Development of NFIQ 2.0

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http://www.nist.gov/itl/ial/ig/development_nfiq_2.cfm

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Winchester, UK
2004 - present

2004
- Release of NFIQ 1.0
- Novel definition of biometric quality
- Performance related
- Accepted by the community
- Interoperability
- Uniform interpretation
- Tuned to a class of matcher
- Open source
- Extensively examined
- By NIST and others
- Tools for quality summarization, slap, ...

2010 workshop
- Workshop on March 6, 2010 (IBPC 2010)
- NFIQ 2.0 wish-list as of March 2010
- Several options for NFIQ 2.0 were discussed
- The community overwhelmingly recommended a new, open source, generalized version of NFIQ to be developed in consultation and collaboration with users and industry.
  - Same technical approach, but better, bigger, faster, etc.

2012 workshop
- Workshop on March 5, 2012 (IBPC 2012)
- NFIQ 2.0 wish-list as of March 2010
- Components as of March 2012
- Community asked for:
  - Actionable flags
  - Provider ID
  - Versioning
  - Latent?
# NFIQ 2.0 Community

## Team Members
- NIST (US)
- BSI (Germany)
- BKA (Germany)
- Fraunhofer IGD
- Hochschule Darmstadt / CASED
- Secunet Security Networks AG
- NFIQ 2.0 Participants
- *...and the whole biometrics community*

## Sponsors
- Homeland Security
- Federal Office for Information Security
Architecture of NFIQ 2.0 Framework

**NFIQ 2.0 Development Tools**

**NFIQ 2.0**

**Image Format Converter**

**Framework**

**Input / Output Interface**

**Quality Feature Extraction Interface**

**Utility Estimation Interface**

**Machine Learning Interface**

**Input / Output Module**

**Quality Feature Extraction Module**

**Utility Estimation Module**

**Machine Learning Module**

- Fingerprint images
- Quality features
- Comparison scores
- Utility Values

- Feature extraction
- Utility computation
- Fusion and binning
- Prediction
- Training

**Database**

**Filesystem**

**Quality feature x**

**Utility x**

**MLP**
## NFIQ 2.0 features

### Image/signal processing
- Local clarity score
- Ridge valley uniformity
- Orientation certainty level
- Orientation flow
- Frequency domain analysis
- Radial power spectrum
- Gabor filters (several variants)

### Minutiae based
- FingerjetFx
  - Open source implementation from digitalPersona
  - [Digitalpersona.com/fingerjetfx](http://Digitalpersona.com/fingerjetfx)
- Total count of minutia
- Count of minutia in region of interest
  - Various selection of ROI

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Standardized features allow for plug and play of feature computation implementations that are semantically conformant to the standard (i.e., ISO/IEC 29794-4 and ISO/IEC 19794-4). Different implementations are distinguished via providerID.
NFIQ 2.0 features - 3

false non-match rate

fraction of genuine comparisons rejected

Comparator 2B – Dataset poebva – Finger 02
**Random Forest**

- Ensemble classifier using stochastic process
  - Use vote to determine class memberships
  - Provides class probability in predictions
- Training
  - All features
  - 4874 samples in each of the low and high performers classes
  - 1000 trees in forest
- Test
  - 287,895 comparison scores

**Two class prediction**

- High vs. Low performers
  - 1: High performers are images that result in high genuine scores
    - $> \text{CDF}^{-1}(0.95)$
  - 0: Low performers are images that result in false reject
    - Threshold at $\text{FMR}=0.0001$
- Quality score is the probability that a given image belongs to class 1.
- Map quality score to recognition rate.
NFIQ 2.0 prototype
NFIQ 2.0 prototype

Verification q

Comparator 1Y – Dataset all – Finger 02

Comparator 1O

Fraction of genuine comparisons rejected

Comparator R – Dataset all – Finger 02

Fraction of genuine comparisons rejected

Comparator B – Dataset all – Finger 02

Enrolment q
# Actionable quality

## Feed back to user/operator

- Wet / dry
  - High/low pressure
- Centeredness
  - Singularity detection
- Incompleteness
  - Singularity detection
- Ghost images

## Questions?

- Sensor sensitivity?
- Algorithm sensitivity?
- Already covered by features?
- Any addition or deletion?
  - Fingerness?
  - Alteredness?
  - correctness of phalanx?
NFIQ 2.0 Lite/Mobile

Requirements

» Low computation complexity
  • processing power
  • Processing time

» Therefore, feature computation not feasible!

» Look up table?

Requirements:

- Low computation complexity
  - processing power
  - Processing time

Therefore, feature computation not feasible!

Look up table?
NFIQ 2.0 Lite prototype

Features

performance

false non-match rate

fraction of genuine comparisons rejected

network size 24 network size 32 network size 64 orientationFlow

Enrolment Quality

Verification Quality
## NFIQ 2.0 computation time

<table>
<thead>
<tr>
<th>Lite</th>
<th>NFIQ 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>~65 ms/image</td>
<td>~19.45 msec/image</td>
</tr>
<tr>
<td>- PC - 2.3 GHz Intel Core i7</td>
<td></td>
</tr>
<tr>
<td>- 16 GB of memory.</td>
<td>- MacBook Air, Mid 2011</td>
</tr>
<tr>
<td>- network size of dim = 24</td>
<td>- Processor: 1.7 GHz Intel Core i5 (dual core)</td>
</tr>
<tr>
<td>- block size of n = 24</td>
<td>- Memory : 4 GB 1333 MHz DDR3 (256 KB L2 cache, 3MB L3 cache)</td>
</tr>
<tr>
<td>- With gray scale normalization</td>
<td>- Software: OS X 10.8.3 (12D78)</td>
</tr>
<tr>
<td>~82 ms/image.</td>
<td>~85 msec/image</td>
</tr>
<tr>
<td>- PC - 2.3 GHz Intel Core i7</td>
<td></td>
</tr>
<tr>
<td>- 16 GB of memory.</td>
<td>- for OCL - Expect about the same for other features</td>
</tr>
<tr>
<td>- network size of dim = 24</td>
<td>- Minutia based</td>
</tr>
<tr>
<td>- block size of n = 64</td>
<td>- This is prior to any code optimization</td>
</tr>
<tr>
<td>This is prior to any code optimization</td>
<td>This is prior to any code optimization</td>
</tr>
<tr>
<td>Completed</td>
<td>Underway</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>» Framework design</td>
<td>» Feature Implementation - MATLAB to C/C++</td>
</tr>
<tr>
<td>• Modular, plug and play</td>
<td>• Thanks to FBI</td>
</tr>
<tr>
<td>» Framework implementation</td>
<td>» Exploring machine learning</td>
</tr>
<tr>
<td>» Feature selection and prototype implementation complete</td>
<td>• Random forest, SVM</td>
</tr>
<tr>
<td>• <a href="http://biometrics.nist.gov/cs_links/quality/NFIQ_2/NFIQ-2_Quality_Feature_Definition_Version05.pdf">http://biometrics.nist.gov/cs_links/quality/NFIQ_2/NFIQ-2_Quality_Feature_Definition_Version05.pdf</a></td>
<td>• Self organizing map</td>
</tr>
<tr>
<td>» Feature evaluation complete</td>
<td>» Implementation of actionable flags for detection and mitigation of bad presentations</td>
</tr>
<tr>
<td></td>
<td>• Incomplete finger (tip, etc.) + Wet / dry + Pressure</td>
</tr>
<tr>
<td></td>
<td>» Standardization of NFIQ 2.0 feature (ISO/IEC 29794-4)</td>
</tr>
<tr>
<td></td>
<td>• Allows for plug-and-play of features for implementations that satisfy semantic conformance to the requirements of the ISO/IEC 29794-4 standard</td>
</tr>
<tr>
<td>Promises, promises</td>
<td>So far, we have achieved</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Improved feature</td>
<td>Improved feature</td>
</tr>
<tr>
<td>More level (0-100)</td>
<td>More level (0-100)</td>
</tr>
<tr>
<td>Faster, lighter</td>
<td>Faster – we hope</td>
</tr>
<tr>
<td>Actionable feedback</td>
<td>Actionable feedback</td>
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<tr>
<td>NFIQ 2.0 mobile</td>
<td>Towards NFIQ Mobile</td>
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<tr>
<td>Slap</td>
<td>--</td>
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<tr>
<td>Better performance</td>
<td>Better performance – we hope</td>
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<tr>
<td>Modular design</td>
<td></td>
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<tr>
<td>Calibration</td>
<td></td>
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<tr>
<td>Conformance testing</td>
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## Coming up

1. **Publication of NFIQ 2.0 Feature Evaluation (NIST IR)**
   - June 2013

2. **Publication of use of machine learning techniques in NFIQ 2.0 (NIST IR)**
   - August 2013

3. **Biometric quality workshop at BCC 2013 - Tampa, FL**
   - Sept 17, 1040–1200
   - Present NFIQ 2.0 with possible demo at NIST booth
   - Room 20

4. **Standardization of NFIQ 2.0 features (ISO/IEC 29794-4)**
   - 2015+
Thank You.

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