Development of NFIQ 2.0

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

April 26, 2013

Winchester, UK

NIST
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
  - providerID
  - 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

Framework

Input / Output Interface

Quality Feature Extraction Interface

Utility Estimation Interface

Machine Learning Interface

Image Format Converter

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 comparison score provider

FMR vs FNMR for various providers:
- 1F_07_poebva_p2p
- 1F_02_poebva_p2p
- 1O_07_poebva_p2p
- 1O_02_poebva_p2p
- 1T_07_poebva_p2p
- 1T_02_poebva_p2p
- 1Y_07_poebva_p2p
- 1Y_02_poebva_p2p
- id3_07_poebva_p2p
- id3_02_poebva_p2p
- dermalog_07_poebva_p2p
- dermalog_02_poebva_p2p
- pb_07_poebva_p2p
- pb_02_poebva_p2p
- R_07_poebva_p2p
- R_02_poebva_p2p

Graph showing FMR on the x-axis and FNMR on the y-axis for different providers.
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
- Total count of minutia
- Count of minutia in region of interest
  - Various selection of ROI

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.
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
    - \( CDF^{-1}(0.95) \)
  - 0: Low performers are images that result in false reject
    - Threshold at \( FMR=0.0001 \)
- Map quality score to recognition rate.

NIST
NFIQ 2.0 prototype

<table>
<thead>
<tr>
<th>1F</th>
<th>1O</th>
<th>1T</th>
<th>1Y</th>
<th>2B</th>
<th>dermalog</th>
<th>id3</th>
<th>pb</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Probability of sample score &gt; 90th percentile" /></td>
<td><img src="image" alt="Probability of sample score &gt; 90th percentile" /></td>
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<td><img src="image" alt="Probability of sample score &gt; 90th percentile" /></td>
</tr>
</tbody>
</table>

Quantile

Probability of sample score > 90th percentile

NIST
**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?

SOM code book
NFIQ 2.0 Lite prototype

Features

performance

- network size 24
- network size 32
- network size 64
- orientationFlow

false non-match rate

fraction of genuine comparisons rejected

Enrolment Quality

Verification Quality

Enrolment Quality

Network size

OrientationFlow
### 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>- MacBook Air, Mid 2011</td>
</tr>
<tr>
<td>- 16 GB of memory.</td>
<td>- Processor: 1.7 GHz Intel Core i5</td>
</tr>
<tr>
<td>- network size of dim = 24</td>
<td>(dual core)</td>
</tr>
<tr>
<td>- block size of n = 24</td>
<td>- Memory: 4 GB 1333 MHz DDR3</td>
</tr>
<tr>
<td>- With gray scale normalization</td>
<td>(256 KB L2 cache, 3MB L3 cache)</td>
</tr>
<tr>
<td>~82 ms/image</td>
<td>- Software: OS X 10.8.3 (12D78)</td>
</tr>
<tr>
<td>- PC - 2.3 GHz Intel Core i7</td>
<td>- for OCL - Expect about the same</td>
</tr>
<tr>
<td>- 16 GB of memory.</td>
<td>for other features</td>
</tr>
<tr>
<td>- network size of dim = 24</td>
<td>~85 msec/image</td>
</tr>
<tr>
<td>- block size of n = 64</td>
<td>- Minutia based</td>
</tr>
<tr>
<td>This is prior to any code optimization</td>
<td>This is prior to any code</td>
</tr>
<tr>
<td></td>
<td>optimization</td>
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## Current Status

### Completed

- Framework design
  - Modular, plug and play
- Framework implementation
- Feature selection and prototype implementation complete
- Feature evaluation complete

### Underway

- Feature Implementation - MATLAB to C/C++
  - Thanks to FBI
- Exploring machine learning
  - Random forest, SVM.
- NFIQ 2.0 Lite
  - Self organizing map
- Implementation of actionable flags for detection and mitigation of bad presentations
  - Incomplete finger (tip, etc.) + Wet / dry + Pressure
- Standardization of NFIQ 2.0 feature (ISO/IEC 29794-4)
  - Allows for plug-and-play of features for implementations that satisfy semantic conformance to the requirements of the ISO/IEC 29794-4 standard
NFIQ 2.0

Promises, promises
- Improved feature
- More level (0-100)
- Faster, lighter
- Actionable feedback
- NFIQ 2.0 mobile
- Slap
- Better performance
- Modular design
- Calibration
- Conformance testing

So far, we have achieved
- Improved feature
- More level (0-100)
- Faster – we hope
- Actionable feedback
- Towards NFIQ Mobile
- --
- Better performance – we hope
- Plug and play
### Coming up

<table>
<thead>
<tr>
<th></th>
<th>Publication of NFIQ 2.0 Feature Evaluation (NIST IR)</th>
<th>June 2013</th>
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<tbody>
<tr>
<td>2</td>
<td>Publication of use of machine learning techniques in NFIQ 2.0 (NIST IR)</td>
<td>August 2013</td>
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<tr>
<td>3</td>
<td>Biometric quality workshop at BCC 2013 - Tampa, FL Present NFIQ 2.0 with possible demo at NIST booth</td>
<td>Sept 17, 1040–1200 Room 20</td>
</tr>
<tr>
<td>4</td>
<td>Standardization of NFIQ 2.0 features (ISO/IEC 29794-4)</td>
<td>2015+</td>
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</tbody>
</table>
Thank You.

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