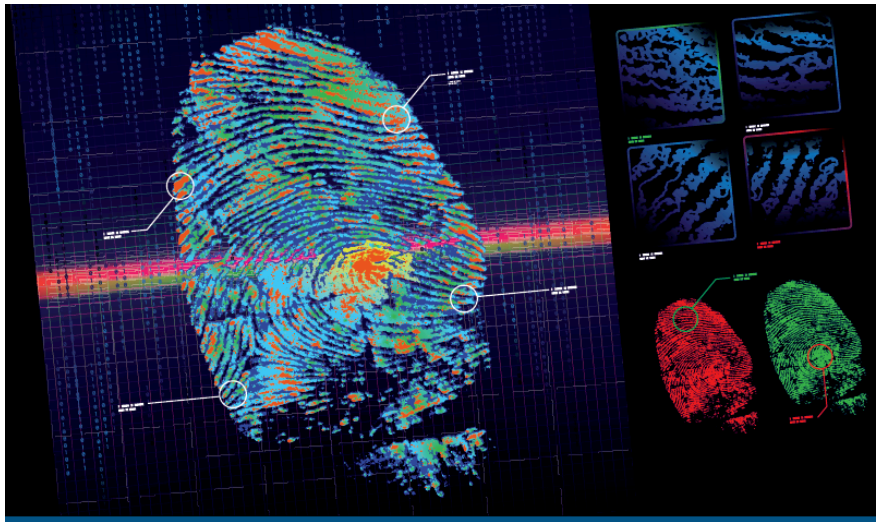


# The push towards zero error biometrics

IBPC 2016
May 4, 2016

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Carol Nowacki, Adam Day, Marc Colosimo (MITRE)

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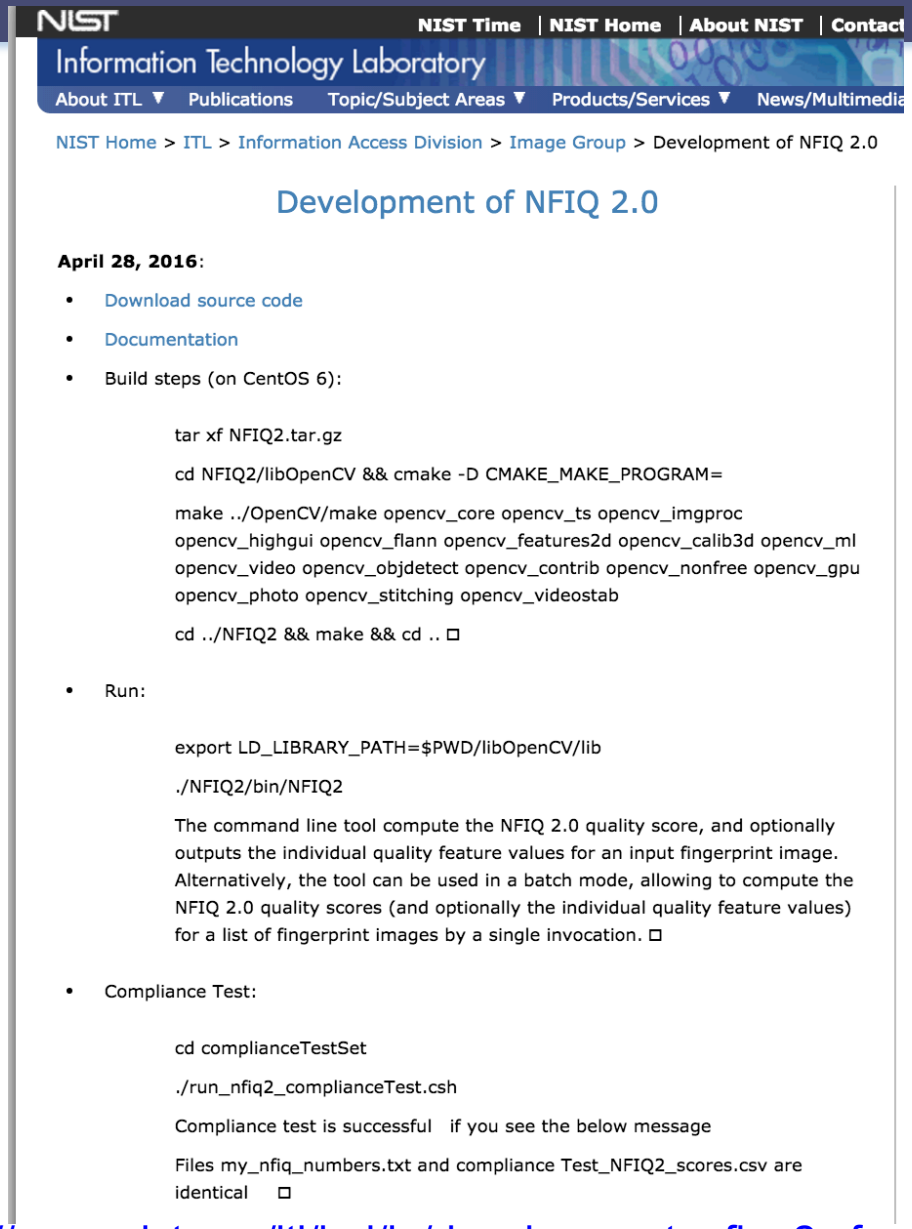
# Public Release



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NIST Home > ITL > Information Access Division > Image Group > Development of NFIQ 2.0

## Development of NFIQ 2.0

**April 28, 2016**:

- Download source code
- Documentation
- Build steps (on CentOS 6):

  tar xf NFIQ2.tar.gz

  cd NFIQ2/libOpenCV && cmake -D CMAKE_MAKE_PROGRAM=

  make ../OpenCV/make opencv_core opencv_ts opencv_imgproc opencv_highgui opencv_flann opencv_features2d opencv_calib3d opencv_ml opencv_video opencv_objdetect opencv_contrib opencv_nonfree opencv_gpu opencv_photo opencv_stitching opencv_videostab

  cd ../NFIQ2 && make && cd .. □

- Run:

  export LD_LIBRARY_PATH=$PWD/libOpenCV/lib

  ./NFIQ2/bin/NFIQ2

  The command line tool compute the NFIQ 2.0 quality score, and optionally outputs the individual quality feature values for an input fingerprint image. Alternatively, the tool can be used in a batch mode, allowing to compute the NFIQ 2.0 quality scores (and optionally the individual quality feature values) for a list of fingerprint images by a single invocation. □

- Compliance Test:

  cd complianceTestSet

  ./run_nfiq2_complianceTest.csh

  Compliance test is successful if you see the below message

  Files my_nfiq_numbers.txt and compliance Test_NFIQ2_scores.csv are identical □

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

It will be on github soon.

# NFIQ 2.0 Community

## Team Members

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

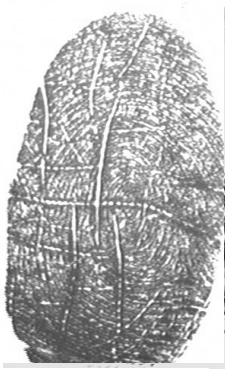
## Sponsors

Homeland Security
Science and Technology

Federal Office for Information Security

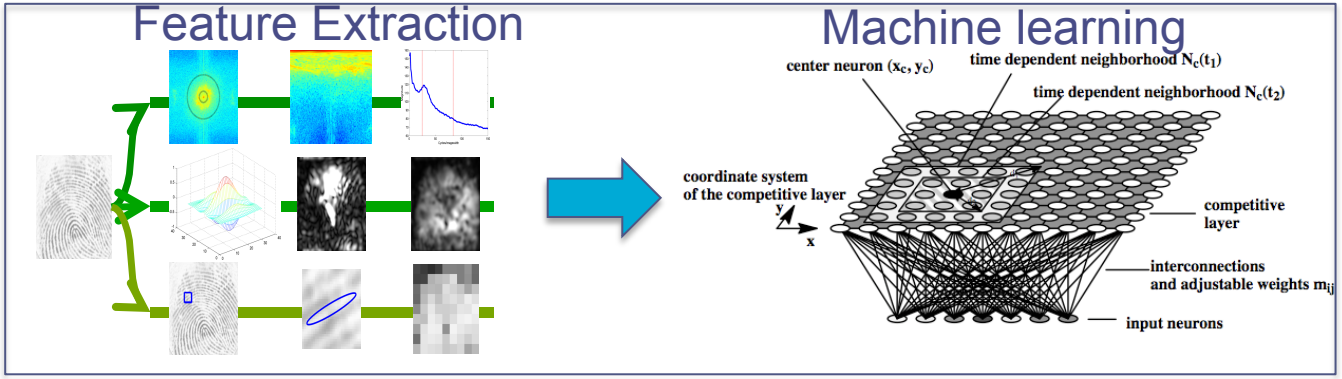
Bundeskriminalamt

# NIST Fingerprint Image Quality (NFIQ)



NFIQ1.0 → quality number =5

NFIQ2.0 → quality number =[0,100]

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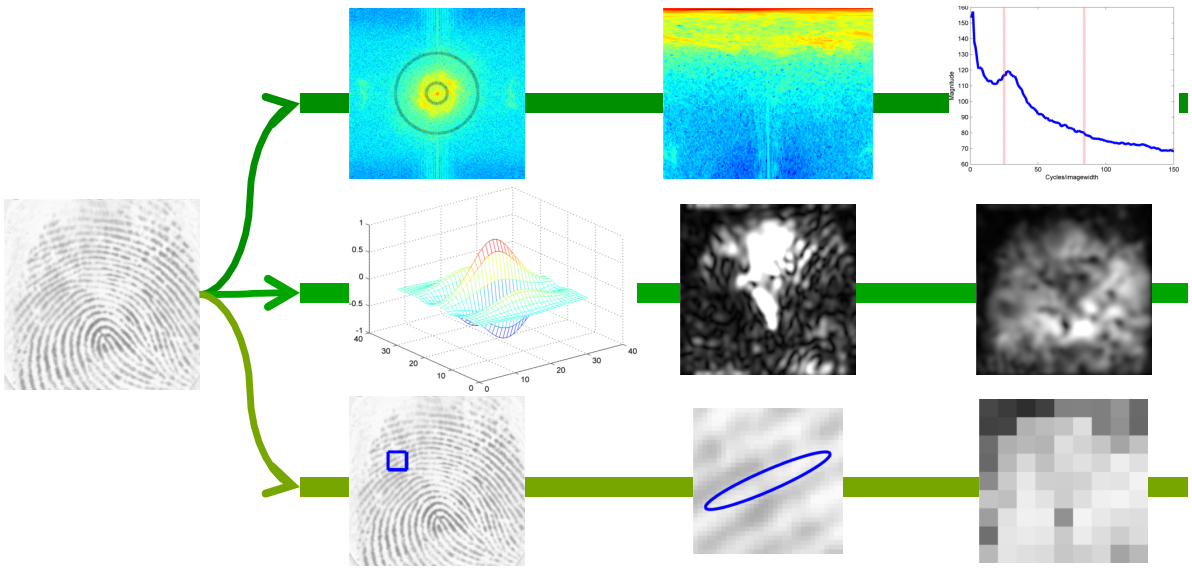


# NFIQ 2.0 Features

NFIQ 1.0 features

Recommended Features in ISO/IEC 29794-4:2009 + our modifications

Surveyed literature + our modifications

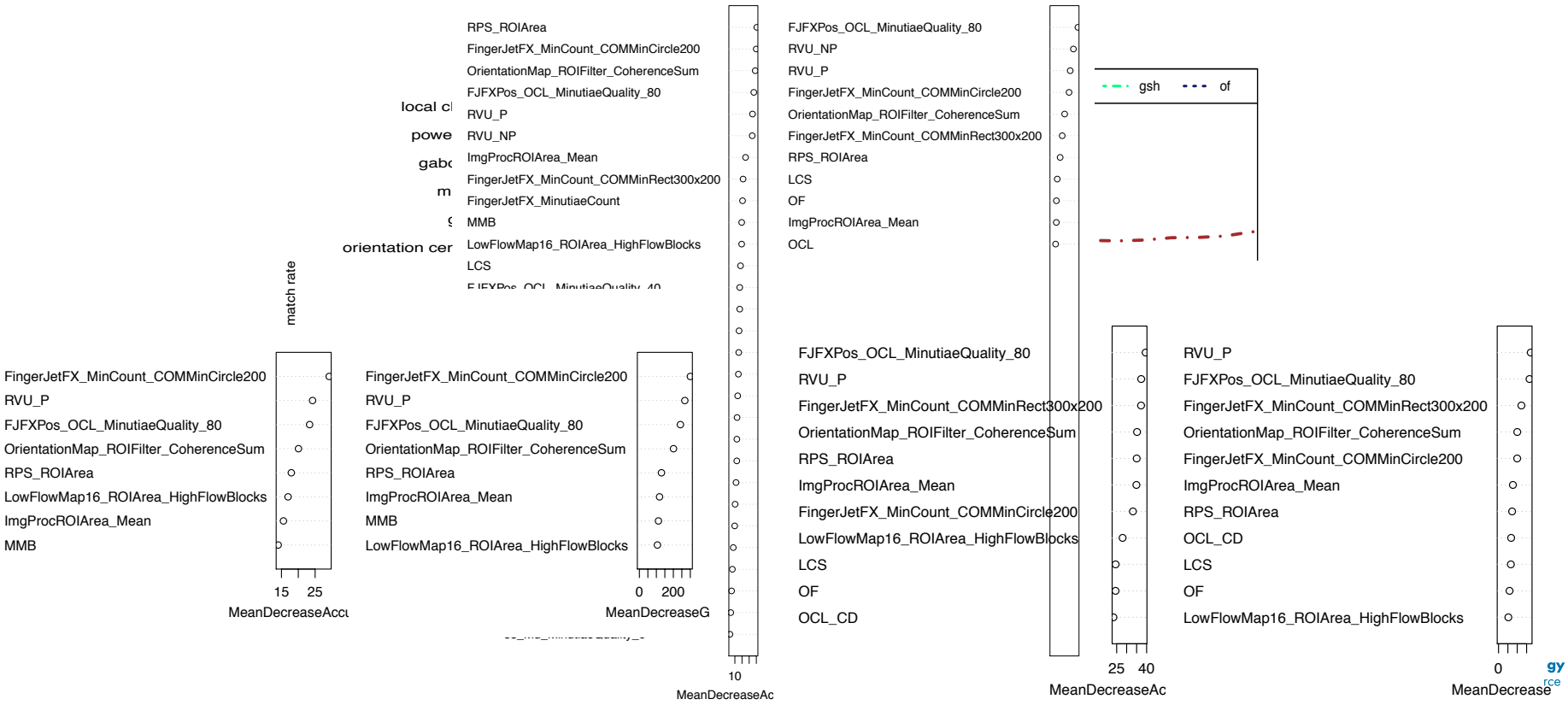
Open source FingerJetFx minutiae extractor

# Feature selection

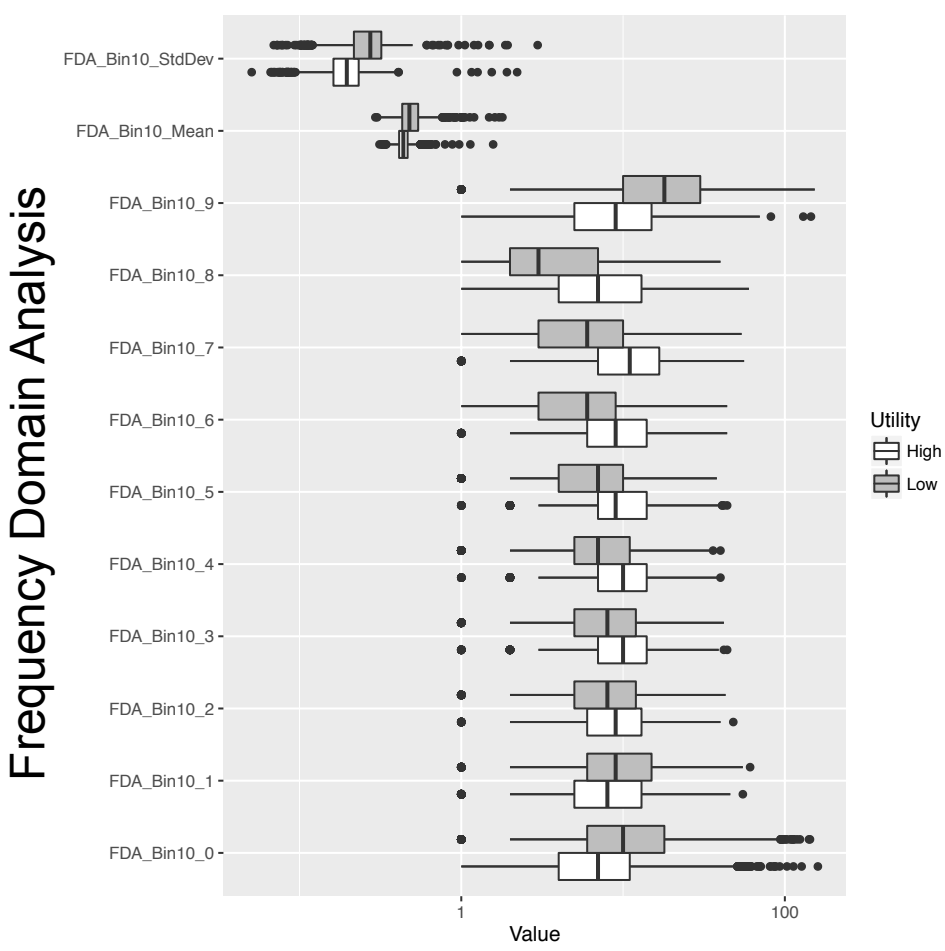
Predictive power of each feature

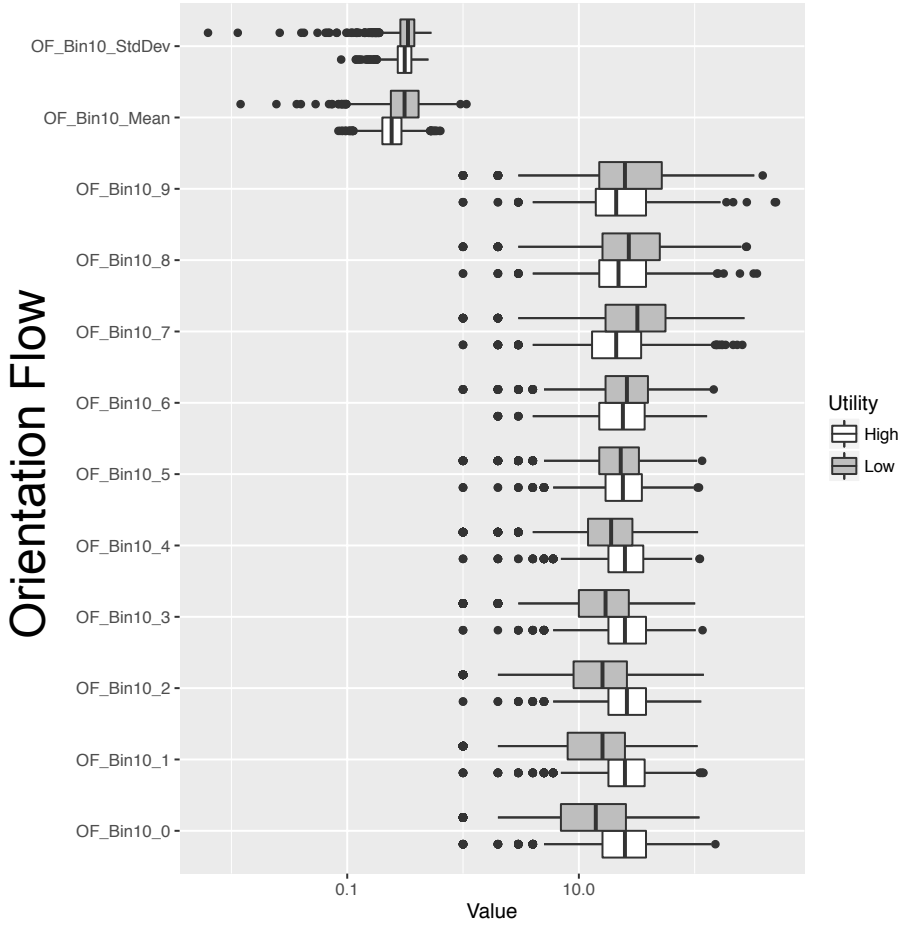
Correlations among features

Random Forest variable importance

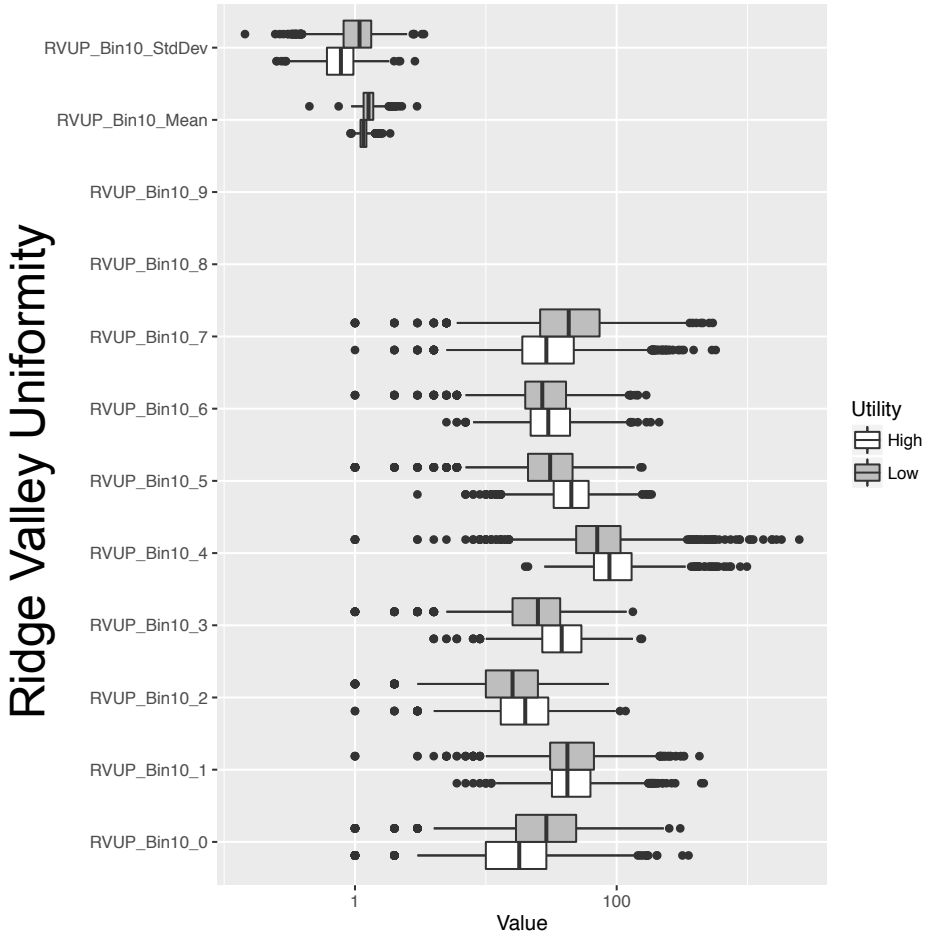


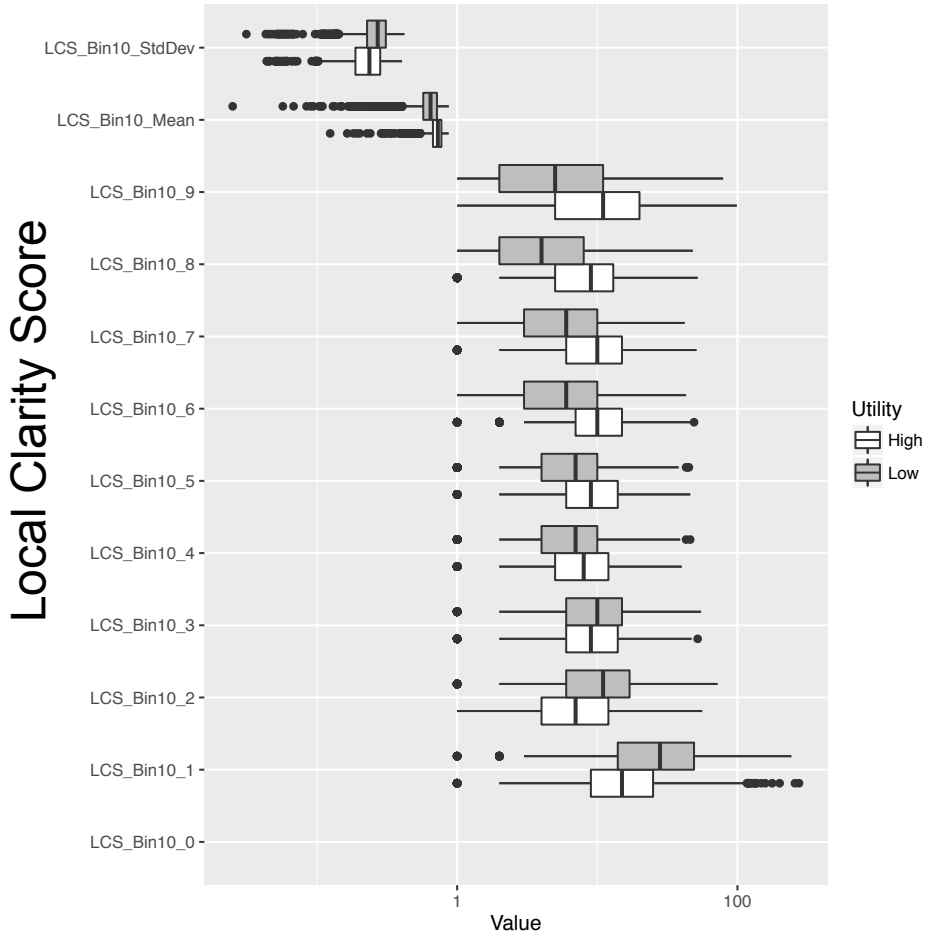
# NFIQ 2.0 Features

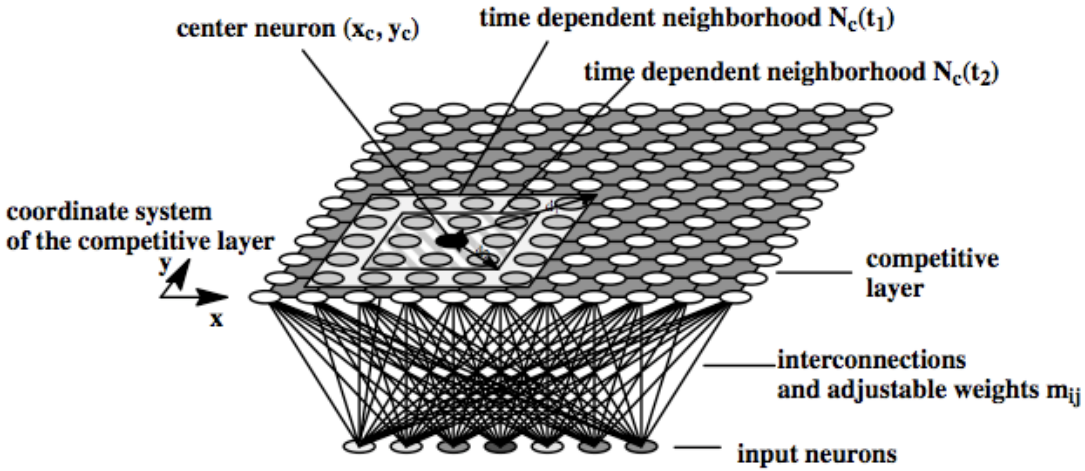


# NFIQ 2.0 Features






# MACHINE LEARNING

We examined:

Random Forest

Support vector machine

K-nearest neighbor

# Machine Learning

## Random Forest

- Ensemble classifier using stochastic process
  - Uses vote to determine class memberships
  - Provides class probability in predictions
  - Analysis of features importance and their ranking
    - We used this to do our final feature selection

## Two class prediction

- High vs. Low performers
  - 1: High performers are images that result in high genuine scores and have NFIQ1=1 with activation score > 0.7.
    - genscore > $CDF^{-1}(0.9)$ & NFIQ1.0 =1
  - 0: Low performers are images that result in false reject and have NFIQ 1.0=5 with activation score > 0.9.
    - FRR at Threshold at FMR=0.0001
  - Training data: intersection of images in Class 0 (or Class 1) across all providers
  - Quality score is the probability that a given image belongs to class 1.
- Map quality score to recognition rate.

Training

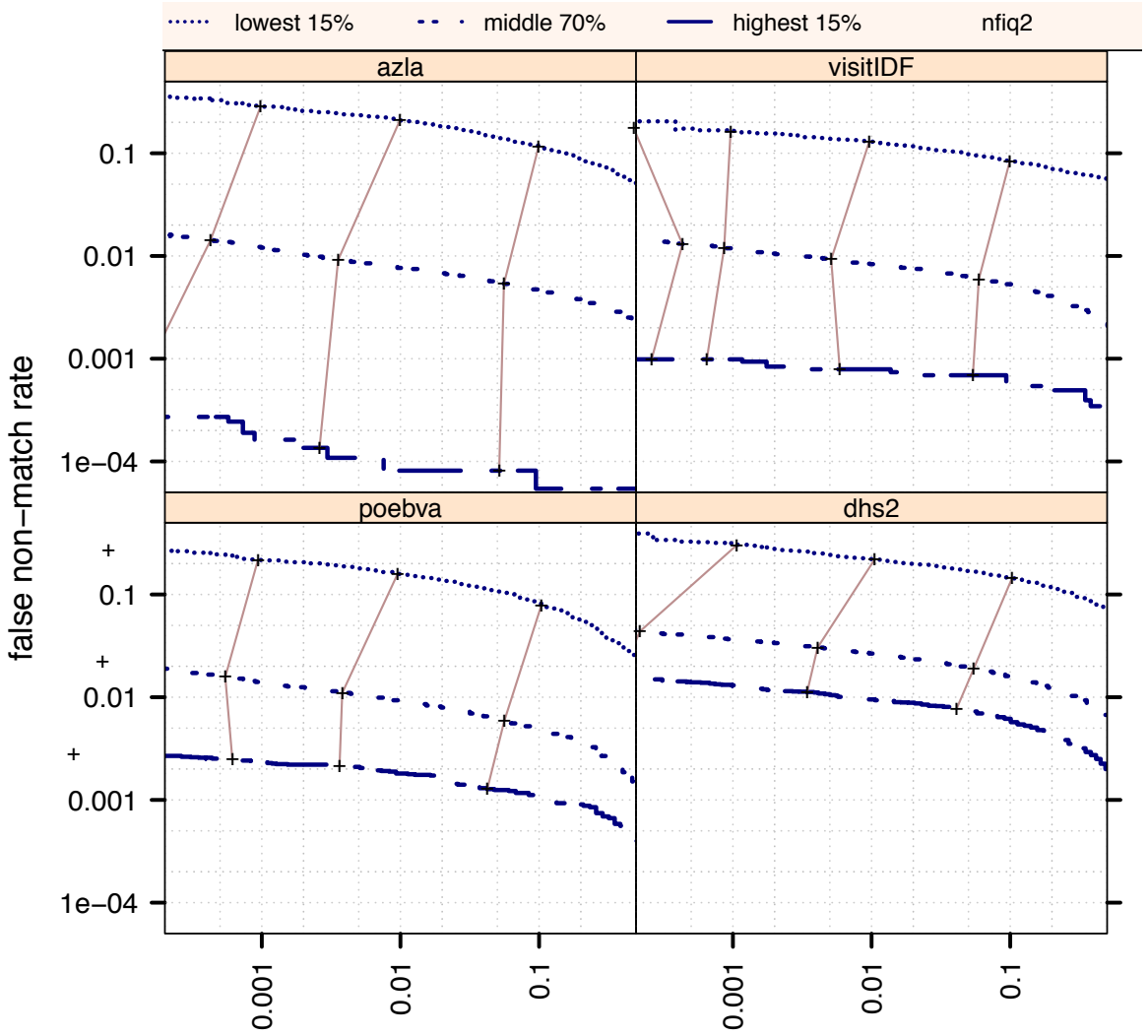
- Features: image processing + #minutiae + minutiae quality
- ~3500 samples in each of the low and high performers classes
- 1000 trees in forest

Test

- 75000 comparison scores

# So, Does It Work?

# NFIQ 2.0 predictive of performance



# NFIQ 1.0 VS NFIQ 2.0

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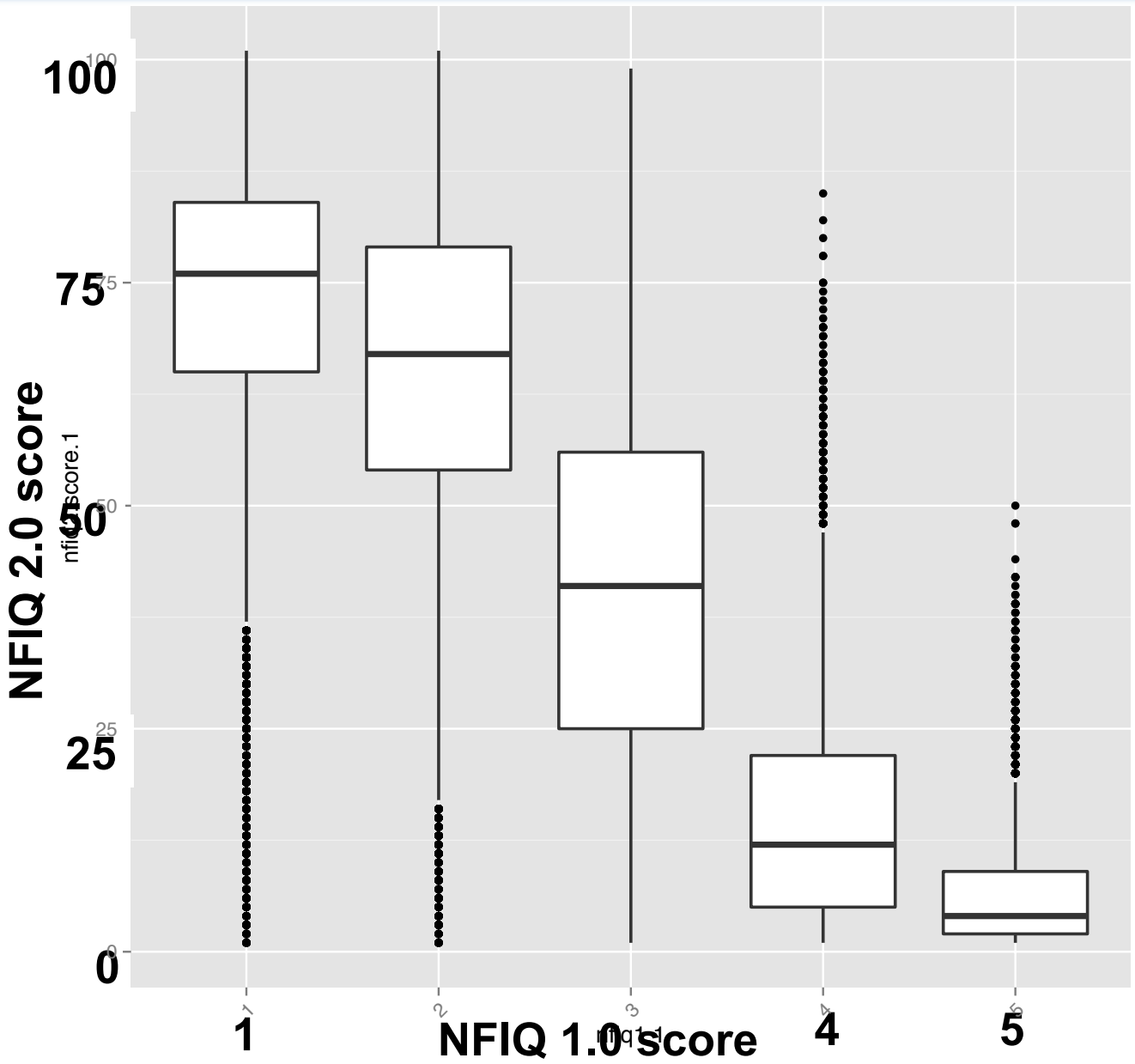
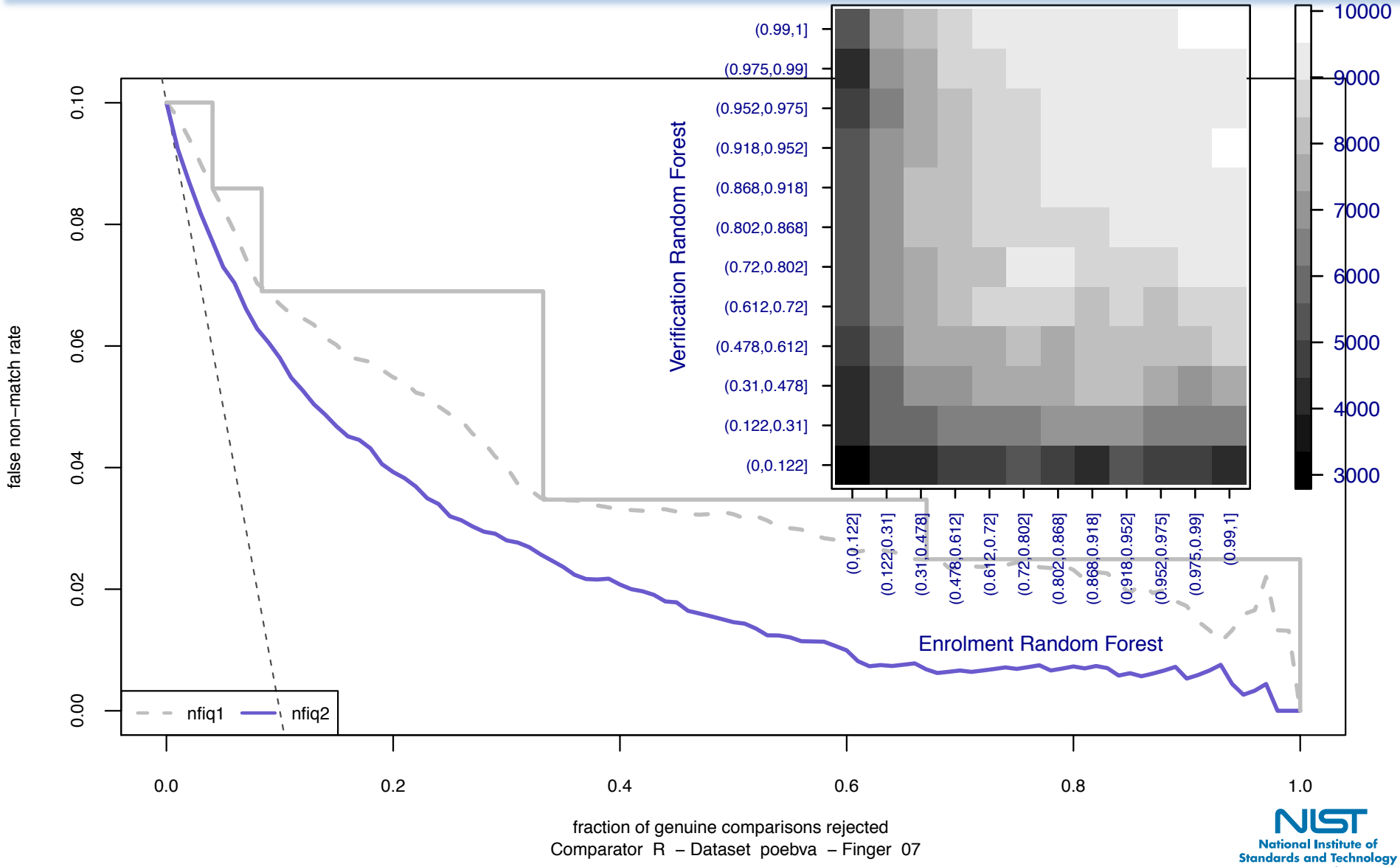
# NFIQ 1.0 vs NFIQ 2.0



# NFIQ 1.0 vs. 2.0 performance

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# At a glance

## NFIQ 1.0

- 5 levels.
  - 1(highest) to 5(lowest)
- 11 features
- Comparison scores of 3 algorithms used for training
- 3400 training images
- Neural network
- ~300 msec per image

## NFIQ 2.0

- 100 levels
  - 0(lowest) to 100(highest)
- 14 (69) features
- Comparison scores of 7 algorithms used for training
- ~5000 training images
- Random forest
- ~ 120 msec per image
- Actionable quality
  - Flags for blank image, low contrast
- Design for NFIQ Mobile

# Tools for easier adaption and migration

# Calibration :: setting quality threshold

## General: based on large scale operational data

- Calibration:
  - general calibration curves or tables for NFIQ 1.0 → NFIQ 2.0.
- Decision Table
  - For enrollment and verification quality threshold setting
  - Tabulation of estimated rejection rate and improvement in FNMR for each value of NFIQ 2.0 (i.e., [0,100]).

## On-demand: based on application-specific data

- Calibration
  - We will provide software tools and technical guidance on how to compute calibration curves.
- Decision Table
  - Ditto above.
- This allows for optimal calibration and decision making considering data properties.

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tabassi@nist.gov

# THANK YOU.

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# NIST Biometric Quality Program

## Push Towards Zero Error Biometrics

| Strengthening Science | Advancing metrology | Developing Standards | Developing Tool Box | Best Practice Guidance | Enumerative Bibliography | Coordination+ Collaborations |
|---|---|---|---|---|---|---|
| Failure Analysis | Performance Evaluation | Requirements Specifications | Open source Public domain | Instructional + Guidance | Technical Literature | Workshops, Conferences |
| Identifying the likely causes of recognition error, quantifying their effect and ways to mitigate them. | Quantitative means of assessing performance of quality assessment algorithms (IREX II IQCE) | On image properties affecting performance, and on capture device | Reference implementations of quality assessment algorithm, iris segmentation | Materials for quality score summarization + Best capture practice + example images of various quality | Reports, white papers, publications relevant to biometric quality and iris image quality in particular | Grants (WVU, NYU Poly) |
| Research | Evaluation | Standard | Software | Report | Webpage | |
| NIST IR 7155<br>ICIP 2005<br>NIST IR 7820 | NIST IR 7820<br>PAMI 2007<br>ICPR 2010 | ISO/IEC 29794<br>ISO/IEC 19794 | NFIQ 1.0<br>NFIQ 2.0<br>NIIQ 1.0 | NIST IR 7422<br>NIST IR 8XXX | www.nist.gov/itl/iad/ig/bio_quality.cfm | BQW 2006, 07<br>IBPC 2010, 12<br>NFIQ 2010,12 |