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# Information technology — Biometric data interchange formats —

## Part 6: Iris image data

*Technologies de l'information — Formats d'échange de données biométriques —*

*Partie 6: Données d'image de l'iris*

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

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.

ISO/IEC 19794-6 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 37, *Biometrics*.

This second edition cancels and replaces the first edition (ISO/IEC 19794-6:2005), which has been technically revised.

ISO/IEC 19794 consists of the following parts, under the general title *Information technology — Biometric data interchange formats*:

— *Part 1: Framework*

— *Part 2: Finger minutiae data*

— *Part 3: Finger pattern spectral data*

— *Part 4: Finger image data*

— *Part 5: Face image data*

— *Part 6: Iris image data*

— *Part 7: Signature/sign time series data*

— *Part 8: Finger pattern skeletal data*

— *Part 9: Vascular image data*

— *Part 10: Hand geometry silhouette data*

— *Part 11: Signature/sign processed dynamic data*

— *Part 13: Voice data*

— *Part 14: DNA data*

 

# Introduction

The purpose of this part of ISO/IEC 19794 is to define a standard for exchange of iris image information. This part of ISO/IEC 19794 contains a specific definition of attributes, a data record format for storing and transmitting the iris image and certain attributes, and conformance criteria.

Currently, exchange of iris information between equipment from different vendors can be done using images of the eye. While some applications can successfully operate with full size uncompressed rectilinear images, there are others for which this is expensive with respect to storage and bandwidth. To provide interoperability among vendors, this part of ISO/IEC 19794 also defines compact representations of the human iris.

This part of ISO/IEC 19794 revises ISO/IEC 19794-6:2005 for interoperable iris data formats. The revision has focused mainly on three sets of issues: (1) compact image data formats; (2) acceptable compression targets and algorithms; and (3) specification of data to be included in records and record headers in coordination with harmonization efforts across all the parts of ISO/IEC 19794, replacing the former header structures.

Before this revision, the standard iris image format was a 307 kB image array (640 x 480), with optional JPEG compression (ISO/IEC 10918), but the recommended maximum compression factor was set arbitrarily at 6:1 (ISO/IEC 19794-6:2005, A.1.6). Meanwhile, academic papers appeared [5] showing that the 307 kB image size could be reduced by about a factor of 150:1, to around 2 kB, with minimal impairment, provided that JPEG2000 (ISO/IEC 15444) was the compression algorithm used, not JPEG (ISO/IEC 10918), and also that cropping and region-of-interest masking was used. Small payload storage devices (e.g. ISO/IEC 7816 smartcard), and limited bandwidth transmission protocols, mandated that iris *images* be reduced to a few kB. ISO/IEC 19794-6:2005 had attempted to provide for this by polar sampling of iris pixels, but vulnerabilities and defects in polar methods were pointed out and so in January 2008, WG3 voted to remove the old polar formats. NIST offered to undertake an extensive, independent, empirical investigation of various proposals and compressibility claims, producing in late 2009 the *Interoperable Iris Exchange ("IREX-1")* Report [8]. The new image data formats in this part of ISO/IEC 19794 are based empirically on the IREX-1 conclusions. In addition to the two new compact formats, iris images are also amenable to lossless compression. The lossless PNG standard, ISO/IEC 15948, may be applied to preserve completely the iris texture while affording iris image sizes in the range of 20 kB to 70 kB, well below those achievable for uncompressed images.

In addition, Annex A, when published as Amendment 1 of this part of ISO/IEC 19794, will include normative assertions for testing conformance of iris image records. Annex B of this part of ISO/IEC 19794 gives recommendations on iris image capture.

While the data structure advanced here is syntactically incompatible with the previous version, software implementations can differentiate the records by inspecting the version number in the second four bytes of the record.

# Information technology — Biometric data interchange formats —

## Part 6: Iris image data

## 1 Scope

This part of ISO/IEC 19794 specifies iris image interchange formats for biometric enrolment, verification and identification systems. The image information might be stored as

- an array of intensity values optionally compressed with ISO/IEC 15948 or ISO/IEC 15444, or
- an array of intensity values optionally compressed with ISO/IEC 15948 or ISO/IEC 15444 that might be cropped around the iris, with the iris at the centre, and which might incorporate region-of-interest masking of non-iris regions.

This part of ISO/IEC 19794 does not establish

- requirements on the optical specifications of cameras, or
- requirements on photometric properties of iris images, or
- requirements on enrolment processes, workflow and use of iris equipment.

## 2 Conformance

A biometric data record conforms to this part of ISO/IEC 19794 if it satisfies all of the normative requirements related to

- its data structure, data values and the relationships between its data elements, as specified throughout Clause 7 of this part of ISO/IEC 19794, and
- the relationship between its data values and the input biometric data from which the biometric data record was generated, as specified throughout Clause 6 of this part of ISO/IEC 19794.

A system that produces biometric data records is conformant to this part of ISO/IEC 19794 if all biometric data records that it outputs conform to this part of ISO/IEC 19794 (as defined above) as claimed in the Implementation Conformance Statement (ICS) associated with that system. A system does not need to be capable of producing biometric data records that cover all possible aspects of this part of ISO/IEC 19794, but only those that are claimed to be supported by the system in the ICS. The test for output record conformance shall be conducted in accordance with the normative content of Annex A.

A system that uses biometric data records is conformant to this part of ISO/IEC 19794 if it can read, and use for the purpose intended by that system, all biometric data records that conform to this part of ISO/IEC 19794 (as defined above) as claimed in the ICS associated with that system. A system does not need to be capable of using biometric data records that cover all possible aspects of this part of ISO/IEC 19794, but only those that are claimed to be supported by the system in an ICS.

## 3 Normative references

The following referenced documents are indispensable for the application 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 15444-1, *Information technology — JPEG 2000 image coding system*: *Core coding system*

ISO/IEC 15948:2004, *Information technology — Computer graphics and image processing — Portable Network Graphics (PNG): Functional specification*

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

## 4 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19794-1 and the following apply.

**4.1**
**grey scale**
continuous-tone image that has one component, which is luminance

**4.2**
**iris**
coloured annular structure in the front portion of the eye comprised of muscular and connective tissue and pigmented layers, that defines the pupil and controls its size

**4.3**
**iris centre**
centre of a circle modelling the boundary between iris and sclera

**4.4**
**iris radius**
radius of a circle modelling the boundary between iris and sclera

**4.5**
**limbus**
outer boundary of the iris where it is joined to the sclera

**4.6**
**margin**
distance in an image from the iris-sclera border, when modelled as a circle, to the closest image border, expressed in pixels

NOTE Throughout this part of ISO/IEC 19794, margins are defined in terms of the iris radius R. When written as an ordered pair, the order is (horizontal, vertical).

EXAMPLE (0,6R, 0,2R) indicates that for an iris radius of R, there shall be margins of image data 0,6·R to the right and left of the iris and 0,2·R above and below the iris.

**4.7**
**Modulation Transfer Function**
ratio of the image modulation to the object modulation as a function of spatial frequency

**4.8**
**pupil**
optical opening in the centre of the eye that serves as a variable light aperture and defines the inner boundary of the iris

**4.9**
**pupil centre**
average of coordinates of all the pixels lying on the boundary of the pupil and the iris

**4.10**
**round**
mathematical function applied to a number x such that round(x) is the integer that is closest in value to x

**4.11**
**sclera**
generally white wall of the eye peripheral to the iris

**4.12**
**spatial frequency**
measure of the repetition rate of a sinusoidal intensity pattern in space, in units of cycles/deg or of cycles/mm at a given target range

# 5 Symbols and abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

**BDIR**
Biometric Data Interchange Record

**JPEG2000**
Joint Photographic Experts Group enhanced compression standard for images as defined in ISO/IEC 15444

**PNG**
Portable Network Graphics lossless compression standard for images as defined in ISO/IEC 15948:2004

**VGA**
Video Graphics Array image format having width 640 pixels and height 480 pixels

# 6 Iris image content specification

## 6.1 General

This clause establishes requirements on the semantic content of the images that are allowed by this part of ISO/IEC 19794. These requirements relate to the geometric structure, pre-processing, compression protocol, format, and dimensions of the image data. (Guidance on iris image capture is given in Annex B.) Image data may be uncompressed or compressed. If uncompressed then it shall be represented as a two-dimensional array of monochrome pixels, organised in row-major order, with the lowest address corresponding to the upper left corner of the image. All uncompressed raw images shall have an 8 bit pixel depth. Images having a pixel depth other than 8 bits shall be encoded using PNG or JPEG2000.

The remaining subclauses of clause 6 group these requirements according to the type of image. As shown in Table 1, four image types are defined according to a hierarchy inherited from an unconstrained abstract basic iris image. The associated type values are provided in clause 7.4.1. The requirements of clause 7 establish the encoding specifications for the image and its associated metadata.

NOTE The specifications of image types, compression protocols, formats and cropping dimensions in this edition of this part of ISO/IEC 19794 have been determined by the NIST Interoperable Iris Exchange (IREX-1) study [8] (2009), which was commissioned for this purpose.

**Table 1 — Hierarchy of iris image types**

| FORMAT NAME | Iris Centring | Margins | | Width and Height | Data Size | Compression | |
|---|---|---|---|---|---|---|---|
| | | Horizontal | Vertical | | | Mode | Method |
| **IMAGE_TYPE_UNCROPPED** | no | ≥0,6R | ≥0,2R | unspecified | variable | none | n/a |
| | | | | | variable | lossless | PNG or JPEG2000 |
| | | | | | variable | lossy | JPEG2000 |
| **IMAGE_TYPE_VGA** | no | ≥0,6R | ≥0,2R | W = 640, H = 480 | 307,2 kB | none | n/a |
| | | | | | typically 70-140 kB | lossless | PNG or JPEG2000 |
| | | | | | variable | lossy | JPEG2000 |
| **IMAGE_TYPE_CROPPED** | yes | =0,6R | =0,2R | unspecified | variable | none | n/a |
| | | | | | typically 40-70 kB | lossless | PNG or JPEG2000 |
| | | | | | typically 8-24 kB (compact) | lossy (see NOTE 4) | JPEG2000 |
| **IMAGE_TYPE_CROPPED_AND_MASKED** | yes | =0,6R | =0,2R | unspecified | variable | none | n/a |
| | | | | | typically 20-50 kB | lossless | PNG or JPEG2000 |
| | | | | | typically 2-6 kB (compact) | lossy | JPEG2000 |

NOTE 1 The application of lossy compression to IMAGE_TYPE_UNCROPPED images is not recommended for images with spatial sampling rate below10 pixels/mm.

NOTE 2 Typical data sizes for IMAGE_TYPE_CROPPED and IMAGE_TYPE_CROPPED_AND_MASKED assume an iris of about 120 pixels radius. Other sizes are listed as variable to reflect variations in spatial sampling rate and in iris size.

NOTE 3 The use of cropping, masking, or lossy compression may degrade iris recognition accuracy.

NOTE 4 For applications of 1:1 comparison, the compressed IMAGE_TYPE_CROPPED data size may be as low as 3 kB.

## 6.2 Uncropped Iris Image

An Uncropped iris image shall contain a raster scan image of a single eye. An example is shown in Figure 1. For an iris radius of R, there shall be margins of image data at least 0,2R above and below the iris, and at least 0,6R to the right and left of the iris. These margins of image data shall be acquired from the actual object being imaged, not synthesised values. It is not assumed that the iris is centred within the image.

If Uncropped image data is compressed then ideally it should be compressed losslessly. PNG shall not be used in its interlaced mode. If JPEG2000 is used, image data shall be stored in JPEG2000 format.

The Uncropped iris image type shall be identified in the record structure of clause 7 by assigning a value of 1 to the image type field on line 9 of Table 4.

## 6.3 VGA Iris Image

A VGA Iris Image is a special case of the Uncropped Iris Image; the image width shall be 640 pixels and the image height shall be 480 pixels. Additional constraints of margins and container are inherited from the Uncropped Image type in clause 6.2.

 

If images are compressed, then images shall be compressed in accordance with either PNG or JPEG2000 for lossless compression, or JPEG2000 for lossy compression.

The VGA Iris Image type shall be identified in the record structure of clause 7 by assigning a value of 2 to the type field on line 9 of Table 4.

**Figure 1 — Example of Uncropped Iris Image or VGA Iris Image**

## 6.4 Cropped Iris Image

A cropped version of a rectilinear iris image may be instantiated. This supports moderately compact storage. It requires a coarse localization of the iris.

The cropped rectilinear image shall contain an iris centred relative to the geometric centre of the raster representation. An example is shown in Figure 2.

The crop region shall be sized such that a margin 0,6R pixels wide is included on both the right and left sides of the iris, where R is an estimate of the iris radius. Margins above and below the iris shall include 0,2R pixels. Margin pixels shall represent actual sensor readings, not substitute values.

Parts of the iris estimated to have been cropped during capture (i.e. absent in the input image) shall be replaced with pixels of value 0. Note that records with partially or fully missing iris data should not ordinarily be generated; instead, the defect should be detected and another capture attempted.

The Cropped Iris Image type inherits all of the normative requirements of the Uncropped Iris Image type in clause 6.2 with respect to compression.

The Cropped Iris Image type shall be identified in the record structure of clause 7 by assigning a value of 3 to the type field on line 9 of Table 4.

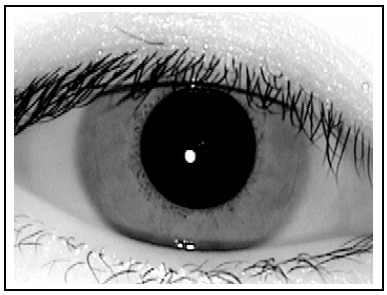

**Figure 2 — Example of Cropped Iris Image**

## 6.5 Cropped and Masked Iris Image

### 6.5.1 General

A cropped rectilinear image may be masked to produce a highly compressible image. This masking operation involves pixels in three regions: the upper and lower eyelids, and the sclera. At least one region shall be masked. A mask shall consist of a single grey value assigned to a four-connected region of pixels. Examples are shown in Figure 3. The utility of this approach has been documented in the academic literature [5].

The Cropped and Masked Iris Image type inherits all of the normative requirements of the Cropped Iris Image type in clause 6.4 with respect to compression.

The Cropped and Masked Iris Image type shall be identified in the record structure of clause 7 by assigning a value of 7 to the type field on line 9 of Table 4.

NOTE Masking serves compressibility only; the presence of a mask grey value cannot be used as a reliable segmentation indicator. When an image is compressed the mask value might be altered by the compression algorithm.

### 6.5.2 Masking of the sclera

The pixels in the sclera region shall be substituted with a fixed mask value of 200. The sclera mask shall extend to the first and last columns unless the upper and lower eyelids touch there.

### 6.5.3 Masking of the eyelids

The pixels in the upper and lower eyelid regions shall be substituted with a fixed mask value of 128.

The upper eyelid mask shall extend to the first (top) row of the image. The upper eyelid mask shall extend to the leftmost and rightmost columns of the image. The lower eyelid mask shall extend to the last (bottom) row of the image. The lower eyelid mask shall extend to the leftmost and rightmost columns of the image.

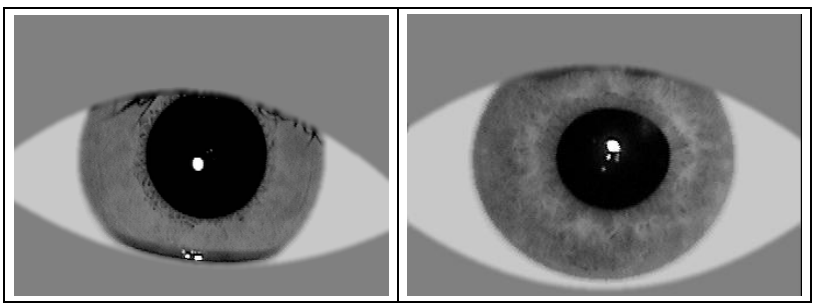

**Figure 3 — Examples of Cropped and Masked Iris Images**

### 6.5.4 Mask transition blurring

The transitions from iris and sclera regions to the eyelid mask regions, and from the iris to the sclera mask regions, shall be locally smoothed to minimise the boundary's impact on the compression coding budget.

The method shall be as follows: After the eyelid mask and the sclera mask values have replaced the original image pixel values, the borders of these mask regions shall be smoothed by low-pass filtering. Each image pixel, whose centred 7 x 7 neighbourhood contains at least one mask pixel, shall be replaced by a weighted sum of a 7 x 7 binomial kernel. The coefficients of this kernel are defined by the outer product,

$$K = 1/(64\times64)\ UU^T \qquad \text{where:} \qquad U = [\ 1\ 6\ 15\ 20\ 15\ 6\ 1\ ]^T$$

The border-smoothing pixel values shall be computed after the masking operation but before further pixel replacement begins; and in the case of pixels that belong to both the iris-sclera mask transition and the iris or sclera to eyelid transition neighbourhoods, the replacement values used shall be those of the eyelid border-smoothing operation.

## 7 Iris image format specification

### 7.1 General

This clause specifies header and data structures that support storage of iris images in a compound biometric data record.

Unless otherwise specified, all numeric values shall be encoded as fixed-length, unsigned integer quantities. All header data shall be stored in network byte (big-endian) order. Where bit-level data definitions are specified, bit 1 shall be interpreted as the least significant bit (LSB). Signed fields shall use 2's complement encoding.

### 7.2 Iris image biometric data record

Table 2 illustrates the structure of the iris image biometric data record. The record shall contain images from a single individual. It shall have an iris general header that contains information about the number of images that follow, the number of eyes represented and the total length. The record shall contain images from one or two eyes. If the capture device is unable to determine which eye was presented, then the eye label shall be entered as unknown, i.e., SUBJECT_EYE_LABEL_UNDEF = 0 = $00_{Hex}$.

Each iris image is preceded by an iris representation header as specified in clause 7.4, Table 4. Each image shall be padded with extra bits, if necessary, to end on an integral byte boundary.

**Table 2 — Iris image biometric data record**

| # | Content | | Data Type |
|---|---|---|---|
| 1 | Iris general header | | Compound, see Table 3 |
| 2 | First image | Iris representation header | Compound, see Table 4 |
| 3 | | Image | unsigned char |
| 4 | Second image | Iris representation header | see Table 4 |
| 5 | | Image | unsigned char |
| 6... | Further captures | ... | ... |

## 7.3 Iris general header structure

The iris general header shall contain data values in the format shown in Table 3.

**Table 3 — Iris general header**

| # | Name | Length | Value | Description |
|---|---|---|---|---|
| 1 | Format identifier | 4 bytes | $49495200_{Hex}$ ('I' 'I' 'R' $00_{Hex}$) | The format identifier shall be recorded in four bytes. The format identifier shall consist of three characters "IIR", standing for iris image record, followed by a zero byte as a NULL string terminator. |
| 2 | Version number | 4 bytes | $30323000_{Hex}$ ('0' '2' '0' $00_{Hex}$) | This number indicates the second version of this part of ISO/IEC 19794 used for constructing the iris image data record and shall be placed in four bytes. This version number shall consist of three ASCII numerals followed by a zero byte as a NULL string terminator. |
| 3 | Length of record | 4 bytes | 69 to $2^{32}$-1 | The length (in bytes) of the entire iris image data record shall be recorded in four bytes. This count shall be the total length of the data block including the iris general header and one or more representation records. |
| 4 | Number of iris representations | 2 bytes | 1 ... 65 535 | The total number of iris representations in this record. This shall be recorded in two bytes. A minimum of one representation is required. |
| 5 | Certification flag | 1 byte | $00_{Hex}$ | No certification schemes are available for this part of ISO/IEC 19794. |
| 6 | Number of eyes represented | 1 byte | 0, 1, 2 | Assign 1 if left or right eye is known to be present.<br>Assign 2 if left and right eyes are known to be present.<br>Assign 0 if the laterality of the eye image(s) is unknown.<br>The first representation follows this field. |

## 7.4 Iris representation header structure

The iris representation header shall contain data values in the format shown in Table 4.

**Table 4 — Iris representation header**

| # | Name | Length | Valid values | Description |
|---|---|---|---|---|
| 1 | Representation Length | 4 bytes | 53 to (( $2^{32}$ −1) – 16) | The representation-length field denotes the length in bytes of the representation including the representation header field. |
| 2 | Capture date and time | 9 bytes | See ISO/IEC 19794-1, clause 12.3.2<br><br>EXAMPLE: Thursday 17:35:20 December 15, 2005 is encoded as<br>07 D50C 0F11 2314 $FFFF_{Hex}$ | The capture date and time field shall indicate when the capture of this representation started in Coordinated Universal Time (UTC). The capture date and time field shall consist of 9 bytes. Its value shall be encoded in the form given in ISO/IEC 19794-1. |
| 3 | Capture device technology identifier | 1 byte | 0 ($00_{Hex}$ ): Unknown or Unspecified<br>1 ($01_{Hex}$ ): CMOS/CCD | The capture device technology ID shall be encoded in one byte. This field shall indicate the class of capture device technology used to acquire the captured biometric sample. A value of $00_{Hex}$ indicates unknown or unspecified technology. |
| 4 | Capture device vendor ID | 2 bytes | $0000_{Hex}$ (Unspecified) or<br>Registered Value (IBIA or otherwise) | The capture device vendor identifier shall identify the biometric organisation that owns the product that created the BDIR. The capture device vendor identifier shall be encoded in two bytes carrying a CBEFF biometric organization identifier (registered by IBIA or other approved registration authority). A value of all zeros shall indicate that the capture device vendor is unreported. |

| | | | | |
|---|---|---|---|---|
| 5 | Capture device type ID | 2 bytes | $0000_{Hex}$ (Unspecified) or<br>Registered Value (IBIA or otherwise) | The capture device type identifier shall identify the product type that created the BDIR. It shall be assigned by the registered product owner or other approved registration authority. A value of all zeros shall indicate that the capture device type is unreported. |
| 6 | Quality block | 1 to n bytes | See ISO/IEC 19794-1 | A quality record shall consist of a length field followed by zero or more quality blocks. The length field shall consist of one byte. It shall represent the number of quality blocks as an unsigned integer.<br>Each quality block shall consist of<br>– a quality score,<br>– a quality algorithm vendor identifier, and<br>– a quality algorithm identifier.<br>A quality score should express the predicted comparison performance of a representation. A quality score shall be encoded in one byte as an unsigned integer. Allowed values are<br>– 0 to 100 with higher values indicating better quality,<br>– IMAGE_QUAL_FAILED = 255 ($FF_{Hex}$), indicating that an attempt to calculate a quality score failed.<br>The quality algorithm vendor identifier shall identify the provider of the quality algorithm. The quality algorithm vendor identifier shall be encoded in two bytes carrying a CBEFF biometric organization identifier (registered by IBIA or other approved registration authority). A value of all zeros shall indicate that the quality algorithm vendor is unreported.<br>The quality algorithm identifier shall identify the vendor's quality algorithm that created the quality score. It shall be assigned by the provider of the quality algorithm or an approved registration authority. The quality algorithm identifier shall be encoded in two bytes. A value of all zeros shall indicate that the quality algorithm is unreported. |
| 7 | Representation number | 2 bytes | 1 to … number of representations < 65 536 | Representation sequence number |
| 8 | Eye label | 1 byte | SUBJECT_EYE_LABEL_UNDEF = 0 ($00_{Hex}$)<br>SUBJECT_EYE_LABEL_RIGHT = 1 ($01_{Hex}$)<br>SUBJECT_EYE_LABEL_LEFT = 2 ($02_{Hex}$) | These refer to the subject's own eyes. |
| 9 | Image type | 1 byte | IMAGE_TYPE_UNCROPPED = 1 ($01_{Hex}$) | An uncropped rectilinear iris image. |
| | | | IMAGE_TYPE_VGA = 2 ($02_{Hex}$) | A rectilinear iris image in VGA (640x480) format. |
| | | | IMAGE_TYPE_CROPPED = 3 ($03_{Hex}$) | A cropped, centred, iris image with (0,6R 0,2R) margins. |
| | | | IMAGE_TYPE_CROPPED_AND_MASKED = 7 ($07_{Hex}$) | A cropped and region-of-interest masked, centred, iris image with (0,6R 0,2R) margins. |
| | | | | For all Image types, see Table 5 and the normative requirements of the clauses cited. |
| 10 | Image format | 1 byte | IMAGEFORMAT_MONO_RAW = 2 ($02_{Hex}$)<br>IMAGEFORMAT_MONO_JPEG2000 = 10 ($0A_{Hex}$)<br>IMAGEFORMAT_MONO_PNG = 14 ($0E_{Hex}$) | Format of image data |

| | | | | |
|---|---|---|---|---|
| 11 | Iris image properties bit field | 1 byte | Bits 1-2, i.e. least significant bits:<br>ORIENTATION_UNDEF = 0<br>HORZ_ORIENTATION_BASE = 1<br>HORZ_ORIENTATION_FLIPPED = 2<br>Bits 3-4:<br>ORIENTATION_UNDEF = 0<br>VERT_ORIENTATION_BASE = 1<br>VERT_ORIENTATION_FLIPPED = 2<br>Bits 5-6: 0,0<br>Bits 7-8:<br>PREVIOUS_COMPRESSION_UNDEF = 0<br>PREVIOUS_COMPRESSION_LOSSLESS_OR_NONE = 1<br>PREVIOUS_COMPRESSION_LOSSY = 2 | Horizontal orientation<br><br><br><br>Vertical orientation<br><br><br><br>Reserved by SC 37 for future use; default to 0,0<br>Compression history |
| 12 | Image width | 2 bytes | > 0 | Width in pixels |
| 13 | Image height | 2 bytes | > 0 | Height in pixels |
| 14 | Bit depth | 1 byte | At least 8 | Bit depth in bits per pixel. (Images having > 8 bpp shall be encoded using PNG or JPEG2000.) |
| 15 | Range | 2 bytes | 2 to ($2^{16}$ – 2)<br>RANGE_UNASSIGNED = 0<br>RANGE_FAILED = 1<br>RANGE_OVERFLOW = $2^{16}$ – 1 | The "Range" field shall specify an estimate of the distance between the optical centre of the camera lens and the subject iris, measured in mm.<br>NOTE The magnification cannot be derived from the range value if the camera can change its focal length, using a zoom lens or other method. |
| 16 | Roll angle of eye | 2 bytes | 0 to 65 534<br>ROLL_ANGLE_UNDEF = 65 535 | Roll angle = (unsigned short) round (65 535 x angle/360) modulo 65 535, where angle is measured counter-clockwise in degrees, as per clause 7.4.2.1. |
| 17 | Roll angle uncertainty | 2 bytes | 0 to 65 534<br>ROLL_UNCERTAIN_UNDEF = 65 535 | Roll angle uncertainty = (unsigned short) round (65 535 x uncertainty/180)<br>where 0 ≤ uncertainty < 180, where uncertainty is measured in degrees and is the absolute value of maximum error. See clause 7.4.2.2. |
| 18 | Iris centre, smallest X | 2 bytes | 1 to 65 535<br>COORDINATE_UNDEF = 0 | Smallest expected iris centre X coordinate in pixels, measured from the left side of the image |
| 19 | iris centre, largest X | 2 bytes | 1 to 65 535<br>COORDINATE_UNDEF = 0 | Largest expected iris centre X coordinate in pixels, measured from the left side of the image |
| 20 | Iris centre, smallest Y | 2 bytes | 1 to 65 535<br>COORDINATE_UNDEF = 0 | Smallest expected iris centre Y coordinate in pixels, measured from the top of the image |
| 21 | Iris centre, largest Y | 2 bytes | 1 to 65 535<br>COORDINATE_UNDEF = 0 | Largest expected iris centre Y coordinate in pixels, measured from the top of the image |
| 22 | Iris diameter, smallest | 2 bytes | 1 to 65 535<br>COORDINATE_UNDEF = 0 | Smallest expected iris diameter in pixels |
| 23 | Iris diameter, largest | 2 bytes | 1 to 65 535<br>COORDINATE_UNDEF = 0 | Largest expected iris diameter in pixels |
| 24 | Image length | 4 bytes | 1 to 4 294 967 226 | Size of the image data (Representation body), in bytes |

### 7.4.1 Image type

The single byte in field 9 shall indicate the type of image that follows. The image shall conform to the normative requirements of the clauses cited in Table 5.

**Table 5 — Image types and their requirements**

| Image type | Name | Governing clauses |
|---|---|---|
| 1 | Uncropped Iris Image | 6.2 |
| 2 | VGA Iris Image | 6.3 |
| 3 | Cropped Iris Image | 6.4 |
| 7 | Cropped and Masked Iris Image | 6.5 with subclauses 1, 2, 3, 4 |

### 7.4.2 Optional estimation of relative head and camera roll

#### 7.4.2.1 Relative roll angle

Iris image capture systems that record images of both eyes simultaneously might have the capability to measure the roll angle of the subject's head e.g. by defining a line between the pupil centres of the left and right eyes and determining the angular difference between this line and the horizontal axis of the imaging system. This information might be useful for the matching process and to expedite searching large databases. If the relative roll angle between head and camera is measured and recorded in field 16, it shall be measured in degrees between the horizontal axis of the camera system and the line between the centres of the two eyes, with a positive value signifying counter-clockwise rotation, as seen from the camera, of the line between the eyes. If roll angle information is not available then the value in field 16 shall be set to $FFFF_{Hex}$.

#### 7.4.2.2 Roll angle uncertainty

The roll angle uncertainty is an estimate, dependent on the imaging device, of the maximum error associated with the roll angle. If it is recorded in field 17 it shall be measured as a nonzero value in degrees. If roll angle information is not available then the roll angle uncertainty value in field 17 shall be set to $FFFF_{Hex}$.

### 7.4.3 Localisation

The optional values of expected centre and diameter limits in fields 18 to 23 are intended to guide the iris localisation and segmentation process. They might be populated either per image, by an iris localisation step during capture, or per camera, based on capture-specific constants such as image size, magnification and depth of field. This guidance can speed up the localisation and might avoid segmentation errors due to overly large search ranges. Note that depending on the accuracy of the recorded values, the guided search might miss the correct iris segmentation. These values can be used or ignored during subsequent processing.

### 7.4.4 Image data length

The iris representation header shall be concluded in field 24 by the length of the image data, which is followed by the image data itself (the Representation body).

### 7.4.5 Header constants

Significance of specific constants named in the iris representation header are as follows:

**Table 6 — Iris representation header constant definitions**

| Constant | Description | Field in Table 4 |
|---|---|---|
| *_UNDEF | Usage in any constant indicates that the parameter is undefined. | Various |
| IMAGE_QUAL_FAILED | An attempt to assess the sample image quality has been made, but failed. | 6 |
| SUBJECT_EYE_LABEL_RIGHT | Signifies that an image is of the subject's right eye | 8 |
| SUBJECT_EYE_LABEL_LEFT | Signifies that an image is of the subject's left eye | 8 |
| IMAGEFORMAT_MONO_RAW | Image is monochrome and uncompressed. | 10 |
| IMAGEFORMAT_MONO_JPEG2000 | Image is monochrome and compressed using JPEG2000 algorithm as specified in ISO/IEC 15444-1, in JPEG2000 file format. | 10 |
| IMAGEFORMAT_MONO_PNG | Image is monochrome and compressed using PNG algorithm as specified in ISO/IEC 15948:2004. | 10 |
| HORZ_ORIENTATION_BASE | Left side of eye facing subject (i.e. nasal side of subject's left eye, or temporal side of subject's right eye) is on left side of the image as viewed. | 11 |
| HORZ_ORIENTATION_FLIPPED | Horizontal orientation is opposite from that described for ORIENTATION_BASE, i.e. mirrored about a vertical axis. | 11 |
| VERT_ORIENTATION_BASE | Superior edge of eye is at top of image. | 11 |
| VERT_ORIENTATION_FLIPPED | Vertical orientation is opposite from that described for ORIENTATION_BASE, i.e. mirrored about a horizontal axis. | 11 |
| PREVIOUS_COMPRESSION_LOSSLESS_OR_NONE | The image was not compressed, or was losslessly compressed, before being represented in the current format. | 11 |
| PREVIOUS_COMPRESSION_LOSSY | The image was compressed lossily before being represented in the current format. | 11 |
| RANGE_UNASSIGNED | No attempt has been made to estimate the range. | 15 |
| RANGE_FAILED | An attempt to estimate the range has been made, but failed. | 15 |
| RANGE_OVERFLOW | Estimated range in mm exceeds $2^{16}$ — 2. | 15 |

### 7.5 Representation body

This field shall contain all of the data of a captured or processed iris image. Each pixel of uncompressed greyscale data should normally be quantised to 8 bits (256 grey levels) contained in a single byte. If compression is used, the pixel data shall be compressed in accordance with the compression technique specified in field 10, Image format.

## 8 Registered Format Type Identifier

The registrations listed in Table 7 have been made with the CBEFF Registration Authority (see ISO/IEC 19785-2) to identify the iris image record format. The format owner is ISO/IEC JTC 1/SC 37 with the registered format owner identifier 257 ($0101_{Hex}$).

**Table 7 — Format Type Identifier**

| CBEFF BDB format type identifier | Short Name | Full object identifier |
|---|---|---|
| 09 ($0009_{Hex}$) | iris-image-rectilinear | {iso(1) registration-authority(1) cbeff(19785) organizations(0) jtc1-sc37(257) bdbs(0) iris-image-rectilinear (9)} |

# Annex A
(normative)

# Conformance testing methodology

This part of ISO/IEC 19794 specifies a biometric data interchange format for storing, recording, and transmitting one or more iris representations. Each representation is accompanied by modality-specific metadata contained in a header record. This annex establishes tests for checking the correctness of the record.

The objective of this part of ISO/IEC 19794 cannot be completely achieved until biometric products can be tested to determine whether they conform to those specifications. Conforming implementations are a necessary prerequisite for achieving interoperability among implementations; therefore there is a need for a standardised conformance testing methodology, test assertions, and test procedures as applicable to specific modalities addressed by each part of ISO/IEC 19794. The test assertions will cover as much as practical of the ISO/IEC 19794 requirements (covering the most critical features), so that the conformity results produced by the test suites will reflect the real degree of conformity of the implementations to ISO/IEC 19794 data interchange format records. This is the motivation for the development of this conformance testing methodology.

This normative annex is intended to specify elements of conformance testing methodology, test assertions, and test procedures as applicable to this part of ISO/IEC 19794. The content of this annex will be published as an amendment to this part of ISO/IEC 19794.

# Annex B
(informative)

# Iris image capture

## B.1 Modulation Transfer Function and spatial sampling rate

The Modulation Transfer Function (MTF) of the imaging system should be attenuated to no less than 0,6 at a spatial frequency of 2 cycles/mm. The digital image that is captured from the iris should have a spatial sampling rate equal to at least 10 pixels per mm. Alternatively to measuring the MTF using sinusoids, it may also be measured using a line target (squarewave) having a frequency of 2 line pairs/mm. The corresponding maximum attenuation limit is (4/π) x 0,6 which is 2 decibels less attenuation, since the ratio of the squarewave amplitude to that of its fundamental Fourier component (sinewave) amplitude is $-20 \log_{10}(\pi/4) = 2$ dB.

## B.2 Compression ranges and recommended roles for the image types

Table B.1 is adapted from Figure 1 of IREX-1 [8] and illustrates the recommended image Types to use in different applications (such as 1:1 verification or 1:N identification) for various target data size ranges in bytes.

**Table B.1 — Image types for target record sizes and uses**

| Configuration | | Target Record Size |
|---|---|---|
| **Role** | **Recommended Type and Compressor** | 2kB 4kB 8kB 16kB 32kB 64kB 128kB 256kB |
| All | IMAGE_TYPE_UNCROPPED<br>PNG lossless or JPEG2000 lossless | |
| All | IMAGE_TYPE_VGA (640x480)<br>PNG lossless or JPEG2000 lossless | |
| All | IMAGE_TYPE_CROPPED<br>PNG lossless or JPEG2000 lossless | |
| All | IMAGE_TYPE_CROPPED_AND_MASKED<br>PNG lossless or JPEG2000 lossless | |
| 1:N | IMAGE_TYPE_CROPPED<br>JPEG2000 | |
| 1:N | IMAGE_TYPE_CROPPED_AND _MASKED<br>JPEG2000 | |
| 1:1 | IMAGE_TYPE_CROPPED<br>JPEG2000 | |
| 1:1 | IMAGE_TYPE_CROPPED_AND_MASKED<br>JPEG2000 | |

## B.3 Focus quality

Images should have focus quality adequate to preserve the specified spatial resolution. Figure B.1 illustrates a representative iris image with adequate resolution and focus quality. Note that image compression and defocus cause different types of degradations of an image. One algorithm for assessing image focus and assigning a Focus Score in the range of [0, 100] is given in the Appendix of [7].

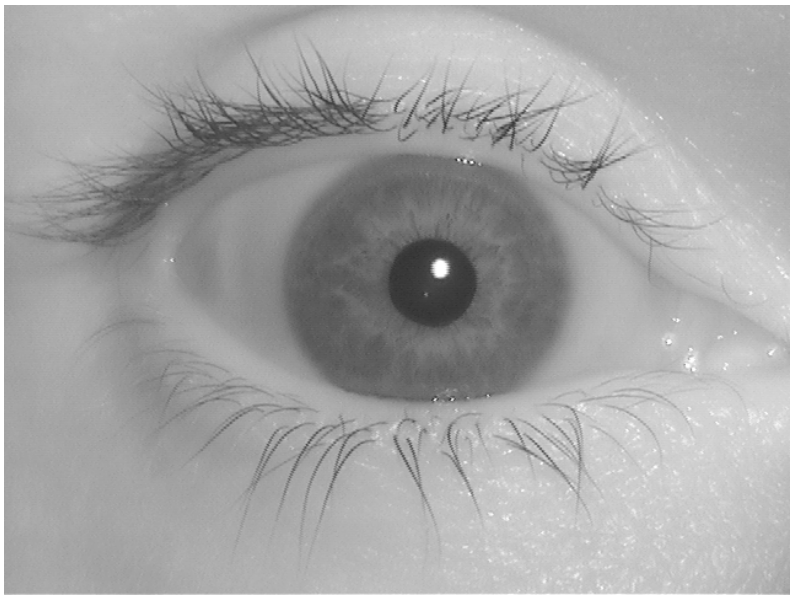

**Figure B.1 — Iris image in good focus**

## B.4 Contrast

The iris image should have good grey level separation between the iris and sclera, and between the iris and pupil, as shown in Figure B.2, and should have sufficient contrast to reveal the iris texture.

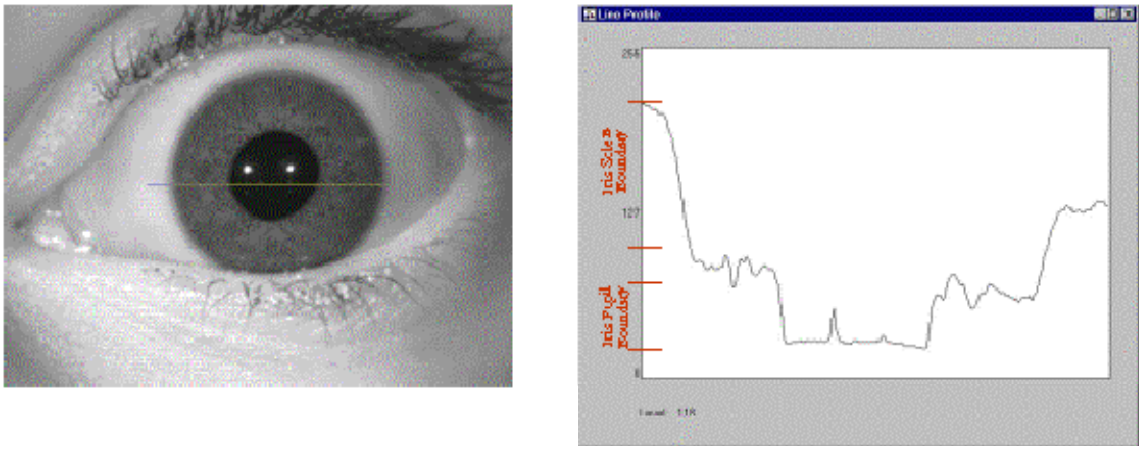


**Figure B.2 — Iris image and grey level profile through the indicated line**

## B.5 Visible iris

At least 70 percent of the iris should be visible, i.e., not obscured by specular reflections, eyelids, eyelashes, or other obstructions. It is recognized that this can be difficult to achieve among some ethnic populations.

## B.6 Greyscale density

The image should have a dynamic range spanning 256 grey levels, allocating one byte (8 bits) per intensity value and providing at least 7 bits of useful intensity information. If specular reflections from the illumination source occur their intensity should be set to the saturation level (the maximum value grey level) or to a grey value of 0. Other areas within the pupil, iris, and sclera of the eye should have intensities greater than 0 and

less than the maximum grey level. This recommendation might be amended based on availability of performance data.

## B.7 Illumination

The eye should be illuminated using near-infrared wavelengths between approximately 700 and 900 nanometres (nm). These recommendations represent current best practice, but do not preclude the use of other wavelengths, including visible light, in future systems. The angle between a line extending from the centre of the illumination source to the pupil centre, and the optical axis of the iris camera should be at least 5 degrees in order to prevent “red-eye” effect. The illumination source should be alongside or below the camera to prevent creation of shadows by the eyebrows.

## B.8 Pixel aspect ratio

The image capture system should produce square pixels, in which the horizontal and vertical dimensions of the pixels are equal. Any difference between horizontal and vertical pixel dimension should be less than 1 percent, that is, the ratio of horizontal to vertical pixel dimension should be between 0,99 and 1,01.

## B.9 Optical distortion

The iris image should not exhibit effects of optical distortion including spherical aberration, chromatic aberration, astigmatism and coma consistent with standard optical design practices [6].

## B.10 Noise

Noise should not be observable in the captured image.

## B.11 Image orientation

The image should contain either the left or right eye and should be presented in the following canonical form.

If it is necessary to flip the image either horizontally or vertically to attain this form, then parameters in the header structure (field 11 of Table 4) will indicate the flip required. The canonical form is as follows:

— The image is right-side up, i.e., upper eyelids and eye brows are in the upper part of the image.

— The tear duct (or nasal canthus) of the right eye is on the right side of the image; the tear duct of the left eye is on the left side of the image.

## B.12 Presentation

In order to obtain the best iris recognition performance and interoperability certain practices regarding presentation of the iris should be observed. Recommendations are as follows:

— The head should be held approximately vertical (not rolled either way) so that a line drawn between the centres of the left and right irises is horizontal ± 10 degrees. Some cameras will be able to measure the roll angle by imaging both eyes and constructing a line between their iris centres.

— The eye being imaged should be opened as wide as possible in order to maximize the exposed iris area.

— Excessive pupil dilation might affect the quality of enrolment, so ambient illumination should be sufficient such that a pupil diameter less than 7 mm is presented.

— Eyeglasses should be removed when capturing images for enrolment use in order to optimise the enrolment quality and minimise the subsequent false non-match rate.

— Hard contact lenses and patterned soft contact lenses should be removed, both for enrolment and for recognition/verification.

## B.13 Quality score

If a biometric sample quality score can be derived from a representation then the goal is to maximise this score for all representations. The quality score should quantitatively express the utility of the representation, which is the predicted performance of a biometric sample in a biometric system. The quality score might be dependent on several quality factors, including resolution, contrast and image noise level. Averaged over a larger number of images, the quality score is intended to predict the identification and verification performance of the biometric algorithm used. For a particular pair of iris images from the same eye it could express the contribution of the pair to the overall predicted performance of the system.

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