Designing Multi-modal Biometric Identification System for India’s Unique ID Program

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Background

• UIDAI mandates assigning a unique number to every resident of India in order to streamline delivery of government social welfare services

• Biometrics Proof of Concept was commissioned to learn
  – If biometrics will work in Indian conditions
  – If biometrics will work at a scale of 1.2 billion people
  – What process will result in best data quality
Collected info. of each subject

- Ten fingers (tenprint (4-2-2) + single finger images)
- Two eyes (iris images)
- One face image
- Demographics (name, gender, birthday, address)
Set-up
Set-up
Set-up
Capture

WATCH THIS VIDEO
Capture

WATCH THIS VIDEO
Capture Process
FP Capture
Iris Capture
Challenges
Juvenile Capture
Databases

- Rural areas were emphasized
- Adult1 (2 sessions, ~20K subjects)
- Adult2 (2 sessions, ~20K subjects)
- Adult3 (2 sessions, ~20K subjects) - NA
- Children (2 sessions, ~1K subjects)
## Initial Analysis

<table>
<thead>
<tr>
<th>DBs</th>
<th>Age</th>
<th>Gender</th>
<th>Any fingers missing</th>
<th>Any eyes missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult1</td>
<td><img src="image1" alt="Age Distribution" /></td>
<td><img src="image2" alt="Gender Distribution" /></td>
<td>1%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Adult2</td>
<td><img src="image3" alt="Age Distribution" /></td>
<td><img src="image4" alt="Gender Distribution" /></td>
<td>0.7%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Children</td>
<td><img src="image5" alt="Age Distribution" /></td>
<td><img src="image6" alt="Gender Distribution" /></td>
<td>0.3%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Missing finger/eye can be caused by either amputation or bandage
Missing Fingers and Eyes

- Missing thumb
- Missing ring & little
- Eye disease
Process Related Conclusions

• Total capture time variation largely due to
  – Fingerprint attempts (age, occupation)
  – Iris capture process (tripod, active participation of subject)
  – More frequent iris capture needed but capture is quick
• Variation not significant in overall context
  – 50% spread
• Zero FTE is possible even with 4 year children & 80 year adults
• Social customs are not major obstacles
1:20K Identification ROCs
(normal acquisition process)
1:20K Identification ROCs
(special acquisition process)

Subjects are asked to open their eyes with fingers during iris capture
1:20K Identification ROCs (special acquisition process)
## Multimodal False Negative Error - Iris

<table>
<thead>
<tr>
<th></th>
<th>Right Eye</th>
<th>Left Eye</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session 1</strong></td>
<td><img src="image1" alt="Right Eye" /></td>
<td><img src="image2" alt="Left Eye" /></td>
</tr>
<tr>
<td><strong>Session 2</strong></td>
<td><img src="image3" alt="Right Eye" /></td>
<td><img src="image4" alt="Left Eye" /></td>
</tr>
</tbody>
</table>
# Multimodal False Negative Error - Finger

<table>
<thead>
<tr>
<th></th>
<th>Segmentated Tenprint</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session 1</strong></td>
<td><img src="image1" alt="Fingerprints Session 1" /></td>
</tr>
<tr>
<td><strong>Session 2</strong></td>
<td><img src="image2" alt="Fingerprints Session 2" /></td>
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Multimodal False Negative Error - Face
Example 1: False Negative Error - Iris

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<td><img src="image4" alt="Left Eye" /></td>
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Example 1: False Negative Error - face
Example 2: False Negative Error - Iris

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<tr>
<th>Session 1</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Image 1" /></td>
<td><img src="image2.png" alt="Image 2" /></td>
<td><img src="image3.png" alt="Image 3" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 2</th>
<th>Right Eye</th>
<th>Left Eye</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4.png" alt="Image 4" /></td>
<td><img src="image5.png" alt="Image 5" /></td>
<td><img src="image6.png" alt="Image 6" /></td>
</tr>
</tbody>
</table>
Example 2: False Negative Error - Face
Example 3: False Negative Error - Iris

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Example 3: False Negative Error - Face
Example 4: False Negative Error - Finger

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Verification ROCs
(single finger vs. segmented finger)
Principles

• Minimum Demographical Data
• “Over design” biometrics
  – Multiple Modalities
  – Multiple ABIS/De-duplication
• Vendor independence
• Standards & Open System
• Enrolment suitable for mobile operation
• Ubiquitous authentication
Multiple ABIS & Allocation

- **CBEFF**
- **Master DB**
- **UID Middleware**
  - Aadhaar ABIS API
  - Multi-model ABIS Vendor 1
    - DB
  - Multi-model ABIS Vendor 2
    - DB
  - Multi-model ABIS Vendor 3
    - DB
Multi-Vendor ABIS

• Each ABIS independently de-duplicates across entire gallery
  – Each ABIS keeps complete gallery
  – Each enrolment must be “inserted” in the gallery
  – Gallery must be synchronized
  – ABIS gallery can be rebuilt from enrolment data
  – ABIS gallery will contain proprietary templates
  – Gallery contains every encounter

• Enrolment (probe) can be given to one or more ABIS
  – Each ABIS unaware of other ABIS
  – Duplicate decision made outside of ABIS
Multi-Vendor ABIS

• Vendor independent, upgradable
• Incentive for continuous improvement
  – Allocation of volume based on performance
    • Accuracy, Throughput, Efficiency (resource- H/W per de-dup)
  – Reallocation every 10M de-duplication
• Continuous accuracy measurement in production
  – Initial: PoC data of 75,000 persons (2 encounters each)
  – Auto generation of probe data
  – ABIS unaware of probe vs. real data
Thank you