Challenges of Integrating NFIQ into an Existing Biometric Application

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NIST Biometric Quality Workshop
November 7 - 8, 2007
Agenda

§ Overview
  – US-VISIT Biometrics Quality Assurance
  – Use of Fingerprint Image Quality Scores in US-VISIT

§ NFIQ and IDENT Scores
  – Score Range and Initial Mapping

§ Where NFIQ Encounters Challenges
  – Score Mapping and Correlation of NFIQ = 3

§ Desired Characteristics of an Image Quality Score Algorithm and Its Score Range

§ Summary
IDENT Image Quality Monitoring, Reporting and Analysis

Image Quality Reports:

- By application
- By site/terminal
- By capture device
- By new or repeated subject
- By matcher enrollment
- By finger and between fingers
- Trend analysis

<table>
<thead>
<tr>
<th>#</th>
<th>Application</th>
<th>Fingerprint Type</th>
<th>Total Images</th>
<th>Good (Q1-Q4) %</th>
<th>Ave. (Q5-Q6) %</th>
<th>Poor (Q7-Q8) %</th>
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<tbody>
<tr>
<td>1</td>
<td>Application A</td>
<td>F</td>
<td>9562</td>
<td>91.00</td>
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<td>15.28</td>
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<tr>
<td>5</td>
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<td>11.91</td>
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<tr>
<td>6</td>
<td>Application D</td>
<td>R</td>
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<td>17.50</td>
<td>27.50</td>
<td>55.00</td>
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<tr>
<td>7</td>
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<td>R</td>
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<td>76.40</td>
<td>11.50</td>
<td>12.00</td>
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<tr>
<td>8</td>
<td>Application F</td>
<td>F</td>
<td>6962</td>
<td>83.34</td>
<td>6.92</td>
<td>9.74</td>
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Summary Report

<table>
<thead>
<tr>
<th>Application</th>
<th>Total Images</th>
<th>Good % (Q1-Q4)</th>
<th>Average % (Q5-Q6)</th>
<th>Poor % (Q7-Q8)</th>
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</thead>
<tbody>
<tr>
<td>1205626</td>
<td>85.9%</td>
<td>8.92</td>
<td>7.03</td>
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</table>

Detailed Report by Site and by Terminal within the Site

<table>
<thead>
<tr>
<th>SiteCode</th>
<th>SiteName</th>
<th>Terminal ID</th>
<th>TotalImages</th>
<th>Good % (Q1-Q4)</th>
<th>Average % (Q5-Q6)</th>
<th>Poor % (Q7-Q8)</th>
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</thead>
<tbody>
<tr>
<td>Site A</td>
<td>JFK INTL AIRPORT</td>
<td>Terminal A</td>
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<tr>
<td>Site B</td>
<td>JFK INTL AIRPORT</td>
<td>Terminal B</td>
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<td>85.9%</td>
<td>8.92</td>
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<tr>
<td>Site C</td>
<td>JFK INTL AIRPORT</td>
<td>Terminal C</td>
<td>12056268</td>
<td>85.9%</td>
<td>8.92</td>
<td>7.03</td>
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</table>

Scanner A Application App.X Total Images Good % (Q1-Q4) Ave. % (Q5-Q6) Poor % (Q7-Q8)

Scanner B Application App X Total Images Good % (Q1-Q4) Ave. % (Q5-Q6) Poor % (Q7-Q8)

Scanner C Application App X Total Images Good % (Q1-Q4) Ave. % (Q5-Q6) Poor % (Q7-Q8)

Matcher A Good (Q1 - Q4) % Average (Q5 - Q6) % Poor (Q7 - Q8) %

Matcher B 76.68 9.14 14.18
Matcher C 87.20 5.77 7.03
Matcher C 88.49 6.06 5.45
IDENT Matcher Accuracy Monitoring, Reporting and Analysis

Accuracy, Performance and Trend:

- 1:1 True Accept Rate (TAR)
- 1:N False Accept Rate (FAR)
- Examiner (CVT) Workload
- FAR vs. Database Size
Use of Fingerprint Image Quality Scores in US-VISIT

Usages:

- Fingerprint Recapture
- Updating Prints on Matchers
- Match Accuracy Prediction/Optimization

Objectives:

- Ensure High Quality Fingerprint (Biometrics) Capture
- Ensure High Fingerprint (Biometrics) Identification Performance
Fingerprint Recapture

Current 2-Print System

Emerging 10-Print System

Client Image Quality Checks

- Quality check of individual fingers
- Recapture requested if the specified thresholds for the individual fingers are not met
Fingerprint Updating Based on Quality

Existing Implementation:

- Perform best quality fingerprint updates when the sum of the IDENT quality scores is less than the sum of the scores of the enrolled prints.

Proposed Implementation:

- When using NFIQ, similar replacement rules need to be developed.
NFIQ and IDENT Image Quality

IDENT Quality:
- Scores range from 1 to 127
  - 1 is the highest quality
  - 127 is the lowest quality
- Thresholds were created based on match accuracy

NFIQ:
- Scores range from 1 to 5
  - 1 is the highest quality
  - 5 is the lowest quality
- Similar thresholds were created to map to existing IDENT Quality thresholds*

*NFIQ thresholds were based on the following:
- NIST IR 7151 – “Fingerprint Image Quality”
  - NFIQ Scores 1,2,3,4,5
  - Excellent, Very Good, Good, Fair, Poor.
- NIST SP 800-76-1 – “Biometric Data Specification for Personal Identity Verification”
  - “NFIQ values of 1,2, or 3 (i.e., good quality)”
Differences Between NFIQ and IDENT Image Quality

NFIQ Algorithm (1 to 5):

- Good
- Fair
- Poor

1, 2, 3, 4, 5

- Direction map
- Contrast map
- Flow map
- High curve map

IDENT Algorithm (1 to 127):

- Good
- Fair
- Poor

1, 2, 3, 4, 5, 6, 7, 8, 9, …, 127

- Noise level of useful area of image
- Image contrast information
- Size of useful area of image
- Core position and confidence
- Poor quality image area percentage
- Average quality level for minutiae
- Number of minutiae and deleted low confidence minutiae
- Percentage of background image area

<table>
<thead>
<tr>
<th>Quality</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
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<tbody>
<tr>
<td>Accuracy</td>
<td>99.4</td>
<td>99.4</td>
<td>99.1</td>
<td>59.4</td>
<td>27.0</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Quality</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8-127</th>
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</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>99.4</td>
<td>99.2</td>
<td>99.1</td>
<td>98.2</td>
<td>95.2</td>
<td>89.3</td>
<td>83.8</td>
<td>53.6</td>
</tr>
</tbody>
</table>

* Statistics from NIST IR 7110. “Matching Performance for the US-VISIT IDENT System Using Flat Fingerprints”. Values are TAR at FAR 1.0%.
Score Mapping and Correlation: IDENT vs. NFIQ

- Nice mapping in Very Good and Poor images
- Ambiguities occur in good and fair images (NFIQ = 3 and 4)

<table>
<thead>
<tr>
<th>IDENT Score</th>
<th>NFIO Score 1</th>
<th>NFIO Score 2</th>
<th>NFIO Score 3</th>
<th>NFIO Score 4</th>
<th>NFIO Score 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>1, 2, 3, 4, 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td></td>
<td>1, 2, 3, 4, 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td></td>
<td></td>
<td>1, 2, 3, 4, 5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Table and bar graph showing score mapping and correlation between IDENT and NFIQ scores.](image)
Score Mapping and Correlation: NFIQ = 3

- NFIQ Score 3 has a wide distribution across IDENT Quality Scores
- For this reason US-VISIT Capture Guidelines differ from NIST PIV Capture Guidelines
- US-VISIT does not recommend acceptance of NFIQ Score 3 on most important fingers (thumbs, index, and middle)

IDENT Quality Score Distribution of NFIQ=3 Samples

- Approximately 10% of images in the study are NFIQ=3
Desired Characteristics of a Fingerprint Image Quality Algorithm and its Score Range

- **High Scale Resolution**
  - e.g., [ 0, ..., 100 ] scale range
  - Easier to map between quality algorithms
  - ANSI/NIST-ITL 1-2007

- **Linear and Uniform Scale**
  - Score difference could indicate both machine matching and human examiner inspection difference in linear and uniform scale
Summary

§ In US-VISIT Fingerprint Quality Scores are primarily used for Fingerprint Recapture and Updating Prints on Matchers

§ Currently integrating NFIQ into the IDENT system

§ Challenges have been encountered when attempting to correlate scores

§ More distinct quality levels will improve ability to correlate different quality algorithm scores

§ Additional work is required for achieving interoperability of quality measures
Comments or Questions?

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