Automated Face Recognition

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The iPRoBe Lab

http://iprobe.cse.msu.edu **https://twitter.com/iPRoBeLab**

- Integrated Pattern Recognition and Biometrics Lab
- Currently: 8 PhD Students + 2 Post-Docs +1 UG Student
- Graduated: 24 MS Thesis Students + 8 PhD Students

Research Theme

- **Adversarial Biometrics**
  - Spoofing Biometric Traits
  - Digitally Altered Biometric Data
  - Degraded Biometric Data
- **Ethics and Privacy**
  - What Else Does Your Biometric Data Reveal?
  - Privacy Preserving Biometrics
- **Biometric Fusion**
  - Multiple Biometrics
  - Multispectral Biometrics
  - Biometrics + Demographics + Spoof Detector + Quality

Related Resources

- A. K. Jain and A. Ross, "Bridging the Gap: From Biometrics to Forensics," Philosophical Transactions of The Royal Society B, Vol. 370, Issue 1674, August 2015.
- A. K. Jain, K. Nandakumar, A. Ross, "50 Years of Biometric Research: Accomplishments, Challenges, and Opportunities," Pattern Recognition Letters, Vol. 79, pp. 80 - 105, August 2016.
- A. Ross, S. Banerjee, C. Chen, A. Chowdhury, V. Mirjalili, R. Sharma, T. Swearingen and S. Yadav, "Some Research Problems in Biometrics: The Future Beckons," Proc. of 12th IAPR International Conference on Biometrics (ICB), (Crete, Greece), June 2019.
- A. K. Jain, B. Klare, A. Ross, "Guidelines for Best Practices in Biometrics Research," Proc. of 8th IAPR International Conference on Biometrics (ICB), (Phuket, Thailand), May 2015.

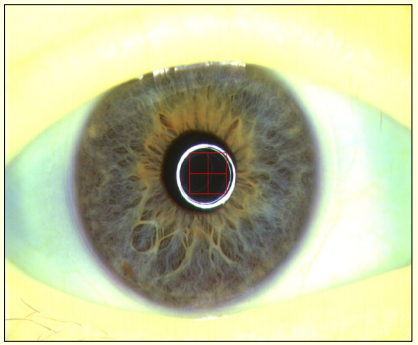
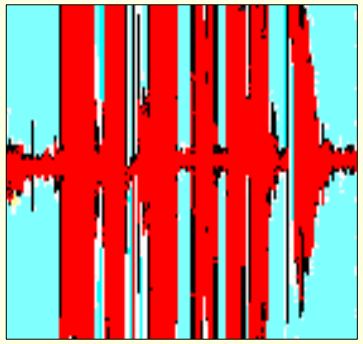
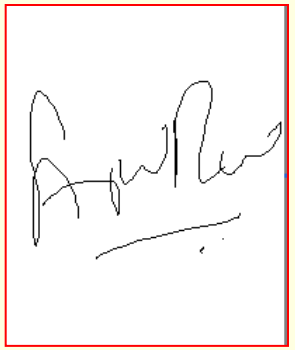
Biometrics

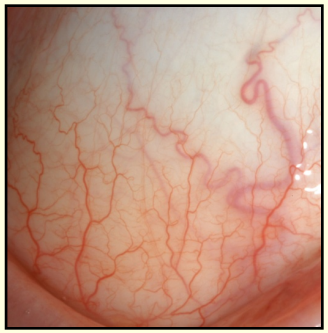
- Automated recognition of individuals based on their **biological** and **behavioral** characteristics
- Traits from which **distinguishing**, **repeatable** features can be extracted

H.T. F. Rhodes, Alphonse Bertillon: Father of Scientific Detection, 1956

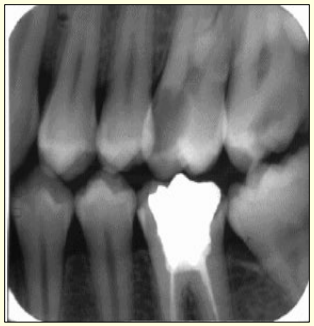
Biometric Traits



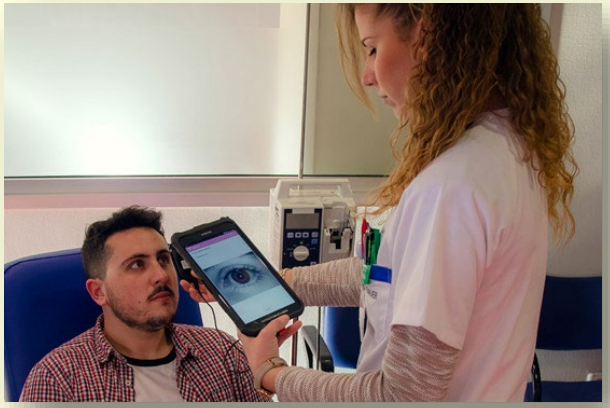







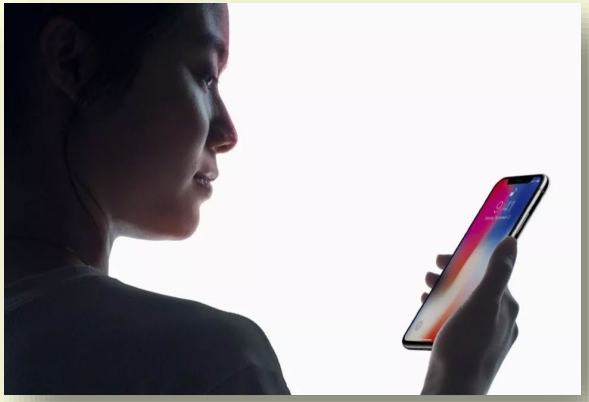


Biometric Applications

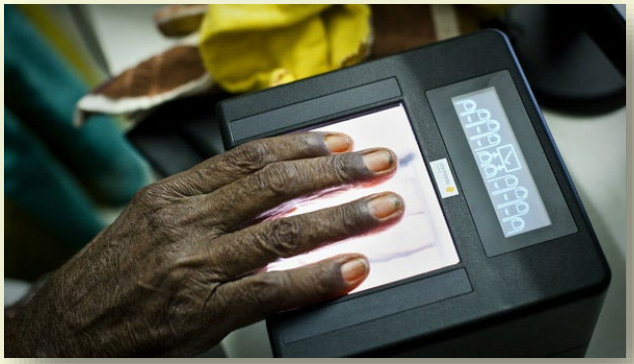


Iris: Health Care

Fingerprint: US OBIM



Face: Apple Face ID



Fingerprint: Refugee Services

Finger Vein: Japan ATMs

Automated Face Recognition

- Given two face images, estimate two numbers:
  - the likelihood that they are of the same person
  - the likelihood that they are of different people

Components of a Biometric System

- **Sensor**: To acquire face image
- **Feature extractor**: To extract a set of discriminative features from the image
- **Matcher**: To compare two extracted feature sets
- **Database**: To store face templates of individuals

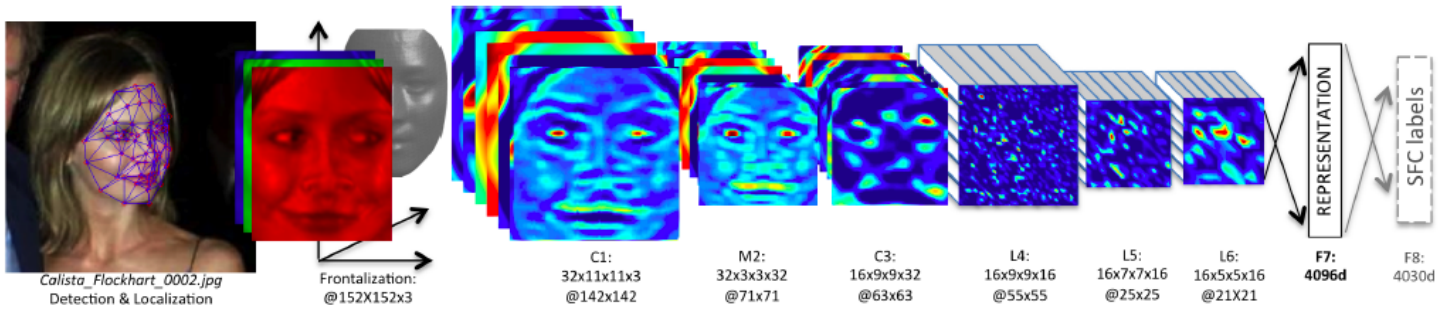
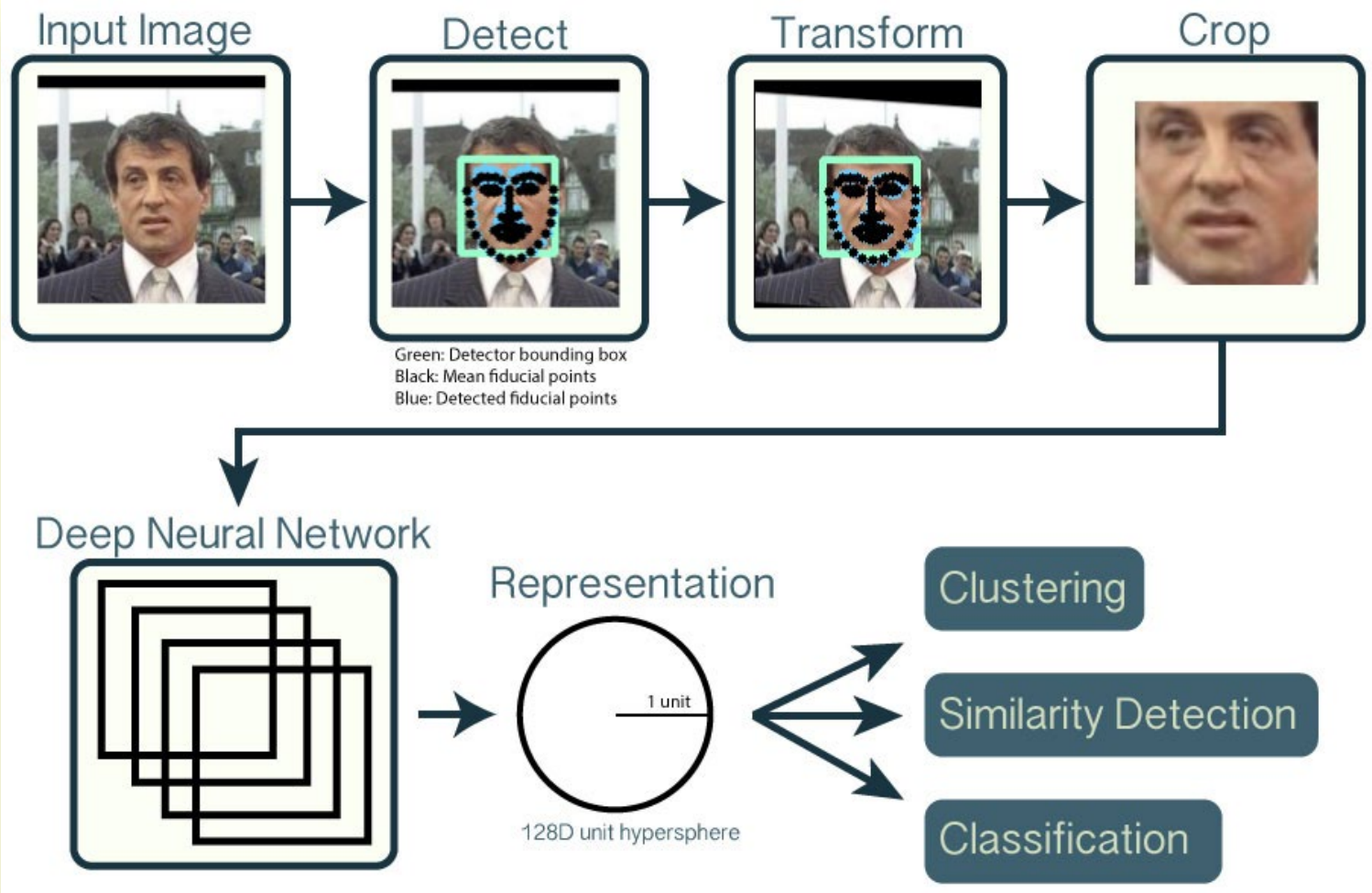


Figure 2. **Outline of the *DeepFace* architecture**. A front-end of a single convolution-pooling-convolution filtering on the rectified input, followed by three locally-connected layers and two fully-connected layers. Colors illustrate outputs for each layer. The net includes more than 120 million parameters, where more than 95% come from the local and fully connected layers.

Deep Neural Networks



© https://cmusatyalab.github.io/openface/

Verification vs Identification

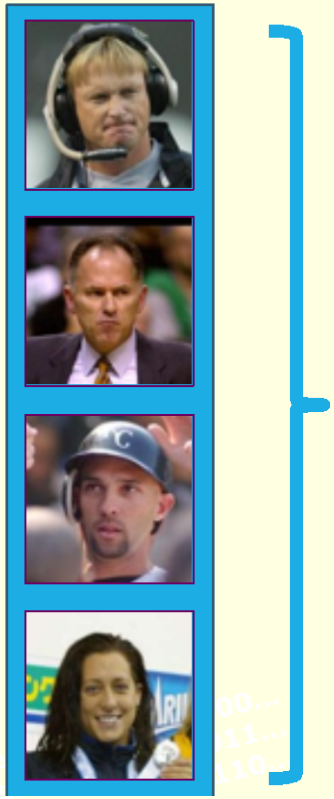
Verification

(Known Image of Claimed Identity)

MATCH / NON-MATCH

Identification

Gallery



RANKED LIST OF MATCHES

Intra-user variations

© Nostra

FNMR: False Non-Match Rate (False Negative)

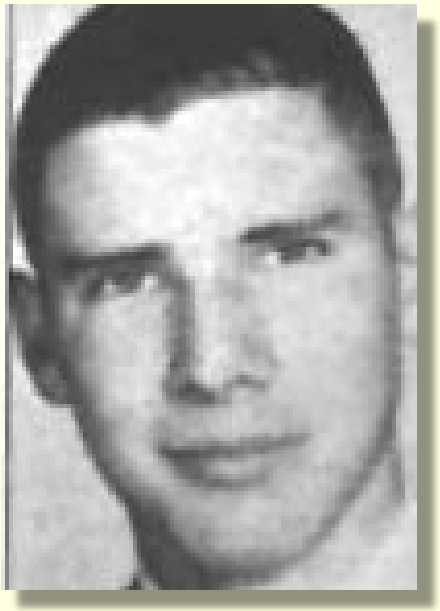
Inter-user similarity

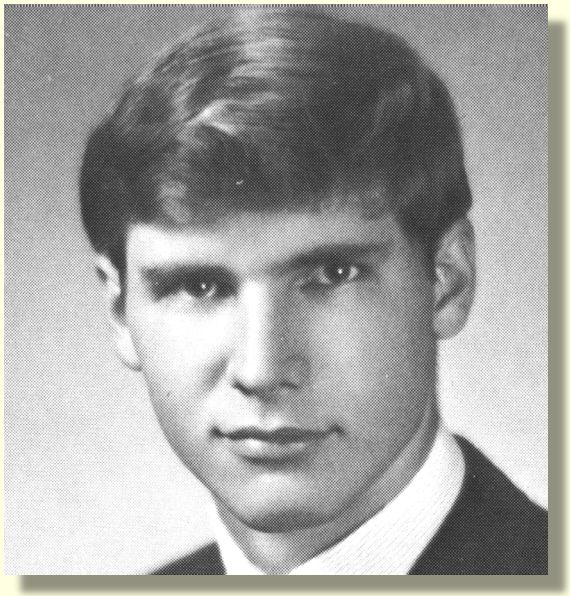
TWIN BROTHERS
© Martin Schoeller

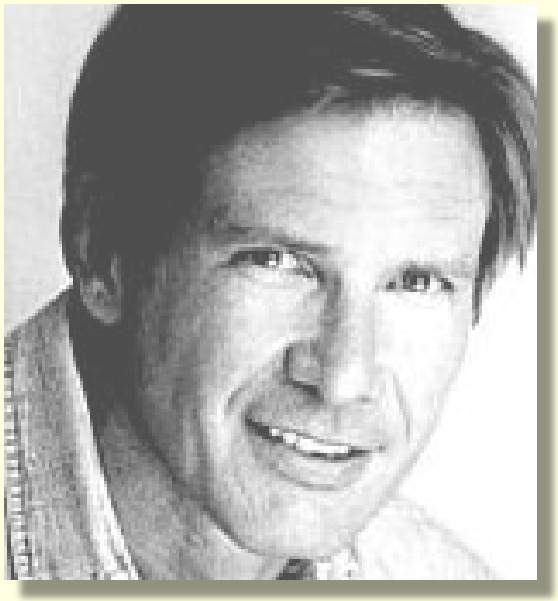
MOTHER DAUGHTER
© PleasantonWeekly.Com

FMR: False Match Rate (False Positive)

Impact of Ageing

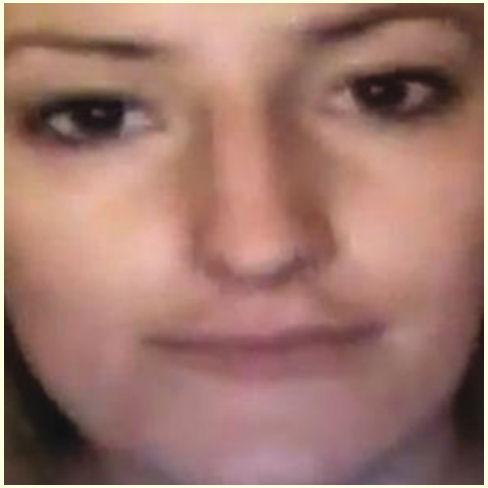






Impact of Cosmetics

- Cosmetics: To spoof another person's face image



Before-makeup

After-makeup

Target identity

Rank 734 → Rank 1

[13,334 gallery images]

Chen et al, "Spoofing Faces Using Makeup: An Investigative Study", ISBA 2017

FRVT: Verification Scenarios

Images from:
NIST 2019 Report
Ongoing Face Recognition Vendor Test (FRVT) Part 1: Verification
Patrick Grother, Mei Ngan, Kayee Hanaoka

FRVT: Identification Scenarios

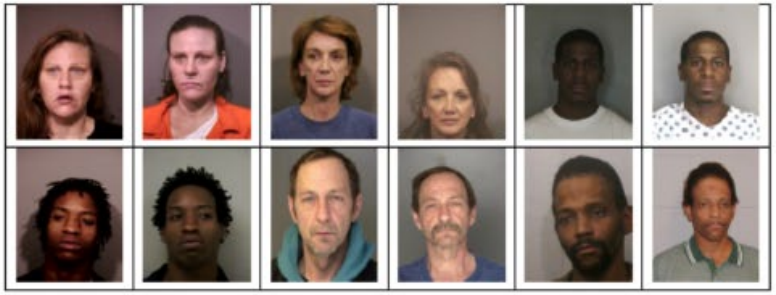
Unconstrained Faces

Surveillance and Access Systems

Profile Faces

Surveillance and Transactional Systems

Mugshot Images



Law Enforcement and Passport Type of Applications

Webcam Images

Immigration and Transactional Systems

Images from:
NIST 2019 Report
Ongoing Face Recognition Vendor Test (FRVT) Part 2: Identification
Patrick Grother, Mei Ngan, Kayee Hanaoka

Search Scenario

Error Rates on a 12M Face Image Search Database

Algorithm	Error Rates *FNIR @ FPIR = 0.001*	Template Size *Bytes*	Memory Requirements *GB*	Search Speed* *milliseconds*
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

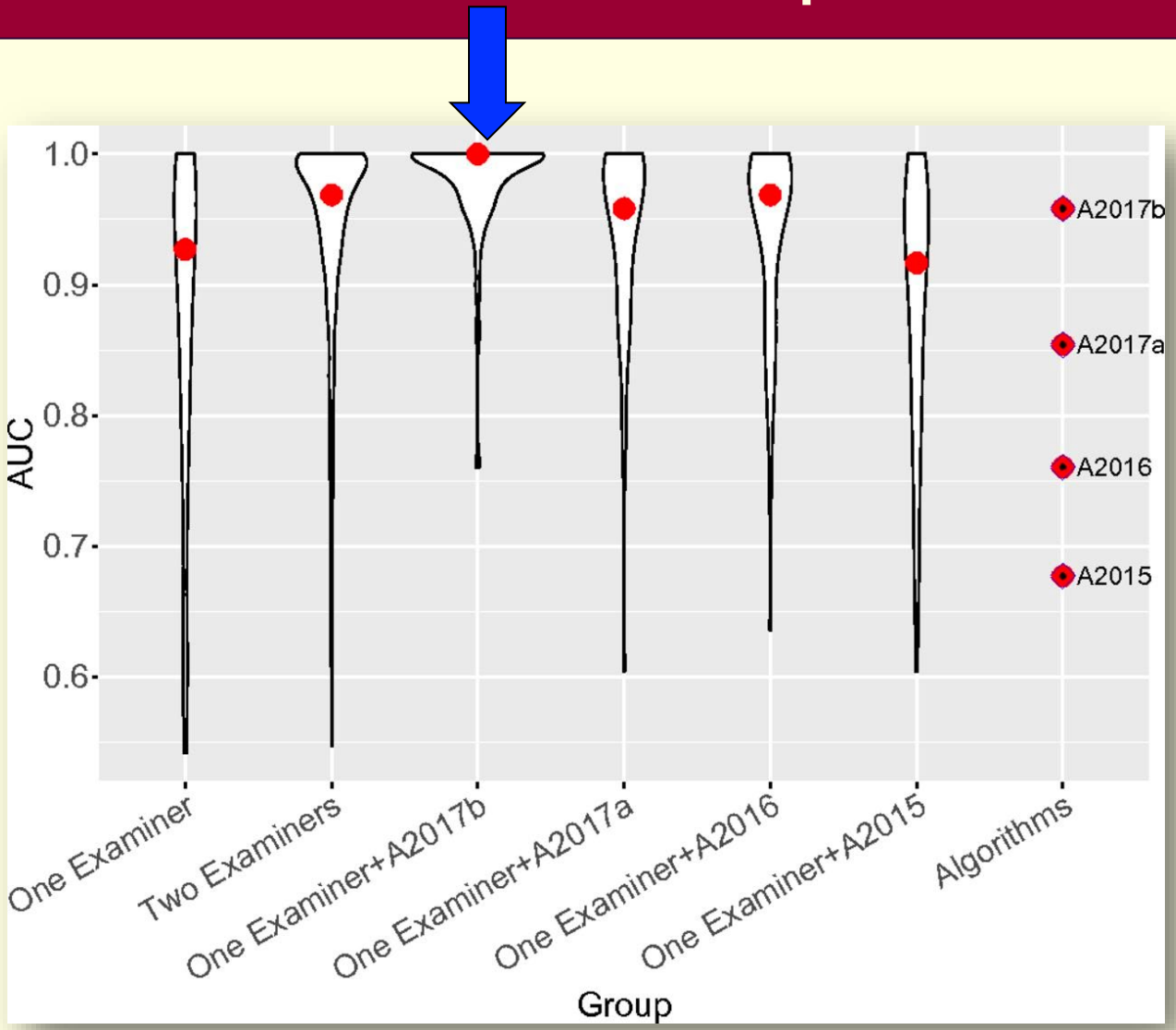
FNIR = False Negative Identification Rate
FPIR = False Positive Identification Rate

Humans versus Computers

- "We present data comparing state-of-the-art face recognition technology with the best human face identifiers"
- "The best machine performed in the range of the best humans: professional facial examiners"
- "However, optimal face identification was achieved only when humans and machines worked in collaboration"

Phillips et al., "Face recognition accuracy of forensic examiners, superrecognizers, and face recognition algorithms", PNAS 2018

Humans + Computers



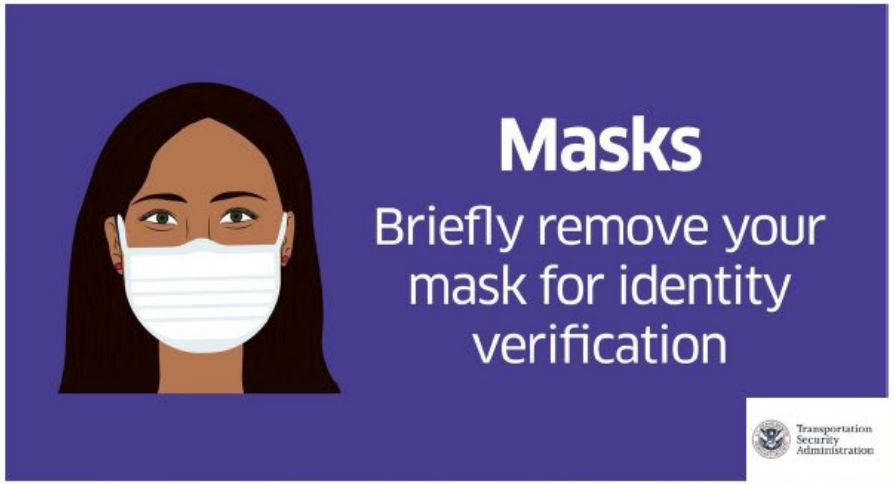
Phillips et al., "Face recognition accuracy of forensic examiners, superrecognizers, and face recognition algorithms", PNAS 2018

NIST Evaluation

- "Between 2014 and 2018, facial recognition software got 20 times better at searching a database to find a matching photograph, according to the National Institute of Standards and Technology's (NIST) evaluation of 127 software algorithms from 39 different developers—the bulk of the industry"

Please also see
Grother *et al.*, "Ongoing Face Recognition Vendor Test (FRVT) Part 2: Identification," NISTIR 8238, 2018

Novel Challenge



Summary

- Performance of face recognition has improved considerably over the past decade
- Face recognition systems must be used in conjunction with human examiners/reviewers as well as other pieces of evidence
- Factors impacting performance:
  - Quality of probe and gallery images
  - Face recognition algorithm that was used
  - Size and composition of the database

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