# Biometrics: The Foundation of Aadhaar

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Aadhaar Vision Subcommittee on Biometrics

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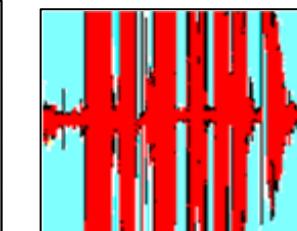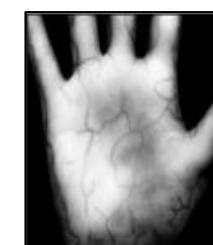
# Aadhaar

*Issue a 12-digit unique identification number (UID) to Indian residents that can be used to* eliminate duplicate and fake identities.
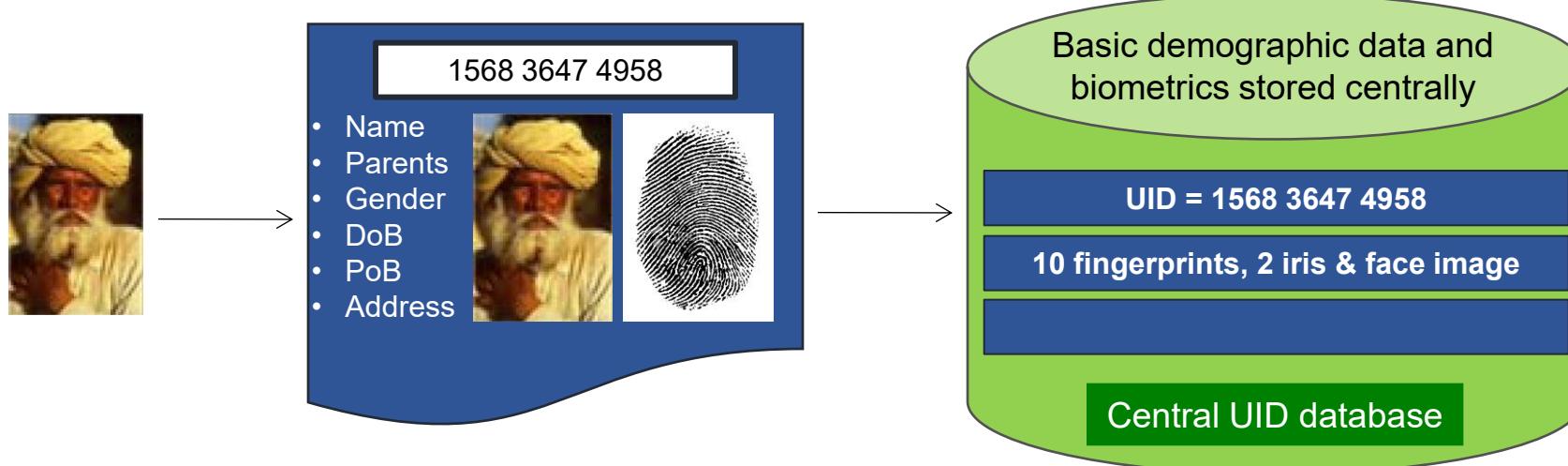


**Biometrics is the only way to eliminate duplicate and fake identities**

https://uidai.gov.in/

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# Most Frequently Used Body Traits
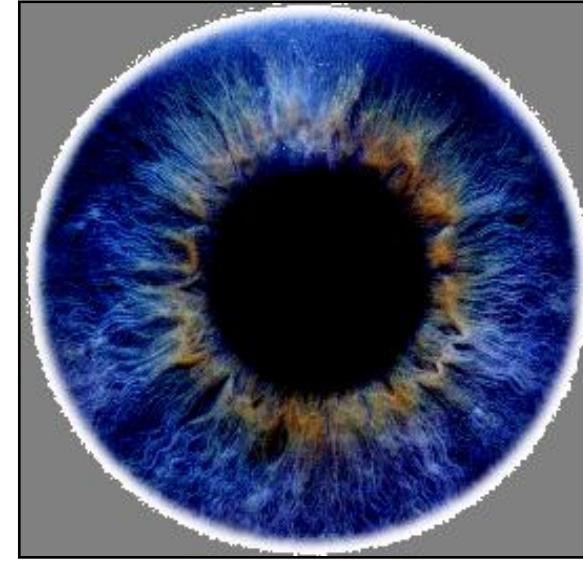


- *Individuality* and *permanence* properties.
- High accuracy and low latency (small template size) in NIST evaluations.
- **Identical twins birth rate: 3 to 4 per 1000 live births.**

# Need For High Quality Capture



No. of false minutiae = 0
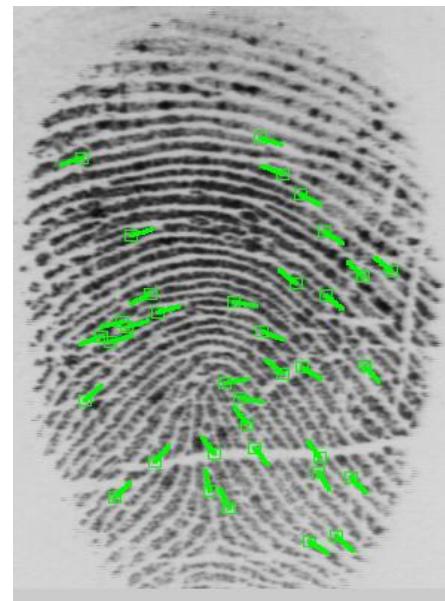
No. of false minutiae = 7
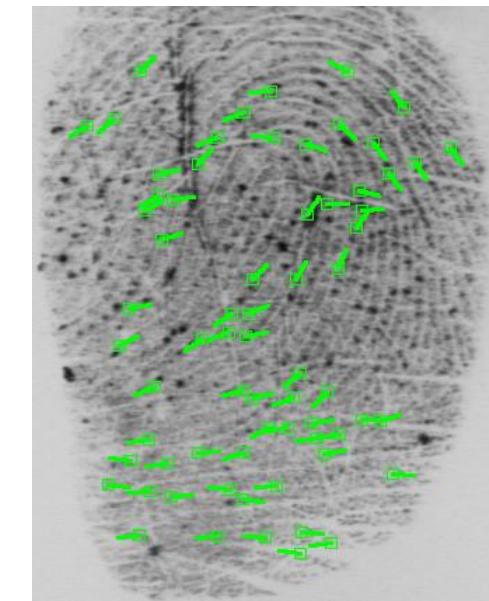
No. of false minutiae = 27

# Fingerprint Performance Over Time
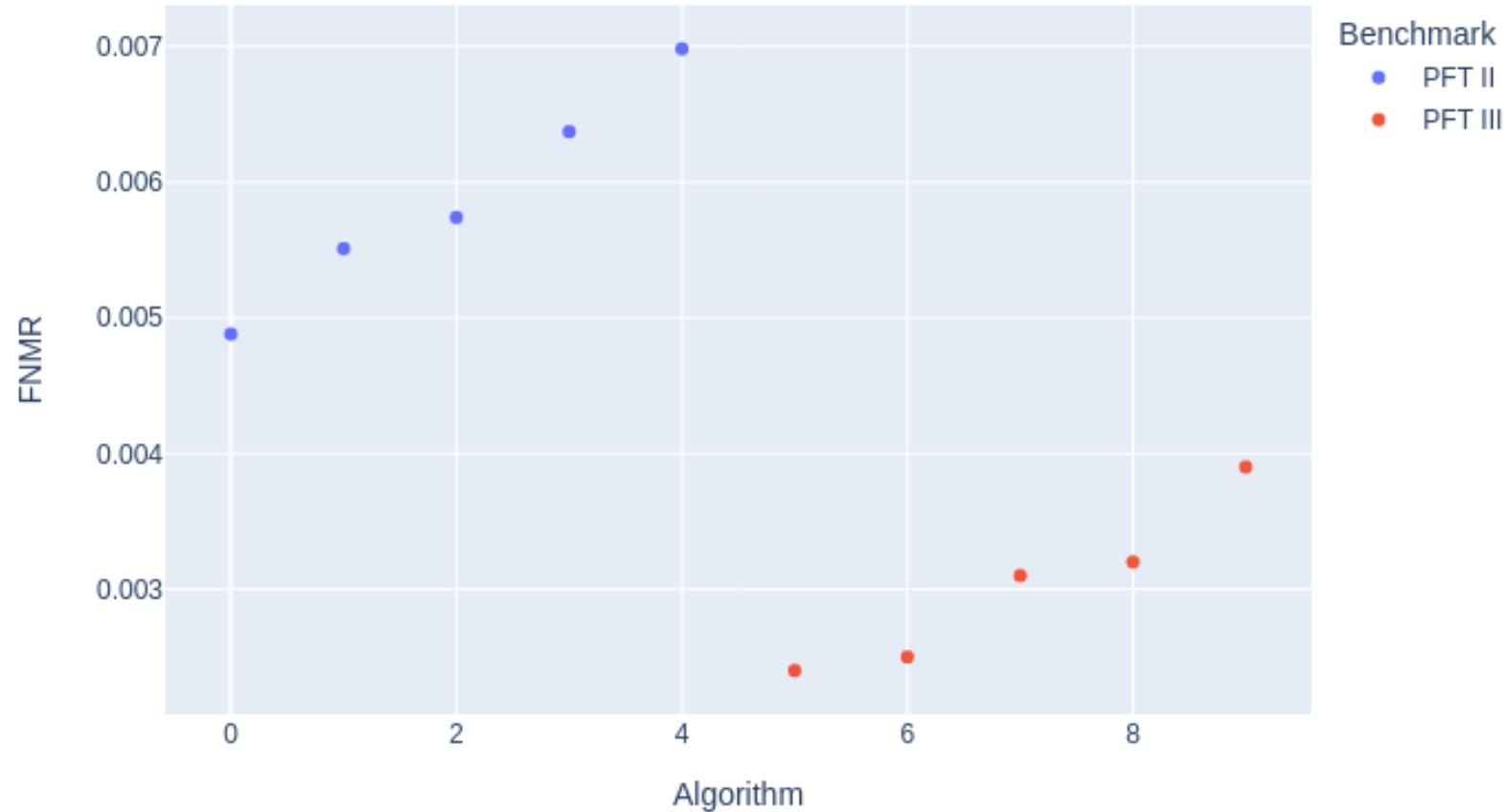


Performance of top-5 algorithms in PFT II (2010-2019) & PFT III (2019-): FNMR @FMR=1e-4)

# 1:1 Face Accuracy Gains Over Time
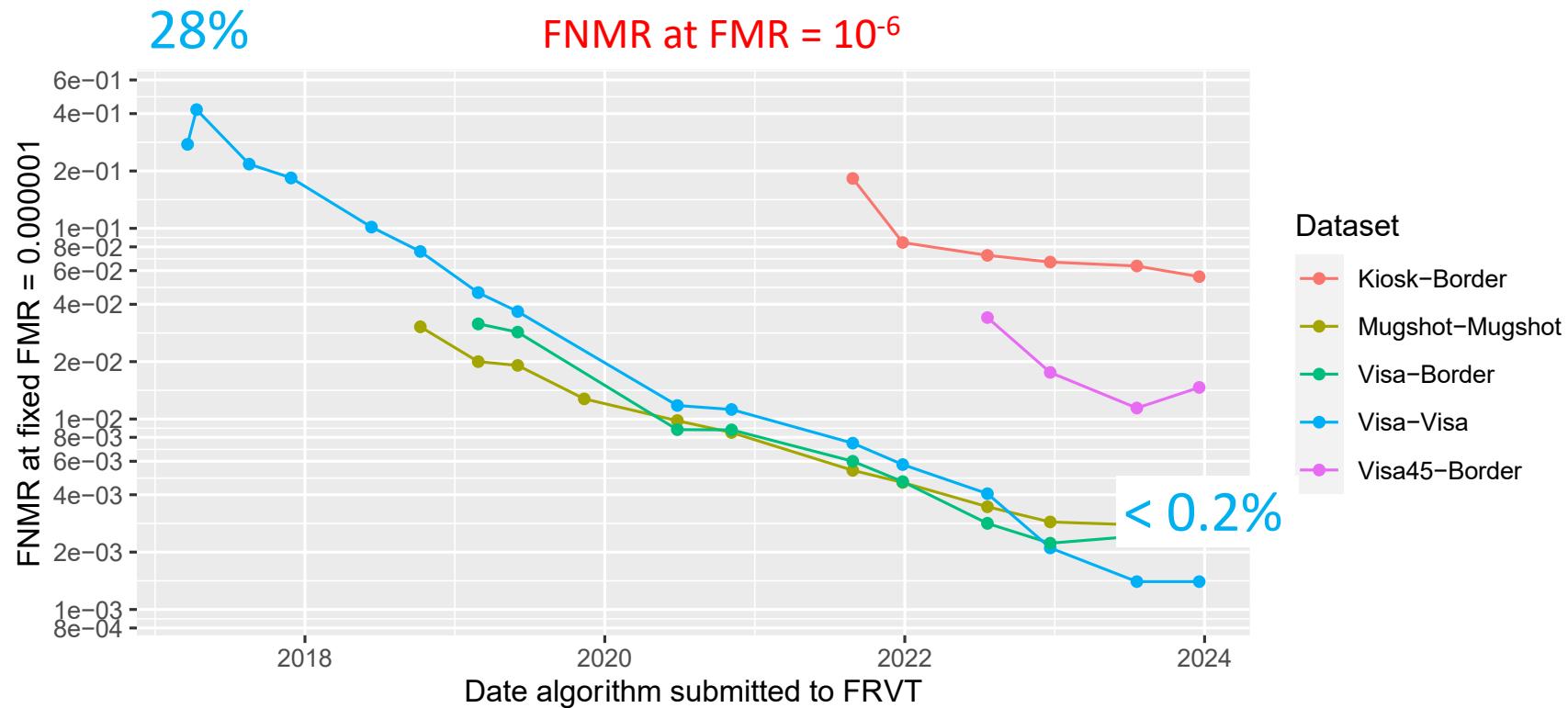
# Face Representation



**+**

(a)   (b)
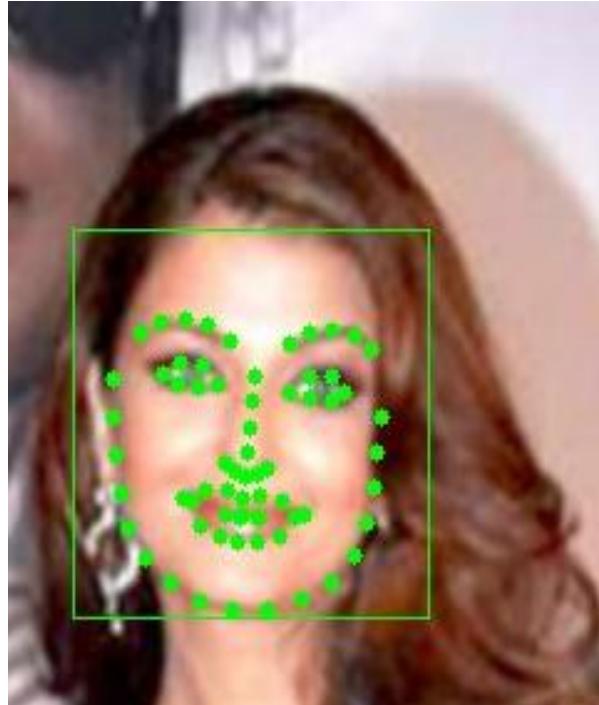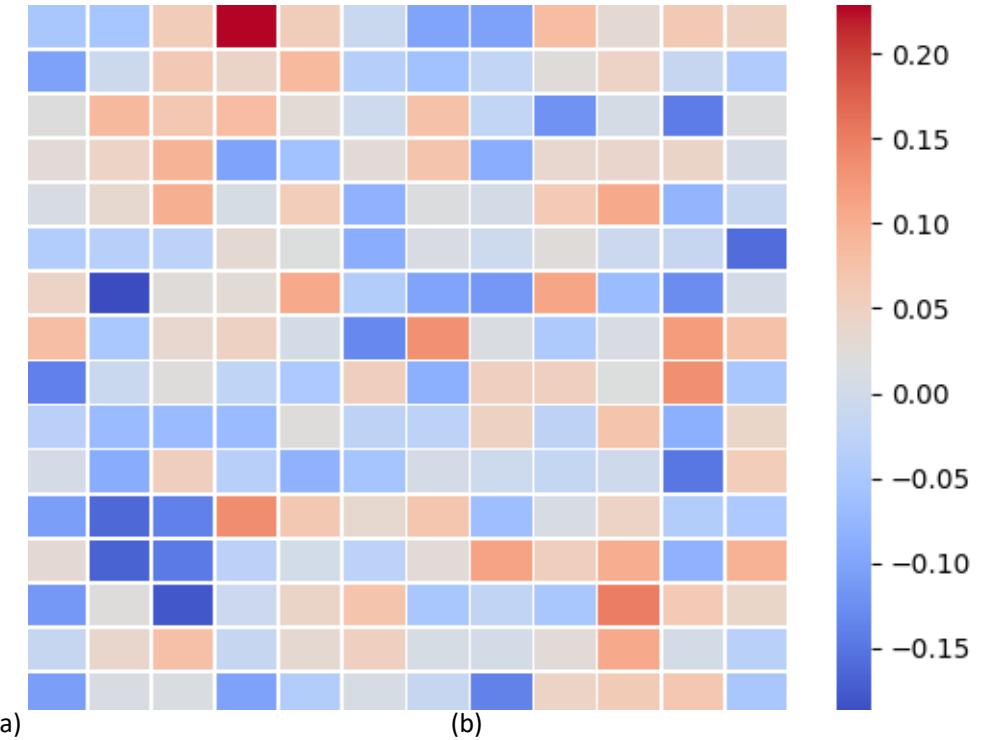
**Fusion of landmarks & embeddings has boosted face recognition**

# Gains in Recognition Accuracy



0.56    0.38    0.57

0.48    0.48    0.35    0.01
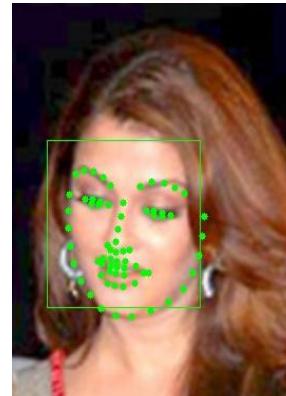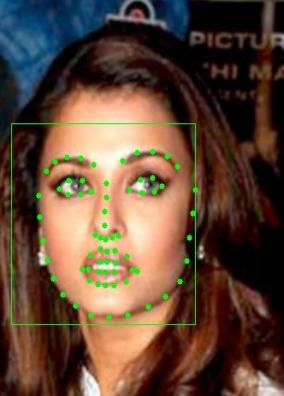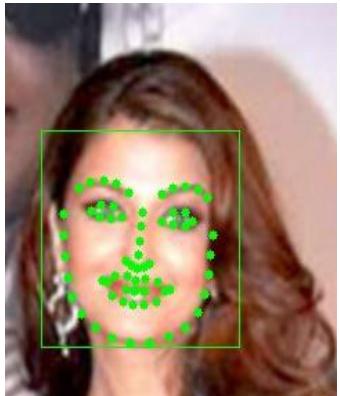
Doppelgänger of Obama 0.31
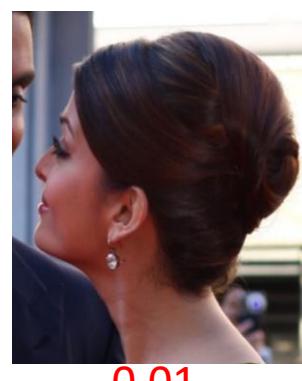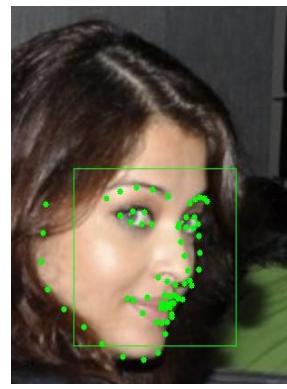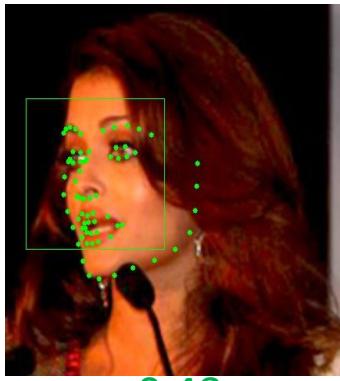
Identical twins 0.69

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# Robust to PIE, Occlusion & Aging



**Probe (1984)**

Threshold=0.54 @ FAR=0.01%

0.83   0.89   0.72   0.81
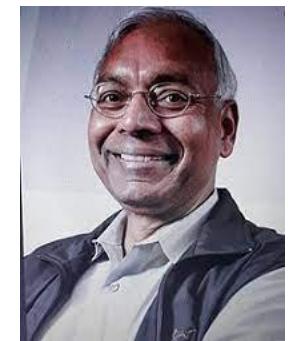
0.58   0.72   0.82   0.71

0.74   0.66   0.63   0.49   0.17

# Summary/Discussion

- **Biometrics is the only way to assure *"a person is who they say they are."***

- Fingerprint and face will continue to dominate the market.

- Enrollment age of 3 yrs. is feasible (child can follow instructions).

- Challenges:  2-Billion scale search; 200M authentications/day; recognition under "non-ideal" conditions; system integrity; latency; model training on "Aadhaar-like" data.

- What to do about deceased individuals? Remove from database?

- Recommendations:
    - Support academic research, train students & foster startups
    - Merge outputs of all three BSPs to further reduce FPIR/FNIR

# Backup Slides

# Real or Synthetic?

# Real or Synthetic?

# Two-factor Authentication



**~90M authentications/day**

# Challenges
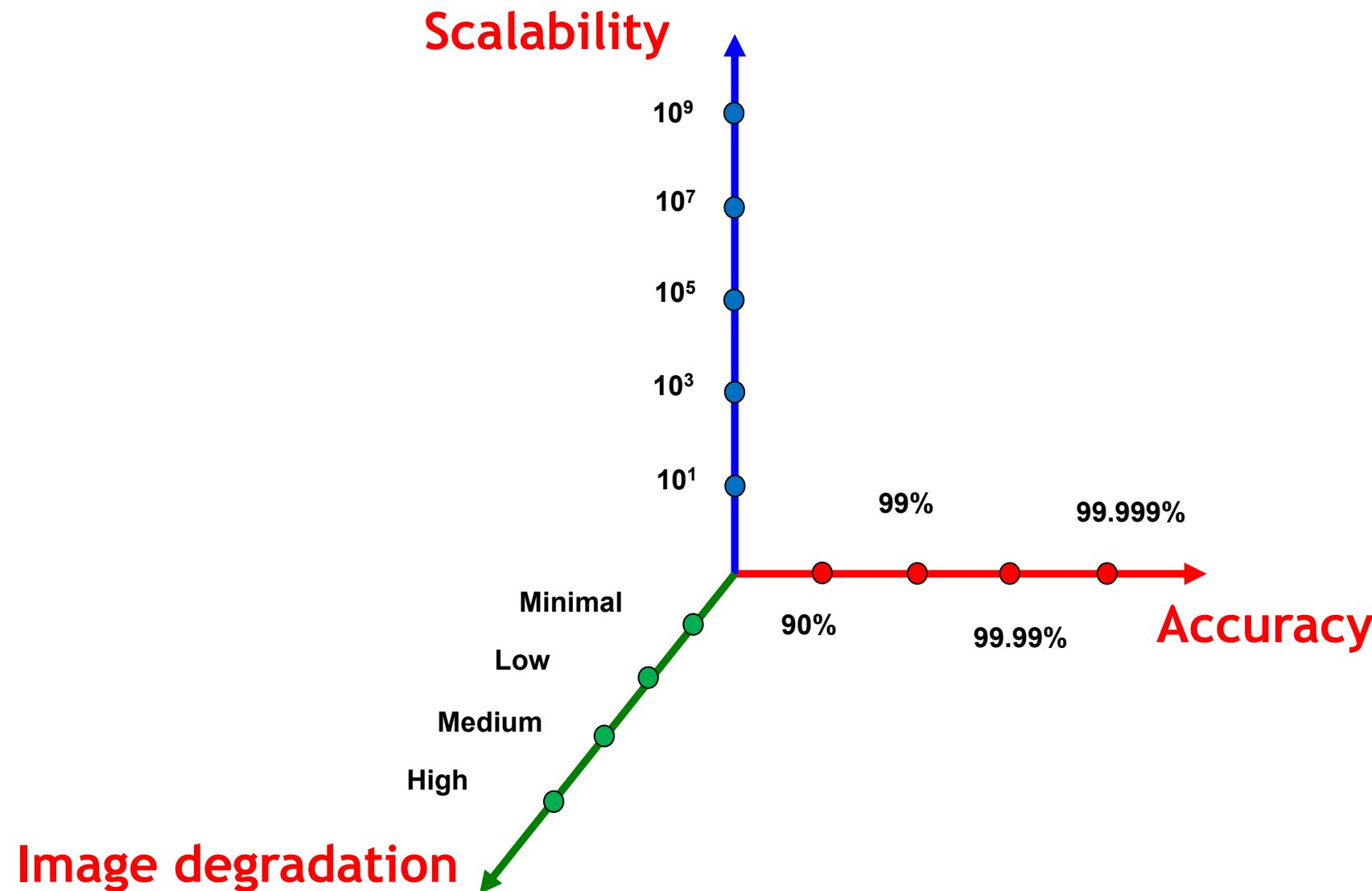


- 1:N accuracy for  2B enrollment
- Quality-based fusion
- System security (presentation attacks, injection attacks)
- Remote IDV
- Integrity of enrollment
- Lower enrollment age

# Additional Biometric Traits?
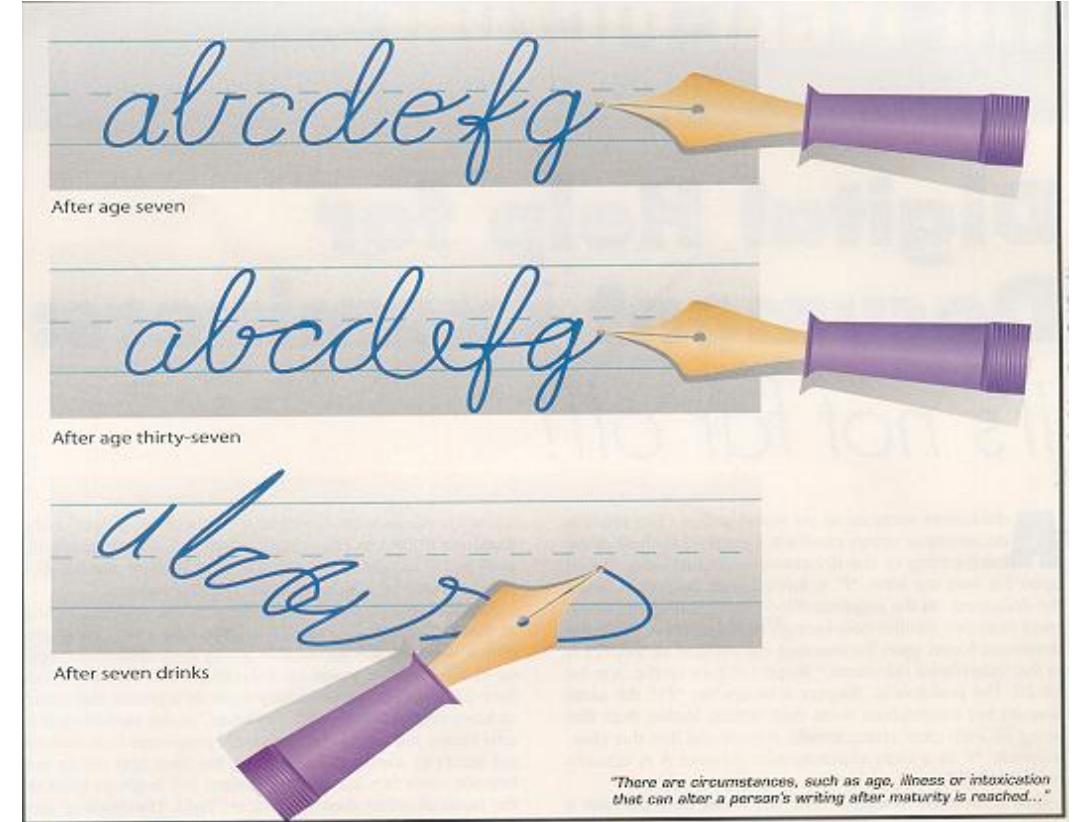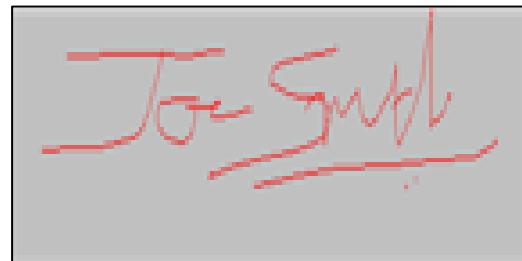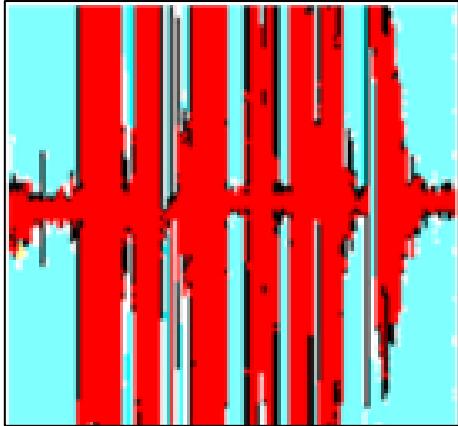


- Do they satisfy individuality and persistence properties?
- Any third-party evaluation for 1:N evaluation?
- How easily can they be spoofed?

# Aadhaar Enrollment

- Minimal supporting documents collected; Never to deny Aadhaar.
- Fingerprint & iris were selected based on their **individuality** and **permanence** properties (cannot be shared); face was not considered a "core" biometric.
- Minimum age of 5 years was based on child understanding instructions.

**Discussion points:**

- Any new modality? Must satisfy properties of distinctiveness, …
- Lowering the enrollment age.
- Integrity of enrolment; who is getting enrolled?
- Any special consideration for identical twins? (~3/1000 live births).
- Investigate backward-compatible sensing technologies.
- Self enrollment? Is it even advisable?

# De-duplication (1:N Comparison)

- Fusion of fingerprints, iris & face to individualize @billion scale

<span style="color:red">Points for Discussion</span>

- What is the current FPIR & FNIR? What has been the trend since 2009?
- Understand failure cases to further improve the algorithms.
- NIST evaluations show continuous improvements in face, fingerprint and iris accuracies. Is Aadhaar getting best of the breed?
- Trade off between accuracy (FPIR, FNIR) and template size!
- What improvements will we get by <span style="color:red">fusing output of all three BSPs?</span>
- New algorithms for quality-based fusion and score modification
- How to predict 1:2B search performance?

# Authentication

- 2-factor (Aadhaar + biometric) authentication; user agencies can decide which modality to use
- ~90 million authentications per day.

- <span style="color:red">Discussion Points:</span>

- What percentage of authentication attempts are unsuccessful in 1, 2 or 3 tries?
- What is the current authentication time? Any system outages?
- How to prepare for, say 200M authentications/day
- Can we bypass Aadhaar server for authentication?
- Detection of presentation attacks

# Aadhaar Enrollment
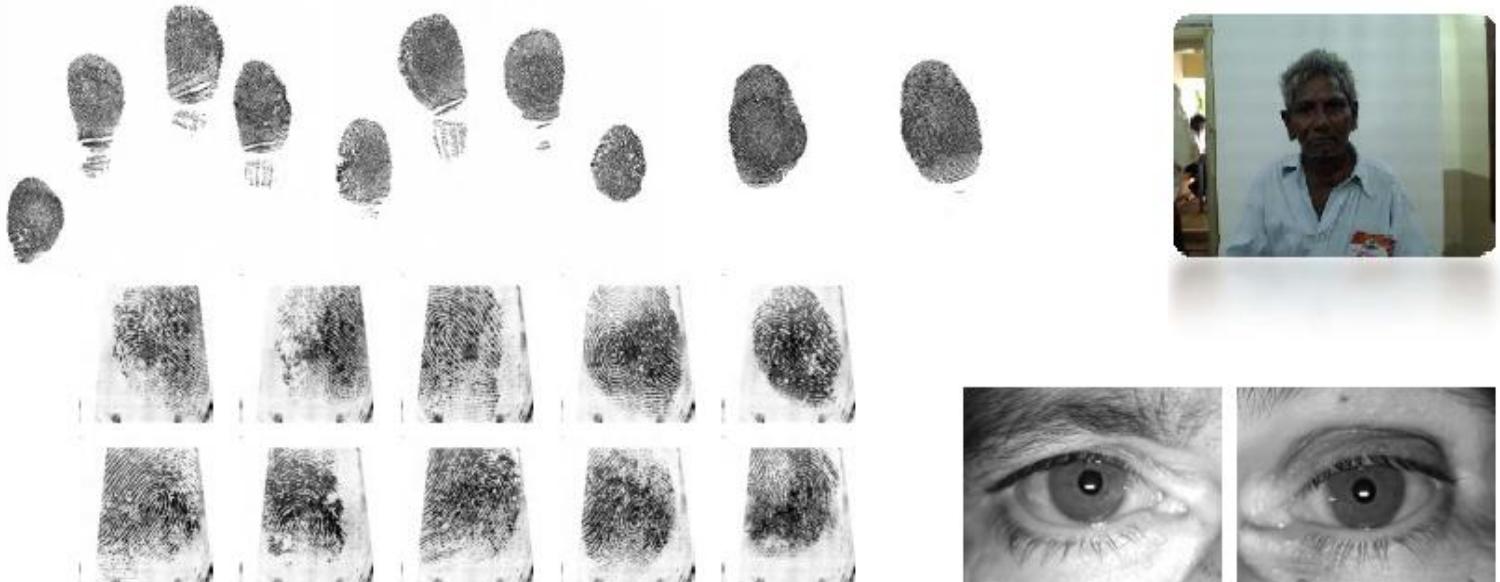


- Face, fingerprint and iris were selected; in 2008, face was not considered a "core" biometric in Aadhaar act
- Attended enrollment
- High search (1:N comparisons) accuracy in NIST evaluations
- ~50 million face comparisons/second; small template size
- Minimum enrollment age set to 5; child understands instructions
- What about identical twins? 3.5 identical twins per 1000 live births

# De-duplication (1:N Comparison)



Biometrics of new Applicant
(No demographic info is used)

Enrollment database

Already in Database?
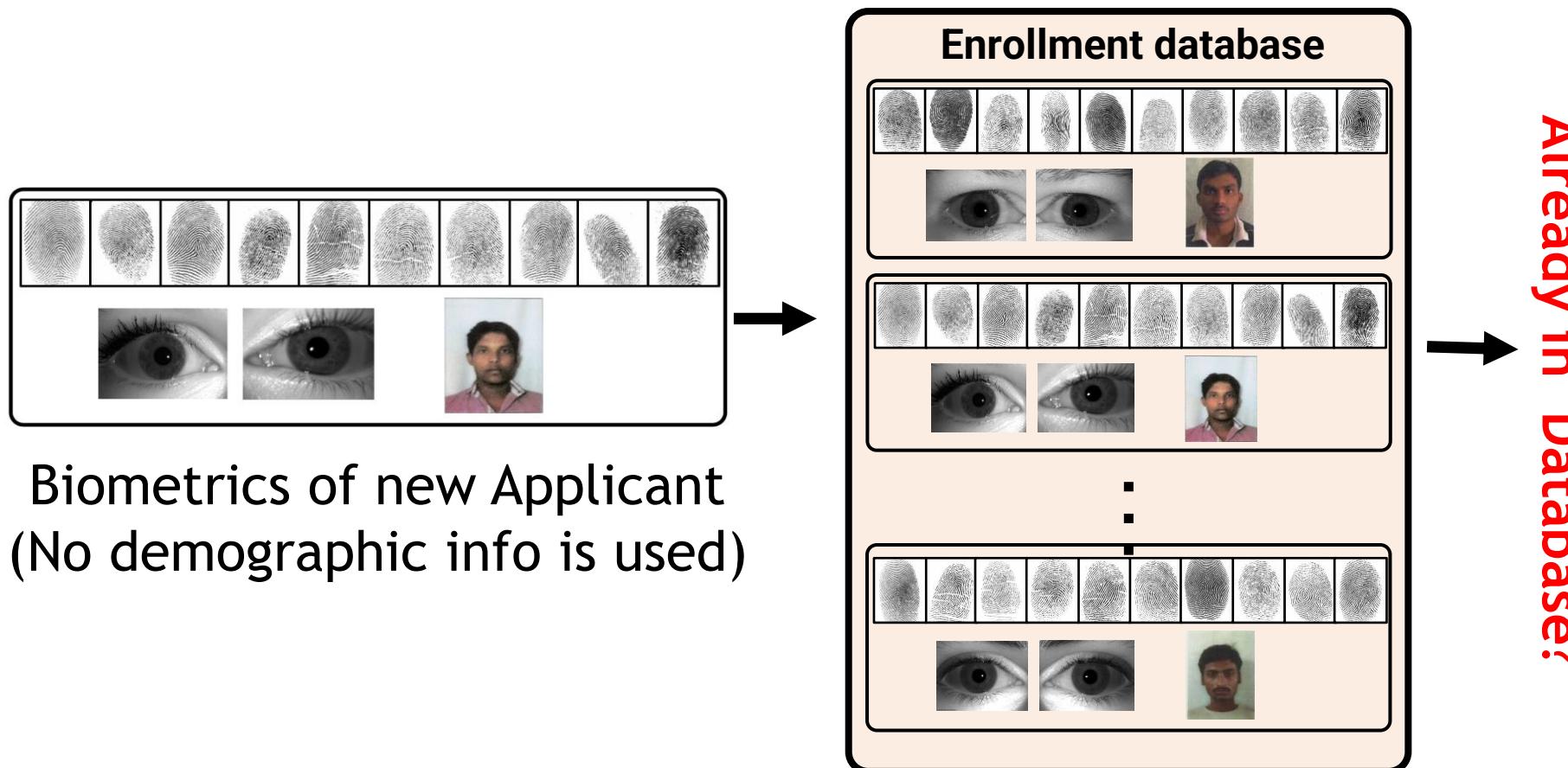
**Fusion of fingerprints, iris & face required to individualize @billion scale**

- **What is the current FPIR, FNIR? What has been the trend since 2009?**
- **What is the main reason for failure? Poor image quality?**

# Biometric Recognition Accuracy: NIST

1. **Face (constrained/semi-constrained)**

   - 1:1 comparison: FNMR = 0.0026 @ FMR = 0.000001.

   <span style="color:red">1 in a million chance *you may be mistaken as someone else* and 26 out of 10,000 times you may not be recognized as you.</span>

   - 1:N comparison (N=12M): FNIR=0.0190 @ FPIR = 0.001.

2. **Fingerprint**

   - One-finger (five-finger) Accuracy: FRR=0.0047 (0.0011) @ FAR=0.0001.

   - <span style="color:red">1 in 10,000 chance of you being mistaken as someone else, and 47 out of 10,000 times you may not be recognized as you.</span>

   - Latent (Crime scene) fingerprint accuracy (N=32M) Rank-1 retrieval=96.12%.

https://pages.nist.gov/frvt/reports/1N/frvt_1N_report.pdf