Candidate Features for Quality Assessment

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Quality Features For NFIQ 2.0

- Requirements
  - Based on publically available algorithms
  - Standardized interface (inputs and outputs)
Implemented Quality Features

- More than 30 features identified and tested on multiple datasets
  - NFIQ
  - Implemented from ISO/IEC TR 29794-4
    - Frequency Domain Analysis
    - Local Clarity Score
    - Orientation Certainty Level
    - Orientation Flow
    - Radial Power Spectrum
    - Ridge Valley Uniformity
  - Gabor filter
  - Ridge line count
  - Gabor (Shen et al., Quality Measures of Fingerprint Images, 2001)
  - Minutiae count in region of interest
  - FingerJetFX
Feature Example
Orientation Certainty Level

- See NFIQ 2.0 project page at http://www.nist.gov/itl/iad/ig/development_nfiq_2.cfm
- ISO/IEC 29794-4:2010
- Block wise approach

### OCL input parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I$</td>
<td>-</td>
<td>Input image</td>
</tr>
<tr>
<td>$B_h$</td>
<td>32</td>
<td>Block height in pixels</td>
</tr>
<tr>
<td>$B_w$</td>
<td>32</td>
<td>Block width in pixels</td>
</tr>
<tr>
<td>$mask$</td>
<td>-</td>
<td>Segmentation mask</td>
</tr>
</tbody>
</table>
Orientation Certainty Level
Algorithm → Covariance

1. Compute the intensity gradient of each block
\[
[dx \quad dy] = \text{gradient}(B)
\]

2. Compute the covariance matrix from the gradients
\[
C = \frac{1}{N} \sum_{N} \begin{bmatrix} dx & dy \end{bmatrix} = \begin{bmatrix} a & c \\ c & d \end{bmatrix}
\]
Orientation Certainty Level
Algorithm → Eigenvalue computation

3. Compute the eigenvalues to obtain OCL for each block

\[ \lambda_{\text{min}} = \frac{a + b - \sqrt{(a - b)^2 + 4c^2}}{2} \]

\[ \lambda_{\text{max}} = \frac{a + b + \sqrt{(a - b)^2 + 4c^2}}{2} \]
Orientation Certainty Level
Algorithm → Computing the quality score

- Local orientation certainty level
  - A ratio in the interval $[0, 1]$ where 1 is highest certainty level and 0 is lowest.

$$OCL = 1 - \frac{\lambda_{\text{min}}}{\lambda_{\text{max}}}$$
Shaping of Gabor filter according to detected ridge-line frequency

- Feedback from previous workshop at IBPC ’12 to use:
  - Dynamic filter bank based on detected ridgeline frequency
  - In progress using ridgeline counting and detected frequency peak
Actionable Quality
Providing more than a quality value

- Detectors
  - Centeredness (based on singularity position)
  - Wetness/pressure
  - Completeness
  - Ghostprints

- Motivation:
  - “It would be useful to have a detector for too dry/wet fingers, too low/high pressure, and out-of-center fingerprints.” – Greg Cannon during IBPC ’12 NFIQ 2.0 workshop
  - Reply back then was: “Whether this can be detected or not depends on the training data. Contributions of finger images that are known to have low/high pressure etc. are welcome”.

Data collection for wet/dry detection

Overview

- 5 fingerprint sensors (optical)
- 33 subjects
- 4 impressions/finger/sensor
- 6600 images total
- 4 types of treatment
  - No treatment
  - alcohol-dried
  - crème-moisturized
  - water
Data collection for wet/dry detection

Examples

- Objective measurement of skin moisture level

62.5%  84.6%  99.9%
Observations on wet/dry impressions

- Wet fingerprints are generally handled well by recent sensors
- Dry fingerprints cause degradation in comparison score

Older generation sensor  
New generation sensor

See master thesis by Marek Dusio (DTU) – to be published in June 2013
NFIQ 2.0 Lite

- **Motivation:**
  - Execution speed of feature extraction is important in some applications (even though processors are getting faster and faster). Aim at 125–150 ms for inclusion of quality assessment into auto-capture loop of sensors. – IBPC ‘12

- **Potential solution:**
  - Pre-compute a lookup table which can speed up the quality assessment
NFIQ 2.0 Lite
Machine Learning approach

- Two stage process
  - Clustering using Self-Organizing Map
  - Prediction using Random Forest

To be published by Martin Aastrup Olsen, Anton Makarov, Elham Tabassi, Christoph Busch
SOM example

Blocksize: 24 x 24 px
SOM units: 32 x 32

To be published by Martin Aastrup Olsen, Anton Makarov, Elham Tabassi, Christoph Busch
SOM activation histogram

- 64 images with highest comparison score
- 64 images producing false non-match at FNMR = $10^{-4}$

- Difference between histograms.

To be published by Martin Aastrup Olsen, Anton Makarov, Elham Tabassi, Christoph Busch
Performance indication

- FNMR vs. score threshold for each level of quality
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