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ISO/IEC FDIS 29794-5

Information technology — Biometric sample quality —

Part 5: Face image data

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 37, *Biometrics*.

This first edition cancels and replaces the first edition of ISO/IEC TR 29794-5:2010 which has been technically revised.

The main changes are as follows:

— the document has been completely revised to become an International Standard;

— information on the role of quality measures has been added;

— requirements on quality software have been added.

A list of all parts in the ISO/IEC 29794 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

Adoption of deep learning techniques has caused error rates associated with automated face recognition tasks to be reduced. However, errors still occur and are often related to imaging, human factors, the level of biometric capture subject cooperation, the comparison algorithm, and its associated threshold and decision logic. Without significant modernization of capture procedures, recognition errors will become more prevalent as volumes increase. This document is aimed at reducing errors due to image quality, through the use of quality assessment algorithms. Quality assessment algorithms have several roles (see Annex C), primarily those related to sample capture. Drivers for improved capture are as follows.

— Need for improved usability — The general improvement of biometric systems has highlighted that improved usability for both biometric capture subjects and human operators can reduce errors through the improvement of capture. Without a careful consideration of both biometric capture subjects and system operators, system designers risk seeing the limitations inherent in using technology alone.

— Increasing volumes — Vast numbers of face images are being collected in many commercial, civil identity management and law enforcement applications. These photographs are used as reference enrolment samples, or as recognition probes that, in turn, sometimes later serve as references.

— New programs — Future large-scale programs will employ face recognition: For example, in China the railway transportation system uses face recognition for identity verification and to improve passenger check-in efficiency. The European Union uses face recognition for biometric exit confirmation. The United States currently uses face recognition for immigration exit and vessel boarding. In India, the Aadhaar program allows face recognition for authentication.

— Face-blind cameras — Historically, many face images were collected using cameras that were not face-aware. In contrast, in some situations concerning fingerprint and iris biometrics, capture devices run in an auto-capture quality-assessment loop, with explicit awareness of the kind of image intended for collection.

— Reliance on imaging design specifications — Faces collected for ID credentials and authoritative databases are largely collected using cameras set up according to published documentary standards, most recently ISO/IEC 39794-5, regulating geometry and photography. In the best case, face images from such collections are then checked with image compliance tools. When photographs are collected by a human photographer, this can be without any automated quality assessment, relying only on the photographer to check conformance.

— Behaviour not intended by the relevant capture standard — Some recognition failures arise from biometric capture subjects effecting differences in presentation in reference and probe images. Standards define a canonical presentation to be centred and frontal with neutral expression, eyes-open and without eyewear. Facial recognition systems are expected to operate accurately across a wide range of individuals who vary in age, body size, ethnicity, language, culture, literacy and familiarity with technology. Careful human factors design is vital to the acquisition of canonical images and improved face image capture.

— Quality assessment is separated from the capture process — In many cases, a photograph is captured and later submitted to a backend server while ensuring no image tampering occurs, where it is assessed for quality. If poor quality is detected (by human or automated means), re-capture is initiated hours or days later, when possible, with another encounter and attendant expense.

Regarding image quality, Table 1 lists characteristics of face image quality relating to the biometric capture subject and characteristics relating to the capture process, demonstrating that issues due to mis-presentation (often associated with human factors design) and issues related to imaging are in many cases separable. For example, photographs can be systematically de-focused even when the biometric capture subjects present perfectly.

Table 1 — Characterization of face image quality

	Biometric capture subject characteristics	Capture process
Static properties	Biological characteristics; — injuries and scars, — dermatological conditions, — etc.	Capture process and capture device properties: — image resolution, — optical distortions, — sub-optimal camera angle, — field of view, — etc.
	Other static characteristics: — thick or dark glasses, — permanent jewellery, — makeup and cosmetics, — etc.	Static properties of the background: — (textured) wallpaper.
		Affordance: — properties of a data capture subsystem that intuitively imply its functionality and use to biometric capture subjects, — human-centric system physical and process design.
Dynamic properties	Behaviour: — exaggerated expression, — hair across the eye, — facial hair, — etc.	Scenery: — background moving objects, — variation in lightning.
		Capture device variation: — de-focus, — camera vibration, — sub-optimal camera angle, — poor exposure, — etc.

By defining image quality measurements, this document is intended to improve the accuracy of automated face recognition systems. Quality can be tied to recognition accuracy (see Annex B). Improved quality can also improve human review of images. The quality measures included in this document were selected because guidance on how to control them has already been included in ISO/IEC 39794-5. The implementations of some quality measures were evaluated for performance.[62] The reference implementation defines quality measures that use external algorithms with licence conditions.[58]

This document recognizes the Open Face Image Quality (OFIQ)[60] project as the reference implementation of the requirements of the document. It is open-source.[59] Other quality algorithm implementations can conform to this document as described in Clause 5.

Some of the computations of this document can be effective on images captured with illumination at non-visible wavelengths.

Encoding of quality data is defined in ISO/IEC 29794-1. The methodology for performance evaluation of quality assessment algorithms is also defined in ISO/IEC 29794-1.

NOTE Use of this document can be subject to local regulations.

Information technology — Biometric sample quality —

Part 5:
Face image data

1 Scope

This document establishes requirements on implementations that quantify how a face image's properties conform with those of canonical face images, for example those specified in ISO/IEC 39794-5:2019, Clause D.1, for three use-cases:

1) collection of reference samples for ID documents;

2) sample system enrolment; and

3) probes for instantaneous response.

This document also establishes terms and definitions for quantifying face image quality and specifies methods for quantifying the quality of face images.

This document does not establish requirements on:

— assessing the quality of pairs or sequences of images;

NOTE This document establishes requirements for software that inspects exactly one image. This document does not establish requirements for software that compares two or more images (such as biometric recognition). However, the computations of this document can be applied separately to each image in a pair or sequence.

— assessing the quality of 3D captures;

— encodings of face image quality data;

— performance evaluation of face image quality assessment algorithms.

The use cases within scope of this document primarily address the assessment of images from data capture subjects who consent to processing of their biometric data, or for whom biometric capture is operationally authorized.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 29794-1, *Information technology — Biometric sample quality — Part 1: Framework*

ISO/IEC 39794-1:2019, *Information technology — Extensible biometric data interchange formats — Part 1: Framework*

ISO/IEC 39794-5:2019, *Information technology — Extensible biometric data interchange formats — Part 5: Face image data*

ISO/IEC 19794-1:2011, *Information technology — Biometric data interchange formats — Part 1: Framework*

ISO/IEC 2382-37, *Information technology — Vocabulary — Part 37: Biometrics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 2382-37, ISO/IEC 29794-1, ISO/IEC 39794-5 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
canonical face image
face image conformant to an external standard or specification of a reference face image

Note 1 to entry: In many applications, the canonical face image is that given in ISO/IEC 39794-5:2019, Clause D.1, which specifies a reference face image for a machine-readable travel document.

Note 2 to entry: Most of the computations of this document can be effective on images captured in automated border control gates, visa images and other server-side images, which are in scope of this document.

3.2
de-focus
aberration in which an image or part of an image is out of focus

Note 1 to entry: De-focus tends to reduce the sharpness and contrast of the image.

3.3
face detection
process of determining whether and where faces are present in an image

3.4
face image
electronic image-based representation of the face of a capture subject

Note 1 to entry: Any image captured for use-cases 1 – 3 described in Clause 5 is considered as a face image.

Note 2 to entry: ISO/IEC 39794-5 includes a definition for face portrait as the visual representation of the capture subject, which includes the full-frontal part of the head, including hair in most cases, as well as neck and possibly top of shoulders. Face portraits appear in several places on and in a machine-readable travel document (MRTD).

Note 3 to entry: Given an image that has a roll angle of 90 ° or more (which is far from the presentation intended by ISO/IEC 39794-5:2019), a QAA can assign low quality component values or fail to return a record

[SOURCE: ISO/IEC 39794-5:2019, 3.27, modified — Notes to entry have been added.]

3.5
face bounding box
rectangle containing the central region of interest of a face visible in the face image

Note 1 to entry: The face bounding box is used for the estimation of landmarks to restrict the face image to the region of interest.

Note 2 to entry: The face bounding box is the result of the face detection process as defined in 6.4.

3.6
face landmarks
set of anthropometric points in the image marking the contour and different parts of the face

Note 1 to entry: The face landmarks are computed by the algorithm in 6.5.

3.7
landmarked region
minimal convex region of the face image containing all face landmarks

Note 1 to entry: The landmarked region of the face is defined by the landmark estimation algorithm, as described in 6.5. It encompasses the area from (and including) eyebrows to chin and from (but excluding) left ear to right ear.

Note 2 to entry: The inner region, as defined in ISO/IEC 39794-5:2019, 3.39 and D.2.2, is a coarse approximation of the landmarked region.

3.8
face alignment
process of rotating, translating and scaling a face image so that the transformed image has certain dimensions and the eyes, nose and mouth corners are approximately located at pre-defined locations in the transformed image, and applying the same transformation to the face landmarks

3.9
face parsing
process of assigning semantic labels to regions contained in a face image specifying the part of the subject depicted in the region

Note 1 to entry: The set of parts to which the pixels are assigned comprises various parts of the face, neck, hair, clothing and various accessories. Pixels not belonging to the subject (background) are assigned to the value 0.

3.10
native quality measure
output of a quality assessment algorithm without constraints on data format and/or value range

[SOURCE: ISO/IEC 29794-1:2024, 3.10]

3.11
pose estimation
process of determining the 3-axis rotation of the head in an image

Note 1 to entry: Pose estimation requires a specified coordinate system for definition of the angles and their sense (left hand vs. right hand). The default choice is given in ISO/IEC 39794-5:2019, 7.21.

3.12
sharpness
clarity of fine details in an image

Note 1 to entry: Sharpness will be improved with precise focus, good imaging resolution, and absence of biometric capture subject motion relative to the camera.

3.13
ICC profile
International Color Consortium profile
set of data that characterizes colour input or output by defining the mapping between the data and a profile defined colour space

Note 1 to entry: ICC profiles (e.g. sRGB and ROMM RGB) are intended to provide a standard approach to colour management needs.

Note 2 to entry: The captured face portrait is a true-colour representation of the holder in a typical colour space such as sRGB. Other true-colour representations, such as Adobe RGB (1998) or ProPhoto RGB (ROMM RGB), are used as specified in ISO/IEC 39794-5: 2019, D.1.4.2.9.

3.14
quality assessment algorithm
quality algorithm
algorithm to calculate a quality measure

Note 1 to entry: The ISO/IEC 19785 series uses the term "quality algorithm".

[SOURCE: ISO/IEC 29794-1:2024, 3.13]

4 Abbreviated terms

For the purposes of this document, the acronyms and abbreviated terms given in Table 2 apply.

Table 2 — Acronyms and abbreviated terms

Acronym/ abbreviated term	Definition
BGR	colour space with the order of colours (blue, green, red)
BU	background uniformity
CNN	convolutional neural network
DFT	discrete Fourier transform
EVZ	eye visibility zone
ICC	International Color Consortium
IED	inter-eye distance
IM	illumination mean
IU	illumination uniformity
NaN	not a number
QAA	quality assessment algorithm
QC	quality component
QCV	quality component value
OFIQ	Open Source Face Image Quality
QM	quality measure
OpenCV	OpenCV version 4.5.5
QS	(unified) quality score
RGB	colour space with the order of colours (red, green, blue)
UC	use-case

5 Conformance

A claim of conformance to this document is made by asserting support for one or more use-case(s) (see below) and a dated edition of this document.

To conform with this document, a face image quality assessment implementation shall:

— implement the computations marked as mandatory (M) in Table 3 for the claimed use case(s);

— conform to the requirements of Clauses 6 and 7;

— conform to the requirements of 8.1 and 8.2 (face image quality block encoding); and

— meet the requirements specified in Annex A.

Conformance to the requirements of Clause 8 fulfils Level 1 and Level 2 conformance as specified in ISO/IEC 39794-1:2019, Annex C. Conformance to the requirements of 7.2, 7.3 and 7.4 fulfils Level 3 conformance as specified in ISO/IEC 39794-1:2019, Annex C.

NOTE 1 Organizations deploying quality assessment algorithms in the various use cases can choose to compute the provided quality measures and to relate their values to any use-case specific thresholds.

NOTE 2 For standardized interchange of quality values produced by implementations of this document, ISO/IEC 29794-1 defines a standardized quality block and requires quality measures to be an integer between 0 and 100.

Three use-cases are considered:

— UC1: Collection of reference samples for ID documents. The face image will be stored on a document, used for example for a maximum of 10 years, and should support human examination.

— UC2: System enrolment, current or later creation of a reference, delayed recognition. Acquisition of face images where quality should be high enough to ensure later usage and interoperability.

— UC3: Collection of probe samples for instantaneous recognition. Single use face image with instantaneous response.

Table 3 — Conformance requirements by activity

#	Face image quality measure	Sub-clause	UC1 (ID Documents)	UC2 (System enrolment)	UC3 (Probe for instantaneous recognition)
1.	Quality score (unified)	7.2	M	M	M
2.	Background uniformity	7.3.2	M	O	O
3.	Illumination uniformity	7.3.3	M	O	O
4.	Luminance mean	7.3.4.2	O	O	O
5.	Luminance variance	7.3.4.3	M	O	O
6.	Under-exposure prevention	7.3.5	O	O	O
7.	Over-exposure prevention	7.3.6	O	O	O
8.	Dynamic range	7.3.7	M	O	O
9.	Sharpness	7.3.8	M	O	O
10.	No compression artefacts	7.3.9	O	O	O
11.	Natural colour	7.3.10	O	O	O
12.	Single face present	7.4.2	M	M	O
13.	Eyes open	7.4.3	M	O	O
14.	Mouth closed	7.4.4	M	M	O
15.	Eyes visible	7.4.5	M	M	O
16.	Mouth occlusion prevention	7.4.6	M	M	O
17.	Face occlusion prevention	7.4.7	M	M	O
18.	Inter-eye distance	7.4.8	M	M	M
19.	Head size	7.4.9	M	M	M
20.	Leftward crop of face in image	7.4.10.1	M	M	M
21.	Rightward crop of face in image	7.4.10.2	M	M	M
22.	Margin above face in image	7.4.10.3	M	M	M
23.	Margin below face in image	7.4.10.4	M	M	M
24.	Pose angle yaw frontal alignment	7.4.11.2	M	M	O
25.	Pose angle pitch frontal alignment	7.4.11.3	M	M	O
26.	Pose angle roll frontal alignment	7.4.11.4	M	M	O
27.	Expression neutrality	7.4.12	M	O	O
28.	No head covering	7.4.13	M	O	O
29.	Radial distortion	D.2.1	O	O	O
30.	Pixel aspect ratio	D.2.2	O	O	O
31.	Gaze	D.3.1	O	O	O

Key

M mandatory for the QAA to implement this quality measure

O optional

Table 3 *(continued)*

#	Face image quality measure	Sub-clause	UC1 (ID Documents)	UC2 (System enrolment)	UC3 (Probe for instantaneous recognition)
32.	Shoulder presentation	D.3.2	O	O	O
33	Camera subject distance	D.3.3	O	O	O
34	Motion blur prevention	D.3.4	O	O	O
Key					
M mandatory for the QAA to implement this quality measure					
O optional					

6 Common computations

6.1 Overview

Quality measures defined in this document can be applied to either 8 bit encoded greyscale images, or 24 bit encoded colour images. Clause 6 supports the computations in Clause 7 by defining certain steps that appear in more than one of its subclauses.

Several subclauses of Clauses 6 and 7 reference the usage of the pre-trained neural networks listed in Table 4. For each, their implementation description, model, weights, and alternative implementations, are provided in Reference [58].

Table 4 — List of neural networks used in computations of Clauses 6 and 7

#	Clause	Model	Implementation	Dataset
1	6.4	Face detection	See Reference [30]	NA
2	6.5	Face landmark estimation	See Reference [53]	Wider Facial Landmarks in the Wild (WFLW) See Reference [31]
3	6.8	Face parsing	See Reference [68]	CelebMask-HQ[69]
4	6.9	Face extraction	See Reference [32]	CelebMask-HQ[69]
5	6.11	Head pose estimation	See Reference [50]	300W-LP[70]
6	7.2	Unified quality	See Reference [53]	MS1MV2[54]
7	7.3.9.2	No Compression artefacts	See Reference [58]	OFIQ Development Dataset[60]
8	7.4.12.2	Expression neutrality	See References [9], [51], [52]	OFIQ Development Dataset[9], [51], [52], [60]

6.2 Conversion of 16 bits per channel images to 8 bits per channel images

Conversion of 16-bit scRGB images shall be performed as defined in Reference [66], using conversions as defined in IEC 61966-2-2:2003, Clause A.2.[67]

NOTE IEC 61966-2-2:2003, 3.1 and 4.1 show the conversion chain for 16-bit scRGB to 1931 CIEXYZ to 8-bit sRGB.

Images with other ICC profiles shall be converted according to their profile.

6.3 Conversion of high bit-depth images to 8 bit greyscale or 24 bit colour images

ISO/IEC 39794-5:2019 allows high-bit depth face captures with native camera formats that are encoded as defined in ISO/IEC 39794-5:2019, D.1.4.2.4. ISO/IEC 39794-5:2019 allows also proprietary formats with