Study on Uniqueness of Fingerprints

Hale Kim
hikim@inha.ac.kr
Purpose

- To quantitatively evaluate the uniqueness of fingerprints

Background

- Since identical twins and family members have the closest genetic attributes, it is considered that the similarity between fingerprints of different members from the same family yield relatively high matching scores than from different families.
Experiments

Fingerprint database

- Fingerprint reader: Optical
- Family:
  - 30 family × 4 member × 10 finger × 3 impression
- Twin:
  - 61 twin × 2 member × 10 finger × 3 impression

Evaluation methods

- Comparison of distributions of matching scores between twins and non-twins
- Comparison of distributions of matching scores for all possible combinations of family members
- Analysis of dependency in fingerprint types between parents and children
Results (1)

Percentage of the Same Type between Father & Mother

- LL: 57%
- LR: 37%
- LM: 40%
- LI: 33%
- LT: 43%
- RT: 37%
- RI: 47%
- RM: 30%
- RR: 37%
- RL: 63%

Avr: 42%

Percentage of the Same Type between Child & Child

- LL: 60%
- LR: 57%
- LM: 57%
- LI: 27%
- LT: 47%
- RT: 43%
- RI: 47%
- RM: 57%
- RR: 60%
- RL: 77%

Avr: 57%

Finger
Results (2)

Percentage of the Same Type between Father & Child

Percentage of the Same Type between Mother & Child

Avr: 54%

Avr: 4
Results (3)

<table>
<thead>
<tr>
<th>Type</th>
<th>Type</th>
<th>Type</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent</td>
<td></td>
<td></td>
<td>Twin-Twin Genuine</td>
</tr>
<tr>
<td>Twin</td>
<td>Twin</td>
<td>Imposter &amp; Twin-Twin Genuine</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children</td>
<td></td>
<td></td>
<td>Twin-Twin Genuine</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Percentage (%)

- Parent: 68.11
- Children: 31.89
- Twin-Twin Genuine: 71.67
- Twin-Non-Twin Imposter: 28.33
The percentages of same types between siblings and between twins are 10% and 15% higher than that of parents, respectively.

The percentage of same types between a parent and a child is 5~10% higher than that of parents.

The type of a child follows either of parents’ type about 70%.

The distribution of matching scores for twins is similar to the distribution of imposter matching.

The distributions of matching scores among family members are also similar to the distribution of imposter matching.
An Empirical Study of Multi-modal Biometrics using Face, Fingerprint and Voice

Hale Kim
hikim@inha.ac.kr

School of Information & Communication Engineering
Biometrics Engineering Research Center
Purpose

- To demonstrate the feasibility of improving the performance and availability of biometric technology by integrating different modes of biometrics

Background

- Each single biometrics technology has its own limitations in different aspects.
Experiments

Experiment I
- Fingerprint + Face
- Scenario test
- 488 imposter matching and 3,228 genuine matching with 25 experienced subjects

Experiment II
- Fingerprint + Face
- Operational test
- 361 imposter matching and 1,810 genuine matching with 59 unexperienced subjects

Experiment III
- Fingerprint + Face + Voice
- Operational test
- 174 imposter matching and 403 genuine matching with 20 unexperienced subjects
Results (1)

<table>
<thead>
<tr>
<th></th>
<th>Scenario Evaluation (Test 1)</th>
<th>Operational Evaluation (Test 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FNMR (3228)</td>
<td>FMR (488)</td>
</tr>
<tr>
<td>Senior</td>
<td>456</td>
<td>0</td>
</tr>
<tr>
<td>Force</td>
<td>189</td>
<td>7</td>
</tr>
<tr>
<td>Carded Sum</td>
<td>55</td>
<td>6</td>
</tr>
<tr>
<td>Gaussian Classifier</td>
<td>38</td>
<td>6</td>
</tr>
</tbody>
</table>
## Results (2)

<table>
<thead>
<tr>
<th>Evaluation Type</th>
<th>FNMR</th>
<th>FMR</th>
<th>FMR+FNMR</th>
<th>Error Rate(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single Mode</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingerprint</td>
<td>67</td>
<td>9</td>
<td>76</td>
<td>13.3%</td>
</tr>
<tr>
<td>Face</td>
<td>108</td>
<td>10</td>
<td>118</td>
<td>20.6%</td>
</tr>
<tr>
<td>Voice</td>
<td>67</td>
<td>20</td>
<td>87</td>
<td>15.2%</td>
</tr>
<tr>
<td><strong>Bayesian Classifier</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingerprint + Face</td>
<td>22</td>
<td>7</td>
<td>29</td>
<td>5.1%</td>
</tr>
<tr>
<td>Face + Voice</td>
<td>29</td>
<td>8</td>
<td>36</td>
<td>6.2%</td>
</tr>
<tr>
<td>Fingerprint + Voice</td>
<td>35</td>
<td>10</td>
<td>45</td>
<td>7.9%</td>
</tr>
<tr>
<td>Fingerprint + Face + Voice</td>
<td>38</td>
<td>8</td>
<td>46</td>
<td>8.1%</td>
</tr>
<tr>
<td><strong>Weighted Sum</strong></td>
<td></td>
<td></td>
<td></td>
<td>4.9%</td>
</tr>
<tr>
<td><strong>Voting 2 out of 3</strong></td>
<td></td>
<td></td>
<td></td>
<td>7.7%</td>
</tr>
</tbody>
</table>
Observations

Even a simple combination rule such as ‘Weighted sum’ of matching scores can improve EER. Most of FNMR cases are due to user’s misuse. Overall, The multi-mode biometrics outperforms single biometrics in recognition with the cost of processing time and memory space. Choosing two out of three biometric modes is a trade-off.