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

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Agenda

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- 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 Securet 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 ..."

L 57/18	EN.	Official Journal of the European Union	26.2.2015				
	83	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)						
TH	THE EUROPEAN COMMENSION,						
Ha	Having regard to the Treaty on the Functioning of the European Union,						
esta cro end No	Horing regard to Regulation (BD 2017)2225 of the Intersector Pointment and of the Courted of 10 November 2017 resulting as Europhit Syntoms BD response runs was class also and need for the Anti-Chevenery networks crossing the external borders of the Member Stams and determining the conditions for access to the EES for law enforcement purposes and anterneding the Courseling implementing the Schweng Argeneran and Regulation (BZ). No 767/2006 and Regulation (BZ) No 1077/2011 (3), and in particular points (4) and (b) of Article 16 first paragraph thereod.						
W	ereas:						
(1)	time and place of en	(2226 established the Entry/Exit System (EES) as a system which regi try and exit of third-country nationals admitted for a short stay t hich calculates the duration of their authorised stay.	isters electronically the to the territory of the				
(2)	the management of m who does not fulfil o	ove the management of external borders, to prevent irregular immig signation flows. The EES should, in particular, contribute to the ident or no longer fulfils the conditions of the authorised stay on the ten the ES should contribute to the prevention, detection and investigatis riminal offences.	ification of any person rritory of the Member				
(3)	to lay down the spo- biometric verification the electronic Machin impacts years after re-	ity of biometric data are key success factors for EES to reach its full p cifications for the quality, resolution and use of both fingerprints and identification in the EES, including where taken line or estrata in Readule Travel Document (MRTD). As the quality of registration guitzation on the proper functioning of the EES, environmental and attration inhould be closely monitored on the long run.	and facial image for ted electronically from fingerprints will have				
(4)	This decision does not	t create any new standards; it is coherent with ICAO standards.					
(5)	systems in the area of	sures, the European agency for the operational management of 1 of freedom, security and justice should then be able to define the 3 5 including its Communication Infrastructure, as well as the technic- p the EES.	design of the physical				
(6)	In this framework, it and facial image for bi	is thus necessary to adopt specifications for the quality, resolution a iometric verification and identification in the Entry/Exit System (EES).	and use of fingerprints				
(7)	This Decision is withe the Council (').	out prejudice to the application of Directive 2004/18/EC of the Europ	pean Parliament and of				
(8)	European Union and t adoption of Regulation Regulation (EU) 2017 Protocol, notified on	rticles 1 and 2 of Protocol No 22 on the position of Demmark, and to the Tursty on the Functioning of the European Usion, Demmark 6 m (33) 2017/2266 and is not boomd by it or subject to its application r(2226 builds upon the Schengen acquit. Demmark, in accodance 20 May 2018 its decision to implement Regulation (33) 2017/22.	lid not take part in the e. However, given that with Article 4 of that				
	family members to move and	European Pachament and of the Council of 29 April 2004 on the right of citize 1 reside freely within the territory of the Member Status amending Regulation Reg. 64/3642017, 7219498[127: 73148]	e (EEC) No 1612/68 and				

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 typ

What does that mean?

Data subjects need actionable feedback

If quality is poor, then what went wrong?

	INTERNATIONAL STANDARD	ISO/IEC 19794-5			
be		Second edition 2011-11-01			
	Information technology — Biometric o interchange formats —				
	Part 5: Face image data				
	Technologies de l'information — Formats d'éch biométriques — Partie 5: Données d'image de la face	ange de données			



Compliant image



Pose



Eyes open





Inhomogenous background

Source: ISO/IEC 39794-5

Christoph Busch

Quality Measures for Facial Images

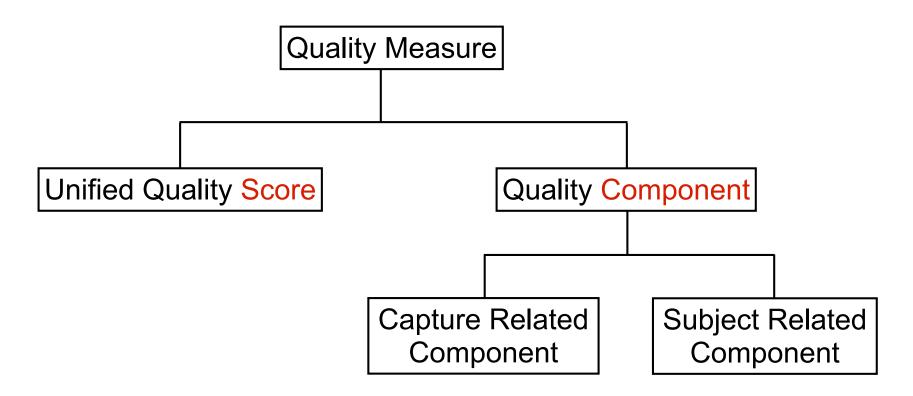
How to develop face quality measures? - Standardisation

- 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)			a b
2.	Background uniformity			Contraction of the second
3.	Illumination uniformity			
4.	Luminance mean			
5.	Luminance variance			
6.	Under-exposure prevention			
7.	Over-exposure prevention		—— Capture device related	
8.	Dynamic range	[a) Compliant image b) Low contrast
9.	Sharpness			Image Source: ISO/IEC 39794-5
10.	No compression artefacts			
11.	Natural colour			
12.	Single face present			
13.	Eyes open		Explainable Quality Assessment	
14.	Mouth closed			
15.	Eyes visible			
16.	Mouth occlusion prevention			-
17.	Face occlusion prevention			$ \land \land$
18.	Inter-eye distance			
19.	Head size		Subject related	
20.	Leftward crop of face in image	- r		
21.	Rightward crop of face in image			
22.	Margin above face in image			
23.	Margin below face in image			Image Source: ISO/IEC 39794-5
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 FDIS 29794-5	

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Open-Source Face Image Quality

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)
 - Iow computational complexity
 - Iberal license (MIT or alike)

Quality Measures for Facial Images



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How to find the best face quality measures?

Accuracy testing



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Category	ISO/IEC 29794-5 Quality Check	SIDD Quality Componen	
pture	6.3.2 Background uniformity	Background uniformity	
vice-related	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		
bject-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		

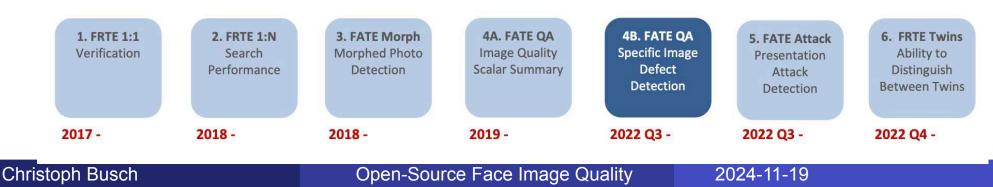


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FATE Quality - Specific Image Defect Detection (SIDD)

Sub

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

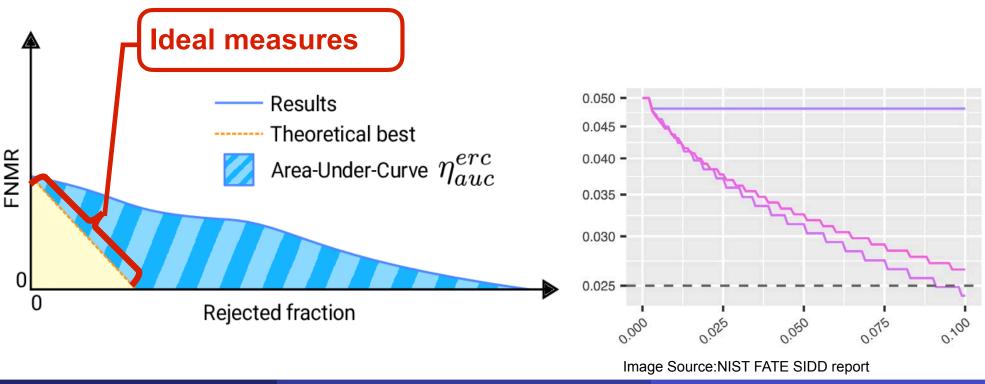
OFIQ-UQS=26

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?



Open-Source Face Image Quality

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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 most is closed
- Algorithms based on landmarks
- Maximum distance between lips
- Normalized by distance T between eye's midpoint and chin

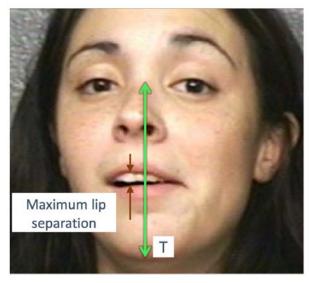


Image Source:NIST FATE SIDD report

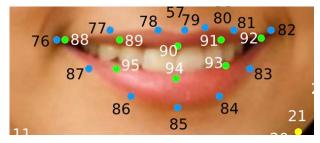


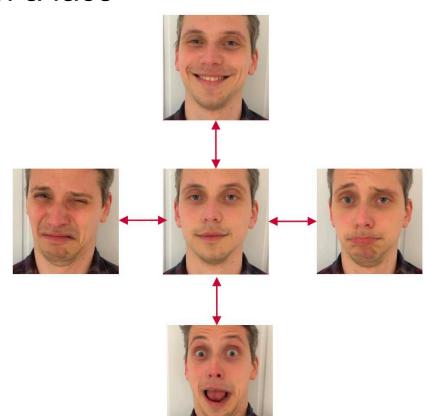
Image Source: ISO/IEC FDIS 29794-5

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



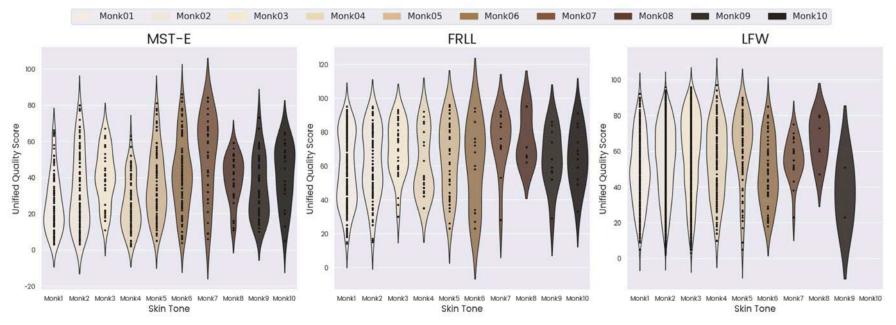
[GRVB2023] M. Grimmer, C. Rathgeb, R. Veldhuis, C. Busch: "NeutrEx: A 3D Quality Component Measure on Facial Expression Neutrality", in Proceedings of International Joint Conference on Biometrics (IJCB), (2023)

[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

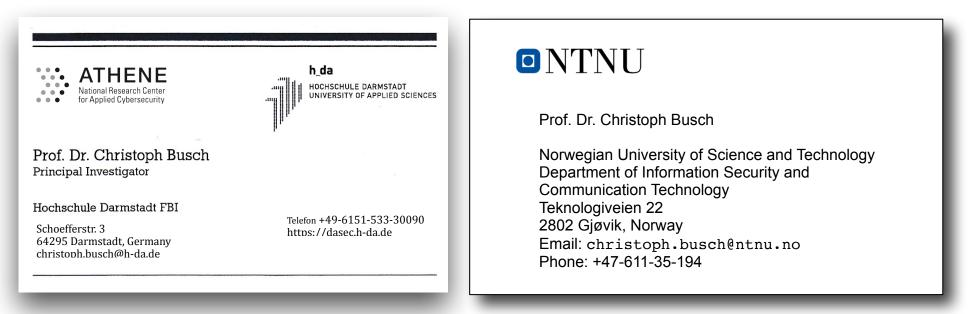
https://github.com/BSI-OFIQ/OFIQ-Project/blob/main/doc/reports/Public_Report_V1.1_2024_09_30.pdf

• 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



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