Open Source Face Image Quality (OFIQ)

2026-11-17

3rd INTERPOL Fingerprint and Face Symposium

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

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ATHENE

European Association for Biometrics eab Human Identity in Europe

NTNU

Biometric Sample Quality







Factors impacting Quality

Defects caused by the capture device

- Image capture device out of focus
- Sampling error, low contrast for fingerprints



Defects caused by the capture subject‘s behaviour

- No frontal perspective
- Elastic deformation
- Improper finger placement (too low, rotated, etc)
- Defect caused by the source
  - Skin condition such as moist, oily, dry and so on
  - Scars, wrinkles, blisters, eczema, dirt





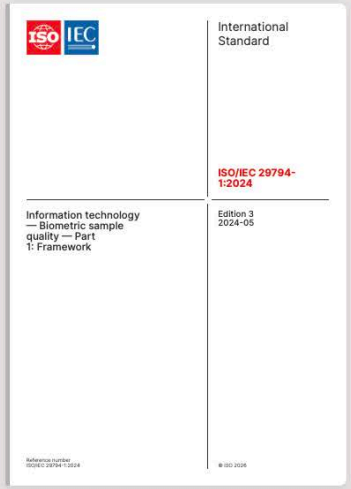


If poor quality is known,
constructive feedback should be provided (actionable quality)

Relevant Standards

Biometric sample quality - Framework

ISO Standards Sectors About ISO Insights & news Taking part Store



Read sample

← TC ← ISO/IEC JTC 1/SC 37

ISO/IEC 29794-1:2024

Information technology — Biometric sample quality

Part 1: Framework

Published (Edition 3, 2024)

https://www.iso.org/standard/79519.html

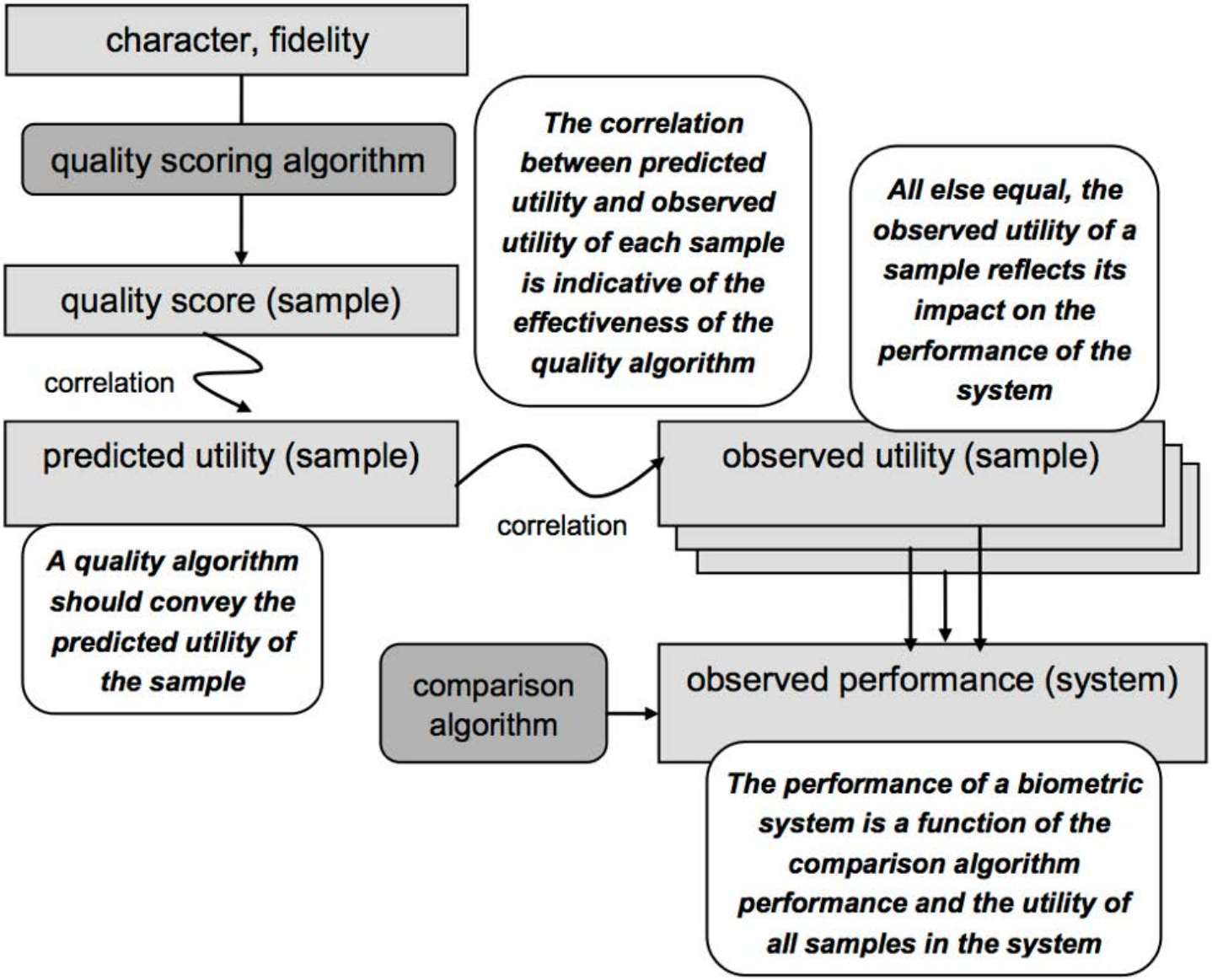
Factors impacting Quality

What is reflected by „quality“

- Character of a sample
  - Expression of quality based on the inherent properties of the source from which the biometric sample is derived.
  - For example, a scarred fingerprint has a poor character
- Fidelity of a sample to the source from which it is derived
  - Expression of quality based on fidelity reflects the degree of its similarity to its source.
  - For example sensor quality, noise related to capture process
- Utility of a single sample within a biometric system.
  - Expression of quality based on utility reflects the predicted positive or negative contribution of an individual sample to the overall performance of a biometric system.
  - Is there valuable biometric information in the sample?

Quality and Performance

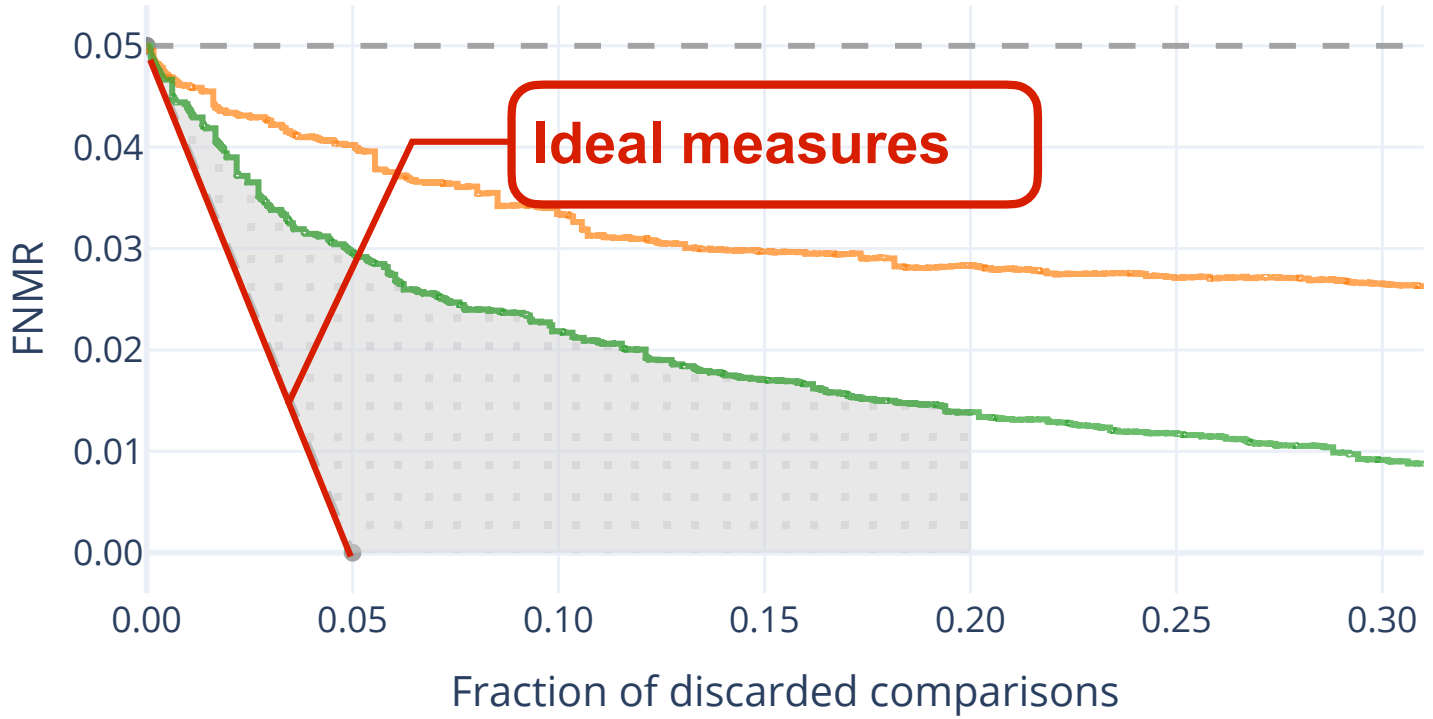
Relationship between quality and system



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



- Report the partial area under curve (pAUC) in the range 0 to 0,2

Face Image Quality

Motivation for Face Image Quality Assessment (FIQA)

- Quality matters, especially in large-scale databases and with diverse application scenarios.
  - The European Entry Exit System (EES) started 12th October 2025
    - Applied to all external Schengen borders
    - Central register to record all entries/exists to the Schengen area
      https://travel-europe.europa.eu/ees_en



    - For each traveller a record with facial image and fingerprint images
    - Operated by eu-LISA and 29 countries

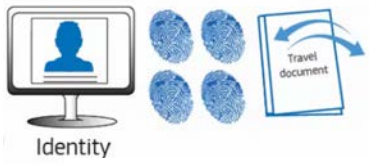


Image Source: eu-LISA

- Standardisation of minimal quality and harmonisation is essential for (semantic) interoperability.

Relevant Standards

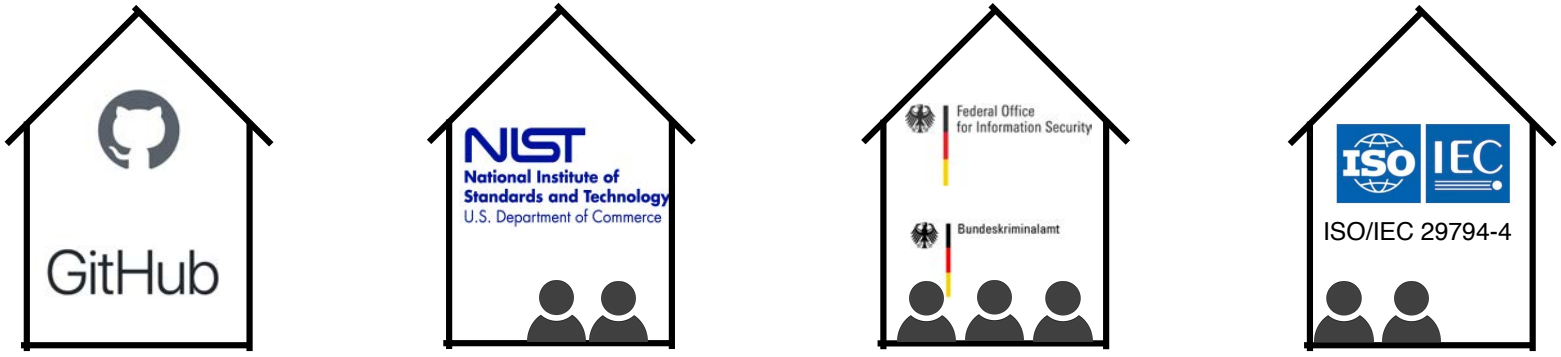
Biometric sample quality - Finger image data



https://www.iso.org/standard/83827.html

Quality Measures for Fingerprint Images

How was NFIQ2.0 developed?



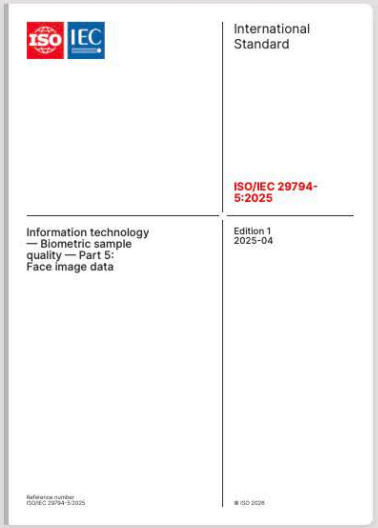
Maintenance | Testing | Development | Standardisation

- Status 2026
  - NFIQ2.3 in GitHub: https://github.com/usnistgov/NFIQ2
  - ISO/IEC 29794-4: https://www.iso.org/standard/83827.html
  - Active AdHoc-Group preparing the next edition

Relevant Standards

Biometric sample quality - Face image data

ISO Standards Sectors About ISO Insights & news Taking part Store



Read sample

← TC ← ISO/IEC JTC 1/SC 37

ISO/IEC 29794-5:2025

Information technology — Biometric sample quality

Part 5: Face image data

Published (Edition 1, 2025)

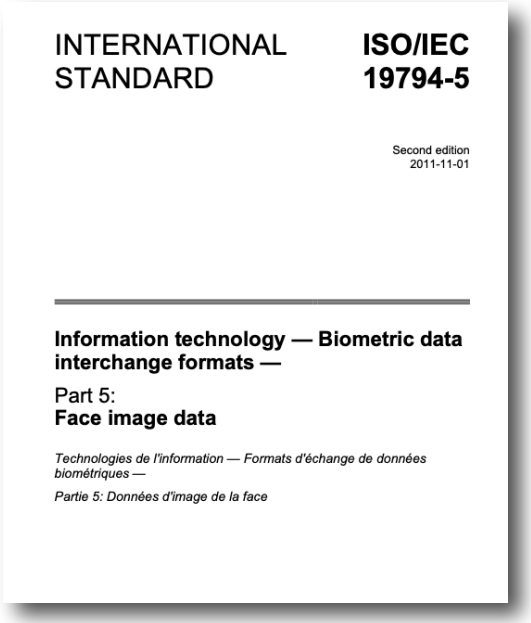
https://www.iso.org/standard/81005.html

Quality Requirements for Facial Images

The requirement in EES implementing decision 2019/329

- *„The quality of the facial images, … 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 —

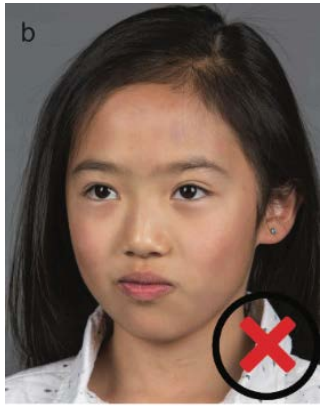
Partie 5: Données d'image de la face

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

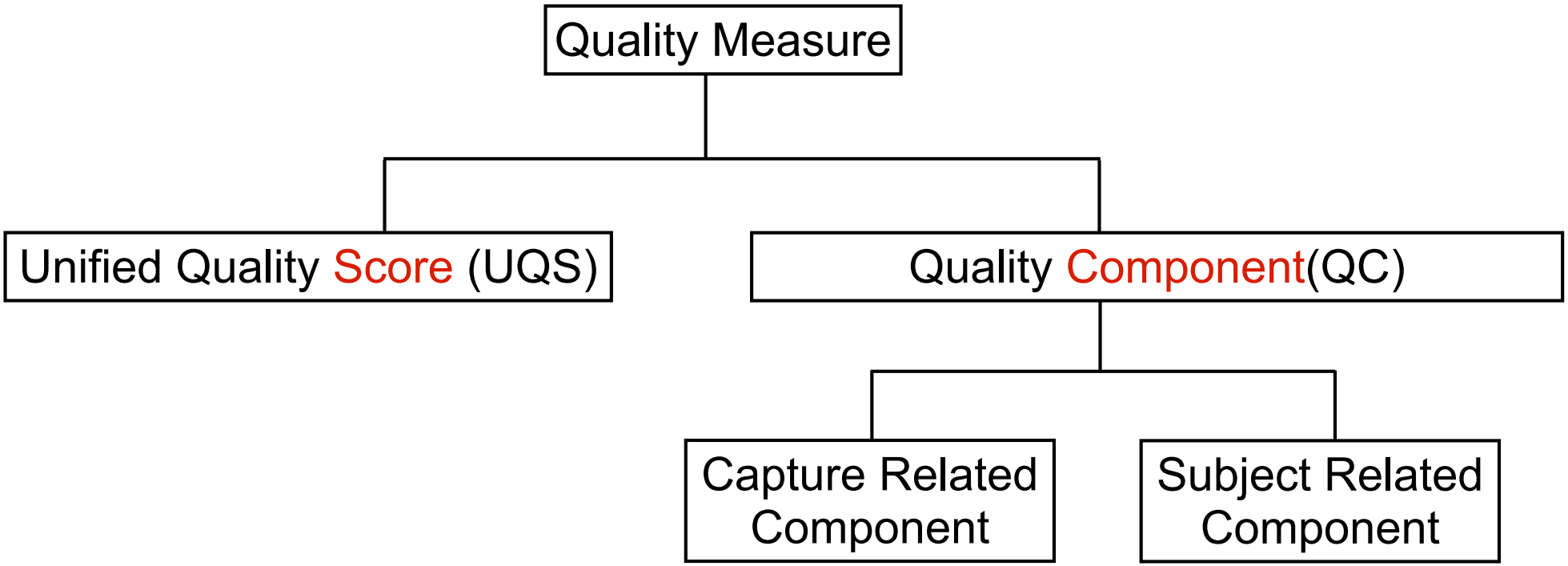
Quality Measures for Facial Images

Face image quality measures

- ISO/IEC 29794-5, Information technology - Biometric sample quality - Part 5: Face image data, https://www.iso.org/standard/81005.html
- Providing measures for requirements from ISO/IEC 19794-5:2011 and ISO/IEC 39794-5:2019
  - Use Case-1: Reference image for MRTD
  - Use Case-2: Reference image for Live-Enrolment at EES Kiosk
  - Use Case-3: Probe images (e.g. ABC gate)

ISO/IEC 29794-5: Face Image Quality

Quality assessment algorithms



- Higher UQS and QC imply higher biometric utility

ISO/IEC 29794-5: Face Image Quality

ISO/IEC 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 artefacts
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.	Margin above face in image
23.	Margin below 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

Image Source:ISO/IEC 29794-5

Unified Quality Score

Capture device related

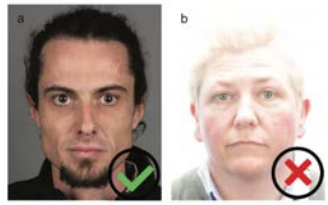


Image Source: ISO/IEC 39794-5

Explainable Quality Assessment

Subject related



Image Source: ISO/IEC 39794-5

Open Source Face Image Quality (OFIQ)

Reference implementation of ISO/IEC 29794-5

- Library with quality assessment algorithms
- Open source https://github.com/BSI-OFIQ/OFIQ-Project
  - Commercial use is enabled
- Support for major OS platforms (including mobile OS)
  - C/C++
- Selection criteria for integrated algorithms
  - Accuracy (NIST FATE SIDD evaluation)
    https://pages.nist.gov/frvt/reports/quality_sidd/frvt_quality_sidd_report.pdf
  - Low computational complexity
  - Liberal license (MIT or alike)
  - Limited demographic variability **NEW for OFIQ 2**

OFIQ - Unified Quality Score

General, holistic unified quality score (OFIQ-UQS)

- Determine an overall quality score for the face image
  - CNN MagFace (iResNet 50 model)
- Shows good prediction of face recognition scores



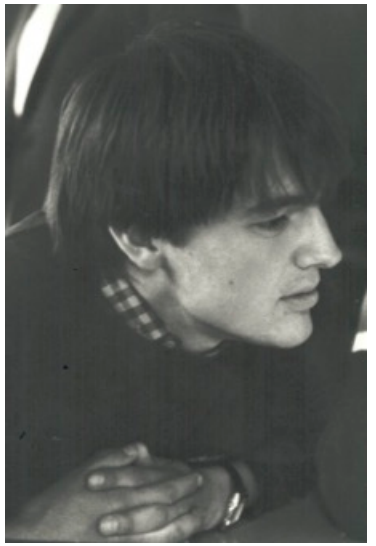
OFIQ-UQS=84



OFIQ-UQS=61



OFIQ-UQS=26

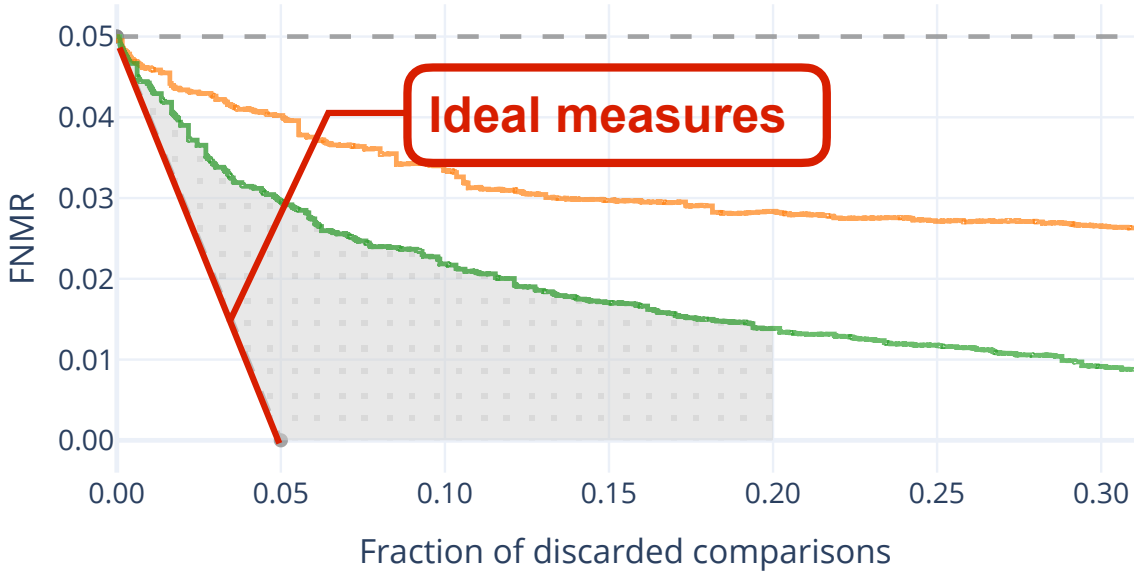


OFIQ-UQS=7

OFIQ - Unified Quality Score

Prediction of low face recognition scores

- OFIQ is the best performing algorithm in NIST SIDD Error versus Discard Characteristic (EDC) curves
  - How much is the FNMR reduced, when poor images are discarded/rejected?



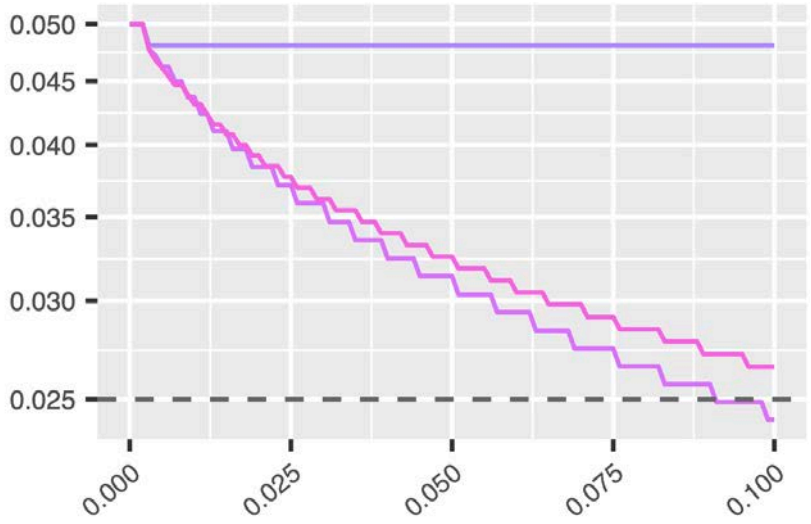


Image Source:NIST FATE SIDD report

[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)

OFIQ - Processing

Pre-processing for quality measures

- Face Detection: bounded box of all detected faces
- Face Landmark Estimation: localization of 98 key points
- Alignment: bring eyes on the same height
- Face Occlusion Segmentation: identify un-occluded region
- Face Parsing: identify different regions of subject in the image (eyes, eye brows, nose, lips, skin / neck, ears, hair / glasses, clothes, hats, earrings, necklaces / background)

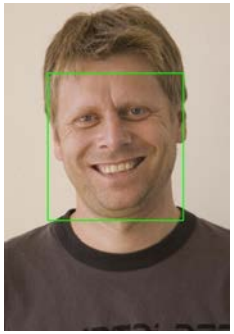
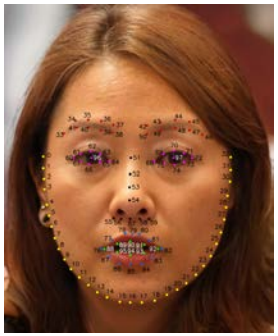






Image Source: OFIQ public report and ISO/IEC FDIS 29794-5

OFIQ - Quality Components

Example algorithm: Mouth Closed

- Detecting if the most is closed
- Algorithms based on landmarks
- Maximum distance between lips

$$D_L = \max\left(\|L_{89} - L_{95}\|_2, \|L_{90} - L_{94}\|_2, \|L_{91} - L_{93}\|_2\right)$$

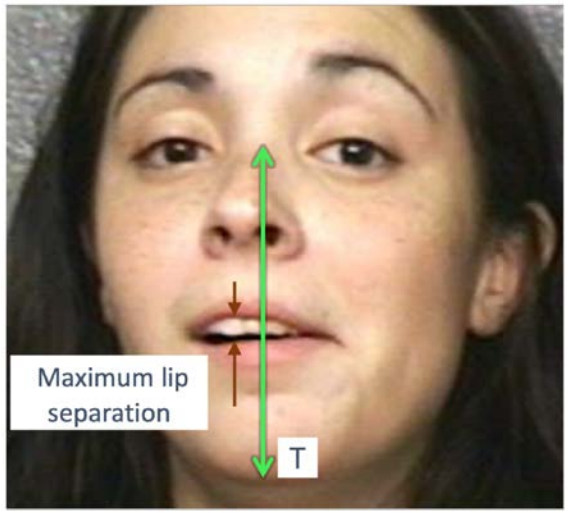
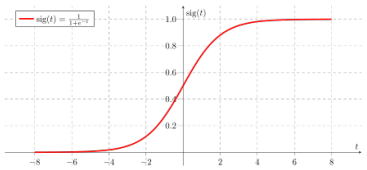


Image Source:NIST FATE SIDD report

- Normalized by distance T between eye‘s midpoint and chin
- Mouth opens aspect

$$\omega = \frac{D_L}{T}$$



$$Q = \text{ROUND}(100(1 - \text{SIGMOID}(\omega, 0.2, 0.06)))$$

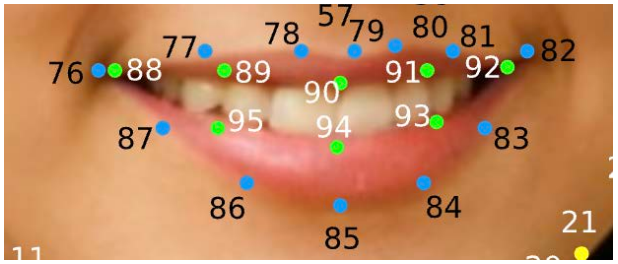


Image Source:ISO/IEC 29794-5

OFIQ - Quality Components

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



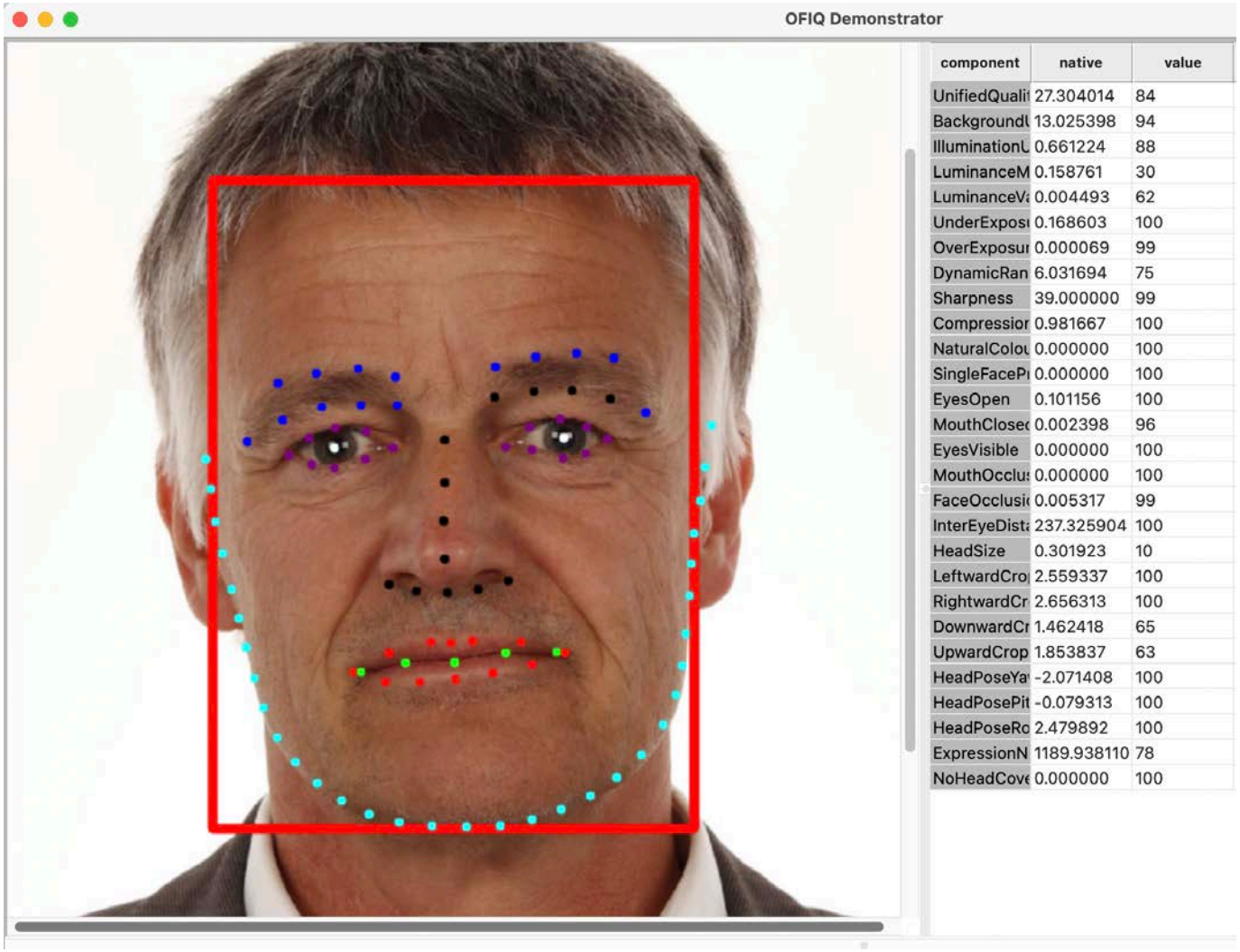
[GRVB2023] M. Grimmer, C. Rathgeb, R. Veldhuis, C. Busch: "NeutrEx: A 3D Quality Component Measure on Facial Expression Neutrality", in Proceedings of International Joint Conference on Biometrics (IJCB), (2023)

[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, (2024)

OFIQ - Demonstrator

Demonstrator to understand the processing

- Available in GitHub:
  https://github.com/BSI-OFIQ/OFIQ-Project



Fairness of Algorithms



Image Source: https://www.flaticon.com (2020)

Fairness of Biometric Algorithms

Possible Consequences of unfair algorithmic (and human) decision systems

- Differential treatment
  - **Definition**: *different set of actions for a biometric enrolee or biometric capture subject based on their demographic group*
    https://www.iso.org/obp/ui/en/#iso:std:iso-iec:19795:-10:ed-1:v1:en
- Unintentional discrimination
- Individual and collective social harms
  - social stigmatisation (e.g. Uigur people in China)



Demographic Factors in Biometrics

Measure and report

- Demographic differentials
  - **Definition**: *extent of difference in outcome of a biometric system across socially recognized sectors of the population*
    https://www.iso.org/obp/ui/en/#iso:std:iso-iec:2382:-37:ed-3:v1:en:term:37.09.28
- Demographic variables
  - gender
  - age
  - glasses
  - skin tone



Fitzpatrick Skin Types Image Source: HSBRS, (2016)

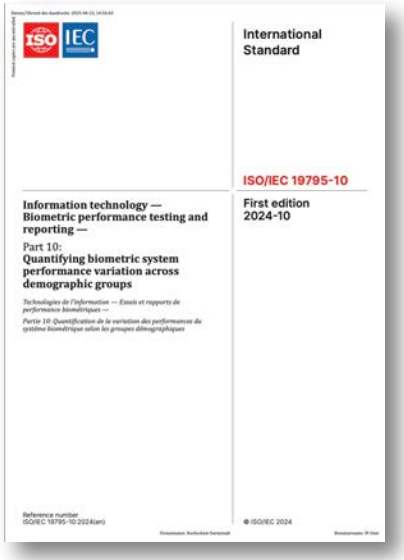
Demographic Effects

Current findings for facial biometric characteristics

- Most studies observed influence of demographic variables on biometric recognition.
  - Generally, lower biometric performance was consistently observed for females and children
  - The country of algorithm development (and hence training data) may be a large factor in this context.

International Standard

- ISO/IEC 19795-10
  https://www.iso.org/standard/81223.html

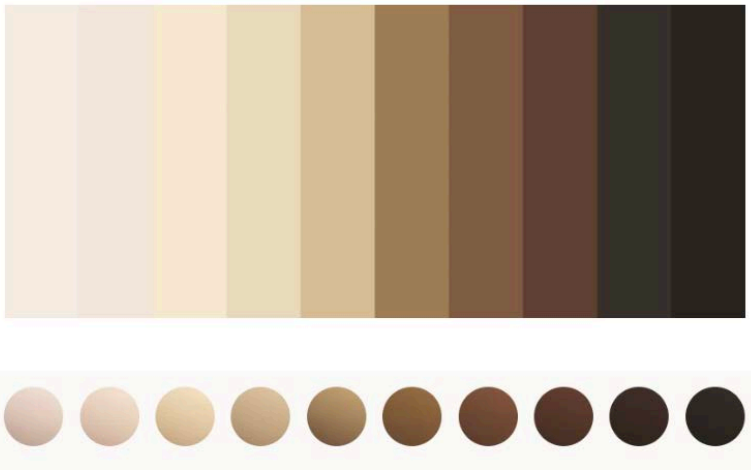


[Drozd2020] P. Drozdowski, C. Ratgeb, A. Dantcheva, N. Damer, C. Busch: "Demographic Bias in Biometrics: A Survey on an Emerging Challenge“, in IEEE Transactions on Technology and Society (TTS), (2020)

Face Image Quality - Demographic

Research tasks

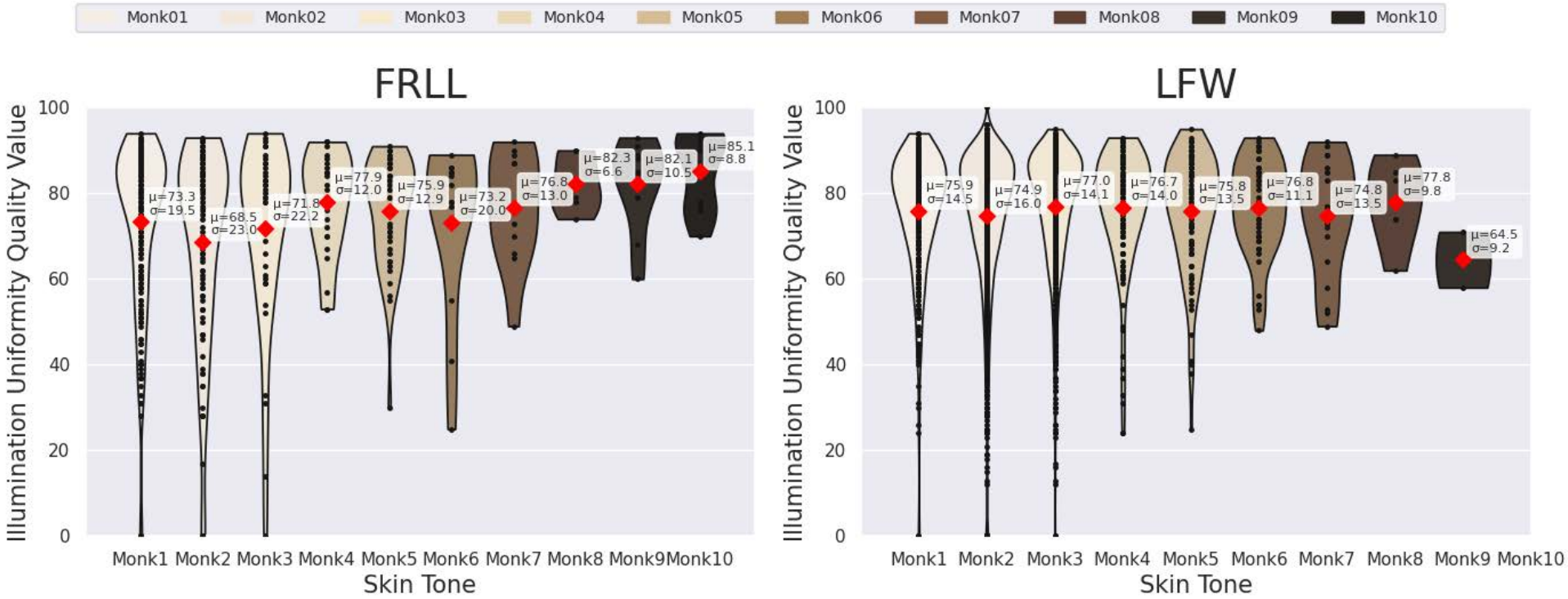
- Investigate demographic variability (DV) of quality measures
- Skin tone variation is a continuous demographic variable
- Transformation to discrete categories
  - Monk skin tone scale (MST) vs.
  - Colorimetric skin ton (CST) vs.
  - PANTONE Skin Tone (PST)



Face Image Quality - Demographic

Research tasks

- Investigate variability across demographic groups
  - Distribution of unified quality score (UQS)



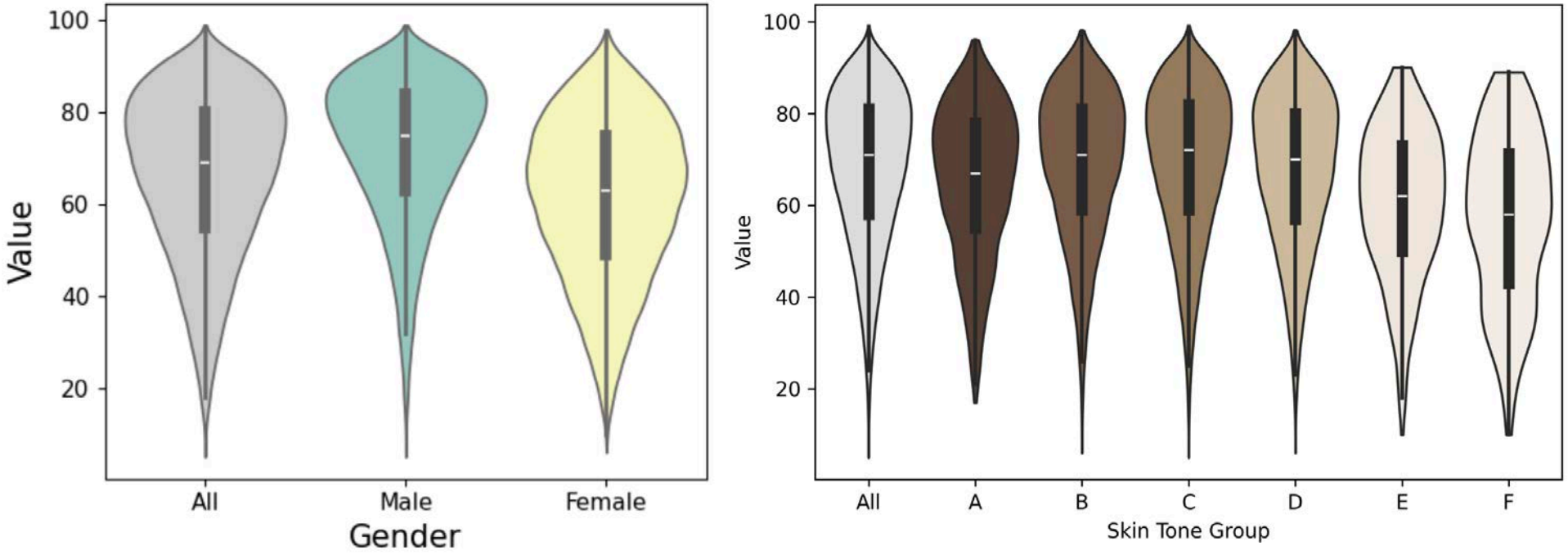
[KRRB2024] W. Kabbani, K. Raja, R. Raghavendra, C. Busch: "Demographic Differentials in Face Image Quality Measures", in Proceedings of the IEEE 23rd International Conference of the Biometrics Special Interest Group (BIOSIG), Darmstadt, September 25-27, (2024)

Face Image Quality - Demographic

Research tasks

- Investigate variability across demographic groups
  - Distribution of unified quality score (UQS)
  - Based on operational data 100.000+ images for UC1

Demographic groups		UC1	UC3
Gender	Female	57,133	90,199
	Male	52,391	81,884
Age Group	0–20	5,169	7,534
	20–30:	24,576	37,802
	30–40:	27,878	46,140
	40–50:	18,710	29,702
	50+:	33,191	50,905
Skin Tone	A	1,308	1,410
	B	15,994	16,519
	C	51,954	55,126
	D	38,894	47,104
	E	384	419
	F	240	291
Origin	Africa	39	485
	America	4,616	7,360
	Asia	56,052	99,934
	Europe	45,050	58,435
	Oceania	3,765	5,866

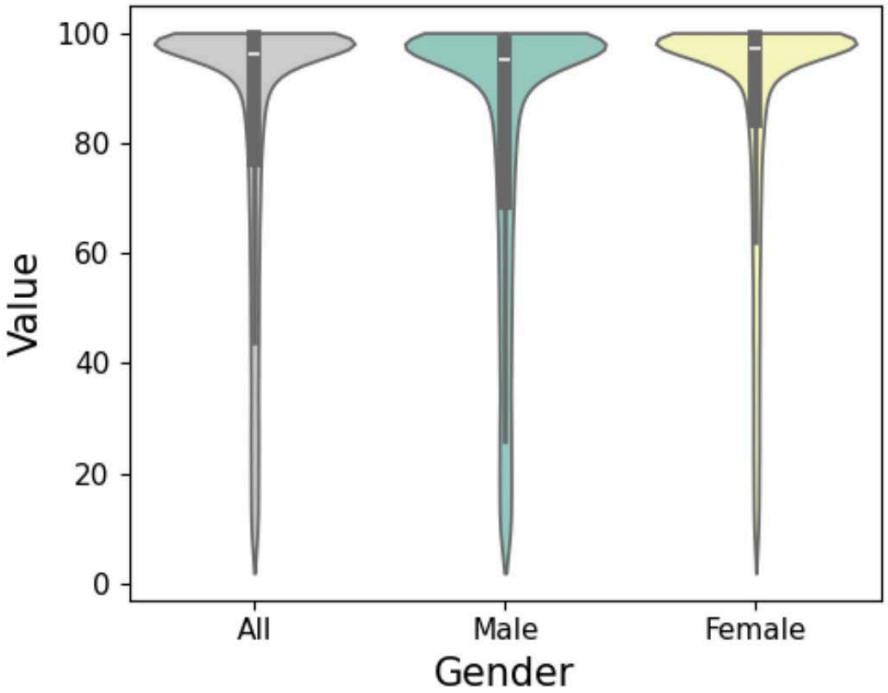


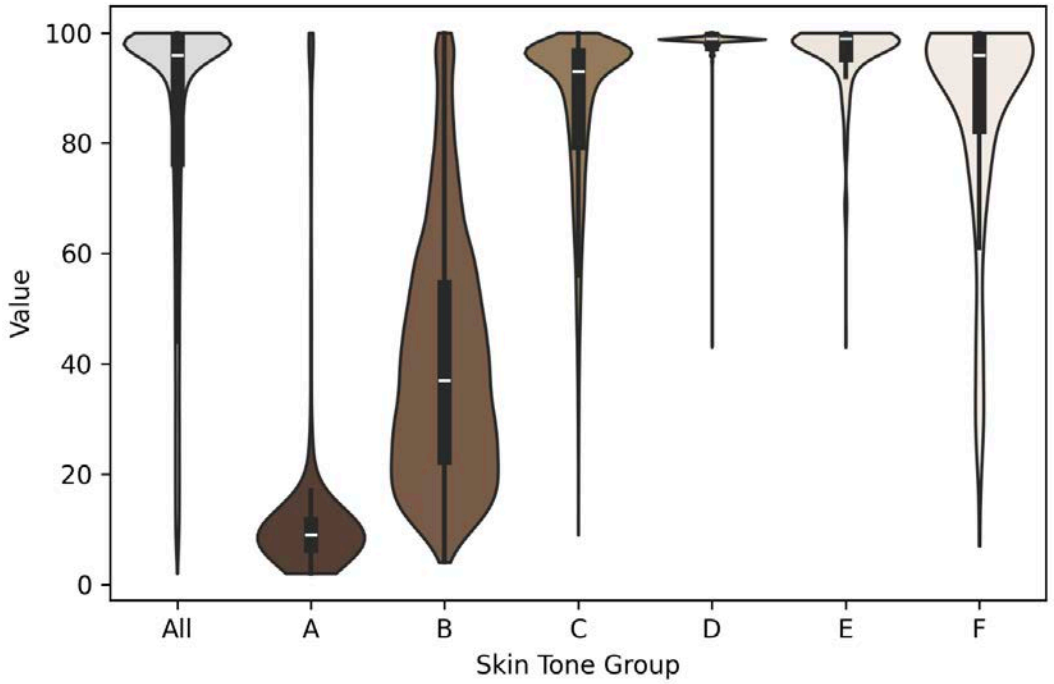
[Utcke2026] S. Utcke et al.: "Demographic Variability of Face Image Quality Measures in Operational Data", in IEEE Access, (2026), https://ieeexplore.ieee.org/document/11411711

Face Image Quality - Demographic

Research tasks

- Investigate variability across demographic groups
  - Distribution of component quality measures (CQM)
    Luminance Mean quality component values
  - Based on operational data 100.000+ images for UC1



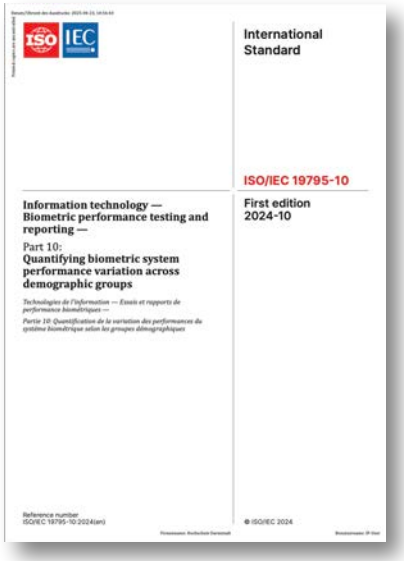


[Utcke2026] S. Utcke et al.: "Demographic Variability of Face Image Quality Measures in Operational Data", in IEEE Access, (2026), https://ieeexplore.ieee.org/document/11411711

Face Image Quality - Demographic

International Standard

- ISO/IEC 19795-10
  https://www.iso.org/standard/81223.html
- Clause 5.2.1
  "*Demographic group membership should not be inferred directly from biometric samples. An example of this is assigning the value of ethnicity or the value of gender from a face sample*"

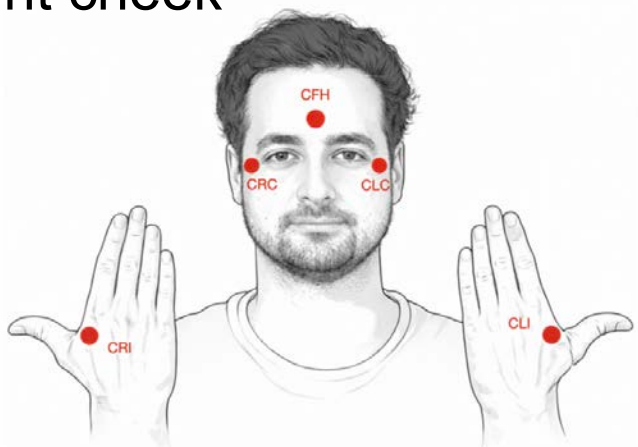


DArmstadt Skin Tone Dataset (DAST)

Ground truth skin tone measurement



- Handheld DSM-4 colorimeter
  - measures a skin area of approximately 50 mm^2 under standardised D65 illumination generated by four light-emitting diodes.
  - Skin color is quantified using diffuse reflectance spectroscopy
- Locations of colorimeter measurements
  - CFH: Colorimeter measure forehead of the face
  - CLC: Colorimeter measure forehead of the left cheek
  - CRC: Colorimeter measure forehead of the right cheek
  - CLI: Colorimeter measure left hand
  - CRI: Colorimeter measure right hand



[Busch2026] C. Busch et al.: A Skin Tone Annotated Face Image Dataset for Studying Demographic Variability", in Proceedings of 14th International Workshop on Biometrics and Forensics (IWBF), (2026)
https://christoph-busch.de/files/Busch-DAST-IWBF-2026.pdf

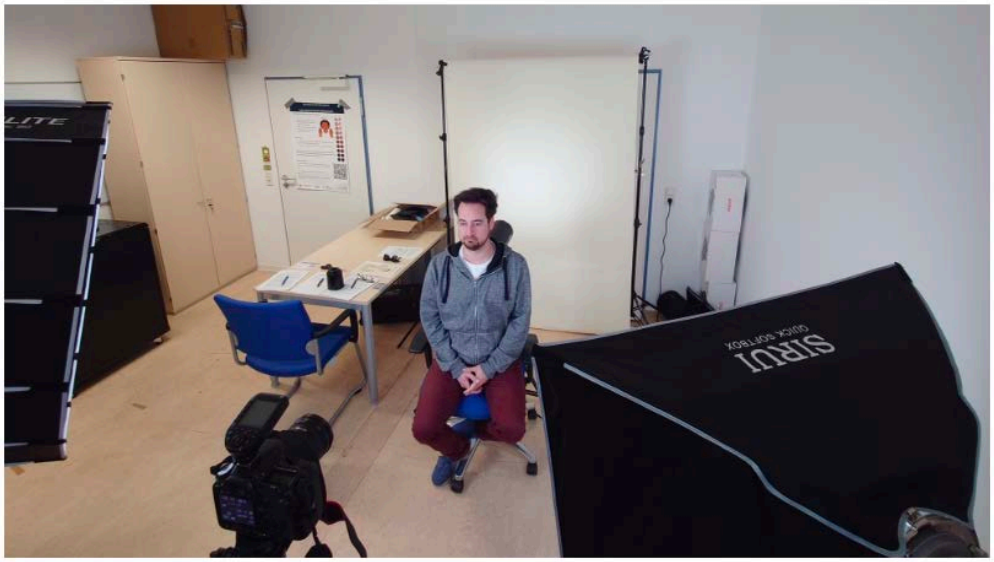
DArmstadt Skin Tone Dataset (DAST)

Ensure homogeneous illumination

- Compliant with ISO/IEC 39794-5:2019, Annex E
- Nanlite SBPR90Q and Sirui Quick Release softboxes

Capture devices

- Canon EOS 50D (3,168×4,752 px) equipped with a Canon EF-S 18–200 mm f/3.5–5.6 IS lens
- Sony ILCE-7M2 (4,000×6,000 px) equipped with a FE 90 mm F2.8 Macro G OSS lens.



DArmstadt Skin Tone Dataset (DAST)

Exposure Levels

- Examples of 12 face images per subject in different illumination conditions
  - 2 cameras
  - 5 exposure levels



TABLE II: Number of subjects per gender and skin tone class

Gender	CST classes									
	1	2	3	4	5	6	7	8	9	10
Male	0	4	8	9	9	8	6	9	8	0
Female	2	6	2	1	1	2	4	1	0	0

TABLE I: Settings for face image acquisition.

EL	Flash settings	Camera settings
EL1	small SB 1/8 +0.3 large SB 1/8 BG 1/64	SS 1/100 iso 100 F22
EL2	small SB 1/8 +0.3 large SB 1/8 BG 1/64	SS 1/100 iso 100 F16
EL3	small SB 1/8 +0.3 large SB 1/8 BG 1/64	SS 1/100 iso 100 F11
EL4	small SB 1/4 +0.3 large SB 1/4 BG 1/32	SS 1/125 iso 100 F11
EL5	small SB 1/2 +0.3 large SB 1/2 BG 1/16	SS 1/160 iso 100 F11

SB: Softbox, BG: Background, SS: Shutter speed

https://github.com/dasec/DAST-SkinTone-database

Relevant Standards

Demographic variability of face image quality measures

ISO Standards Sectors About ISO Insights & news Taking part Store



← TC ← ISO/IEC JTC 1/SC 37

ISO/IEC CD TR 25722

Demographic variability of face image quality measures

Under development

A draft is being reviewed by the committee.

https://www.iso.org/standard/91308.html

Status for OFIQ

Perspective

- OFIQ will (likely) replace the proprietary FIQA
  - wherever used and avoid a vendor-lock-in
- OFIQ 2.0 project and revision of ISO/IEC 29794-5 is ongoing
  - Draft documents available in the ISO-portal



Take home information on face image quality

- OFIQ open source code:
  https://github.com/BSI-OFIQ/OFIQ-Project
- OFIQ public report
  https://github.com/BSI-OFIQ/OFIQ-Project/blob/main/doc/reports/Public_Report_V1.1_2024_09_30.pdf
- NIST test report:
  https://pages.nist.gov/frvt/reports/quality_sidd/frvt_quality_sidd_report.pdf
- Face image quality website:
  https://christoph-busch.de/projects-ofiq.html
- Next OFIQ user group meeting is on 2027-02-16:
  https://eab.org/events/program/416

Questions and Answers?

Take home information:

- Fingerprint image quality website:
  https://www.christoph-busch.de/projects-nfiq2.html
- Face image quality website:
  https://christoph-busch.de/projects-ofiq.html
- Standards website:
  https://www.christoph-busch.de/standards-sc37wg3.html



