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Information technology — Biometric sample quality —

Part 6: Iris image data

Technologies de l'information — Qualité d'échantillon biométrique —

Partie 6: Image d'iris

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, SC 37, *Biometrics*.

ISO/IEC 29794 consists of the following parts, under the general title *Information technology — Biometric sample quality*:

— *Part 1: Framework*

— *Part 4: Finger image data*

— *Part 5: Face image data* (Technical Report)

— *Part 6: Iris image data*

ISO/IEC 29794 will be prepared to accommodate new, additional parts that address other modalities specified by ISO/IEC 19794, with part numbers and titles aligning appropriately.

Introduction

The assessment of biometric sample quality through the calculation of quality metrics can be used to predict the resulting identification accuracy in the framework of a given biometric system. With proper use, quality metrics can enhance the functionality of a biometric system. For example they can provide feedback regarding the integrity of collected biometric data during the enrolment or identification process.

The purpose of this part of ISO/IEC 29794 is to define terms and quantitative methodologies relevant to characterizing the quality of iris images and to assess their potential for high confidence biometric match decisions.

ISO/IEC 19784-1 and ISO/IEC 19785-1 standards allocate a quality field and specify a quality score range applicable to iris images with a qualitative foundation. ISO/IEC 19794-6 includes an informative annex covering the subject of iris image capture and provides image quality guidelines. However, these International Standards do not contain specific content to guide the quantitative formation of iris image quality metrics or the interpretations of such metrics. This part of ISO/IEC 29794 establishes required ranges of covariate values where definitive empirical data exists to justify such ranges. In other cases, ranges of covariate values are specified as non-normative recommendations.

This part of ISO/IEC 29794 is structured as follows. The first five Clauses state Scope, Conformance, Normative references, Terms and definitions, and Acronyms. Clause 6 specifies a set of quality metrics for assessing the quality of iris images. Some of the metrics are declared as normative, as their impacts on recognition rates have been quantified, while others are only informative, allowing their use as they may provide valuable information for further stages in the biometric system. Some of the metrics in Clause 6 are applicable to the analysis of single images, while others are applicable to assessing the utility of a given pair of images for mutual comparison.

Clause 7 is dedicated to provide guidance to acquisition device manufacturers by defining quality parameters that shall be considered for generating conformant iris images.

Clause 8 establishes encoding of the iris image quality data record.

Information technology — Biometric sample quality —

Part 6: Iris image data

1 Scope

This part of ISO/IEC 29794 establishes

— methods used to quantify the quality of iris images,

— normative requirements on software and hardware producing iris images,

— normative requirements on software and hardware measuring the utility of iris images,

— terms and definitions for quantifying iris image quality, and

— standardized encoding of iris image quality.

Outside the scope is

— performance evaluation of specific iris quality assessment algorithms.

2 Conformance

An iris image shall be of sufficient utility if the measurements required by 6.2.X.3 satisfy the valid range/thresholds specified in 6.2.X.4.

A pair of images of an iris shall be of sufficient utility if the pair conforms to the requirements of 6.4. Specifically, they shall satisfy valid range/thresholds specified in 6.4.X.4 using computation method specified in 6.4.X.3.

An iris image quality record shall conform to this part of ISO/IEC 29794 if its structure and data values conform to the formatting requirements of Clause 8 (Iris image quality data record) and its quality values are computed using the methods specified in 6.2.X.3. Conformance to the normative requirements of Clause 8 fulfils Level 1 and Level 2 conformance as specified in ISO/IEC 19794-1:2011, Annex A. Conformance to the normative requirements of Clause 6.2.X.3 is Level 3 conformance as specified in ISO/IEC 19794-1:2011, Annex A.

An iris acquisition device shall conform to this part of ISO/IEC 29794 if it conforms to the normative requirements of Clause 7.

Computation of the utility of an iris image shall conform to the requirements of 6.2, specifically the computation methods described in 6.2.X.3. Computation of the utility of the pair of images shall be assessed per normative requirements of 6.4, specifically the computation methods described in 6.4.X.3.

If an implementation of the metrics in this part of ISO/IEC 29794 reports an unacceptable (low) quality value for one or more quality metrics, another image of the subject should be re-captured. This should be repeated until

— a fully conformant image has been acquired, or

— it is determined that repeated acquisitions will not yield a sufficient quality (e.g., correct enrolment) within the application time constraint. In this case, one unacceptable image is chosen and retained as the best possible candidate.

3 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO/IEC 19794-6:2011, *Information technology — Biometric data interchange formats — Part 6: Iris image data*

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

4 Terms and definitions

For the purpose of this document, the terms in ISO/IEC 19794-6:2011, ISO/IEC 29794-1, and the following apply.

4.1
covariate
variable or parameter that either directly, or when interacting with other covariates, affects iris recognition accuracy

Note 1 to entry: Synonyms are variable, explanatory variable, and quality parameter.

Note 2 to entry: Accuracy might be stated in terms of false negative identification rate, false positive identification rate, false non-match rate, false match rate, failure-to-enrol rate, or failure-to-acquire rate.

4.2
defocus
image impairment due to the position of the iris along the optical axis of the camera away from the plane or surface of best focus, generally resulting in reduced sharpness (blur) and reduced contrast

4.3
depth of field
a distance range relative to the entrance aperture of a capture device over which the iris image has greater than a specified quality with respect to focus

4.4
iris centre
centre of a circle approximating the boundary between the iris and the sclera

4.5
iris radius
radius of a circle approximating the boundary between the iris and the sclera

4.6
metric
quantification of a covariate using a prescribed method

4.7
modulation
waveform with maximum and minimum values, max and min, 100(max-min)/(max+min)%

4.8
modulation transfer function
ratio of the image modulation to the object modulation at specified spatial frequencies

4.9
normalised image
iris portion of the image that is mapped into doubly-dimensionless polar coordinates in which the radial coordinate between the inner and outer boundaries of the iris along any angular ray from the iris centre is normalised to lie between 0 and 1, in order to impart both size invariance for the imaged iris and also invariance to pupil dilation

4.10
pupil centre
centre of a circle approximating the boundary between the iris and the pupil

Note 1 to entry: This definition gives a more robust estimate of pupil centre than the definition in ISO/IEC 19794-6:2011 because it is less sensitive to occlusions on the iris pupil boundary. ISO/IEC 19794-6:2011 defines pupil centre as the average of coordinates of all the pixels lying on the boundary of the pupil and the iris.

4.11
segmentation
process of determining, within an image containing an iris, the boundaries between areas containing visible iris tissue and those that do not

Note 1 to entry: This process is preceded by localisation of the iris, and typically followed by cropping or masking regions that are not iris tissue.

4.12
spatial sampling rate
number of picture elements (pixels) per unit distance in the object plane or per unit angle in the imaging system

5 Acronyms and abbreviated terms

MTF Modulation Transfer Function

6 Iris image quality metrics

6.1 General

This Clause establishes requirements for assessing the quality of an iris image (Clause 6.2 and 6.3) and pairs of iris images to be compared (Clause 6.4). Image quality metrics computed from a single image (quality metrics hereafter) are useful to ensure the acquired images are suitable for biometric comparison. Image quality metrics computed from a pair of images (mutual quality metrics hereafter) are useful to ensure the reliability of the outcome when comparing the two images. Mutual quality metrics indicate how the difference of image-specific covariates between two iris images affect their expected comparison scores.

Clause 6.2 specifies the normative quality requirements for an iris image of sufficient utility. Quality metrics in Clause 6.2 are ordered in terms of their effects on recognition error rates,[11] such that the one with the largest effect on recognition performance is listed first.

Clause 6.3 specifies recommended quality requirements for an iris image. These quality metrics have been reported to affect recognition accuracy, but either their effect on recognition accuracy or the methods for computing them have not been quantitatively verified to be reliable or interoperable. Therefore, these metrics are not considered normative in the scope of this part of ISO/IEC 29794.

Clause 6.4 specifies normative requirements for mutual quality metrics including units of measurement, the method of computation, and the acceptable range of mutual quality metrics of the two iris images to be compared.

Required or recommended values or bounds in Clauses 6.2.X.4 and 6.4.X.4 are based on currently available empirical studies.[11][12] If an implementation of the metrics in this part of ISO/IEC 29794 reports an

unacceptable (low) quality value for one or more quality metrics, another image of the subject should be re-captured. This should be repeated until either a fully conformant image has been acquired, or it is determined that repeated acquisitions will not yield a sufficient quality (e.g., correct enrolment) within the application time constraint. In this case, one unacceptable image is chosen and retained as the best possible candidate. A NOTE at the end of each 6.2.X.4 and 6.3.X.4 sub-clauses instruct an enrolment official on how to remedy the problem.

Informative Annex B provides information on iris image covariates that are influential on image quality and hence recognition accuracy. It distinguishes between iris covariates based on the fixed design parameters of the acquisition device or the operation of the device (Clause B.2 Iris acquisition covariates) and subject covariates (Clause B.3).

6.2 Required iris image quality metrics computed from a single image

6.2.1 Usable iris area

6.2.1.1 Description

USABLE_IRIS_AREA is the fraction of the iris portion of the image that is not occluded by eyelids, eyelashes, or specular reflections. USABLE_IRIS_AREA shall be computed as the non-occluded fraction of the area between two circles approximating iris-sclera and iris-pupil boundaries, expressed as a percentage.

Patterned contact lenses hide iris tissue and should be avoided.

NOTE 1 Figure 1 shows examples of iris images with various occlusions.

NOTE 2 Usable iris area computed for a single image is important for ensuring that images are of adequate utility. Therefore, a subject enrolment process has to aim for maximising this covariate for the individual concerned. Meanwhile, estimating the common usable iris area in the context of two iris images to be compared is also valuable, since the image area used for biometric comparison consists of regions that are not occluded in either image. See Clause 6.4.1.

6.2.1.2 Units of measure

USABLE_IRIS_AREA is dimensionless.

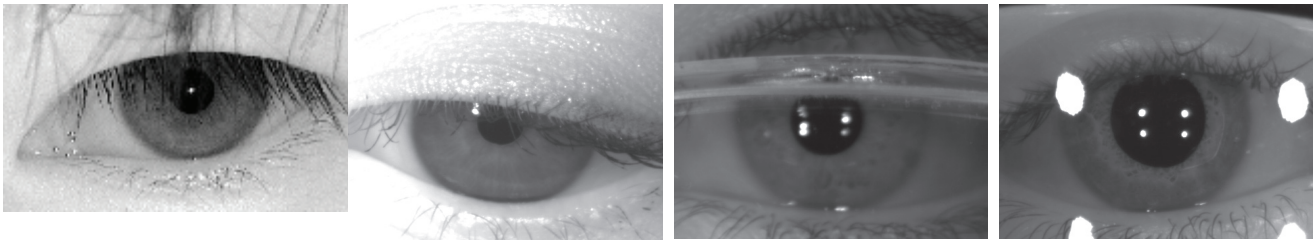
6.2.1.3 Computational method

USABLE_IRIS_AREA shall be measured following iris segmentation and after locating all occluded pixels in the iris portion of the image using the procedure below:

1. Approximate iris-sclera and iris-pupil boundaries as two circles.
2. Denote N_{iris} as the count of the pixels between the two circles.
3. Denote N_{occluded} as the count of the pixels between the two circles that are occluded by eyelids, eyelashes, or specular reflections.
4. Compute USABLE_IRIS_AREA as follows:

$$\left(1-\frac{N_{\text{occluded}}}{N_{\text{iris}}}\right)\times 100$$

NOTE Regions of the iris occluded by eyelashes may be excluded by applying a threshold to the histogram of the pixels in the segmented iris portion of the image between the detected eyelids.[2]



(a) Eye lashes (b) Eye lid (c) Eyeglass frame (d) Specularities

Figure 1 — Example images with different occlusions

6.2.1.4 Value range/threshold

USABLE_IRIS_AREA shall be 70 or larger.[11]

The presence of an artifice such as patterned contact lenses should be detected and if detected it shall be recorded in the quality record (see Table 2) and shall be included as an occlusion in computation of USABLE_IRIS_AREA (Step 3 in 6.2.1.3).

NOTE If an image has unacceptable USABLE_IRIS_AREA, further images might be collected after the subject has been asked to open the eyes more widely, to push away long eye lashes, and to look directly into the camera.

6.2.2 Iris-sclera contrast

6.2.2.1 Description

IRIS_SCLERA_CONTRAST represents the image characteristics at the boundary between the iris region and the sclera. Sufficient contrast is needed in many implementations of iris segmentation algorithms. Low or insufficient contrast may result in a failure to process an iris image during feature extraction.

NOTE 1 The intrinsic iris-sclera contrast varies among human irises. Iris-sclera contrast of an iris image is affected by both the intrinsic contrast and extrinsic conditions such as illumination wavelength and other capture device characteristics.

NOTE 2 This metric is different from GREY_SCALE_UTILISATION.

6.2.2.2 Units of measure

IRIS_SCLERA_CONTRAST is dimensionless, expressed as a percentage.

6.2.2.3 Computational method

IRIS_SCLERA_CONTRAST shall be computed as follows:

1. Approximate iris-sclera and iris-pupil boundaries as two circles.
2. Normalise so that iris-sclera boundary is at a radius of 1,0.
3. Select all pixels in an annulus whose outer radius is 0,9 and whose inner radius extends to the midpoint between iris-pupil and iris-sclera boundaries, which are not occluded by eyelids, eyelashes, specular reflections, or boundaries of hard contact lenses. Let these be termed iris pixels.
4. Set *iris_value* as the median of iris pixels.
5. Select all pixels that are not occluded by eyelids, eyelashes, or specular reflections in an annulus with inner radius of 1,1 and outer radius of 1,2. Let these be termed sclera pixels.

6. Set *sclera_value* as the median of sclera pixels.

7. IRIS_SCLERA_CONTRAST

$$= \begin{cases} 0 & pupil\_value \geq iris\_value \ \ OR \ \ pupil\_value \geq sclera\_value \\ \dfrac{\left|sclera\_value - iris\_value\right|}{sclera\_value + iris\_value - 2 \times pupil\_value} \times 100 & otherwise \end{cases}$$

NOTE This computation can proceed even if the approximating iris-sclera and iris-pupil circles are not concentric.

Pupil_value is defined in 6.2.3.3.

6.2.2.4 Value range/threshold

IRIS_SCLERA_CONTRAST shall be larger than 5.

NOTE If an image has unacceptable IRIS_SCLERA_CONTRAST, another image might be captured, perhaps after moving away from extraneous light. If the problem persists an alternative camera might be used. Generally, increased illumination or camera gain may help improve IRIS_SCLERA_CONTRAST.

6.2.3 Iris-pupil contrast

6.2.3.1 Description

IRIS_PUPIL_CONTRAST represents the image characteristics at the boundary between the iris region and the pupil. Sufficient iris-pupil contrast is needed in many implementations of iris segmentation algorithms. Low or insufficient contrast may result in a failure to process an iris image during feature extraction.

NOTE 1 The intrinsic iris-pupil contrast varies among human irises. Iris-pupil contrast of an iris image is affected by both the intrinsic contrast and extrinsic conditions such as illumination wavelength and other capture device characteristics.

NOTE 2 Intrinsic contrast may be different between visible light illuminated iris images and near infrared illuminated iris images.

NOTE 3 This metric is different from GREY_SCALE_UTILISATION.

6.2.3.2 Units of measure

IRIS_PUPIL_CONTRAST is dimensionless.

6.2.3.3 Computational method

IRIS_PUPIL_CONTRAST shall be computed as follows:

1. Approximate iris-pupil and iris-sclera boundaries as two circles.

2. Normalize so that iris-pupil boundary is at a radius of 1,0.

3. Select all pixels inside a circle of radius 0,8 that are not occluded by eyelids, eyelashes, or specular reflections. Let this be denoted as pupil pixels.

4. Set *pupil_value* as the median of pupil pixels.

