

Biometric Sample Quality: Open Source Face Image Quality (OFIQ)

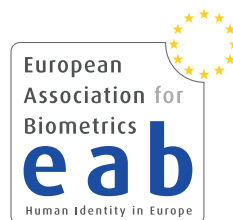
eu-LISA Research Lunch Talk
2024-11-19

Christoph Busch

copy of slides available at:

<https://christoph-busch.de/about-talks-slides.html>

ATHENE / Hochschule Darmstadt, Germany
Norwegian University of Science and Technology (NTNU), Norway



Agenda

Agenda

- Motivation for Biometric Sample Quality
- Biometric quality standards developed in SC37
- ISO/IEC 29794-5
- Open source face image quality (OFIQ)
- Deployment
- Ongoing research

Objective of OFIQ

What happened in the last 4 years?

- Project by German Federal Office for Information Security (BSI)
- Aligned with ISO/IEC standardisation
- Implementation by Secunet Security Networks AG
- Supported by
 - the ISO/IEC SC37 community,
 - ATHENE, iMARS and others
 - eu-LISA

Thanks to BSI for supporting quality assessment standards

Motivation for Quality Assessment

Motivation for Face Image Quality Assessment (FIQA)

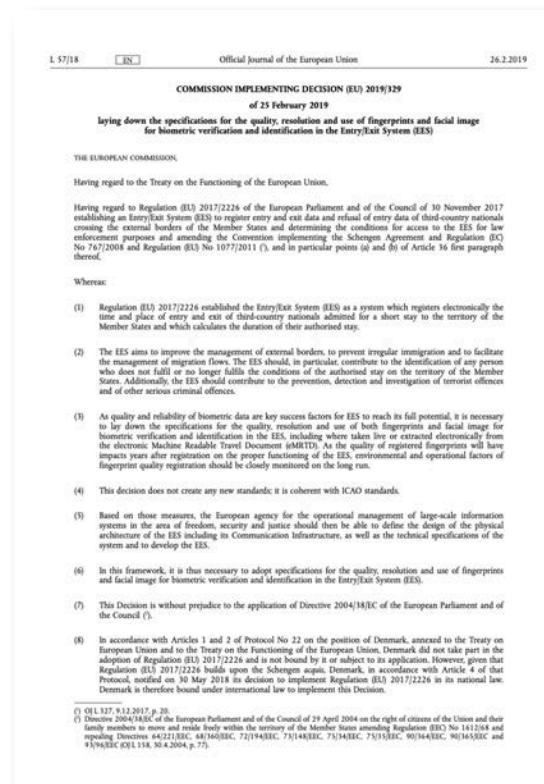
- Quality matters, especially in **large-scale databases** and with diverse **application scenarios**.
 - ▶ The European Entry Exit System will start soon
- **Standardization** and harmonization is essential for (semantic) **interoperability**.



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 ...*“



Quality Requirements for Face Image Data

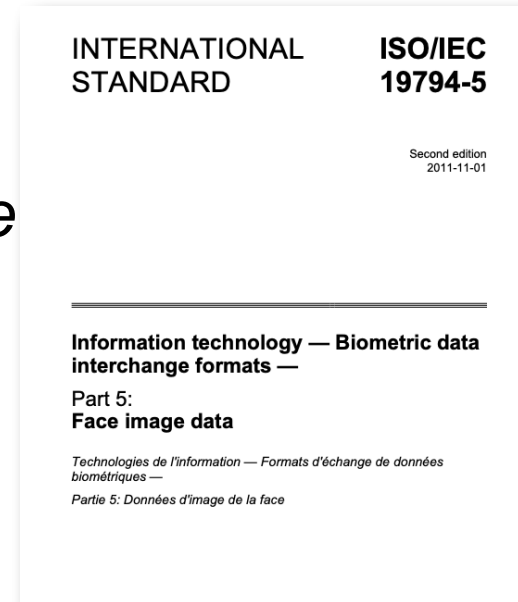
The requirement in EES implementing decision 2019/329

- „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**

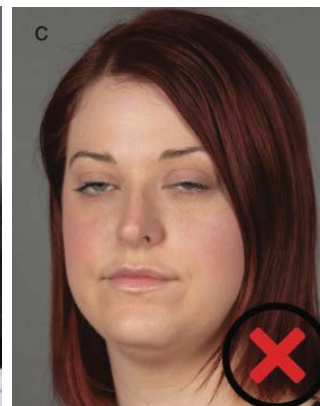
- If quality is poor, then what went wrong?



Compliant image



Pose



Eyes open



Mouth open



Inhomogenous background

Source: ISO/IEC 39794-5

Quality Measures for Facial Images

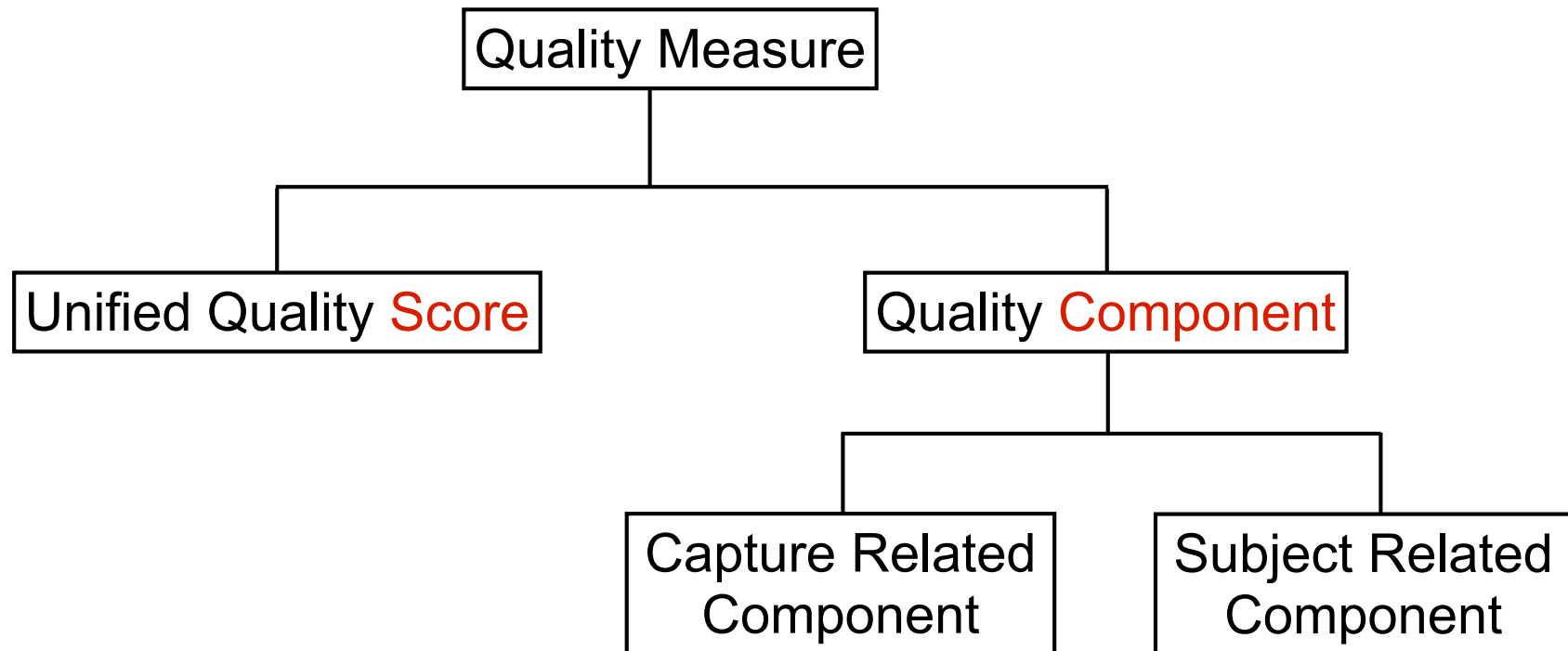
How to develop face quality measures? - Standardisation

- 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 FDIS 29794-5 quality **measures** in detail

#	Face image quality measure
1.	Quality score (unified)
2.	Background uniformity
3.	Illumination uniformity
4.	Luminance <u>mean</u>
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

Capture device related

Explainable Quality Assessment

Subject related



a) Compliant image b) Low contrast
Image Source: ISO/IEC 39794-5



Image Source: ISO/IEC 39794-5

Image Source:ISO/IEC FDIS 29794-5

Open Source Face Image Quality (OFIQ)

Approach

- **Library** with quality assessment **algorithms**
- Open source
 - ▶ 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** (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?

- Accuracy 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
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 - Specific Image Defect Detection (SIDD)

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



OFIQ - Unified Quality Score

General, holistic **unified quality score** (OFIQ-UQS)

- Determine an overall quality score for the picture
 - ▶ 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 Error versus Discard Characteristic (EDC) curve
 - ▶ How much is the FNMR reduced, when poor images are discarded/rejected?

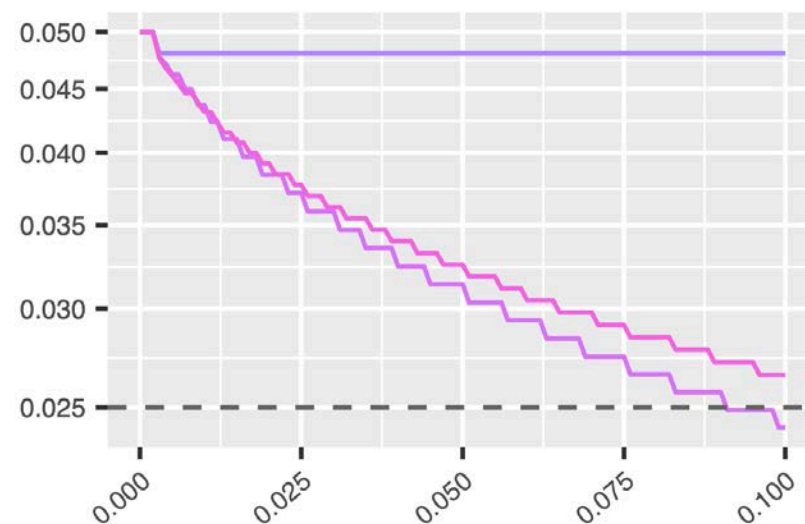
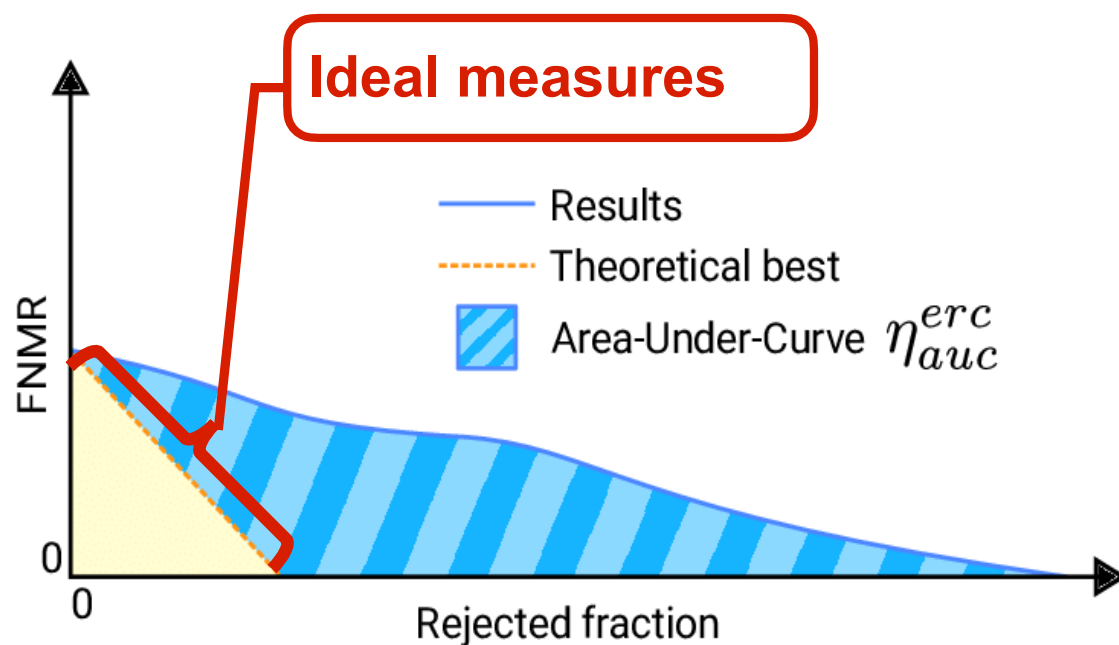


Image Source: NIST FATE SIDD report

Open Source Face Image Quality (OFIQ)

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)

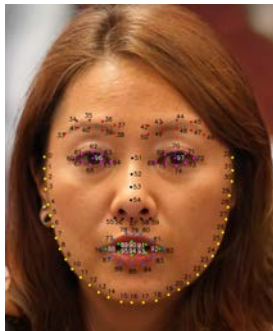
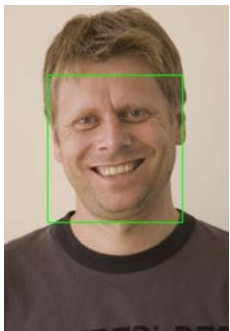


Image Source: OFIQ public report and ISO/IEC FDIS 29794-5

OFIQ - Quality Components

Example algorithm: **Sharpness**

- Detecting the sharpness of an image
- Is the **subject** in focus or the background?

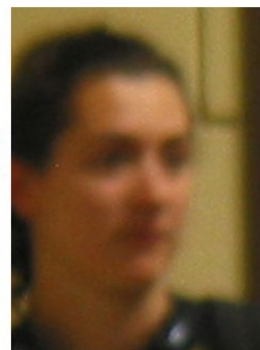


Image Source: FRGCv2 database

- Restricted to landmarked region



Image Source: OFIQ public report

OFIQ - Quality Components

Example algorithm: Mouth Closed

- Detecting if the mouth is closed
- Algorithms based on **landmarks**
- **Maximum distance between lips**
- Normalized by distance T between eye's midpoint and chin

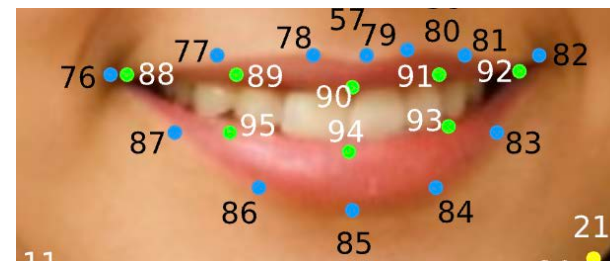


Image Source:ISO/IEC FDIS 29794-5

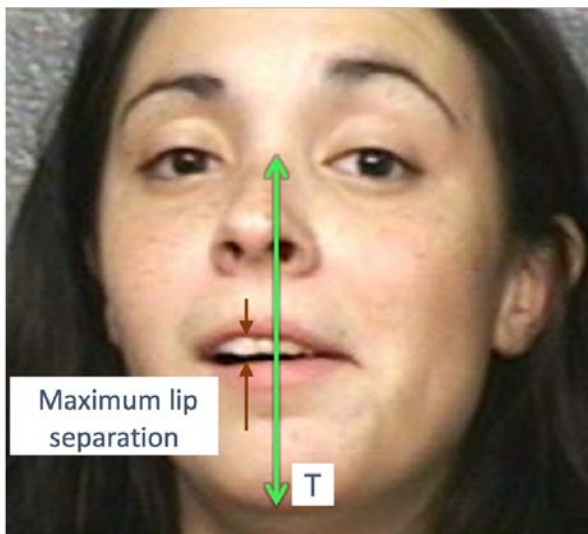
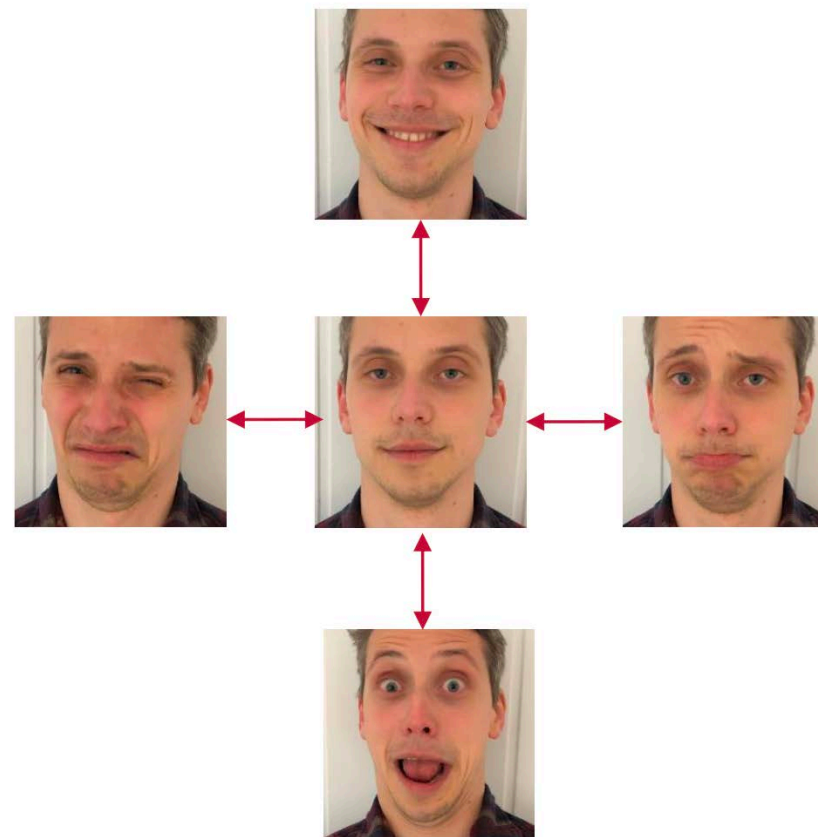


Image Source:NIST FATE SIDD report

OFIQ - Quality Components

Example algorithm: **Expression** Neutrality

- Detecting the neutral expression of a face
- Known fact:
 - ▶ reduced biometric performance for **extreme** facial expressions
 - ▶ best-possible **utility** through neutral expressions
- Goal:
 - ▶ **quantify** expression neutrality



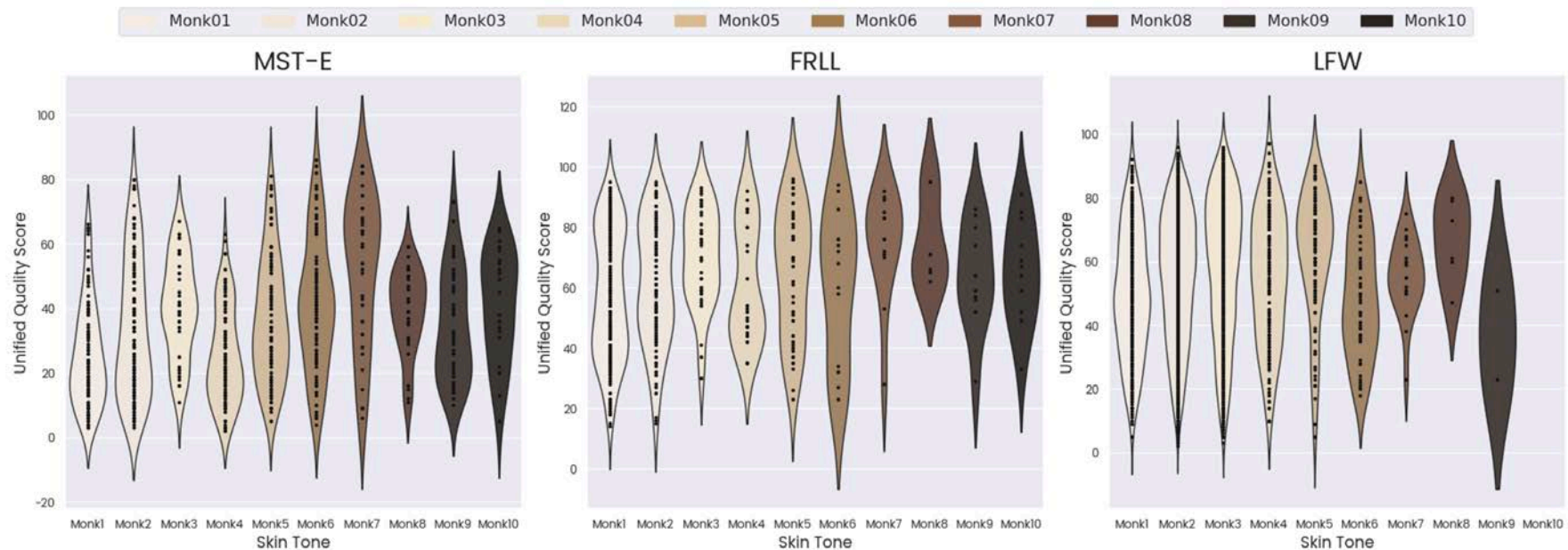
[GRVB2023] M. Grimmer, C. Rathgeb, R. Veldhuis, C. Busch: "NeutrEx: A 3D Quality Component Measure on Facial Expression Neutrality", in Proceedings of International Joint Conference on Biometrics (IJCB), (2023)

[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)

Future work

Open research tasks

- Further **innovation** of quality measures
- Add **missing** components (e.g. **motion blur**)
- Investigate **demographic variability**
 - ▶ Unified quality score **distributions** across MST 10 skin tone scale



[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)

Summary

Summary

- OFIQ determines an **overall quality score** for a face image
- Face image quality assessment is **accurately possible** with open source algorithms
- OFIQ provides **explainable feedback** to the user on why a face image is of insufficient quality
- Better image quality leads to **better recognition performance**

Outlook

Status of OFIQ

- OFIQ is the **reference implementation** of ISO/IEC 29794-5
- Maintenance of OFIQ → eu-LISA

Perspective

- First operational use cases:
 - ▶ Entry-Exit-System (EES) enrolment at German airports
 - ▶ eu-LISA USK

Questions and Answers?

Take home information

- OFIQ open source code:
<https://github.com/BSI-OFIQ/OFIQ-Project>
- Image Source: 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>



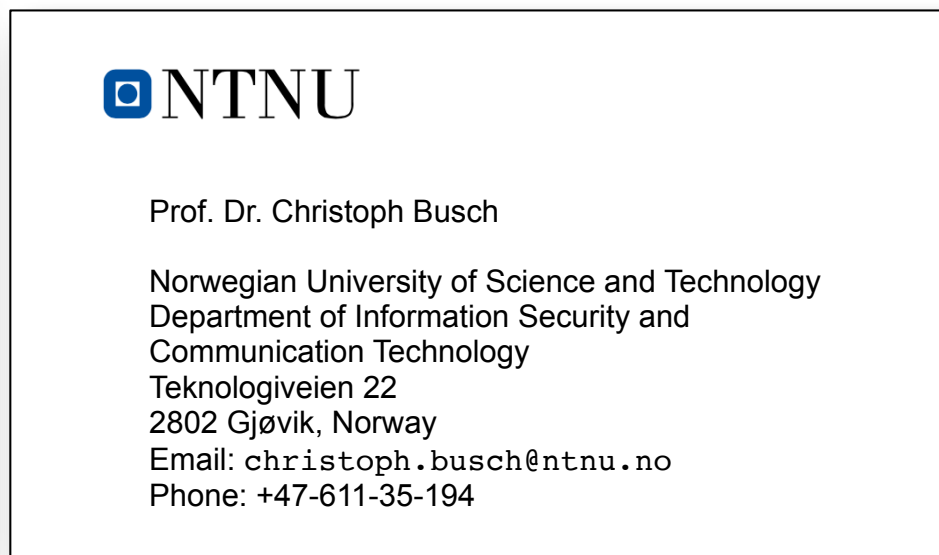
ATHENE
National Research Center
for Applied Cybersecurity

h_da
HOCHSCHULE DARMSTADT
UNIVERSITY OF APPLIED SCIENCES

Prof. Dr. Christoph Busch
Principal Investigator

Hochschule Darmstadt FBI
Schoefferstr. 3
64295 Darmstadt, Germany
christoph.busch@h-da.de

Telefon +49-6151-533-30090
<https://dasec.h-da.de>



NTNU

Prof. Dr. Christoph Busch

Norwegian University of Science and Technology
Department of Information Security and
Communication Technology
Teknologiveien 22
2802 Gjøvik, Norway
Email: christoph.busch@ntnu.no
Phone: +47-611-35-194