Biometric quality for error suppression

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Outline

- Why measure quality?
- What is meant by quality?
- What are they good for?
- What are the challenges in quality computation?
- Quality standardization
Why measure quality?
Push towards zero-error biometrics

- While recognition technologies are good at what they are being used, or contemplated for use, their performance drop in difficult operational scenarios and with imperfectly controlled data.

- Although only a small fraction of input data are of poor-quality, the bulk of recognition errors can be attributed to poor-quality samples.

- Improving quality either by sensor design, by user interface design, or by standards compliance, better performance can be realized.

- For those aspects of quality that cannot be designed-in, an ability to analyze the quality of a live sample is needed.

What is meant by quality?
Predictive of performance

Quality problem: “The Last 1%”
Or maybe “The Last 0.1% or 10%”

- Fraction of samples that should not be sent to the matcher
  - finger, iris scanners have been designed specifically for the task, face cameras (mostly) have not
  - providing constructive feedback only possible if cause of poor quality is known

- character, e.g. scar
- behavior, e.g. pose
- environment, e.g. imaging, e.g. focus
- shadows
What are the uses of quality?

Initiating the reacquisition from a user
- Enrollment
  - for credential issuance (visa, passport, access card, PIV)
  - pruning the poorest quality samples (1.65% of dataset) reduced EER from 0.0047 to 0.0024
- Verification
  - of the samples just captured which one to send for matching?
  - or acquire still more?
- Identification
  - is the subject offering a poor sample deliberately?

Selective invocation of different processing methods
- Preprocessing phase
  - image restoration algorithms (e.g., contrast adjustment) or a different feature extraction
- Matching phase
  - invoke a slower but more powerful matching algorithm when low-quality samples are compared
  - sending poor quality (NFIQ=4.5) to a more accurate (but perhaps costly) matcher reduced FNMR from 0.0136 to 0.0078 at FMR=0.001
- Decision phase
  - quality directed fusion, dynamic threshold
  - performing quality based multi-algorithm contingent likelihood ratio fusion reduced FNMR from 0.0136 to 0.0068 at FMR=0.001

Sample replacement/Template update
- negate template aging
Quality monitoring
- are some biometric field locations giving low quality?
- only in the evening?

Predictive of performance

A biometric quality assessment method derives a numerical quality value from an input biometric sample. The quality value is related to the biometric error rates that are likely to be realized when the sample is matched.
Quality: rank statistic for performance

NFIQ: (fmr, fnmr) at fixed threshold

NIST fingerprint image quality

- NIST developed NFIQ in 2004
  - Open source
    http://www.itl.nist.gov/iad/894.03/nigos/nigos.html
- Key innovation: quality as a rank statistic for performance
- NFIQ is a machine learning algorithm
  - Exploratory variables: image properties (minutiae, ridge density and clarity)
  - Response variable: separation of genuine and impostor comparison
NFIQ 1.0

- **feature extraction**: computes appropriate signal or image fidelity characteristics and results in an 11-dimensional feature vector.
- **neural network**: classifies feature vectors into five classes of quality based on various quantiles of the normalized match score distribution.
- **quality number**: an integer value between 1 (highest) and 5 (poorest).

Error rates per NFIQ level

- Error per Quality Level nfiq – Threshold @ fmr=0.001
  - False non-match rate vs. false match rate
  - Data points indicate error rates for different NFIQ levels.
Quality challenges

Scalar vs vector
Matcher dependency
How many levels?
Pair-wise quality
Calibration

How many levels?

Statistically different level of performance
Dependence on matcher

Each point corresponds to one algorithm.

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Pair-wise quality

\[ Q_1 = F(I_1) \; ; \; Q_2 = F(I_2) \; ; \; Q_{12} = G(F(I_1), F(I_2)) \]

when the enrollment sample is of good quality and better than that of the authentication sample, the authentication sample’s quality is sufficient to predict performance.
Calibration Curve: Error vs reject : NFIQ

![Calibration Curve: Error vs reject : NFIQ](image)

BIOMETRIC QUALITY STANDARDS
FACILITATING UNIVERSAL SEEMLESS EXCHANGE OF BIOMETRIC DATA QUALITY INFORMATION
Purpose

- establish an interoperable definition, interpretation, and formats for exchange of biometric quality data
- create grounds for a marketplace of interoperable off-the-shelf products

Quality standards

- ISO/IEC 29794
- ISO/IEC 19794

BioAPI quality field

ANSI/NIST ITL 1-2007 quality field
Three components of quality character, fidelity, and utility

“An expression of quality based on utility reflects the predicted positive or negative contribution of an individual sample to the overall performance of a biometric system.” (SC 37 N 3084)

“Character, e.g. scar behavior, e.g. pose environment, e.g. imaging, e.g. focus

“The term “quality” should not be solely attributable to the acquisition settings of the sample, such as image resolution, dimensions in pixels, grayscale/color bit depth, or number of features. Though such factors may affect sample utility and could contribute to the overall quality score.” (SC 37 N 3084)

ISO/IEC 29794
Structure of “Quality Field”

<table>
<thead>
<tr>
<th>Source ISO/IEC SC 37 N 3084</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Size</th>
<th>Valid Values</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Quality Blocks</td>
<td>1 byte</td>
<td>[0, 255]</td>
<td>This field is followed by the number of 5-byte Quality Blocks reflected by its value. A value of zero (0) means that no attempt was made to assign a quality score. In this case, no Quality Blocks are present.</td>
</tr>
<tr>
<td>Quality Block</td>
<td>5 bytes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality score</td>
<td>1 byte</td>
<td>[0, 100] 255</td>
<td>0: lowest 100: highest 255: failed attempt to assign a quality score</td>
</tr>
<tr>
<td>Quality algorithm vendor ID</td>
<td>2 bytes</td>
<td>[1, 65535]</td>
<td>Quality Algorithm Vendor ID shall be registered with IBIA as a CBEFF biometric organization. Refer to CBEFF vendor ID registry procedures in ISO/IEC 19785-2.</td>
</tr>
</tbody>
</table>
ISO/IEC 29794-1
Informative annexes

- Annex A (informative)
  - Procedures to construct a quality score normalisation dataset

- Annex B (informative)
  - Example - standardized exchange of quality algorithm results

- Annex C (informative)
  - Procedures for aggregation of utility-based quality scores
ISO/IEC 29794-6
iris image quality standard (SC 37 N 3331)

1 Scope

This Part 6 of ISO/IEC 29794, iris image sample quality document establishes
• terms and definitions that are useful in the specification, characterization and test
  of iris image quality,
• methods used to characterize and assess the quality of iris images,
• normative requirements on software and hardware producing an iris image, and
• normative requirements on software and hardware measuring utility of iris images.

Outside the scope are
• performance assessment of specific quality algorithms, and
• standardization of specific quality algorithms.

... is organized by the distinction of quality covariates related to: 1) the design and
implementation of the image acquisition equipment and environment (6.2), and 2)
subject-specific or subject-influenced/controlled factors 6.3).

FY 09-10 activities
IREX II – Iris quality calibration and evaluation (IQCE)
An evaluation based program for development of clear, implementable, and interoperable iris quality standard
ISO/IEC 29794-6.
IQCE :: outcome

- A refined list of iris image quality metrics with tolerance bounds
  - Quantitative support to ISO/IEC 29794-6

- Iris image quality tool box
  - Technical papers on iris image quality
    - Mathematical equations on how to compute quality e.g. SNR
  - Software implementations
    - Open source or proprietary compiled libraries

- Calibration curve per IQAA.

Thank You

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www.itl.nist.gov/iad/894.03/quality
Iris.nist.gov/irexII
pair-wise quality