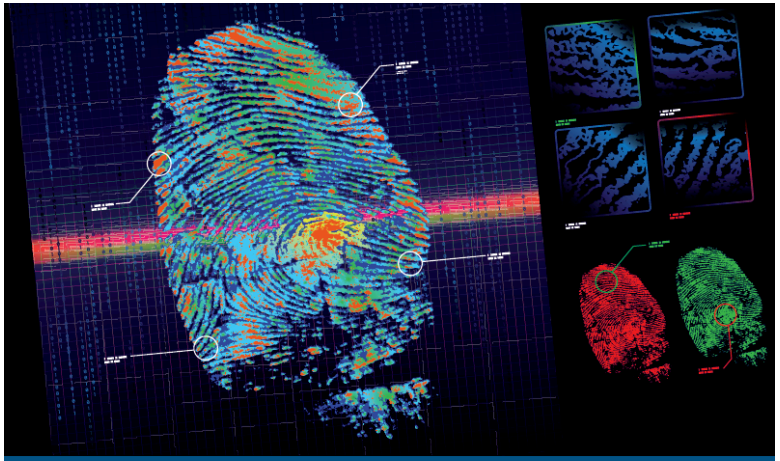

Biometric Quality

The push towards zero error biometrics

NIST Forensic Symposium

Elham Tabassi
Image Group
Information Access Division
Information Technology Laboratory
Friday, November 30, 12

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Open set 1:N Search

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1:N Latent Search

Latent image

Search Template

Features

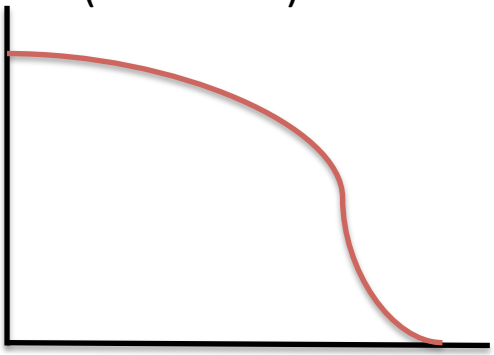
N template Enrollment Database

Template

Candidate List

Bob	1278
Alice	357
Mike	267
Lisa	245
Matt	209

FNIR (Miss Rate)



FPIR
(False Alarm Rate)

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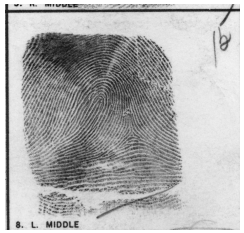
ACE-V

Analysis

- Value Determination (VID, VOE, NV)
- Feature Markup (EFS)
- 1:N search (AFIS)

Comparison

Candidate Pairs



Level-1 detail
Level-2 detail
Level-3 detail

Evaluation

- Individualization
- Exclusion
- Inconclusive

Verification

- Analysis
- Comparison
- Evaluation
- Validate or Reject the conclusion

Quality of latent, Quality of the exemplar and the size of the overlap area between the two play significant role in accuracy and reliability of the conclusion.
If the exemplar is not of sufficient quality, the conclusion should be Inconclusive.

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Need for numerical evaluation of quality

- To supplement the fingerprint examination process by one that has a statistical model, supported by appropriate databases for calculating numerical measures of weight of evidence
  - Perhaps based on automatic latent recognition algorithms
    - Some of VEO or NV were successfully identified by latent comparison algorithm. (NIST ELFT- EFTS).

- Resolve the variability among the examiner's value determination
  - For 356 latents, unanimous value determination achieved 43%.
  - 85% of NV decisions and 93% of VID decisions were repeated by the same examiner after a time gap while only 55% of VEO decisions were repeated. (*Ulery et. al – PNAS 2011).*

- While acknowledging the overall reliability of the conclusions of majority of fingerprint comparisons performed over the past century, and their contribution to the criminal justice system

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Lights-out Latent search

Examiner Adjudication of search results

Lights out Identification

Quality assessment for error suppression

- Quantify information content of latent
  - Suitable for automatic feature markup or manual?
- Quantify quality of the reference print
- Reliability of latent to reference comparison
  - Sufficient overlap area?

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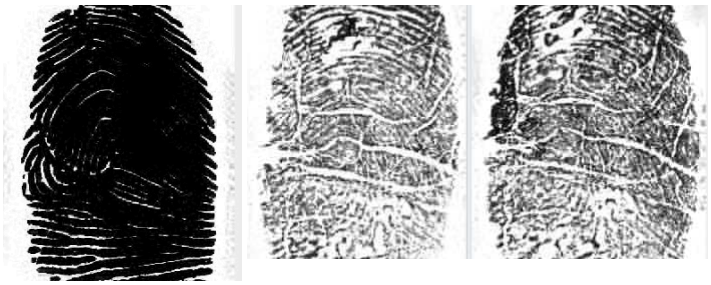
Quality assessment for error suppression

Reference print

- Quantitative assessment of utility of the friction ridge print.
  - Is this suitable for matching?
  - NFIQ, others.
- By numbers:
  - 34.5% of operational IAFIS exemplars are of low quality (NFIQ 3,4,5).

(Ulery, et. Al PNAS 2011).



Crime scene Latent print

- Quantitative assessment of information content of the latent.
- Latents recovered from crime scenes are often limited in size, of poor quality, distorted and affected by interference from the substrate.
- A growing body of literature questions scientific foundation and transparency of the evaluation of the weight of evidence associated with any particular fingerprint comparison
  - Zabell (2005); Office of the US Inspector General (2006); Saks and Koehler (2005, 2008); National Research Council of the National Academies (2009)
- Recent related work
  - On latent fingerprint Quality Yoon, Liu, Jain, 2012
  - Quantifying the weight of evidence from a forensic finger- print comparison: a new paradigm, C. Neumann, 2011

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What is `quality'?

`standard' definition

quality

the degree to which a biometric sample fulfils specified requirements for a targeted application

NOTE: Specified quality requirements may address aspects of quality such as focus, resolution, etc. Implicit quality requirements address the likelihood of achieving a correct matching result.

quality score

a quantitative expression of quality

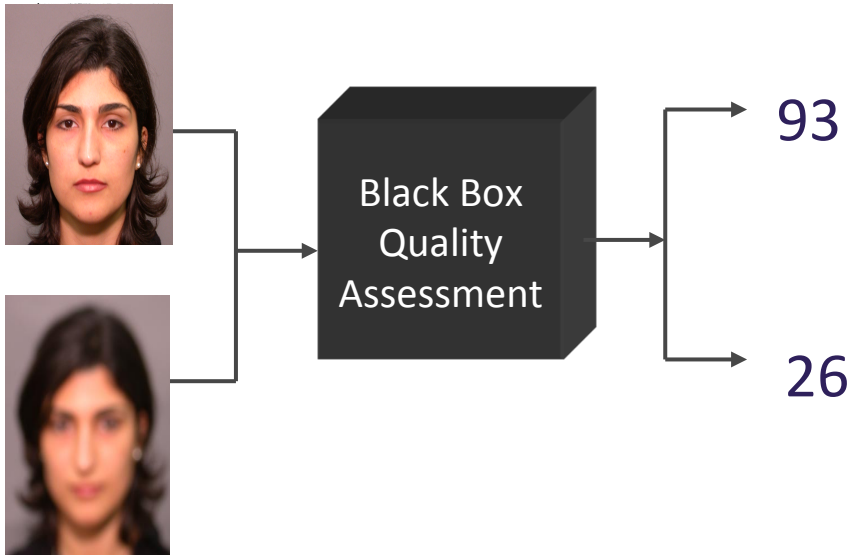
utility

the observed performance of a biometric sample or set of samples in one or more biometric systems

NOTE: The character of the sample source and the fidelity of the processed samples contribute to—or similarly detract from—the utility of the sample

NOTE: Utility may combine performance measures such as FMR, FNMR, failure to enrol rate, and failure to acquire rate

Predictive of performance



A biometric quality assessment method derives a numerical quality value from an input biometric sample. The quality value is related to the biometric error rates that are likely to be realized when the sample is matched.

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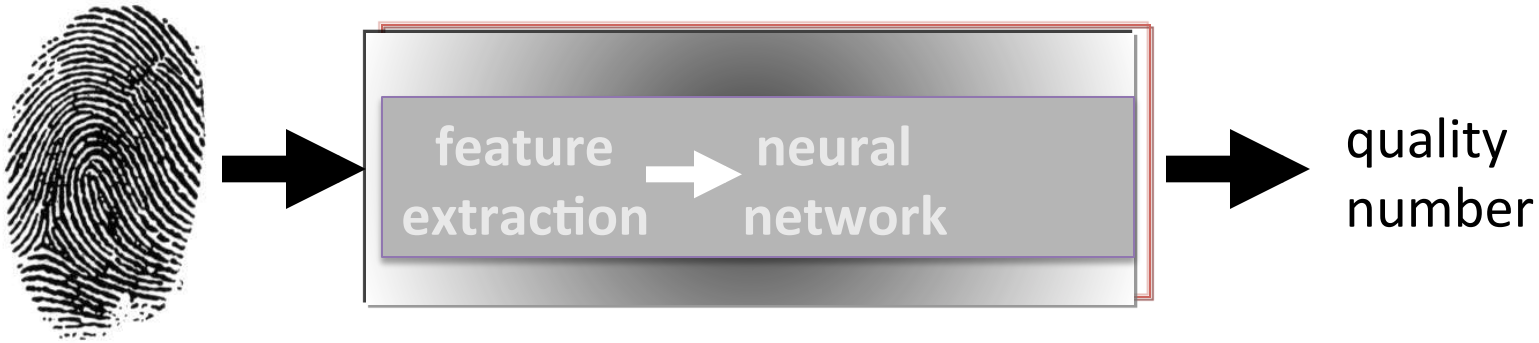
NIST fingerprint image quality (NFIQ 1.0)

- NIST developed NFIQ in 2004
  - Open source, publicly available
- Has become the de-facto standard
- Key innovation: quality as a rank statistic for performance
- NFIQ is a machine learning algorithm
  - Exploratory variables: image properties (minutiae, ridge clarity)
  - Response variable: separation of genuine and impostor comparison

NIST Fingerprint Image Quality



- **feature extraction**: computes appropriate signal or image fidelity characteristics and results in an 11-dimensional feature vector.
- **neural network**:classifies feature vectors into five classes of quality based on various quantiles of the normalized match score distribution.
- **quality number**: an integer value between 1(highest) and 5 (poorest).

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NIST Fingerprint Image Quality

NFIQ's 5 levels of quality are intended to be predictive of the relative performance of a minutia based fingerprint matching system.

NFIQ=1 indicates high quality samples, so lower FRR and/or FAR is expected.

NFIQ=5 indicates poor quality samples, so higher FRR and/or FAR is expected.

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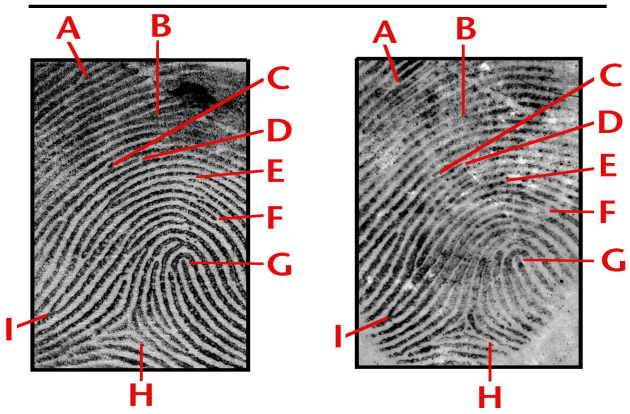
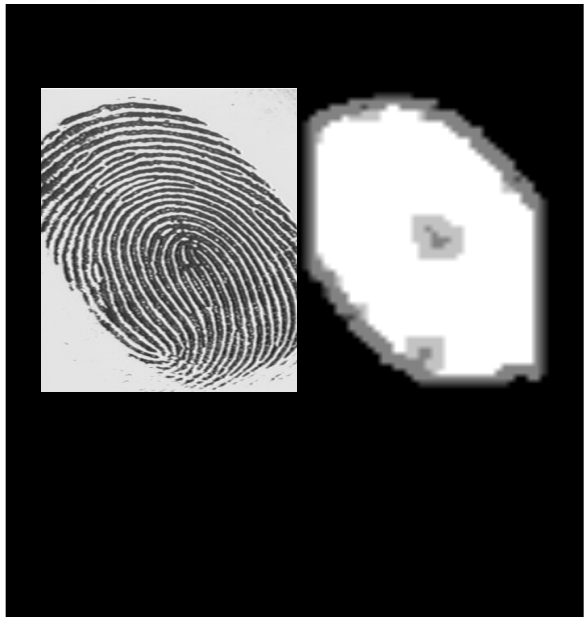
NFIQ – feature vector



gray scale fingerprint image

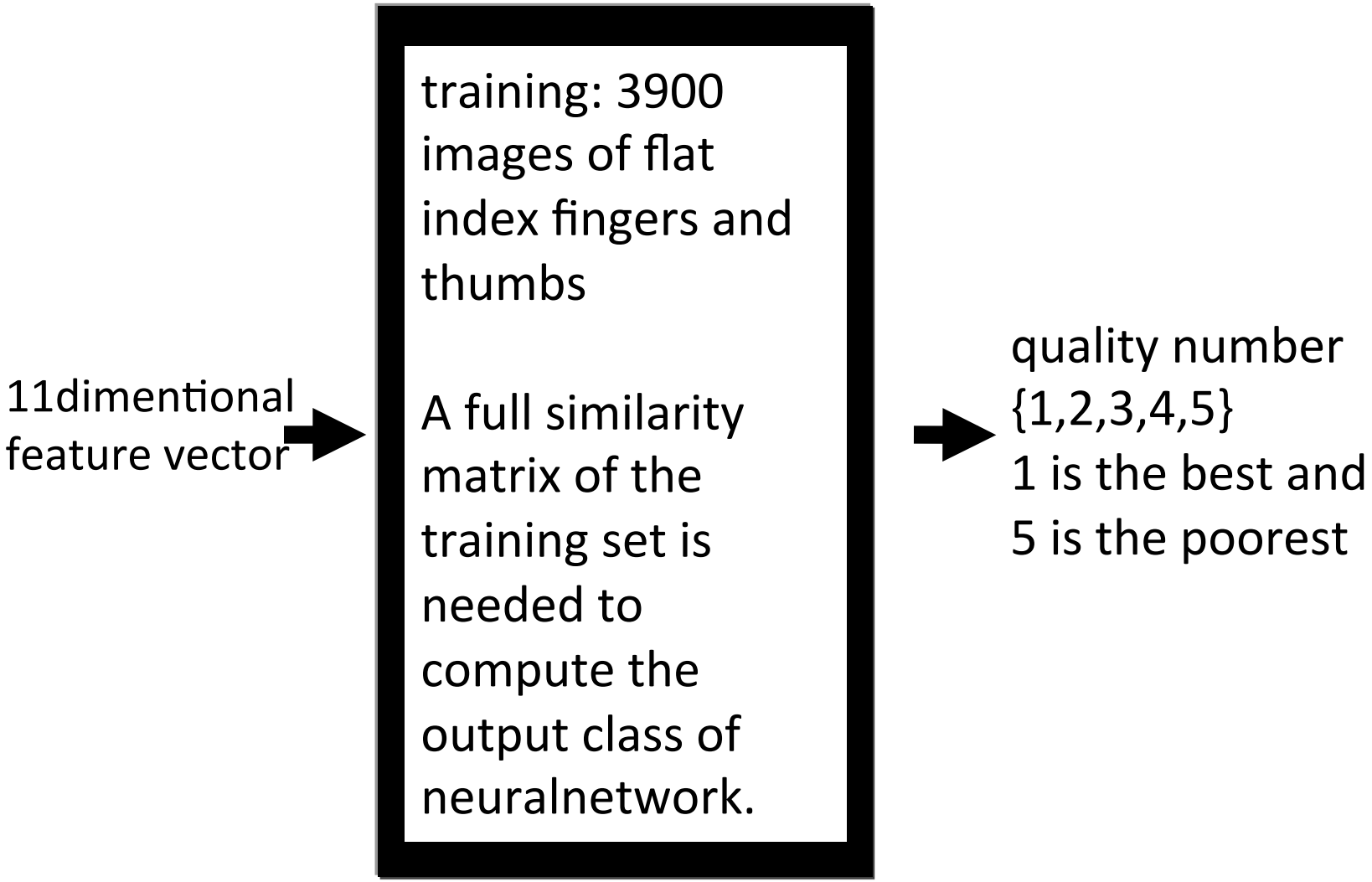


1 total # of minutia
2 #of min. with q≥.5
3 #of min. with q≥.6
4 #of min. with q≥.7
5 #of min. with q≥.8
6 #of min. with q≥.9

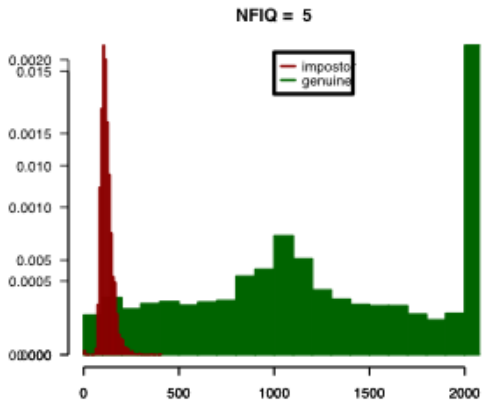
7 size of foreground
8 quality zone 1
9 quality zone 2
10 quality zone 3
11 quality zone 4

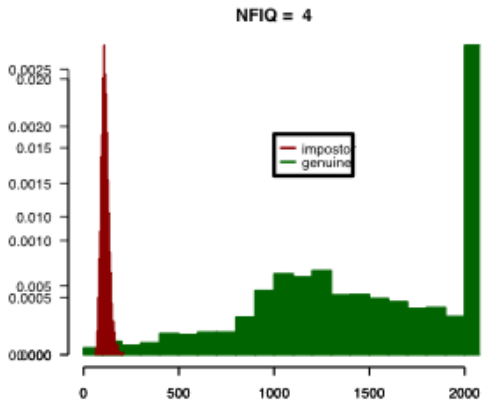
NIST Minutiae detector (mindtct of NBIS distribution) has been used for feature extraction.

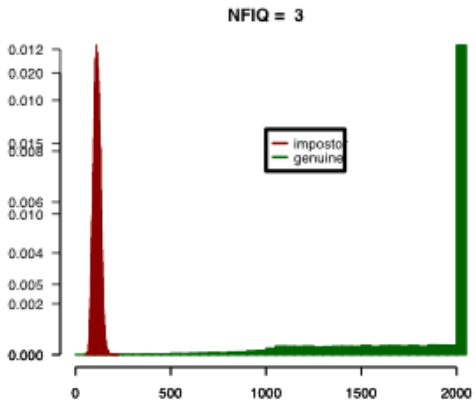
NFIQ 1.0 – training

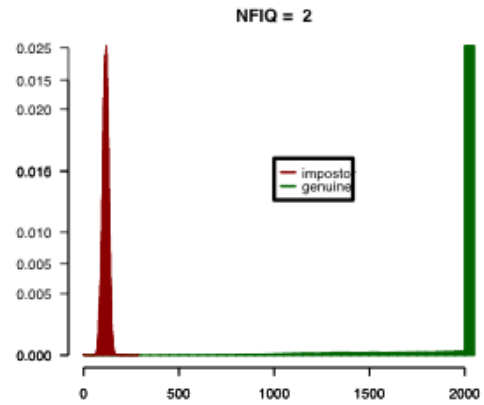


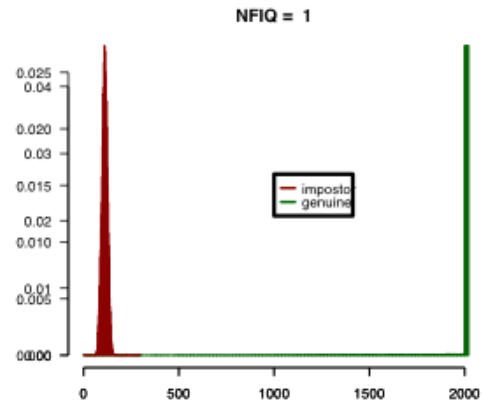
Separation of genuine and impostor distribution



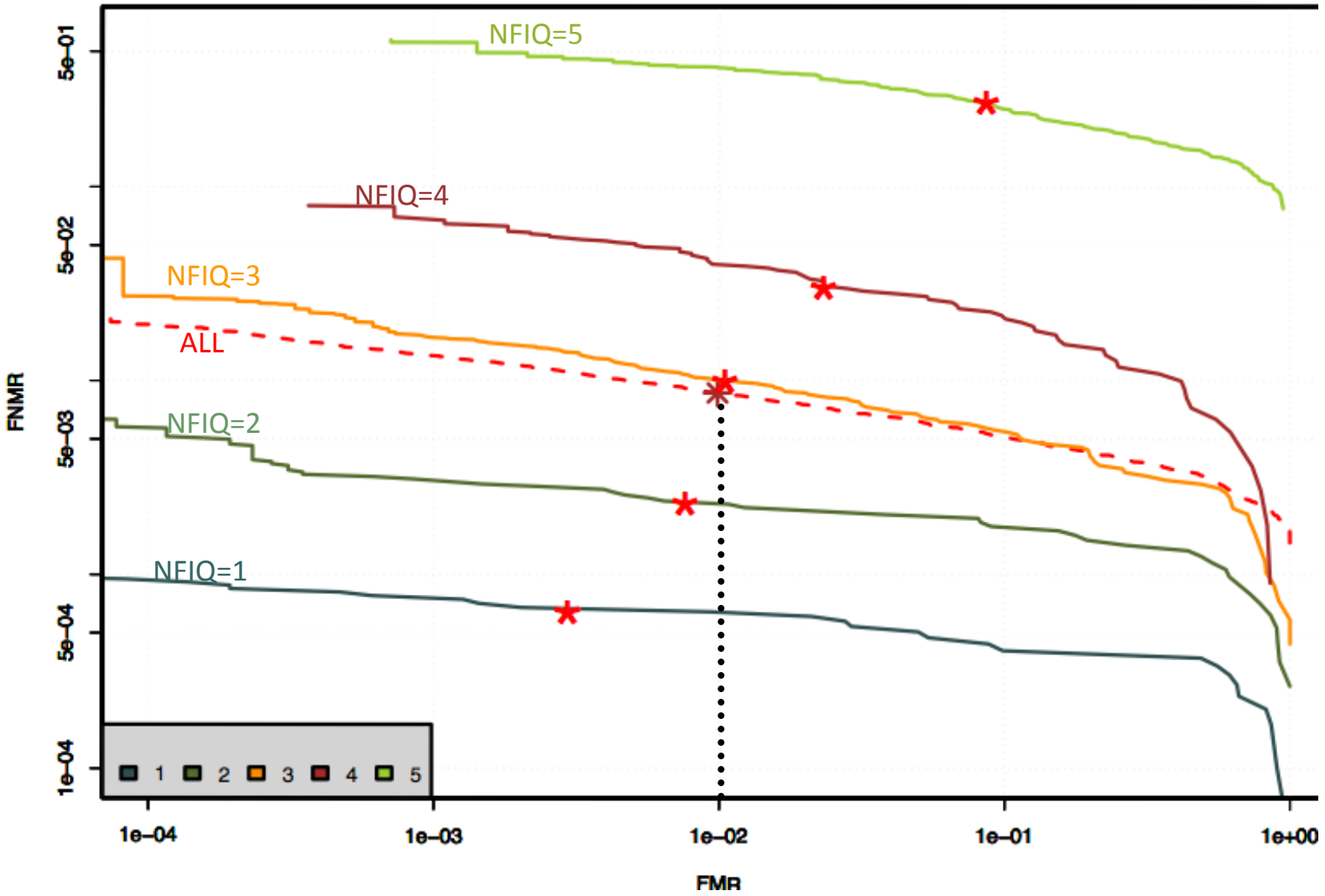








NFIQ – rank statistic for performance



NFIQ 1.0 – test of time

+

- 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, …

–

- Aging
  - recognition technology has advanced since 2004.
- Efficiency
  - ~300 msec per image - not fast enough for real time
  - takes 4 times for 4-finger slap
- Not enough levels
  - Still statistically significant
- Insensitive to partial prints

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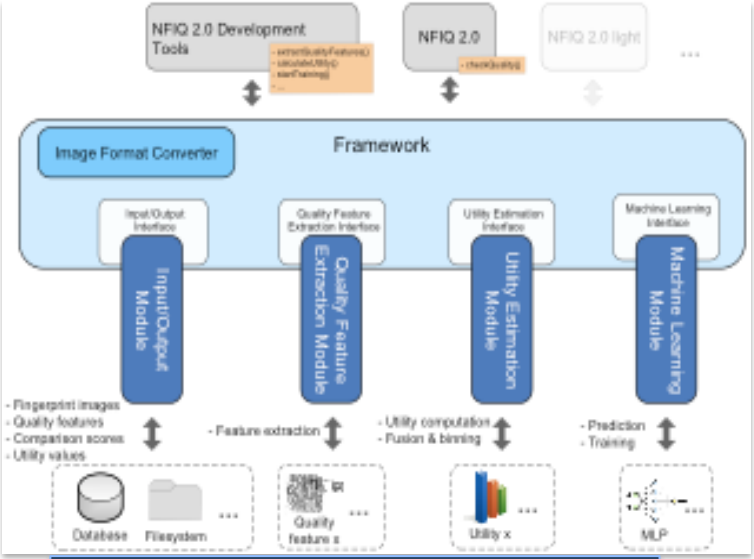
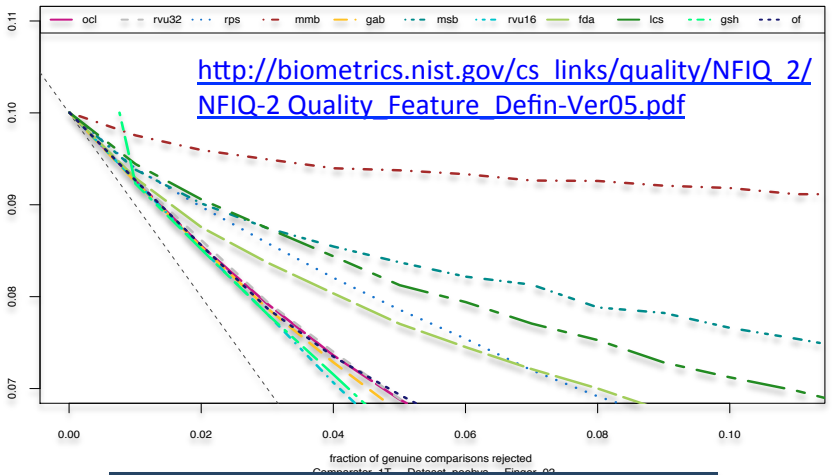
NFIQ 2.0

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



Modular Architecture



`Standardized' features (ISO/IEC 29794-4)

Flags to identify:

- Fingerness
- Completeness
- Wrong Phalanges
- Centerness
- Low/high pressure
- Alteredness

Actionable feedback

NFIQ Lite

- Fast for Mobile applications
- Use of innovative methods such as self organizing map

Mapping curves

- With NFIQ 1.0
- Calibration curve for each NFIQ 2.0 comparator participants.

Tools

Uses of quality assessment

Subject presentation

- Improper presentation detection
- Presentation attack detection

Acquisition device

- Hardware built-in. Quality in capture loop.
- `peak' imaging capability
- No control on FTA - Hard to tweak to certain applications

Beyond scanner

- Automated (e.g., NFIQ) or visual by human
- Automated at client-side or backend
- Actionable feedback for re-capture

Operator review

- Particularly for high value images
- It is expensive
  - Requires training of operators + takes time

Allows for

- Adopting threshold for specific scenario
- Monitoring Seasonal variations, atypical collection site/queue/device, etc.

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Quality in large scale deployments

National

- DHS US-VISIT
- Low enforcement
  - FBI CJIS
- DoD

International

- Unique Identification Authority of India
- EU-VIS
- Law enforcement (Germany BKA)
- E-passport

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Available Quality Assessment Algorithms

NIST Open source implementation

- Finger
  - NFIQ (circa 2004)
    - www.nist.gov/itl/iad/ig/nbis.cfm
    - NIST IR 7151
  - Next Generation NFIQ (NFIQ 2.0) underway
    - www.nist.gov/itl/iad/ig/development_nfiq_2.cfm
  - Latent
- Iris
  - Not yet, but in near future
    - NIST Iris Image Quality (NIIQ)
    - Some methods are documented in technical literature
- Face
  - Not yet – no plans yet.

Proprietary implementation

- Needs testing
  - Their effectiveness in predicting performance have to evaluated.
- Need calibration
  - To interpret scores
  - To achieve interoperability
- Issues with vendor lock-in

Academia? Others?

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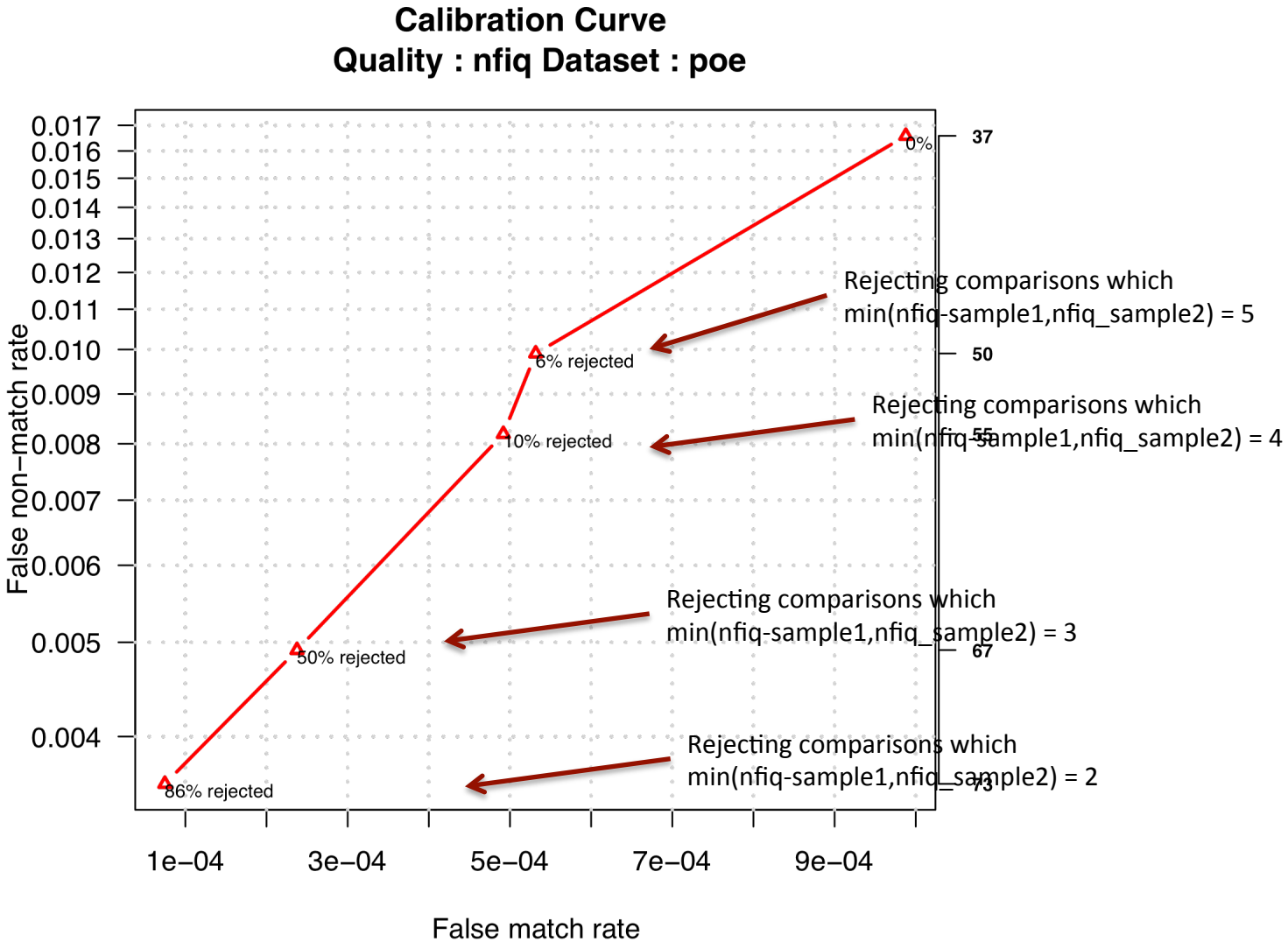
Calibration



Challenges

- Pairwise Q
- Computation time
- Different matcher – different sensitivities
- Limitation on available data, particularly data with know degree of specific impairments

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WE, AT NIST

Focus and Impact

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 ICIP 2005 NIST IR 7820	NIST IR 7820 PAMI 2007 ICPR 2010	ISO/IEC 29794 ISO/IEC 19794	NFIQ 1.0 NFIQ 2.0 NIIQ 1.0	NIST IR 7422 NIST IR 8XXX	www.nist.gov/itl/iad/ig/bio_quality.cfm	BQW 2006, 07 IBPC 2010, 12 NFIQ 2010,12

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Thanks

Sponsors

Homeland Security

Science and Technology

Collaborators + NFIQ 2.0 partners

Federal Office for Information Security

Fraunhofer IGD

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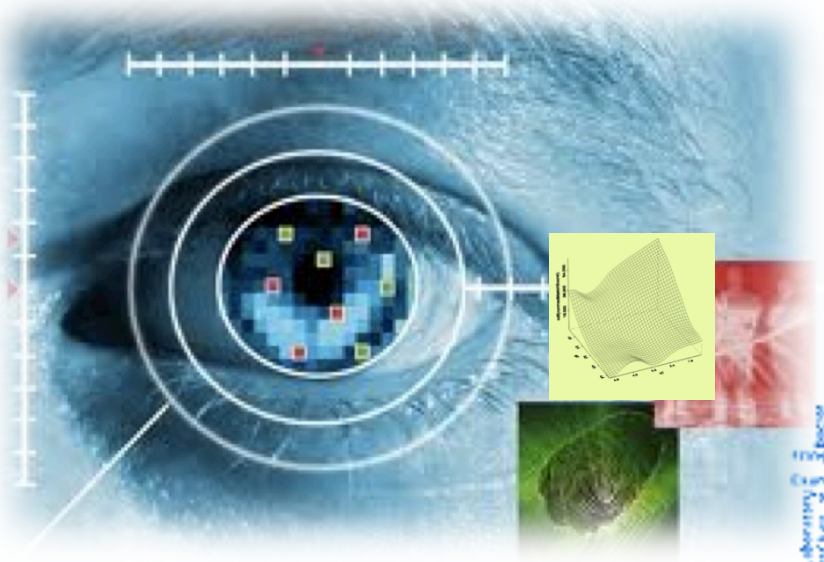

Contact Info:
Elham Tabassi
tabassi AT nist DOT gov
301 975 5292

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