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Biometric Recognition: How do I Know Who You are?

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Michigan State University

<http://biometrics.cse.msu.edu>

September 1, 2020

mbzuai.ac.ae

Airport Security in UAE



Multi-Biometric Entry/exit



Biometric Boarding (Face + iris)

<https://bit.ly/2POOmIP>, <https://bit.ly/2E4bGQc>, <https://bit.ly/2E4bh08>, <https://bit.ly/2XWjqdO>

Security Concerns

We now live in a society where individuals cannot be trusted based on their ID documents and PIN/passwords



Interpol's Stolen and Lost Travel Documents database contains ~84M records; It was searched nearly 3 billion times in 2018 by officials worldwide, resulting in more than 289,000 positive 'hits'.

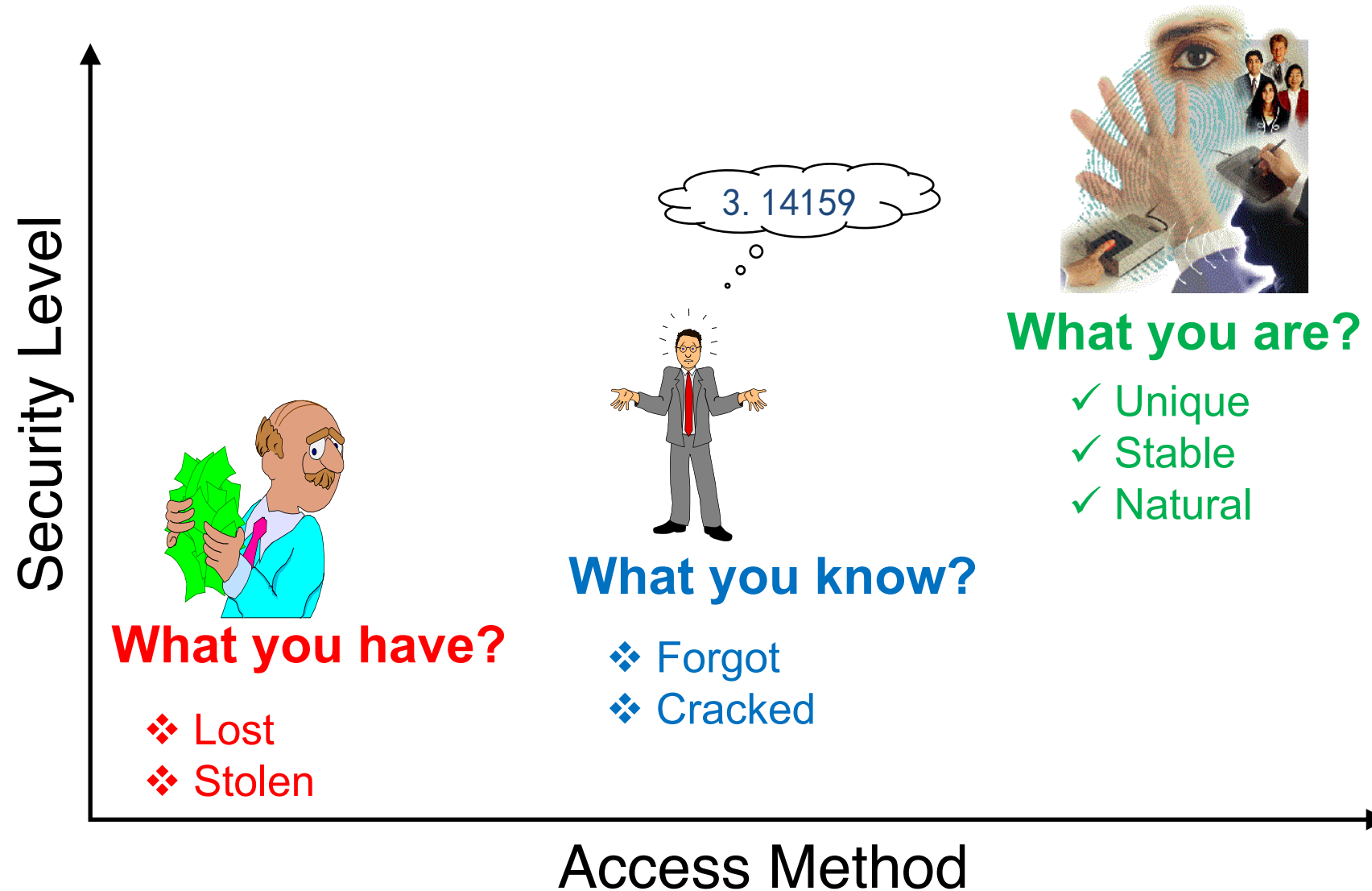
Security Concerns

Copyright 1996 Randy Glasbergen. www.glasbergen.com



“Sorry about the odor. I have all my passwords tattooed between my toes.”

Why Biometrics?

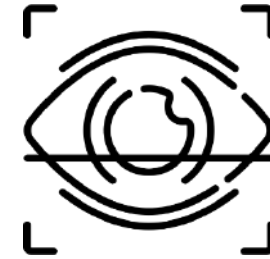
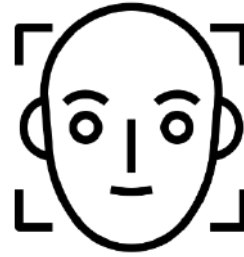


Biometric Recognition

- ***“Automated recognition of individuals based on their behavioral and biological characteristics”*** ISO/IEC JTC1 2382-37:2012
- ***Bios: life; Metron: measure*** (Morris, 1875)



Most Popular Traits



Incheon, South Korea: Smart Entry



Australia: SmartGate



Amsterdam: Privium border passage

Legacy databases, high accuracy and fast search

http://www.homestaykorea.com/?document_srl=73667&mid=bbs_koreainfo_news

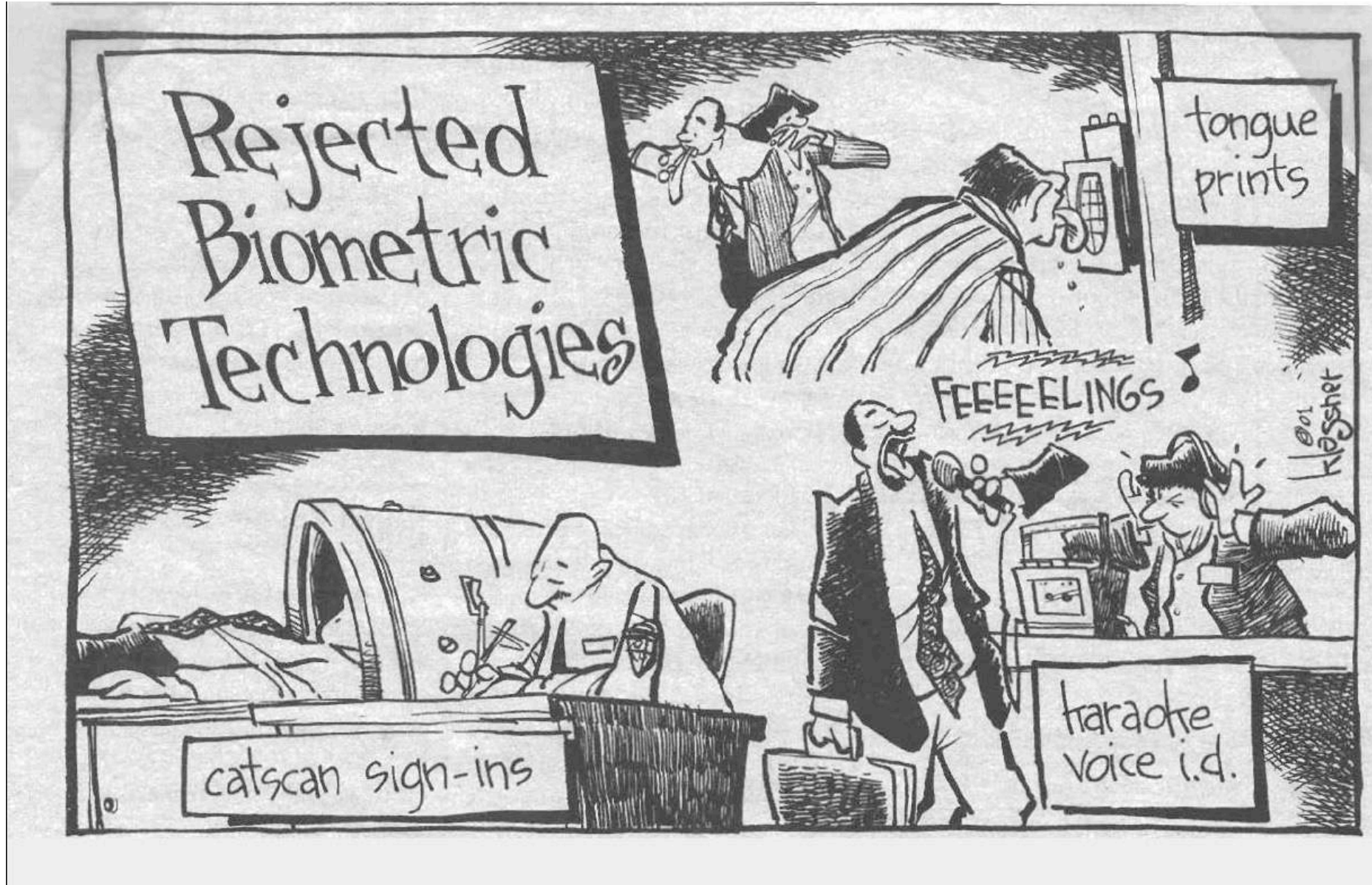
<https://tottnews.com/tag/smart-gates/>

<https://www.idemia.com/news/multi-biometrics-future-border-control-2016-04-21>

Multi-biometrics



Rejected Traits



Applications



Requirements: Throughput, usability, low cost, high accuracy, robust, secure

Amazon Go: Just Walkout Shopping!

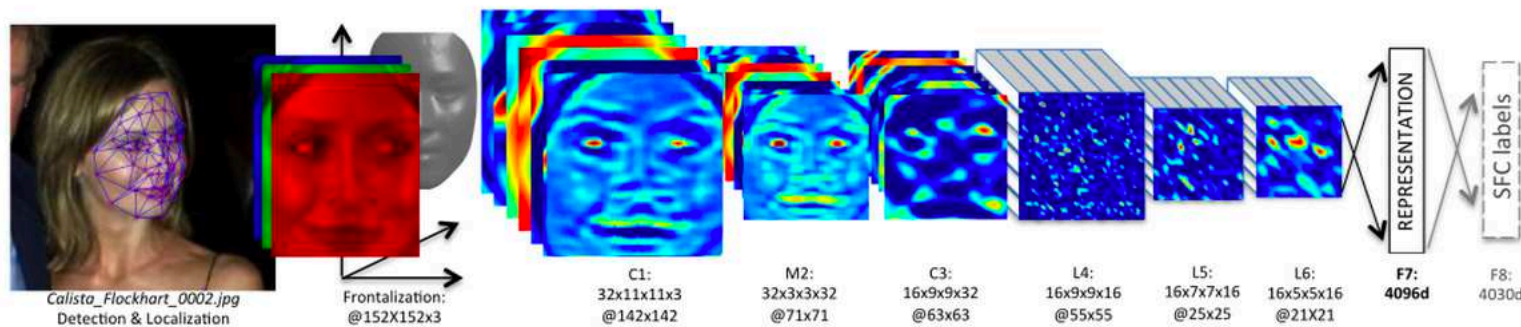


Biometric Milestones



Y. Taigman, M. Yang, M. Ranzato, L. Wolf, "DeepFace: Closing the Gap to Human-Level Performance in Face Verification", CVPR 2014

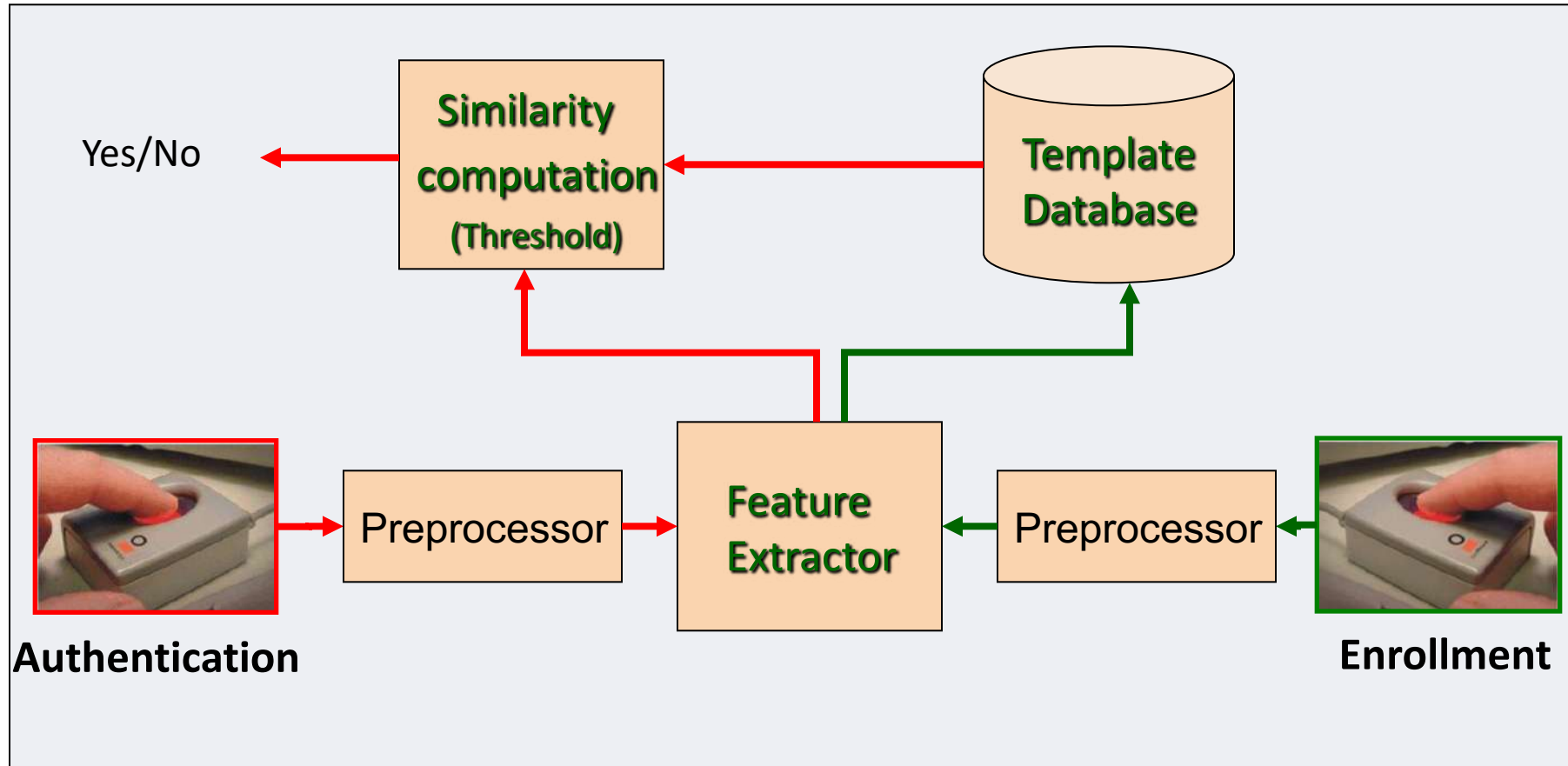
Fingerprint: I
Face: V
Iris: L. I
Voice: S. P



of America, 1963



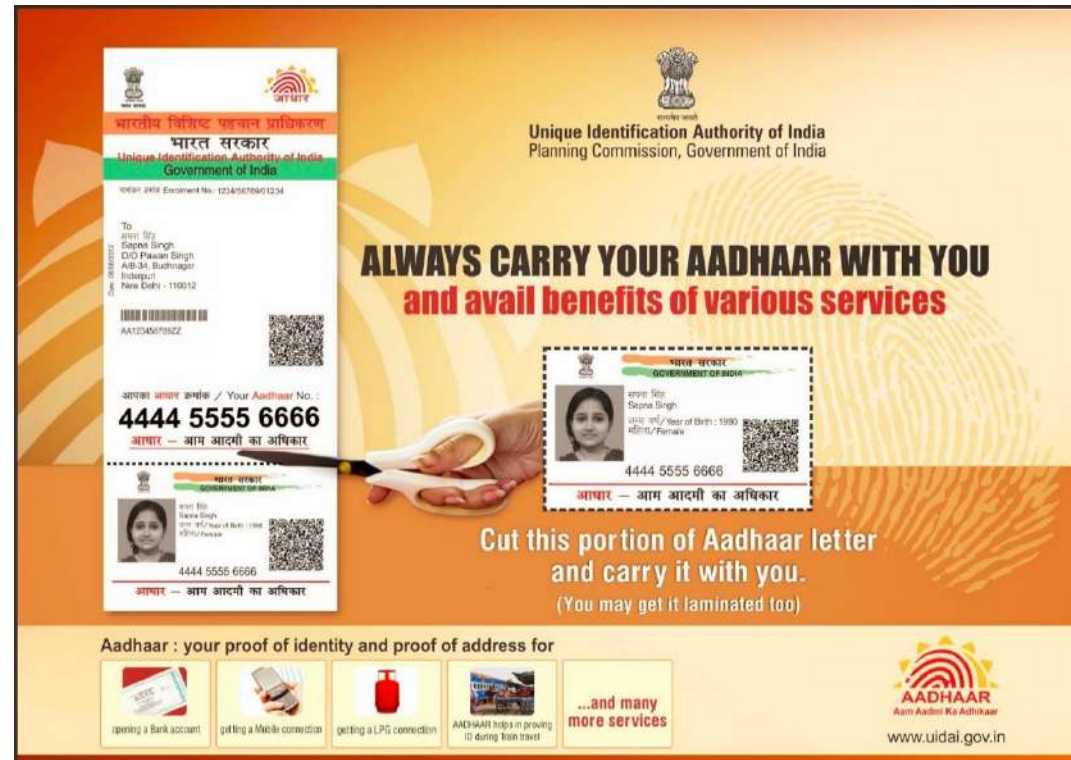
Biometrics Recognition System



- **Learning: Representation (features) & similarity**
- **Operation mode: Authentication (1:1) vs. Search (1:N)**

Aadhaar:

World's Largest Biometric System



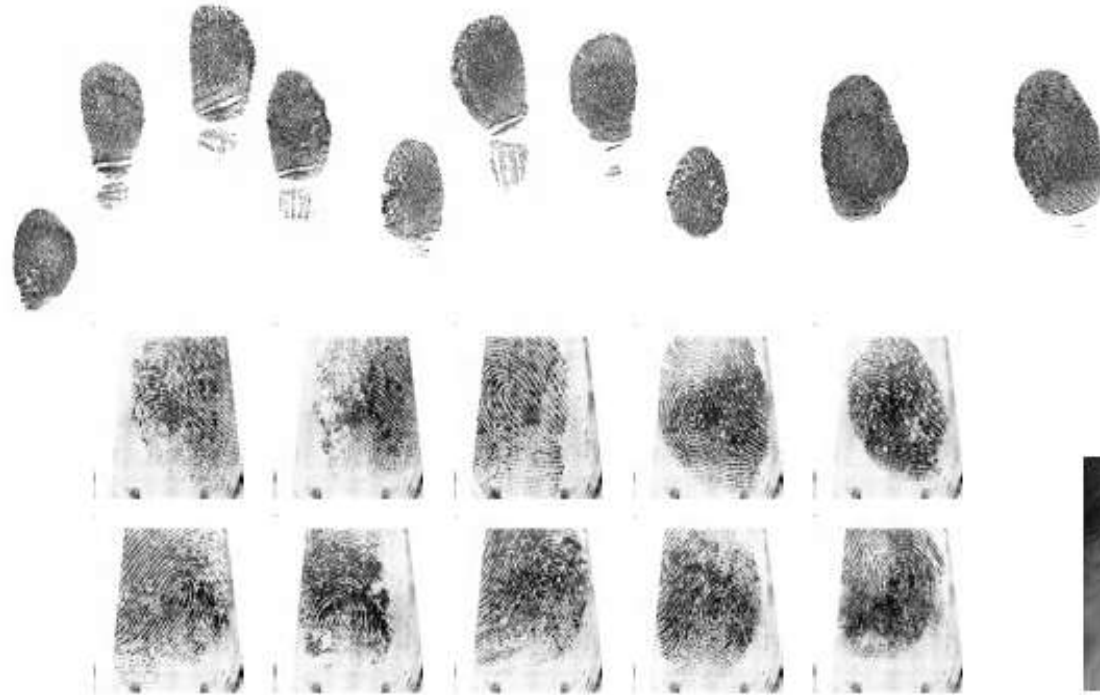
12-digit unique ID

“To empower residents of India with a unique identity and a digital platform to authenticate anytime, anywhere.”

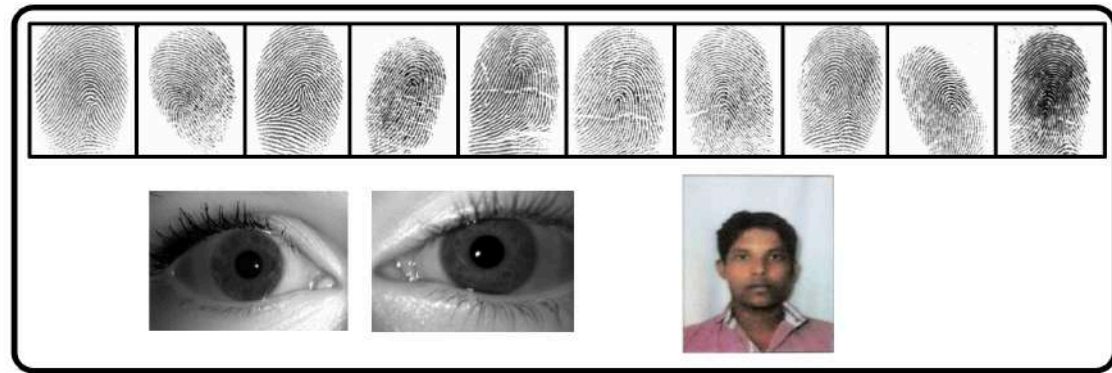
Enrollment



Minimal documentation needed

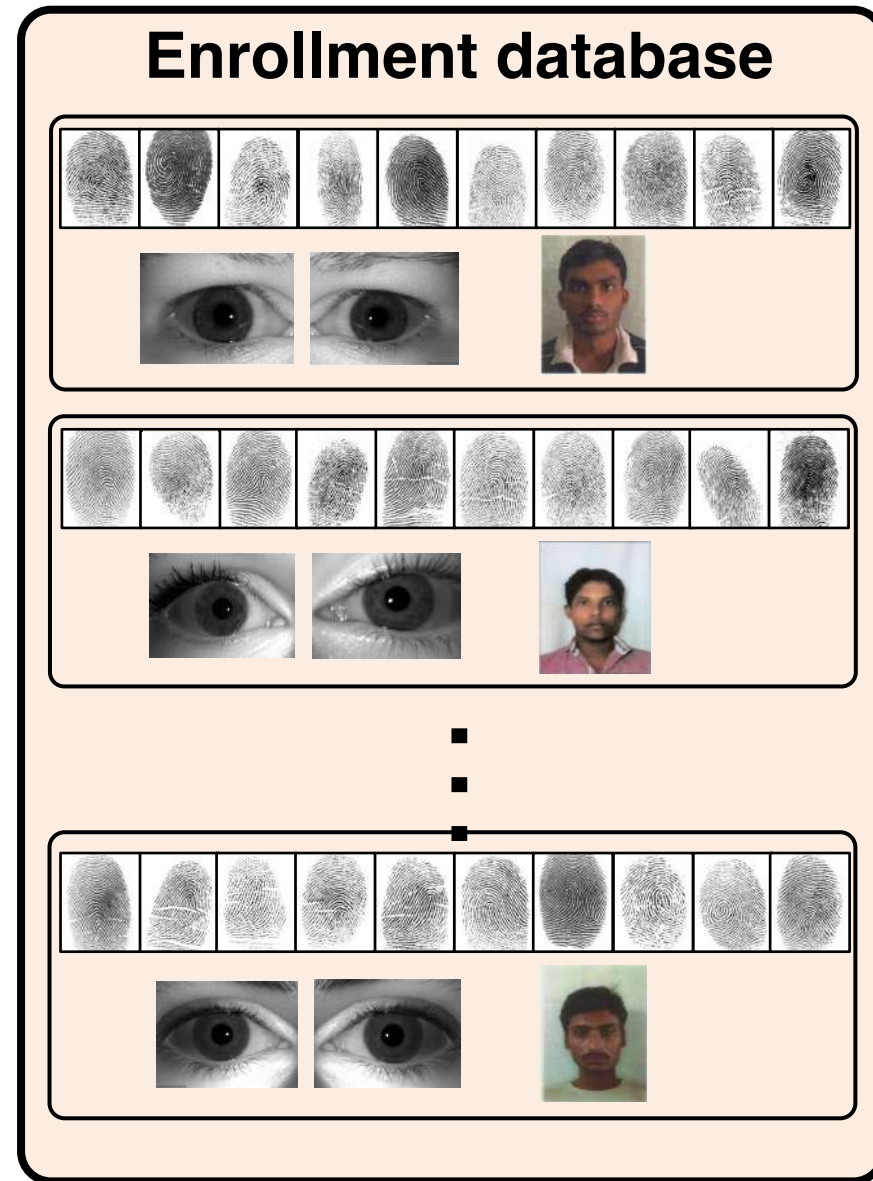


De-duplication



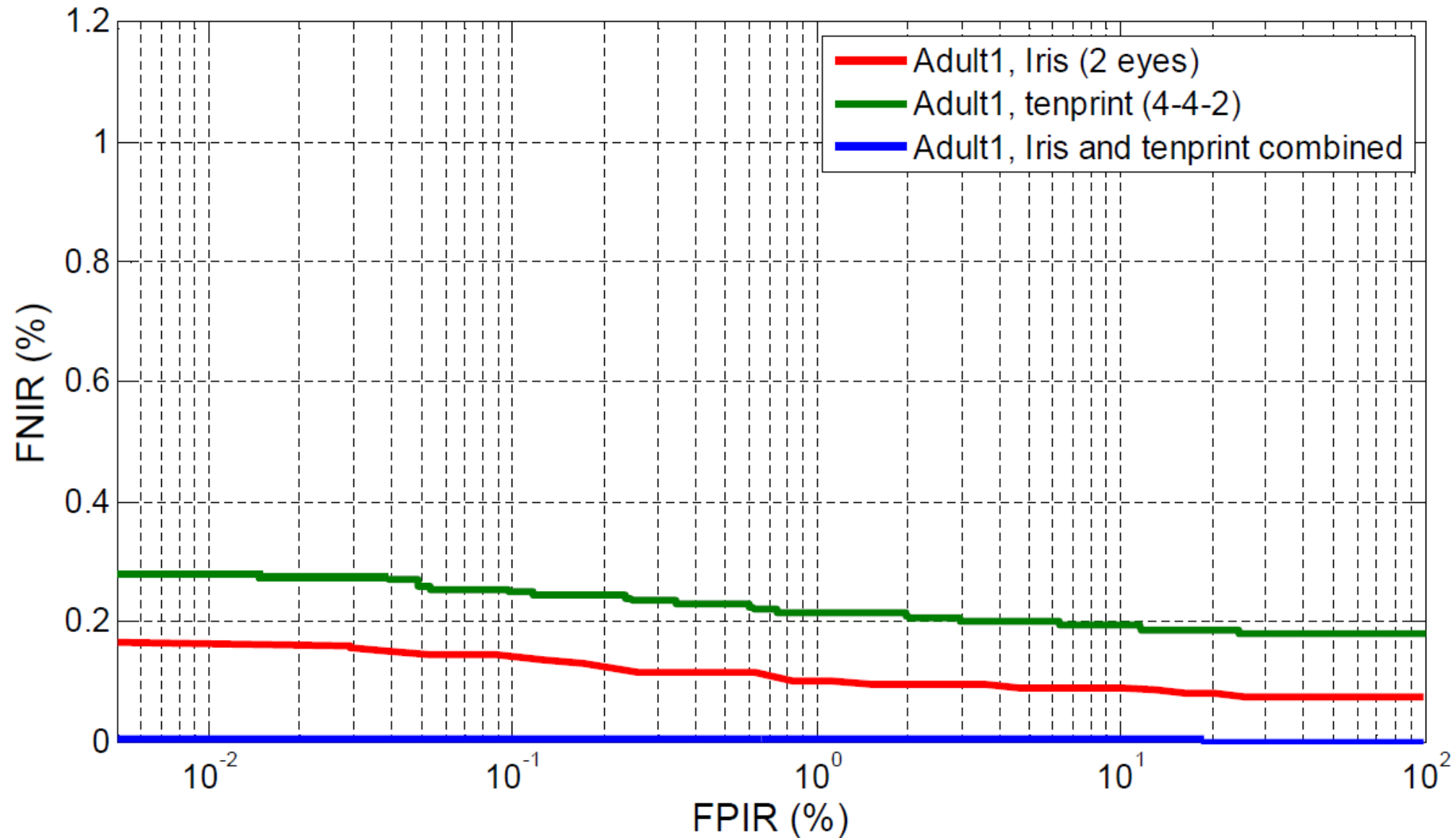
New Applicant

Fusion of face, fingerprint, iris



Already in database?

Biometric Fusion

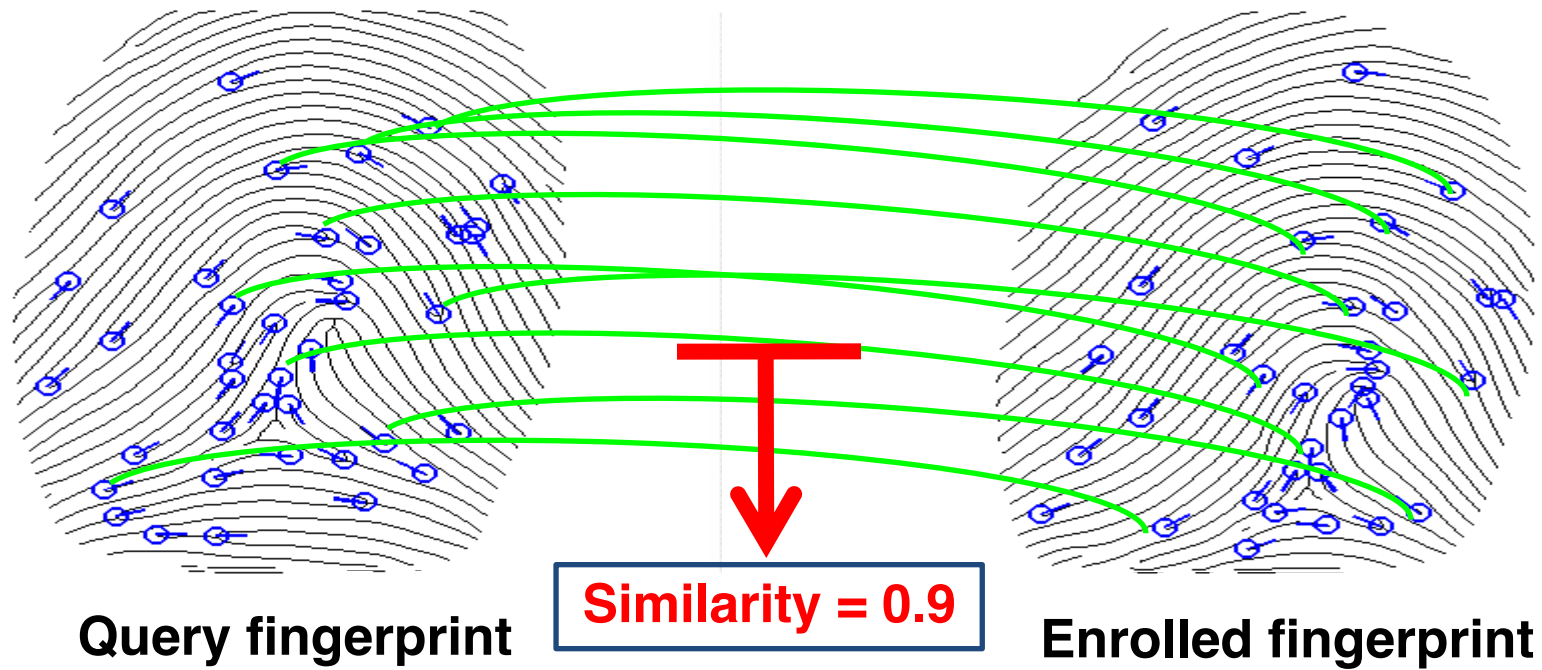


Authentication

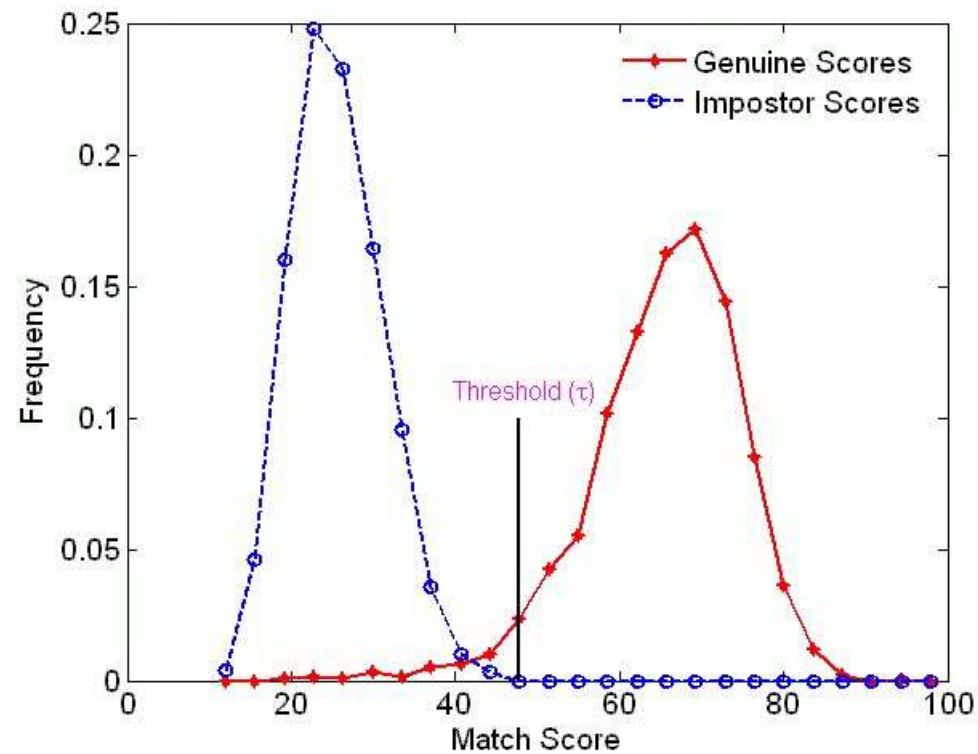


Two-factor authentication

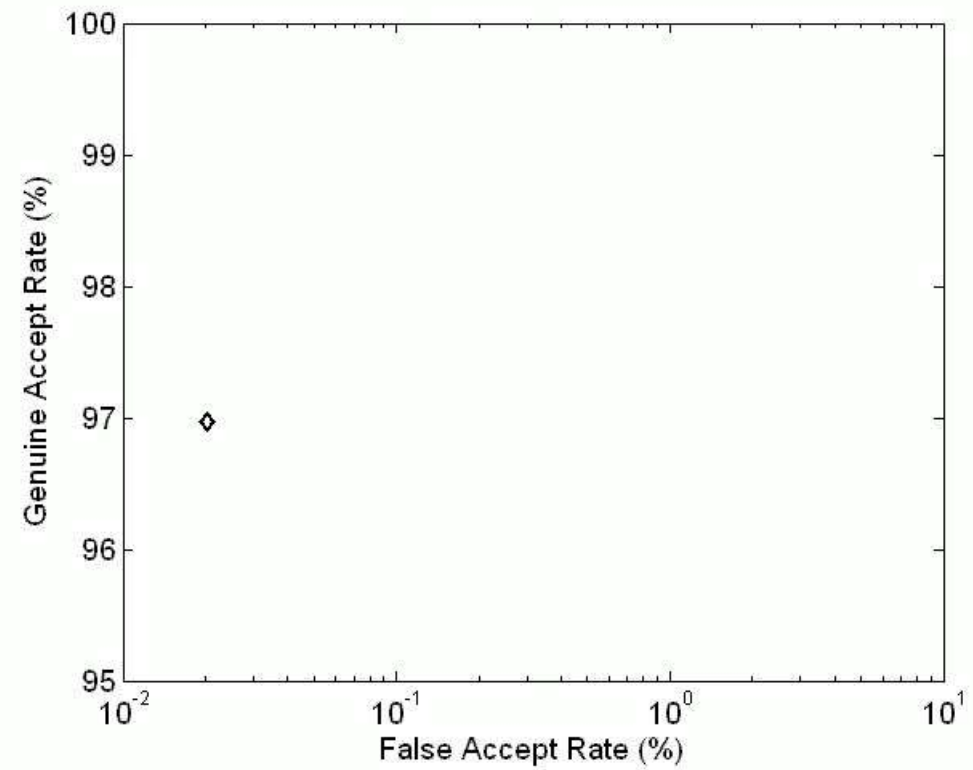
Fingerprint Comparison



Authentication Performance

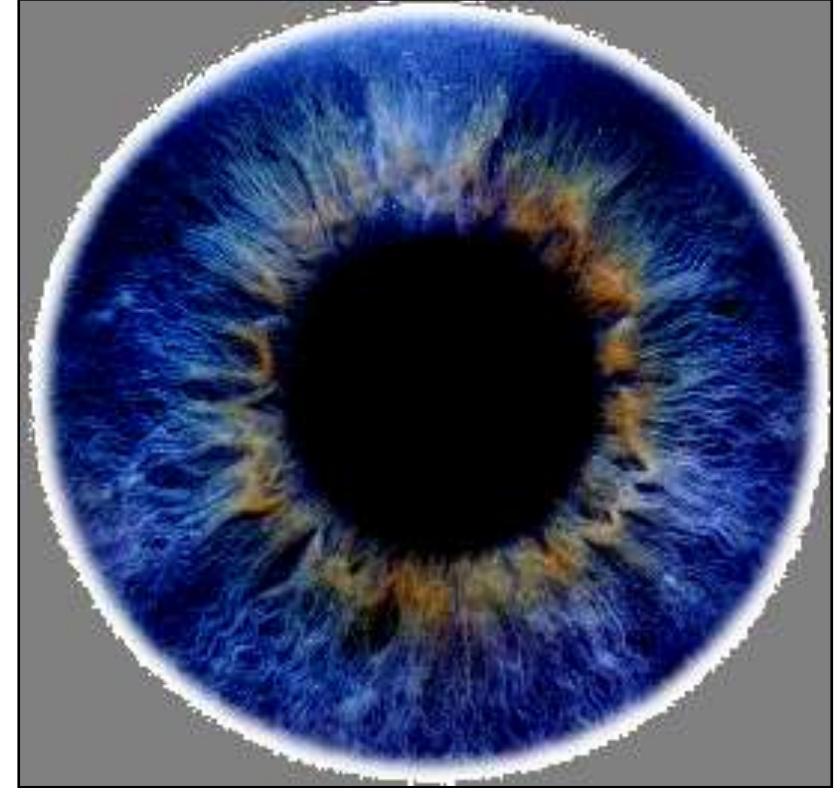


Similarity Score Distribution



ROC Curve

Authentication: State of the Art

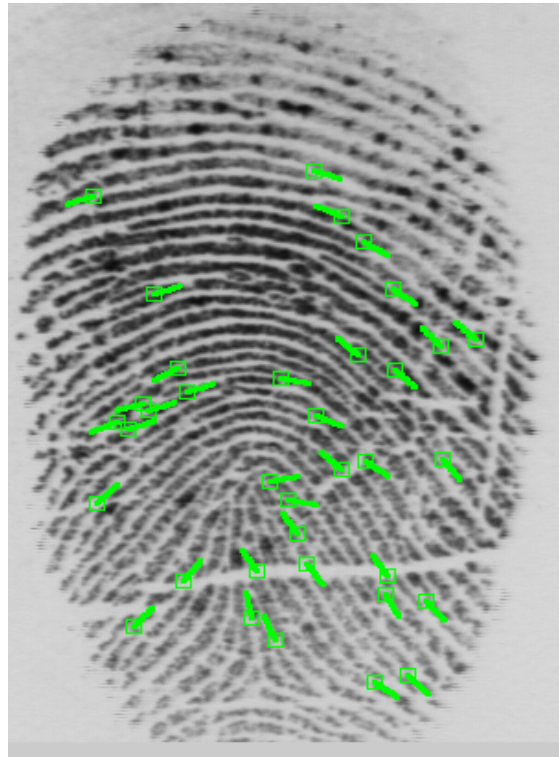


Fingerprint: TAR = 99.96% @ **FAR = 0.01%** (FVC-ongoing)

Iris: TAR = 99.82% @ **FAR = 0.01%** (NIST IREX II)

Face: TAR = 99.7% @ **FAR = 0.1%** (NIST FRVT 2010)

Biometric Image Quality



Growing Popularity of Face



Identity: John Doe

Age: ~ 40

Gender: Male

Ethnicity: White

Hair: Short, Brown

Moustache: Yes

Beard: Yes

Mole: Yes

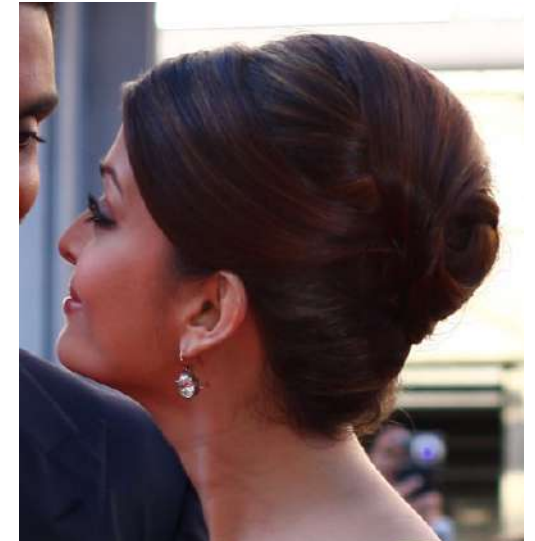
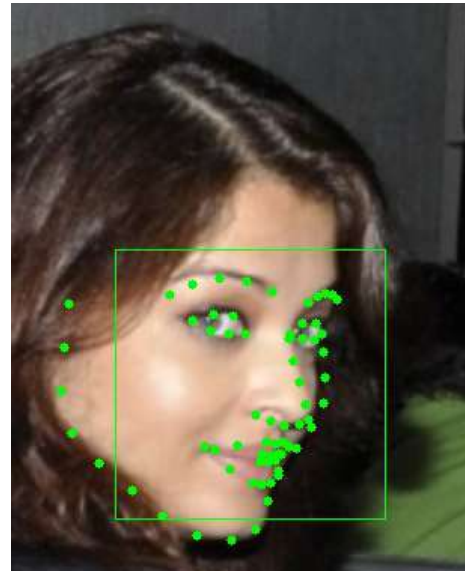
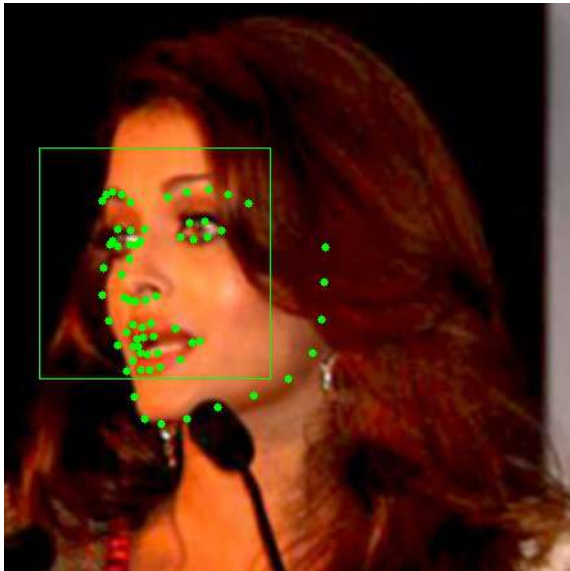
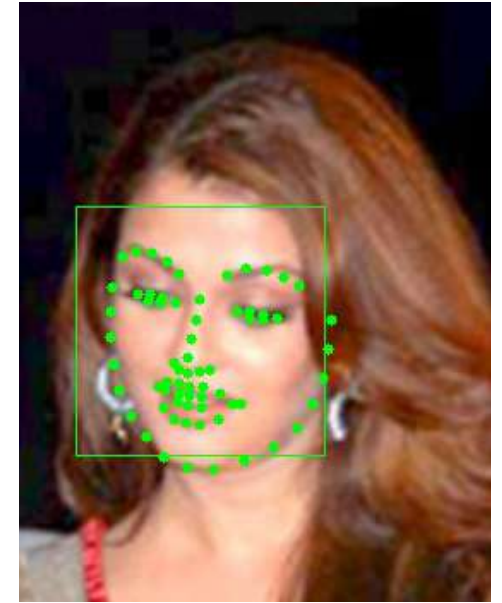
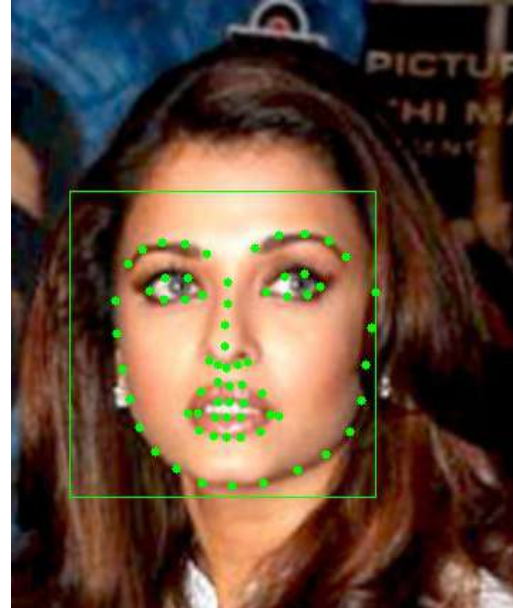
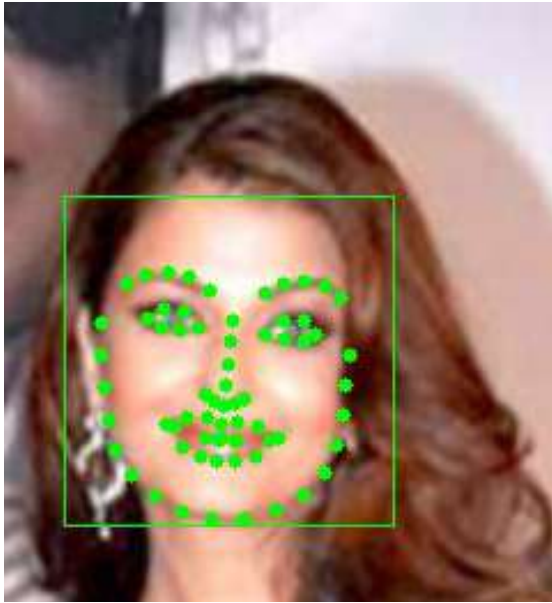
Scar: Yes

Expression: None



Touchless and covert acquisition

Pose, Expression and Illumination



Face Image Quality vs. Performance



LFW (2009)



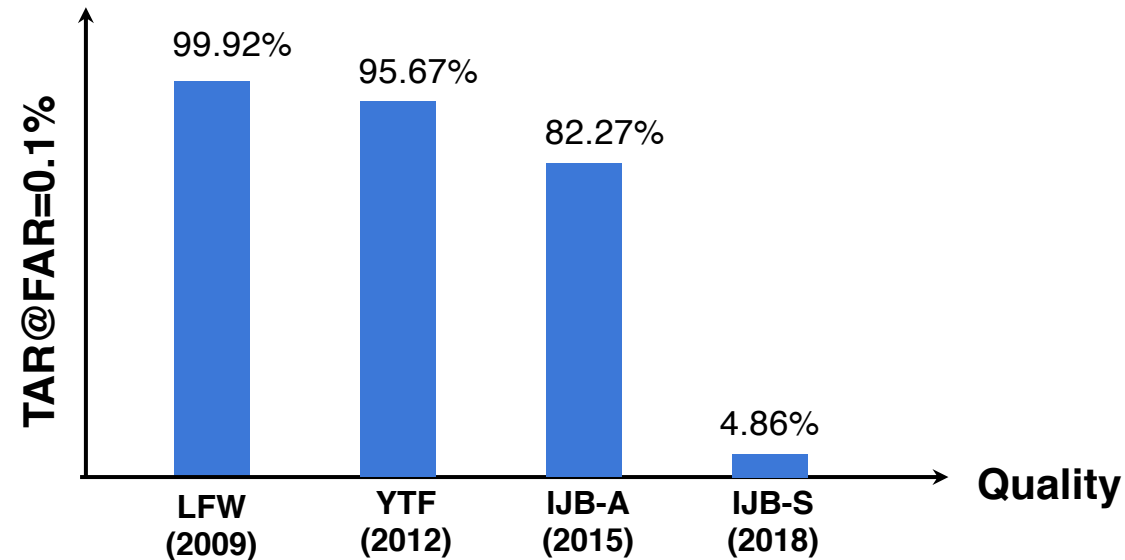
YTF (2012)



NIST IJB-A (2015)



NIST IJB-S (2018)



1:N Search

Probe

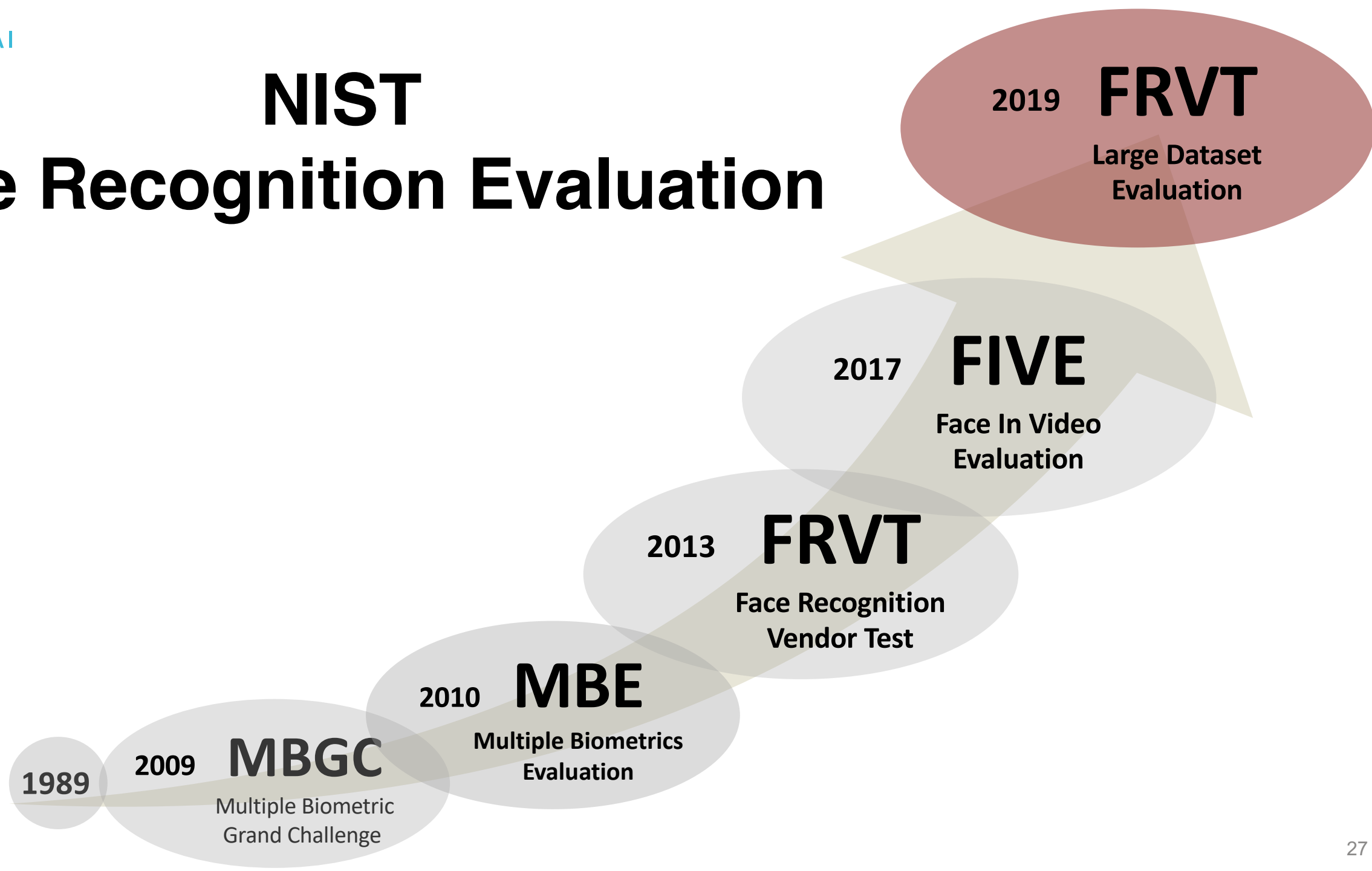


Gallery of size N



Rank-k ($k < N$) search accuracy

NIST Face Recognition Evaluation



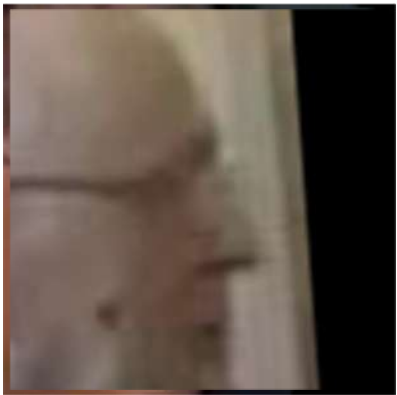
1:N Search Accuracy

Error rates on a 12M Face database (search speed on single core CPU, Intel® Xeon® CPU E5-2630 v4)

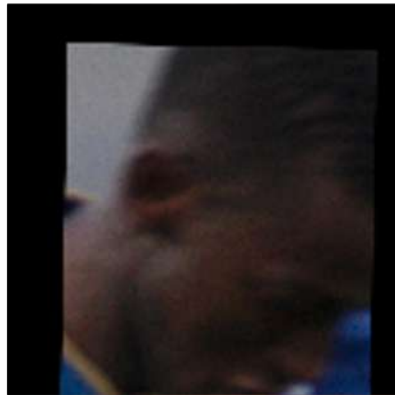
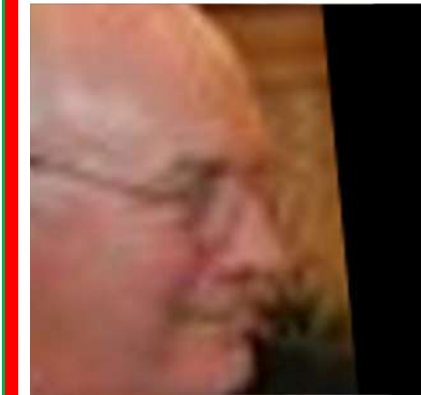
Algorithm	Error Rates <i>FNIR @ FPIR = 0.001</i>	Template Size <i>Bytes</i>	Memory <i>GB</i>	Search Speed* <i>milliseconds</i>
NEC	0.058	1712	20.5	697
Paravision	0.106	4096	49.2	1417
RankOne	0.116	165	2.0	393
Innovatrics	0.142	1076	12.9	414
Microsoft	0.154	1024	12.3	2312
Idemia	0.166	528	6.3	880
Cognitec	0.184	2052	24.6	2088
Neurotechnology	0.214	2048	24.6	1604
Toshiba	0.214	1548	18.6	7250
Cogent	0.224	1043	12.5	3131
Aware	0.264	3100	37.2	924

* Search time includes template generation and search speed https://pages.nist.gov/frvt/reports/1N/frvt_1N_report.pdf

Search Errors



Probe



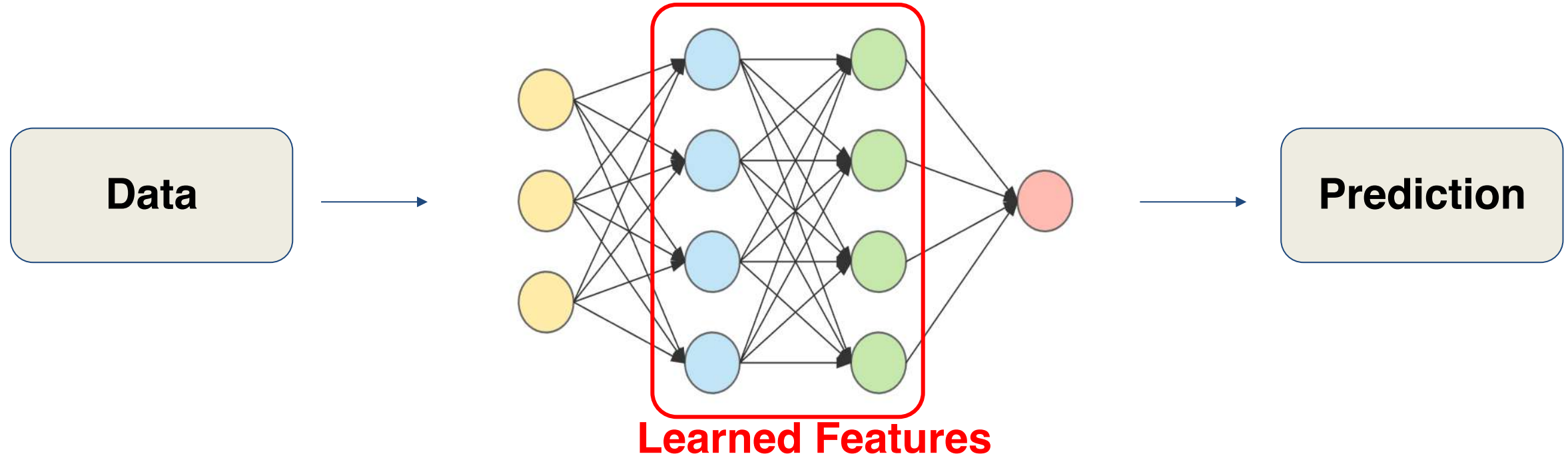
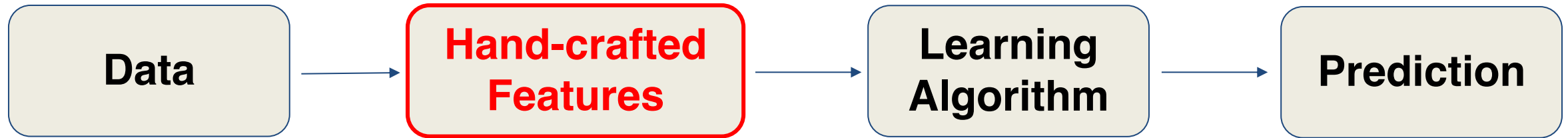
Top-5 Retrievals

Results on IJB-C using ArcFace* (Rank-1 retrieval = 94%)

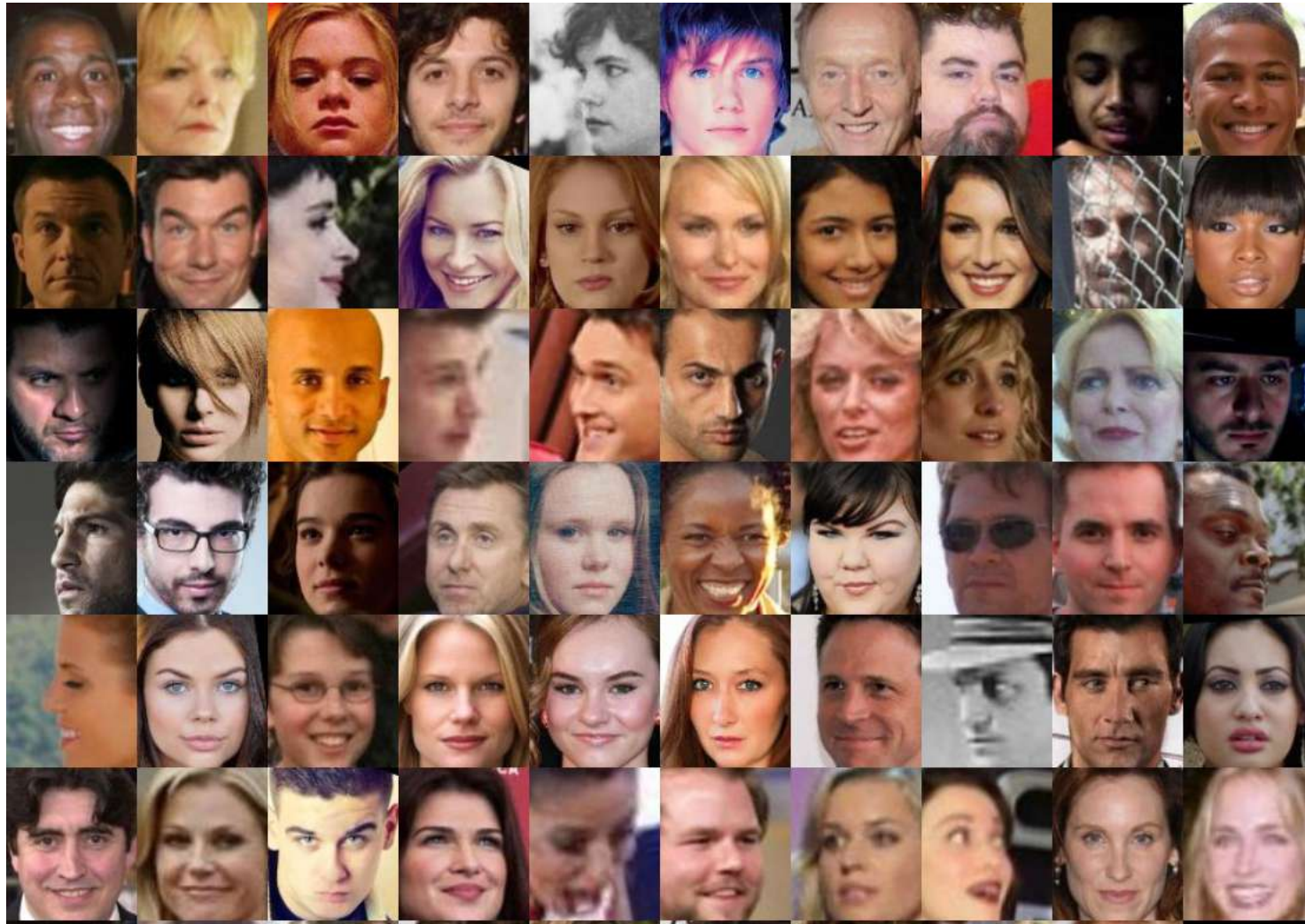
Enablers & Challenges

Deep Networks

End-to-end approach to jointly learn features and predictor



Large-Scale Annotated Datasets



MS1M: 5.8M *images* from 85K subjects collected from the web

Faster Computation



NVIDIA Tesla V100

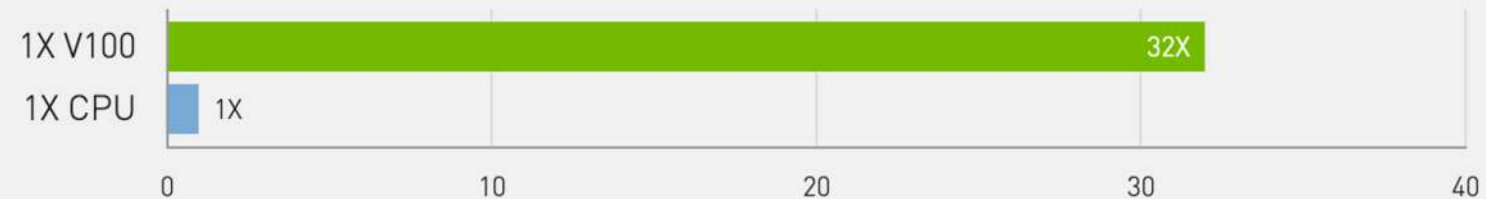
RAM: 32-64 GB

Tensor Performance: 100 TFLOPS

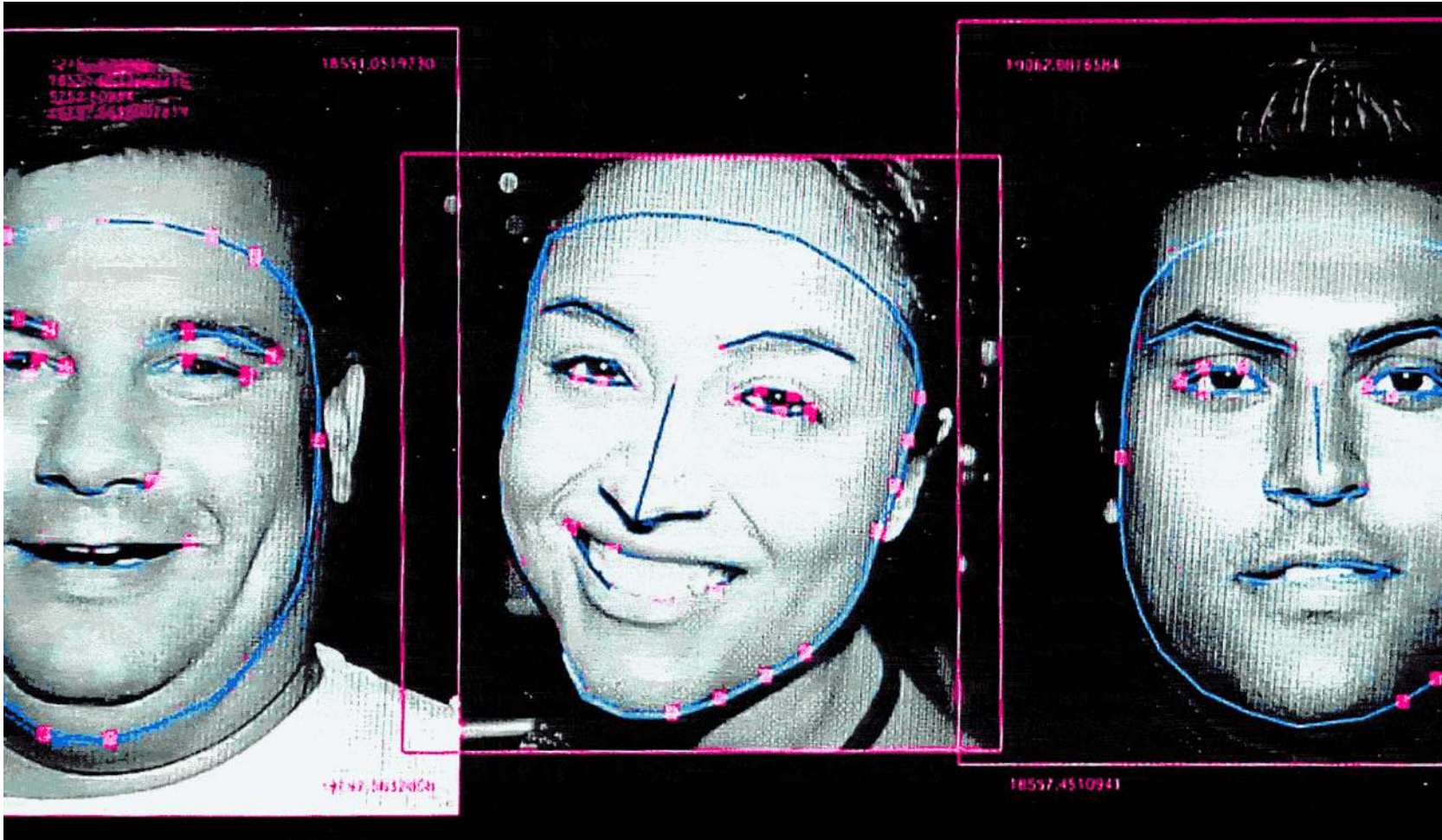
Memory Bandwidth: 900GB/s

Cost: \$10,664

32X Faster Training Throughput than a CPU



Privacy Concerns



Concerns about our faces being used without our consent

<https://www.nbcnews.com/tech/internet/facial-recognition-s-dirty-little-secret-millions-online-photos-scraped-n981921>

Face Aging

Jan 1995



Gallery seed

Jul 1998



Score=0.99

Nov 1999



Score=0.62

Nov 2003



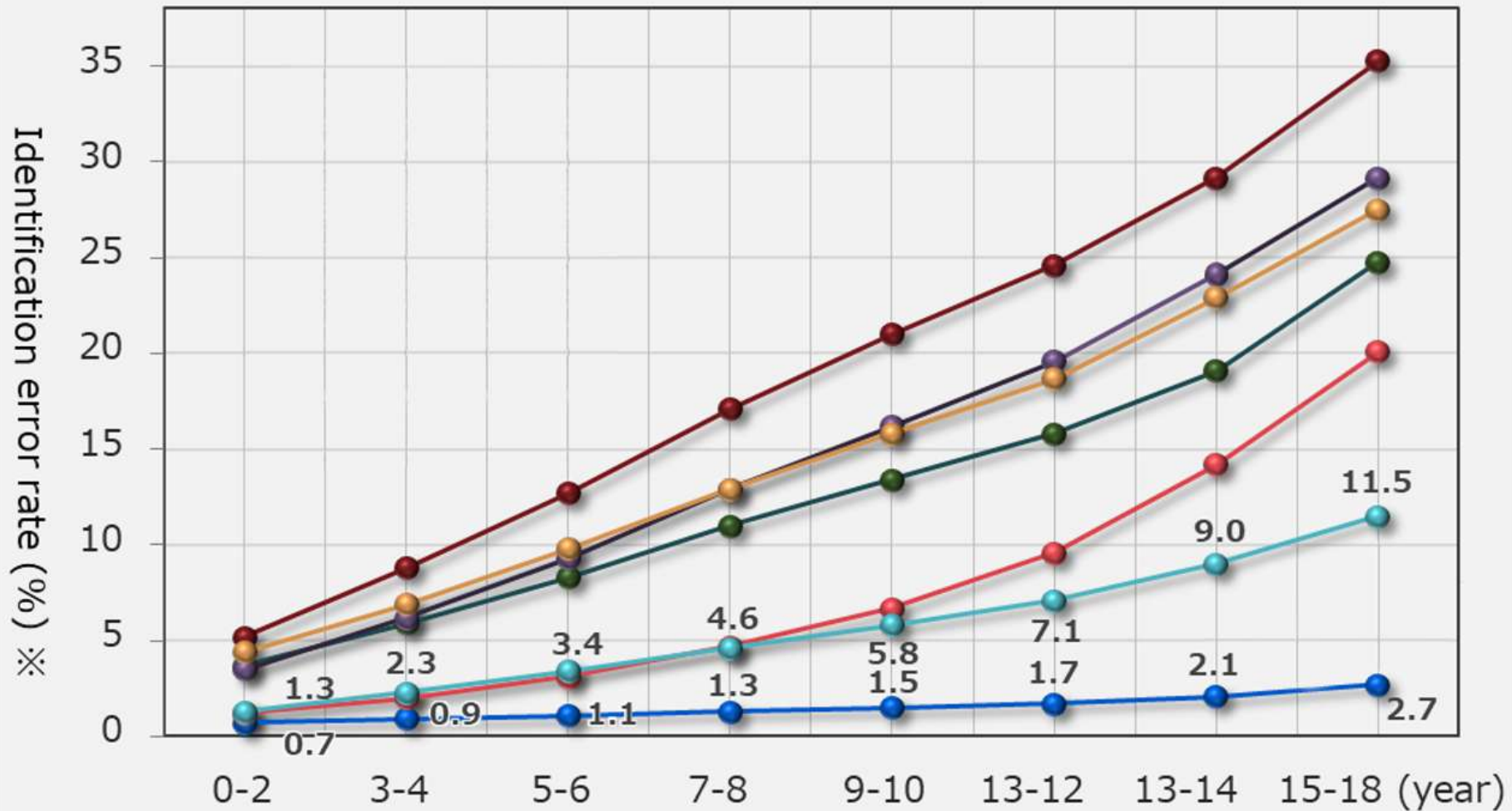
Score=0.41

Feb 2005



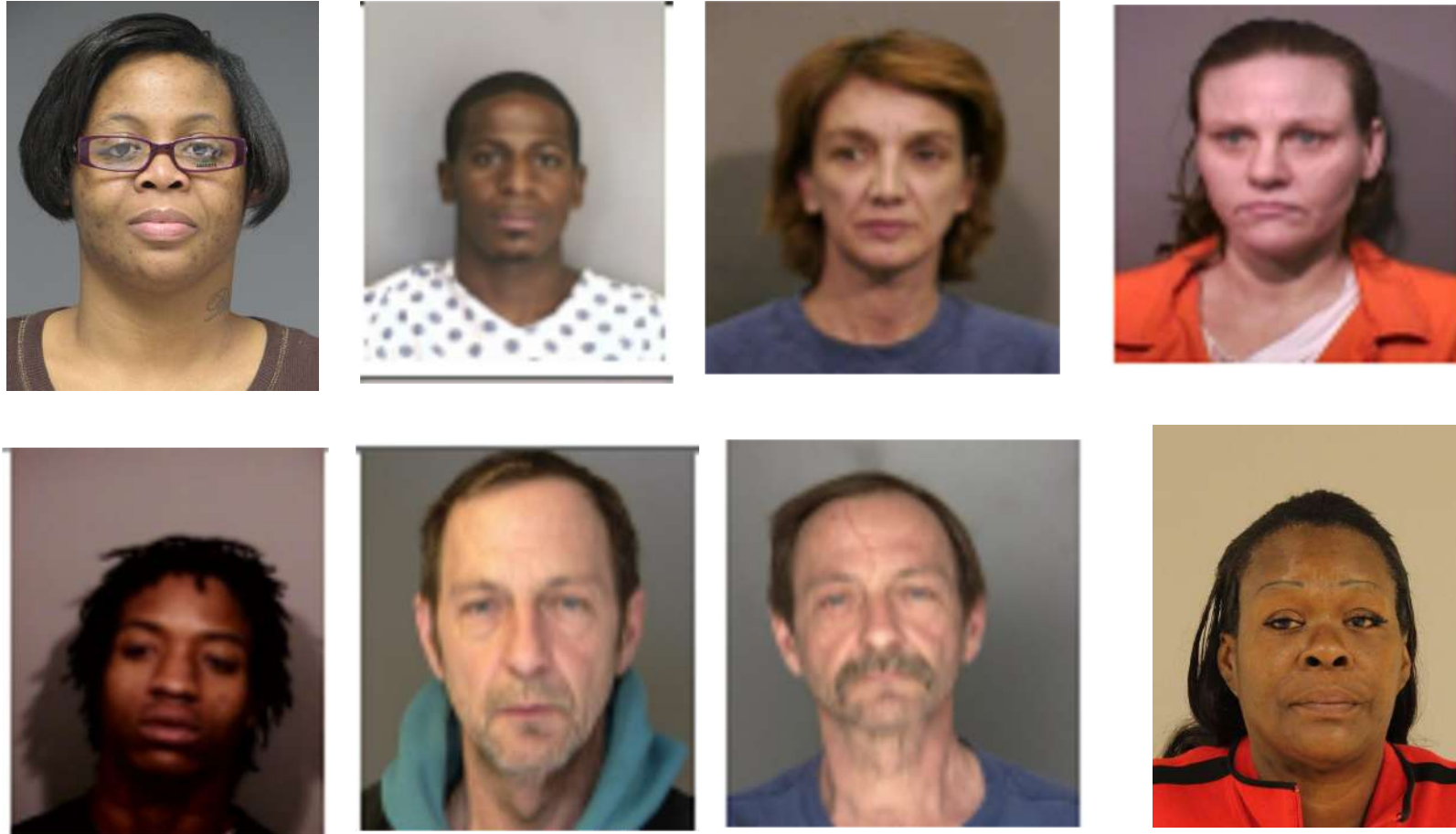
Score=0.26

Algorithm Accuracies Over Aging Photos



※ False-rejection discrimination rate at a false acceptance discrimination rate of 0.1% at the time of registration of 31000 people

Fairness of Face Recognition



**Can we ensure the same recognition accuracy for different demographic groups:
white females, black females, black males and white males?**

Twins



www.cbsnews.com/8301-503543_162-57508537-503543/chinese-mom-shaves-numbers-on-quadruplets-heads

Doppelgänger



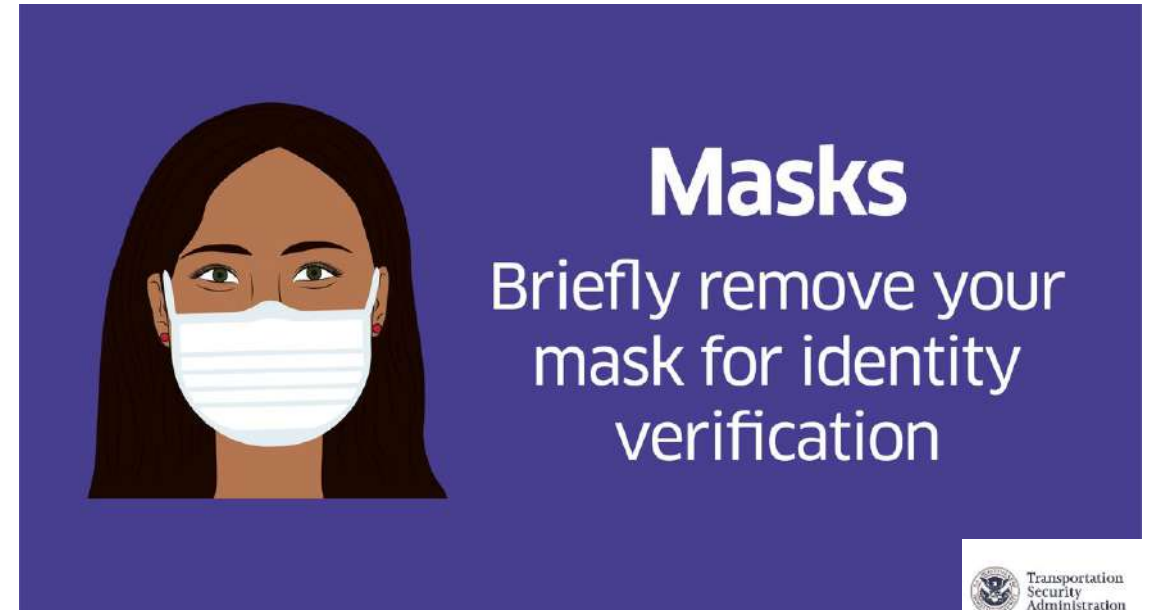
Ilham Anas, a photographer from Java, travels the world cashing in on his uncanny resemblance to the former US president Obama

Scars, Marks & Tattoos



Detroit police linked at least six armed robberies at an ATM on the city's west side after matching up a tipster's description of the suspect's distinctive tattoos

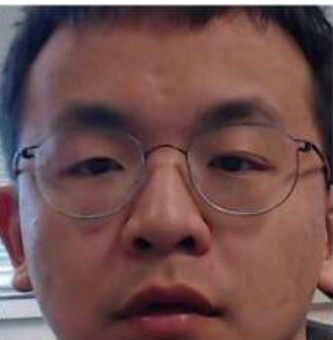


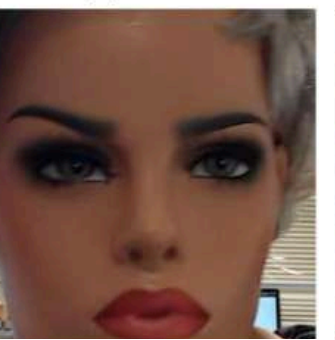
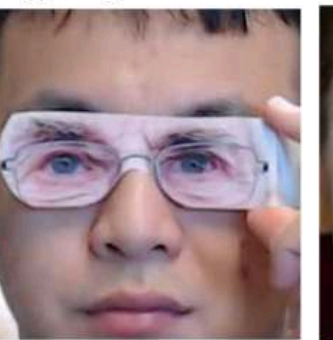
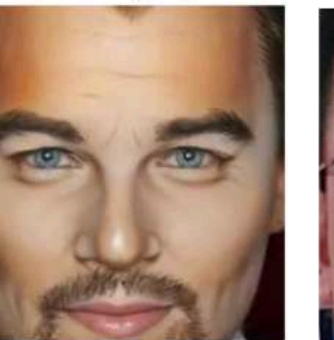



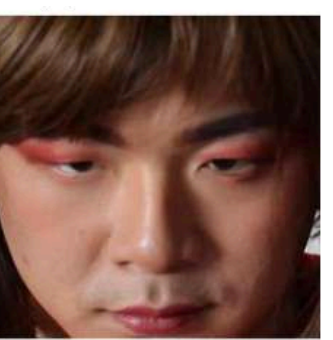

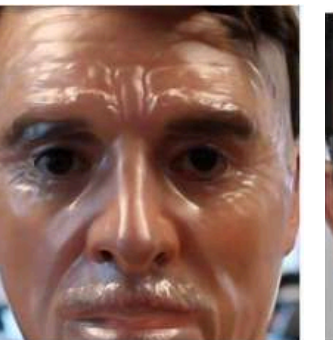
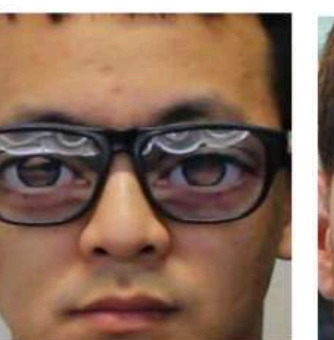

Face Occlusion



Fingerprint Spoof Buster Demo



Face Spoofs

						
Live	Paper Mask	Half Mask	Mannequin	Paper Cut	Impersonation	Replay
TAR @ 2.0% FAR:	100%	96%	95%	95%	90%	72%
						
Silicone Mask	Print	Cosmetic	Paper Glasses	Transparent	FunnyEye	Obfuscation
56%	51%	44%	43%	39%	33%	31%

All spoofs except Mannequin, Impersonation, Transparent, and Obfuscation belong to the same person in Live

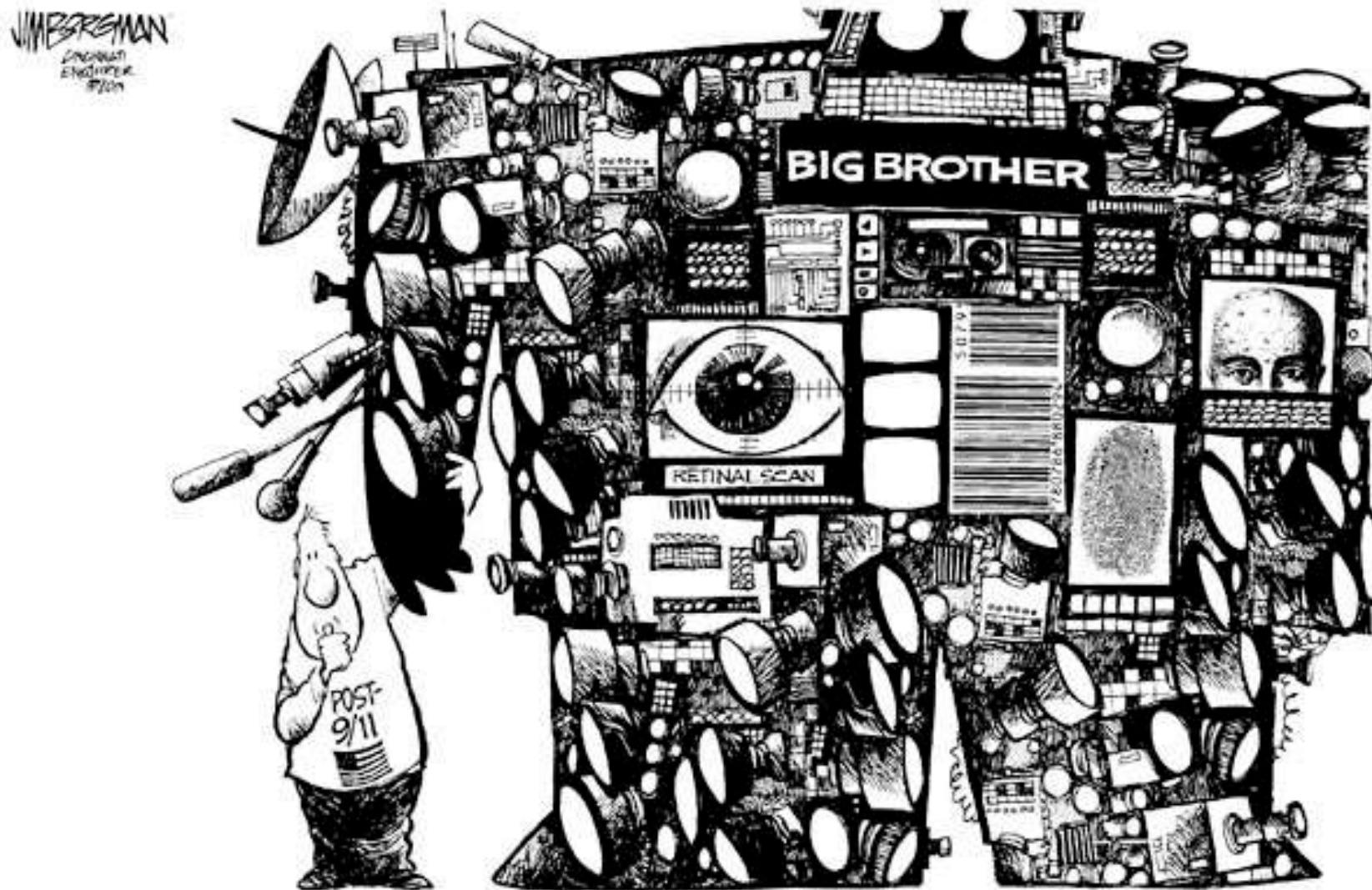
Chongqing: World's Most Heavily Surveilled City



2.58 m cameras for 15 m people (one camera/six residents); 1 billion worldwide by 2021

<https://www.theguardian.com/cities/2019/dec/02/big-brother-is-watching-chinese-city-with-26m-cameras-is-worlds-most-heavily-surveilled>

Security vs. Privacy




Wrongfully Accused!

A shoplifter stole five watches, worth \$3,800, from a Detroit store; CCTV frame searched with 49 m gallery

“This is not me,” Williams told police.
“You think all Black men look alike?”





MICHIGAN STATE POLICE



INVESTIGATIVE LEAD REPORT

LAW ENFORCEMENT SENSITIVE



THIS DOCUMENT IS NOT A POSITIVE IDENTIFICATION. IT IS AN INVESTIGATIVE LEAD ONLY AND IS NOT PROBABLE CAUSE TO ARREST. FURTHER INVESTIGATION IS NEEDED TO DEVELOP PROBABLE CAUSE TO ARREST.

BID DIA Identifier: BID-39641-19 Date Searched: 03/11/2019 Digital Image Examiner: Jennifer Coulson	Requester: CA Yager, Rathe Requesting Agency: Detroit Police Department Case Number: 1810050167 File Class/Crime Type: 3000
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Probe Image	Investigative Lead
	

Scalability

Current World Population

7,805,229,451

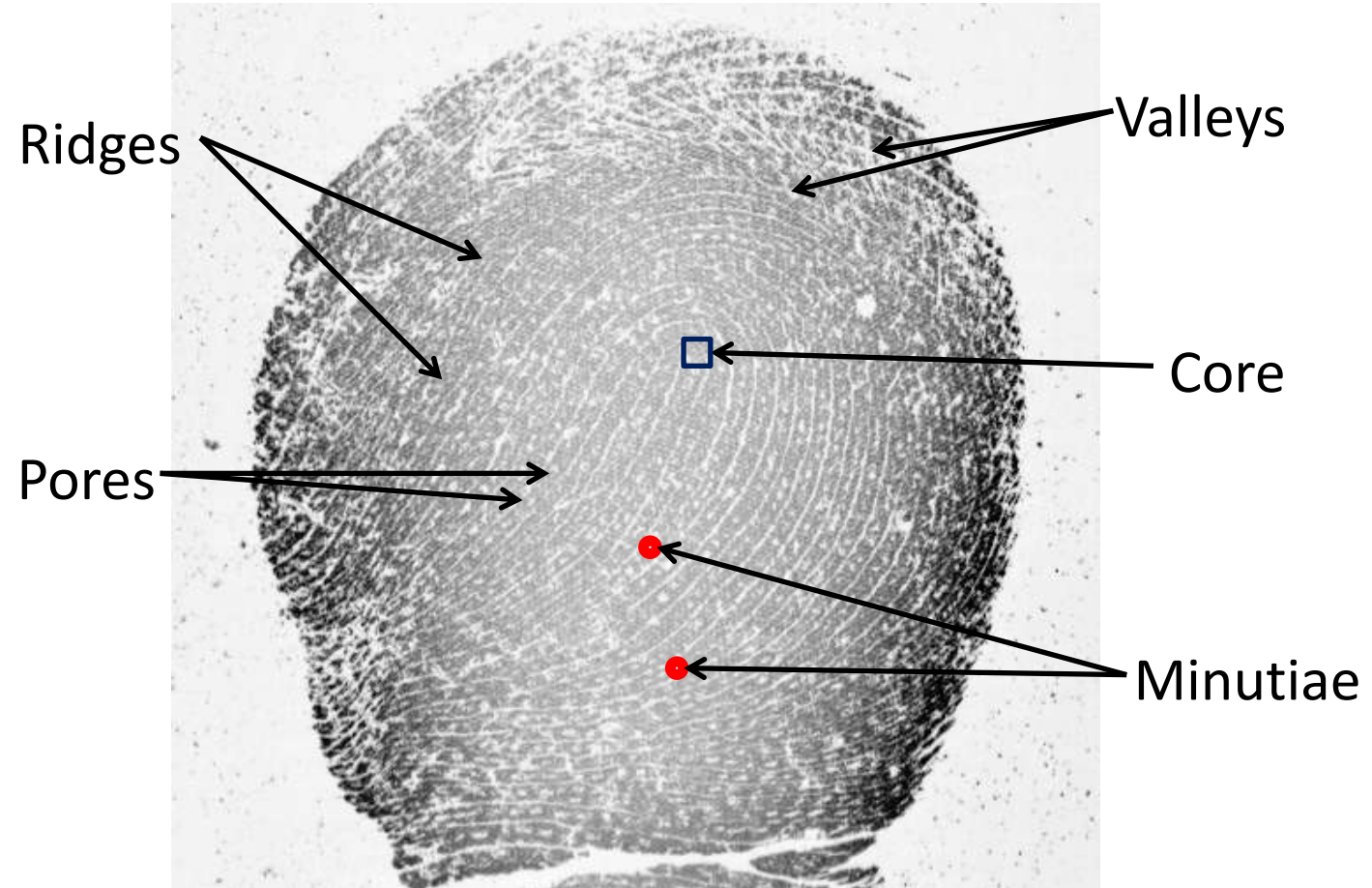
- World population (2020) = 7.8 billion; #births/year = 130 million; projected to increase to 9.8 billion in 2050
- The United Nations Sustainable Development Goal (SDG) Target 16.9: **“to provide legal identity for all, including birth registration” by 2030**

<https://www.worldometers.info/world-population/>

Infant-ID



6-hour old baby



Engelsma, Deb, Jain, Sudhish, Bhatnagar, "Infant-Prints: Fingerprints for Reducing Infant Mortality", in CVPR Workshop on CV4GC, 2019

Summary

- Biometrics is here to stay; it is the only way to verify *who you claim you are?* and *who are you?*
- Applications: enhance security, cut financial fraud, verifiable national ID, secure access control, ...
- Challenges:
 - Recognition in unconstrained acquisitions (e.g., surveillance)
 - Guard against biometric spoofs and template manipulation
 - Protect user privacy and their civil liberties

Contacts

Have any questions?

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Thank you

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