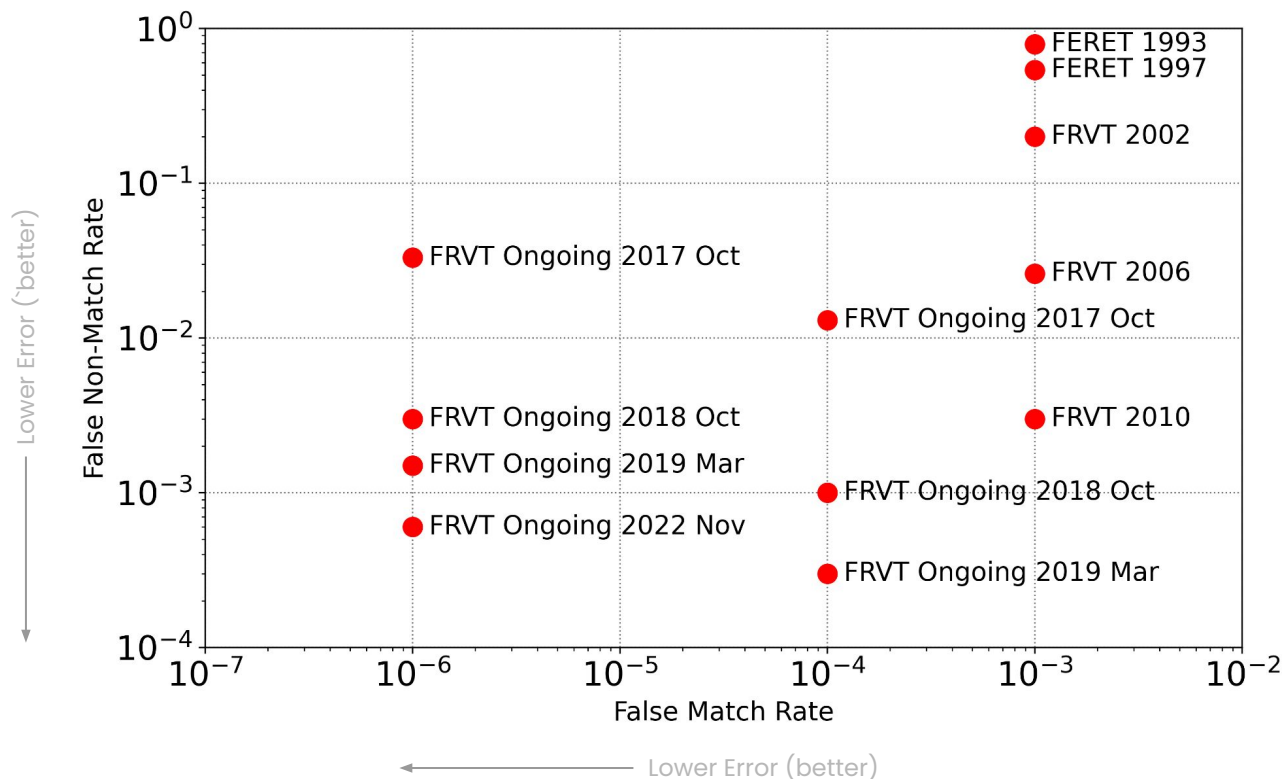# The Pros and Cons of Face Recognition

2022 NIST IFPC Conference
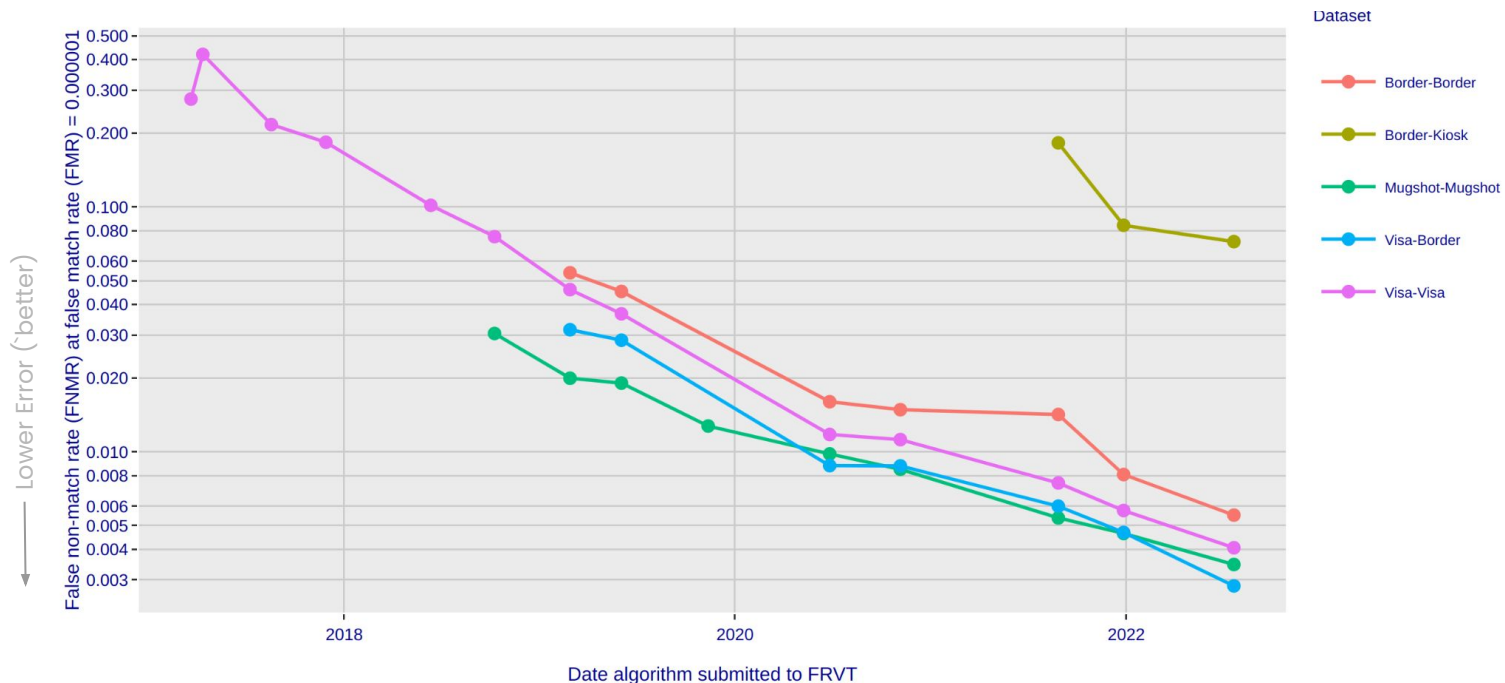Presented by: Brendan F. Klare, Ph.D.
Nov 16th, 2022

Face recognition capabilities have *skyrocketed* the last 5 years
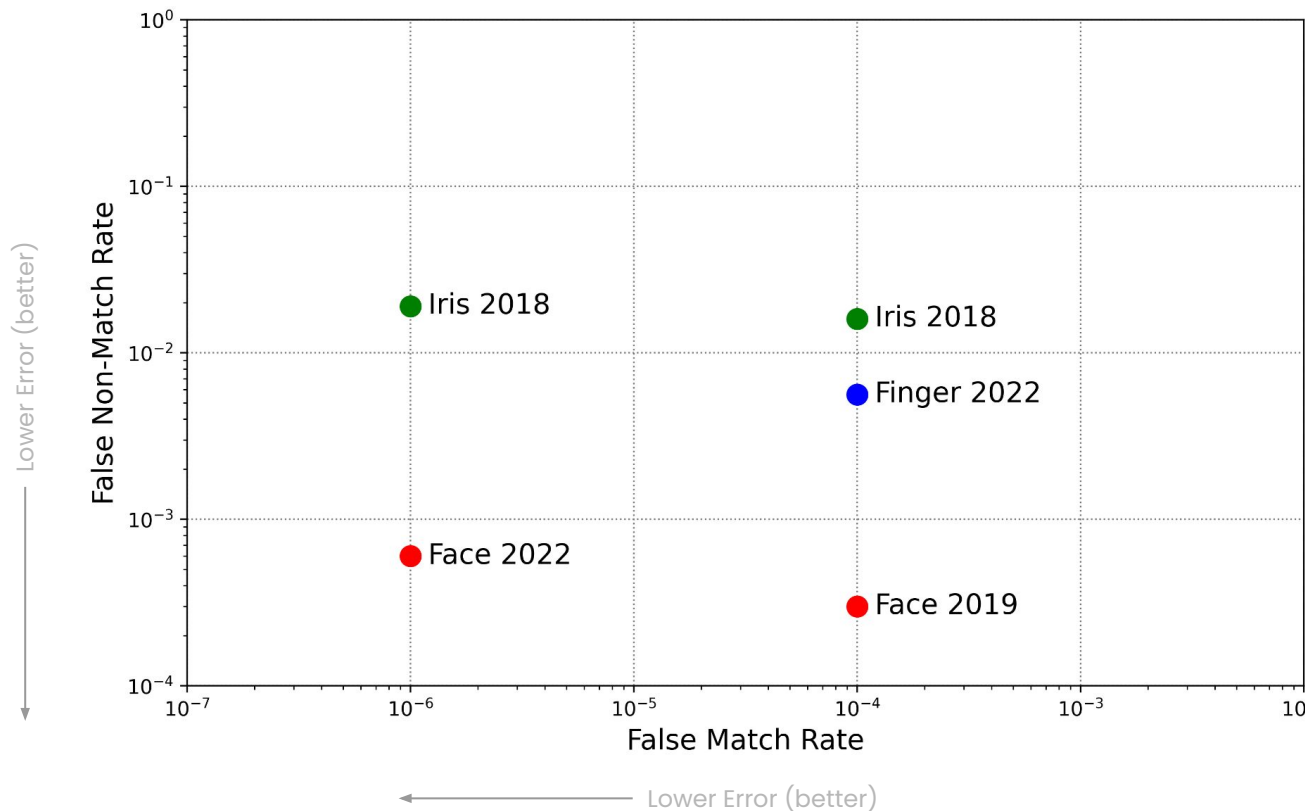
Face recognition improvements over time

Exponential improvements

Over the past 5 years, when operating at a False Match Rate of 1 in 1 Million, the False Non-Match Rate (FNMR) ***error has decreased by ~ 50x*** *across the industry*

4

Is face now the most accurate biometric in the world?

Sources:
- *Face: NIST FRVT Ongoing, Oct 2022, Visa Dataset*
- *Iris: NIST IREX IX report, April 2018, Table D1, Single Eye*
- *Fingerprint: NIST PFT, Oct 2022, MINEX III Dataset, Single Finger*

How did we get here?

- Legacy roots:
  - Face has been the primary biometric trait throughout human existence
  - **Not private:** our facial appearance is more public than our name
- Implication: facial images are widely available
  - Fingerprint and Iris images orders of magnitude more expensive to obtain than facial images

Our facial appearance is *not* private

Yankees fan caught sleeping by ESPN has $10 million lawsuit dismissed

Visit

ClickOnDetroit

Infamous Michigan football fan shares story of becoming viral ...

The infamous University of Michigan football fan recalls the moment that turned him into a meme. Saturday (Oct. 29) will be seven years...

3 weeks ago

Convenience

Face is the only fully unconstrained biometric

- FR requires minimal user effort to engage

- Some scenarios (e.g., continuous authentication) are completely frictionless

- Other scenarios (e.g. access control) require substantially less effort and cooperation than fingerprint or iris recognition

- ***Face is the only primary biometric trait used with success in a fully unconstrained manner***
  - E.g., massive progression on IJB-A benchmark [1]

- Convenience and ubiquity comes with a cost: such public information could be linked to more sensitive private information

IARPA Janus fully unconstrained benchmark:
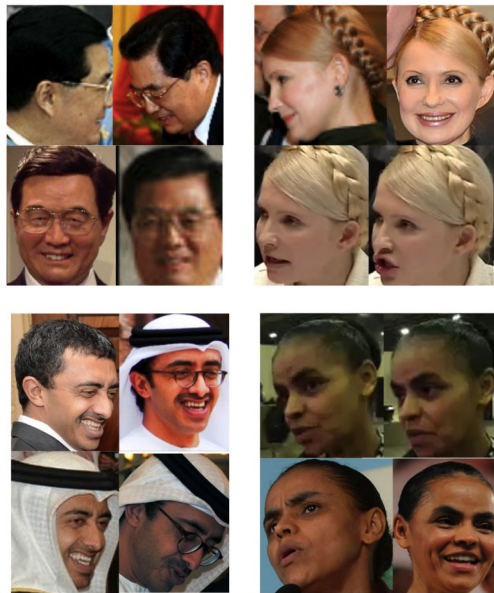
[1] B. Klare, B. Klein, E. Taborsky, A. Blanton, J. Cheney, K. Allen, P. Grother, A. Mah, and A.K. Jain, "Pushing the Frontiers of Unconstrained Face Detection and Recognition: IARPA Janus Benchmark A." Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2015.

How did we get here?

- **Deep learning** using convolutional neural networks
  - Inspired by the human visual processing system
  - Deep learning yields powerful feature representations

- Deep Learning + Deep amounts of Data =

  Algorithmic models that can significantly outperform humans

Are FR Algorithms really more accurate than humans?
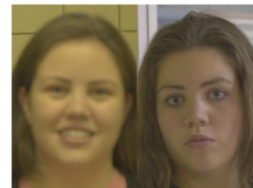
Example NIST FRVT Ongoing vendor scorecard
Similarity scores for 12 genuine and 8 impostor image pairs used in [1]:
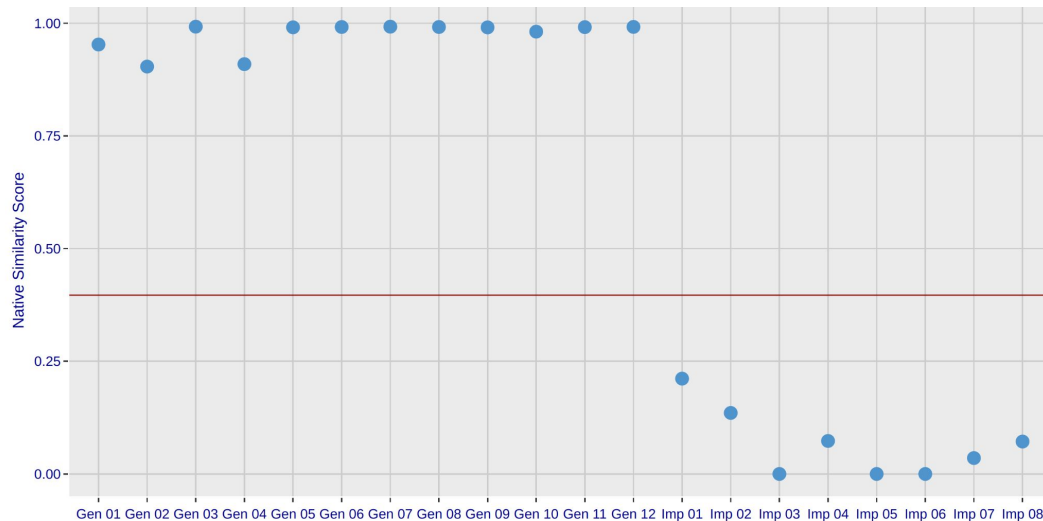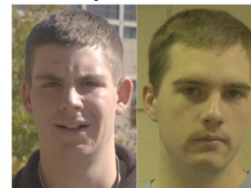

*Some FR algos are now **perfect** on the 20 pairs used in the 2018 PNAS facial examiner study [1]*

Scorecard source: https://pages.nist.gov/frvt/reportcards/11/rankone_013.html
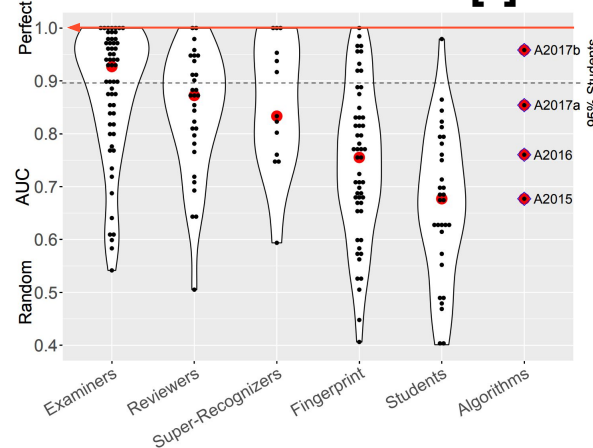
Genuine: Impostor:

Results from 2018 [1]:

[1] Phillips, P. Jonathon, et al. "Face recognition accuracy of forensic examiners, superrecognizers, and face recognition algorithms." *Proceedings of the National Academy of Sciences* 115.24 (2018): 6171-6176.

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Limits of Face Recognition

While face recognition technology offers extreme accuracy and convenience, there are some fundamental limitations and challenges that are more difficult to address

Identical Twins and Familial Relations

A hard problem for FR algorithms

- Identical twins are ~0.3% of the population and a **substantial challenge** for FR algorithms

- Twin facial appearance is incredibly similar

    - Similarity slightly diminishes over time due to different environmental factors

- Familial relation similar challenge

    - Facial appearance is genetic!

- Fingerprint and Iris are phenotypic variations developing in utero

    - Less of an issue

Identical Twins and Familial Relations

Solutions

- Certain algorithmic approaches can be followed
  - E.g., Level III facial features (freckles, marks, wrinkles) are unique between twins [1]

- Most realistic approach may be administrative declaration of whether or not someone has an identical twin
  - Similar to how the gold-standard of DNA has to operate

- Benchmark!
  - It has been a while since the old "Twins Day" initiatives, FR algorithms have changed dramatically since then
  - Thank you NIST FRVT for adding a Twins study! 🎉

[1] B. Klare and A. Jain. "On a Taxonomy of Facial Features." IEEE International Conference on Biometrics: Theory, Applications and Systems (BTAS), 2010

Data: FR's Double-Edged Sword

Data everywhere means plentiful source of spoof imagery

Data everywhere is powering massive deep-learning accuracy gains

Facial Spoofing / Presentation Attack Detection / Liveness

- The prevalence of facial imagery means it is ***easy to acquire copies of someone's facial biometric samples***

    - High percentage of population has face images online, continues to increase

- Limiting access to facial images is untenable; they are widely available for a reason

- For certain use-cases such as ID proofing and verification, facial spoof detection are existentially important

    - Other use-cases, such as forensic FR or when a human operator is present (e.g., at a border crossing), are largely irrelevant

- Other modalities can also be spoofed, but due to the private nature of most other biometrics they are less concerning

Facial Spoofing / Presentation Attack Detection / Liveness

- Thank you NIST FRVT for adding a PAD study! 🎉
  - Vitally important that NIST measures capabilities in our industries, not a single for-profit company

- FRVT Specific Image Defect Detection (SIDD) challenge is also very important for PAD
  - Enforcing quality standards at time of capture is one of the best ways to improve PAD accuracy

- While we are here…. *Let's **please** stop unnecessarily long error metric terms!*
  - Bona Fide Presentation Classification Error Rate (BPCER) 🤦
    - Perhaps "Genuine Reject Rate"?
  - Attack Presentation Classification Error Rate (APCER) 🤦
   - Perhaps "Spoof Accept Rate"?

Decorative Cosmetics

- Makeup / decorative cosmetics intentionally alter facial appearance

- Relative to other factors influencing facial recognition accuracy, *our knowledge of the impact of cosmetics is quite low*

- Consistently lower accuracy on female persons means cosmetics are almost certainly is playing a role

- Other biometrics have different but similar challenges

    - Gloves for fingerprint

    - Sunglasses for iris

- Big challenge currently: reliably detecting makeup

Other limiting factors for face recognition

- Single trait
    - We have one face, but two irises and 10 fingers
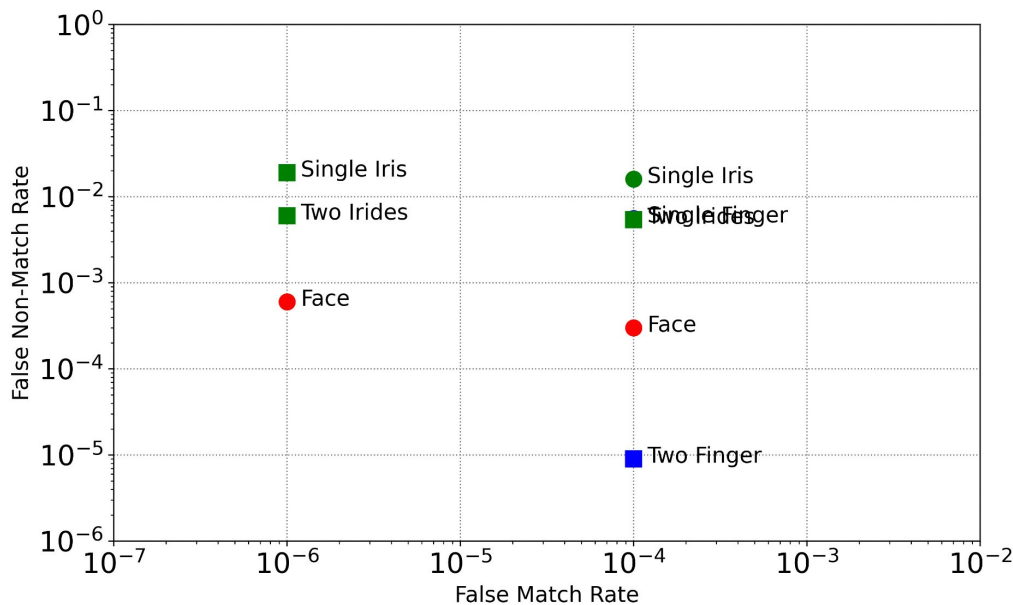
Other limiting factors for face recognition

- Ground truth
  - Legacy databases have incidence of erroneous ground truth identity labels (more than most agencies would care to believe)
  - Face DB are easier to de-duplicate than finger or iris, though

- Influence of laypersons on the use of FR
  - Fingerprint and DNA sound complex, aren't scrutinized much
  - Face recognition is something we all do everyday innately
  - Familiarity causes some lawyers and politicians to claim to have "expert knowledge" after reading a few news headlines
  - Hinders honest discussions on the role of the technology in society

Summary

- Exponential accuracy improvements in face recognition algorithms
  - Has now achieved unprecedented accuracy for any of the "Big Three" biometrics
  - Automated algorithms are more accurate than humans
  - Largely due to data prevalence combined with deep learning
- More improvements to come, but certain highly challenging limits exist:
  - Twins
  - Wide prevalence of spoofs
  - Cosmetics
- Tradeoffs will always exist (No Free Lunch)
  - We must design systems accordingly

Thank you for attending!

Questions?

Please come visit us in Denver, Colorado

Or our new office in Morgantown, West Virginia

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