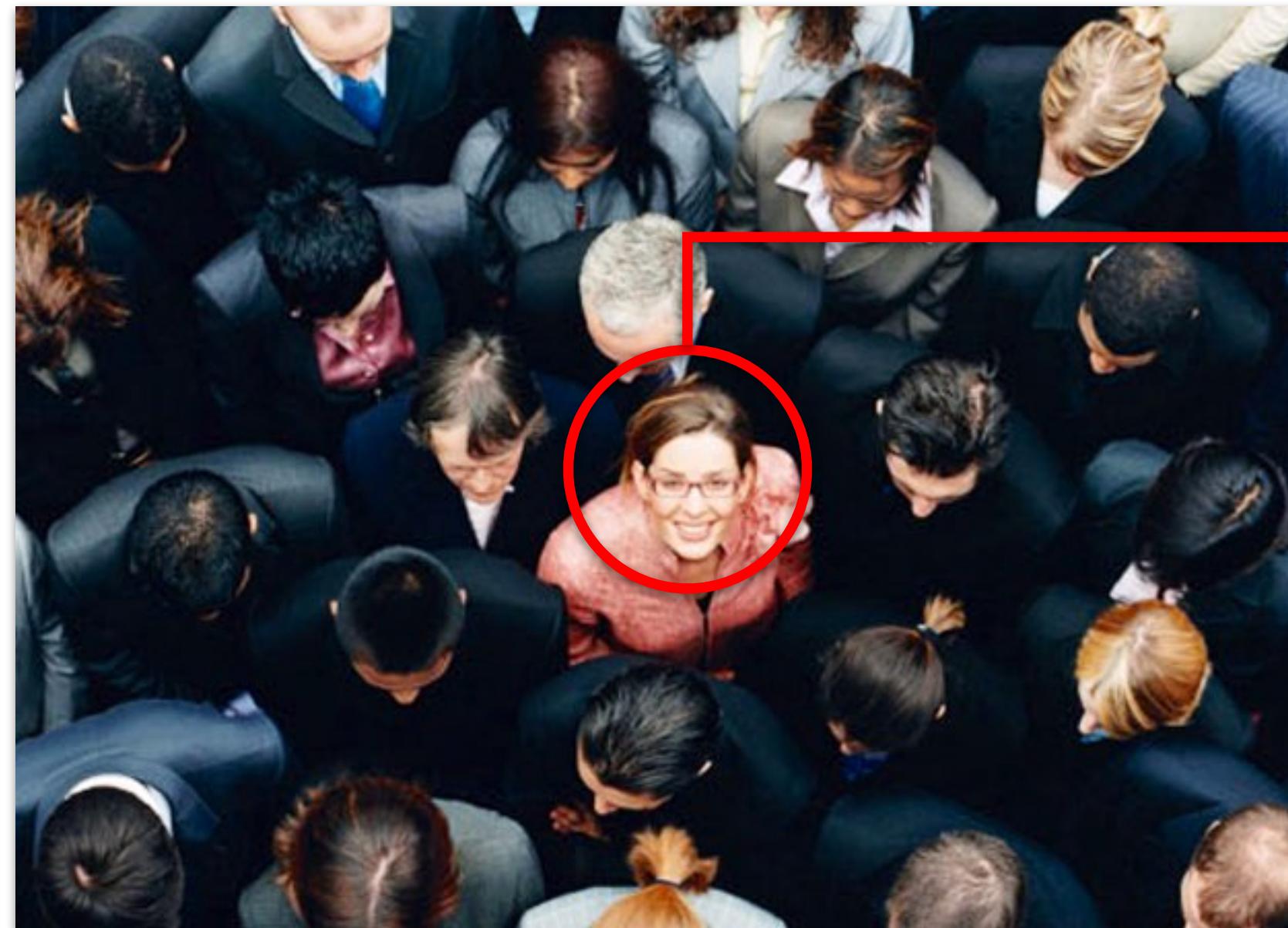
Please fill out the form

forms.gle/R9S6J4QaQntLHupU8



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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?



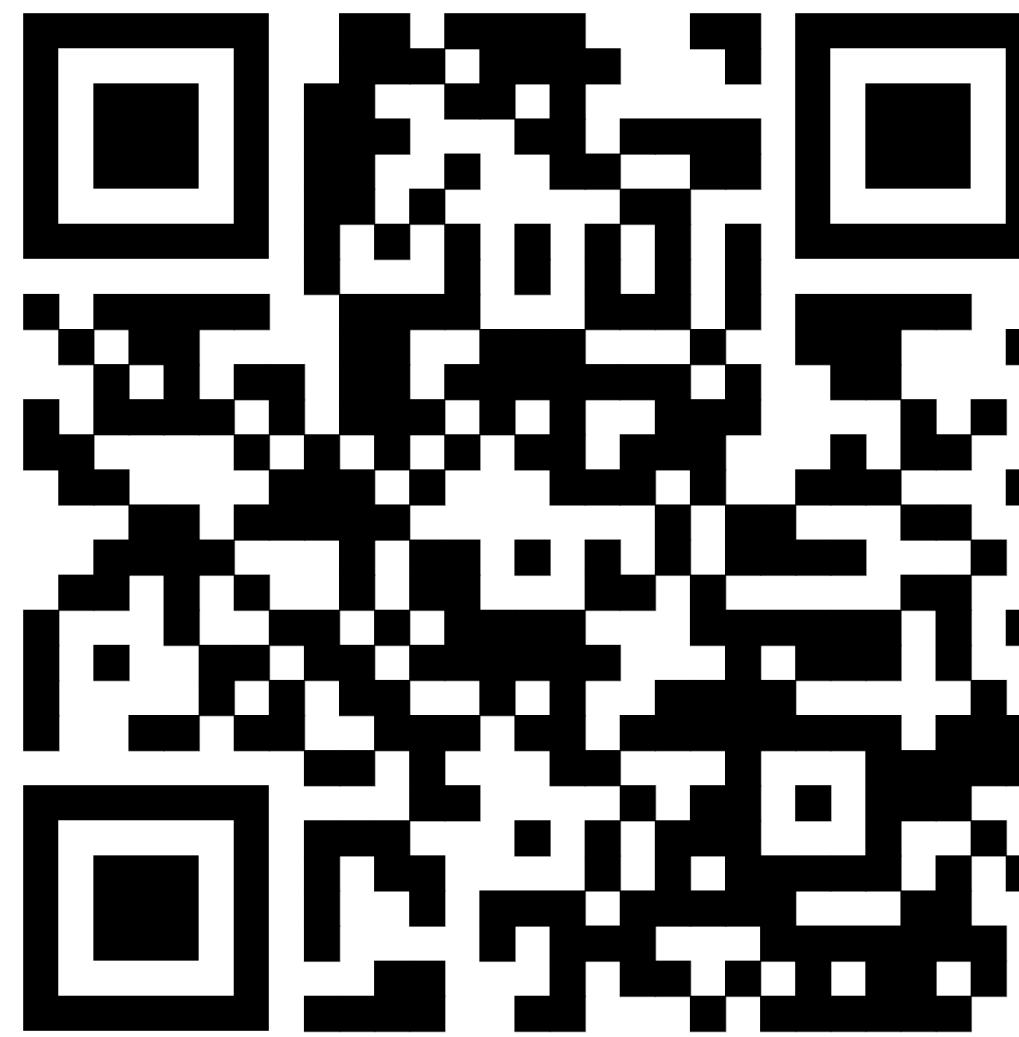
In this course, we aim at
computer-aided Biometrics.

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

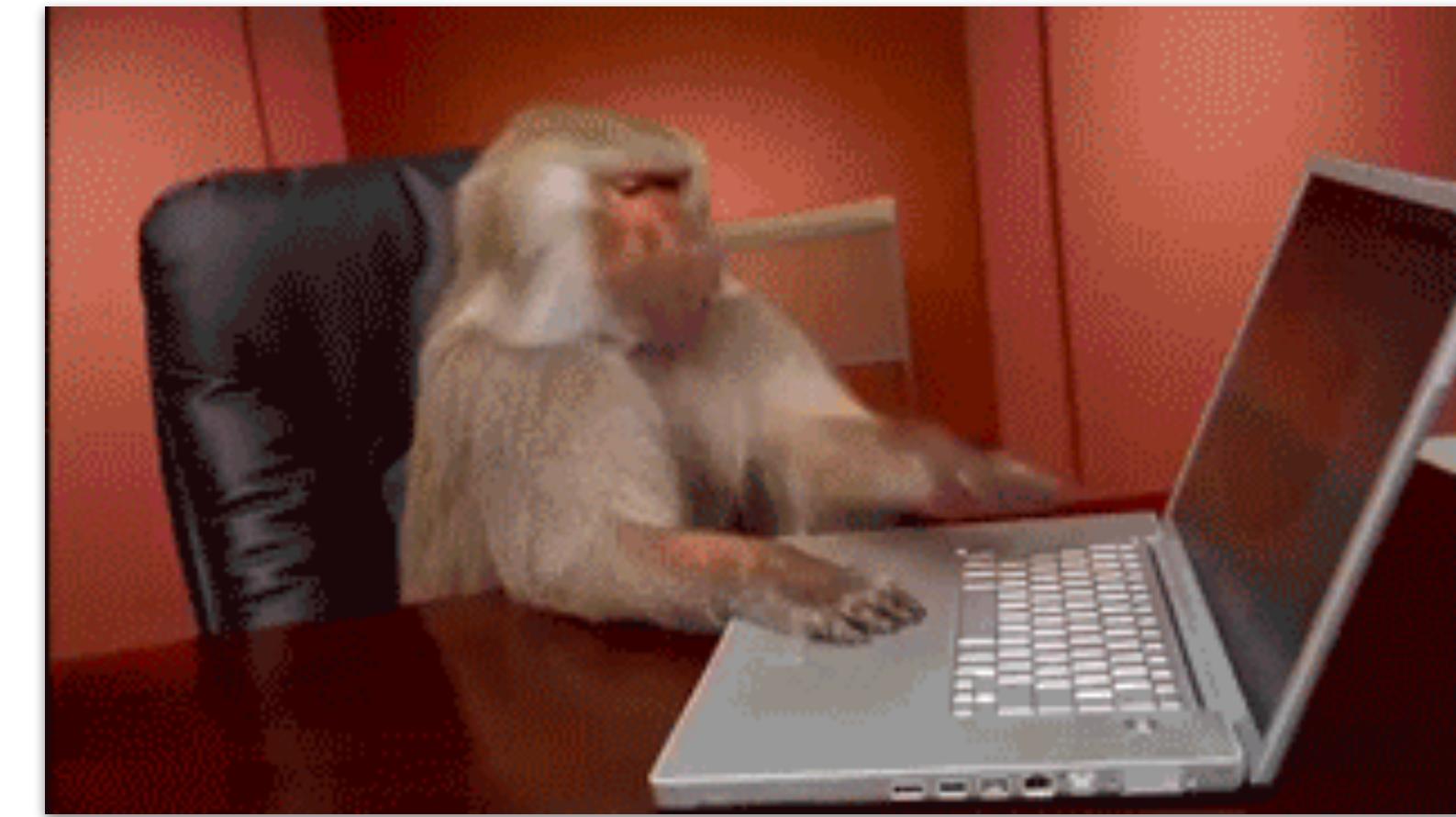
But we'll get to use some
devices, I promise.

What is Biometrics?

Why computers?



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



What is Biometrics?

Why computers?

- High throughput
- Repeatability
- Predictability
- Accountability

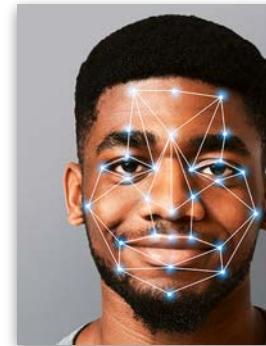


What is Biometrics?

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/

Why use Biometrics?

Biometrics is safer
But not absolutely safe!

The screenshot shows the BBC News homepage with a red banner at the top. The BBC logo is in the top left, followed by a 'Sign in' button. Below the banner, the word 'NEWS' is prominently displayed. A navigation bar below the banner includes links for Home, Video, World, US & Canada, UK, Business, Tech, Science, Stories, and Entertainment. Under the 'World' section, links for Africa, Asia, Australia, Europe, Latin America, and Middle East are shown. The main headline in the center reads 'Doctor 'used silicone fingers' to sign in for colleagues'. Below the headline is a timestamp '12 March 2013' and social sharing icons for Facebook, Twitter, and Email.

<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!

= WIRED

SUBSCRIBE



Experience that new-car feeling.

ANDY GREENBERG SECURITY 11.14.2017 07:00 AM

Watch a 10-Year-Old's Face Unlock His Mom's iPhone X

Yes, twins can unlock each other's iPhones. But kids accessing their parents' devices raises different concerns.



<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.

The New York Times

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

By David Stout

Nov. 17, 2004

f t e-mail share bookmark

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



latent
fingerprint

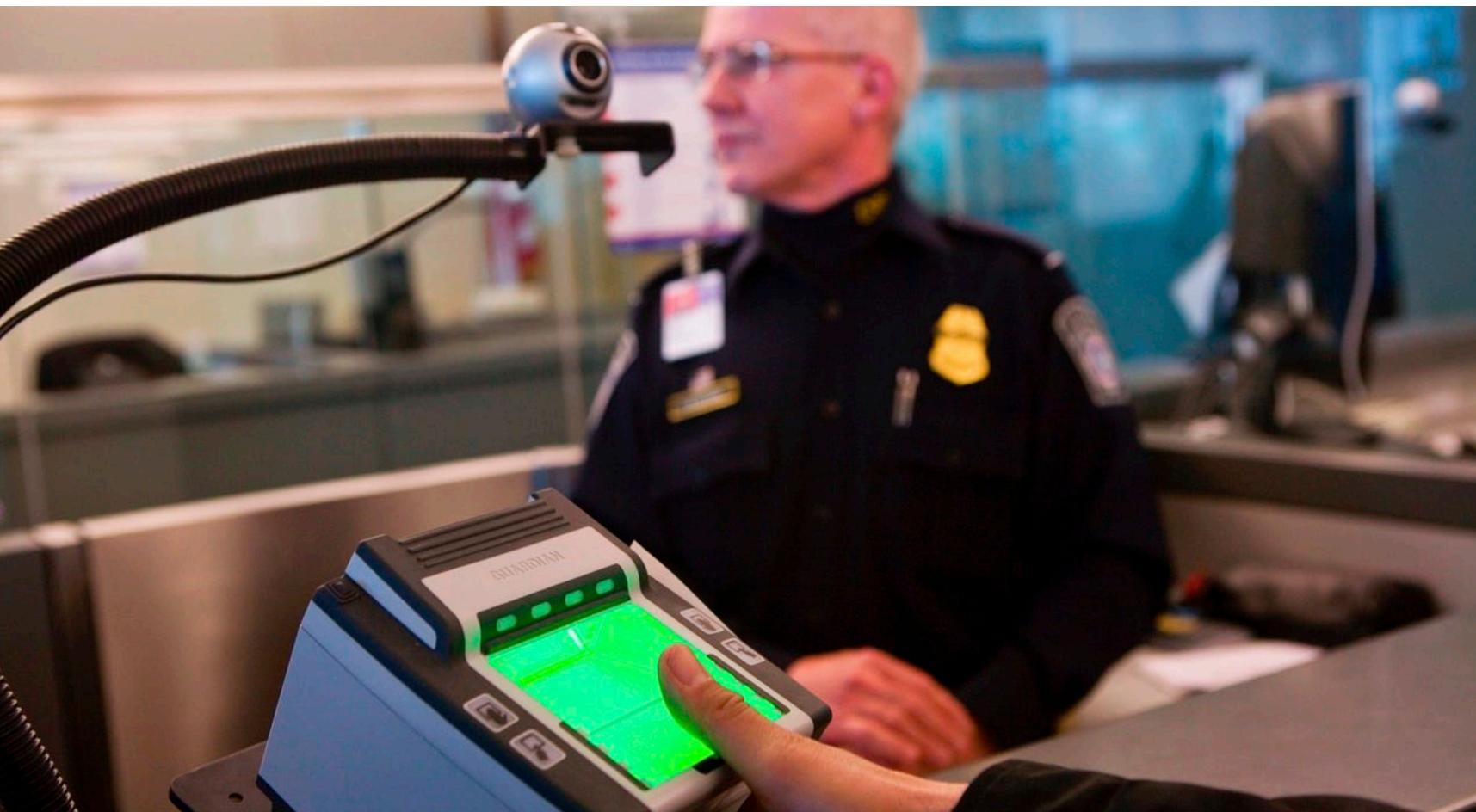


collected
fingerprint

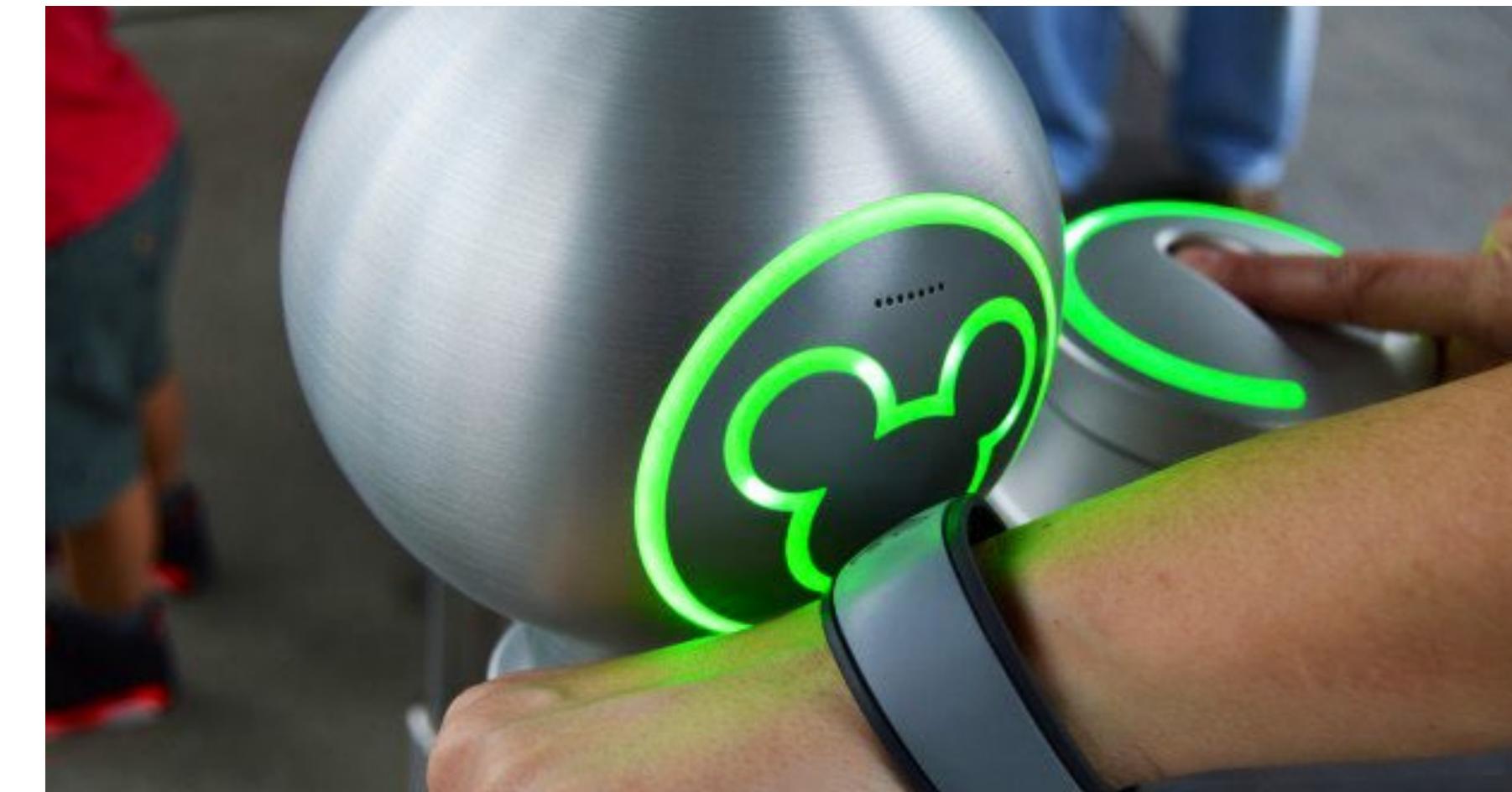
WASHINGTON, Nov. 16 - The Federal Bureau of Investigation wrongly implicated an Oregon lawyer in a deadly train bombing in Madrid because the F.B.I. culture discouraged fingerprint examiners from disagreeing with their superiors, a panel of forensic experts has concluded.

Biometrics Use

Biometrics is a reality



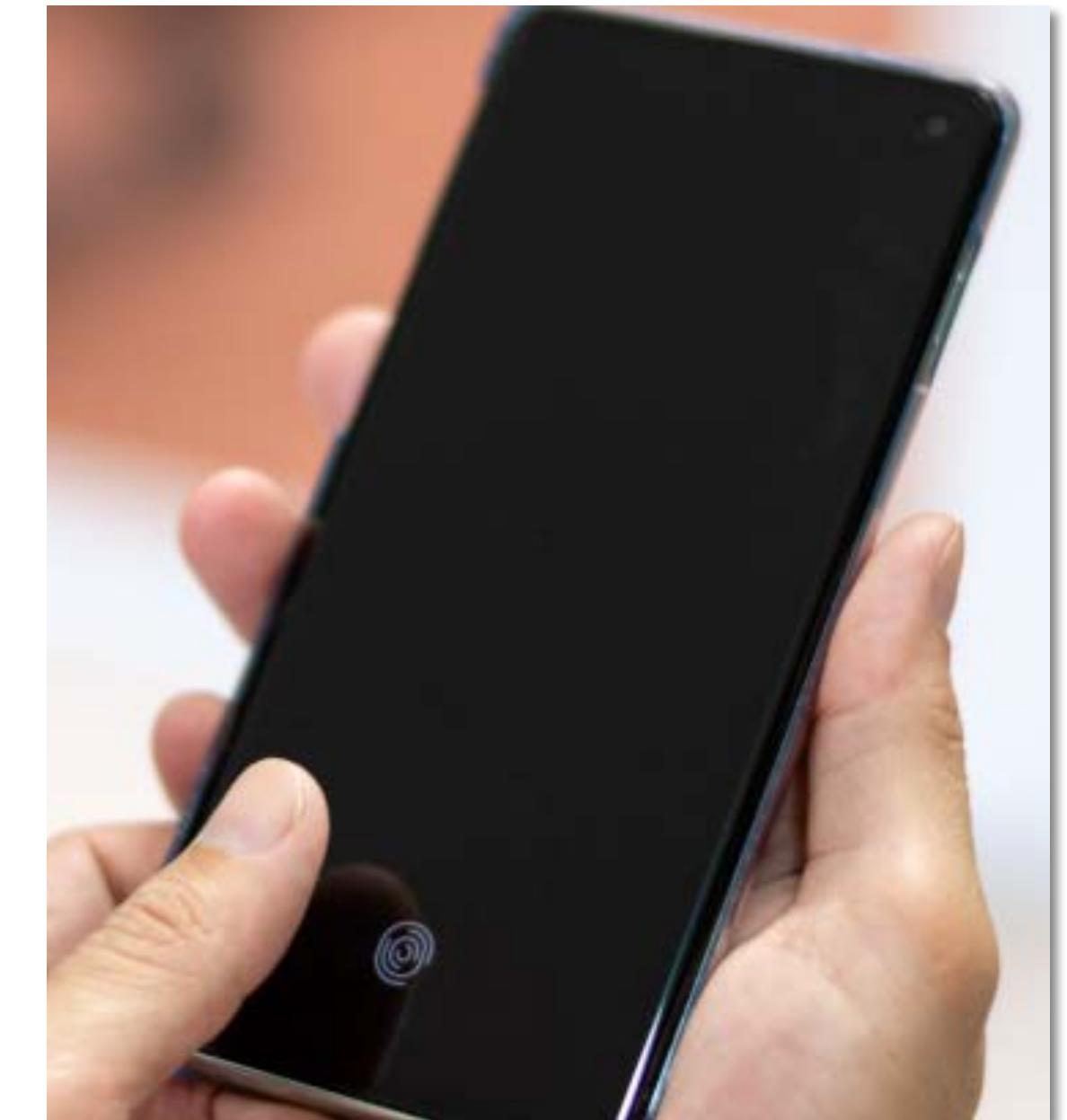
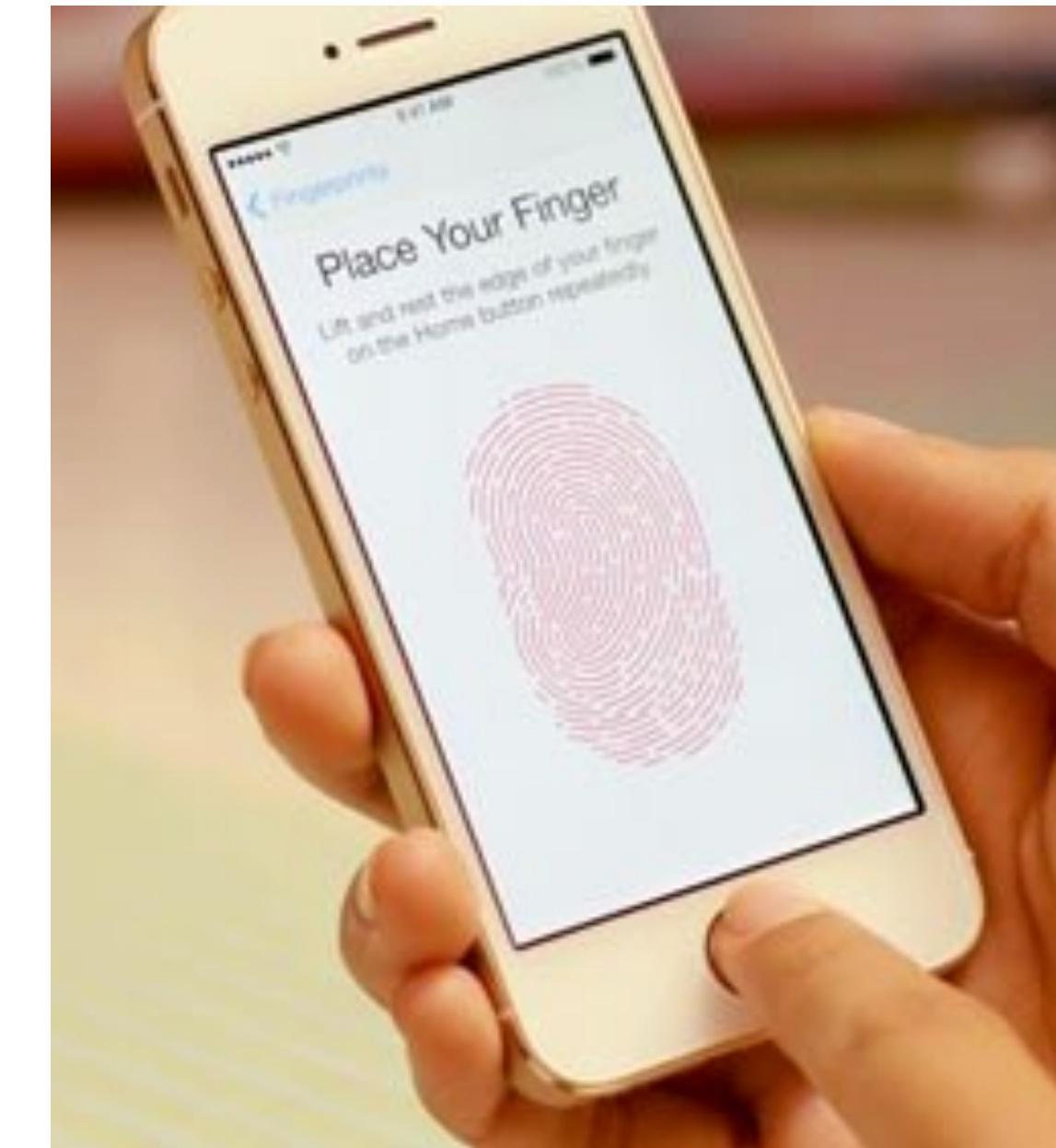
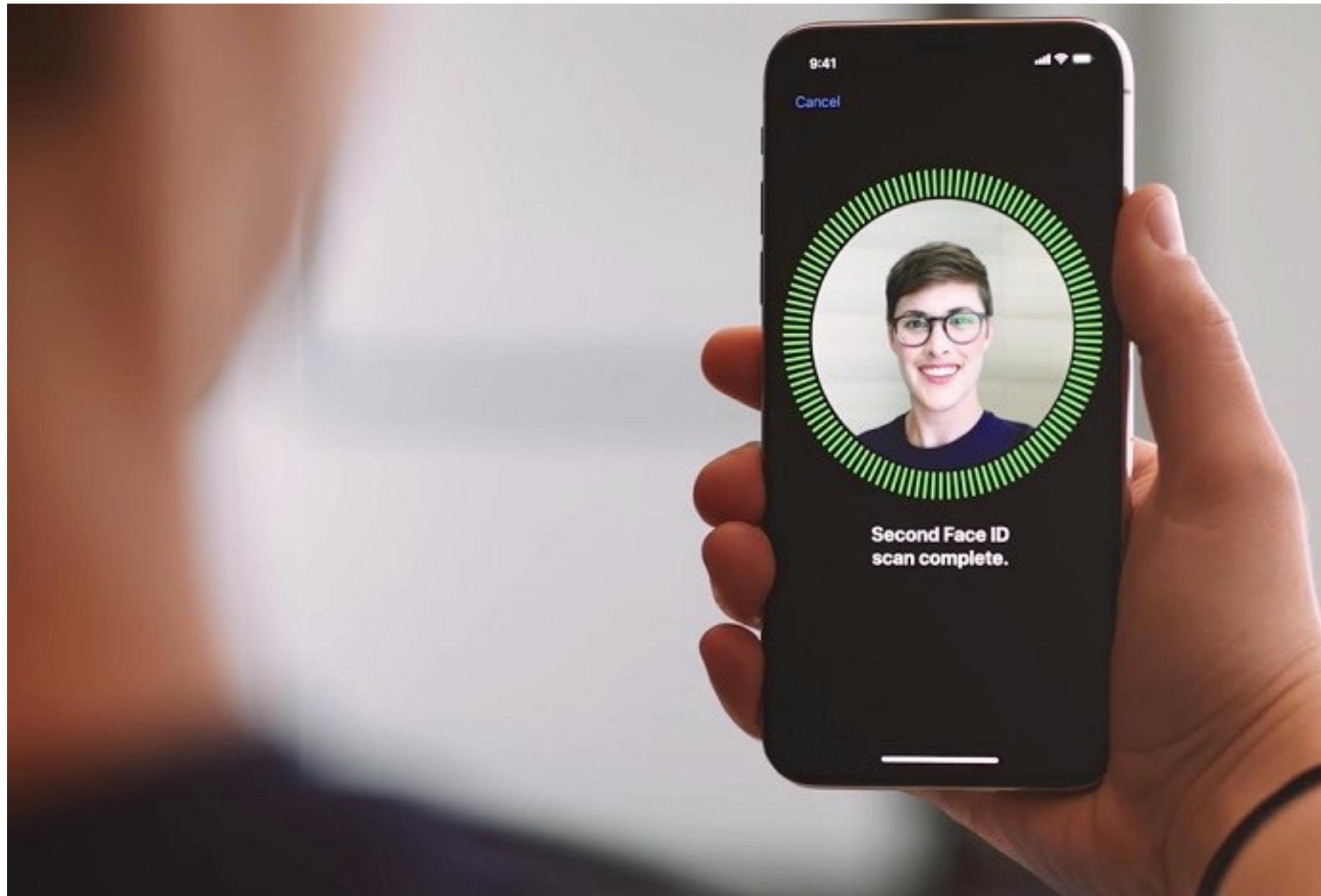
border patrol



entertainment

Biometrics Use

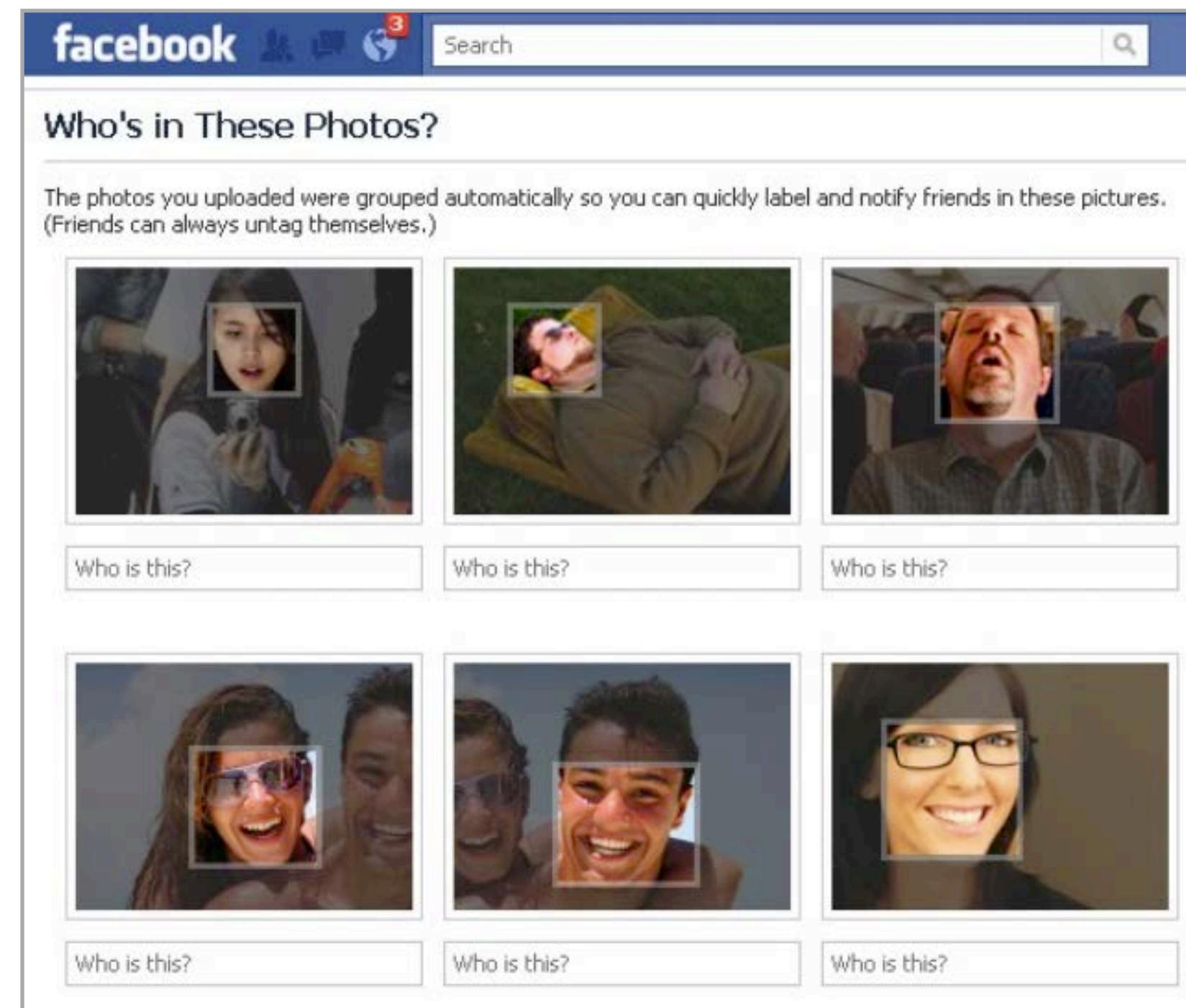
Biometrics is a reality



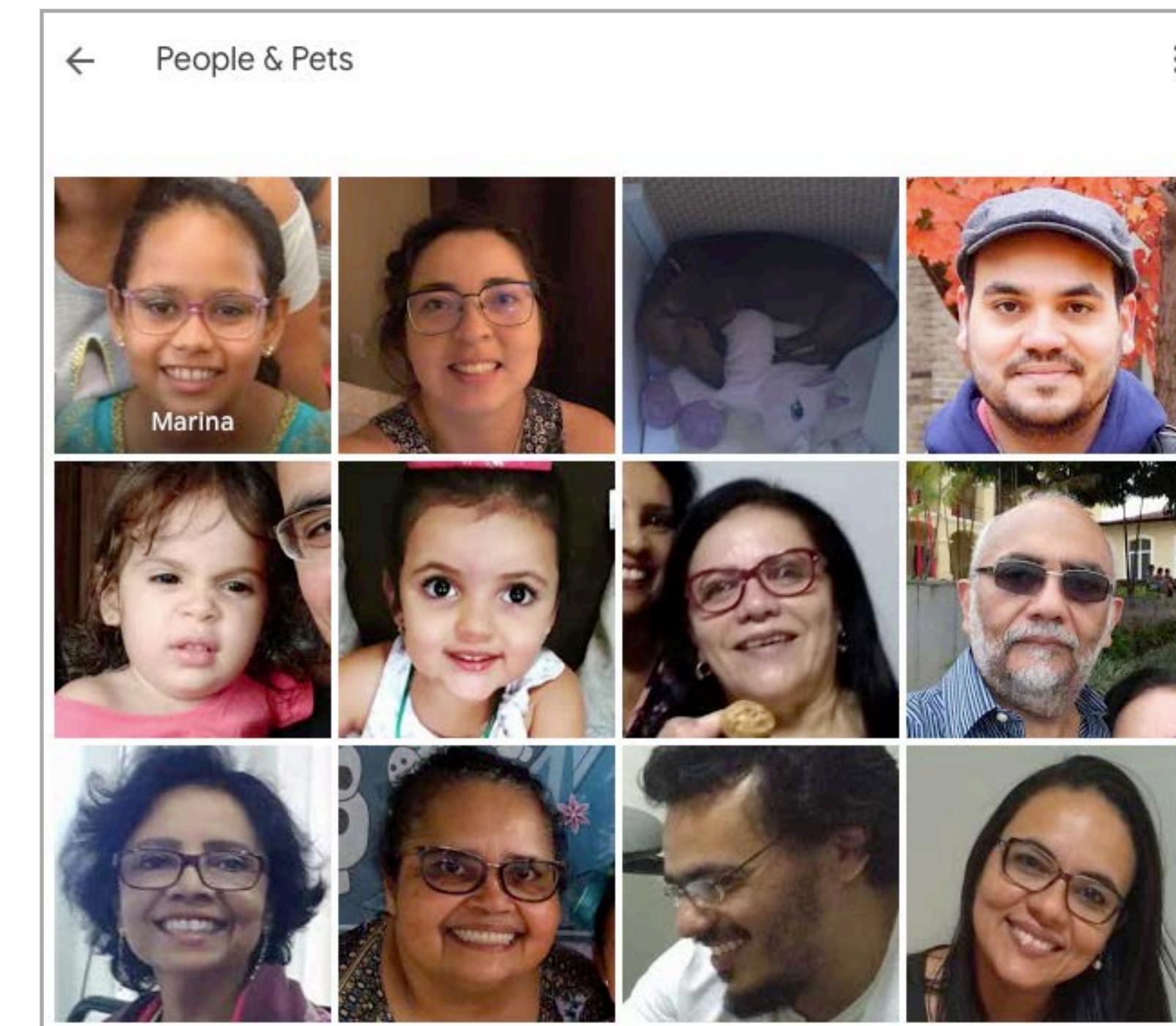
personal devices

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

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

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

discover india cities opinion world cricket entertainment election trending videos tech ••• Q 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-iR6HB8RmqPDAwkX2Oj5EJ.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

f t m r b 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

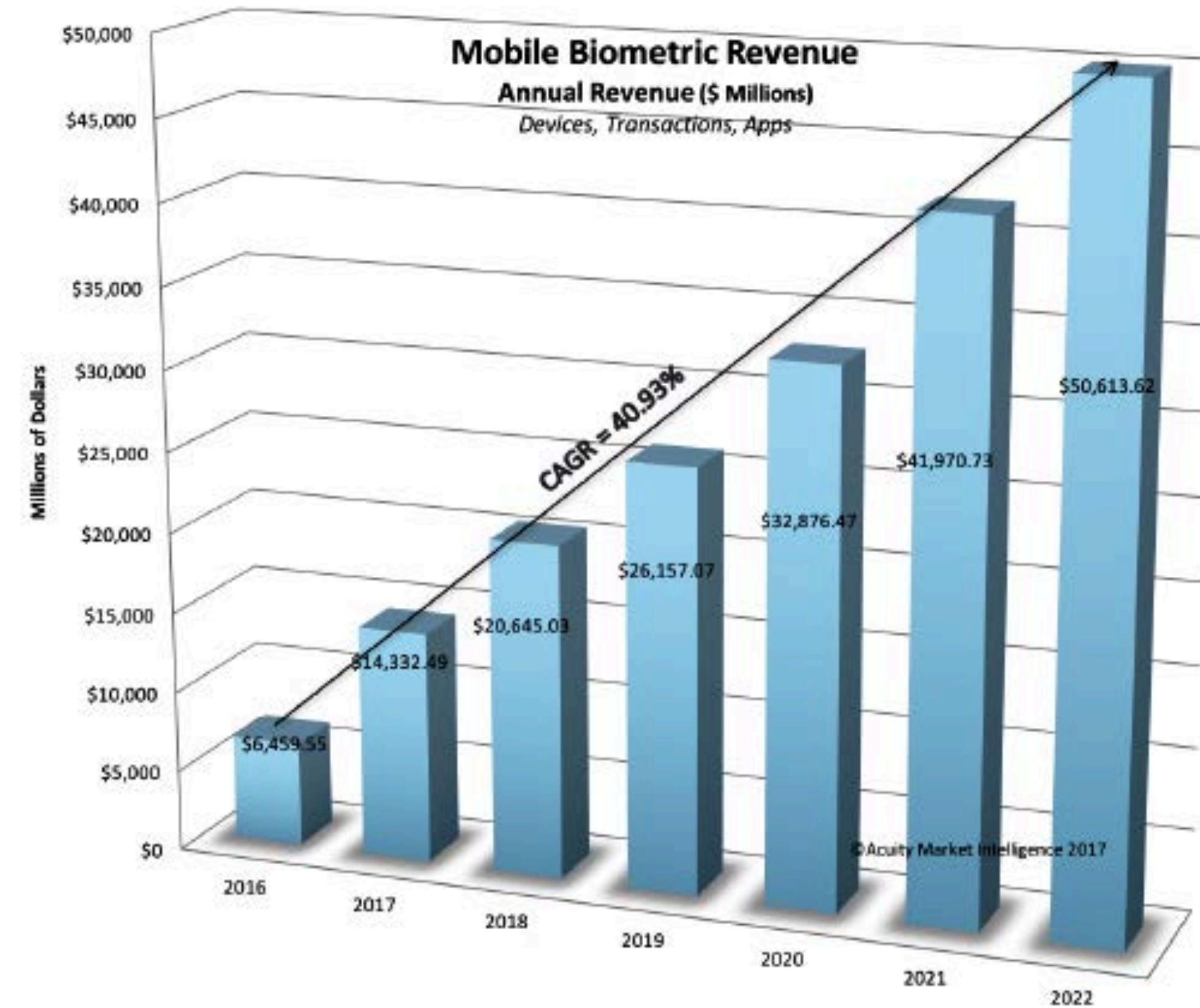
People cannot change their biometric data in response to a leak.
Irreversible for whole lifetime.



Please, don't.

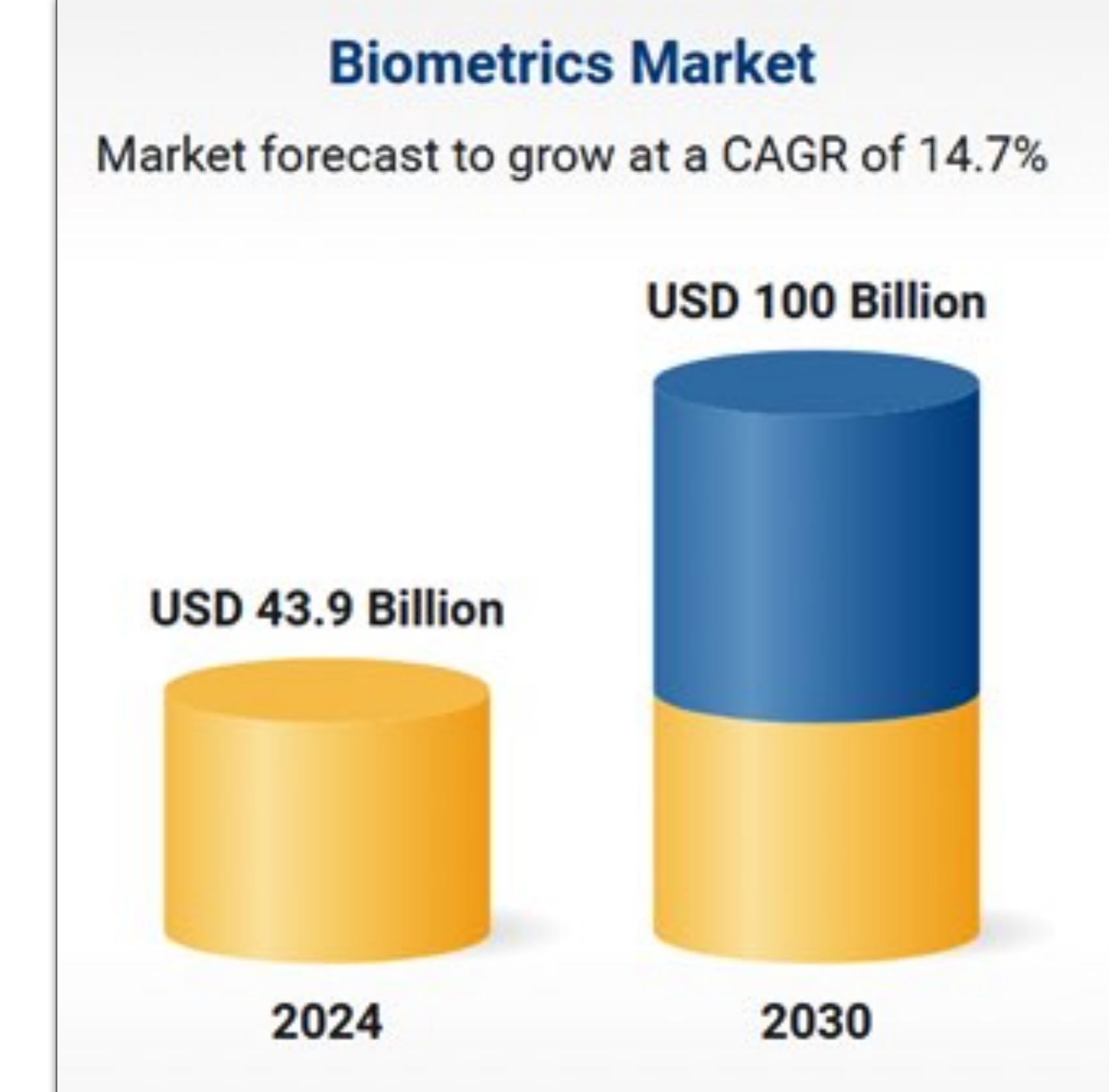
Biometrics Appeal

2017 Forecast



Source: acuitymi.com

CAGR: Compound Annual Growth Rate

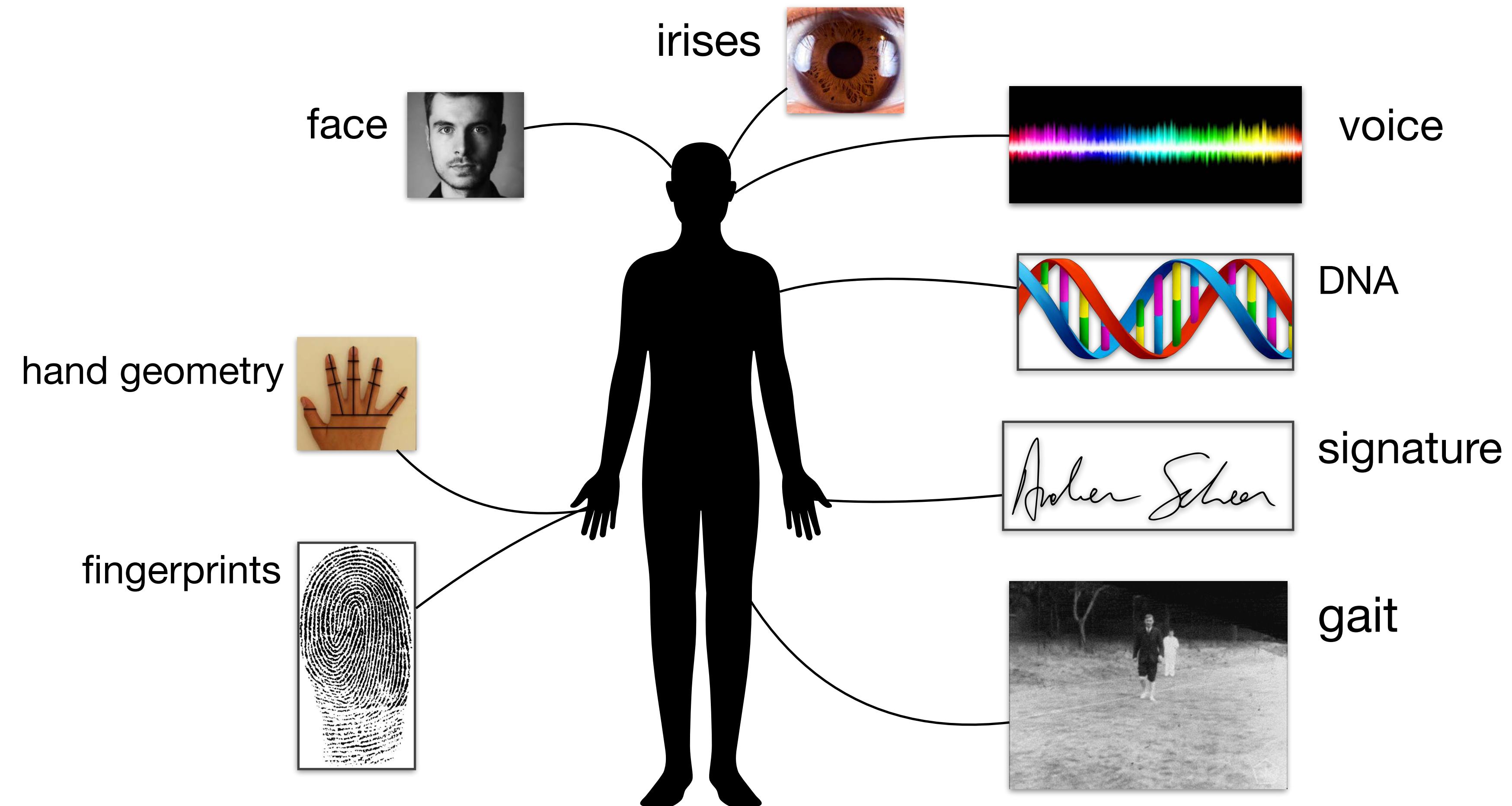


Source: researchandmarkets.com/reports/6064810/biometrics-global-market-overview



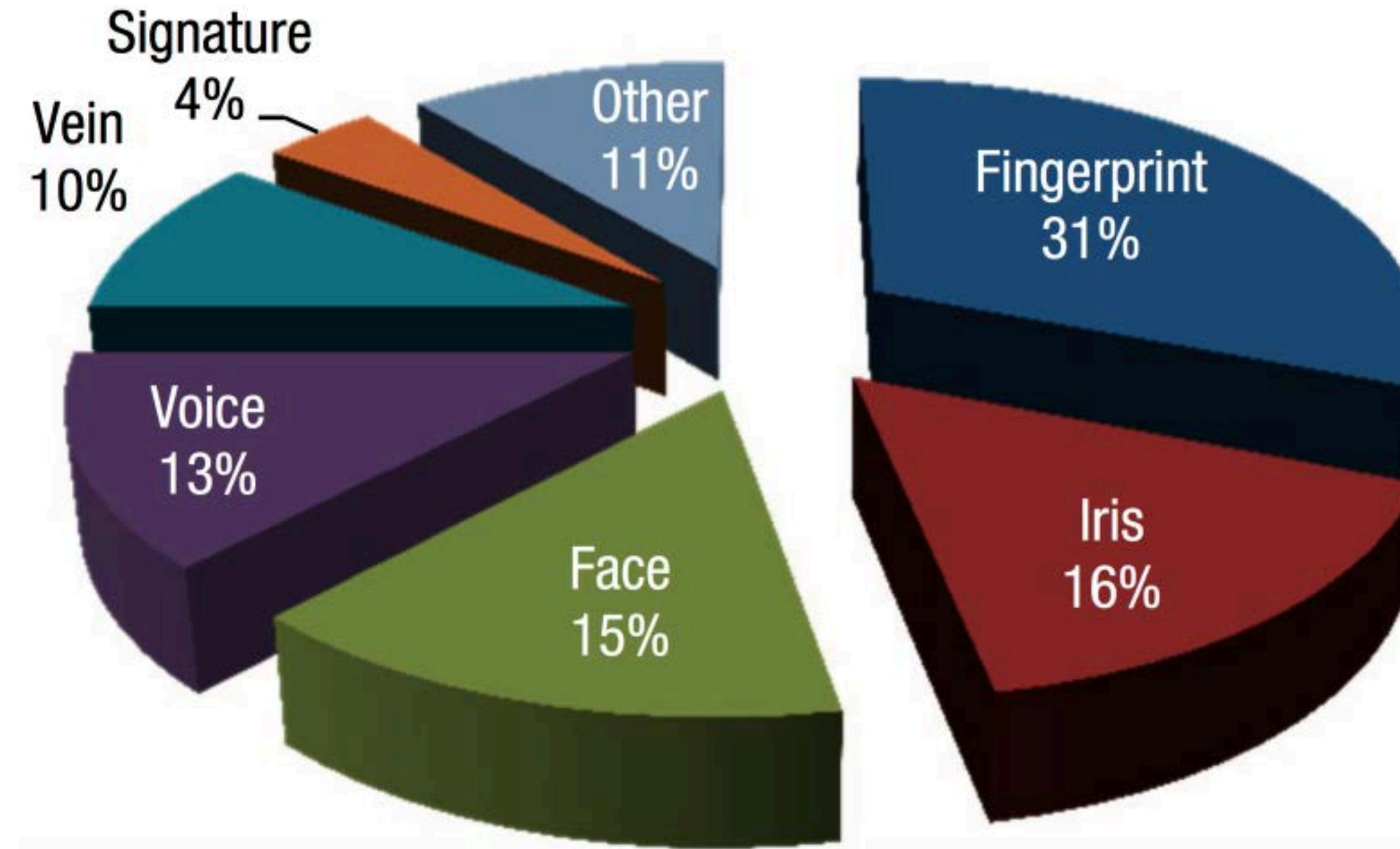
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Biometric Traits



Biometric Traits

Market



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

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?

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>

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?

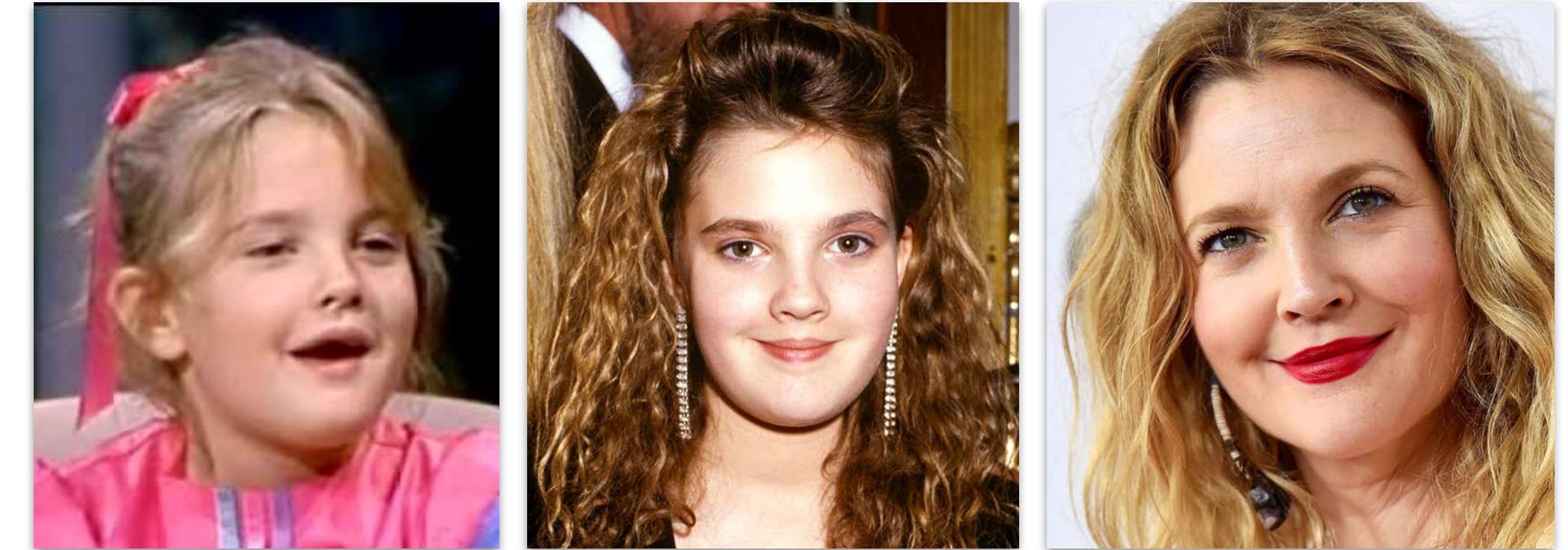
The image shows a screenshot of a BuzzFeed News article. The header features the BuzzFeed logo and navigation links for 'ABOUT US', 'GOT A TIP?', 'SUPPORT US', 'BUZZFEED.COM', and 'SECTIONS'. Below the header, there are several news headlines: 'Trending' (Taal Volcano Eruption), 'Cory Booker', 'Oscar Nominations', and 'Royal Family'. The main article is titled 'This Man Failed A Paternity Test Due To His Vanished Twin's DNA' under the 'SCIENCE' category. The article discusses how DNA researchers report a father failing a paternity test because the genes in his saliva differ from his sperm's. It notes that one in eight people might possess such "chimeric" genes caused by a twin lost in the womb. The author is Dan Vergano, a BuzzFeed News Reporter, and the post was made on October 24, 2015, at 10:16 a.m. ET.

<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?

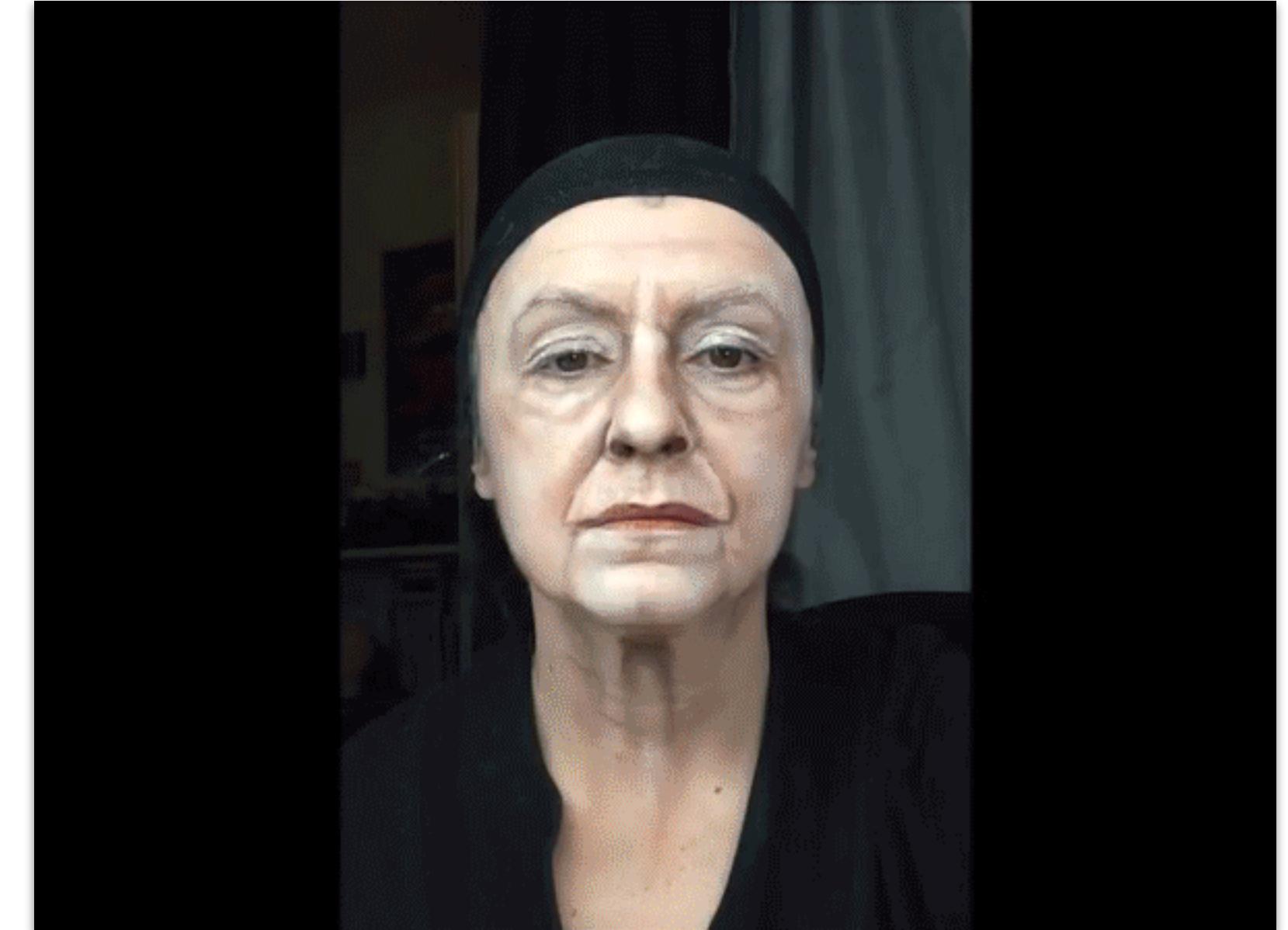


Biometric Traits

What do we want to consider?

Some traits might be more suitable than others.

Circumvention (6/8)



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

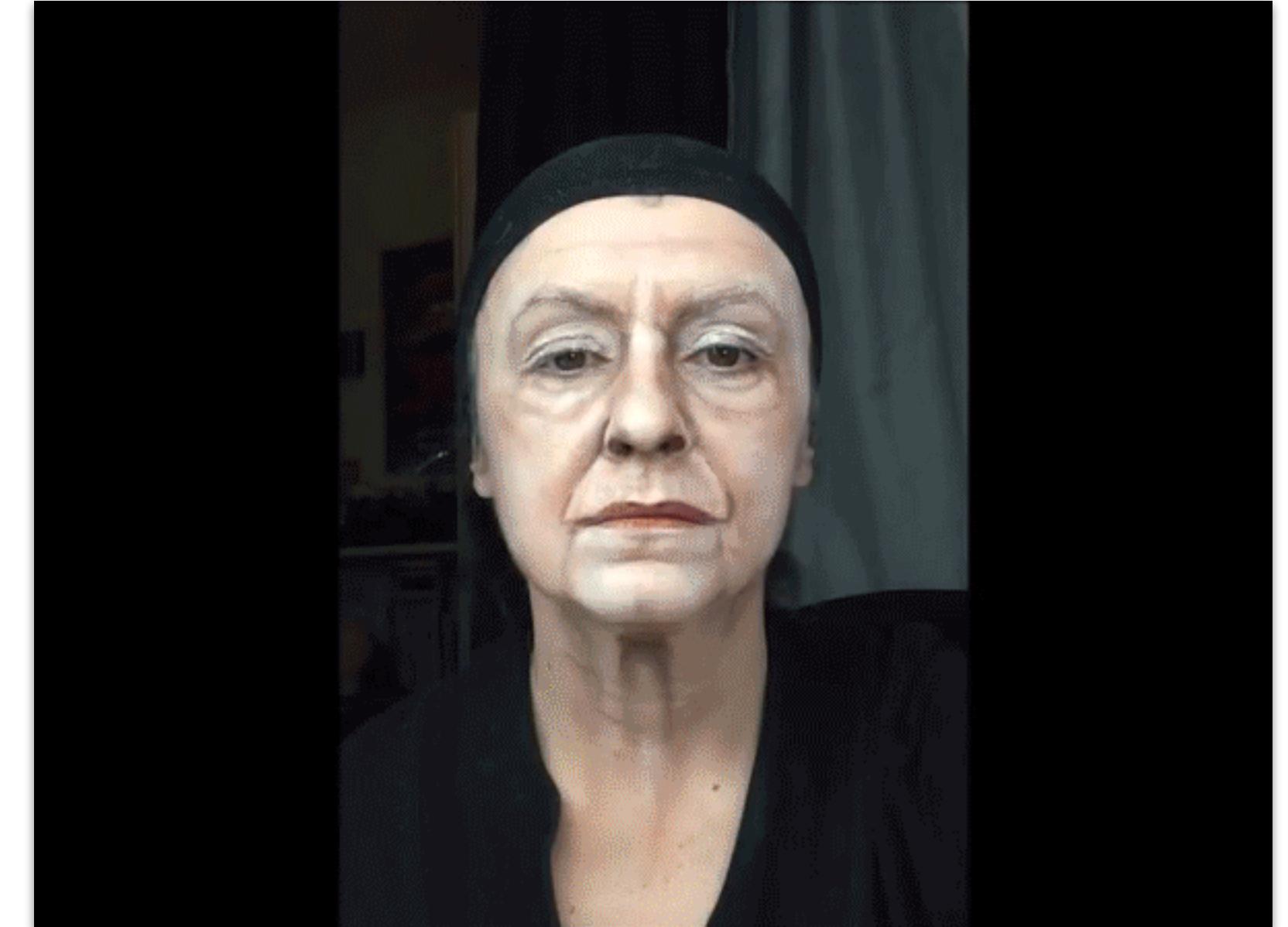
Biometric Traits

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?

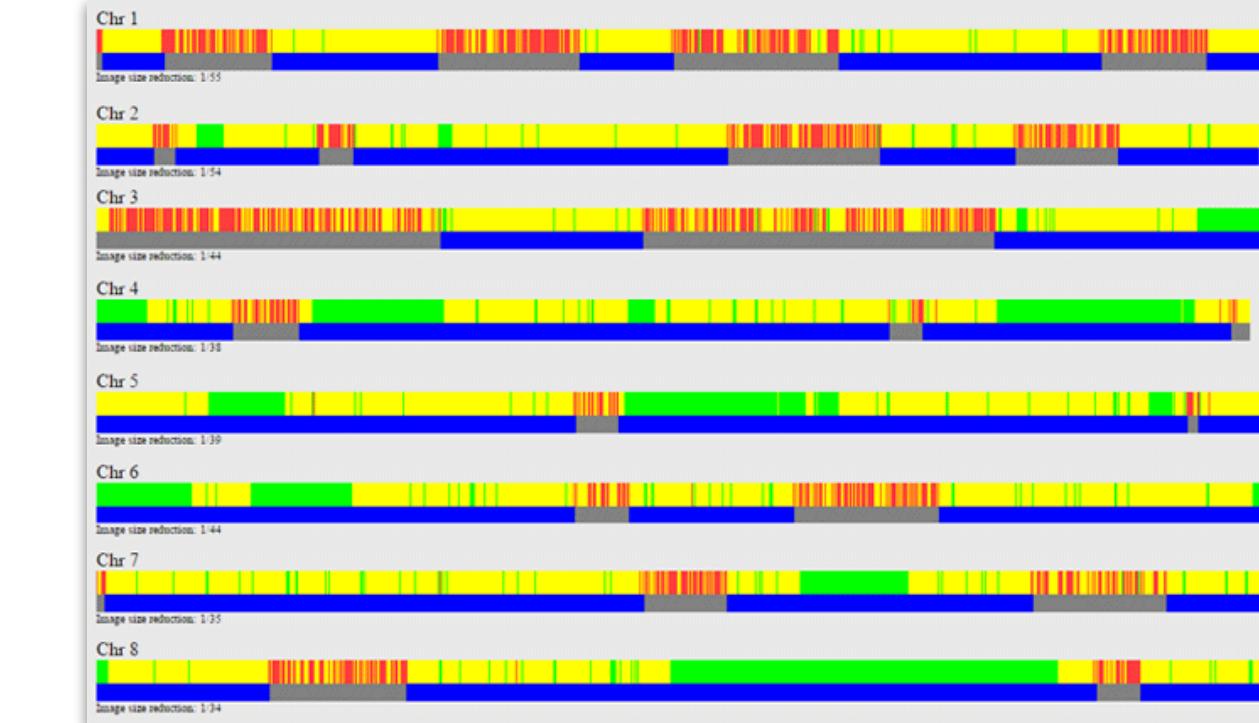


<https://www.youtube.com/watch?v=SIII8L43nng>

Biometric Traits

What do we want to consider?

Some traits might be more suitable than others.



Explainability (7/8)



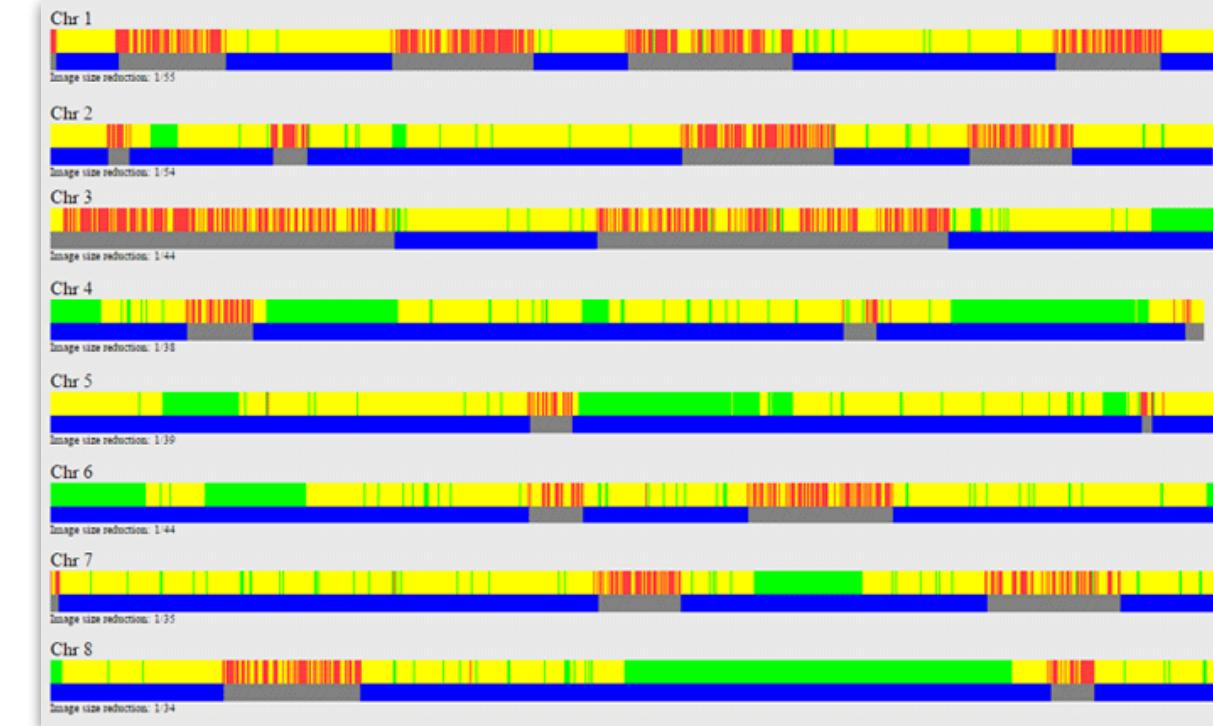
Biometric Traits

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?

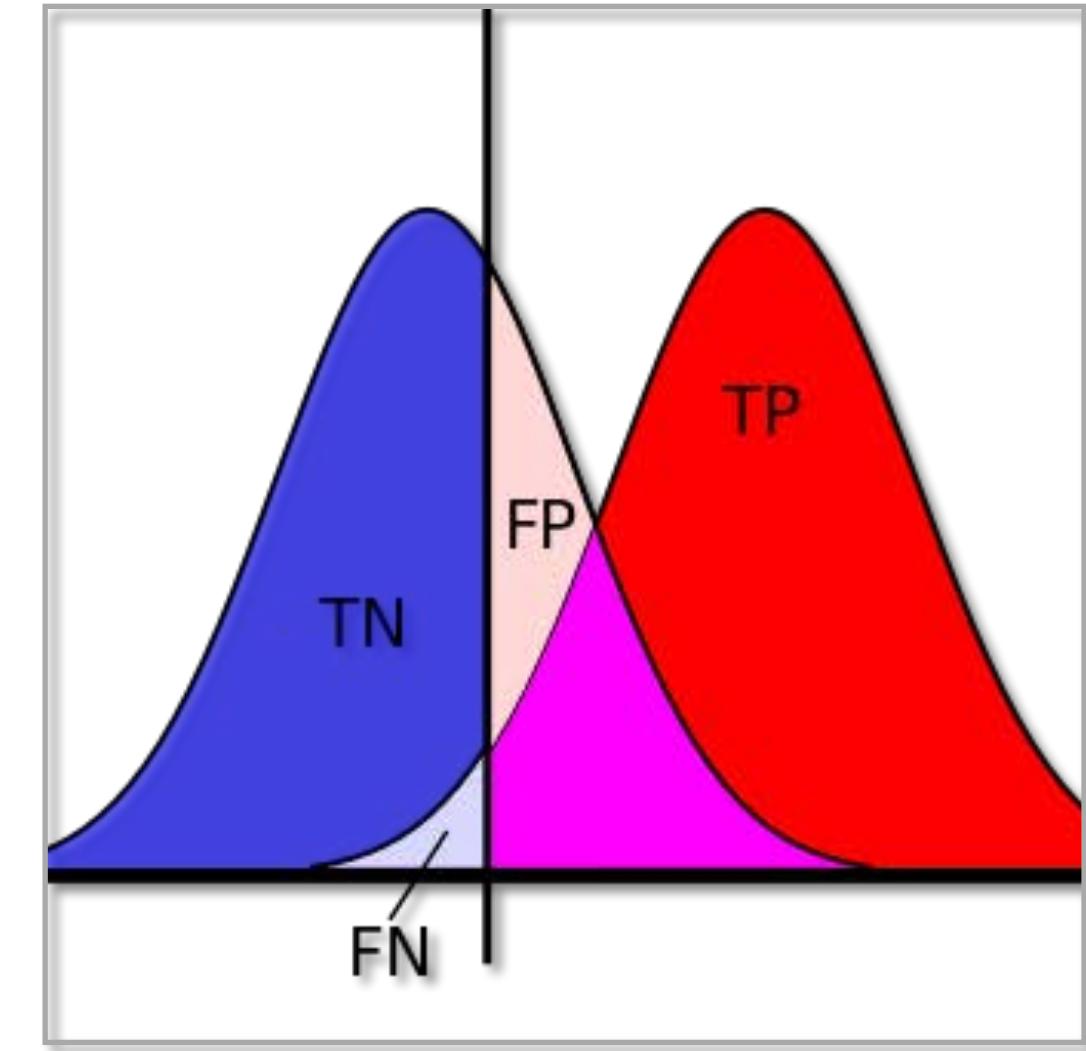


Biometric Traits

What do we want to consider?

Some traits might be more suitable than others.

Performance (8/8)



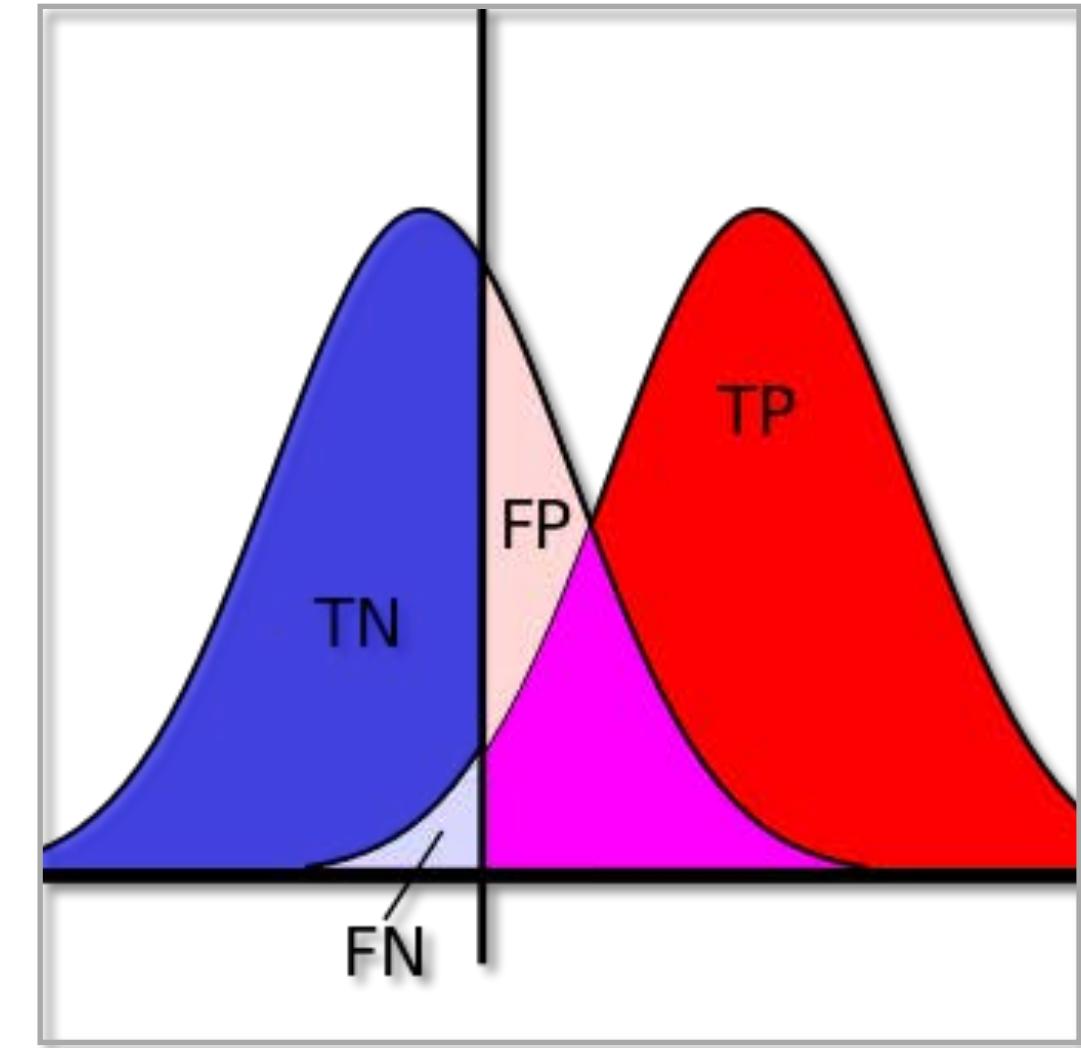
Biometric Traits

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)



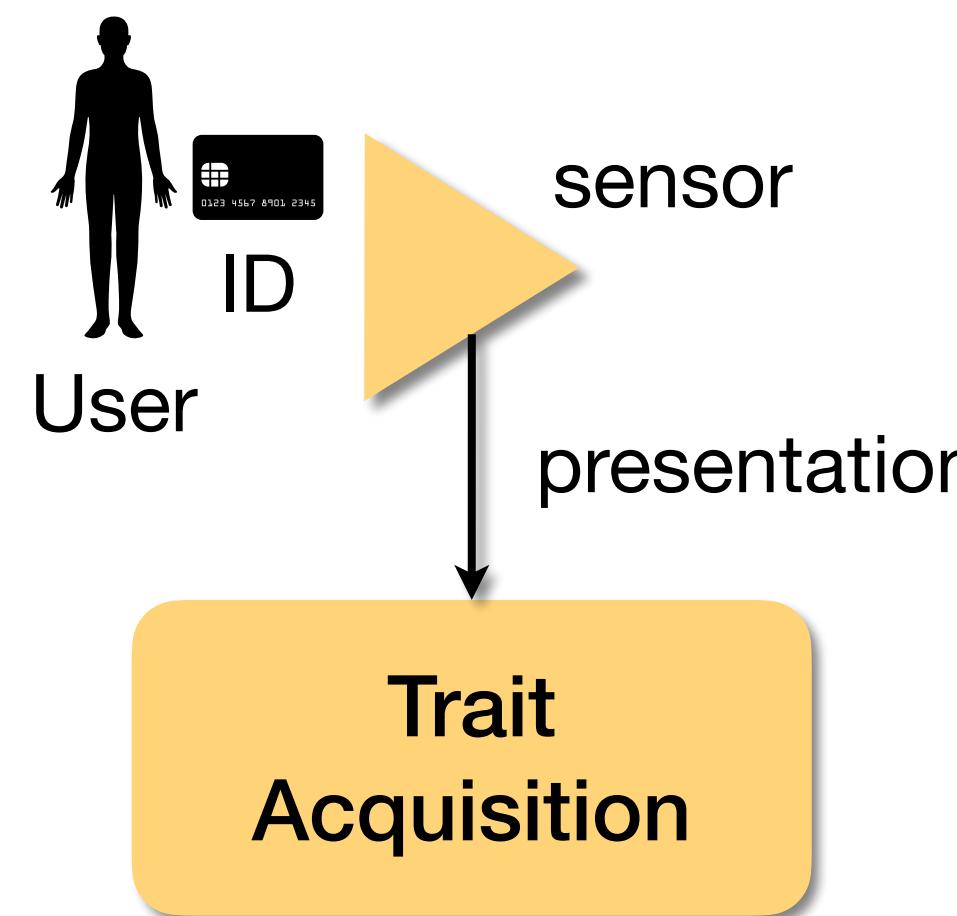
Activity

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



Biometric Systems

Enrollment



Trait Acquisition

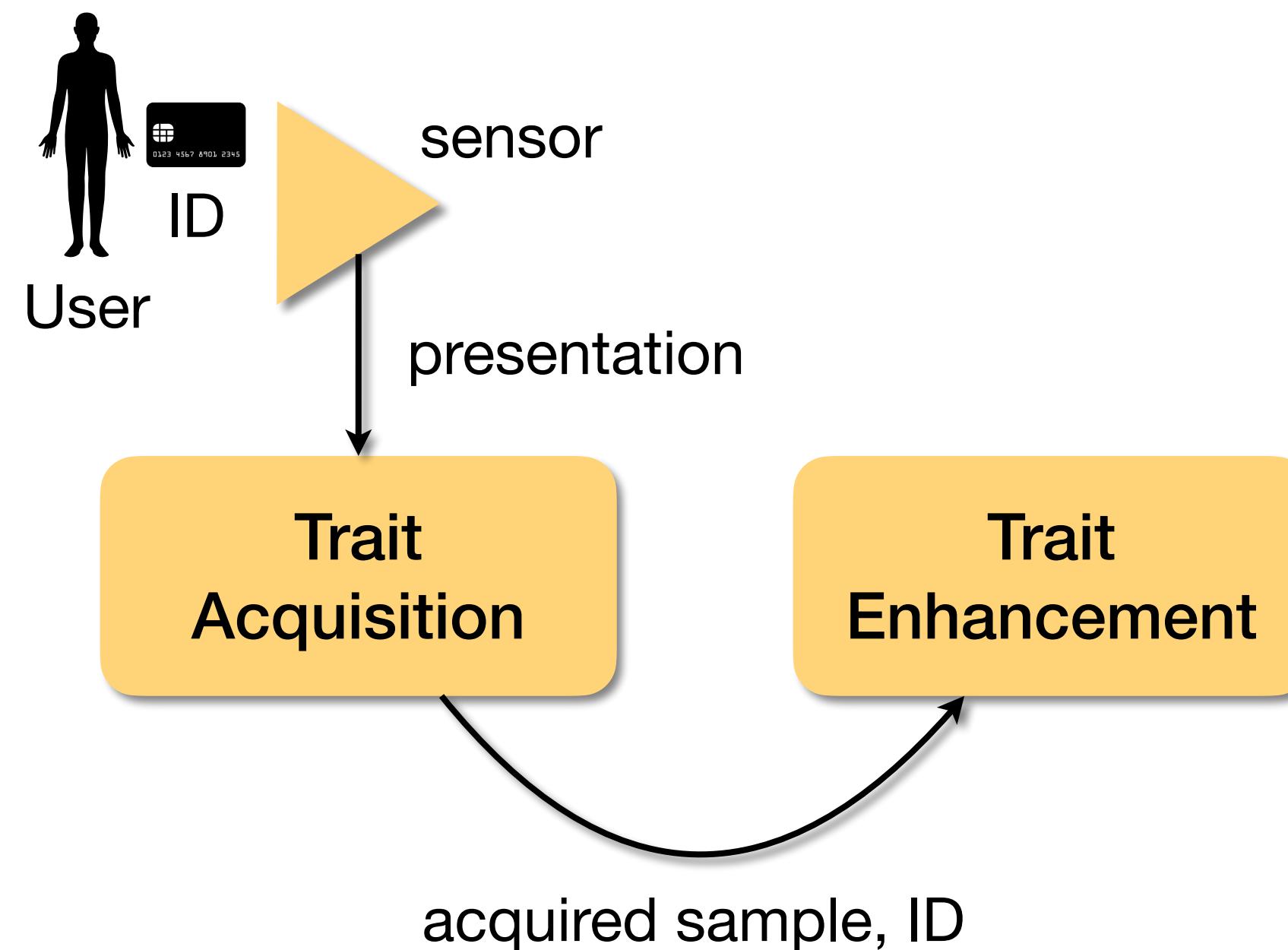
We'll have data-collection classes.
We'll use real-world sensors.

What to observe?

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

Biometric Systems

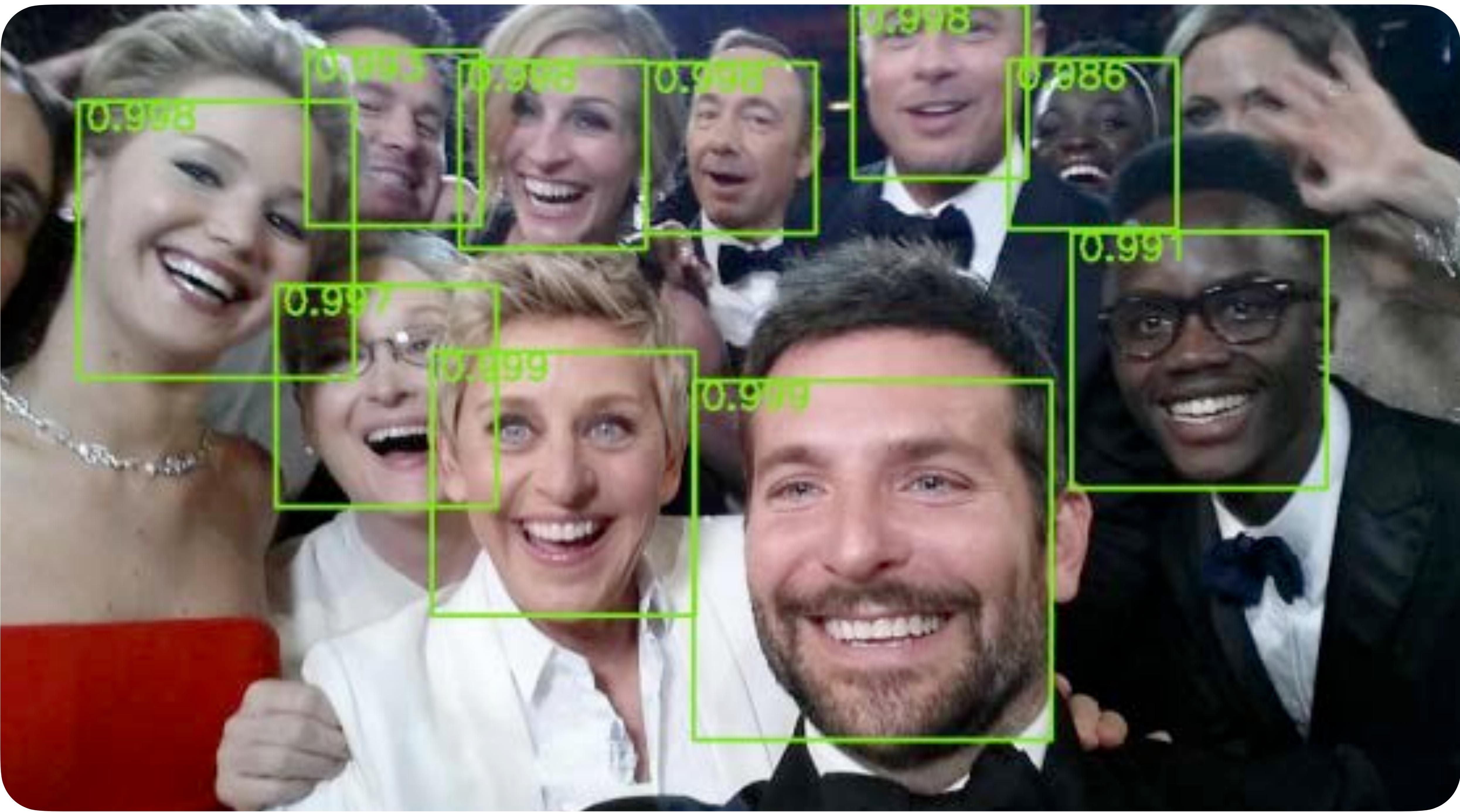
Enrollment



Trait Enhancement

Noise removal.

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



0.998

0.99

0.999

0.999

0.985

0.986

0.986

0.987

0.998

0.986

0.991

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 1x 1.0 3.0

Human-Interpretable Features

<input checked="" type="checkbox"/> TSHEPII	<input type="checkbox"/> Show Matched	<input type="checkbox"/> Show Unmatched	<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>-</td><td>0</td><td>+</td></tr> <tr><td>-</td><td>1</td><td>+</td></tr> </table>	-	0	+	-	1	+	out of 0	<input checked="" type="checkbox"/> MSER	<input type="checkbox"/> Show Matched	<input type="checkbox"/> Show Unmatched	<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>-</td><td>0</td><td>+</td></tr> <tr><td>-</td><td>1</td><td>+</td></tr> </table>	-	0	+	-	1	+	out of 0
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-	0	+																			
-	1	+																			

Manual Annotation

Annotate... Matching Regions Non-Matching Regions

Show Matching Regions Show Non-Matching Regions

Undo last removal

Non-Human-Interpretable Features

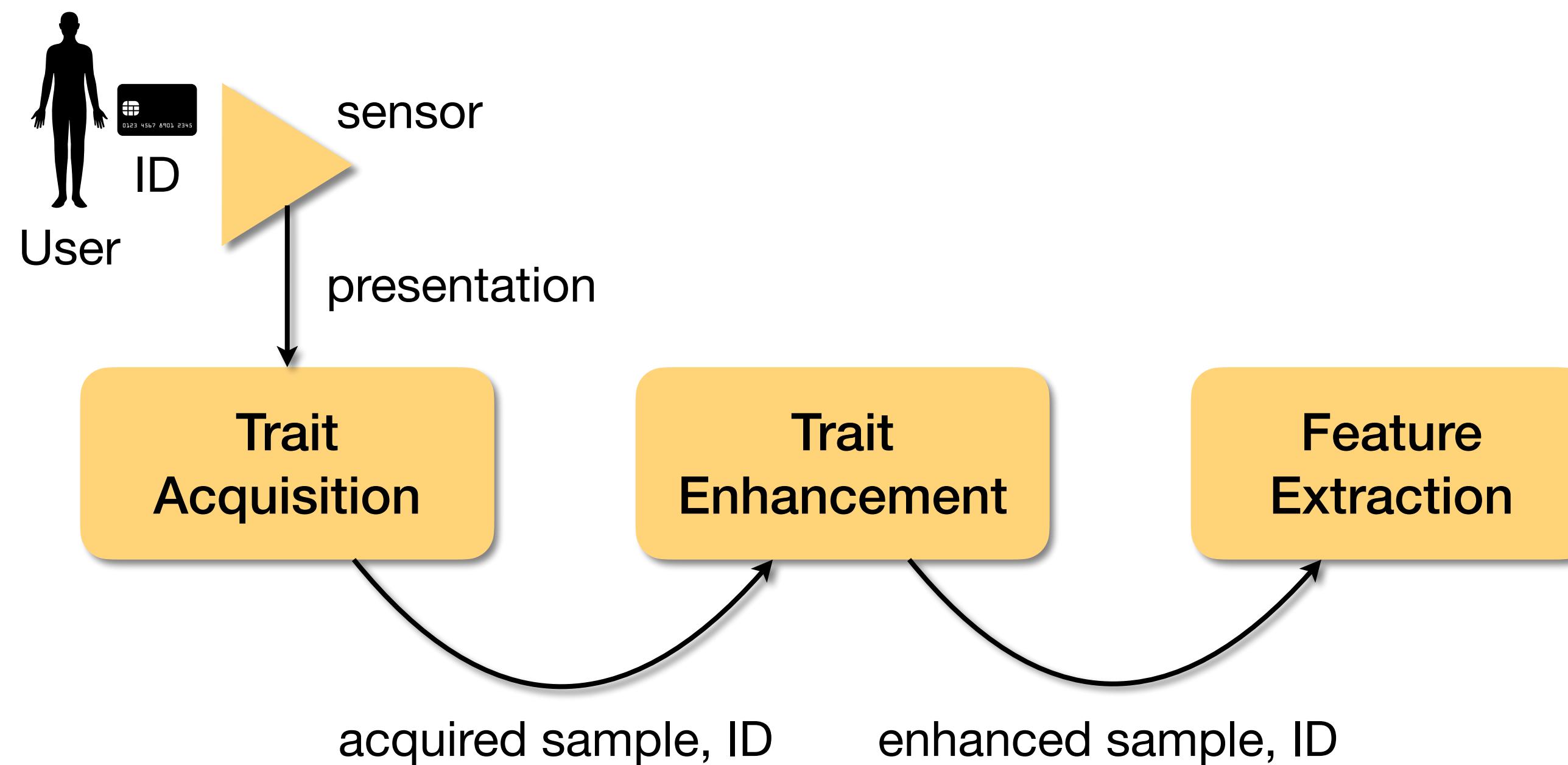
Gabor Filters thr: 0.4461

BSIF Filters thr: 0.4216

Global match score

Biometric Systems

Enrollment Modules



Feature Extraction

Compact but expressive digital representation of the trait.

Types

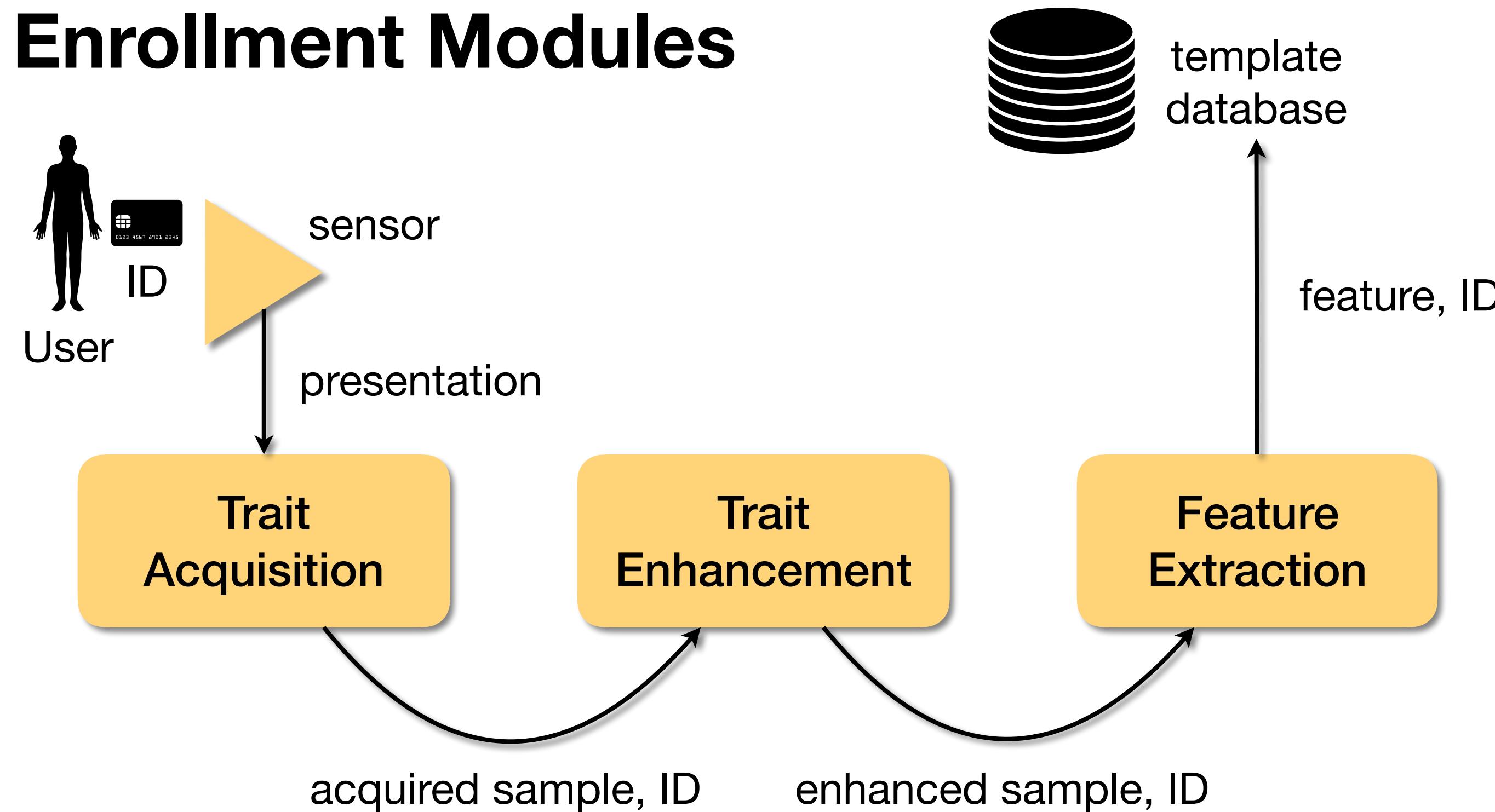
Handcrafted or learned with machine learning.
We'll see both cases.



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Biometric Systems

Enrollment Modules

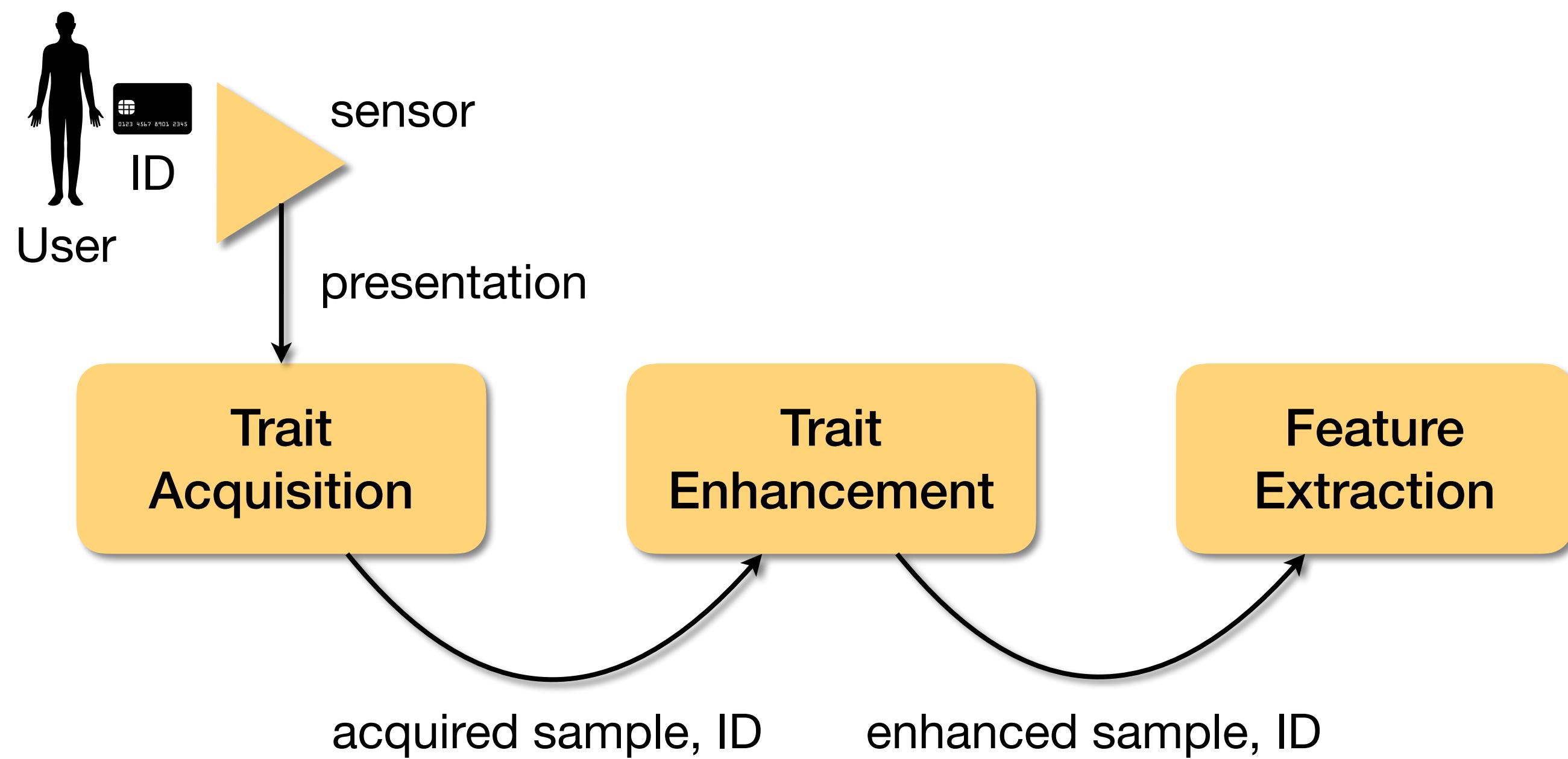


Template Database

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

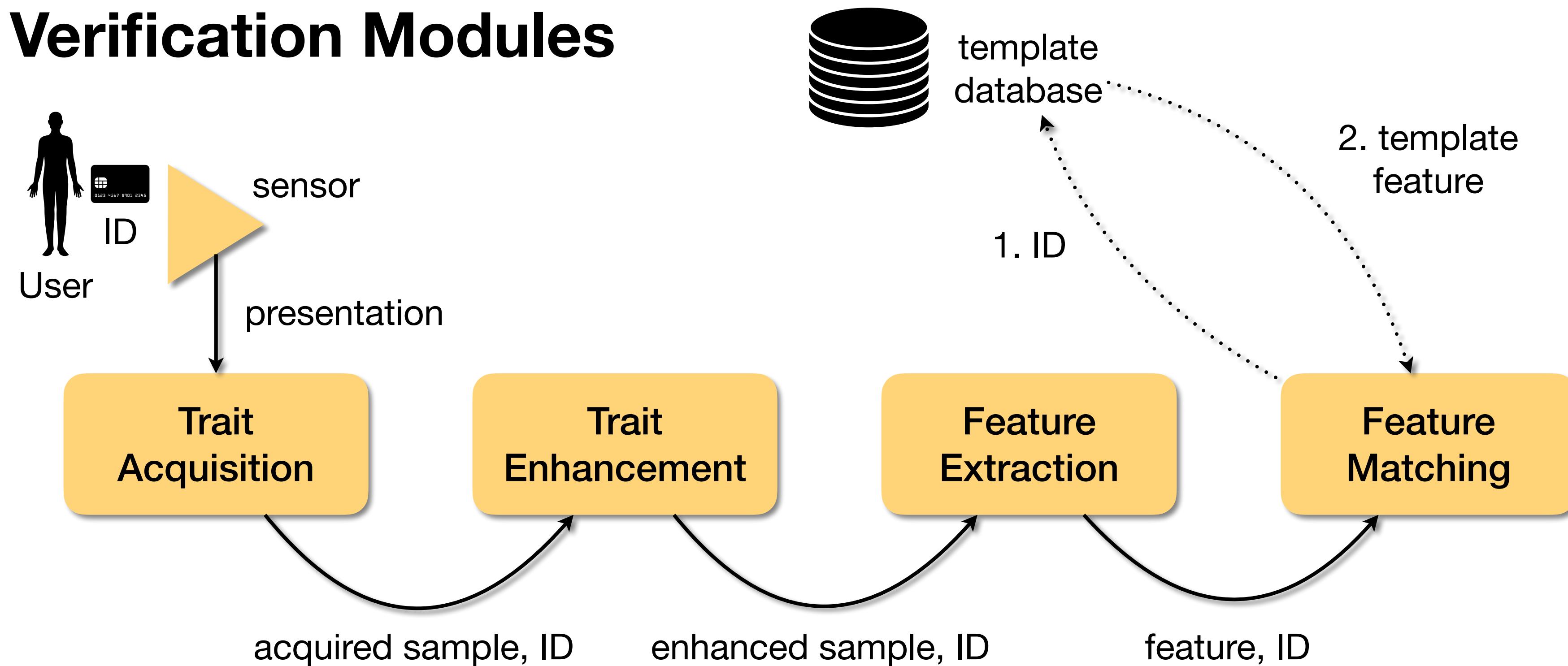
Biometric Systems

Verification Modules



Biometric Systems

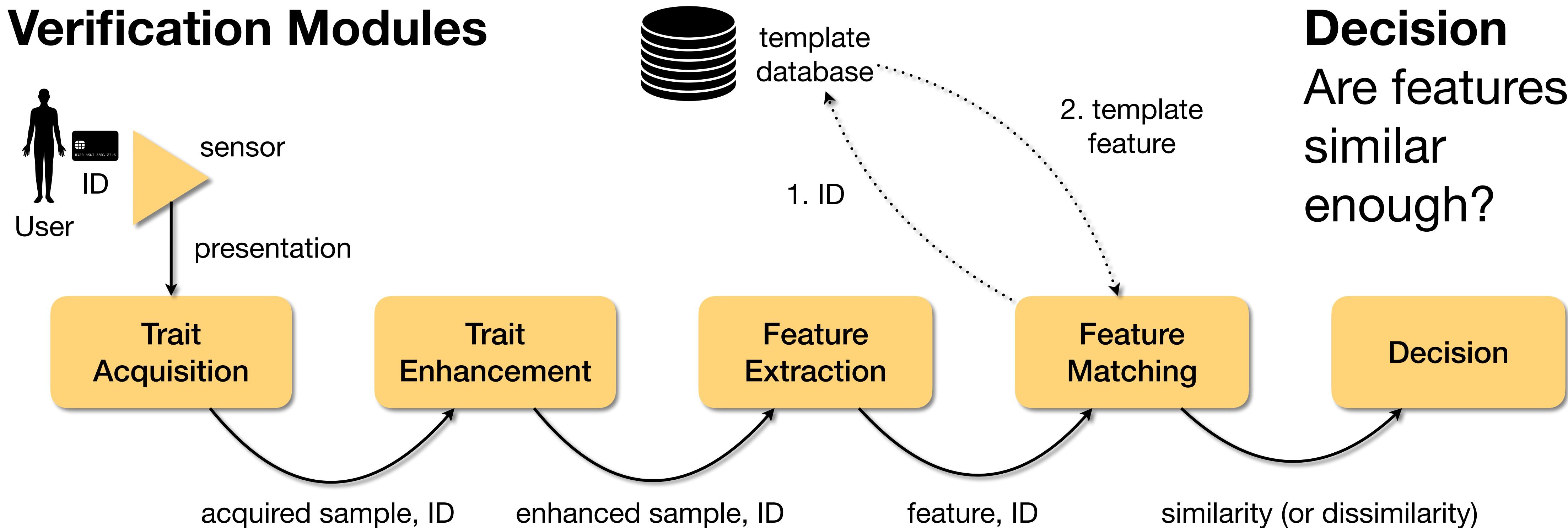
Verification Modules



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

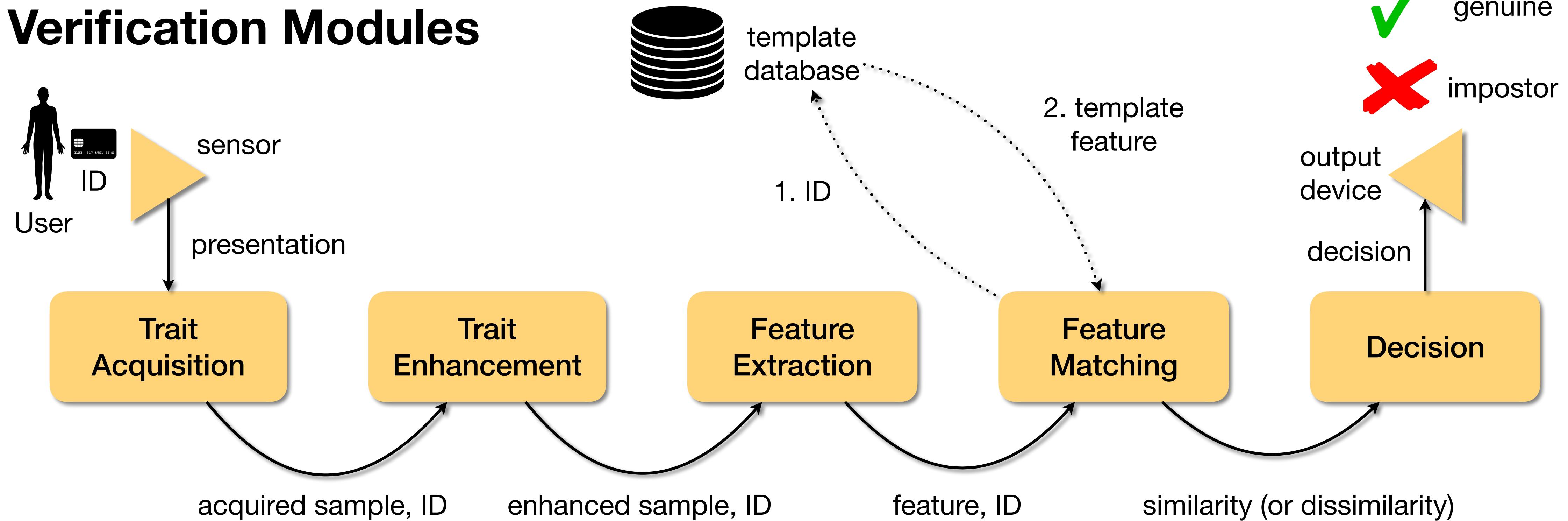
Biometric Systems

Verification Modules



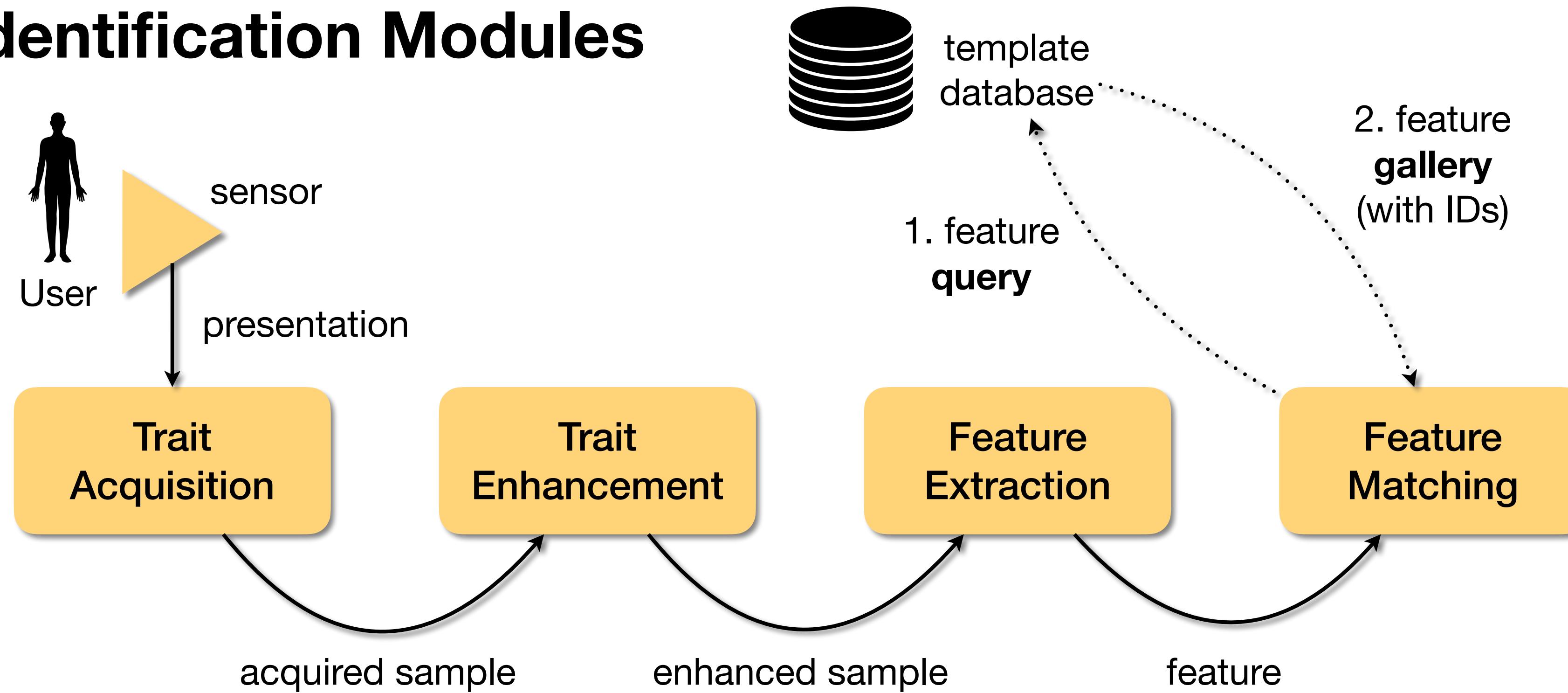
Biometric Systems

Verification Modules



Biometric Systems

Identification Modules



Gallery
Closest template features to query.

Biometric Systems

Query and Gallery Example



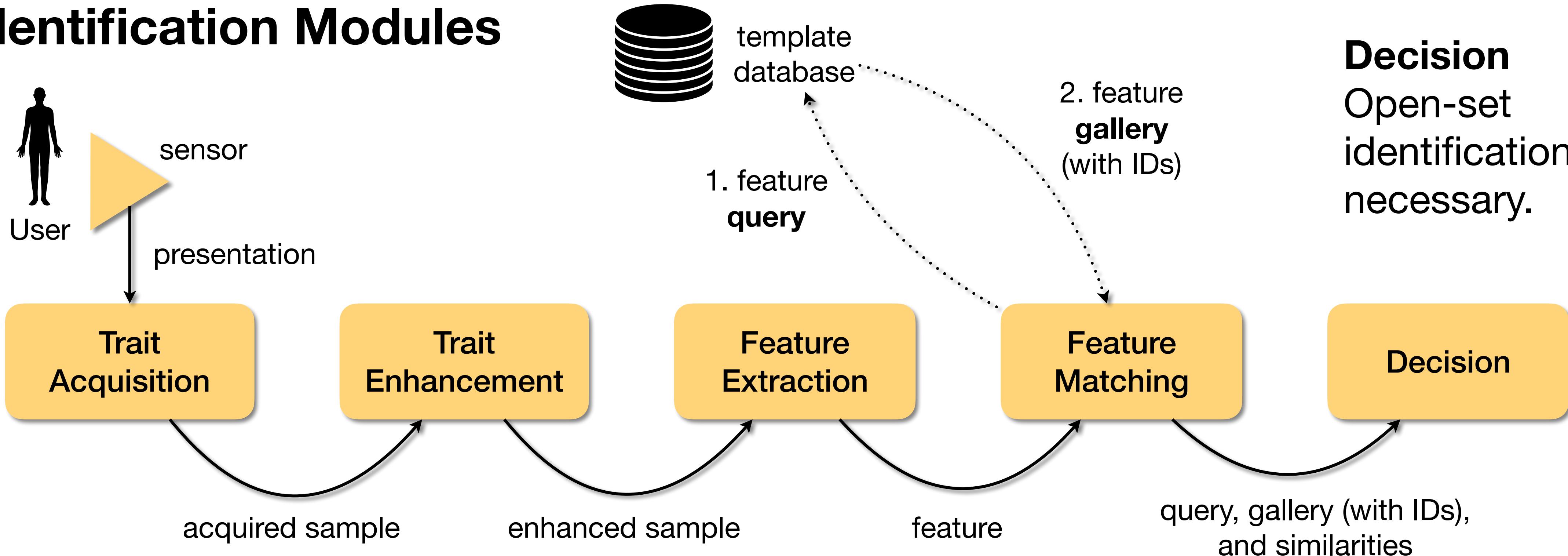
query



gallery

Biometric Systems

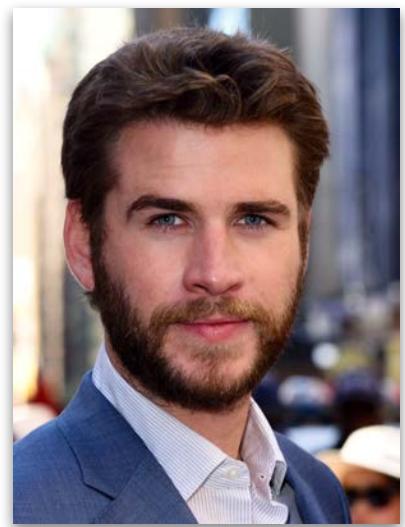
Identification Modules



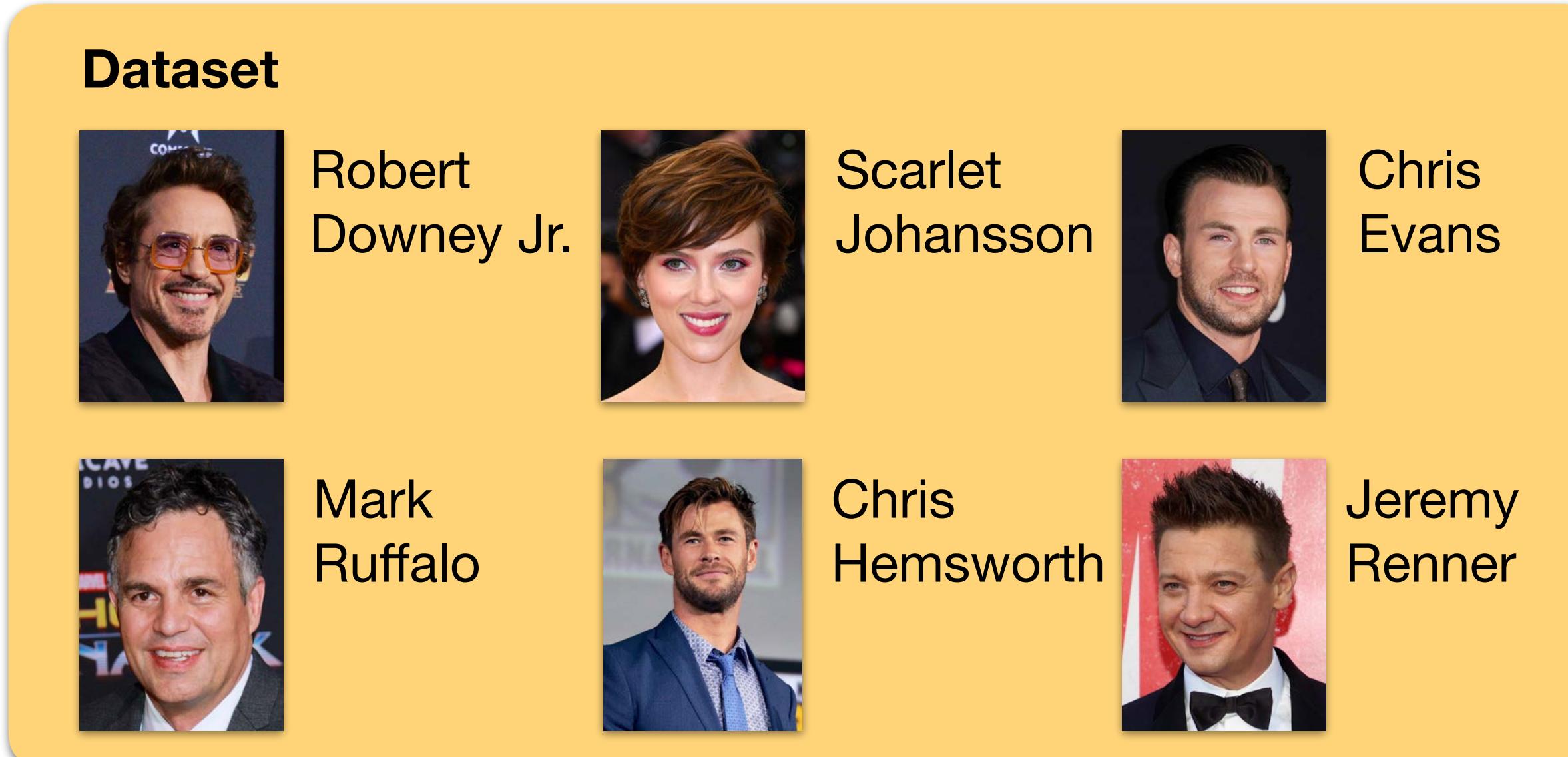
Decision
Open-set
identification is
necessary.

Biometric Systems

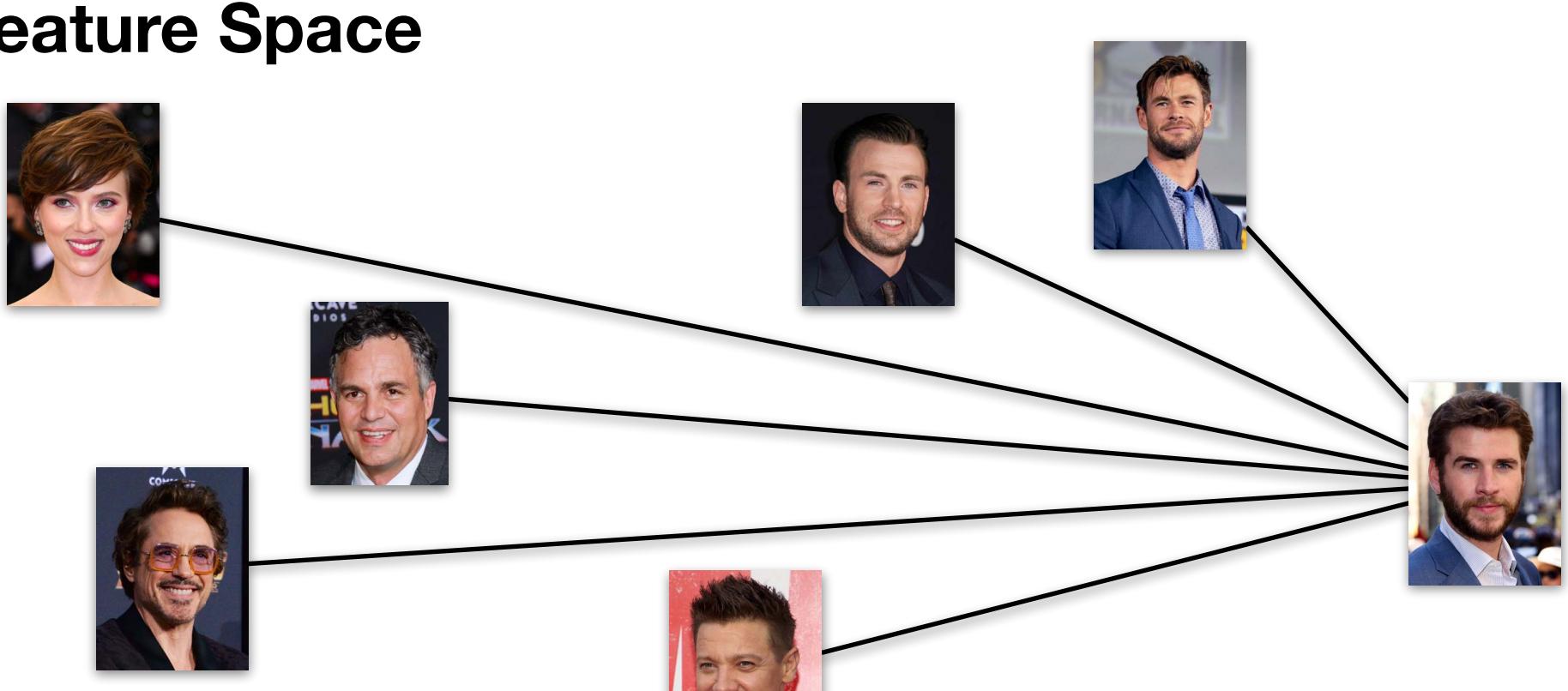
Open-set vs. Closed-set Identification



Query
(Liam Hemsworth)



Feature Space



Closed Set

Output
This is
Chris Hemsworth!



Open Set

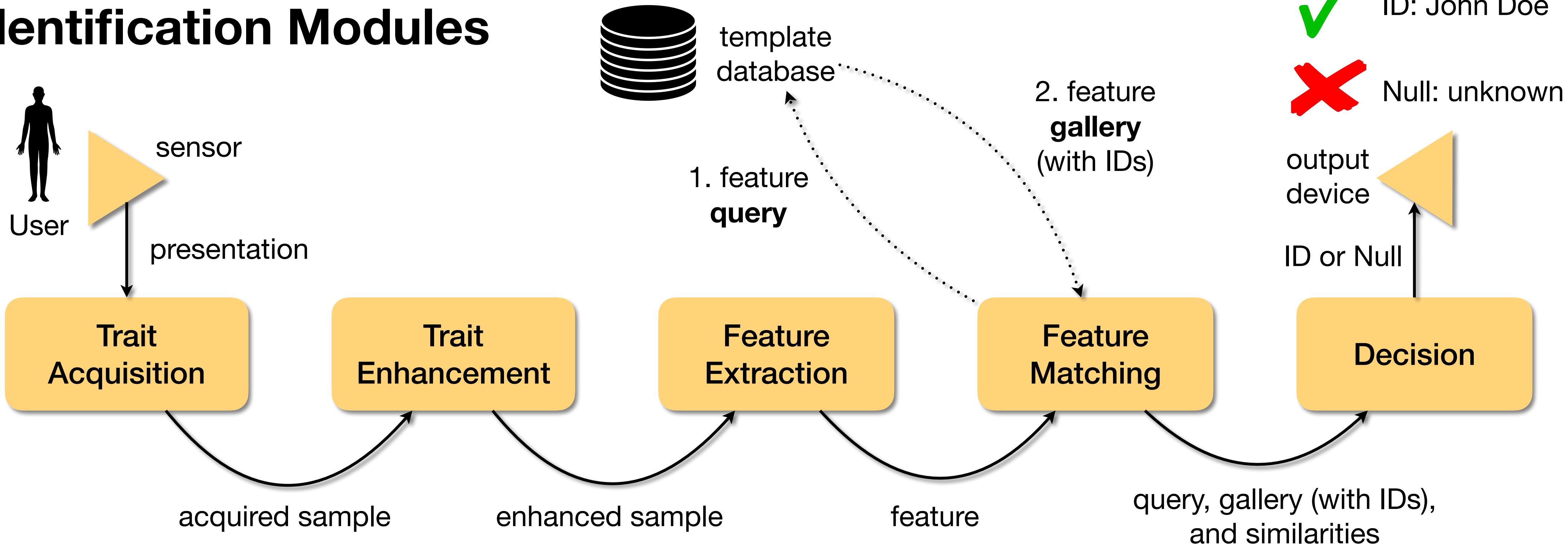
Output
I don't know
this person!



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Biometric Systems

Identification Modules



What's Next?

Relax

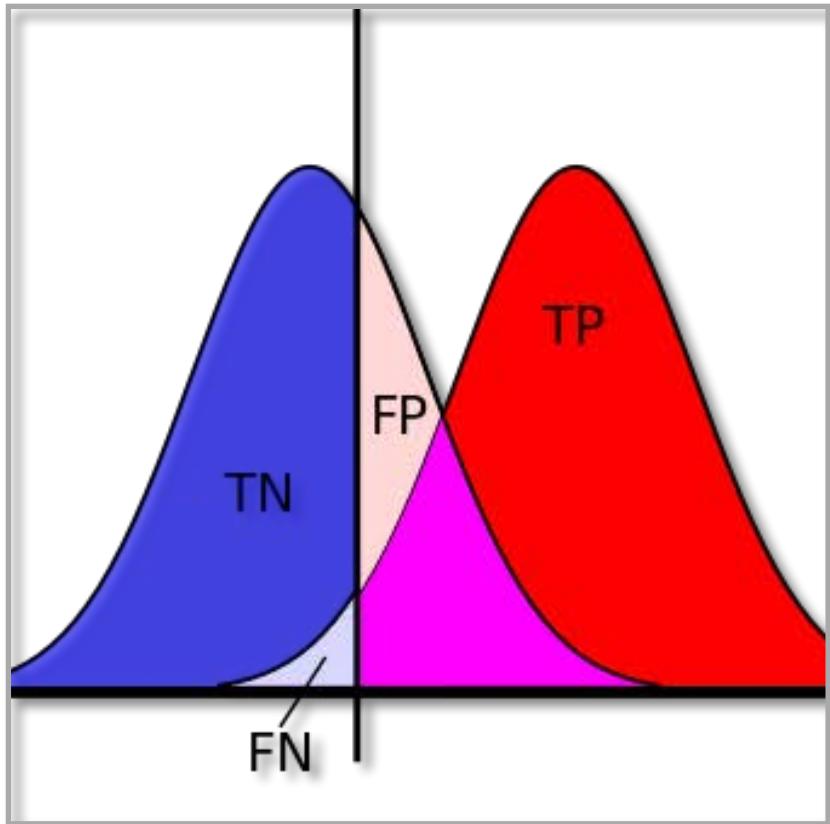
Any issues? Please come and talk to me.

Enjoy Labor Day!

More basics

Biometric system errors and metrics.

Fill out your *Today-I-missed* Statement
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