INTERNATIONAL STANDARD

ISO/IEC 29794-6

First edition
2015-07-01

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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Reference number
ISO/IEC 29794-6:2015(E)

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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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.

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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.

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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.

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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

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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

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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).

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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]

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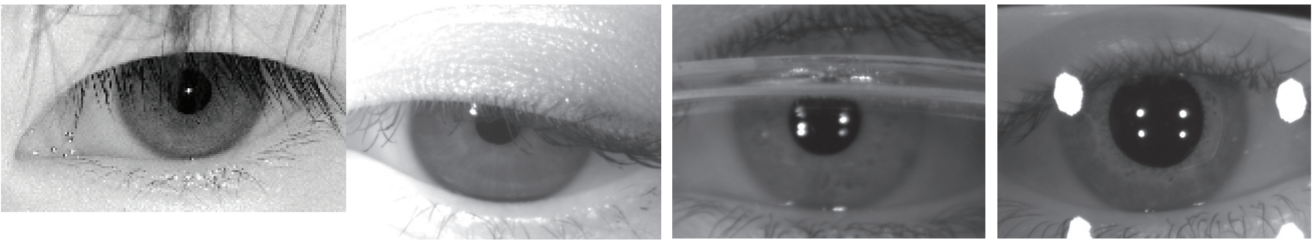

(a) Eye lashes (b) Eye lid (c) Eyeglass frame (d) Specularities

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.

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

7. IRIS_SCLERA_CONTRAST

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

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.

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5. Select all pixels in an annulus whose inner radius is 1,1 and whose outer 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.

6. Set *iris_value* as the median of iris pixels.

7. Compute $weber\_ratio = \dfrac{|iris\_value - pupil\_value|}{20 + pupil\_value}$

8. $\text{IRIS\_PUPIL\_CONTRAST} = \dfrac{weber\_ratio}{0.75 + weber\_ratio} \times 100$

NOTE 1 Eyelashes can occlude pupil as shown in Figure1a.

NOTE 2 If the pupil is black, then the definition of (Michelson) contrast of the IRIS_PUPIL_CONTRAST will always be 100%. Therefore, normalised Weber contrast is more informative.

6.2.3.4 Value range/threshold

IRIS_PUPIL_CONTRAST shall be 30 or more.

NOTE If an image has unacceptable IRIS_PUPIL_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_PUPIL_CONTRAST.

6.2.4 Pupil boundary circularity

6.2.4.1 Description

PUPIL_BOUNDARY_CIRCULARITY represents the circularity of the iris-pupil boundary.

NOTE 1 Deviation from circularity in the iris-pupil boundary can affect segmentation accuracy. The effect of this metric on performance depends on the sensitivity of the segmentation algorithm to the deviation from circularity in iris-pupil boundaries.

NOTE 2 The non-circularity could be due either to natural anatomical variation or to non-frontal gaze or both.

NOTE 3 Certain medical conditions or treatments can induce highly non-circular pupils.

6.2.4.2 Units of measure

PUPIL_BOUNDARY_CIRCULARITY is dimensionless.

6.2.4.3 Computational method

PUPIL_BOUNDARY_CIRCULARITY shall be measured by the total modulus (sum of the squared coefficients) of the real and imaginary parts of a Fourier series expansion of the pupil boundary, in radius as a function of angle around the centre. Specifically:[2]

1. Compute a Fourier expansion of N regularly spaced angular samples of radial gradient edge data $\{r_\theta\}$ for $\theta = 0$ to $N - 1$ spanning $[0,2\pi]$.

A set of M discrete Fourier coefficients $\{C_k\}$, $k = 0, \ldots, M\text{-}1$, where M is much smaller than N, is derived from data sequence $\{r_\theta\}$ as $C_k = \sum_{\theta=0}^{N-1} r_\theta e^{-2\pi i k\theta/N}$

2. $\text{PUPIL\_BOUNDARY\_CIRCULARITY} = \max(0, 100 - \dfrac{1}{N}\sum_{k=1}^{M-1} \|C_k\|^2)$

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The above calculation shall include only the non-occluded pixels on the boundary of iris and pupil. M is the number of activated Fourier coefficients and specifies the degrees of freedom in the shape model. M should be set to 17 to capture the true pupil boundary with appropriate fidelity.[2]

NOTE In the case of a truly circular boundary, all frequency coefficients higher than DC (the zeroth-term C_0) in this Fourier series would be 0, and the C_0/N is exactly the radius of that perfect circle. To the extent that frequency components higher than the DC term have non-zero coefficients, the boundary is non-circular. The total modulus measures this non-circularity.

6.2.4.4 Value range/threshold

PUPIL_BOUNDARY_CIRCULARITY will be 100 for a circle and [0,100) for anything else.

NOTE The non-circular pupil may be innate to the eye being imaged and may therefore not be remediable.

6.2.5 Grey scale utilisation

6.2.5.1 Description

GREY_SCALE_UTILISATION examines pixel values of an iris image for evidence of a spread of intensity values in iris portion of the image. A useful iris image should have a dynamic range of 256 grey levels, allocating at least 8 bits with a minimum of 6 bits of useful information. An “underexposed” image would have too few high intensity pixels, and conversely for “overexposed”. An image with a high score indicates a properly exposed image, with a wide, well distributed spread of intensity values.

6.2.5.2 Units of measure

GREY_SCALE_UTILISATION shall be measured in bits.

6.2.5.3 Computational method

For each grey level i present in the image, compute its probability p_i of occurring. Thus p_i is the total count of pixels at grey level i, divided by the total number of pixels in the image. The entropy H of the pixel histogram, in bits, is:

$$H = -\sum_i p_i \log_2 p_i$$

NOTE When $x \to 0$, $x \log_2 x \to 0$ so pixel values that never occur in an image can be ignored in the calculation of entropy.

6.2.5.4 Value range/threshold

Entropy of the pixel histogram shall be 6 bits or higher.

NOTE If an image has unacceptable GREY_SCALE_UTILIZATION, 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 GREY_SCALE_UTILIZATION.

6.2.6 Iris radius

6.2.6.1 Description

IRIS_RADIUS is the radius of a circle approximating the iris-sclera boundary.

NOTE The average human iris radius is 5,9 millimetres with a reported range of 5,1 to 6,5 millimetres.[10]

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6.2.6.2 Units of measure

IRIS_RADIUS shall be measured in pixels.

6.2.6.3 Computational method

IRIS_RADIUS shall be measured as the radius of a circle approximating the boundary between the iris and the sclera.

NOTE This metric should be computed after segmentation.

6.2.6.4 Value range/threshold

IRIS_RADIUS shall be at least 80 pixels for the smallest reported human iris of 5,1 millimetre radius.

6.2.7 Pupil dilation

6.2.7.1 Description

PUPIL_IRIS_RATIO represents the degree to which the pupil is dilated or constricted.

6.2.7.2 Units of measure

PUPIL_IRIS_RATIO is dimensionless.

6.2.7.3 Computational method

$$\text{PUPIL\_IRIS\_RATIO} = \frac{\text{PUPIL\_RADIUS}}{\text{IRIS\_RADIUS}} \times 100$$

PUPIL_RADIUS shall be measured as the radius of the circle approximating pupil shape. The DC (zeroth-term C_0) in the Fourier series expansion of pupil boundary (Clause 6.2.4.3) approximates radius of the pupil.

IRIS_RADIUS shall be measured as specified in Clause 6.2.6.3.

NOTE This metric should be computed after segmentation.

6.2.7.4 Value range/threshold

PUPIL_IRIS_RATIO shall be between 20 and 70.

NOTE 1 This is the only quality metric for which the higher-the-better rule for quality does not apply.

NOTE 2 If pupil dilation is not within the desired range, another image might be captured after adjusting the ambient light levels to decrease or increase dilation.

6.2.8 Iris pupil concentricity

6.2.8.1 Description

IRIS_PUPIL_CONCENTRICITY represents the degree to which the pupil centre and the iris centre are in the same location.

NOTE Pupil and iris are naturally never exactly concentric. Pronounced deviation from concentricity can cause segmentation error. Conversely, pronounced measured non-concentricity can indicate a segmentation error.

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6.2.8.2 Units of measure

IRIS_PUPIL_CONCENTRICITY is dimensionless.

6.2.8.3 Computational method

The value for iris and pupil concentricity shall be computed using the Euclidean distance between the iris and pupil centres divided by the iris radius, as given by:

$$100 \times \max\{1 - \frac{\sqrt{\left(X_{\text{pupil}} - X_{\text{iris}}\right)^2 + \left(Y_{\text{pupil}} - Y_{\text{iris}}\right)^2}}{\text{IRIS\_RADIUS}}, 0\}$$

(X_{iris}, Y_{iris}) and (X_{pupil}, Y_{pupil}) are the coordinates of iris centre and pupil centre respectively.

NOTE This metric should be computed after segmentation.

6.2.8.4 Value range/threshold

IRIS_PUPIL_CONCENTRICITY shall be 90 or more.

NOTE Non-concentric iris and pupil may be innate to the eye being imaged and may therefore not be remediable. Another image might be collected after the subject has been asked to look directly into the camera and to open their eyes widely.

6.2.9 Margin adequacy

6.2.9.1 Description

MARGIN_ADEQUACY quantifies the degree to which the iris portion of the image is centred relative to the edges of the entire image. The maximum value for this metric shall occur when the margin requirements of ISO/IEC 19794-6:2011 are satisfied.

6.2.9.2 Units of measure

MARGIN_ADEQUACY is dimensionless.

6.2.9.3 Computational method

There are four individual margin values: LEFT_MARGIN, RIGHT_MARGIN, UP_MARGIN and DOWN_MARGIN.

The individual margin values shall be computed as:

$$\text{LM} = \frac{X_{iris} - \text{IRIS\_RADIUS}}{\text{IRIS\_RADIUS}}$$

$$\text{RM} = \frac{\text{IMAGE\_WIDTH - }(X_{iris} + \text{IRIS\_RADIUS})}{\text{IRIS\_RADIUS}}$$

$$\text{DM} = \frac{\text{IMAGE\_HEIGHT - }(\text{Y}_{iris} + \text{IRIS\_RADIUS})}{\text{IRIS\_RADIUS}}$$

$$\text{UM} = \frac{Y_{iris} - \text{IRIS\_RADIUS}}{\text{IRIS\_RADIUS}}$$

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$$\text{LEFT\_MARGIN} = \max\left\{0, \min\left\{1, \frac{\text{LM}}{0{,}6}\right\}\right\}$$

$$\text{RIGHT\_MARGIN} = \max\left\{0, \min\left\{1, \frac{\text{RM}}{0{,}6}\right\}\right\}$$

$$\text{UP\_MARGIN} = \max\left\{0, \min\left\{1, \frac{\text{UM}}{0{,}2}\right\}\right\}$$

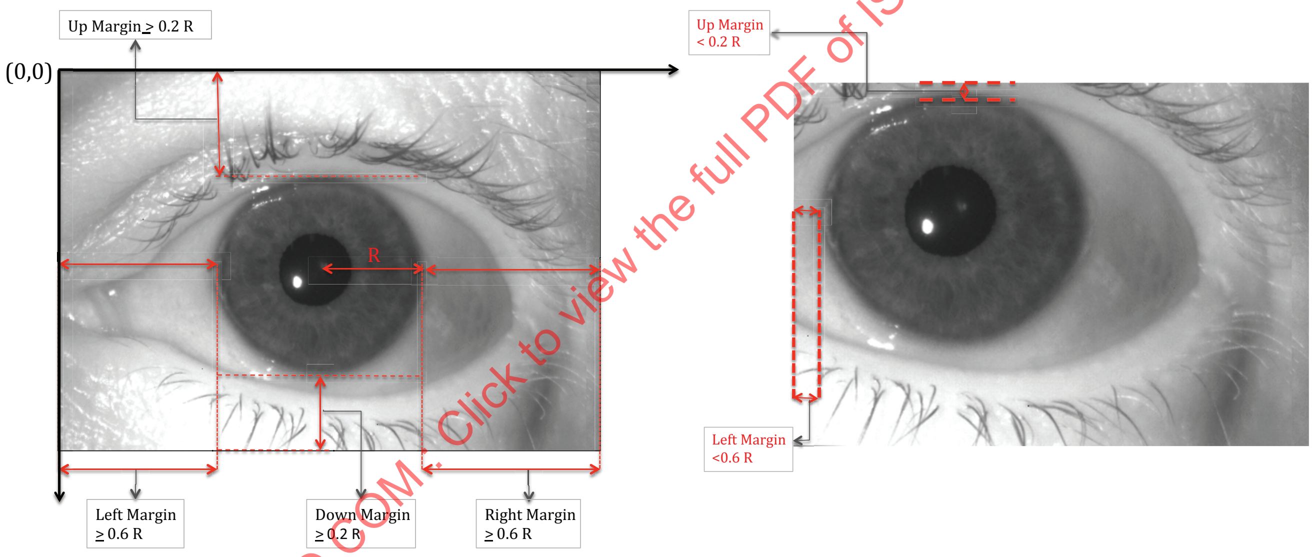
$$\text{DOWN\_MARGIN} = \max\left\{0, \min\left\{1, \frac{\text{DM}}{0{,}2}\right\}\right\}$$

(X_{iris}, Y_{iris}) are iris centre in the horizontal and vertical directions where (0,0) is the top left corner of the image (See Figure 2). IMAGE_WIDTH, IMAGE_HEIGHT, and IRIS_RADIUS are measured in pixels.

The margin adequacy value shall be computed as:

$$\text{MARGIN\_ADEQUACY}=100\times\min\{\text{LEFT\_MARGIN, RIGHT\_MARGIN, UP\_MARGIN, DOWN\_MARGIN}\}$$

NOTE This metric could be computed after coarse segmentation.



(a) An iris image with adequate margins. Note that (0,0) is at the upper left corner of the image.

(b) An iris image where LEFT_MARGIN and UP_MARGIN are inadequate.

Figure 2 — Example of iris images with adequate and inadequate margins.

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6.2.9.4 Value range/threshold

MARGIN_ADEQUACY shall be greater than 80.

NOTE 1 A value of 100 indicates that all four margin values conform to the requirements established in ISO/IEC 19794-6:2011 namely that the margin between the iris boundary and its closest edge of the image shall be at least 0,6 × IRIS_RADIUS in the horizontal direction and 0,2 × IRIS_RADIUS in the vertical direction.

NOTE 2 If an image has unacceptable MARGIN_ADEQUACY another image might be collected after the subject has been asked to look directly into the camera

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6.2.10 Sharpness

6.2.10.1 Description

SHARPNESS measures the degree of focus present in the image.[3][5][6][7] Sharpness is measured as a function of the power spectrum after filtering with a Laplacian of Gaussian operator.

6.2.10.2 Units of measure

SHARPNESS is dimensionless.

6.2.10.3 Computational method

Calculation of the sharpness of an image is determined by the power resulting from filtering the image with a Laplacian of Gaussian kernel. The standard deviation of the Gaussian is 1,4.

1. The convolution kernel (F) is defined thus:

$$F = \begin{vmatrix} 0 & 1 & 1 & 2 & 2 & 2 & 1 & 1 & 0 \\ 1 & 2 & 4 & 5 & 5 & 5 & 4 & 2 & 1 \\ 1 & 4 & 5 & 3 & 0 & 3 & 5 & 4 & 1 \\ 2 & 5 & 3 & -12 & -24 & -12 & 3 & 5 & 2 \\ 2 & 5 & 0 & -24 & -40 & -24 & 0 & 5 & 2 \\ 2 & 5 & 3 & -12 & -24 & -12 & 3 & 5 & 2 \\ 1 & 4 & 5 & 3 & 0 & 3 & 5 & 4 & 1 \\ 1 & 2 & 4 & 5 & 5 & 5 & 4 & 2 & 1 \\ 0 & 1 & 1 & 2 & 2 & 2 & 1 & 1 & 0 \end{vmatrix}$$

2. If $I(x,y)$ is the image, then the weighted sum of $I(x,y)$ as per F is computed for every fourth row and column location in $I(x,y)$. Denote $I_F(x,y)$ to represent the filtered output. Thus

$$I_F(x,y) = \sum_{i=-4}^{4} \sum_{j=-4}^{4} I(x+i, y+j) F(i+5, j+5) \forall x \in [1,5,\ldots w], y \in [1,5\ldots h]$$

where w and h are the width and height of $I(x,y)$ respectively.

3. Compute the squared sum (ss) of $I_F(x,y)$:

$$ss = \sum_{\forall x,y \in I_F(x,y)} I_F(x,y)^2$$

4. Compute the power in $I_F(x,y)$ via ss:

$$power = ss / (w_F \times h_F)$$

where w_F and h_F are the width and height of $I_F(x,y)$ respectively.

5. Compute the SHARPNESS score from the power:

$$\text{SHARPNESS} = 100 \times \frac{power^2}{power^2 + c^2}$$

where the value of c has been chosen empirically to be 1 800 000.

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6.3 Recommended iris image quality metrics computed from a single image

6.3.1 Frontal gaze–elevation

6.3.1.1 Description

FRONTAL_GAZE-ELEVATION should express in fractional terms how much the eye gaze-elevation deviates from ideal gaze orientation, i.e., fully on-axis with the camera.

Eye gaze-elevation is the angle between the optical axis of the eye and the optical axis of the camera in their vertical plane components, measured in degrees in absolute value (unsigned).

NOTE 1 Figure 3 shows examples of on-axis and off-axis images.

NOTE 2 Eye gaze-elevation is in the range of 0 to 90 degrees.

6.3.1.2 Units of measure

FRONTAL_GAZE-ELEVATION is dimensionless.

6.3.1.3 Computational method

$$\text{FRONTAL\_GAZE-ELEVATION} = (1 - \frac{eyegaze\_elevation}{90}) \times 100$$

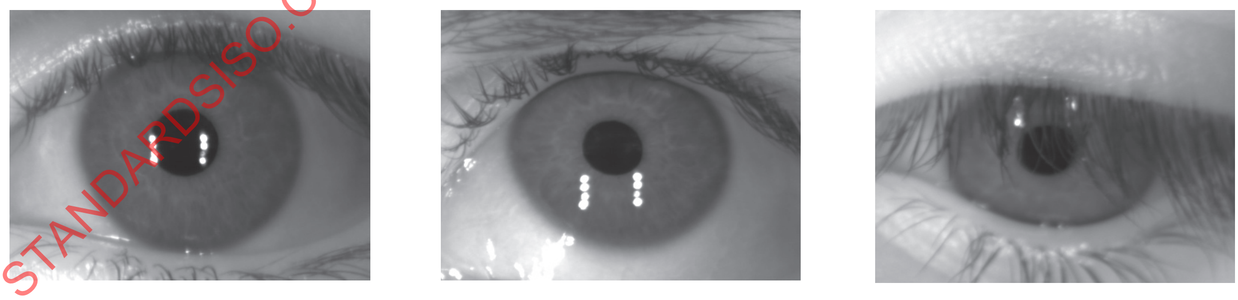
NOTE A candidate method for estimation of the angle is given in.[2]

6.3.1.4 Value range/threshold

The theoretical range of FRONTAL_GAZE-ELEVATION is 0 to 100, where 0 is the worst and 100 is the best.

The value of FRONTAL_GAZE-ELEVATION should be 100 when eye gaze-elevation is 0 degrees (i.e. on-axis with the camera).

NOTE If an image has unacceptable FRONTAL_GAZE-ELEVATION another image might be collected after the subject has been asked to look directly into the camera.



(a) Neutral (good quality) (b) Gaze up (poor quality) (c) Gaze down (poor quality)

Figure 3 — Example images with high and low gaze elevation quality values

6.3.2 Frontal gaze-azimuth

6.3.2.1 Description

FRONTAL_GAZE-AZIMUTH should express in fractional terms how much the eye gaze-azimuth deviates from ideal gaze orientation, i.e. fully on-axis with the camera. Eye gaze-azimuth is the angle between the

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optical axis of the eye and the optical axis of the camera in their horizontal plane components, measured in degrees in absolute value (unsigned).

NOTE 1 Figure 4 shows examples of on-axis and off-axis images.

NOTE 2 Eye gaze-azimuth is the horizontal component of the gaze angle relative to camera. This measure is inclusive of both non-frontal head angular positions and eye-gaze angles relative to the head.

NOTE 3 Eye gaze-azimuth is in the range of 0 to 90 degrees.

NOTE 4 The inclusive approach for gaze direction is not intended to be representative of the possible difficulty with iris segmentation due to non-frontal head orientation. Hence, two images with the same FRONTAL_GAZE_AZIMUTH, but significantly different frontal head pitch orientations (causing different FRONTAL_GAZE_ELEVATION) may perform differently with different segmentation and/or different comparison algorithms.

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6.3.2.2 Units of measure

FRONTAL_GAZE-AZIMUTH is dimensionless.

6.3.2.3 Computational method

$$\text{FRONTAL\_GAZE-AZIMUTH} = \left(1 - \frac{eyegaze - azimuth}{90}\right) \times 100$$

NOTE 1 Ellipticity of the pupil may be an indication of off-axis image acquisition. Therefore a method of determining the FRONTAL_GAZE-AZIMUTH may be based on estimating the elongation and orientation of that ellipse.

NOTE 2 A candidate method for estimation of the angle is given in.[2]

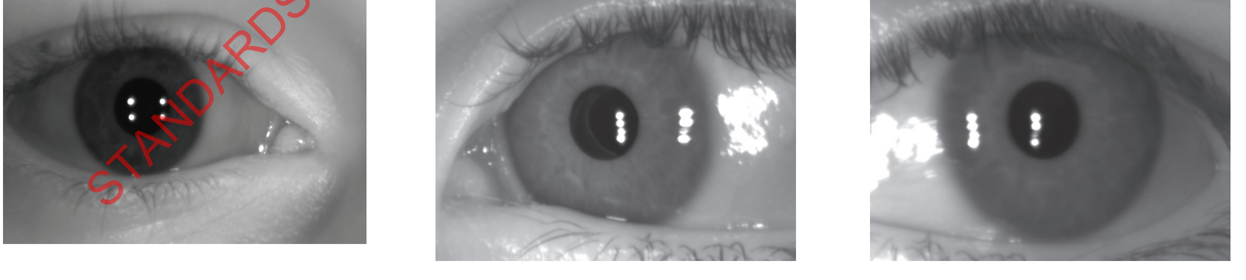
6.3.2.4 Value range/threshold

The theoretical range of FRONTAL_GAZE-AZIMUTH is 0 to 100, where 0 is the worst and 100 is the best.

The value of FRONTAL_GAZE-AZIMUTH should be 100 when eye gaze-azimuth is 0 degrees (i.e. on-axis with the camera).

A value of 0 corresponds to eye gaze-azimuth of 90 degrees, which is unattainable.

NOTE If an image has unacceptable FRONTAL_GAZE-AZIMUTH another image might be collected after the subject has been asked to look directly into the camera.



(a) Neutral (good quality) (b) Gaze left (poor quality) (c) Gaze right (poor quality)

Figure 4 — Example images with high and low azimuthal gaze quality values

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6.3.3 Motion blur

6.3.3.1 Description

MOTION_BLUR should measure the degree of distortion in the image due to motion.

6.3.3.2 Computational method

A candidate method for expressing MOTION_BLUR is the relative magnitude and direction of image motion, measured in pixels and angle of motion (zero degrees signifying horizontal motion), respectively.

NOTE If an image has unacceptable MOTION_BLUR another image might be collected after the subject has been asked to look directly into the camera and to remain still.

6.4 Iris image quality metrics computed from two images

6.4.1 Common usable iris area

6.4.1.1 Description

COMMON_USABLE_IRIS_AREA shall be a measure of the extent of the iris image tissue in common and available in both of the images being compared. The iris area actually used for biometric comparison is the intersection of the sets of usable pixels in the two iris images. Hence common usable iris area, or its complement, iris OR-occlusion, should be defined for a pair of images to be compared. Both iris images must be normalised to correct for any variation in their sizes or pupil dilations.

6.4.1.2 Units of measure

COMMON_USABLE_IRIS_AREA is dimensionless.

6.4.1.3 Computational method

$$\text{COMMON\_USABLE\_IRIS\_AREA} = \text{MAX}_{\phi}\left(\frac{\left|N(iris^{(1)}(r,\theta+\phi)) \cap N(iris^{(2)}(r,\theta))\right|}{F\left(\left|N(iris^{(1)}(r,\theta+\phi))\right|,\left|N(iris^{(2)}(r,\theta))\right|\right)}\right)$$

Θ and ϕ are iris rotation angles and are added here because Iris images are usually compared under different rotation angles. $|N(.)|$ is the number of usable pixels in the normalized image, and $F(.)$ the total number of pixels in a normalised iris image without occlusions, which is determined by the normalised format used for both the iris images being compared.

6.4.2 Dilation constancy

6.4.2.1 Description

DILATION_CONSTANCY shall measure the similarity of the pupillary dilation in two iris images being compared. This metric should be used in the comparison stage only.

6.4.2.2 Units of measure

DILATION_CONSTANCY is dimensionless.

6.4.2.3 Computational method

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$$\text{DILATION\_CONSTANCY}=\frac{100-\max(D^{(1)},D^{(2)})}{100-\min(D^{(1)},D^{(2)})}$$

Where $D^{(1)}$ and $D^{(2)}$ are the PUPIL_IRIS_RATIOs of the first and second iris images as estimated in Clause 6.2.7.3.

NOTE 1 This formula can be restated in terms of the iris and pupil radii in the two images:

$$\text{DILATION\_CONSTANCY}=\left(\frac{R_I^{(1)}-R_P^{(1)}}{R_I^{(2)}-R_P^{(2)}}\right)\left(\frac{R_I^{(2)}}{R_I^{(1)}}\right)\times 100$$

Where the first term is the ratio of radial thicknesses and the second term in the product is a camera magnification term, assuming the anatomical iris has constant size.

NOTE 2 The log of false negative identification rate is approximately linear with DILATION_CONSTANCY for many recognition algorithms.

6.4.2.4 Value range/threshold

The maximum value for DILATION_CONSTANCY shall be 100 (perfect match), and the minimum value should be 80.

NOTE 1 For a typical PUPIL_IRIS_RATIO of 36, this lower limit implies that the other iris should have PUPIL_IRIS_RATIO above 20 or below 49.

NOTE 2 Based on the ratio range of 20 to 70 of Clause 6.2.7.4 the theoretical lower limit for DILATION_CONSTANCY is 37.

6.4.3 Illumination similarity

6.4.3.1 Description

ILLUMINATION_SIMILARITY shall measure the extent to which two iris images show evidence of the presence (or absence) of image acquisition system illumination difference. The effect of this metric on performance depends on the sensitivity of the segmentation or iris recognition algorithm to the difference in acquisition illumination intensity and wavelength of the enrolment and recognition images. Therefore, this measure supports interoperability of iris images when enrolment and recognition deploy different camera systems.

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6.5 Unified (overall) quality score

6.5.1 General

The quality metrics defined in Clause 6.2 and Clause 6.3 can be combined to compute a single scalar overall iris quality score, which is an actionable predictor of expected performance of the iris image. Examples of candidate methods are weighted sum, neural networks, or support vector machines. The best predictor of performance is a product of power functions because it allows for both veto power and importance tailoring. The importance of veto power is to prevent some aspects of quality (such as sharpness) compensating for other fatal problems e.g., highly occluded iris. Linear combination regression functions are inappropriate because they too easily permit such incorrect compensations. The exponents of the power functions allow for tailoring the relative importance of the metrics.

6.5.2 Computational method

An OVERALL_QUALITY score shall be computed as follows:

1. Each of the L quality metrics q_i of clause 6.2 (and 6.3 if computed) shall be mapped onto [0,1] with the following normalisation

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$$n_i = q_i^2 / (q_i^2 + c_i^2)$$

where the coefficient c_i should be chosen to distribute the values across the range [0,1]. This computation should use floating point q_i before integer rounding needed to store the values in the image quality record.

2. Compute a single actionable quality score by combining the normalised quality metrics as a product of various power functions:

$$\text{OVERALL\_QUALITY} = \prod_{i=1}^{L} q_i^{\alpha_i}$$

Where L is the number of quality metrics considered or computed.

3. The coefficients α_i and c_i shall be determined from nonlinear regression that maximises the predictive power of OVERALL_QUALITY.

NOTE The simplest case of all linear powers (α_i=1 for i=1,…,L) is an option but it does not allow for relative importance tailoring.

7 Iris acquisition quality

7.1 General

Iris acquisition quality involves the conditions required to obtain 1) satisfactory resolution and sharpness, 2) sufficient contrast in the iris to support information extraction and template generation, and 3) positioning of the subject's iris in the camera's field of view with good focus while minimizing or eliminating impairments, such as specular reflections.

This Clause defines and establishes requirements on covariates related to the design and implementation of the image acquisition equipment and environment.

An iris acquisition device is capable of producing images of high utility as specified in this part of ISO/IEC 29794 if in addition to conforming to the normative requirements of Clause 7, no fewer than 900 iris images out of 1000 iris images captured by the device shall conform to the requirements of Clause 6.2. To the extent possible, the images shall be representative of the expected user population.

7.2 Dedicated illumination

7.2.1 Description

For the near infrared illuminators, the wavelength shall be in the range of 700 to 900 nanometre.

NOTE 1 See ISO/IEC 19794-6:2011, Clause B.7.

NOTE 2 Cross device recognition accuracy might be measured according to ISO/IEC 19795-4:2008 Performance Interoperability Testing.

NOTE 3 This part of ISO/IEC 29794 does not establish requirements on the use of visible lights during capture.

7.2.2 Units of measure

Spectral composition is specified using non-dimensional values.

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7.2.3 Computational method

The spectral composition of the illuminant shall be measured using a spectrometer whose wavelength resolution is 10 nanometre or better and whose signal-to-noise ratio is 40dB or better over the interval [680,920] nanometre.

7.2.4 Value range/threshold

Given a power spectrum measurement $P(\lambda)$ from 7.2.3, the following shall hold:

$$\frac{\int_{700}^{900} P(\lambda)d\lambda}{\int_{680}^{920} P(\lambda)d\lambda} \geq 0{,}9 \text{and} \frac{\int_{800}^{900} P(\lambda)d\lambda}{\int_{700}^{900} P(\lambda)d\lambda} \geq 0{,}35$$

For safety purposes, power density shall not exceed the Maximum Permissible Exposure (MPE), as defined in CIE S 009 / E:2002 / IEC 62471:2006.[8]

7.3 Modulation transfer function

7.3.1 Description

The MODULATION_TRANSFER_FUNCTION (MTF) is the ratio of the image modulation to the object modulation as a function of spatial frequency. An MTF chart represents the evolution of the contrast of the image as a function of the spatial frequency of the object.

7.3.2 Units of measure

MTF is dimensionless.

7.3.3 Computational method

Measuring an MTF requires measuring the contrast transfer of sinusoidal targets whose spatial frequencies cover the entire relevant range, which is normally several octaves of spatial frequency modulation in sinusoidal grey-level targets. Alternatively, square-wave targets having a range of repetition frequencies (line pairs per millimetre) may be used.

7.3.4 Value range/threshold

Devices shall be able to deliver images that result in a measured MTF with a modulation of more than 50% at 2lp/mm using appropriate targets.

If square wave (line pair) targets are used, corresponding maximum attenuation limit is (4/π) x 0,5 which is 2 decibels less attenuation, since the ratio of the square wave amplitude to that of its fundamental Fourier component (sine wave) amplitude is -20 log10 (π/4) = 2 dB. This relationship can be used to model the difference between contrast values for square wave vs. sinusoidal targets only if the MTF response of the third and higher harmonics is negligible.

NOTE High frequency information content (greater than 2lp/mm) is useful in calculating quality elements but MTF requirement for high frequency information content are not specified in this standard.

7.4 Spatial sampling rate

7.4.1 Description

SPATIAL_SAMPLING_RATE shall be a measurement of the number of picture elements (pixels) per unit distance in the object plane or per unit angle in the imaging system.

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7.4.2 Units of measure

SPATIAL_SAMPLING_RATE shall be measured in pixels per millimetre.

7.4.3 Computational method

SPATIAL_SAMPLING_RATE shall be measured as the number of pixels per unit distance (millimetre) in the object plane.

7.4.4 Value range/threshold

The digital image that is captured from the iris shall have SPATIAL_SAMPLING_RATE equal to at least 15,7 pixels per millimetre.

NOTE 1 Using the reported range of human iris radius from 5,1 to 6,5 millimetre [15], and to accommodate the population with the smallest iris size (i.e. 5,1 millimetre radius), the minimum iris radius of 80 pixels corresponds to a minimum sampling rate of 80/5,1 = 15,7 pixels/millimeter.

7.5 Optical distortion

Any effect of optical distortion including spherical aberration, chromatic aberration, astigmatism and coma that an iris image may exhibit should be such that they cause no significant worsening of error performance for the designed configuration.

7.6 Pixel aspect ratio

7.6.1 Description

PIXEL_ASPECT_RATIO is the ratio between width and height of a rectangular pixel.

The imaging device shall produce a square pixel, i.e., rectangular with an aspect ratio of 1:1.

7.6.2 Units of measure

PIXEL_ASPECT_RATIO is dimensionless.

7.6.3 Computational method

PIXEL_ASPECT_RATIO shall be measured as the ratio of the linear spatial extent of N pixels taken in the horizontal direction to that of N pixels in the vertical direction. The value of N should be as large as possible to minimize measurement error.

7.6.4 Value range/threshold

PIXEL_ASPECT_RATIO shall be between 0,99 and 1,01.

7.7 Sensor signal-to-noise ratio

7.7.1 Description

The sensitivity of a camera is the minimum discernible signal that can be detected and is ultimately limited by the sensor noise e.g., read noise, photon noise and device driver related artefacts.

7.7.2 Units of measure

SENSOR_SIGNAL_TO_NOISE_RATIO shall be measured in decibels.

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7.7.3 Computational method

Sensor noise should be estimated by imaging a uniform test target or an integrating sphere that provides uniform image intensity. The test target shall have a modulation depth and a base albedo similar to the iris. Typical iris albedo is 12% to 15%. The signal_to_noise_ratio in decibels (dB) should be calculated as $20\log(\mu/\sigma)$ dB, where μ is sample mean intensity values and σ is sample standard deviation of intensity values. μ and σ shall be calculated for a local region spanning at least 16 × 16 pixels.

NOTE Non-uniformity in the measured image region will tend to underestimate the signal to noise ratio.

7.7.4 Value range/threshold

SENSOR_SIGNAL_TO_NOISE_RATIO in the ocular region shall be larger or equal to 36 dB.

NOTE See Table 6 of Mobile ID Best Practice.[4] Mobile ID Best Practices suggest SENSOR_SIGNAL_TO_NOISE_RATIO greater than 36dB. 36 dB was derived under the simplifying assumption that image noise consists mainly of quantization noise and that only 6 out of 8 bits are used (= 6x 6dB = 36dB).

8 Iris image quality data record

8.1 Binary encoding

The iris image quality binary record shall contain data values in the format shown in Table 1.

Each quality score of the metrics specified in Clause 6.2, 6.3 and 6.5, if computed, shall be encoded in a 5-byte Quality Block as specified in ISO/IEC 19794-1:2011 and Part 1 of ISO/IEC 29794.

The first byte of a 5-byte Quality Block shall contain the quality score.

The second and third bytes shall contain the CBEFF biometric organization whose algorithm was used to compute the quality score. CBEFF biometric organization identifier for the ISO/IEC JTC 1 SC 37-Biometrics is 257 or 0101_{HEX} and shall be used if and only if an SC 37 approved reference implementation is used to compute the quality scores of the standard quality metrics described in Clause 6.2, 6.3 and 6.5.

The fourth and fifth bytes shall contain the numeric identifier of the quality metric which was computed for the representation image. The identifiers for the standard iris image quality metrics are 1 to 15 as defined in Table 2.

This ISO/IEC JTC 1 SC 37-Biometrics CBEFF biometric organization identifier is 257 and is registered by International Biometrics and Identification Association (IBIA).

Quality score of 255 (FF_{Hex}) indicates that an attempt to calculate a quality score failed.

Table 1 — Iris image quality data record structure

	Byte #	Name	Length	Valid values	Description + Notes
Record Length	0	Number of Quality Blocks	1 byte	0 to 255	This field is followed by the number of 5-byte Quality Blocks reflected by its value. A value of zero (0) means that no attempt was made to assign a quality score. In this case, no Quality Blocks are present.

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Table 1 *(continued)*

	Byte #	Name	Length	Valid values	Description + Notes
5-byte Quality Block(s) [0 to 15]	1	Quality score	1 byte	0 to100, 255	Quality score of the metric identified by the Quality Algorithm Identifier (QAID) in bytes 4 and 5 of this Quality Block. If quality score is equal to 255 (FF_{Hex}), an attempt to calculate a quality score has failed. See Table 2 for valid values of standard quality metrics.
	2-3	Quality Algorithm Vendor Identifier	2 bytes	0 to 65535 257 (0101_{HEX}) if and only if QAID is between 1 and 14 and an SC 37 approved reference implementation is used to compute the quality score of standard quality metrics defined in Table 2.	This field shall contain the identifier of the vendor whose algorithm was used to compute the quality score. Quality algorithm vendor identifier shall be registered with IBIA or other approved registration authority as a CBEFF biometric organization in accordance with CBEFF vendor ID registry procedures in ISO/IEC 19785-2. A value of all zeros shall indicate that the value for this field is unreported. SC37 vendor ID is 257 or 0101_{HEX} and shall be used if and only if an SC 37 approved reference implementation is used to compute the quality scores for standard quality metrics described in Clause 6.2, 6.3 and 6.5. The Quality Algorithm Identifiers (QAID) of the standard quality metrics are identified in Table 2.
	4-5	Quality Algorithm Identifier (QAID)	2 bytes	1 to 65535 1 to 15 for standard iris image quality metrics defined in Table 2.	The quality algorithm identifier shall be encoded in two bytes. A value of all zeros is not permitted. If encoding standard quality metrics using the computation methods defined Clause 6.2, 6.3, or 6.5 quality metric identifiers defined in Table 2 shall be used. Standard quality metrics are described in Clause 6.2, 6.3 and 6.5 and their quality algorithm identifiers are identified in Table 2.

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Table 2 — Quality metric identifier

Quality metric Identifier (to be used for QAID in Table 1)	Quality metric	Length	Valid values	Acceptable range for high utility	Governing section + Description + Notes
1	Overall quality score	1 byte	0 to 100, 255		An overall quality score shall express the predicted recognition performance of a representation. A quality score shall be encoded in one byte as an unsigned integer. Allowed values are 0 to 100 with higher values indicating better quality. See Clause 6.5.
2	Usable iris area	1 byte	0 to 100, 255	70 to 100	6.2.1
3	Iris-sclera contrast	1 byte	0 to 100, 255	5 to 100	6.2.2
4	Iris-pupil contrast	1 byte	0 to 100, 255	30 to 100	6.2.3
5	Pupil boundary circularity	1 byte	0 to 100, 255		6.2.4
6	Grey scale utilisation	1 byte	0 to 20, 255	6 to 20	6.2.5
7	Iris radius	1 byte	0 to 254, 255	80 to 253	6.2.6
8	Pupil to iris ratio	1 byte	0 to 100, 255	20 to 70	6.2.7
9	Iris pupil concentricity	1 byte	0 to 100, 255	90 to 100	6.2.8
10	Margin adequacy	1 byte	0 to 100, 255	80 to 100	6.2.9
11	Sharpness	1 byte	0 to 100, 255		6.2.10
12	Frontal gaze – elevation	1 byte	0 to 100, 255		6.3.1
13	Frontal gaze - azimuth	1 byte	0 to 100, 255		6.3.2
14	Motion blur	1 byte	0 to 100, 255		6.3.3
15	Enumerated flag for presence of anomalies	1 byte	0 to 3	1	6.2.1.4 Value — Meaning 0 — No attempt to detect artifice or not encoded 1 — None present 2 — Artefact present 3 — Disease

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8.2 XML encoding

```
#################### START COPY TO SCHEMA ####################
<xs:simpleType name="QualityScoreType">
        <xs:restriction base="xs:unsignedByte">
                <xs:maxInclusive value="100"/>
        </xs:restriction>
</xs:simpleType>

<xs:complexType name="RegistryIDType">
```

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