Measuring Biometric Sample Quality By Biometric Information

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Biometric Sample Quality

Biometric Sample Quality views
- character
  - inherent features
- Fidelity
  - accuracy of features
- utility
  - predicted biometrics performance

INCITS, Biometric Sample Quality Standard Draft, M1/06-0003
Utility

If images match better (ie. lower errors) then samples were better
Utility

- Fairly simple conceptually
- Dependent on matching algorithm
- Doesn’t allow quantification of “inherent” quality
Character / Fidelity

Descriptions of “inherent” quality of a biometric sample

- Character
  - Blur
  - Shadows
  - Poor lighting

- Fidelity
  - A good image of the wrong part
Example: *Character*

Best Faces  Human Selections  Worst Faces

Example: *Fidelity*

Biometric Sample Quality in terms of Biometric Information
How can we measure quality

☐ Probing question:

Why do we worry about low quality images?

☐ Answer:

They have less “biometric information”
We define “biometric information” as: the decrease in uncertainty about the identity of a person due to a set of biometric measurements.
Biometric Information: relative entropy $D(p \| q)$

$$BI = D(p \| q) = \int p(x) \log_2 \frac{p(x)}{q(x)} dx$$

- Distributions
  - Individual, $p(x)$
  - Population, $q(x)$
- $D$ measures extra information in $p$ than $q$

- Distribution models
  - Gaussian models, PCA features, regularization
### Example: Height

<table>
<thead>
<tr>
<th>Measure #1</th>
<th>Average (5½’ tall)</th>
<th>Tall (6½’ tall)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(doctor’s office</td>
<td></td>
<td></td>
</tr>
<tr>
<td>= accurate)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.23 bits</td>
<td>2.7 bits</td>
</tr>
<tr>
<td>Measure #2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(via telescope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>= inaccurate)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.05 bits</td>
<td>1.1 bits</td>
</tr>
</tbody>
</table>

What is the *quality difference* between measures?
Quality of a biometric measure

- quality difference between “instruments” \( f \) and \( g \) is

\[
\Delta BI = \frac{1}{N_f} \sum_{i=1}^{N_f} \left( D(p_{f_i} \parallel q_{f_i}) - D(p_{g_i} \parallel q_{g_i}) \right)^2
\]

- Person #1: \( \Delta BI = (0.23 - 0.05/0.23)^2 = 0.61 \)
- Person #2: \( \Delta BI = (2.7 - 1.1/2.7)^2 = 0.36 \)
Application #2: Face Recognition

Aberdeen Face database

- 18 frontal images of 16 persons
- Variability in lighting and expression between images
- $D(p||q)$ computed for 100 features using
  - PCA (eigenface)
  - FLD (fisherface)
## PCA / FLD / PCA+FLD

<table>
<thead>
<tr>
<th>PCA</th>
<th>FLD</th>
<th>PCA+FLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>45.0 bits</td>
<td>37.0 bits</td>
<td>55.6 bits</td>
</tr>
</tbody>
</table>

- Extra information from both PCA and FLD is small.
- Values seem reasonable.
- Our extrapolations from FRVT2002 give 27.3 bits for lead algorithm.
Quality decrease with blur

Steady-state
Aside: our initial mistake

☐ Must compare

$\text{(Instrument \#1)} - \text{(Instrument \#2)}$

<table>
<thead>
<tr>
<th>Individual (p)</th>
<th>Population (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument #1</td>
<td><img src="image1" alt="Green Distribution" /></td>
</tr>
<tr>
<td>Instrument #2</td>
<td><img src="image3" alt="Blue Distribution" /></td>
</tr>
</tbody>
</table>
Our wrong calculation

<table>
<thead>
<tr>
<th></th>
<th>Individual (p)</th>
<th>Population (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument #1</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>Instrument #2</td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
</tbody>
</table>

- We compared blurry instrument to the clean population
- This increased biometric information
- The algorithm says: *I can recognize p. He always has a blurry face!*
Summary

- relationship between biometric quality and biometric information
- A method to measure the quality change due to an image degradation

Limitation: Can’t measure quality of a single image
Applications

- Clarify nature of biometric quality measures
- Help quantify limits of impact of quality on matcher performance
- Help quantify effects of biometric fusion with low quality data
- Privacy impact of approaches to de-identify face data
Comment: *Quality*

- *Quality* is a value laden term
- Can we tell users this?

- Maybe we need another term: *Clarity*?