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European Association for Biometrics eab Human Identity in Europe

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Open Source Face Image Quality (OFIQ)

ICAO NTWG RFI Meeting – 16./17. September 2024

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Agenda

- Motivation for Biometric Sample Quality
- Biometric quality standards developed in SC37
  - unified quality score
  - quality components
- ISO/IEC 29794-5
- Open source face image quality (OFIQ)

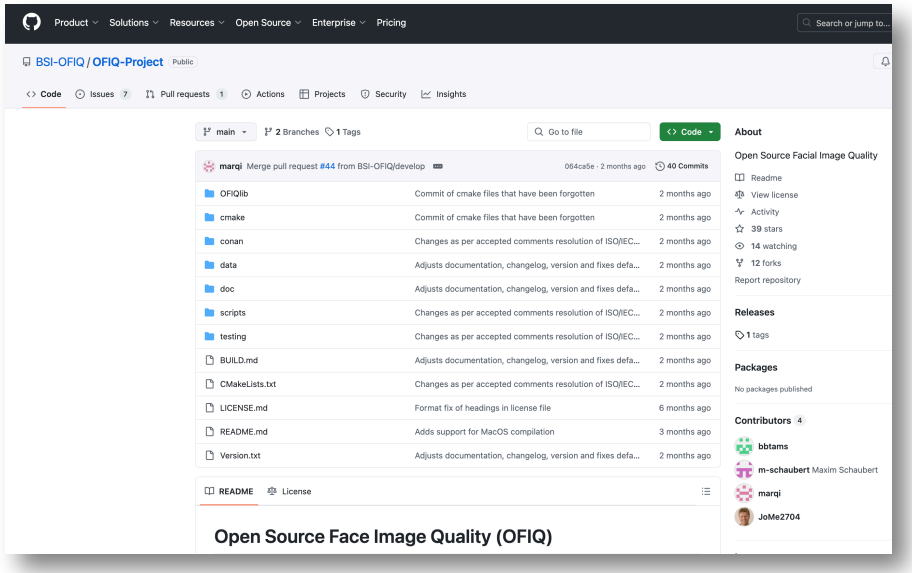
Motivation for Quality Assessment

- Motivation for Open-Source Face Image Quality (OFIQ)
  - Quality matters, especially in large-scale databases and with diverse application scenarios.
  - Garbage in, garbage out!
    - Good data quality is essential but what does “good” mean?
  - Quality requirements depend on application context.
    - A common approach is important.
  - Quality is often a question of time.
    - Specific components contribute differently to overall quality.
  - Standardization and harmonization is essential for (semantic) interoperability.

Objectives of OFIQ

- Open Source, transparent
  - see https://github.com/BSI-OFIQ/OFIQ-Project
- Public available documentation and reports
  - see https://arxiv.org/abs/2211.08030
  - and https://bsi.bund.de/dok/OFIQ-e
- Multiple platforms, including mobile devices

- Project by German Federal Office for Information Security (BSI)
- Implementation by Secunet Security Networks AG
- Support by the ISO-Community, eu-LISA, and others



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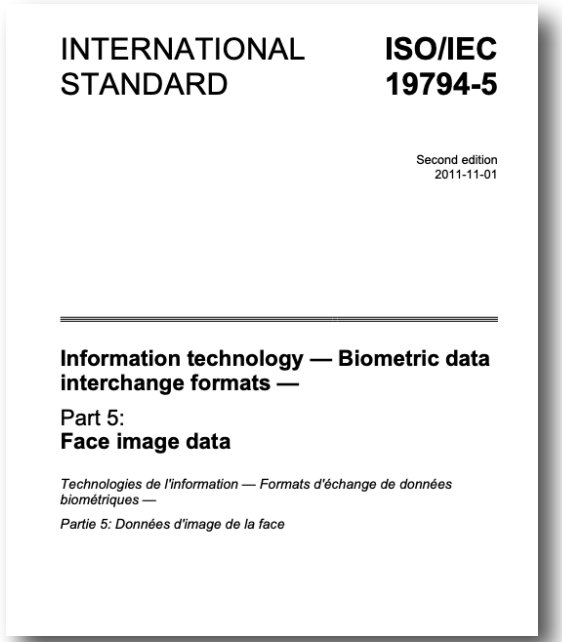
Face Image Quality in the Entry-Exit-System

- 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?
- Data subjects need actionable feedback
  - If quality is poor, then what went wrong?


INTERNATIONAL STANDARD

ISO/IEC 19794-5

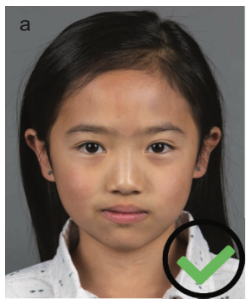
Second edition
2011-11-01

Information technology — Biometric data interchange formats —

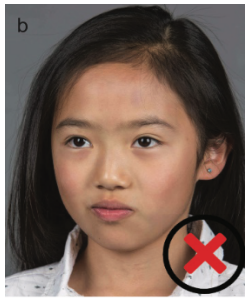
Part 5:
Face image data

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

Partie 5: Données d'image de la face



Compliant image



Pose

Eyes open

Mouth open

Inhomogenous background

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Standardisation and Technical Aspects

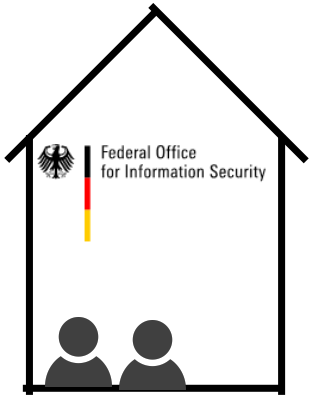
Quality Measures for Facial Images - Roles

eu-LISA

Maintenance

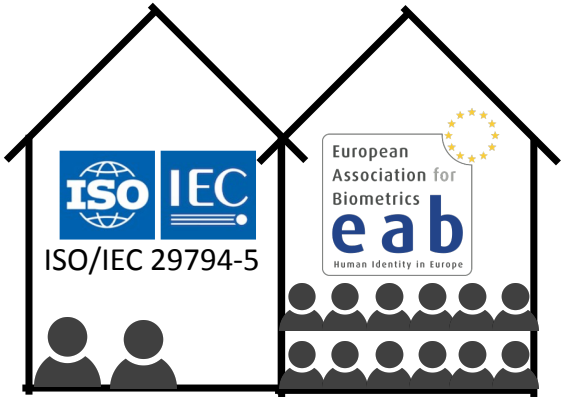
Patrick Grother
Joyce Yang

Testing



Anna Stratmann
Marcel Ginzler

Development



Patrick Grother, Christoph Busch
Benjamin Tams, Johannes Merkle

Standardisation

Research Support

Implementation

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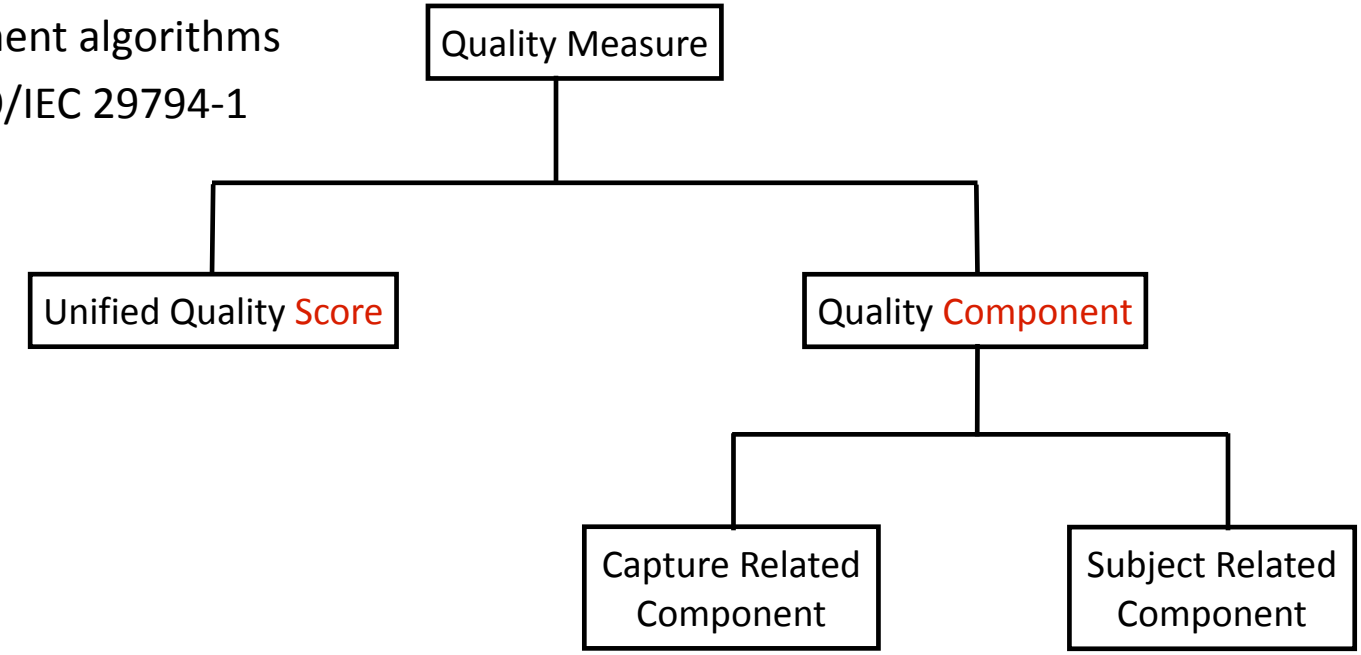
Quality Measures for Facial Images - Standardisation

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

Quality Measures – Framework Standard

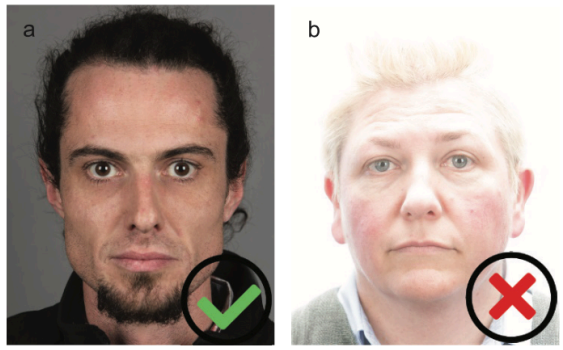
- Quality assessment algorithms
  - According ISO/IEC 29794-1



  - Higher quality scores imply higher biometric utility

ISO/IEC 29794-5: Face Image Quality

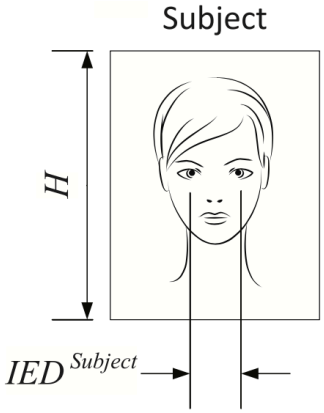
- ISO/IEC 29794-5 is aligned with both
  - ISO/IEC 19794-5:2011
  - ISO/IEC 39794-5:2019



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

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

- Definitions
  - 7.2 Unified quality score
  - 7.3 Capture-related quality measures
  - 7.4. Subject-related quality measures



source: ISO/IEC 39794-5

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

source: ISO/IEC 19794-5:2011

ISO/IEC 29794-5: Face Image Quality

#	Face image quality measure
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

#	Face image quality measure
1.	Quality score (unified)

← Capture Device Related

Subject Related →

#	Face image quality measure
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

Explainable Quality Assessment

Open Source Face Image Quality (OFIQ) - Approach

- Library with quality assessment algorithms
- Open source with liberal license → 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

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	-

  - FATE Quality - Specific Image Defect Detection (SIDD)
    https://pages.nist.gov/frvt/reports/quality_sidd/frvt_quality_sidd_report.pdf

1. FRTE 1:1 Verification	2. FRTE 1:N Search Performance	3. FATE Morph Morphed Photo Detection	4A. FATE QA Image Quality Scalar Summary	4B. FATE QA Specific Image Defect Detection	5. FATE Attack Presentation Attack Detection	6. FRTE Twins Ability to Distinguish Between Twins
2017 -	2018 -	2018 -	2019 -	2022 Q3 -	2022 Q3 -	2022 Q4 -

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Open Source Face Image Quality (OFIQ) – Unified Quality Score

- General, holistic unified quality score (OFIQ-UQS)
  - Not limited to certain quality criteria / defects
  - CNN MagFace (iResNet 50 model)
  - Shows good prediction of face recognition scores

OFIQ-UQS=84

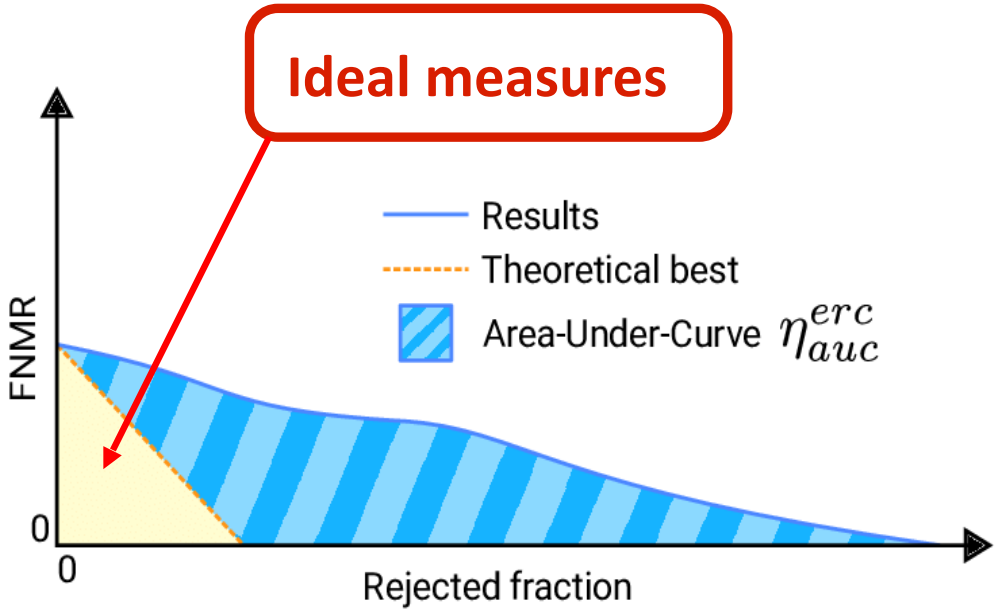
OFIQ-UQS=61

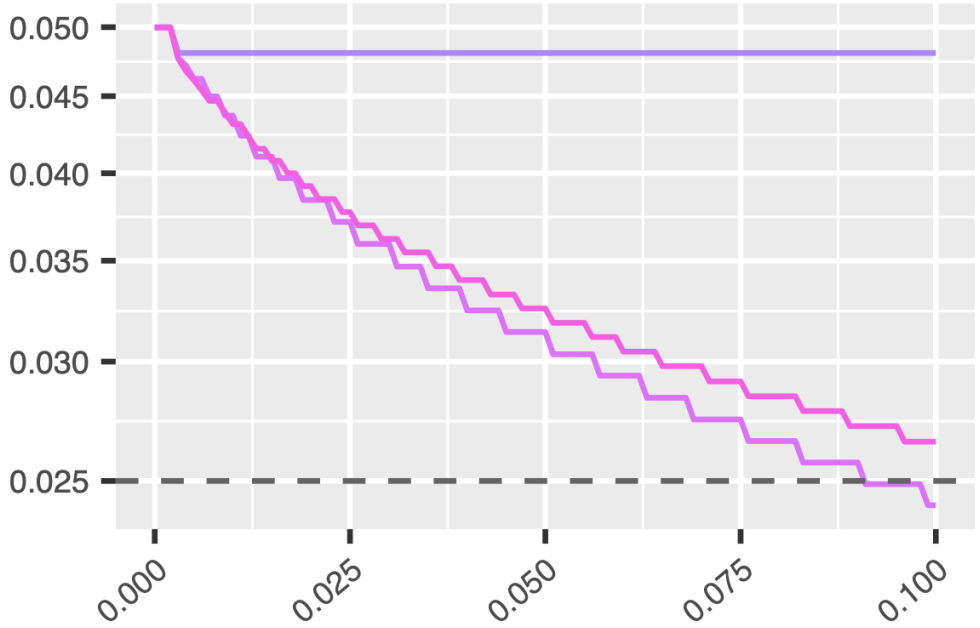
OFIQ-UQS=26

OFIQ-UQS=7

Open Source Face Image Quality (OFIQ) – Unified Quality Score

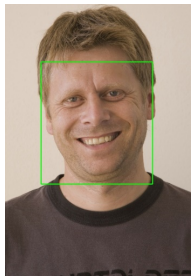
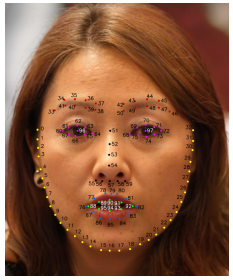
- Excellent results in FATE SIDD (1st of 16)
  - Very good prediction of low face recognition scores
  - Best performing algorithm in Error versus Discard Characteristic (EDC) curve
    - → How much is the FNMR reduced, when poor images are discarded/rejected?





Open Source Face Image Quality (OFIQ) – Pre-Processing

- Face Detection: Bounding box of all detected faces, largest face is assessed further
- Face Landmark Estimation: Localization of 98 key points, most time consuming algorithm
- Alignment: Bring eyes on same height, based on landmarks of eyes, nose & mouth
- Face Occlusion Segmentation: Identify un-occluded region of face
- Face Parsing: Identify different regions of the subject in image (face parts such as eyes, eye brows, nose, lips, skin / neck, ears, hair / glasses, clothes, hats, earrings, necklaces / background)

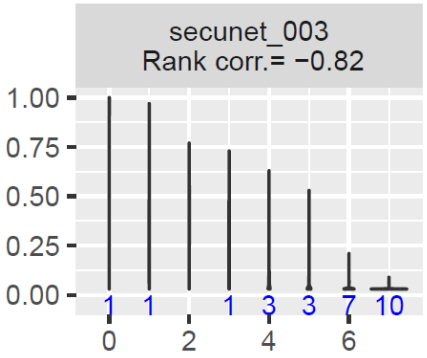



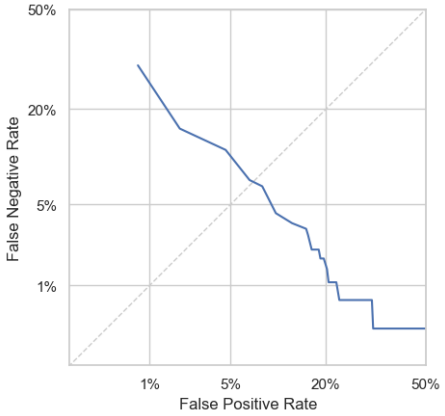

Open Source Face Image Quality (OFIQ) – Quality Components

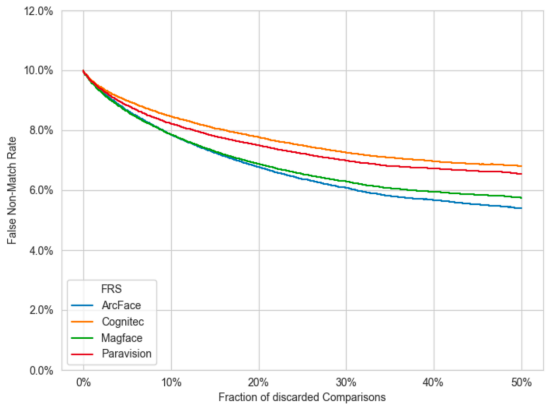
- Example algorithm: Sharpness
  - Restricted to landmarked region
  - Several filters were tested:
    - Laplacian-Filter
    - Difference of image from mean-filtered image
  - Trained on synthetic and real blur
  - Random Forest classifier

Open Source Face Image Quality (OFIQ) – Quality Components

- Example algorithm: Sharpness
  - Very good results in FATE Quality (3rd of 18)
    - Tested with resolution (03’2024)
    - Only synthetic blur
  - Internal evaluation on FRGCv2 (real blur)
    - Accuracy high but not very high
    - Challenging with motion blur







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Open Source Face Image Quality (OFIQ) – Quality Components

- Example algorithm: Eyes Open and Mouth Closed
  - Algorithms based on landmarks
  - Maximum distance between lids / lips

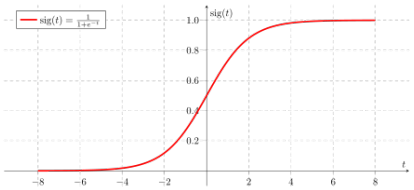
$$D_L = \max\left(\|L_{89} - L_{95}\|_2, \|L_{90} - L_{94}\|_2, \|L_{91} - L_{93}\|_2\right)$$

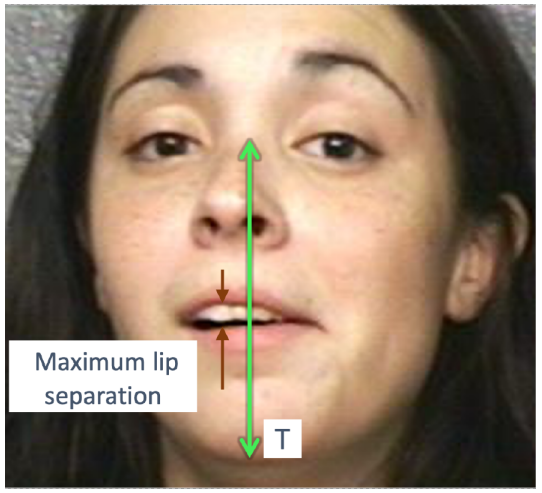
  - Normalized by distance T between eye's midpoint and chin

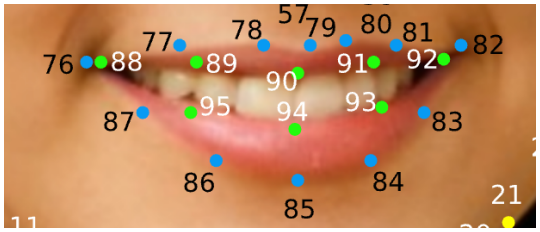
$$T = \left\| \frac{L_{60} + L_{64} + L_{68} + L_{72}}{4} - L_{16} \right\|_2$$

  - Mouth openness aspect

$$\omega = \frac{D_L}{T} \qquad Q = \mathrm{ROUND}(100(1 - \mathrm{SIGMOID}(\omega, 0.2, 0.06)))$$

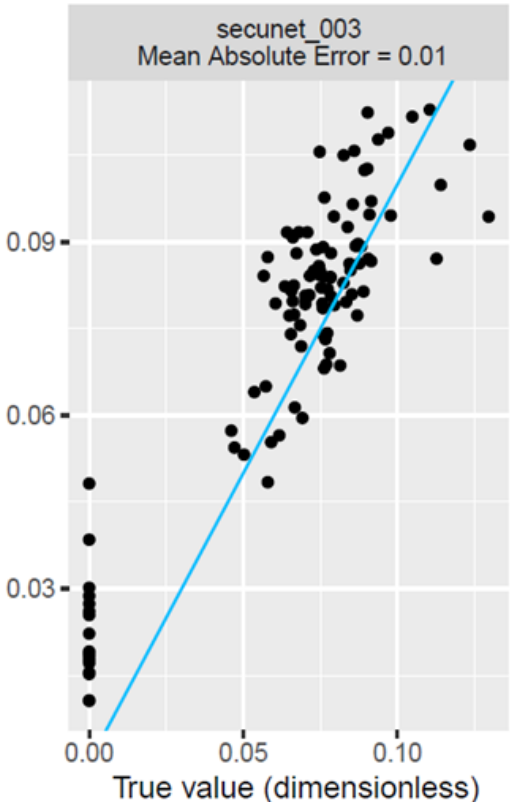




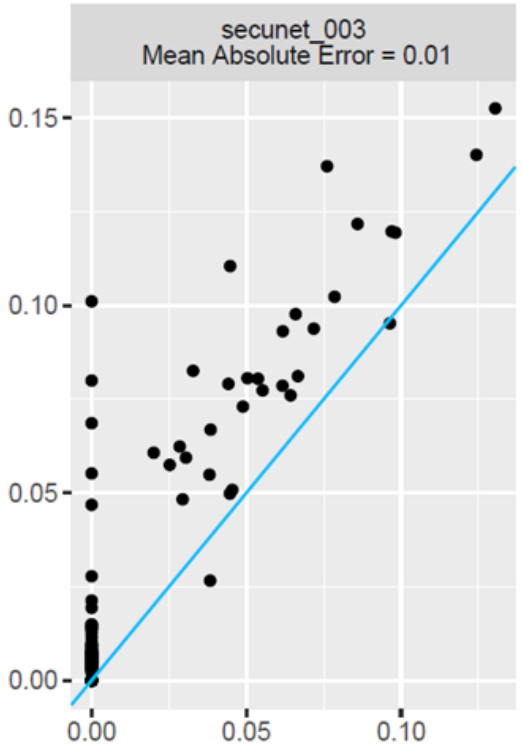


Open Source Face Image Quality (OFIQ) – Quality Components

- Example: Eyes Open and Mouth Closed
  - Excellent results in FATE Quality SIDD
  - 1st of 6 and 1st of 5 (03’2024)
  - No demographic bias found



Eyes Open



Mouth Closed

What‘s next?

Projects OFIQ 1.0 and OFIQ 2.0

- QFIQ 1.0, Status:
  - Current project running
    January 2022 – September 2024
  - OFIQ is the reference implementation
    of ISO/IEC 29794-5
  - Maintenance of OFIQ → eu-LISA
- Perspective
  - First operational use cases:
    - Entry-Exit-System (EES)
    - eu-LISA USK
    - FRONTEX EES App

- OFIQ 2.0, follow-up:
- project will start later this year
  - Further innovation of quality measures
  - Add missing components (e.g. motion blur)
  - Lightweight solutions
  - Investigate fairness of quality measures

Intention: OFIQ Quality Score in eMRTDs as mandatory element

- Usage of OFIQ „Unified Quality Score“ as meta data in chip
- Benefits
  - Quality of facial image is known without new calculation
  - Processes around the chip image can be designed accordingly
    - e.g. border control
    - especially together with „Image Source Type“
  - Improvement of international Interoperability of chip images

7.35 2D capture device technology identifier

Abstract values: The possible values are:

- unknown;
- static photograph from an unknown source;
- static photograph from a digital still-image camera;
- static photograph from a scanner;
- video frame(s) from an unknown source;
- video frame(s) from an analogue video camera;
- video frame(s) from a digital video camera.

Contents: The 2D capture device technology identifier shall indicate the device t
to acquire the captured biometric sample.

source: ISO/IEC 39794-5

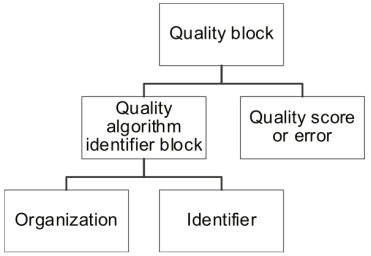
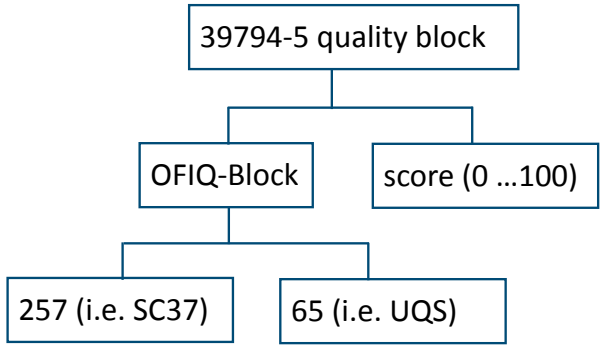


Figure 6 — Structure of a quality block

source: ISO/IEC 39794-1



Intention: OFIQ Quality Score in eMRTDs – Benefit Process Design

- *Meta data in chip can include*
  - *Capture device technology identifier: scanned, live enrolment (digital or video camera), other*
  - *OFIQ Quality Score (0-100)*

- Possible Benefits in Border Control – „low hanging fruits“
  - Image Source Type = „live“ → skip Morphing and Presentation Attack Detection → save time
  - OFIQ Score present → skip assessment of chip image → save time
  - OFIQ Score < x → prohibit usage of automated (self-service) systems → increase security
  - OFIQ Score > y → allow enrolment in databases → increase overall data quality

Intention: OFIQ Quality Score in eMRTDs – Benefit Interoperability

- *Meta data in chip can include*
  - *Capture device technology identifier: scanned, live enrolment (digital or video camera), other*
  - *OFIQ Quality Score (0-100)*

- Possible Benefits for Interoperability
  - Chip image Quality is the same everywhere (Open Source, transparent)
  - Allows homogenous quality levels in (national/international) databases and systems
  - Comparison with commercial algorithms possible

Proposal: OFIQ Quality Score in eMRTDs

- OFIQ 2.0 will look deeper into bias etc.
- OFIQ 2.0 will enhance algorithms and runtimes

- **Proposal:**
  - **Investigate usage of OFIQ 2.0 for chip meta data**
  - **Start Technical Report**

Thank you! Questions?

Take home information

OFIQ information: https://bsi.bund.de/dok/OFIQ-e

OFIQ open source code: https://github.com/BSI-OFIQ/OFIQ-Project

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

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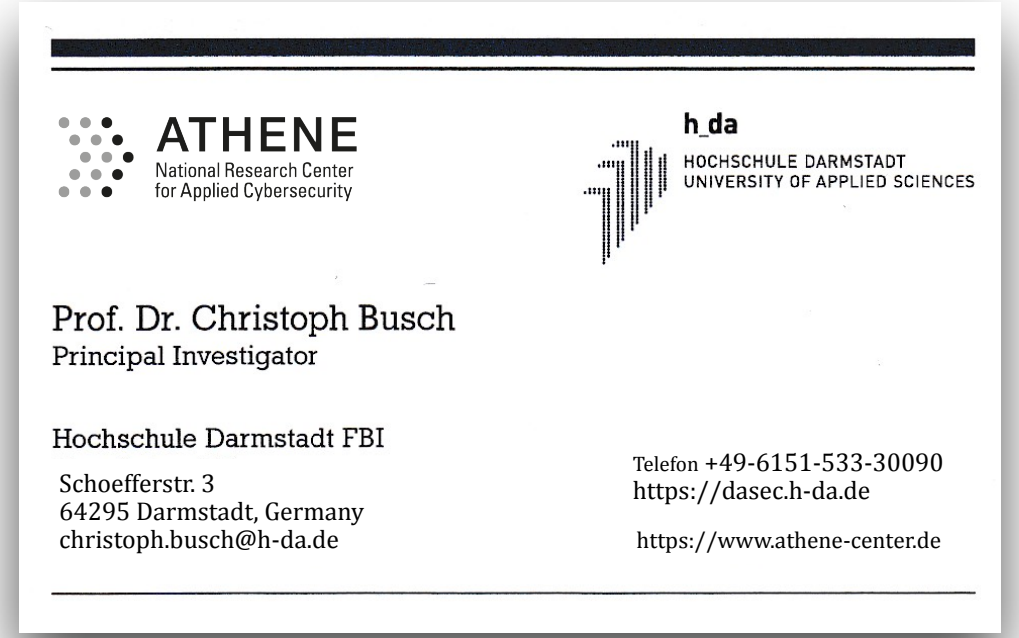

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