

NFIQ 2.0

Open Source Distribution

Michael Schwaiger
secunet Security Networks AG

Elham Tabassi
NIST

Agenda

- Development kit
- Operational software

Distribution packages

- Development kit
 - Aimed for developers and researchers
 - Includes NFIQ 2.0 Framework
 - Plug and play of different combinations of quality features and machine learning techniques
- Operational software
 - Aimed for operational use
 - Includes command line tool

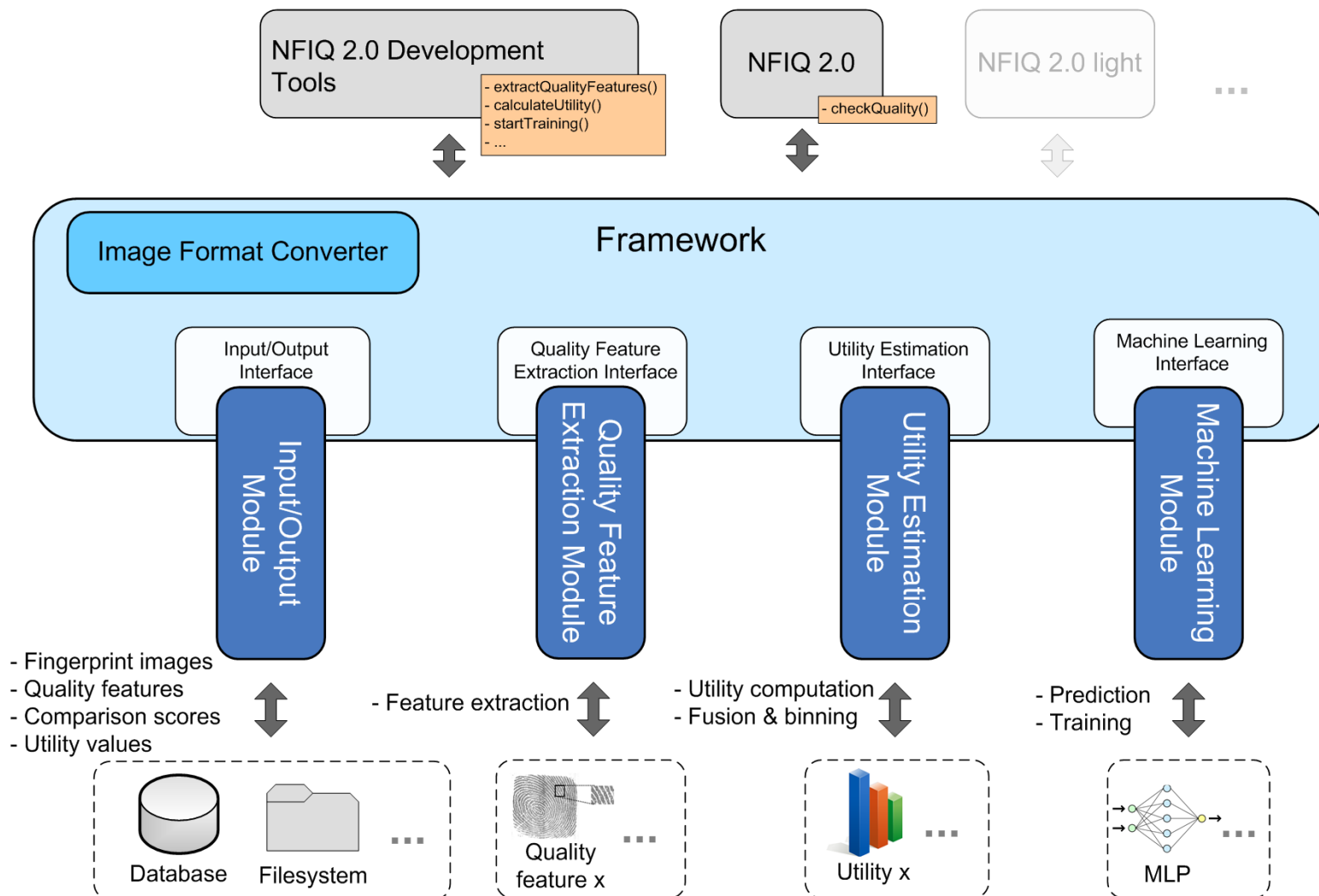
Development kit

Motivation for NFIQ 2.0 Framework

- Lessons learned from NFIQ re-training in 2009/2010
 - NBIS source code changes necessary for adaptation of
 - machine learning algorithm
 - quality features
- Modular approach for NFIQ 2.0 development is desired
 - to be flexible regarding the implementation
 - to have a common basis of functionality needed for NFIQ 2.0 development which might then be extended by exchange of certain modules
 - because project team is distributed and located all over the world
 - because only certain project partners have access to certain fingerprint databases
 - to allow sharing and re-using of results
 - to simplify the development process

Development kit

Architecture of NFIQ 2.0 Framework



Development kit

NFIQ 2.0 development tools and interchange file format

- Implemented on top of the NFIQ 2.0 Framework
 - ComputeQualityFeatureData, ComputeQualityVector
 - ComputeUtilityValues
 - StartTraining
 - ComputeQuality (final or intermediate NFIQ 2.0 algorithm)
 - XMLExportImport
- XML interchange file format defined
 - exchange of training and evaluation data among project partners
 - fingerprint comparison scores of several databases
 - utility values and quality scores
 - quality features
 - referenced by unique IDs

Development kit

Example: How to perform training with the NFIQ 2.0 Framework I

- Assume that necessary data for training is stored in database X
- Compute quality features
`computeQualityFeatureData(X, <featureID_1>, ..., <featureID_M>)`
- Compute and fuse utility values
`computeUtilityValues(X, <providerID_1>, <utility_ID>)`
...
`computeUtilityValues(X, <providerID_N>, <utility_ID>)`
`fuseUtilityValues(X, <providerID_1>, ..., <providerID_N>, <utility_ID>)`
- Select images for training
`defineImagesForTraining(X, <trainingSet_X>, <testSet_X>)`
and/or
`partitionDataForTraining(X, <seed>, <N_train_X>, <N_test_X>)`
- Start training
`train(<providerID_1>, ..., <providerID_N>, <utility_ID>, <featureID_1>, ..., <featureID_M>, useWeights)`

Development kit

Example: How to perform training with the NFIQ 2.0 Framework II

- Select images for evaluation

```
defineImagesForEvaluation(X, <evaluationSet_X>)
```

and/or

```
partitionDataForEvaluation(X, <seed>, <N_eval_X>)
```

- Start evaluation

```
evaluate(<providerID_1>, ..., <providerID_N>, <utility_ID>,  
<featureID_1>, ..., <featureID_M>)
```


Development kit

Open source libraries

- NFIQ 2.0 Framework will be open source
- External library dependencies
 - OpenCV for image processing
 - FingerJetFX minutiae extraction
 - RapidXML for XML parsing
 - NIST Biometric Data Interchange (BIOMDI)

Development kit

Input / output modules

- Modules for
 - PostgreSQL DB
 - NIST Record-Store format
 - File system
- Everyone can add new modules to adapt the NFIQ 2.0 Framework to their existing infrastructure!

Development kit

Quality feature modules

- More than 100 features integrated
 - NFIQ 1 features
 - FJFX minutiae count and minutiae quality features
 - Orientation Certainty Level, Ridge Valley Uniformity, Radial Power Spectrum, Local Clarity Score, ...
 - ROI area features
 - Contrast features (Mu, Mu Mu Block, Sigma, ...)
 - Quality map features
 - Gabor features

- Adding new features is easy!

Development kit

Machine learning modules

- Random Forest implemented
- Self Organizing Maps to be added for NFIQ 2.0 lite

Operational software

Why two different software distributions?

- Operational software package is what will be used in applications
- NFIQ 2.0 has overhead that is not needed in applications
 - Input/output modules
 - Utility modules
 - Features that were not selected for the NFIQ 2.0
- Operational software provides optimized code (not features itself but the usage of them)
- Command line tool will be provided
 - Input: Fingerprint image
 - Output:
 - Quality score
 - Actionable quality feedback
 - Quality feature values (optional)
 - Performance numbers (optional)

Operational software

NFIQ 2.0 command line tool

```
NFIQ2 <fingerprintImage> <imageFormat> <outputFeatureData> <outputSpeed>
```

```
<fingerprintImage>: path and filename to a fingerprint image
```

```
<imageFormat>: one of following values describing the fingerprint image  
format: BMP, WSQ
```

```
<outputFeatureData>: if to print computed quality feature values  
(true|false)
```

```
<outputSpeed>: if to print speed of quality feature computation  
(true|false)
```

- Command line tool calls internal library that can be used to easily integrate NFIQ2 algorithm into applications

Operational software

NFIQ 2.0 examples

- Development version with 29 quality features



NFIQ2: Achieved quality score: 97
Time needed for quality score computation: 213.000 ms
Actionable quality (EmptyImageOrContrastTooLow):
165.580 -> HIGH actionable quality

Operational software

NFIQ 2.0 examples

- Development version with 29 quality features



NFIQ2: Achieved quality score: 7
Time needed for quality score computation: 128.364 ms
Actionable quality (EmptyImageOrContrastTooLow):
199.397 -> HIGH actionable quality

Operational software

NFIQ 2.0 examples

- Development version with 29 quality features



```
NFIQ2: Achieved quality score: 0  
Time needed for quality score computation: 0.515 ms  
Actionable quality (EmptyImageOrContrastTooLow):  
253.108 -> LOW actionable quality
```


Operational software

NFIQ 2.0 examples

- Output with feature values

```
FingerJetFX_MinutiaeCount: 57.000
FingerJetFX_MinCount_COMMinRect300x200: 39.000
FingerJetFX_MinCount_COMMinCircle200: 24.000
FingerJetFX_ROIBlockArea: 0.280
FJFXPos_Mu_MinutiaeQuality_0: 0.000
FJFXPos_Mu_MinutiaeQuality_1: 0.088
FJFXPos_Mu_MinutiaeQuality_2: 0.421
FJFXPos_Mu_MinutiaeQuality_3: 0.491
FJFXPos_COMMin_MMB_224: 127.428
FJFXPos_OCL_MinutiaeQuality_0: 0.000
FJFXPos_OCL_MinutiaeQuality_20: 0.018
FJFXPos_OCL_MinutiaeQuality_40: 0.053
FJFXPos_OCL_MinutiaeQuality_60: 0.421
FJFXPos_OCL_MinutiaeQuality_80: 0.509
Mu: 165.580
MMB: 165.580
OCL: 0.803
OCL_CD: 0.821
ImgProcROIPIxelAbs: 105166.000
ImgProcROIPIxelArea: 0.685
ImgProcROIPIxelArea_Mean: 127.076
OrientationMap_ROIFilter_CoherenceSum: 308.950
OrientationMap_ROIFilter_CoherenceRel: 0.687
LowFlowMap16_ROIArea_HighFlowBlocks: 443.000
RVU_P: 0.485
RVU_NP: 0.494
RPS_ROIArea: 5189.663
LCS: 0.825
OF: 0.864
```


Operational software

NFIQ 2.0 examples

- Output with feature speed

```
Contrast features (Mu, MMB): 0.454 ms
FJFX features (FingerJetFX_MinutiaeCount, FingerJetFX_MinCount_COMMInRect300x200,
FingerJetFX_MinCount_COMMInCircle200, FingerJetFX_ROIBlockArea): 25.113 ms
FJFX minutiae quality features (FJFXPos_Mu_MinutiaeQuality_*): 0.381 ms
FJFX minutiae quality features (FJFXPos_COMMIn_MMB_224): 0.090 ms
FJFX minutiae quality features (FJFXPos_OCL_MinutiaeQuality_*): 0.597 ms
OCL features (OCL): 1.568 ms
OCL features (OCL_CD): 10.233 ms
ROI features (ImgProcROI PixelAbs, ImgProcROI PixelArea, ImgProcROI Area_Mean): 12.259 ms
Quality map features (OrientationMap_ROIFilter_CoherenceSum,
OrientationMap_ROIFilter_CoherenceRel): 2.737 ms
Quality map features (LowFlowMap16_ROI Area_HighFlowBlocks): 26.711 ms
RVU features (RVU_P): 12.518 ms
RVU features (RVU_NP): 12.247 ms
RPS features (RPS_ROI Area): 86.592 ms
LCS features (LCS): 16.166 ms
OF features (OF): 13.611 ms
```

Summary

- Development kit
 - Provides flexible integration and development for future versions and improvements
 - Design of dedicated versions possible (e.g. NFIQ 2.0 lite)
 - Large collection of quality features

- Operational software
 - Optimization done for use in applications
 - Unnecessary data and code removed

- Both will be distributed as open source!

Contact

secunet Security Networks AG

Michael Schwaiger

michael.schwaiger@secunet.com

NIST

Elham Tabassi

elham.tabassi@nist.gov