Real-World Challenges for Biometric Systems

UIDAI Bio-Challenge Webinar
2024-06-26

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

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Agenda

Challenges in population scale biometric solutions in enrolment and authentication

- Biometric Sample Quality
- Presentation Attacks - PAD
- Morphing Attacks - MAD
- Ageing

Biometric Characteristic

Biometric activities

- 25+ years research in Biometrics
- Lecturer in Darmstadt, Gjøvik and Copenhagen
- Principal Investigator in ATHENE
- Convener of the Working Group 3 on Biometric Data Interchange Formats in ISO/IEC JTC1 SC37
- Co-Founder of the CAST Association
- Co-Founder of the European Association for Biometrics
- Chair of the TeleTrusT working group on Biometrics
- Advisor to
  - BSI (German Federal Agency for IT-Security)
  - eu-LISA (European Union Agency for the Operational Management of Large-Scale IT Systems in the Area of Freedom, Security and Justice)

http://www.christoph-busch.de

Biometric Sample Quality

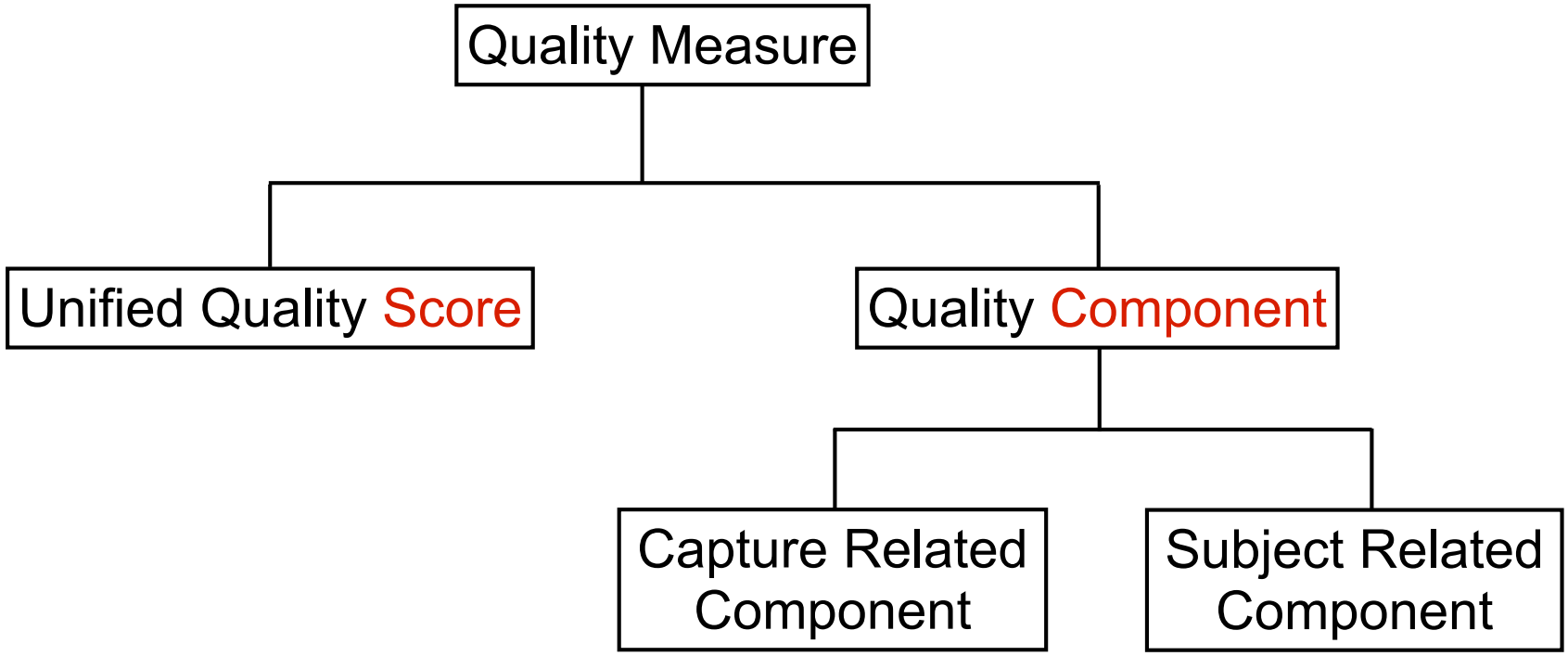
Standards to test Sample Quality

Relevant international standards

- ISO/IEC 29794-1:2024 Quality Framework
  - definitions and evaluation concepts
    https://www.iso.org/standard/79519.html
- ISO/IEC 29794-4:2024 Finger image quality
  - based on reference implementation NFIQ2.2
  - https://github.com/usnistgov/NFIQ2
  - https://www.iso.org/standard/62791.html
- ISO/IEC 29794-5:2024 Face image quality
  - based on reference implementation OFIQ
  - https://github.com/BSI-OFIQ/OFIQ-Project
  - https://www.iso.org/standard/81005.html
- ISO/IEC 29794-6:2015 Iris image quality
  - https://www.iso.org/standard/54066.html

Quality Algorithms - Standards

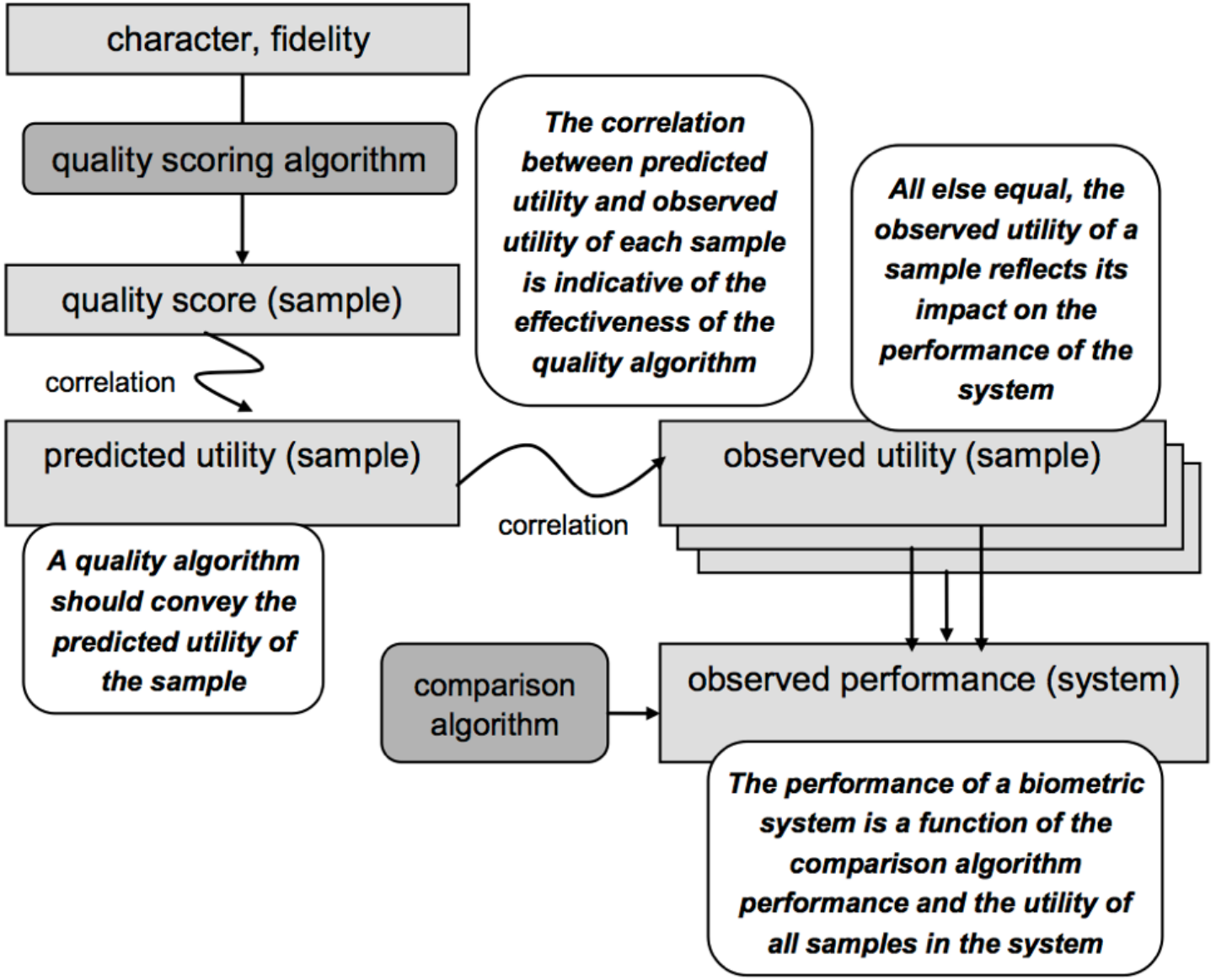
Quality assessment algorithms



- Quality measures in the range of 0 to 100
- Quality scores: higher is better

Quality Algorithms - Standards

Relationship between quality and system performance

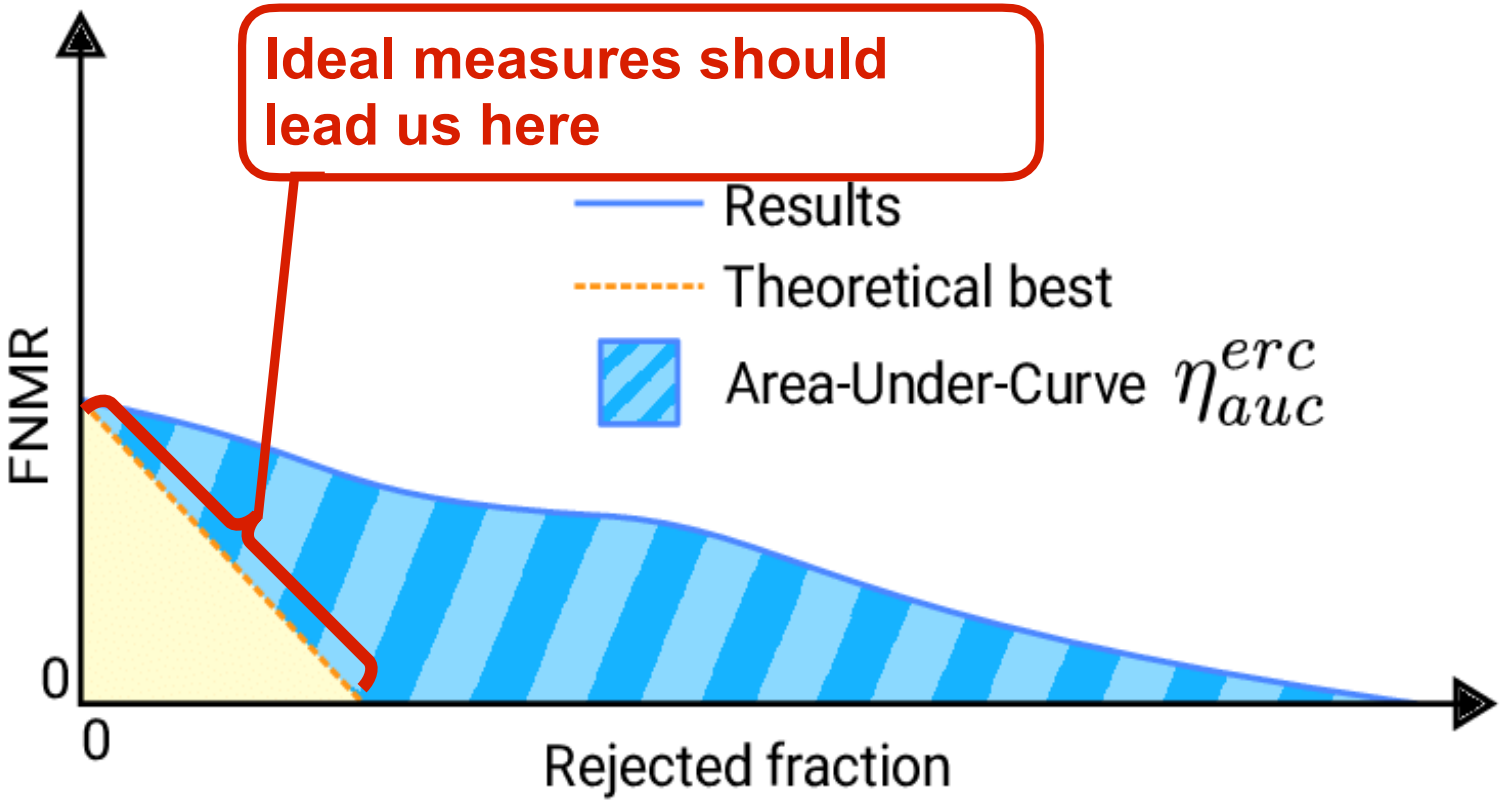


Source: ISO/IEC 29794-1

Evaluation of Predictability

Error versus reject/Discard Characteristic curve (EDC)

- Stronger decrease of the EDC curve indicates a better prediction, meaning really the poorest samples are out



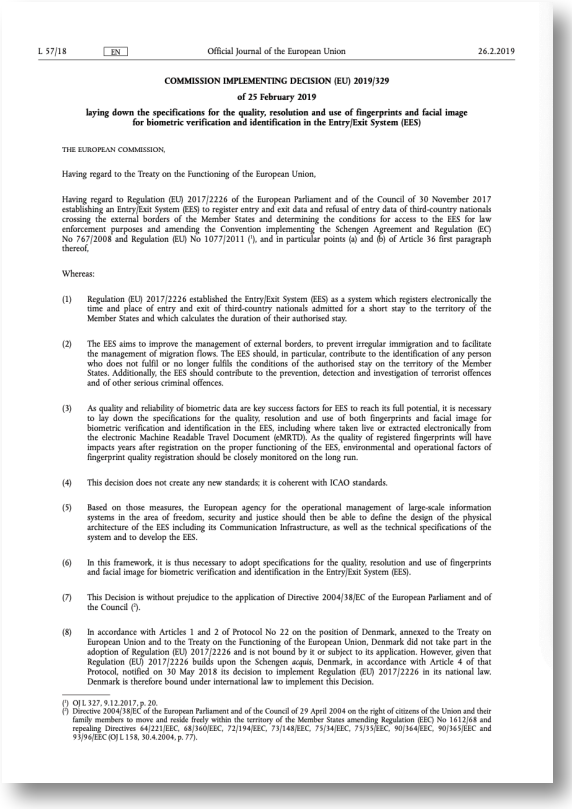
[Schlett2023] T. Schlett, C. Rathgeb, J. Tapia, C. Busch: "Considerations on the Evaluation of Biometric Quality Assessment Algorithms", in IEEE Transactions on Biometrics, Behavior, and Identity Science (TBIOM), (2023)

Quality Measures for Fingerprint Images

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 57/18 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 Regulation (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 standards; 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).

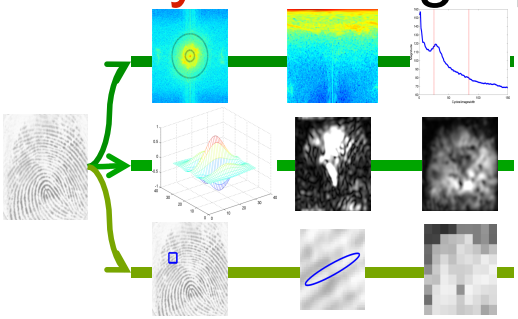
(8) In accordance with Articles 1 and 2 of Protocol No 22 on the position of Denmark, annexed to the Treaty on European Union and to the Treaty on the Functioning of the European Union, Denmark did not take part in the adoption of Regulation (EU) 2017/2226 and is not bound by it or subject to its application. 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 in 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).

Quality Measures for Fingerprint Images

The NFIQ2 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

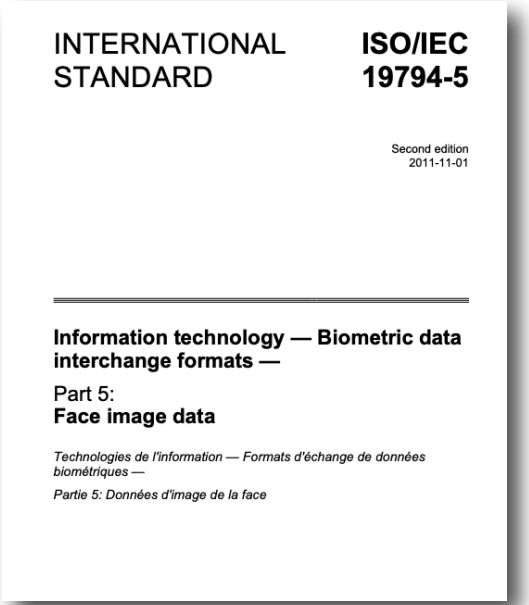
http://www.christoph-busch.de/projects-nfiq2.html

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

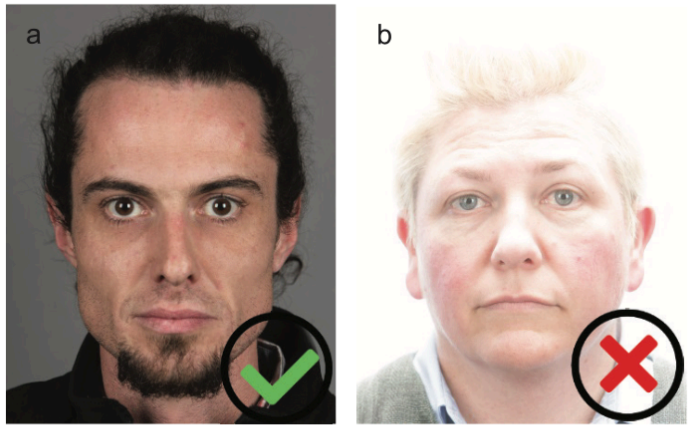
ISO/IEC 29794-5: Face Image Quality

ISO/IEC 29794-5 is aligned with both

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

Measures

- 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

Image Source: ISO/IEC 19794-5:2011

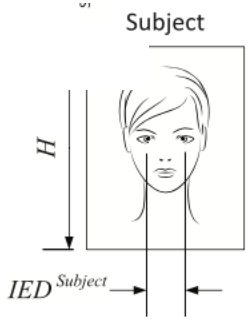


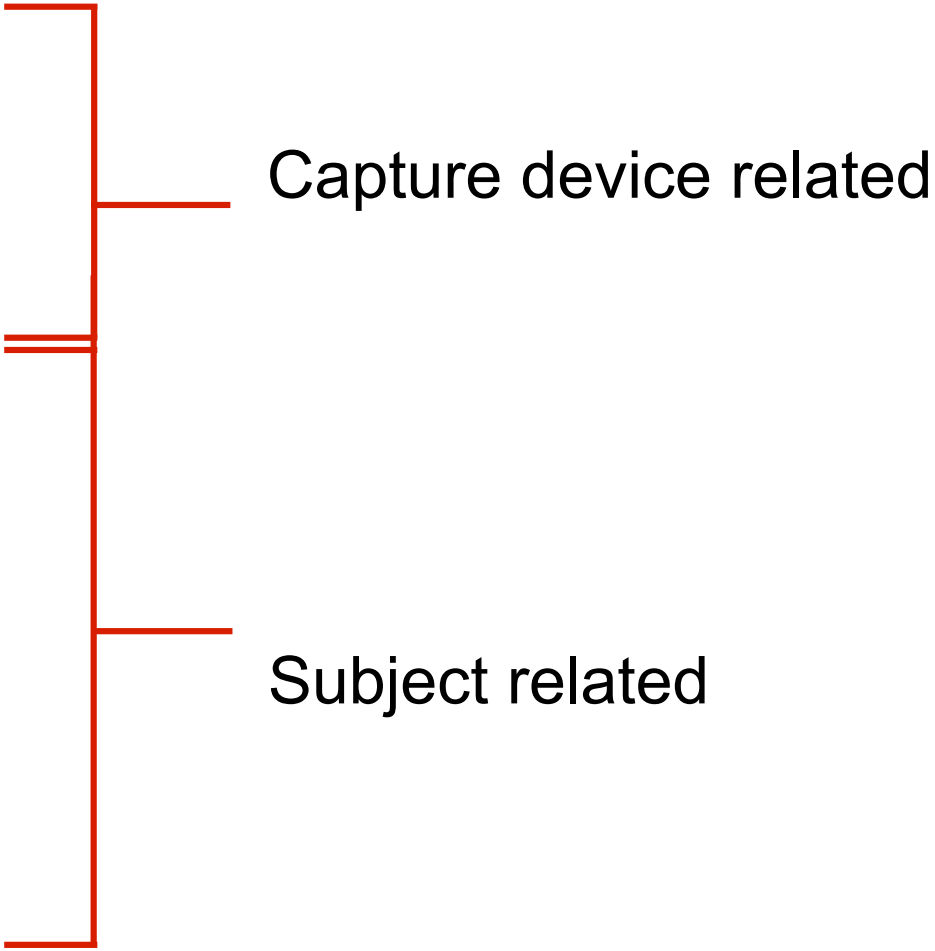
Image Source: ISO/IEC 39794-5

- The components constitute a quality vector and quantitative ICAO compliance checklist

ISO/IEC IS 29794-5: Face Image Quality

ISO/IEC DIS 29794-5 quality measures in detail

#	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)

Quality Measures for Facial Images

How to find the best face quality measures?

- Testing

Patrick Grother
Mei Ngan
Joyce Yang

Category	ISO/IEC 29794-5 Quality Check	SIDD Quality Component
Capture device-related	6.3.2 Background uniformity	Background uniformity
	6.3.3 Illumination uniformity	-
	6.3.4 Moments of the luminance distribution	-
	6.3.5 Under-exposure	Under-exposure
	6.3.6 Over-exposure	Over-exposure
	6.3.7 Dynamic range	-
	6.3.8 De-focus	Resolution
	6.3.9 Motion blur	Motion blur
	6.3.10 Compression ratio	Compression artifacts
	6.3.11 Unnatural color	-
	6.3.12 Radial distortion	-
	6.3.13 Pixel aspect ratio	-
	6.3.14 Camera to subject distance	-
Subject-related	6.4.2 Single face present	Face count
	6.4.3 Eyes visible	Sunglasses + eyeglasses
	6.4.4 Eyes open	Eyes open
	6.4.5 Mouth occlusion	Face occlusion
	6.4.6 Mouth closed	Mouth open
	6.4.7 Nose occlusion	Face occlusion
	6.4.8 Inter-eye distance	Spatial sampling rate
	6.4.9 Horizontal position of the face	Face cropping and margin
	6.4.10 Vertical position of the face	Face cropping and margin
	6.4.11 Pose	Pose
	6.4.12 Shoulder presentation	-
	6.4.13 Expression neutrality	-

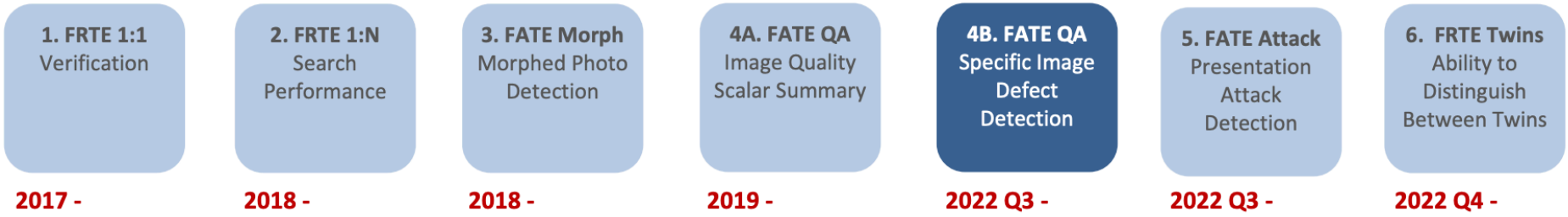
Patrick Grother
Benjamin Tams
Johannes Merkle
Christoph Busch

- FATE Quality - Unified Quality Score

  https://pages.nist.gov/frvt/html/frvt_quality.html

- FATE Quality - Specific Image Defect Detection (SIDD)

  https://pages.nist.gov/frvt/reports/quality_sidd/frvt_quality_sidd_report.pdf



OFIQ - Unified Quality Score

General, holistic quality score

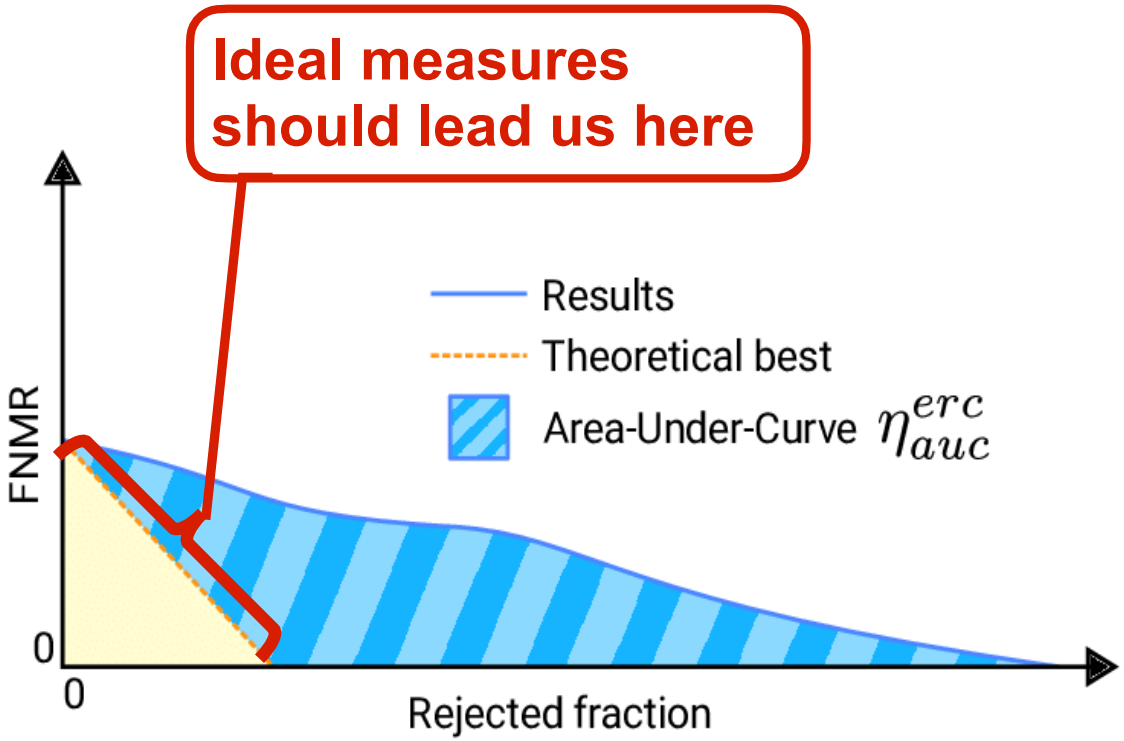
- Not limited to certain quality criteria / defects
- CNN MagFace (iResNet 50 model)
- Shows good prediction of face recognition scores
  - nigher numbers indicate better quality

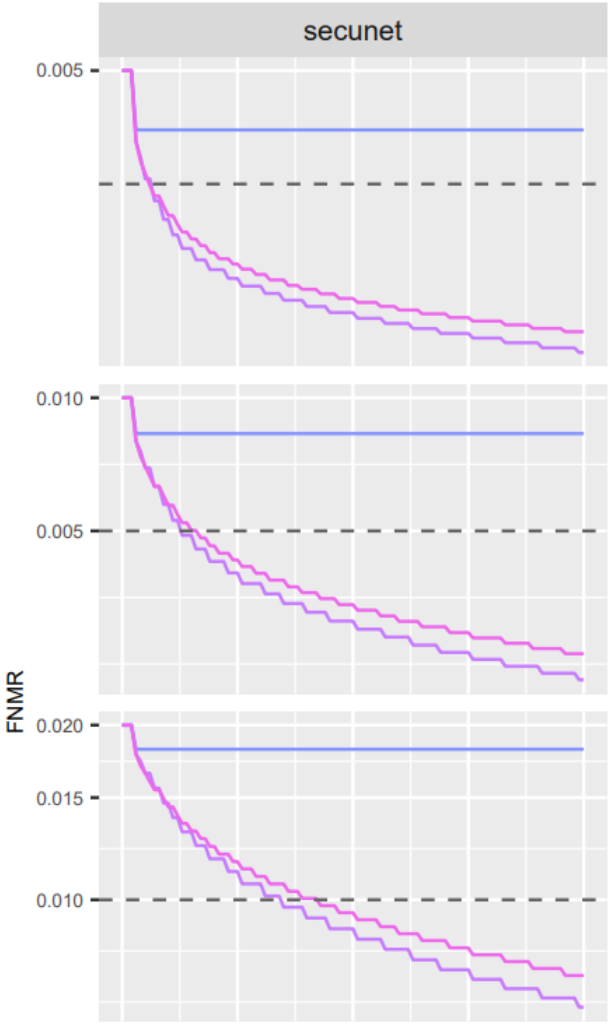
QS = 73	QS = 67	QS = 33	QS = 21

OFIQ - Unified Quality Score

Excellent results in FATE SIDD (1st of 16)

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

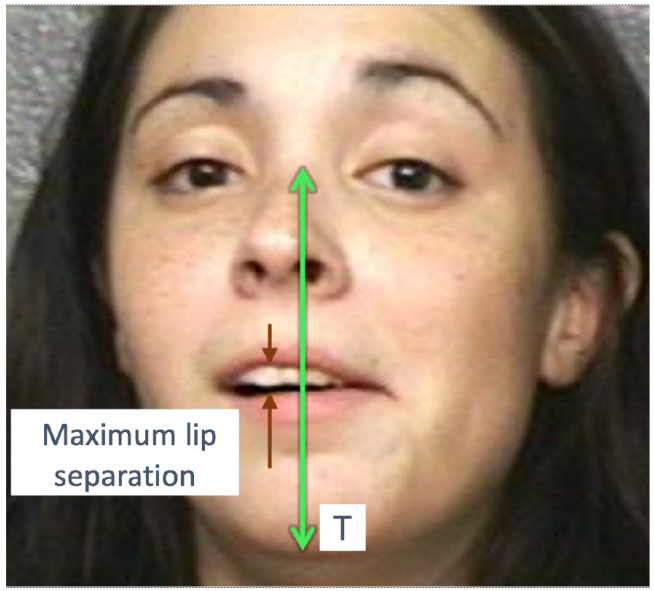




OFIQ - Quality Components

Eyes Open and Mouth Closed

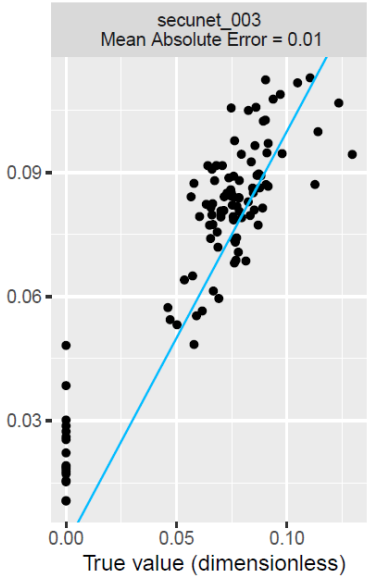
- Algorithms based on landmarks
- Maximum distance between lids / lips
- Normalized by distance T between eye‘s midpoint and chin

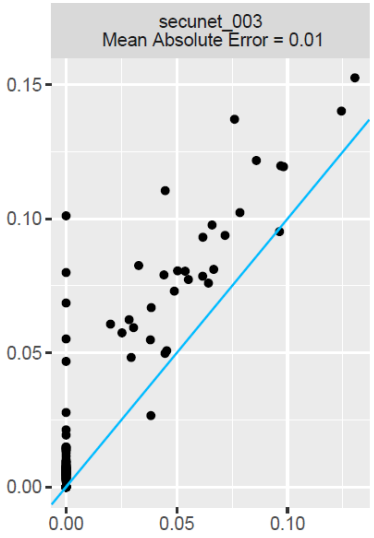


OFIQ - Quality Components

Eyes Open and Mouth Closed

- Excellent results in NIST FATE SIDD
- 1st of 6 and 1st of 5
- No ethnic bias found for Eyes Open





Face 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)

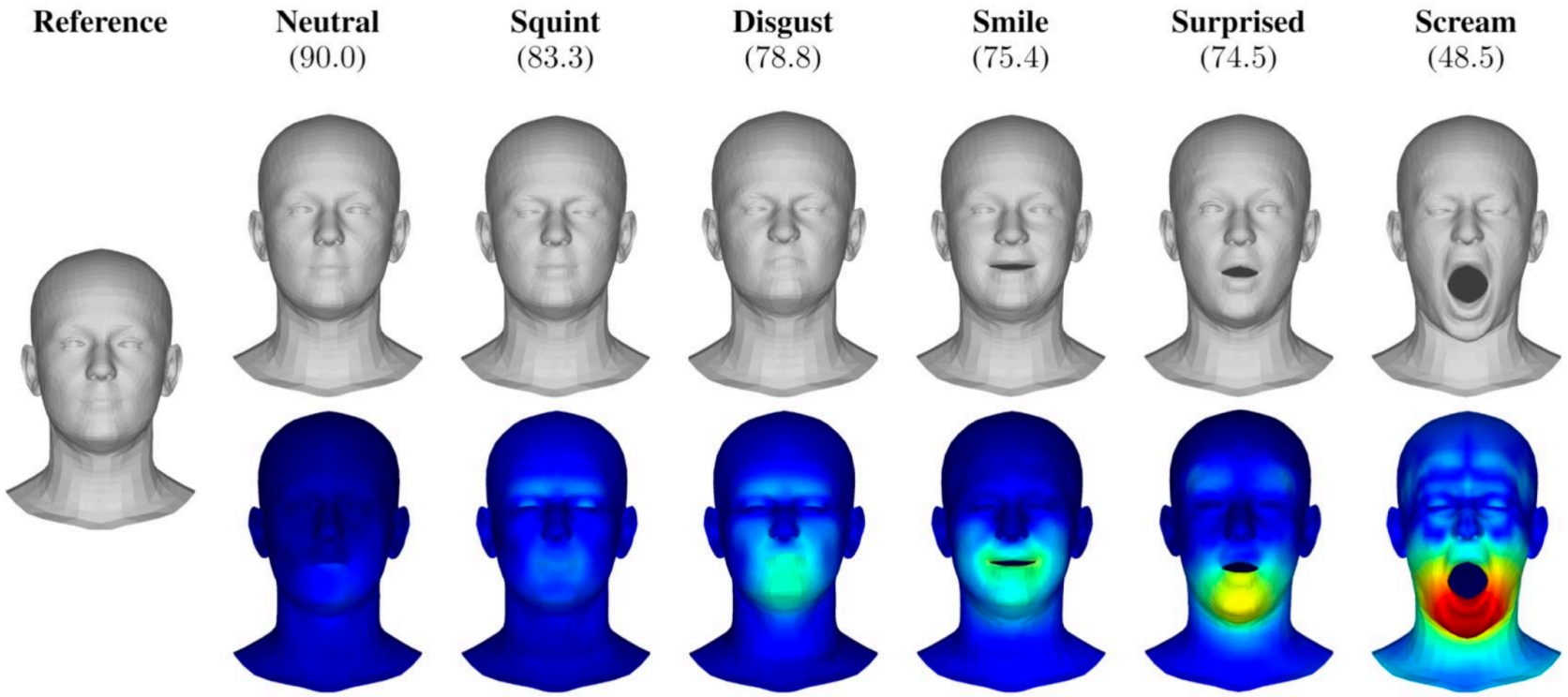
[GVB2024] M. Grimmer, R. Veldhuis, C. Busch: “Efficient Expression Neutrality Estimation with Application to Face Recognition Utility Prediction”, in Proceedings of 12th International Workshop on Biometrics and Forensics (IWBF 2024)

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]

Explainabilitv



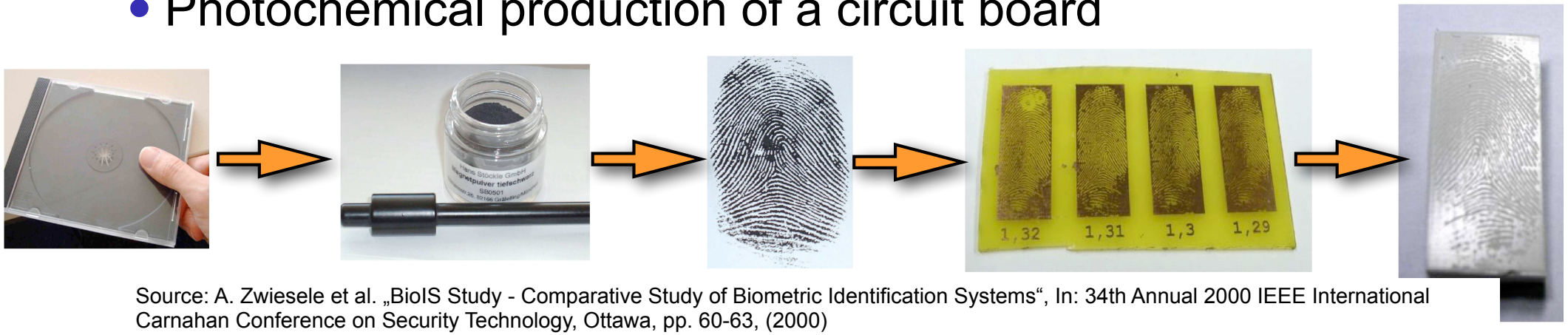
Presentation Attacks - PAD

Fingerprint Presentation Attacks

Attack without support of an enrolled individual

1999

- Recording of an analog fingerprint from flat surface material
  - z.B. glass, CD-cover, etc.
    with iron powder and tape
- Scanning and post processing:
  - Correction of scanning errors
  - Closing of ridge lines (as needed)
  - Image inversion
- Print on transparent slide
- Photochemical production of a circuit board



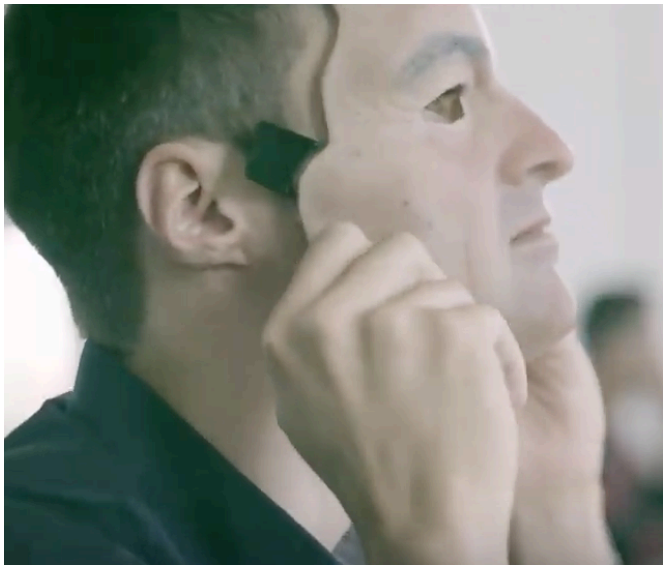
Source: A. Zwiesele et al. „BioIS Study - Comparative Study of Biometric Identification Systems“, In: 34th Annual 2000 IEEE International Carnahan Conference on Security Technology, Ottawa, pp. 60-63, (2000)

Face Presentation Attacks

2018

3D silicone mask

- Targeted attack with 3D silicone custom mask
- Cost more than 3000 USD

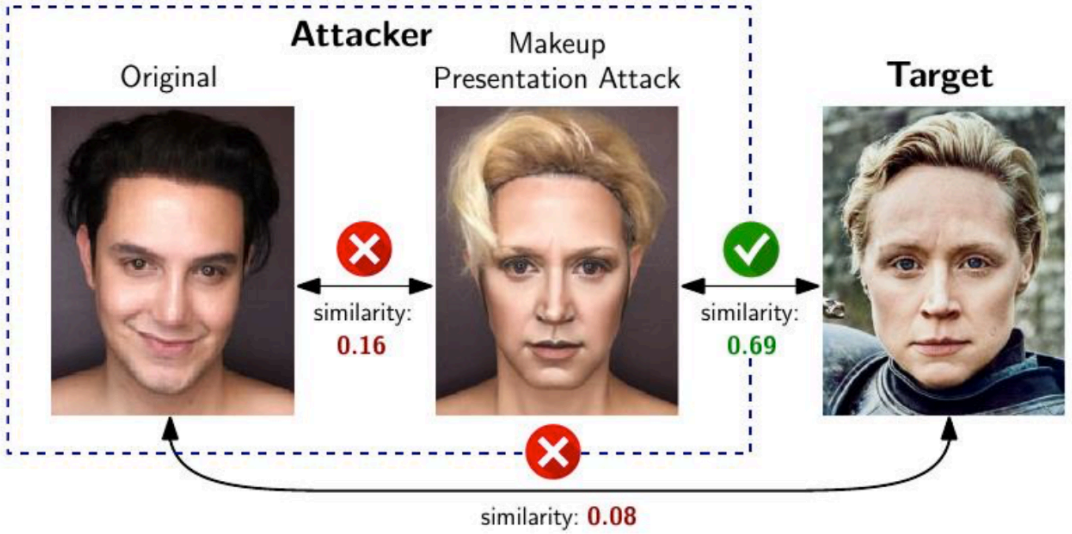


Face Presentation Attacks

Changing facial appearance by makeup alterations 2020

- Makeup for impersonation
- Liveness detection is not sufficient
- Detection difficult since bona fide users may also apply makeup

(a) Before (b) After (c) Target



[RDB2020] C. Rathgeb, P. Drozdowski, C. Busch: "Detection of Makeup Presentation Attacks based on Deep Face Representations“, in Proceedings of 25th International Conference on Pattern Recognition (ICPR), (2020)

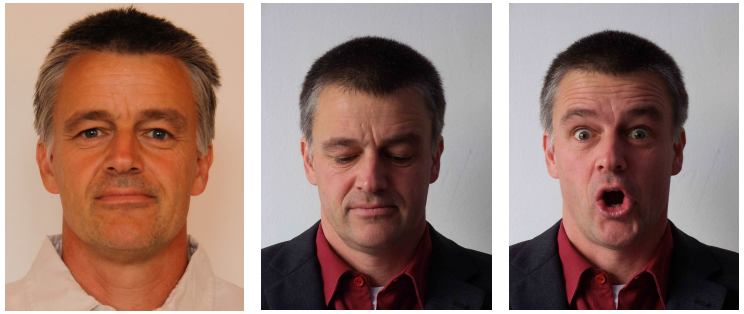
Categories of Presentation Attacks

Impostor

- impersonation attack
  - positive access 1:1 (two factor application)
  - positive access 1:N (single factor application)
- finding a look-a-like
- making appearance similar to the reference
- artefact presentation

Concealer

- evasion from recognition
  - negative 1:N identification (watchlist application)
- depart from standard pose



- evade face detection

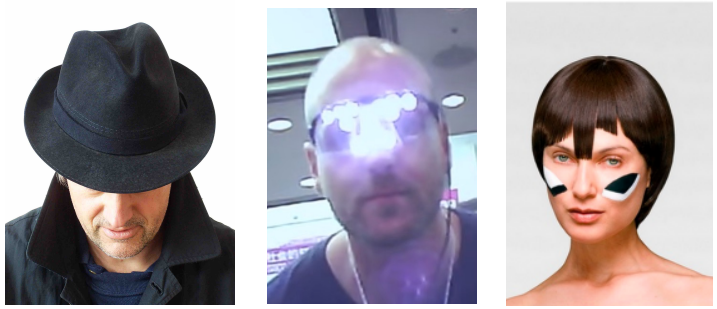


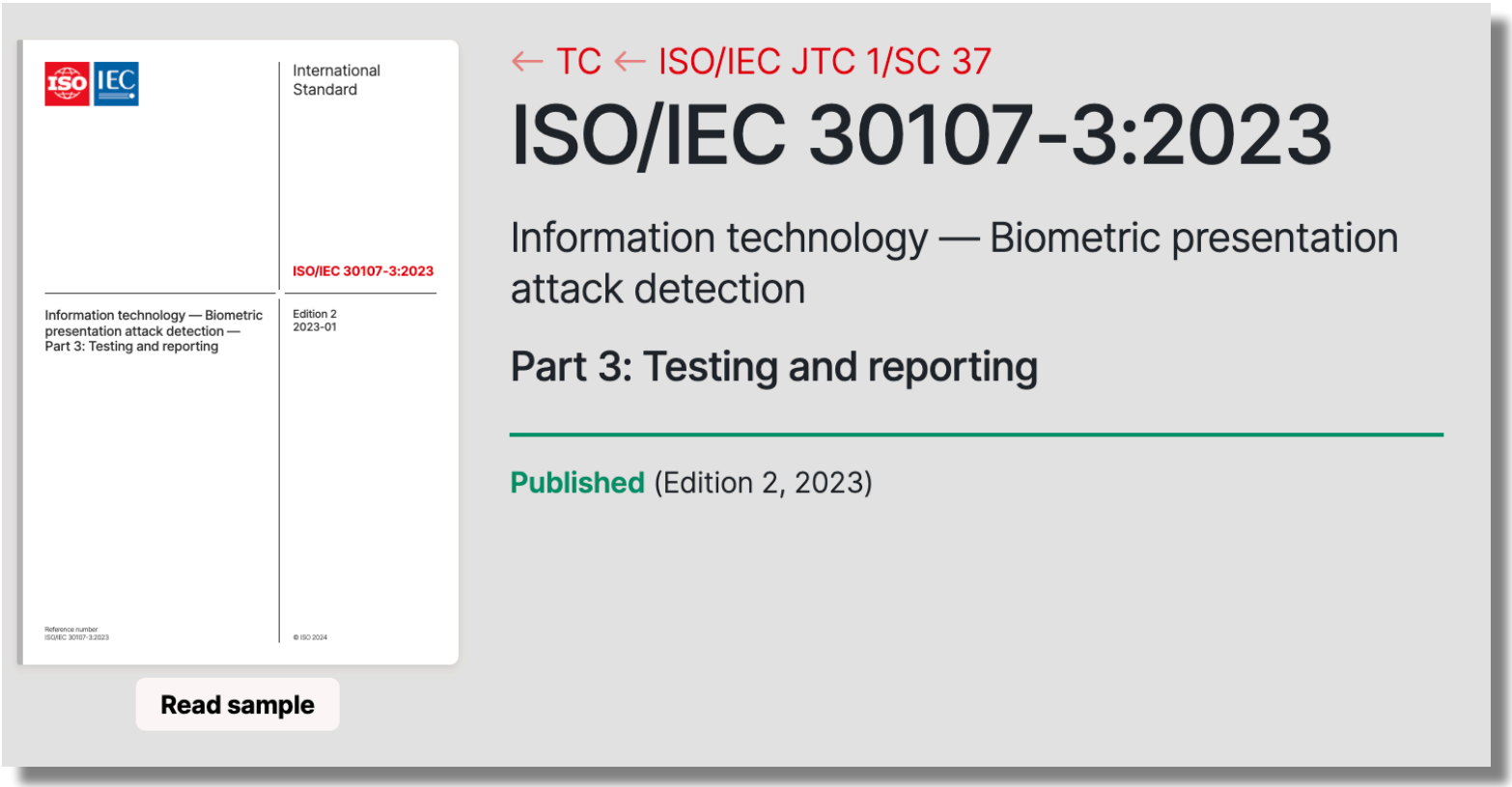
Image Source: https://www.youtube.com/watch?v=LRj8whKmN1M

Image Source: https://cvdazzle.com

Presentation Attack Detection - Testing

ISO/IEC 30107-3:2023

- Provides the testing methodology



Read the sample text:
https://www.iso.org/obp/ui/en/#iso:std:iso-iec:30107:-3:ed-2:v1:en

Presentation Attack Detection - Testing

Definition of detection capabilities metrics

- Testing the PAD subsystem with false-negative and false-positive errors:

- **attack presentation classification error rate (APCER)** *proportion of attack presentations using the same PAI species incorrectly classified as bona fide presentations in a specific scenario*

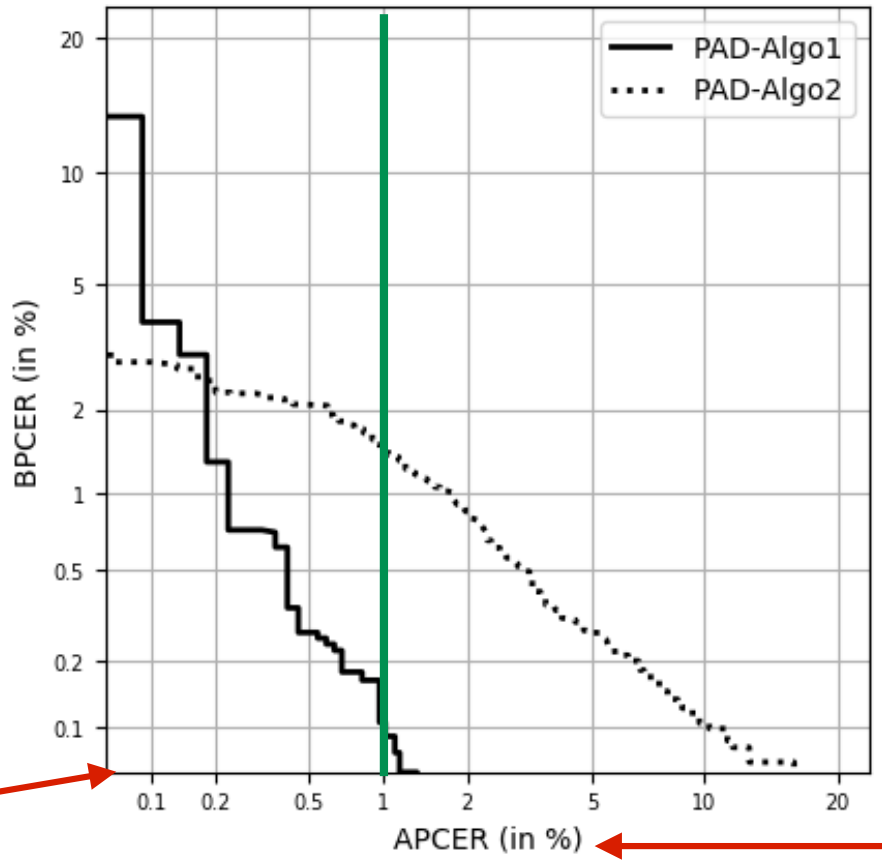
- **bona fide presentation classification error rate (BPCER)** *proportion of bona fide presentations incorrectly classified as attack presentations in a specific scenario*

Source: ISO/IEC 30107-3

Presentation Attack Detection - Testing

Definition of PAD metrics in ISO/IEC 30107-3

- DET curve reports operating points for various thresholds showing security measures versus convenience measures
- Example:



convenience measure

Ideal:
APCER - low
BPCER - low

security measure (strength of function)

Presentation Attack Detection - Testing

New definition in the revised ISO/IEC 30107-3:2023

- Relationship between vulnerability and recognition performance
- System testing!
- ~~Impostor attack presentation match rate (IAPMR)~~
- **Impostor attack presentation accept rate (IAPAR)**
  in a full-system evaluation of a verification system, proportion of impostor attack presentations using the same presentation attack instrument (PAI) species that result in accept

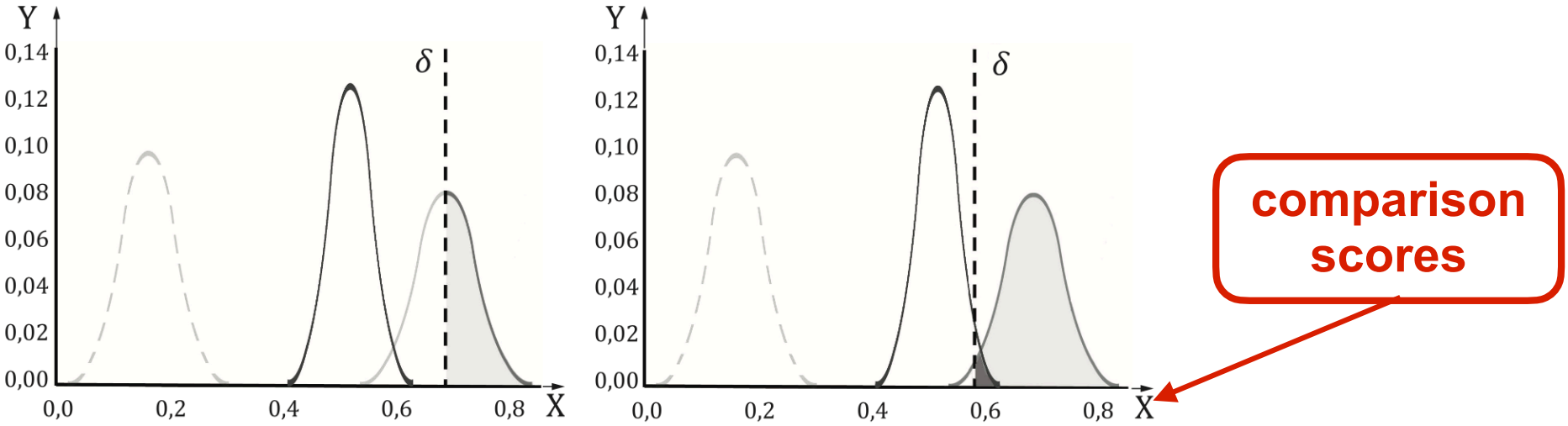
Source: ISO/IEC 30107-3:2023

Presentation Attack Detection - Testing

New definition in the revised ISO/IEC 30107-3

- Relationship between vulnerability and recognition performance
- **Relative imposter presentation accept rate (RIAPAR)**
  sum of IAPAR and FRR at a fixed decision threshold

$$RIAPAR(\tau) = IAPAR(\tau) + FRR(\tau)$$



a) Decision threshold with suboptimal RIAPAR

b) Decision threshold with optimized RIAPAR

Source: ISO/IEC 30107-3:2023

Source: U. Scherhag et al.: "Biometric Systems under Morphing Attacks: Assessment of Morphing Techniques and Vulnerability Reporting", in Proceedings of the IEEE 16th International Conference of the Biometrics Special Interest Group (BIOSIG), Darmstadt, (2017)

Morphing Attacks - MAD

Morphing Attacks

Enrolment attack with morphed facial images

Subject A

Subject A+B

Subject B

Morphing Attacks

Morphing attack scenario

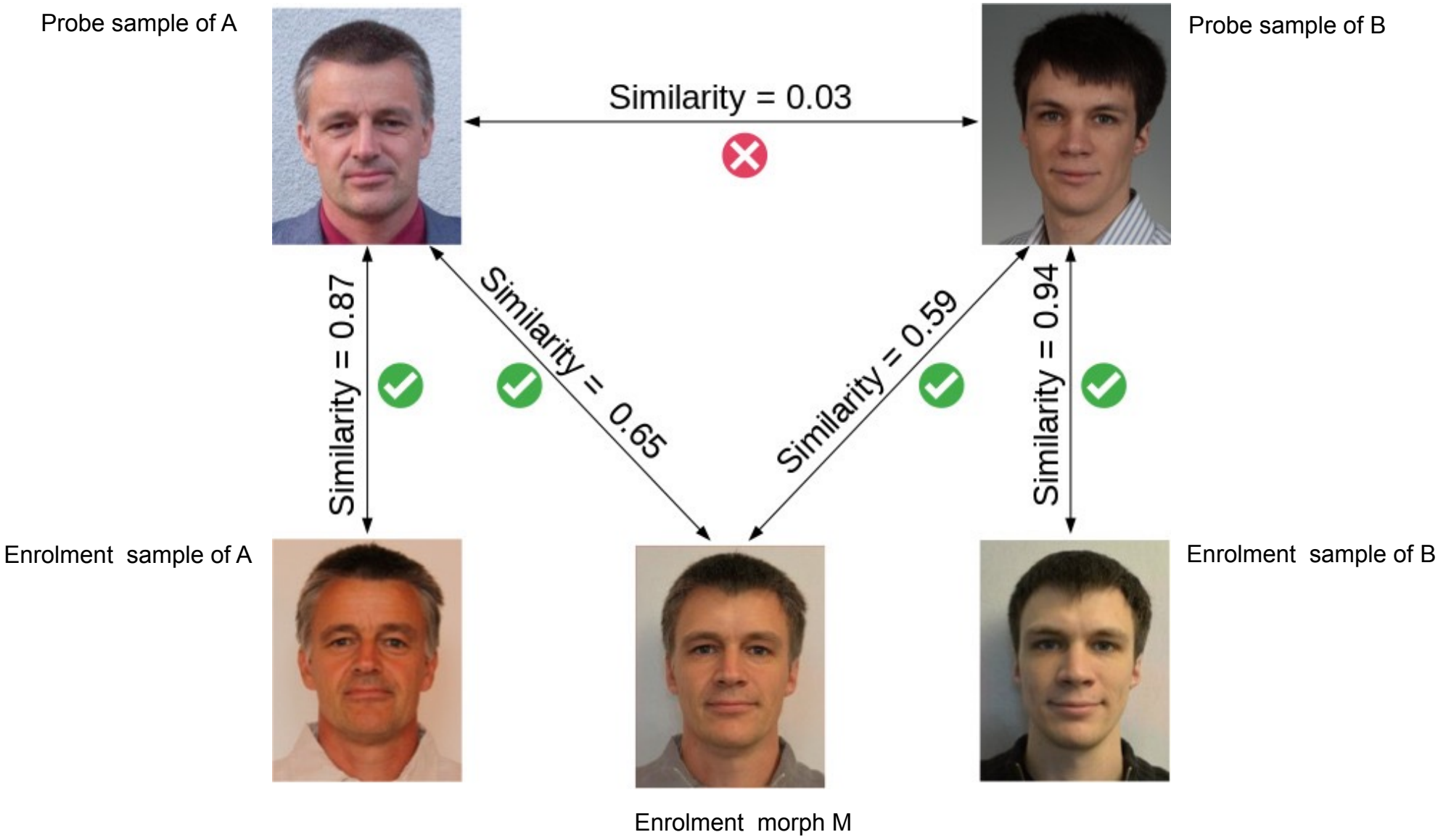
Morphing Attacks

Morphing attack scenario

- Border control

Morphing Attacks

Verification against morphed facial images



Unique Link

Principle of equality - in our society

- One individual - one passport

Principle of unique link of ICAO

- One individual - one passport
- ICAO 9303 part 2, 2006:
  „***Additional security measures:*** *inclusion of a machine verifiable biometric feature linking the document to its legitimate holder*“

image source: https://pixabay.com/de/vectors/tick-sternchen-kreuz-rot-gr%C3%BCn-40678/

Unique Link

Principle of unique link of ICAO

- One individual - one passport

We don’t want this principle of unique link to be broken

- Multiple individuals - one passport

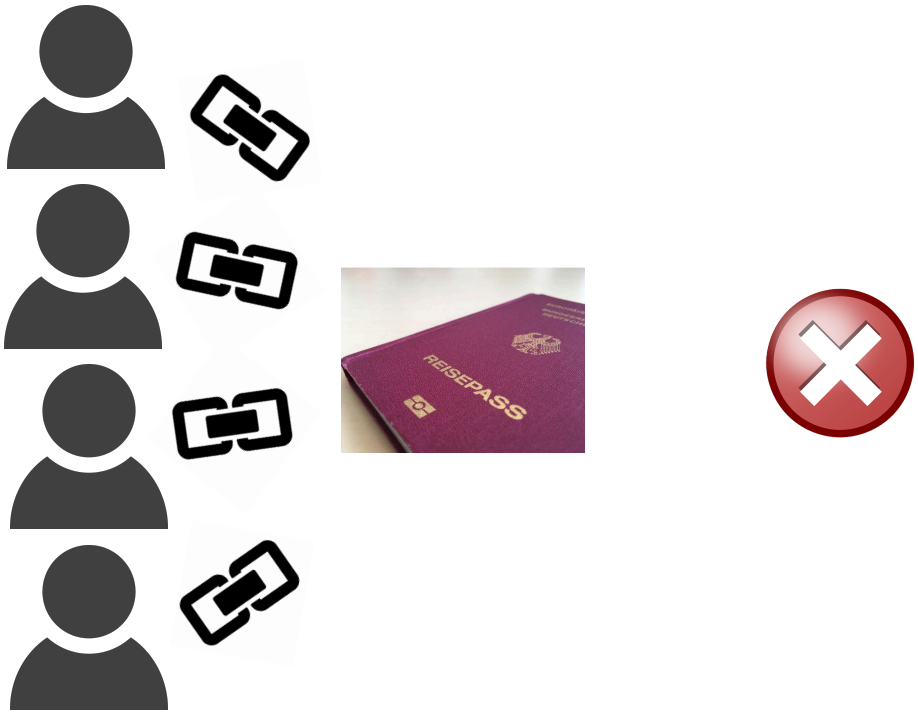
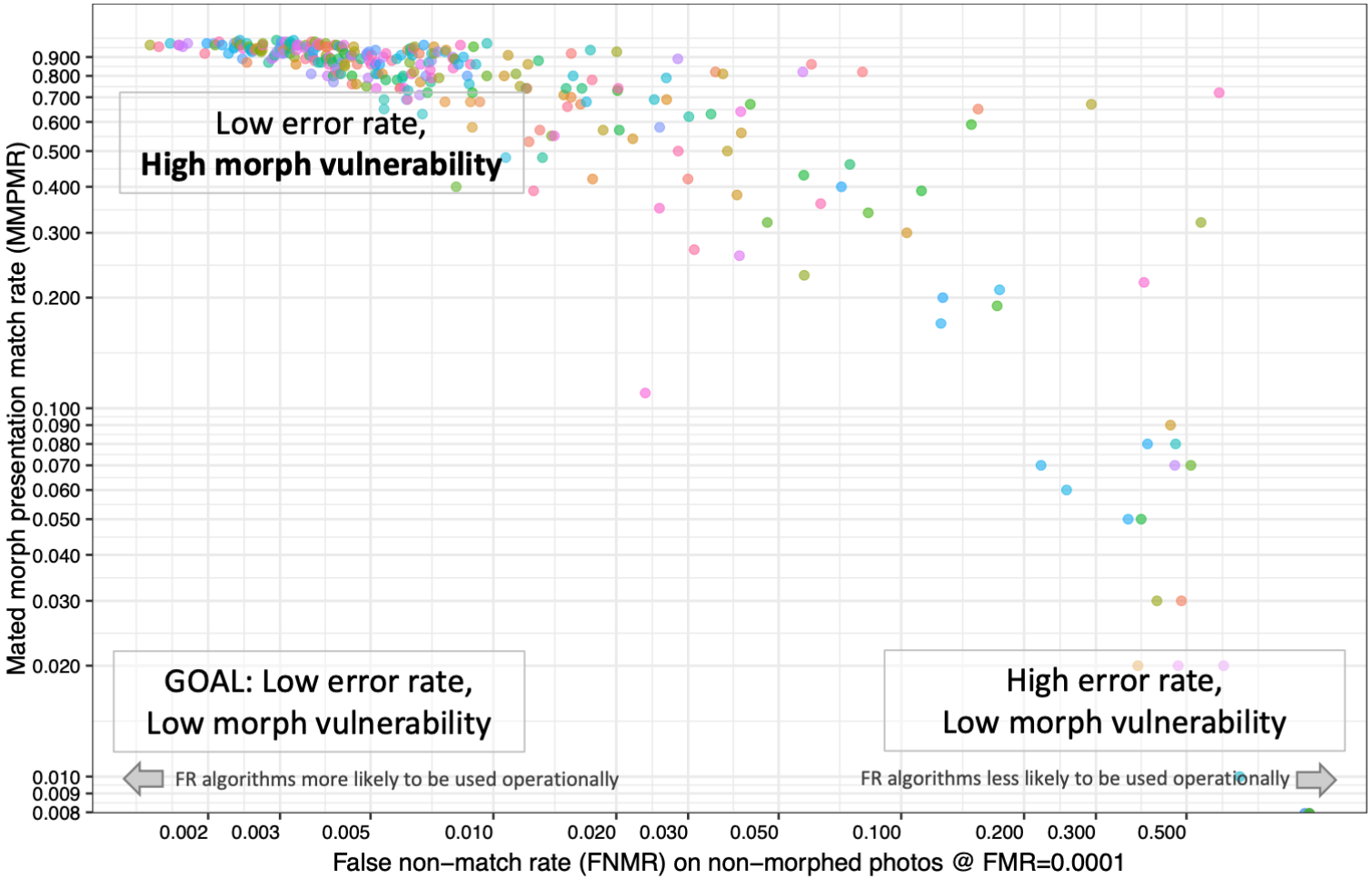


image source: https://pixabay.com/de/vectors/tick-sternchen-kreuz-rot-gr%C3%BCn-40678/

Scale of the Problem: Vulnerability of FRS

NIST IR 8430 report on FRS vulnerability [Ngan2022]

- Accurate FRS are more vulnerable!

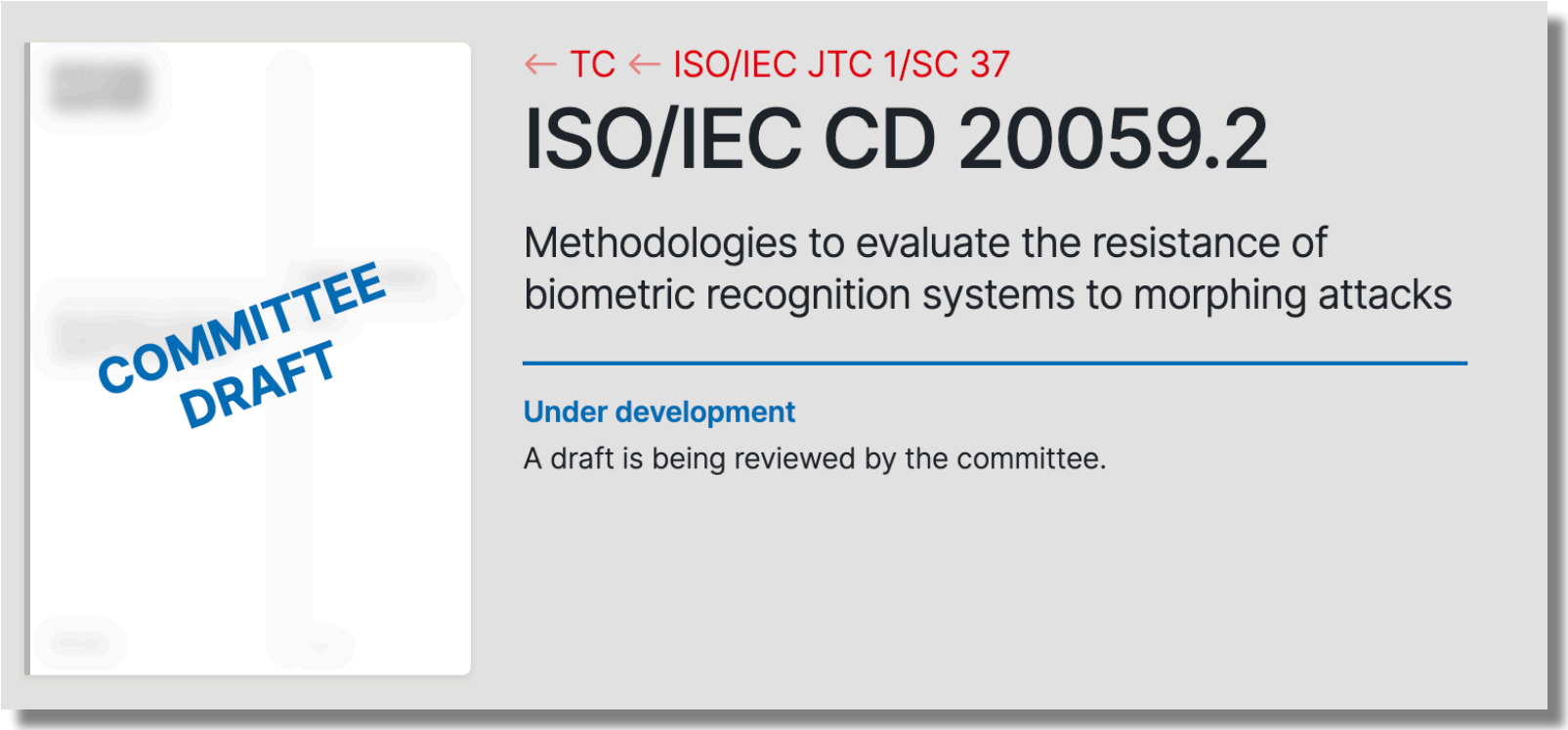


[Ngan2022] NIST IR 8430: "FRVT MORPH: Utility of 1:N Face Recognition Algorithms for Morph Detection“, 2022
https://pages.nist.gov/frvt/reports/morph/frvt_morph_4A_NISTIR_8430.pdf

Morphing Attack - Testing

ISO/IEC 20059

- Will provide the testing methodology



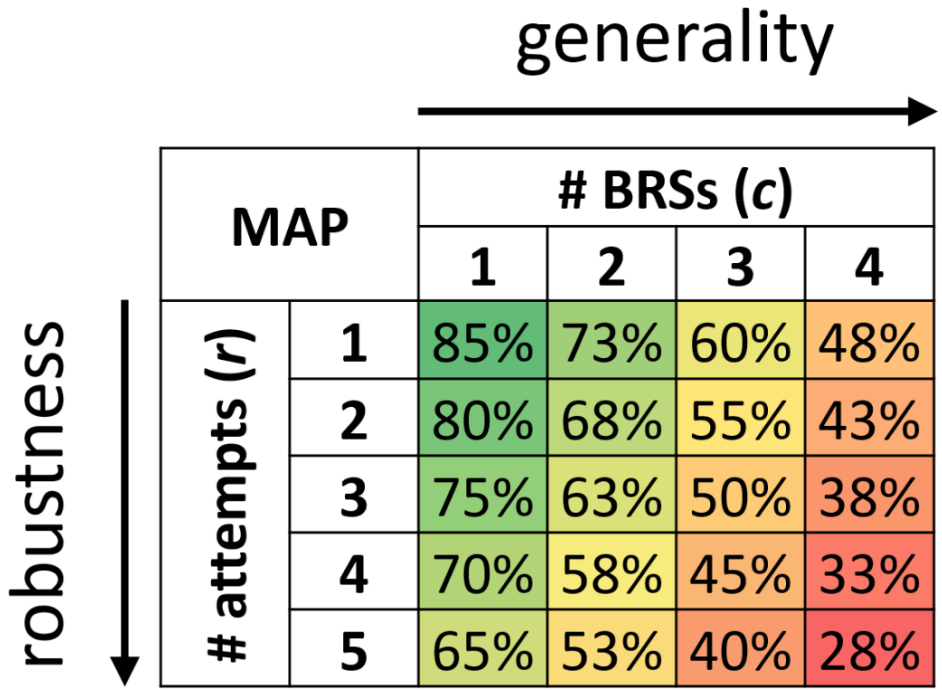
Read the committee draft text:

https://www.iso.org/committee/313770.html?t=JmZzqEdifOdEbu4MS_njlaN-2xjfvCVPgJ4nLW72lTIBGGwuoL_2b-eUixRNm4Nk&view=documents#section-isodocuments-top:~:text=37_N7648_Consultation

Morphing Attack - Testing

ISO/IEC 20059

- Defines the morphing attack potential (MAP)
  „*measure of the capability of a morphing attack to deceive one or more BRSs using multiple recognition attempts*“

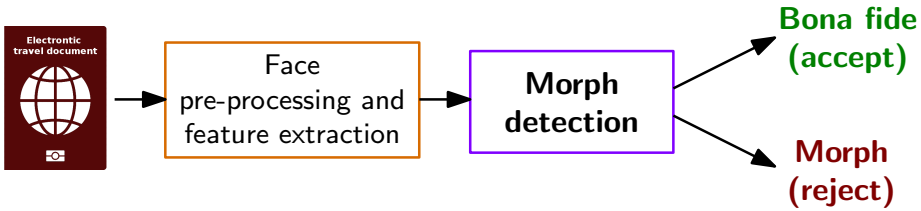


[FFMB2022] M. Ferrara, A. Franco, D. Maltoni, C. Busch: "Morphing Attack Potential", in Proceedings of 10th International Workshop on Biometrics and Forensics (IWBF 2022), Salzburg, AT, April 20-21, (2022)

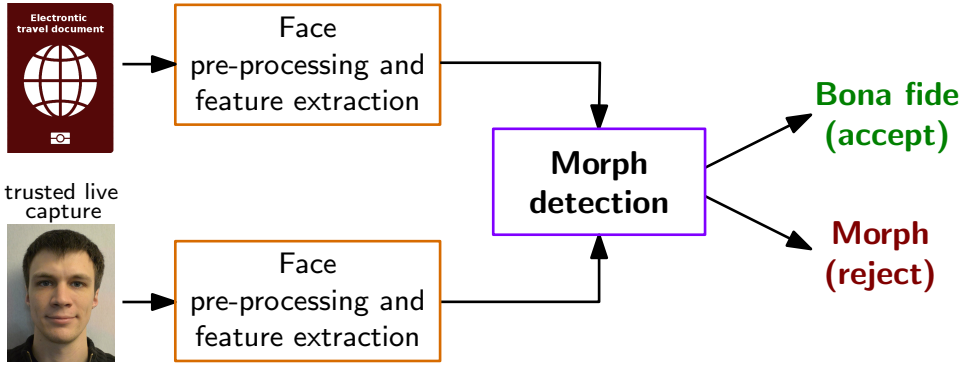
Morphing Attack Detection Scenarios

Real world scenarios

- Single image morphing attack detection (S-MAD)
  - One single facial image is analysed (e.g. in the passport application office)



- Differential morphing attack detection (D-MAD)
  - A pair of images is analysed - and one is a trusted Bona Fide image
  - Biometric verification (e.g. at the border)

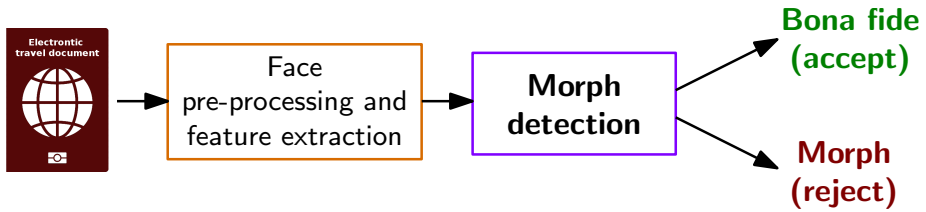


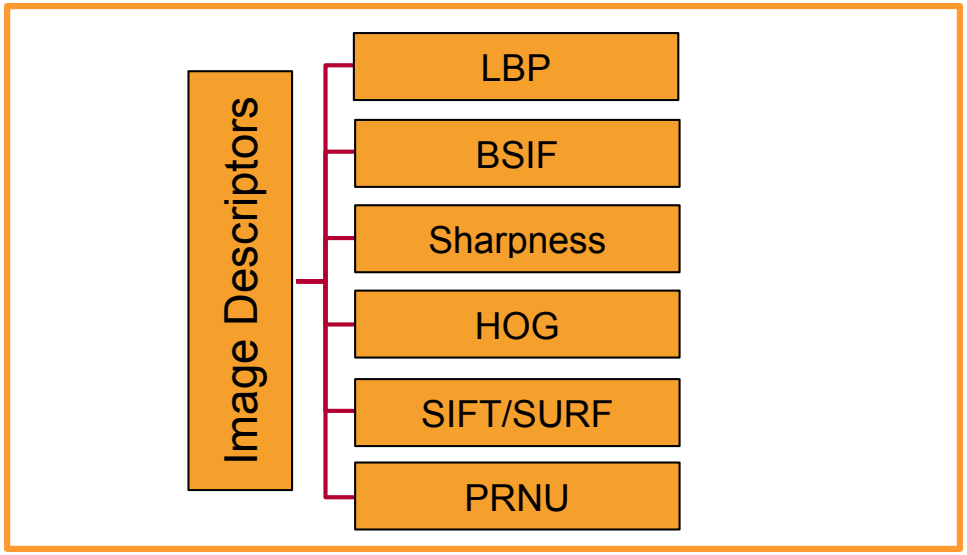
[SRB2018a] U. Scherhag, C. Rathgeb, C. Busch: "Towards Detection of Morphed Face Images in electronic Travel Documents“, in Proceedings of the 13th IAPR International Workshop on Document Analysis Systems (DAS 2018), April 24-27, (2018)

Face Pre-processing and Feature Extraction

Morphing Attack Detection (S-MAD) with texture analysis

- Image descriptors as hand-crafted features





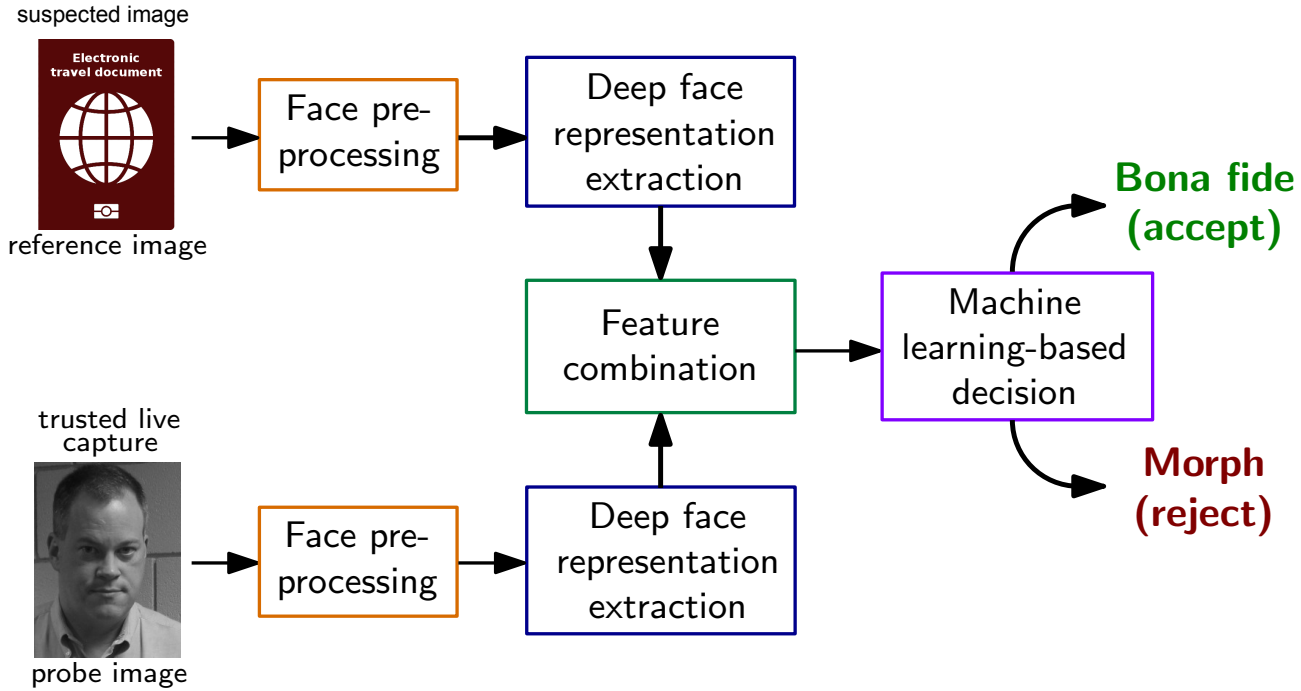
Morph Detection Classifier

[SRB2018b] U. Scherhag, C. Rathgeb, C. Busch: „Detection of Morphed Faces from Single Images: a Multi-Algorithm Fusion Approach“, in Proceedings if of the 2nd International Conference on Biometric Engineering and Applications (ICBEA 2018), Amsterdam, The Netherlands, May 16-18, (2018)

Differential Morphing Attack Detection

D-MAD with deep latent vectors

- Deep Face representations of Deep CNNs



- Deep representations extracted by the neural network (on the lowest layer)
- Feature space with small dimension: 512 (for ArcFace)
- SVM with radial basis function

[SRMB2020] U. Scherhag, C. Rathgeb, J. Merkle, C. Busch: "Deep Face Representations for Differential Morphing Attack Detection", in IEEE Transactions on Information Forensics and Security (TIFS), (2020)

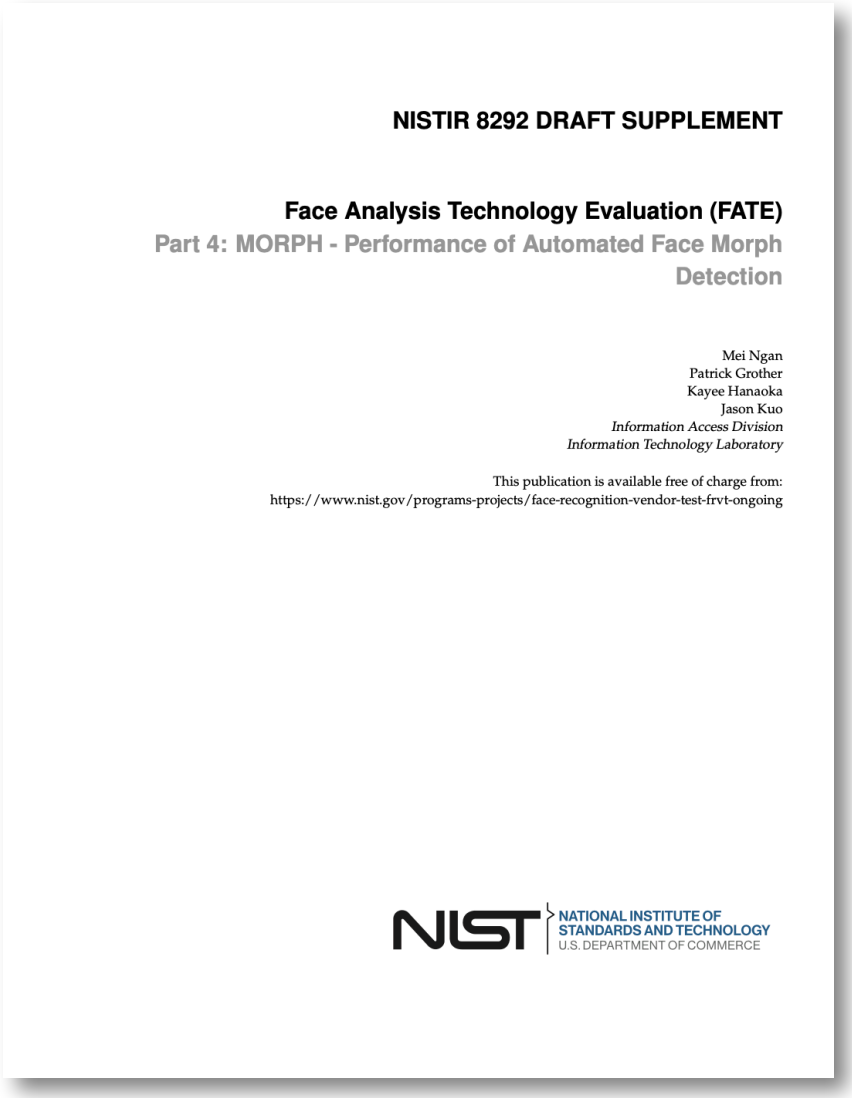
NIST-FATE-MORPH

NIST IR 8292 report presented June, 2024

FATE-MORPH since 2019

https://pages.nist.gov/frvt/html/frvt_morph.html

- Results for MAD algorithms from eleven research labs:
  - University of Bologna (UBO)
  - Norwegian University of Science and Technology (NTNU)
  - Hochschule Darmstadt (HDA)
  - West Virginia University (WVU)
  - Universidade de Coimbra (VIS)
  - Kempelen Institute of Intelligent Technologies
  - Fraunhofer (HHI)
  - Idemia (IDM)
  - secunet (SEC)
  - Neurotechnology (NET)
  - Vision Box (VIS)



NISTIR 8292 DRAFT SUPPLEMENT

Face Analysis Technology Evaluation (FATE)
Part 4: MORPH - Performance of Automated Face Morph Detection

Mei Ngan
Patrick Grother
Kayee Hanaoka
Jason Kuo
Information Access Division
Information Technology Laboratory

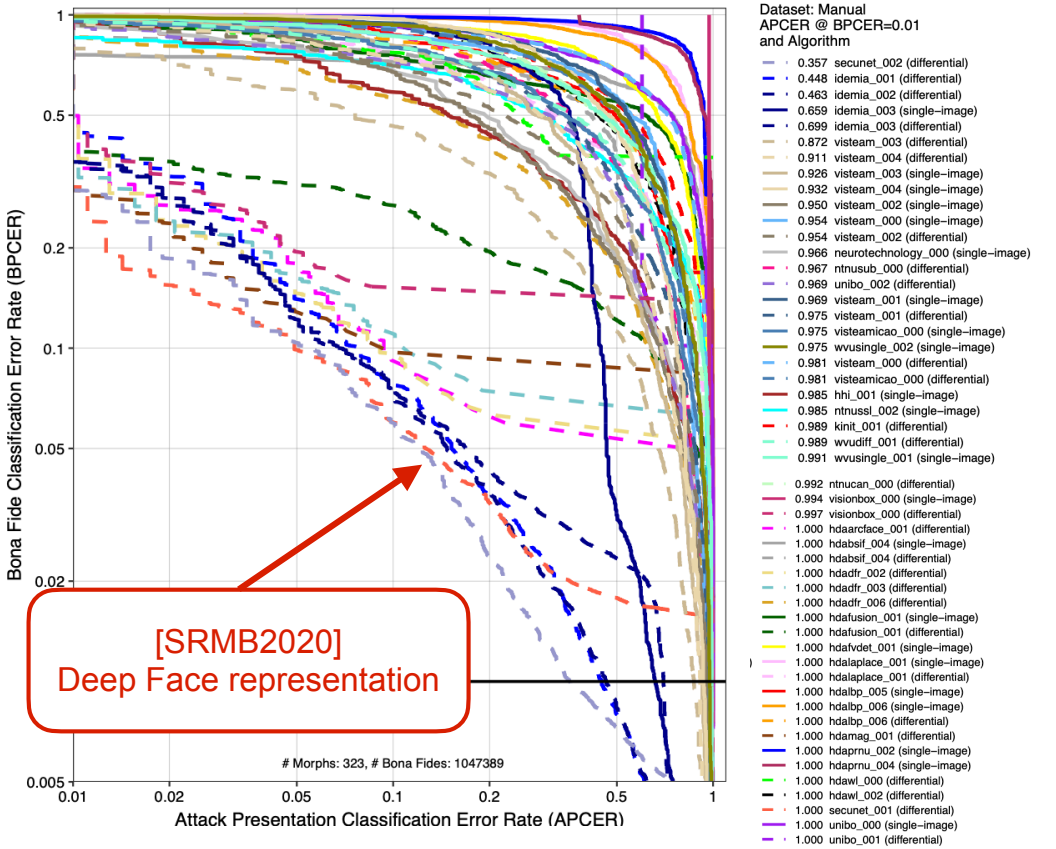
This publication is available free of charge from:
https://www.nist.gov/programs-projects/face-recognition-vendor-test-frvt-ongoing

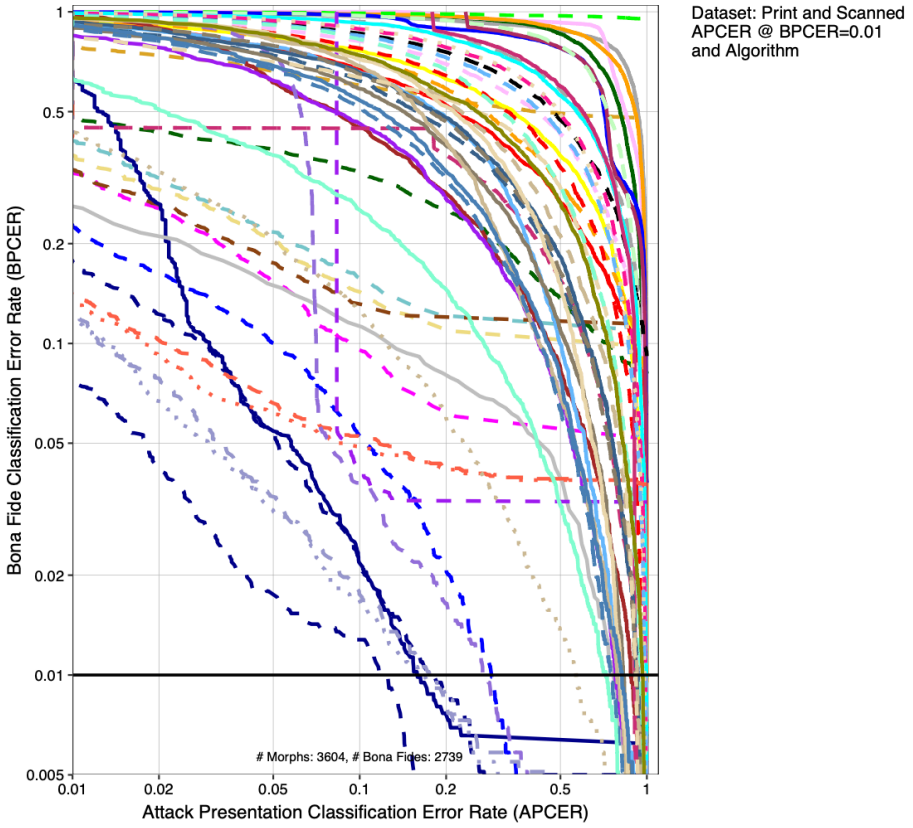
NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY U.S. DEPARTMENT OF COMMERCE

NIST-FRVT-MORPH

NIST IR 8292 report presented June, 2024

- Performance of Automated Face Morph Detection
  https://pages.nist.gov/frvt/reports/morph/frvt_morph_report.pdf
- Results for high quality morphs versus print and scanned
  - note the low number of print and scanned images

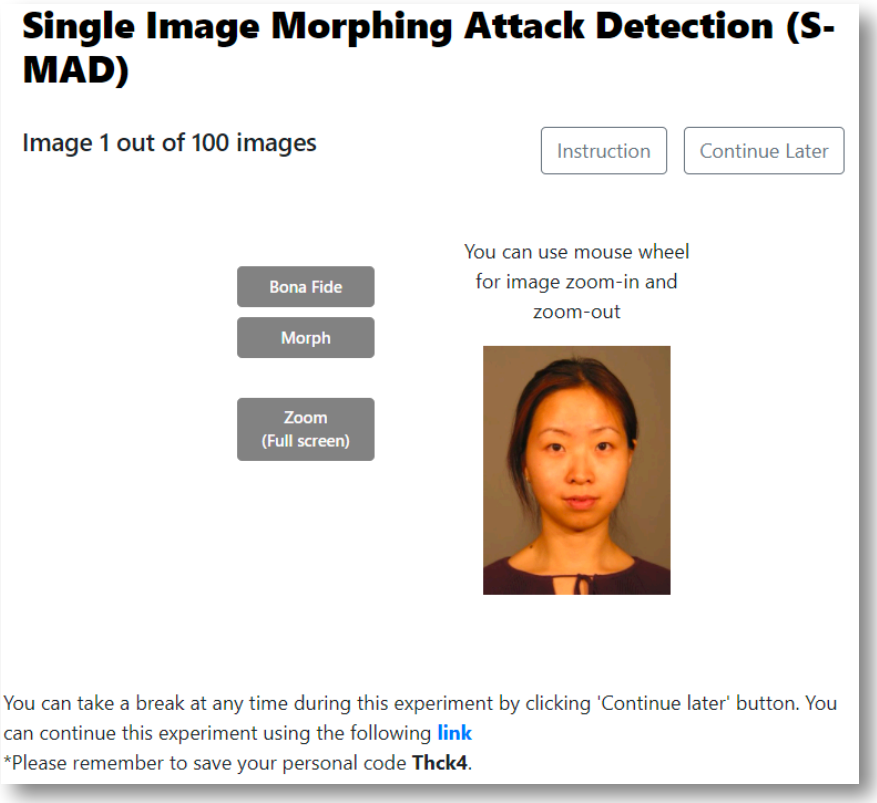


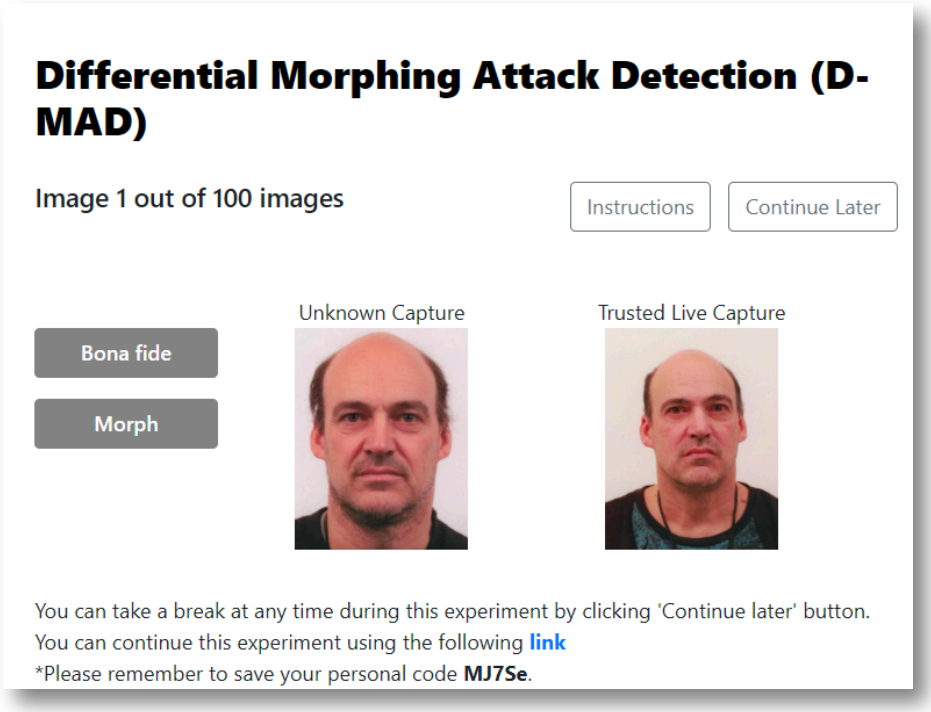


Human Experts in MAD

Border guards, case handlers, document examiners, ID experts

- S-MAD: 410 participants, 180 trials
- D-MAD: 469 participants, 400 trials (4 x 100 tasks)

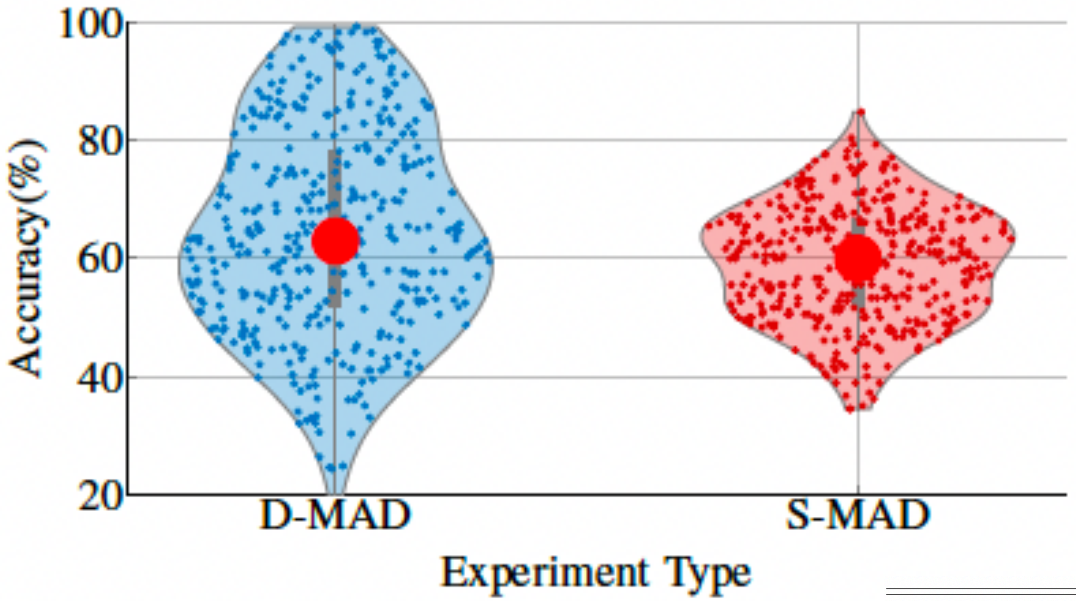




[GOD2022] S. Godage, F. Løvåsdal, S. Venkatesh, K. Raja, R. Raghavendra, C. Busch: “Analyzing Human Observer Ability in Morphing Attack Detection - Where Do We Stand?”, https://arxiv.org/abs/2202.12426

Human Experts in MAD

Overall accuracy



Line of work	D-MAD Number of participants	D-MAD Average Accuracy	S-MAD Number of participants	S-MAD Average Accuracy
Border Guard	30	64.66	26	55.17
Case handler- Passport, visas, ID, etc	150	63.45	137	56.65
Document examiner- 1st line	38	60.79	30	57.63
Document examiner- 2st line	40	68.64	34	62.56
Document examiner- 3rd line	30	65.74	25	61.51
Face comparison expert (Manual examination)	44	72.56	39	64.63
ID Expert	53	63.09	50	57.21
Other	84	64.66	69	55.17
Student	103	56.91	-	-
Total participants	572		410	
Experts	469		410	

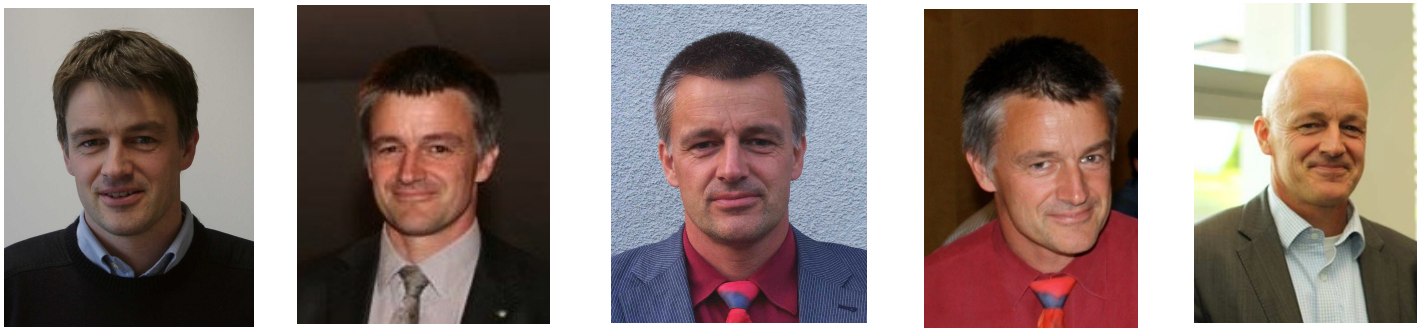
[GOD2022] S. Godage, F. Løvåsdal, S. Venkatesh, K. Raja, R. Raghavendra, C. Busch: “Analyzing Human Observer Ability in Morphing Attack Detection - Where Do We Stand?”, https://arxiv.org/abs/2202.12426

Ageing

Impact of Ageing

Aged reference data can pose a challenge

- For face recognition
  - changing skin properties and facial morphology
  - droopy or baggy eyelid area



2001 2006 2007 2010 2015

- Not for fingerprint recognition

[Kess2021] R. Kessler, O. Henniger, C. Busch: "Fingerprints, forever young?", in Proceedings of 25th International Conference on Pattern Recognition (ICPR), Milan, IT, January 10-15, (2021)

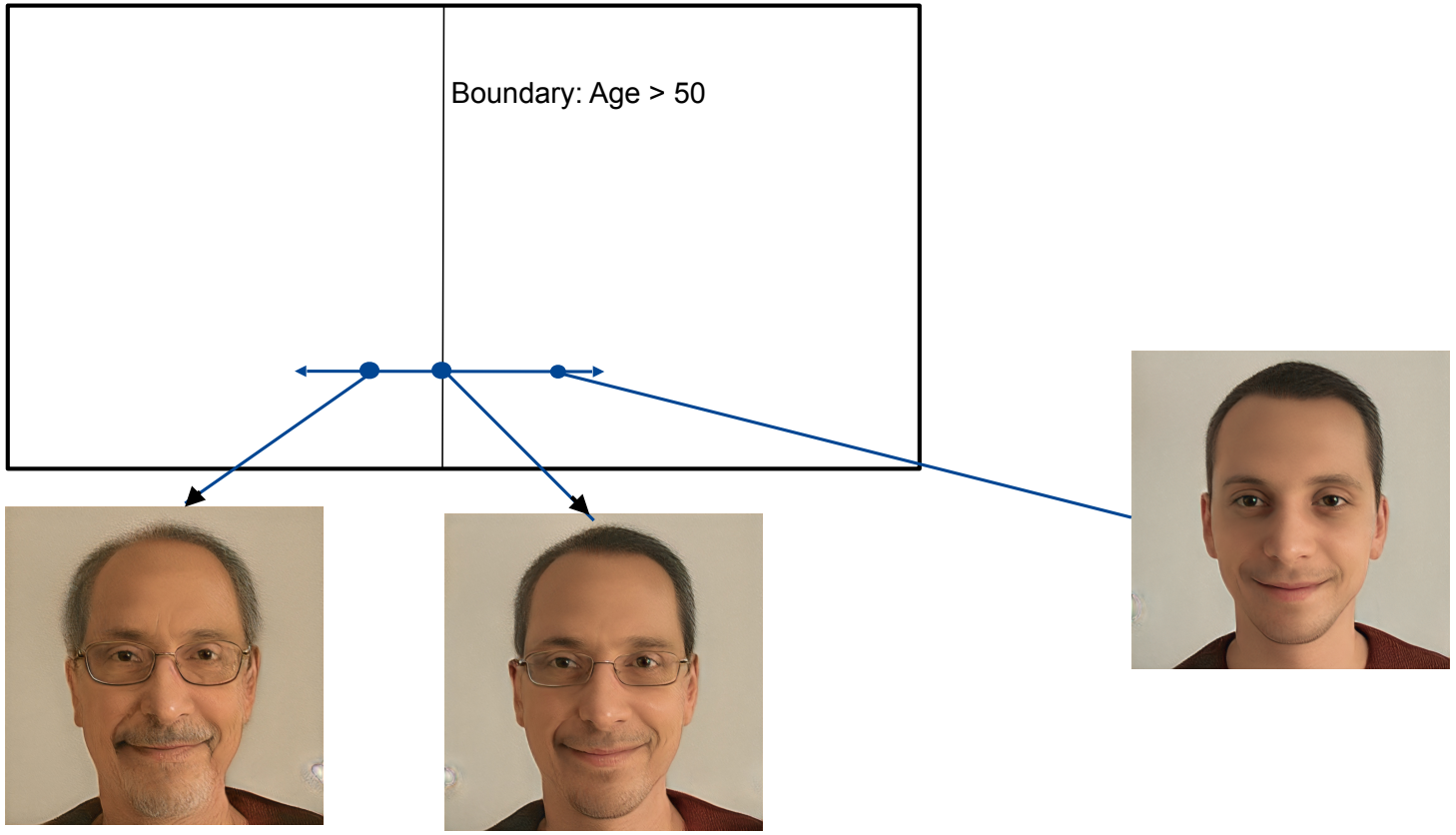
- Not for iris recognition

[Grother2013] P. Grother, J. Matey, E. Tabassi, G. Quinn: "IREX VI - Temporal Stability of Iris Recognition Accuracy", in NISTIR 7948, (2013)

Generative Adversarial Networks

InterFaceGAN - semantic face editing

- Mated sample generation (e.g. with aging)



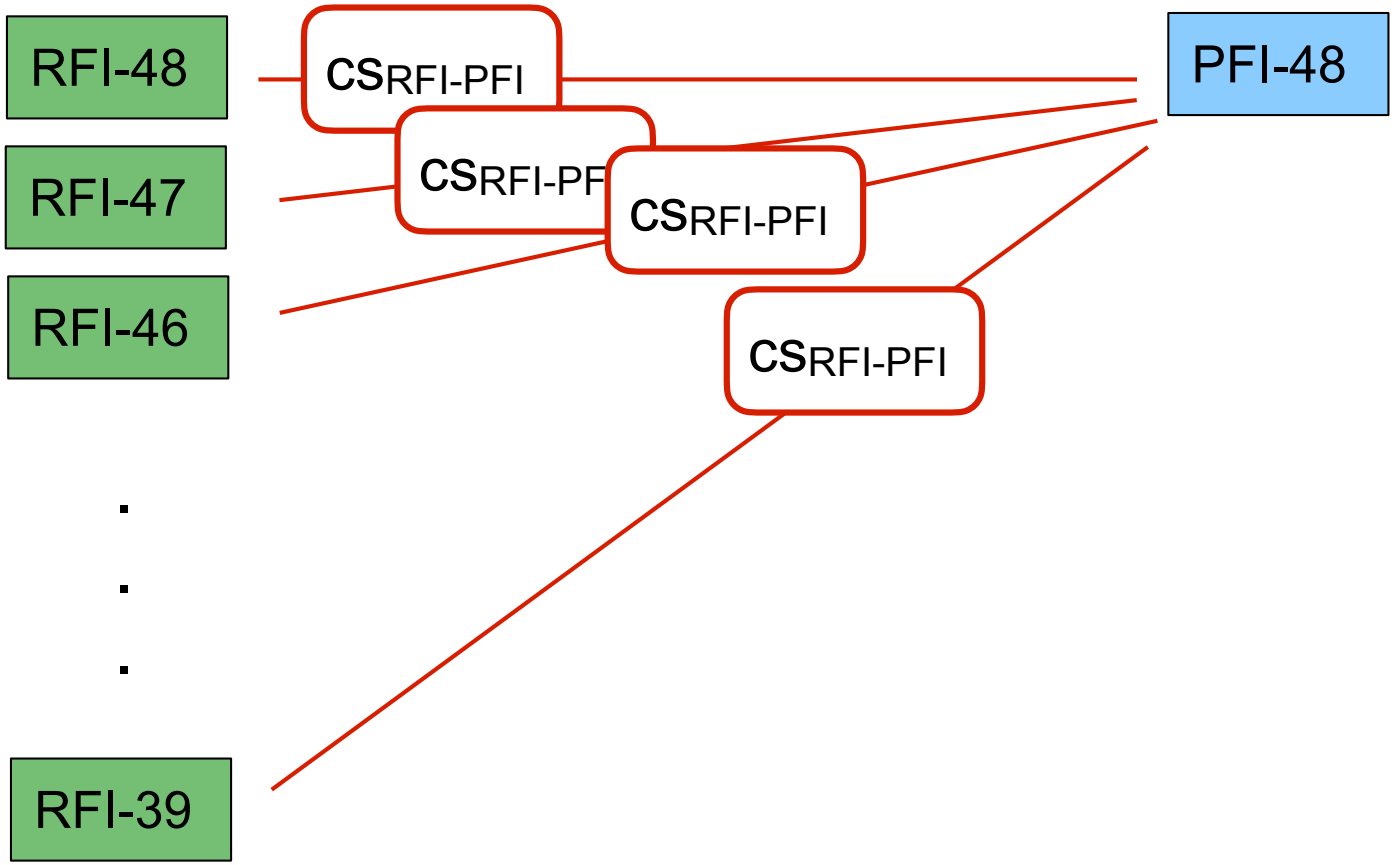
[Grimm2021] M. Grimmer, R. Raghavendra, C. Busch: "Deep Face Age Progression: A Survey", in IEEE Access, (2021)

[JBGB2023] E. Jensen, M. Bjerre, M. Grimmer, C. Busch: "Lifespan Face Age Progression using 3D-Aware Generative Adversarial Networks", in Proceedings IJCB, (2023)

Testing Age Impact

Comparison score (cs) degradation for aged reference images

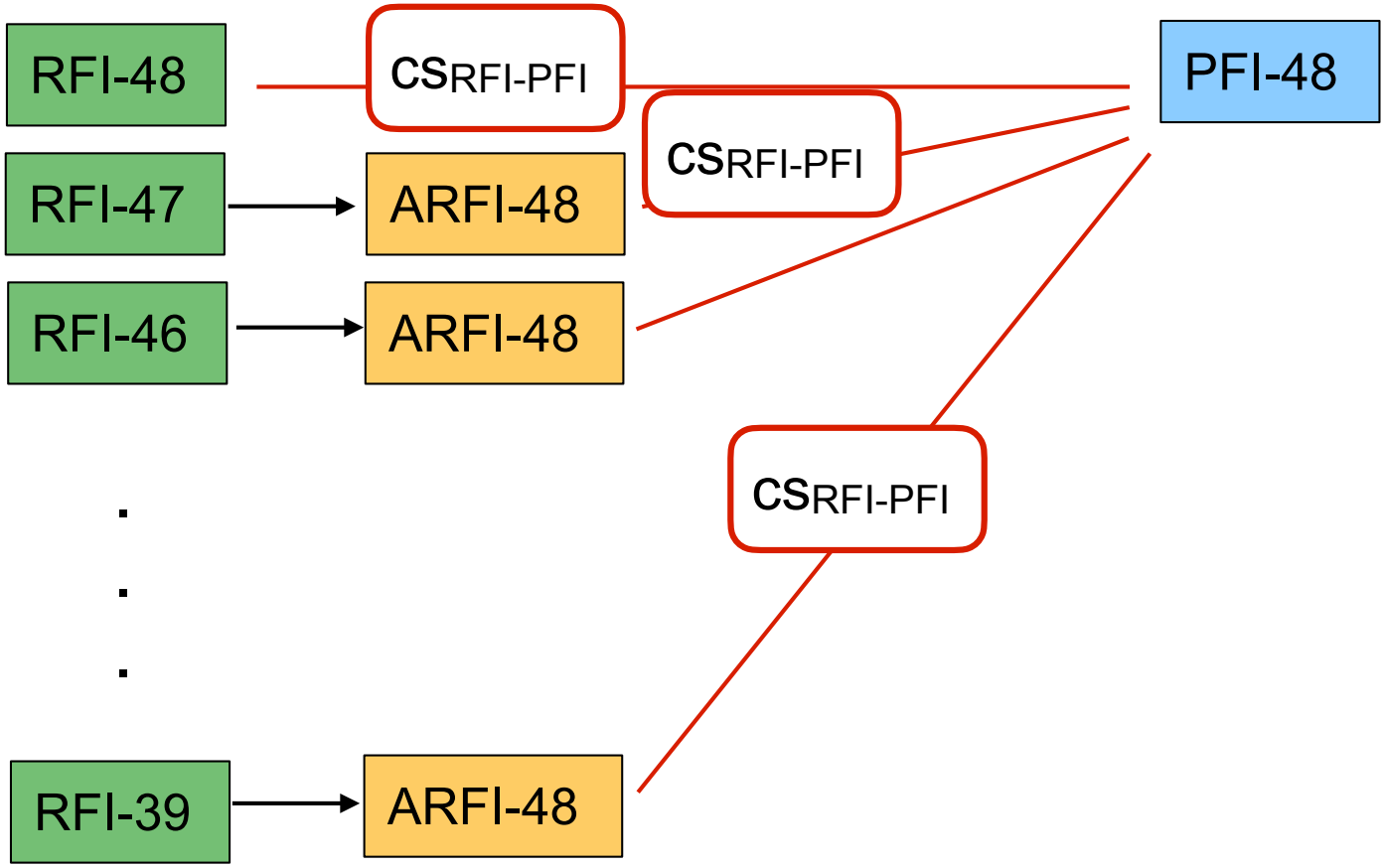
- Open source Face Recognition Systems (FRS)
  - ArcFace, VGGFace2, MagFace
  - Reference Face Image (RFI) versus Probe Face Image (PFI)



Testing Age Impact

Reduced comparison score (cs) degradation
for synthetically adjusted (aged) reference images ?

- Open source Face Recognition Systems (FRS)
  - Adjusted Reference Face Image (ARFI) versus Probe Face Image (PFI)



Conclusions

Address the challenges

- Control the quality of reference data
- Live enrolment only
  - no unsupervised capture process, unless strong PAD is in place
  - no import of face images from passports unless strong MAD is in place
- Renew reference data
  - unless age-resistant FRS are in place
- Interact with academia and research

Contact

For more information

- on face image quality:
  https://christoph-busch.de/projects-ofiq.html
- on finger image quality:
  https://christoph-busch.de/projects-nfiq2.html
- on morphing attack detection:
  https://christoph-busch.de/projects-mad.html
- on biometric standards:
  https://christoph-busch.de/standards-sc37wg3.html