Multi-Modal Biometric Testing and Evaluation

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James J. Jasinski
Multi-Modal Testing and Evaluation

- ISO / NIST MBE / IDENT Pilot
- Thoughts and observations from our R&D work involving multi-modal system/device
- Testing workflow and evaluation criteria
Multiple Meanings of “Multi-Modal”

- Multi-Instance / Presentation
- Multi-Sensing
- Multi-Unit
- Multi-Algorithm
- Multi-Modality
Multiple Meanings of “Multi-Modal”

- Multi-Instance
- Multi-Sensing
- Multi-Unit
- Multi-Algorithm

Within Single Modality

Multi-Modality
Fusion Model

- Fusion Algorithm (method)
  - sample level
  - feature level
  - score level
  - decision level

- Fusion Strategy (operation mode)
  - sequential
  - parallel
  - hierarchical
Fusion Model

- Fusion Algorithms
  - Sample Level
  - Feature Level
  - Score Level
  - Decision Level

- Fusion Strategies
  - Sequential
  - Parallel
  - Hierarchical
Multi-Modal Capability

- Built on Top of Single-Modal Capability (Quality Evaluation/Feature Exaction/Matching)
- Multi-Modal Data Capture
- Fusion Model
Multi-Modal Capability

Fusion Model
Multi-Modal Testing

- Multimodal Data Capture Testing
- Fusion Model Testing

![Diagram showing fusion strategies and algorithms](image)

- Sample Level
- Feature Level
- Score Level
- Decision Level

- Fusion Algorithms
- Fusion Strategies
- Sequential
- Parallel
- Hierarchical
Multi-Modal Testing

- Evaluate Performance
- Validate Multimodal Advantage
- Obtain Reference for R&D – selection of single-modal capability and fusion model
- Focus on Cases Involving Multiple Modalities
Goal

- Multi-Modal Capability Is Used in Biometrics Systems / Products to Improve:
  - accuracy
  - response time
  - availability
  - usability
  - Not addressed for this report
    - a) data integrity
    - b) system interoperability
Multiple Test Cases

Ideally...

Probe

Gallery
Multiple Test Cases

Real World…

Probe

Gallery
Performance Evaluation

- Accuracy
- Response Time
- Fusion Gain – with single modality performance as baseline
Fusion Model Testing

- With given single modality capabilities and testing database, evaluate the performance of the fusion model.
Fusion Model Testing

- Data Preparation for Training and Testing

- Multi-Modal Data
  - Modality # 1 data processing by Modality # 1 Algorithms
  - Single-Modal Data for Modality # 1 (score, quality, etc.)

- Modality # N data processing by Modality # N Algorithms
  - Single-Modal Data for Modality # N (score, quality, etc.)
Fusion Model Testing

- Training (optional)
Fusion Model Testing

- Define Interface with Fusion Model

Single Modality Capabilities ➔ Fusion Model ➔ Fusion Results

Testing DB ➔ Fusion Model ➔ Algorithm – Specific Data
Fusion Model Testing

1. Test Data Preparation
2. Generate Algorithm-Specific Data (optional)
3. Generate Fusion Results
4. Analysis
## Fusion Model Testing

<table>
<thead>
<tr>
<th></th>
<th>Fusion Model A</th>
<th>Fusion Model B</th>
<th>Fusion Model C</th>
<th>Fusion Model D</th>
<th>Fusion Model E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Testing case 1</strong></td>
<td>1.25</td>
<td>2.2</td>
<td>1.43</td>
<td>1.56</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Testing case 2</strong></td>
<td>1.38</td>
<td>2.2</td>
<td>1.39</td>
<td>1.37</td>
<td>2.1</td>
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<tr>
<td><strong>Testing case N</strong></td>
<td>0.99</td>
<td>2.0</td>
<td>1.21</td>
<td>1.79</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Fusion Model Testing
Multi-Modal Data Collection

- Design a collection protocol to cover
  - Collect at different times
  - Collect in different environments
  - Collect with different devices
  - Controls for data integrity
Database Attribute – representative to target?

- Number of subjects
- Quality distribution
- Distribution of age, gender and ethnic group
Observations

- For multi-modal testing, both fusion model and “black box” are of interest.

- Fusion model testing is useful in studying/evaluating fusion model and in building a modularized, multi-modal solution.

- “Black box” testing allows both single modality capability and fusion model to be customized for each other to maximize the gain.
Since the fusion model performed best when the characteristics of single modality capability involved were taken into consideration, fusion model testing should support the option to let the fusion model ‘learn’ about single modality capability.
Observations cont.

- Multi-modal data collection is critical to the testing.

- Test cases can be chosen by application scenarios.
Point of Contact

Mr. James J. Jasinski

Phone: 703.483.4614

E-mail: jamesjasinski@cogentsystems.com