Automatic Enhancement of Interoperability between Optical Fingerprint Sensors

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Summary

- WVU Multi-Sensor Fingerprint Collection
- Fingerprint Interoperability Assessment
- The Proposed Enhancement Approach
- Results
Multi-Sensor Fingerprint Collection

- Data collection performed at West Virginia University
- FBI Certified livescan fingerprint sensors
- Number of participants: 500
  - Rolled individual fingerprints on right and left hands; left, right and thumb slaps per session
    - In the analysis we use right point finger only.
- Two sequential sessions for each sensor
- Inked rolled prints
Optical Fingerprint Sensors

<table>
<thead>
<tr>
<th>Device</th>
<th>Model</th>
<th>Resolution (dpi)</th>
<th>Image Size (pixels)</th>
<th>Capture Area (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D0</td>
<td>Cross Match</td>
<td>Guardian R2</td>
<td>500</td>
<td>800 x 750</td>
</tr>
<tr>
<td>D1</td>
<td>i3</td>
<td>digID Mini</td>
<td>500</td>
<td>752 x 750</td>
</tr>
<tr>
<td>D2</td>
<td>L1 Identity Solutions</td>
<td>TouchPrint 5300</td>
<td>500</td>
<td>800 x 750</td>
</tr>
<tr>
<td>D3</td>
<td>Cross Match</td>
<td>Seek II</td>
<td>500</td>
<td>800 x 750</td>
</tr>
</tbody>
</table>
Collection Demographics

- Provided Ethnicity, Age, Gender, Weight, Height

Diversity in Fingerprint Images

- Optical Sensors
- Image Quality: NFIQ
- Soft-Biometrics: Age / Gender
Diversity from Image Quality

- Average normalized match score vs. NFIQ image quality for all the considered devices
- The size of the square indicates the frequency

<table>
<thead>
<tr>
<th>Participant</th>
<th>Device</th>
<th>D0</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-29</td>
<td>Male</td>
<td>1.530</td>
<td>1.878</td>
<td>1.905</td>
<td>1.702</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.396</td>
<td>1.935</td>
<td>2.104</td>
<td>1.735</td>
</tr>
<tr>
<td>30-59</td>
<td>Male</td>
<td>1.526</td>
<td>2.500</td>
<td>2.513</td>
<td>1.712</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.748</td>
<td>2.684</td>
<td>2.820</td>
<td>2.112</td>
</tr>
<tr>
<td>60+</td>
<td>Male</td>
<td>2.500</td>
<td>3.222</td>
<td>3.278</td>
<td>2.778</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3.071</td>
<td>3.476</td>
<td>3.524</td>
<td>3.095</td>
</tr>
</tbody>
</table>

- Device Ranking by Image Quality
- Average NFIQ image quality measures

Sensor Diversity

• Impact of Sensors on Image Quality

• Impact of Sensors on Matching Algorithm

![Quality distributions graph]

![DET Curves Inter- and Intra-device Scenarios graph]
Sensor Diversity

- Impact of Device Diversity on Matching

- Impact of Device Diversity and Image Quality on Matching
Diversity from Soft Biometrics

- Impact of Age / Gender on Matching Algorithms

- Impact of Age / Gender on Image Quality

- Age Groups
  - Young: 18-29
  - Elderly: 30-75

- TouchPrint 5300 device
One Identity Multiple Biometric Sources

• Can we achieve error rates in cross-device matching as good as within same-device?

• Higher intra-device genuine match scores indicate interoperability problems
Related Works

1. Image Quality (local gradients) for score calibration [1]
   - Biosecure DS2 database, 207 subjects
   - Thermal vs. Optical
   - Results: TER is reduced from 15.834% to 15.150% (at EER)
   - Weakness: association of each device with a quality cluster

2. Distortion compensation model [2]
   - Optical vs. Capacitive
   - WVU data set of 71 subjects, MSU data set of 128 subjects
   - Results: at FAR= 0.01% GAR from 35% to 75% (Verifinger)
   - Weakness: non-linear transformation of minutiae points, old sensors

The Proposed Approach
The Proposed Approach

- Compensation after matching
- Modeling qualitative information of the device and how it relates to match score
- The set of interoperability features is concatenated with the match score

Sample Interoperability Features

- Image quality (NFIQ and MITRE)
- Minutiae count
- Pattern noise
- Intensity-based statistics
- Alignment
Classification

- Random Forest-based classification
- 10-Fold Cross Validation (25% training)

[match score, NFIQ, alignment, ...]

Tree 1
- Match Score
- NFIQ
- NFIQ
- ... Genuines

Tree 2
- Match Score
- Alignment
- Alignment
- ... Genuines

Tree 25
- Match Score
- NFIQ
- NFIQ
- ... Impostors

Genuine
Results

- Using a preliminary set of features

<table>
<thead>
<tr>
<th>Learner</th>
<th>Training</th>
<th>FMR</th>
<th>FNMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random Forest</td>
<td>10-Fold CV 10 Trees</td>
<td>0.006%</td>
<td>3.279%</td>
</tr>
<tr>
<td></td>
<td>25% 10-Fold CV (25 Trees)</td>
<td>0.005%</td>
<td>3.741%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Baseline</th>
<th>FMR</th>
<th>FNMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMR</td>
<td>0.005%</td>
<td>6.696%</td>
</tr>
<tr>
<td>FNMR</td>
<td>1.982%</td>
<td>3.741%</td>
</tr>
</tbody>
</table>

- Error rates of commercial fingerprint matchers increase when images are acquired using **different** devices

- Compensation **after** matching achieves a significant **improvement** of cross-device accuracy
Thanks for your attention!

Any Questions?

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