Herausforderungen in Biometrischen Systemen

Vortrag zum Forschungssemester
2024-06-18

copy of slides available at:
https://christoph-busch.de/about-talks-slides.html

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da/sec
BIOMETRICS AND INTERNET-SECURITY
RESEARCH GROUP

ATHENE

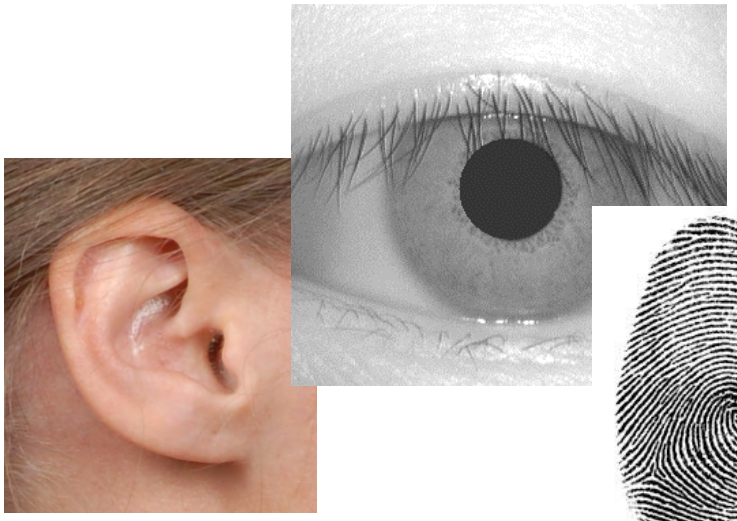
Agenda

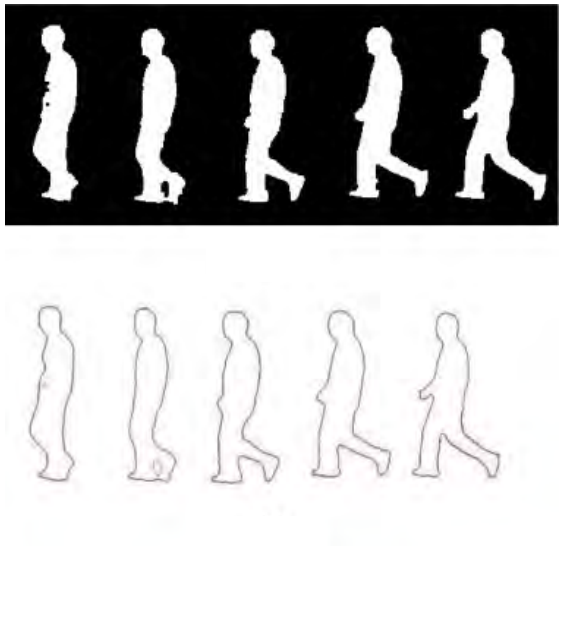
- Intro to Biometrics
- The Plan for the 3 Month
- Biometric Sample Quality
- Fairness of Biometric Systems
- The Reality of the 3 Month

Research Area Biometrics

What is biometrics?

- International Organization for Standardization defines:
  - **Biometrics**:
    "*automated recognition of individuals based on their behavioural and biological characteristics* "
  - Remark: behavioural has to do with the function of the body
    biological / anatomical has to do with the structure of the body

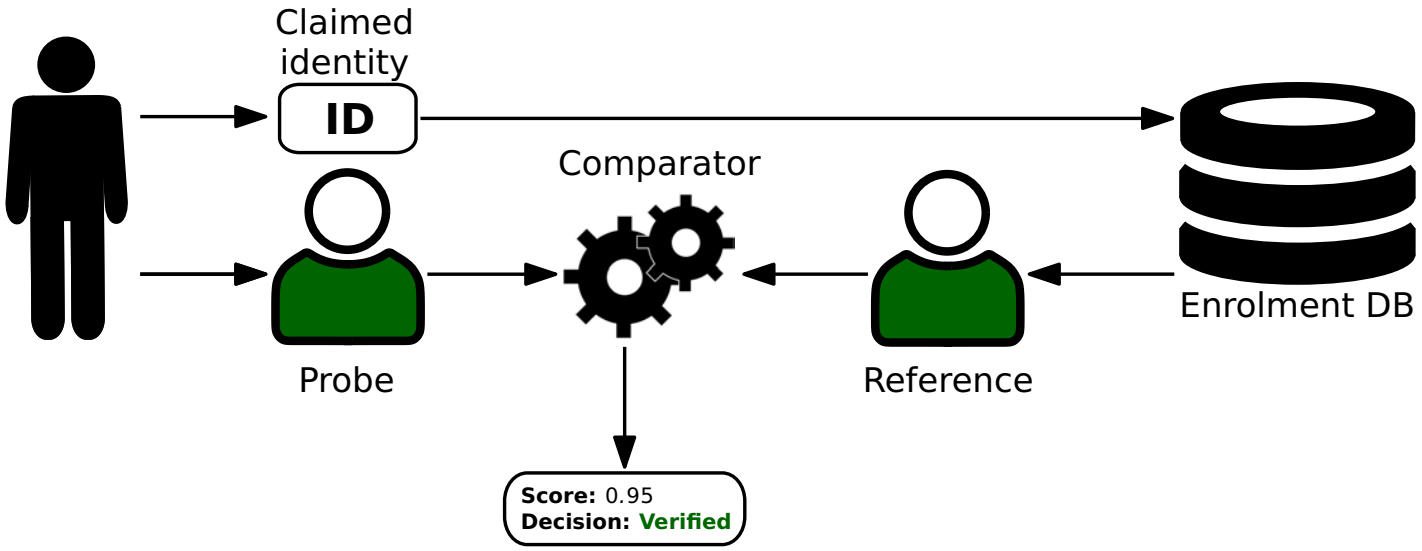




Verification - Identification

Verification

- 1:1
- validate a biometric claim



Verification - Identification

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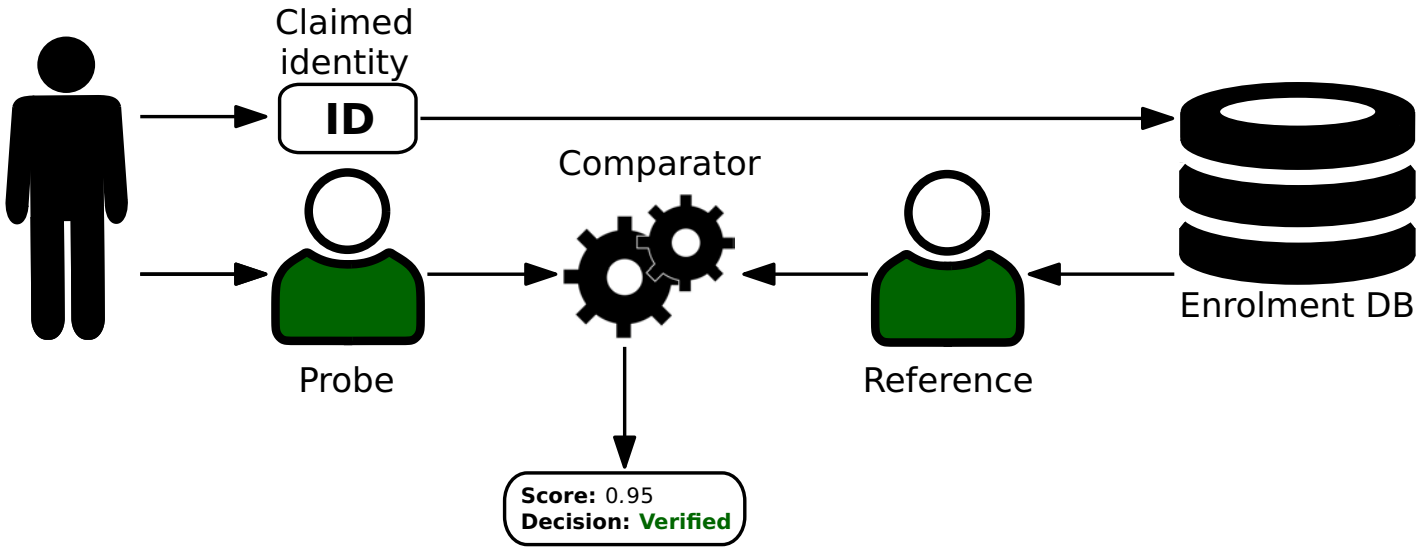
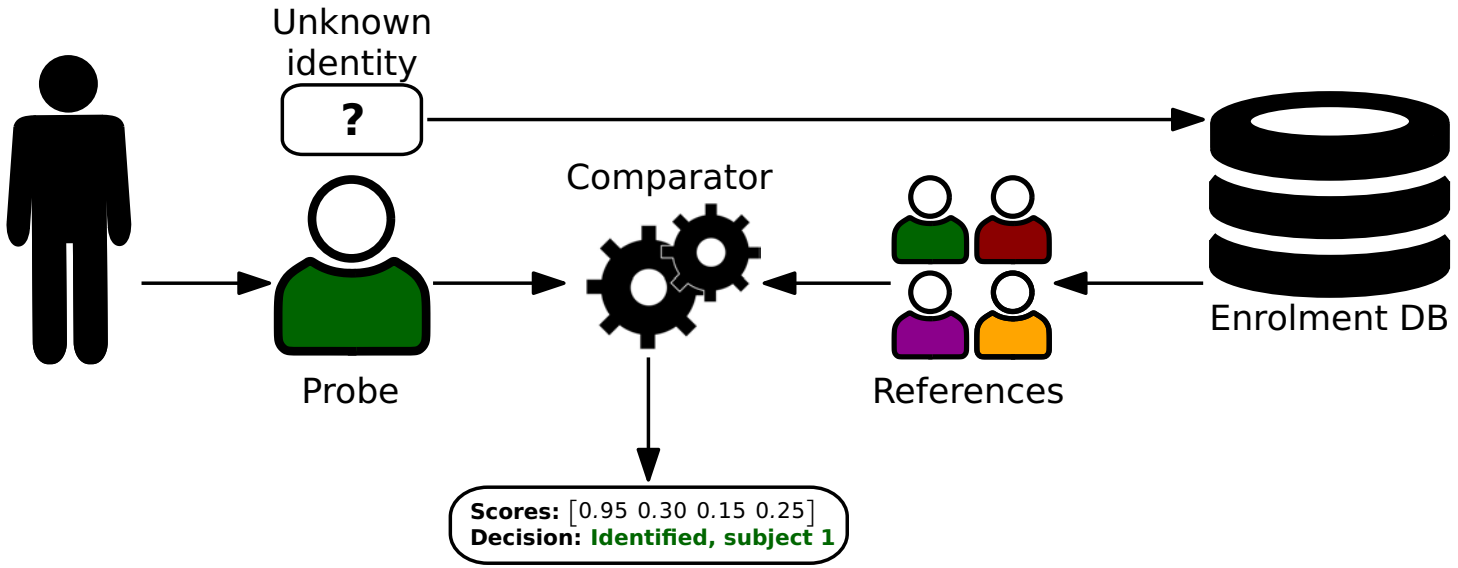


Identification

- 1:n search



Performance Metrics - Security

Probability density Distribution Function (PDF)

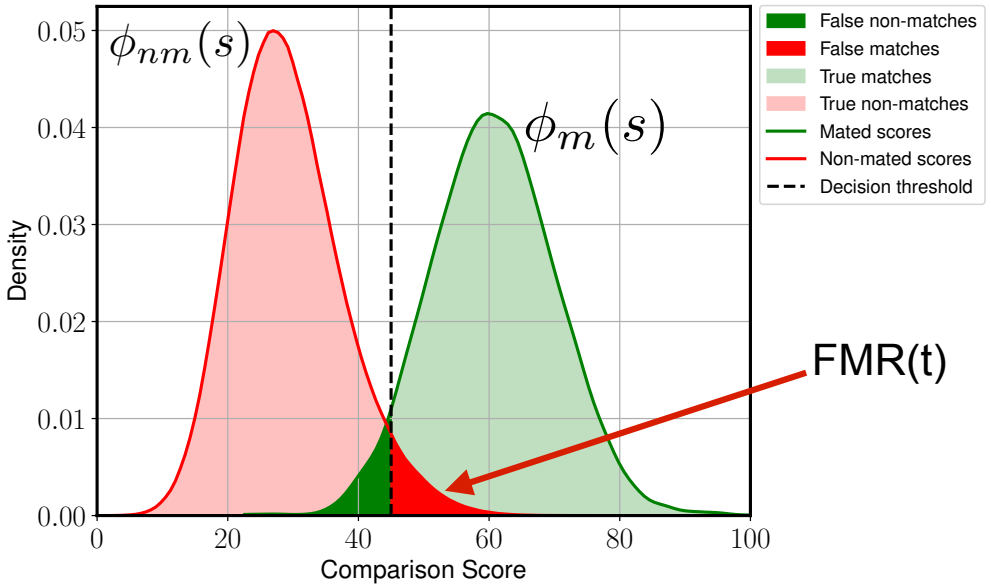
$\phi_m(s)$: PDF of mated similarity score $s(Q, R)$

$\phi_{nm}(s)$: PDF of non-mated similarity score $s(Q, R)$

False-Match-Rate (FMR)

- **Def in ISO-HBV:** *proportion of the completed biometric non-mated comparison trials that result in a false match*
- False positive decision

$$FMR(t) = \int_t^1 \phi_{nm}(s)ds$$



Performance Metrics - Convenience

Probability density Distribution Function (PDF)

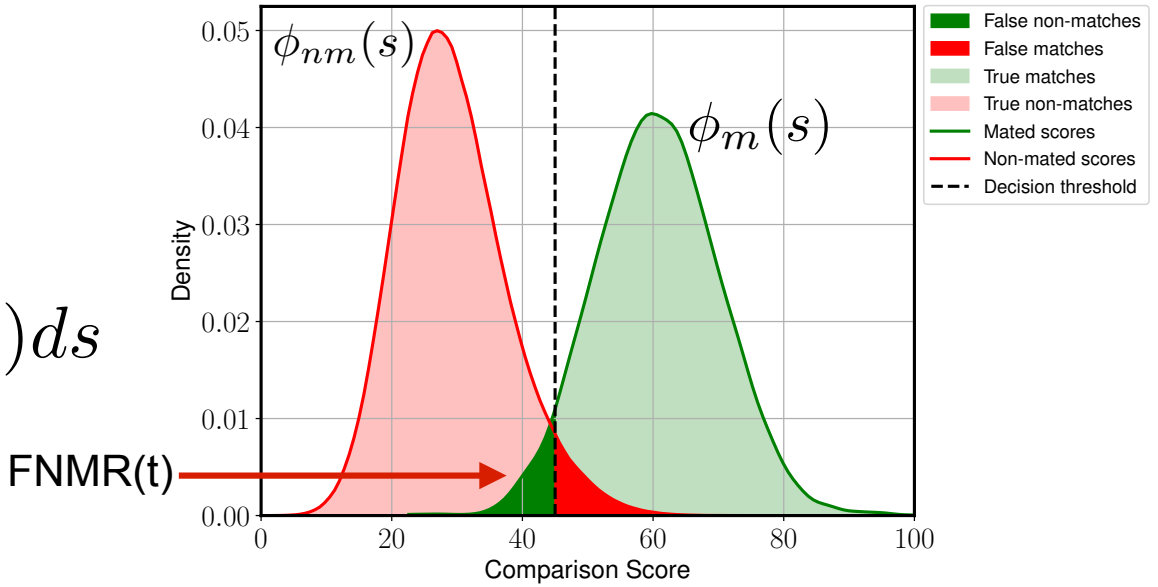
$\phi_m(s)$: PDF of mated similarity score $s(Q, R)$

$\phi_{nm}(s)$: PDF of non-mated similarity score $s(Q, R)$

False-Non-Match-Rate (FNMR)

- **Def in ISO-HBV:** *proportion of the completed biometric mated comparison trials that result in a false non-match*
- False negative decision

$$FNMR(t) = \int_0^t \phi_m(s)ds$$



The Plan

My Plan

Initial version in 2022-12-06

- Work with the colleagues at EURECOM
- Work on bias of biometric systems
  - Understand and apply fairness metrics
  - Find bias mitigation techniques

My Plan

Refined version in summer 2023

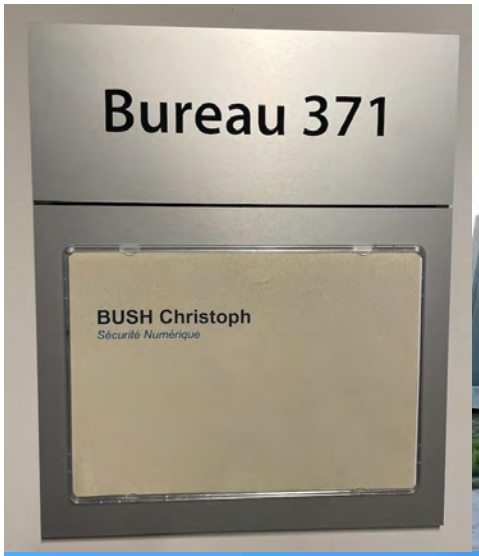
- Live in southern France
- Work with the colleagues at EURECOM
- Convert research results to publication
- Journal paper and book chapter
- Work on biometric sample quality
- Work on bias of biometric systems
  - Understand and apply fairness metrics
  - Find bias mitigation techniques
- Learn french

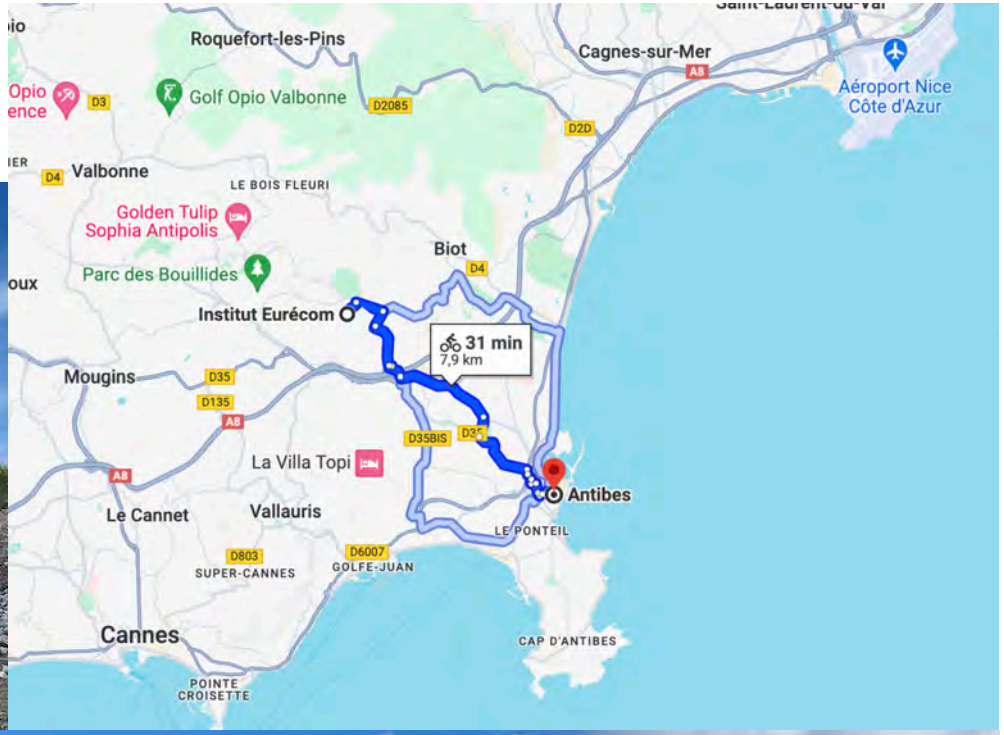
The Implementation

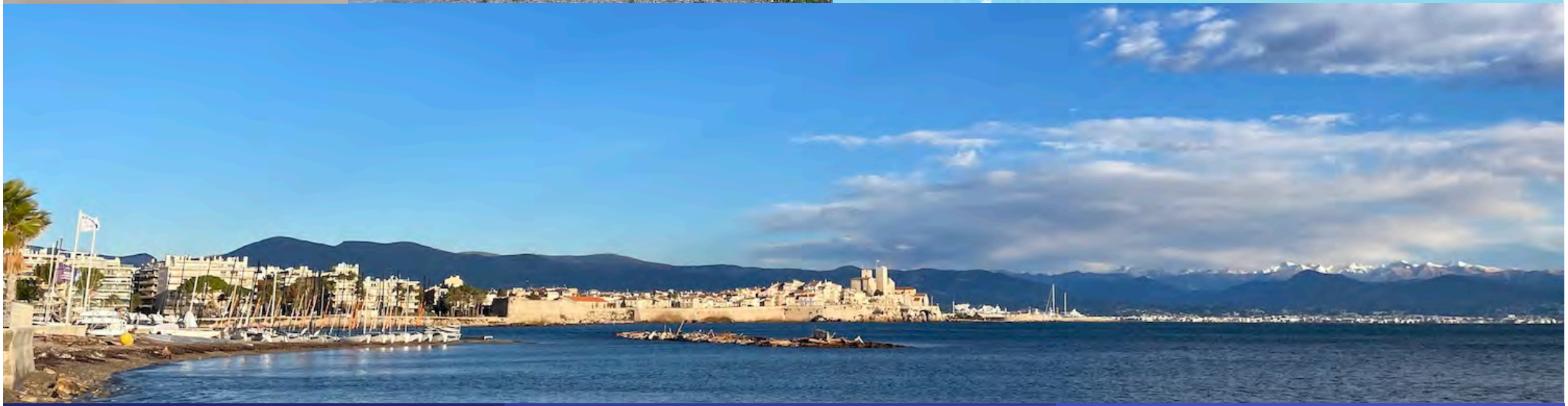
France

Antibes and Sophie Antipolis

- EURECOM: https://www.eurecom.fr







Publications

Convert research results to publication

M. Ibsen, R. Nichols, C. Rathgeb, D. Robertson, J. Davis, F. Løvåsdal, K. Raja, R. Jenkins, C. Busch: “Conditional Face Image Manipulation Detection: Combining Algorithm and Human Examiner Decisions”, in Proceedings of 12th Workshop on Information Hiding and Multimedia Security (ACM IH&MMSEC 2024), Balona, ES, June 24-25, (2024)

O. Chouchane, C. Busch, C. Galdi, N. Evans, M. Todisco: “A Comparison of Differential Performance Metrics for the Evaluation of Automatic Speaker Verification Fairness”, in Proceedings of Speaker and Language Recognition Workshop (ODYSSEY), Québec, CA, June 18-21, (2024)

H. Zhang, R. Raghavendra, K. Raja, C. Busch: "Generalized Single-Image-Based Morphing Attack Detection Using Deep Representations from Vision Transformer", in Proceedings of IEEE Computer Society 19th Workshop on Biometrics (CVPRW), Seattle, U.S., June 17, (2024)

P. Chandaliya, K. Raja, R. Raghavendra, Z. Akhtar, C. Busch: “Towards Inclusive Face Recognition Through Synthetic Ethnicity Alteration”, in Proceedings of 1th International Workshop on Synthetic Data for Face and Gesture Analysis (SDFGA 2024), Istanbul, TK, May 27-31, (2024)

D. Osorio-Roig, C. Rathgeb, J. Gonzalez-Soler, C. Busch: "Privacy-preserving Multi-biometric Indexing based on Frequent Binary Patterns", in IEEE Transactions on Information Forensics and Security (TIFS), (2024)

T. Arican, R. Veldhuis, L. Spreeuwers, L. Bergeron, C. Busch. E. Jalilan, C. Kauba, S. Kirchgasser, S. Marcel, B. Prommegger, K. Raja, R. Raghavendra, A. Uhl: "A Comparative Study of Cross-Device Finger Vein Recognition using Classical and Deep Learning Approaches", in IET Biometrics, (2024)

P. Bauspiess, T. Silde, M. Poljuha, A. Tullot, A. Costache, M. Rathgeb, J. Kolberg, C. Busch: "BRAKE: Biometric Resilient Authenticated Key Exchange", in IEEE Access, (2024)

W. Kabbani, K. Raja, R. Raghavendra, C. Busch: “Eye Sclera for Fair Face Image Quality Assessment”, in Proceedings of 12th International Workshop on Biometrics and Forensics (IWBF 2024), Enschede, NL, April 11-12, (2024)

M. Grimmer, R. Veldhuis, C. Busch: “Efficient Expression Neutrality Estimation with Application to Face Recognition Utility Prediction”, in Proceedings of 12th International Workshop on Biometrics and Forensics (IWBF 2024), Enschede, NL, April 11-12, (2024)

M. Ibsen, C. Rathgeb, S. Marcel, C. Busch: “Multi-Channel Cross Modal Detection of Synthetic Face Images”, in Proceedings of 12th International Workshop on Biometrics and Forensics (IWBF 2024), Enschede, NL, April 11-12, (2024)

X. Liu, K. Raja, R. Wang, H. Qiu, H. Wu, D. Sun, Q. Zheng, N. Liu, X. Wang, G. Huang, R. Raghavendra, C. Busch: "A Latent Fingerprint in the Wild Database", in IEEE Transactions on Information Forensics and Security (TIFS), (2024)

J. Kolberg, Y. Schäfer, C. Rathgeb, C. Busch: "On the Potential of Algorithm Fusion for Demographic Bias Mitigation in Face Recognition", in IET Biometrics, (2024)

I. Joshi, M. Grimmer, C. Rathgeb, C. Busch, F. Bremond, A. Dantcheva: "Synthetic Data in Human Analysis: A Survey", in IEEE Transactions on Transactions on Pattern Analysis and Machine Intelligence (PAMI), (2024)

M. Grimmer, C. Rathgeb, C. Busch: "Pose Impact Estimation on Face Recognition using 3D-Aware Synthetic Data with Application to Quality Assessment", in IEEE Transactions on Biometrics, Behavior, and Identity Science (TBIOM), (2024)

M. Ibsen, J. Soler, C. Rathgeb, C. Busch: "TetraLoss: Improving the Robustness of Face Recognition against Morphing Attacks“, in Proceedings of the 18th IEEE International Conference on Automatic Face and Gesture Recognition (FG), Istanbul, TK, May 27-31, (2024)

C. Yanez, J. Tapia, C. Perezt, C. Busch: "Impact of Occlusion Masks on Gender Classification from Iris Texture", in IET Biometrics, (2024)

T. Schlett, C. Rathgeb, J. Tapia, C. Busch: "Double Trouble? Impact and Detection of Duplicates in Face Image Datasets“, in Proceedings of the 13th International Conference on Pattern Recognition Applications and Methods (ICPRAM), Rome, IT, February 24-26, (2024)

L. Causa, J. Tapia, A. Valenzuela, D. Benalcazar, E. Lopez-Droguett, C. Busch: "Analysis of Behavioral Curves to Classify Iris Images under the Influence of Alcohol, Drugs, and Sleepiness Conditions", in Elsevier Expert Systems With Applications (ESWA), (2023)

D. Benalcazar, J. Tapia, M. Vasquez, L. Causa, E. Lopez-Droguett, C. Busch: "Towards an Efficient Iris Recognition System on Embedded Devices", in IEEE Access, (2023)

T. Schlett, C. Rathgeb, J. Tapia, C. Busch: "Considerations on the Evaluation of Biometric Quality Assessment Algorithms", in IEEE Transactions on Biometrics, Behavior, and Identity Science (TBIOM), (2023)

J. Tapia, C. Busch: "AlphaNet: Single Morphing Attack Detection using Multiple Contributors", in Proceedings of IEEE International Workshop on Information Forensics and Security (WIFS), Nürnberg, DE, December 4-7, (2023)

P. Bauspiess, C. Zok, A. Costache, C. Rathgeb, J. Kolberg, C. Busch: "MT-PRO: Multibiometric Template Protection Based On Homomorphic Transciphering", in Proceedings of IEEE International Workshop on Information Forensics and Security (WIFS), Nürnberg, DE, December 4-7, (2023)

D. Osorio-Roig, C. Rathgeb, C. Busch: "Reversing Deep Face Embeddings with Probable Privacy Protection", in Proceedings of IEEE International Workshop on Information Forensics and Security (WIFS), Nürnberg, DE, December 4-7, (2023)

D. Osorio-Roig, M. Ghafourian, C. Rathgeb, R. Vera-Rodriguez, C. Busch, J. Fierrez: "Optimizing Key-Selection for Face-based One-Time Biometrics via Morphing", in Proceedings of IEEE International Workshop on Information Forensics and Security (WIFS), Nürnberg, DE, December 4-7, (2023)

A. Zafar, C. Busch: "Analyzing eyebrow region for morphed image detection", in Proceedings Norwegian Information Security Conference (NISK), Stavanger, NO, November 27-30, (2023)

P. Bauspiess, P. Bours, C. Rathgeb, J. Kolberg, A. Costache, C. Busch: "Type2: A Secure and Seamless Biometric Two-Factor Authentication Protocol Using Keystroke Dynamics", in Proceedings Norwegian Information Security Conference (NISK), Stavanger, NO, November 27-30, (2023)

S. Lorenz, J. Priesnitz, M. Ibsen, C. Busch: "Towards CNN-based Level 1 Feature Extraction for Contactless Fingerprint Recognition", in Proceedings Norwegian Information Security Conference (NISK), Stavanger, NO, November 27-30, (2023)

H. Zhang, R. Raghavendra, K. Raja, C. Busch: "PIPE: Plugging in Identity Prior to Enhance Face Morphing Attack Based on Diffusion Model", in Proceedings Norwegian Information Security Conference (NISK), Stavanger, NO, November 27-30, (2023)

C. Aravena, D. Pasmino, J. Tapia, C. Busch: "Face Image Quality Estimation on Presentation Attack Detection", in Proceedings of 26th Iberoamerican Congress on Pattern Recognition (CIARP), Coimbra, PT, November 27-30, (2023)

J. Tapia, C. Busch: "Classify NIR Iris images Under Alcohol/Drugs/Sleepiness Conditions Using a Siamese Network", in Proceedings of 26th Iberoamerican Congress on Pattern Recognition (CIARP), Coimbra, PT, November 27-30, (2023)

J. Tapia, C. Busch: "Impact of Synthetic Images on Morphing Attack Detection Using a Siamese Network", in Proceedings of 26th Iberoamerican Congress on Pattern Recognition (CIARP), Coimbra, PT, November 27-30, (2023)

P. Chandaliya, K. Raja, S. Gharat, N. Nain, R. Raghavendra, C. Busch: “MuSTAT: Face Ageing using Multi-Scale Target Age Style Transfer", in Proceedings of the 8th International Conference on Computer Vision & Image Processing (CVIP), Nagpur, IN, November 3-5, (2023)

P. Tinsley, S. Purnapatra, M. Mitcheff, A. Boyd, C. Crum, M. Fang, N. Damer, X. Liu, C. Wang, X. Sun, Z. Chang, X. Li, Z. Guangzhe, J. Tapia, C. Busch, C. Aravena, D. Schulz, S. Schuckers, K. Bowyer, P.k Flynn, A. Czajka: "Iris Liveness Detection Competition (LivDet-Iris) -- The 2023 Edition", in Proceedings of International Joint Conference on Biometrics (IJCB), Ljubljana, SI, September 25-28, (2023)

M. Grimmer, C. Rathgeb, R. Veldhuis, C. Busch: "NeutrEx: A 3D Quality Component Measure on Facial Expression Neutrality", in Proceedings of International Joint Conference on Biometrics (IJCB), Ljubljana, SI, September 25-28, (2023)

E. Jensen, M. Bjerre, M. Grimmer, C. Busch: "Lifespan Face Age Progression using 3D-Aware Generative Adversarial Networks", in Proceedings of International Joint Conference on Biometrics (IJCB), Ljubljana, SI, September 25-28, (2023)

P. Bauspiess, M. Grimmer, C. Fougner, D. Vasseur, T. Stöckling, C. Rathgeb, J. Kolberg, A. Costache, C. Busch: "HEBI: Homomorphically Encrypted Biometric Indexing", in Proceedings of International Joint Conference on Biometrics (IJCB), Ljubljana, SI, September 25-28, (2023)

J. Priesnitz, J. Kolberg, M. Fang, A. Madhu, C. Rathgeb, N. Damer, C. Busch: "COLFIPAD: A Presentation Attack Detection Benchmark for Contactless Fingerprint Recognition", in Proceedings of International Joint Conference on Biometrics (IJCB), Ljubljana, SI, September 25-28, (2023)

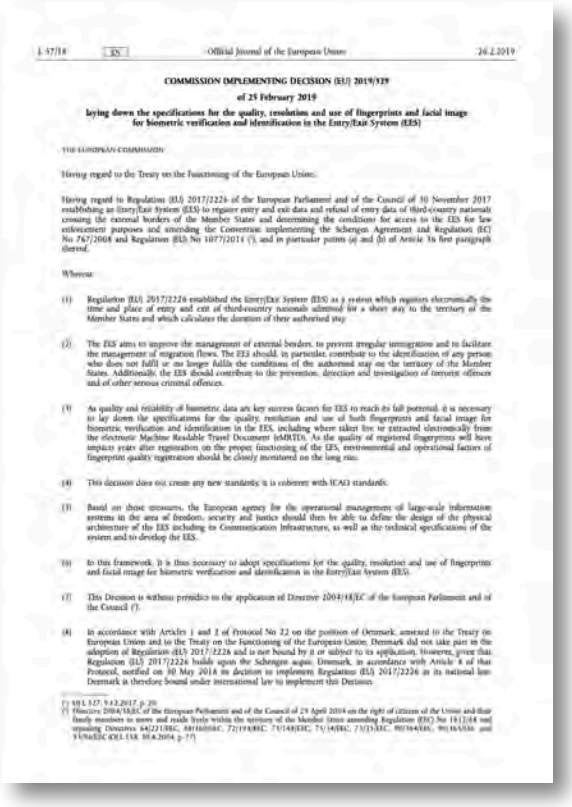
EES and Biometric Sample Quality

Fingerprint Image Quality in the EES

NFIQ2.0

- The Entry Exit System implementing decision 2019/329 defines the mandatory use:

- „*At the moment of enrolment, the version 2.0 (or newer version) of the Fingerprint Image Quality (NFIQ) metric …. shall be used for verifying that the quality of the captured fingerprint data respects the thresholds …*“



L 57/14 EN Official Journal of the European Union 26.2.2019

COMMISSION IMPLEMENTING DECISION (EU) 2019/329

of 25 February 2019

laying down the specifications for the quality, resolution and use of fingerprints and facial image for biometric verification and identification in the Entry/Exit System (EES)

THE EUROPEAN COMMISSION

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Regulation (EU) 2017/2226 of the European Parliament and of the Council of 30 November 2017 establishing an Entry/Exit System (EES) to register entry and exit data and refusal of entry data of third-country nationals crossing the external borders of the Member States and determining the conditions for access to the EES for law enforcement purposes and amending the Convention implementing the Schengen Agreement and Regulations (EC) No 767/2008 and Regulation (EU) No 1077/2011 (1), and in particular points (a) and (b) of Article 36 first paragraph thereof,

Whereas:

(1) Regulation (EU) 2017/2226 established the Entry/Exit System (EES) as a system which registers electronically the time and place of entry and exit of third-country nationals admitted for a short stay to the territory of the Member States and which calculates the duration of their authorised stay.

(2) The EES aims to improve the management of external borders, to prevent irregular immigration and to facilitate the management of migration flows. The EES should, in particular, contribute to the identification of any person who does not fulfil or no longer fulfils the conditions of the authorised stay on the territory of the Member States. Additionally, the EES should contribute to the prevention, detection and investigation of terrorist offences and of other serious criminal offences.

(3) As quality and reliability of biometric data are key success factors for EES to reach its full potential, it is necessary to lay down the specifications for the quality, resolution and use of both fingerprints and facial image for biometric verification and identification in the EES, including where taken live or extracted electronically from the electronic Machine Readable Travel Document (eMRTD). As the quality of registered fingerprints will have impacts years after registration on the proper functioning of the EES, environmental and operational factors of fingerprint quality registration should be closely monitored on the long run.

(4) This decision does not create any new standard(s) it is coherent with ICAO standards.

(5) Based on those measures, the European agency for the operational management of large-scale information systems in the area of freedom, security and justice should then be able to define the design of the physical architecture of the EES including its Communication Infrastructure, as well as the technical specifications of the system and to develop the EES.

(6) In this framework, it is thus necessary to adopt specifications for the quality, resolution and use of fingerprints and facial image for biometric verification and identification in the Entry/Exit System (EES).

(7) This Decision is without prejudice to the application of Directive 2004/38/EC of the European Parliament and of the Council (2).

(8) In accordance with Articles 1 and 2 of Protocol No 22 on the position of Denmark, annexed to the Treaty on European Union and to the Treaty on the Functioning of the European Union, Denmark did not take part in the adoption of Regulation (EU) 2017/2226 and is not bound by it or subject to its application. However, given that Regulation (EU) 2017/2226 builds upon the Schengen acquis, Denmark, in accordance with Article 4 of that Protocol, notified on 30 May 2018 its decision to implement Regulation (EU) 2017/2226 as its national law. Denmark is therefore bound under international law to implement this Decision.

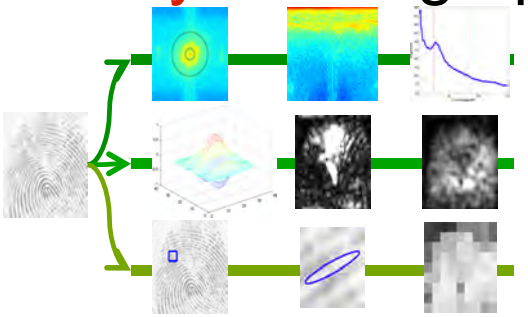
(1) OJ L 327, 9.12.2017, p. 20.

(2) Directive 2004/38/EC of the European Parliament and of the Council of 29 April 2004 on the right of citizens of the Union and their family members to move and reside freely within the territory of the Member States amending Regulation (EEC) No 1612/68 and repealing Directives 64/221/EEC, 68/360/EEC, 72/194/EEC, 73/148/EEC, 75/34/EEC, 75/35/EEC, 90/364/EEC, 90/365/EEC and 93/96/EEC (OJ L 158, 30.4.2004, p. 77).

Fingerprint Image Quality in the EES

The NFIQ2.0 approach

- Measure quality by filtering the signal and determine the utility of a fingerprint sample.



- Providing constructive feedback only possible if cause of poor quality is known.

- NFIQ2.0 constitutes the content of ISO/IEC 29794-4

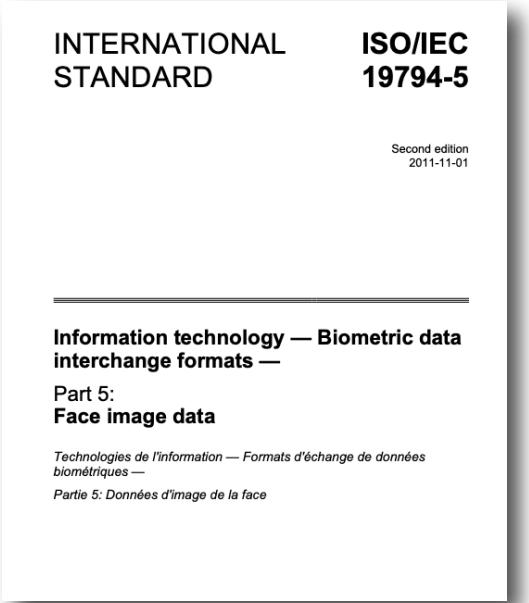
http://www.christoph-busch.de/projects-nfiq2.html

Face Image Quality in the EES

The objective in the EES implementing decision 2019/329

- *„The quality of the facial images, … and with the image requirements of ISO/IEC 19794-5:2011 Frontal image type*

What does that mean?


INTERNATIONAL STANDARD

ISO/IEC 19794-5

Second edition
2011-11-01

Information technology — Biometric data interchange formats —

Part 5:
Face image data

Technologies de l'information — Formats d'échange de données biométriques —

Partie 5: Données d'image de la face

Data subjects need actionable feedback

- If quality is poor, then what went wrong?

Compliant image | Pose | Eyes open | Mouth open | Inhomogenous background

Source: ISO/IEC 39794-5

ISO/IEC 29794-5: Face Image Quality

ISO/IEC 29794-5 will be aligned with both

- ISO/IEC 19794-5:2011
- ISO/IEC 39794-5:2019

Definitions

- 7.2 Unified quality score
- 7.3 Capture-related quality elements
- 7.4. Subject-related quality elements

a) Compliant image **b) Low contrast**

source: ISO/IEC 39794-5:2019, Annex D
https://www.iso.org/standard/72156.html

images with +8 degrees (left) and -8 degrees (right) rotation in roll

Image Source: ISO/IEC 19794-5:2011

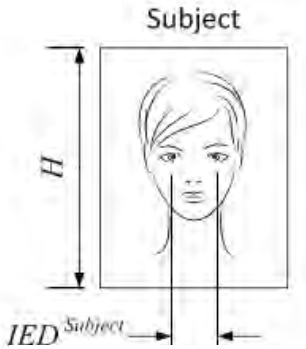
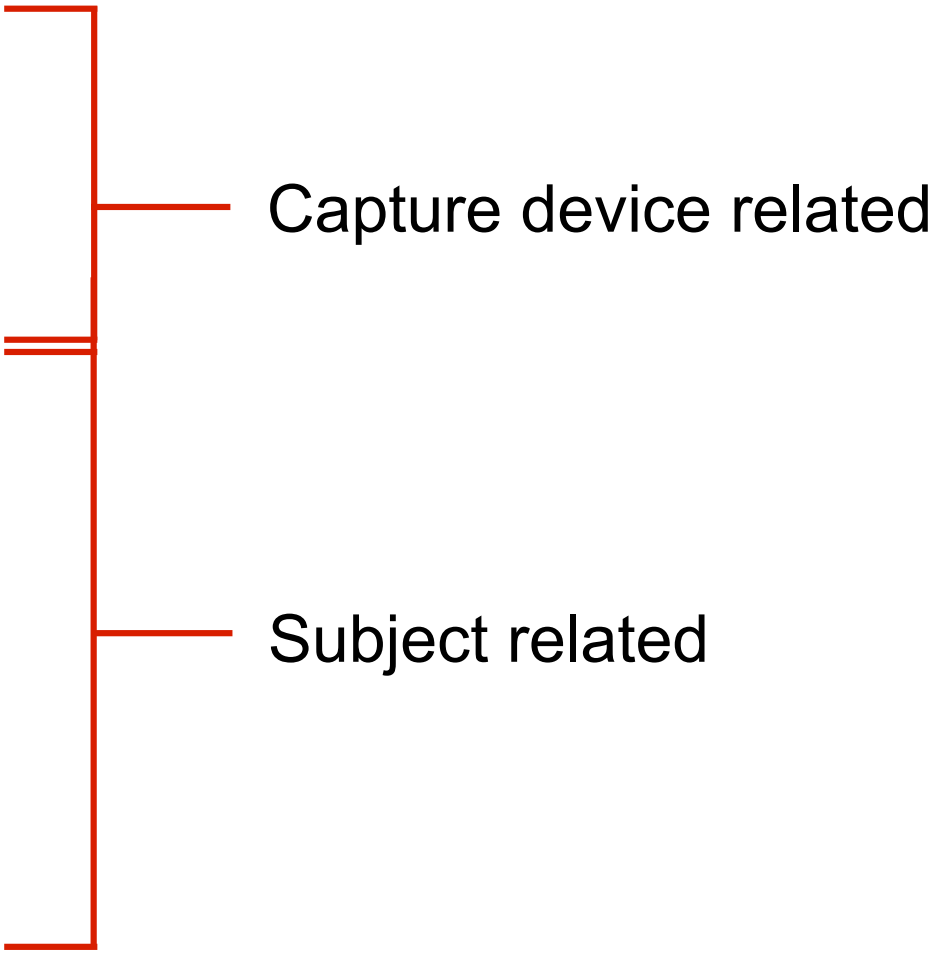


Image Source: ISO/IEC 39794-5

ISO/IEC 29794-5: Face Image Quality

#	Face image quality measure
1.	Quality score (unified)
2.	Background uniformity
3.	Illumination uniformity
4.	Luminance mean
5.	Luminance variance
6.	Under-exposure prevention
7.	Over-exposure prevention
8.	Dynamic range
9.	Sharpness
10.	No compression artifacts
11.	Natural colour
12.	Single face present
13.	Eyes open
14.	Mouth closed
15.	Eyes visible
16.	Mouth occlusion prevention
17.	Face occlusion prevention
18.	Inter-eye distance
19.	Head size
20.	Leftward crop of face in image
21.	Rightward crop of face in image
22.	Downward crop of face in image
23.	Upward crop of face in image
24.	Pose angle yaw frontal alignment
25.	Pose angle pitch frontal alignment
26.	Pose angle roll frontal alignment
27.	Expression neutrality
28.	No head covering



Open Source Face Image Quality (OFIQ)

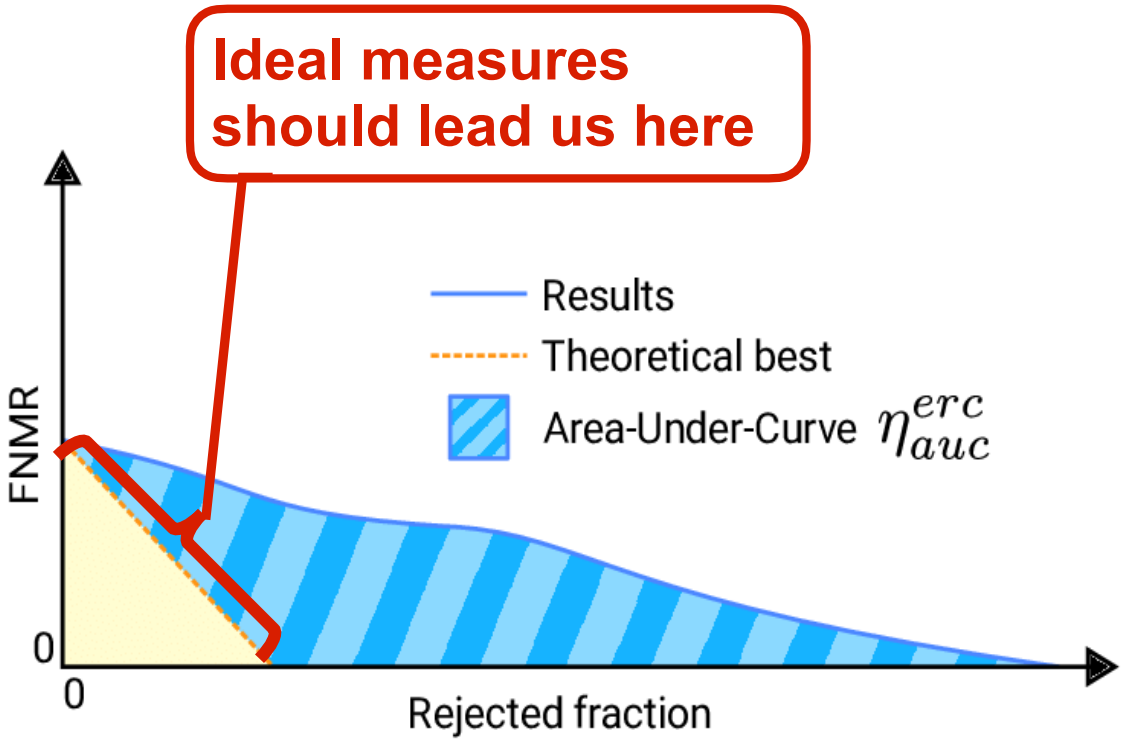
Approach

- Library with quality assessment algorithms
- Open source with liberal license (MIT)
  - enables commercial use
- Support for major OS platforms (including mobile OS)
  - C/C++
- Aligned with ISO/IEC 29794-5
  - serves as reference implementation
  - providing target values for conformance tests
- Selection criteria for integrated algorithms
  - accuracy (OFIQ-evaluation or NIST FATE SIDD evaluation)
  - low computational complexity
  - liberal license (MIT or alike)

OFIQ - Unified Quality Score

Excellent results in FATE SIDD (1st of 16)

- Very good prediction of low face recognition scores
- Best performing algorithm



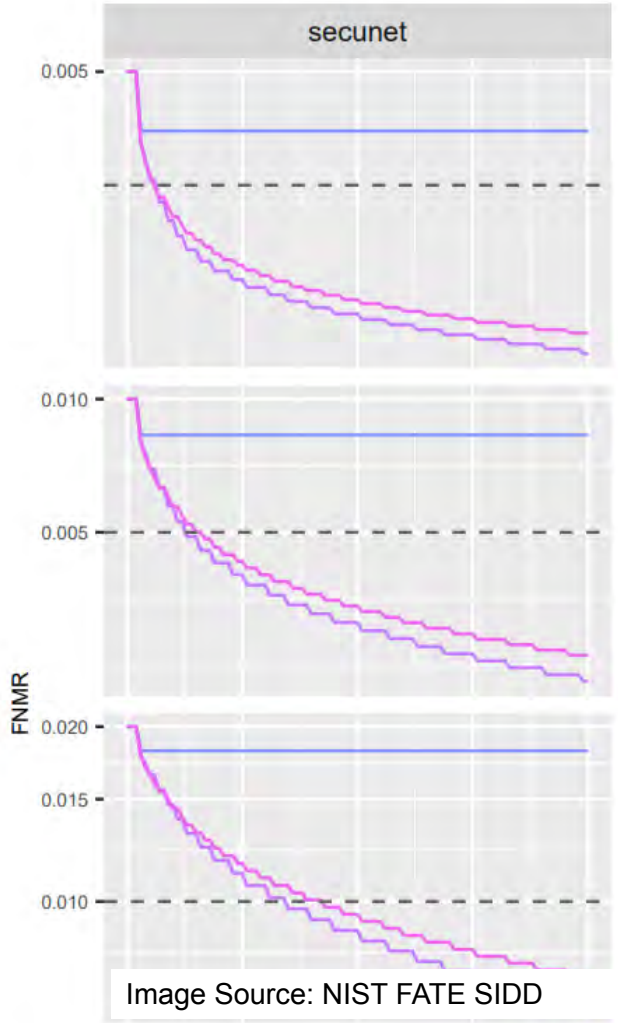
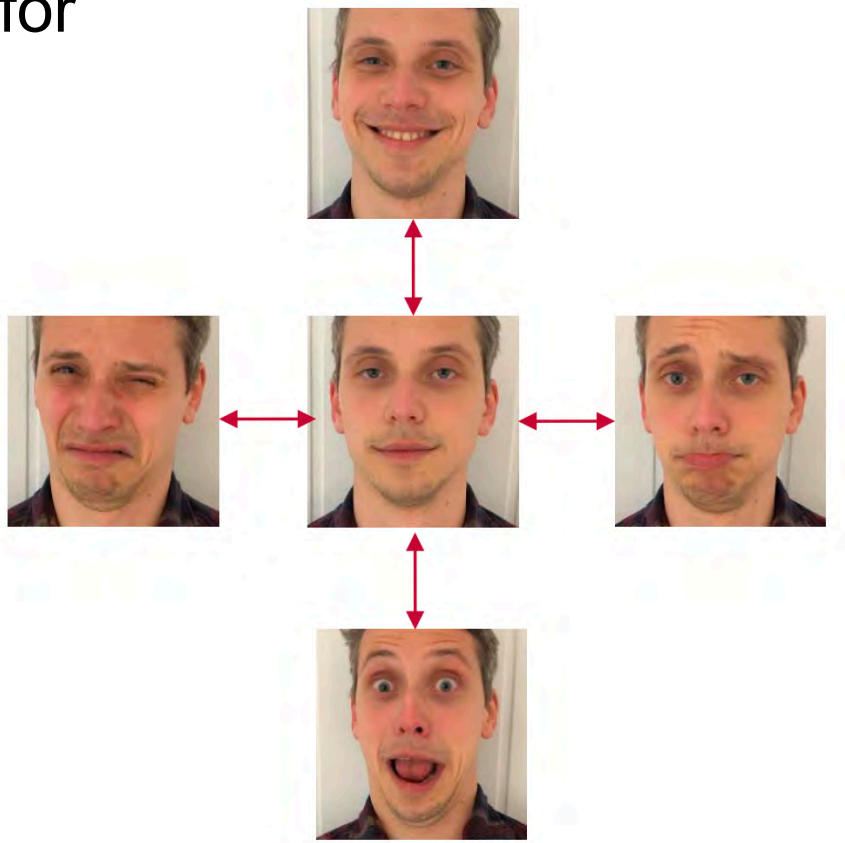


Image Source: NIST FATE SIDD

Fingerprint Image Quality - Expression

Quality Component: Expression Neutrality

- Expression neutrality as quality component
- Reduced biometric performance for extreme facial expressions
- Known fact:
  best-possible utility
  through neutral expressions
- Goal:
  Quantify expression neutrality



[GRVB2023] M. Grimmer, C. Rathgeb, R. Veldhuis, C. Busch: "NeutrEx: A 3D Quality Component Measure on Facial Expression Neutrality", in Proceedings of International Joint Conference on Biometrics (IJCB), (2023)

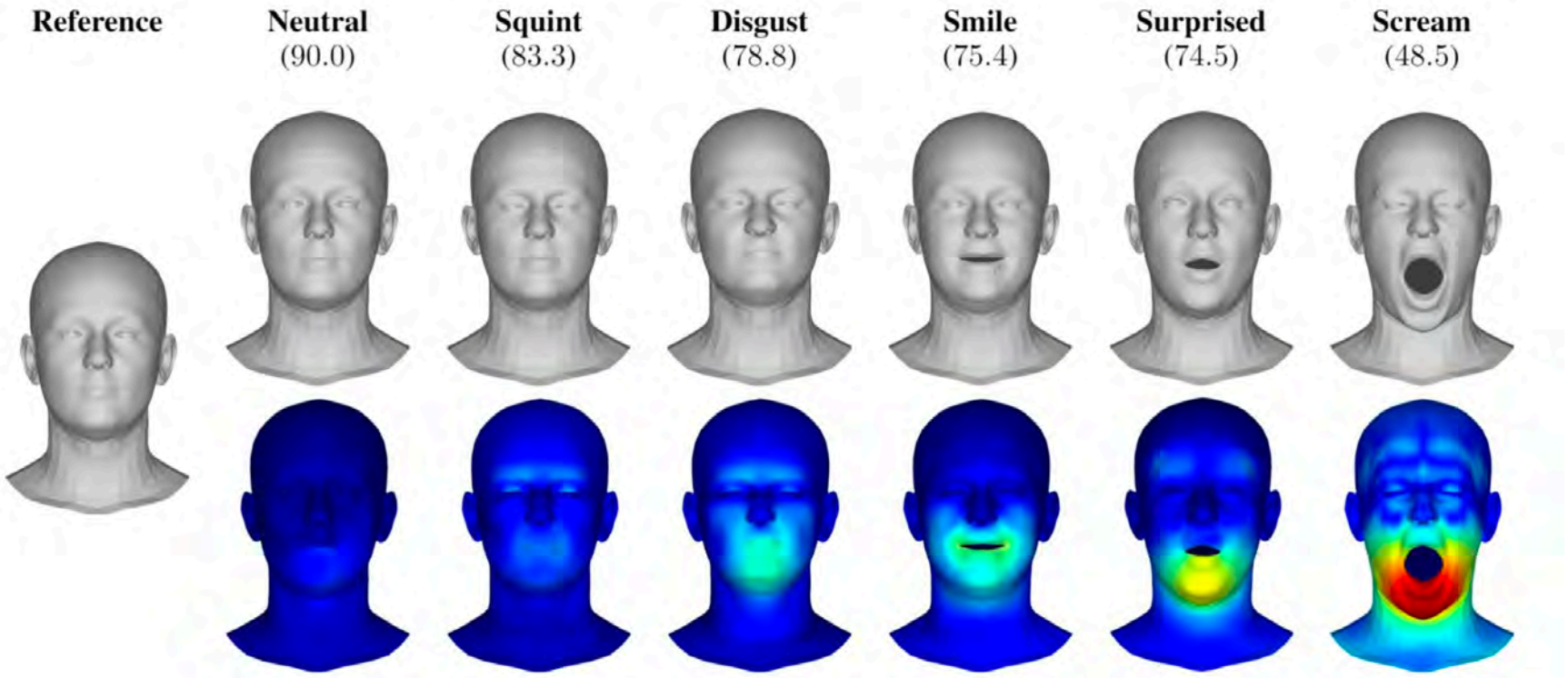
[GVB2024] M. Grimmer, R. Veldhuis, C. Busch: “Efficient Expression Neutrality Estimation with Application to Face Recognition Utility Prediction”, in Proceedings of 12th International Workshop on Biometrics and Forensics (IWBF 2024)

Face Image Quality - Expression

Expression Neutrality Measure: NeutrEx

- Cumulative 2-Norm Distances: $D(V_i, V_A) = ||V_i - V_A||_2$
- NeutrEx Measure: $\text{NeutrEx}(V_i, V_A) = 100 \cdot (1 - \frac{D(V_i, V_A) - D_{min}}{D_{max} - D_{min}})$
- Quality measure between [0, 100]

Explainability



Outlook for OFIQ

Perspective

- OFIQ will become the reference implementation of ISO/IEC 29794-5:2024
- OFIQ open source code:
  https://github.com/BSI-OFIQ/OFIQ-Project
- NIST FATE SIDD test report:
  https://pages.nist.gov/frvt/reports/quality_sidd/frvt_quality_sidd_report.pdf

Fairness of Biometric Systems

Fairness Metrics

Demographic Differentials

- skin tone
- gender
- age
- language

Image Source: HSBRS, (2016)

Fairness Metrics

Fairness Discrepancy Rate (FDR)

- False positive differential (FPD) and the
- False negative differential (FND

$$\mathrm{FPD}(\tau) = \max\left(\left|\mathrm{FMR}_{d_i}(\tau) - \mathrm{FMR}_{d_j}(\tau)\right|\right) \quad (1)$$

$$\mathrm{FND}(\tau) = \max\left(\left|\mathrm{FNMR}_{d_i}(\tau) - \mathrm{FNMR}_{d_j}(\tau)\right|\right) \quad (2)$$

for any $d_i, d_j \in D$.

$$\mathrm{FDR}(\tau, \alpha) = 1 - (\alpha \mathrm{FPD}(\tau) + (1-\alpha)\mathrm{FND}(\tau)) \quad (3)$$

Inequity Rate (IR)

$$\mathrm{FPD}(\tau) = \frac{\max_{d_i} \mathrm{FMR}_{d_i}(\tau)}{\min_{d_j} \mathrm{FMR}_{d_j}(\tau)} \qquad \forall d_i, d_j \in D \quad (4)$$

$$\mathrm{FND}(\tau) = \frac{\max_{d_i} \mathrm{FNMR}_{d_i}(\tau)}{\min_{d_j} \mathrm{FNMR}_{d_j}(\tau)} \qquad \forall d_i, d_j \in D \quad (5)$$

$$\mathrm{IR}(\tau, \alpha) = \mathrm{FPD}(\tau)^{\alpha} \cdot \mathrm{FND}(\tau)^{(1-\alpha)} \quad (6)$$

Fairness Metrics

Gini Aggregation Rate for Biometric Equitability (GARBE)

$$G_{\mathrm{FMR}}(\tau) = \frac{n}{n-1}\left(\frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|\mathrm{FMR}_{d_i} - \mathrm{FMR}_{d_j}|}{2n^2\overline{\mathrm{FMR}}}\right) \quad (7)$$

where $\overline{\mathrm{FMR}}$ is the mean value. Similarly, the Gini coefficient related to the FNMR is defined by:

$$G_{\mathrm{FNMR}}(\tau) = \frac{n}{n-1}\left(\frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|\mathrm{FNMR}_{d_i} - \mathrm{FNMR}_{d_j}|}{2n^2\overline{\mathrm{FNMR}}}\right) \quad (8)$$

for any $d_i, d_j \in D$.

In adapting to be consistent with the notation above, the pair of Gini coefficients are combined according to:

$$\mathrm{FPD}(\tau) = G_{\mathrm{FMR}}, \quad \mathrm{FND}(\tau) = G_{\mathrm{FNMR}} \quad (9)$$

$$\mathrm{GARBE}(\tau, \alpha) = \alpha\mathrm{FPD}(\tau) + (1-\alpha)\mathrm{FND}(\tau) \quad (10)$$

GARBE values range from 0 to 1, with 0 indicating full fairness and 1 indicating full unfairness.

Fairness Metrics

Functional Fairness Measure Criteria (FFMC)

- FFMC.1: The contributions of FMR and FNMR to the fairness metric should be intuitive across typical risk parameters and operationally relevant error rates.
- FFMC.2: The metric needs defined boundaries, with minimum and maximum values, to establish clear benchmarks.
- FFMC.3: The metric must remain computable for demographic groups with no observed errors, a condition becoming more common with more accurate biometric algorithms.

Fairness Metrics Evaluation

Automated Speaker Verification (ASV)

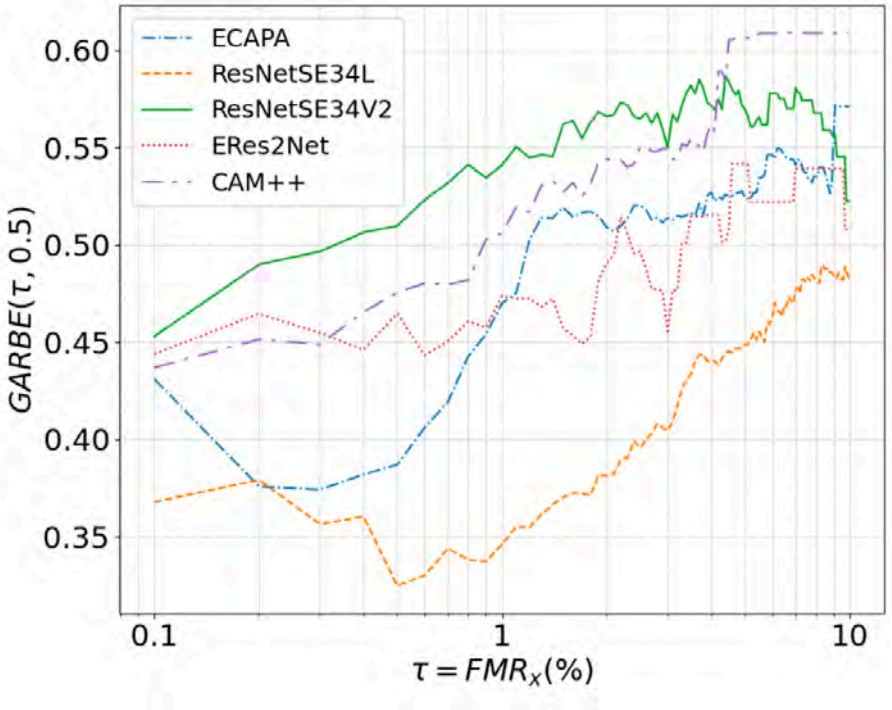
- Models trained on Vox- Celeb2 database (5,994 speakers)
- All evaluation work is performed using VoxCeleb1 database
  - From each of 9 nationality groups, eight speakers were chosen at random, resulting in a total of 72 speakers.
  - For each speaker, 24 utterances were selected. The ASV protocol10 of the pooled data consists of 39,744 comparison trials, with a balanced number of 2,208 mated and 2,208 non-mated combinations for each nationality.

Nationality	ASV Systems									
	ERes2Net		*CAM++*		*ECAPA*		*ResNetSE34V2*		*ResNetSE34L*	
	FMR (%)	FNMR (%)	FMR (%)	FNMR (%)	FMR (%)	FNMR (%)	FMR (%)	FNMR (%)	FMR (%)	FNMR (%)
USA	1.22	1.04	1.40	1.54	1.13	1.45	1.36	1.68	2.76	2.08
UK	0.68	0.45	0.41	0.14	0.72	0.23	0.50	0.50	2.08	1.90
Germany	0.59	2.81	0.63	4.26	2.49	6.34	2.31	6.34	4.17	8.11
Australia	0.68	0.27	1.99	0.14	1.90	0.27	0.86	0.77	1.54	1.72
Italy	1.95	2.58	1.40	2.72	2.58	3.85	3.26	2.54	3.53	4.08
India	2.31	0.09	1.90	0.14	2.76	1.00	6.11	0.00	5.53	0.09
Ireland	0.18	2.04	0.82	2.31	0.77	1.45	0.45	2.36	0.86	4.21
New_Zealand	1.86	0.27	1.86	0.18	2.17	0.27	0.95	1.18	1.86	2.67
Canada	1.13	1.31	1.40	0.86	1.31	1.22	1.13	1.63	5.30	2.17
Pooled EER (%)	**1.18**		**1.37**		**1.79**		**1.88**		**3.01**	

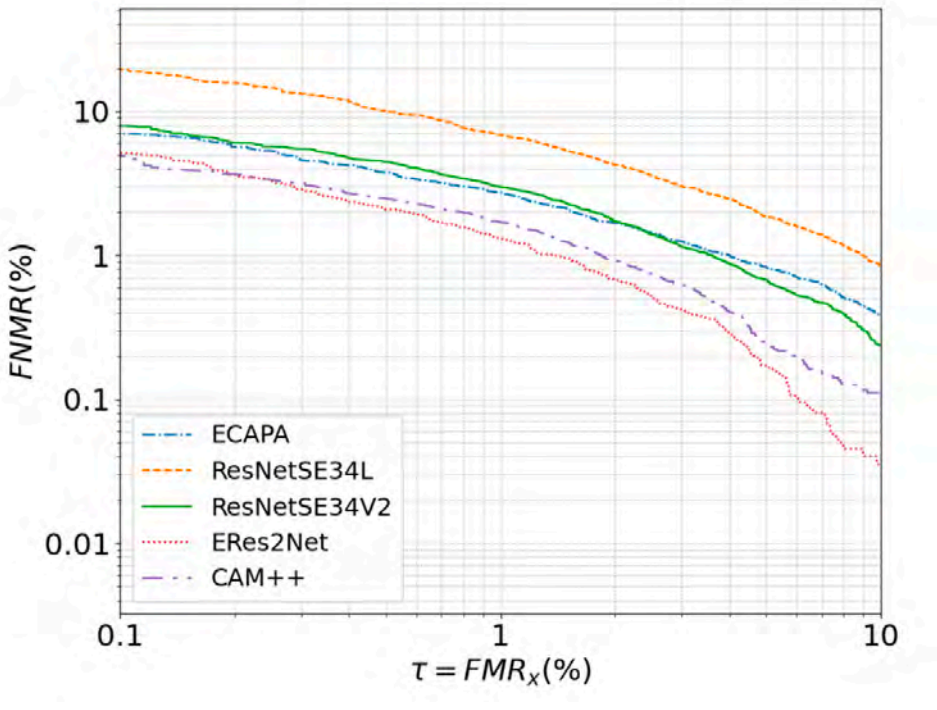
Fairness Metrics Evaluation

Automated Speaker Verification (ASV)

- GARBE values for 5 automatic speaker verification systems at a range of thresholds
  - corresponding to a FMR varying form 0.1% to 10%
  - lower GARBE is better. lower DET is better



GARBE over FMR

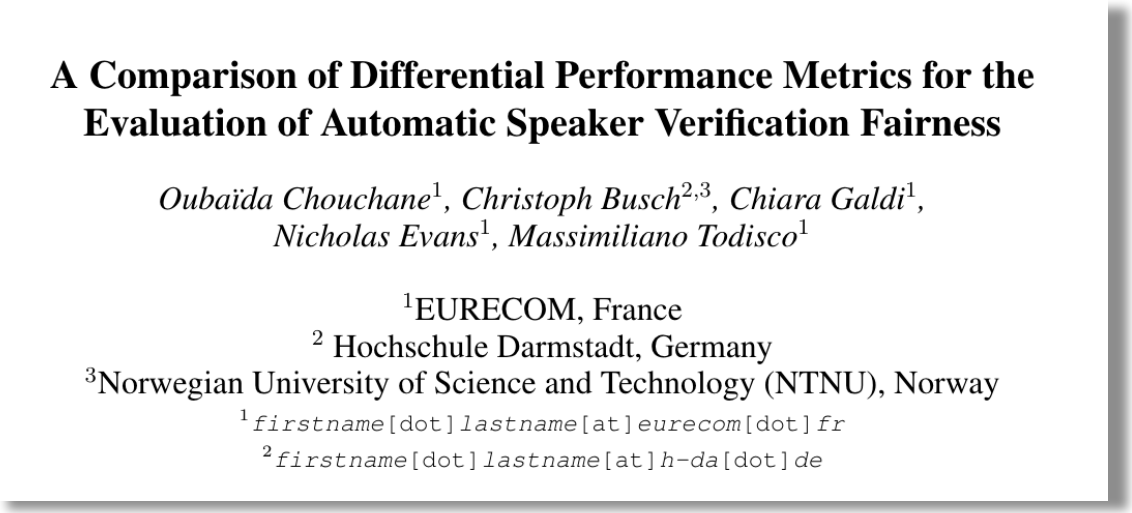


DET: FNMR over FMR

Fairness Metrics Evaluation

Publication

- O. Chouchane, C. Busch, C. Galdi, N. Evans, M. Todisco: "A Comparison of Differential Performance Metrics for the Evaluation of Automatic Speaker Verification Fairness", in Proceedings of Speaker and Language Recognition Workshop (ODYSSEY), Québec, CA, June 18-21, (2024) https://arxiv.org/abs/2404.17810



A Comparison of Differential Performance Metrics for the Evaluation of Automatic Speaker Verification Fairness

Oubaïda Chouchane[1], *Christoph Busch*[2,3], *Chiara Galdi*[1], *Nicholas Evans*[1], *Massimiliano Todisco*[1]

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My Plan

Refined version in summer 2023

- Live in southern France 
- Work with the colleagues at EURECOM 
- Convert research results to publication 
- Journal paper and book chapter 
- Work on biometric sample quality 
- Work on bias of biometric systems 
  - Understand and apply fairness metrics 
  - Find bias mitigation techniques 
- Learn french 

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