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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

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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.

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

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*

The following parts are under preparation:

— *Part 7: Signature/sign behavioral data*

— *Part 8: Finger pattern skeletal data*

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Introduction

The purpose of this document 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, a sample record, and conformance criteria.

Currently, exchange of iris information between equipment from different vendors can only be done using a large-scale image of the entire eye. This is expensive in storage and bandwidth. To provide interoperability among vendors, it is necessary to define a standard, compact representation of a human iris.

The biometric data record specified in this part of ISO/IEC 19794 shall be embedded in a CBEFF-compliant structure in the CBEFF Biometric Data Block (BDB).

The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning iris recognition given in Clause 6 and/or Annex A.

The ISO and IEC take no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured the ISO and IEC that he/she is willing to negotiate licenses under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO and IEC. Information may be obtained from:

Iridian, Technologies, Inc.
Mr. Robert Levin Corporate Counsel
1245 N. Church Street
Moorestown, NJ 08057 USA

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Information technology — Biometric data interchange formats —

Part 6: Iris image data

1 Scope

This part of ISO/IEC 19794 specifies two alternative image interchange formats for biometric authentication systems that utilize iris recognition.

The first is based on a rectilinear image storage format that may be a raw, uncompressed array of intensity values or a compressed format such as that specified by ISO/IEC 15444.

The second format is based on a polar image specification that requires certain pre-processing and image segmentation steps, but produces a much more compact data structure that contains only iris information.

Data that comply with either one of the iris image formats specified in this part of ISO/IEC 19794 are intended to be embedded in a CBEFF-compliant structure in the CBEFF Biometric Data Block (BDB) as specified in ISO/IEC 19785-1.

2 Conformance

Conformity with this part of ISO/IEC 19794 requires compliance with one of the data formats described in clause 6. Recommended image quality criteria described in Annex A are expressed in terms of resolution, contrast, noise level, etc. Because iris recognition applications may have varying image quality requirements, four different levels of image quality are defined in Annex A. In general, the highest image quality level is recommended for high-volume, high-security applications where the lowest possible recognition error rates are required. Lower levels of image quality are appropriate for less demanding applications in which higher error rates can be tolerated but camera cost is a critical factor.

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 19785-1, *Information technology — Common biometric exchange formats framework — Part 1: Data element specification*

ISO/IEC 10918 (all parts), *Information technology — Digital compression and coding of continuous-tone still images*

ISO/IEC 15444 (all parts), *Information technology — JPEG 2000 image coding system*

ISO/IEC 14495 (all parts), *Information technology — Lossless and near-lossless compression of continuous-tone still images*

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

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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
binary large object
BLOB
large block of binary data, typically an image or video file, that may have to be handled in a special way

4.2
continuous tone image
image whose components have more than one bit per sample

4.3
crop
reduce the size of an image by removing unimportant parts of it, typically the outer regions

4.4
grey scale
continuous-tone image that has one component, which is luminance

4.5
iris
coloured annular ring in the front portion of the eye comprised of muscular and connective tissue and pigment cells that defines and controls the central opening of the pupil

4.6
limbus
outer boundary of the iris where it is joined to the sclera

4.7
line pair
lp
measure of spatial feature content, which when associated with a fixed distance measurement provides an estimate of spatial frequency

4.8
pixel
single picture element, one of an *n* by *m* matrix of picture elements where *m* is the number of columns and *n* is the number of rows

4.9
pupil
opening in the centre of the eye that serves as a variable light aperture and defines the inner boundary of the iris

4.10
raw
image file format in which the image is stored in the same format in which it is stored in video memory, typically one byte (for monochrome images) per picture element or three bytes (for color images) per picture element

4.11
resolution
number of picture elements (pixels) per unit distance in the object plane or image plan, specified as the number of pixels per millimetre at the object plane, that is on the eye

4.12
round
mathematical function applied to a number x such that round(x) is the integer that is closest in value to x

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4.13
sclera
white outer covering of the eye peripheral to the iris

5 Symbols and abbreviated terms

5.1
JPEG
compression standard for continuous-tone images [ISO/IEC 10918]

5.2
JPEG2000
enhanced compression standard [ISO/IEC 15444]

5.3
JPEG-LS
lossless/near-lossless compression standard for continuous-tone images [ISO/IEC 14495]

6 Iris image format specification

6.1 General

The iris image format specification defines header and data structures that support storage of the iris image in rectilinear or polar coordinates.

The biometric data record specified in this part of ISO/IEC 19794 shall be embedded in a CBEFF-compliant structure in the CBEFF Biometric Data Block (BDB) as specified in ISO/IEC 19785-1. The CBEFF_BDB_format_owner assigned by the CBEFF Registration Authority to JTC1 SC37 in accordance with ISO/IEC 19785-2 shall be used. This is the sixteen-bit value 0x0101 (hexadecimal 101 or 257 decimal). It is recommended that iris image data transmitted or stored in accordance with this part of ISO/IEC 19794 be encrypted and signed to protect privacy and integrity of the data. The CBEFF structure supports such encryption and signing.

One of the two following CBEFF_BDB_format_type values shall be used in the CBEFF Header. The sixteen-bit value 0x0009 shall be used for records that represent the iris image in rectilinear coordinates and the sixteen-bit value 0x000B shall be used for records that represent the iris image in polar coordinates. These CBEFF_BDB_format_type values have been registered in accordance with ISO/IEC 19785-2.

The CBEFF_BDB_biometric_type value may be used in the CBEFF Header. If used, the value entered shall be the type value assigned to iris by the patron format.

The CBEFF_BDB_biometric_subtype value may be used in the CBEFF Header if the iris data record contains data from only one eye. If used, the value entered shall be 0x00 to indicate that no information is given, 0x01 to indicate right eye, and 0x02 to indicate left eye.

6.2 Image compression

6.2.1 General

The iris image shall be transmitted and stored in one of several possible formats described in the following subclauses.

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6.2.2 Raw format

The image shall be represented as an array of n rows by m columns by at least eight bits. There is no image header, and each pixel in a monochrome image shall be represented by eight or more bits. Colour images shall be represented as three samples per pixel, each comprised of eight or more bits, representing red, green, and blue intensities, in that order. The image shall be organized in row-major order, with the lowest address corresponding to the upper left corner of the image. If the pixel intensity value is represented by more than one byte, the bytes shall be stored in network byte (big-endian) order.

6.2.3 Lossless compression format

If lossless compression is used the image data shall be compressed in accordance with the JPEG-LS lossless compression algorithm specified in ISO/IEC 14495.

6.2.4 Compressed format

If lossy compression is used the image shall be compressed in accordance with the JPEG compression algorithm specified in ISO/IEC 10918 or the JPEG2000 compression algorithm specified in ISO/IEC 15444.

6.3 Image pre-processing

6.3.1 Rectilinear image pre-processing

6.3.1.1 General

If the image is collected by a camera that captures only one eye at a time and is stored using a rectilinear coordinate system no specific pre-processing is required. Cameras that capture images of both eyes simultaneously may use the following processing steps to calculate the rotation angle of the iris images.

6.3.1.2 Rectilinear image rotation angle

Iris image capture systems that record images of both eyes simultaneously may have the capability to measure the 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. If this rotation is measured and recorded, it shall be measured as the angle in degrees between the horizontal axis of the camera system and the line between the pupil centres of the two eyes, with a positive value signifying counter-clockwise rotation of the inter-pupil line relative to the camera's horizontal axis.

NOTE The angle of the subject's head may be computed in ways other than using the pupil centres.

6.3.1.3 Rectilinear image rotation uncertainty

The rotation uncertainty is an estimate, dependent on the imaging device, of the maximum rotation error associated with the rotation angle. It shall be measured as a positive nonzero value in degrees. If rotation information is not available the rotation uncertainty value shall be set to the maximum possible value.

6.3.2 Polar image pre-processing

6.3.2.1 General

If the polar coordinate system is used the following pre-processing operations shall be performed on the rectilinear image in order to convert it to polar form.

6.3.2.2 Boundary extraction

The boundaries of the pupil and iris may be extracted using circular models. If such boundaries are extracted, the horizontal and vertical coordinates of the iris and pupil centres shall be determined with a precision of

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± 1 pixel, the pupil radius with a precision of ± 1 pixel, and the iris radius with a precision of ± 1 pixel. In this case the polar image contains iris data between the inner boundary with the pupil and the outer boundary with the sclera.

NOTE If camera resolution is known the precision of the pupil and iris centres and radii may be calculated in millimetres.

6.3.2.3 No boundary extraction

An alternative storage format is provided, in which the pupil centre is used as the inner boundary and the polar image samples extend radially from the pupil centre to a supplier-defined outer circle that encloses the entire iris. In this case the number of radial samples in the polar image shall be not less than the iris radius in the rectilinear image expressed in pixels, and the number of angular samples shall be not less than one-half the iris/sclera boundary length in the rectilinear image expressed in pixels. Users of this format are expected to apply post-processing algorithms to extract the precise inner and outer iris boundaries using suitable techniques.

6.3.2.4 Iris occlusions

Areas obscured by specular reflections, eyelids, eyelashes, etc. may be located and special intensity values assigned. If such assignment is performed such pixels shall be assigned a reserved iris occlusion value, usually maximum intensity or zero. The occlusion value shall be defined in the header. If such iris occlusion processing is performed and occluded areas are filled by a reserved value, subsequent compression applied to the image shall use only lossless compression algorithms.

6.3.2.5 Scan type

Corrections to accommodate specific scan types such as progressive or interlaced should be applied prior to conversion to polar coordinates. If such corrections are applied, the scan type entry in the image properties bitfield shall be set to SCAN_TYPE_CORRECTED.

6.3.2.6 Orientation correction

Transformations to correct for horizontal or vertical flipping of the image shall be applied prior to conversion to polar coordinates, and the entries for horizontal and vertical orientation in the image properties bitfield shall be set to ORIENTATION_UNDEF or ORIENTATION_BASE.

6.3.2.7 Polar conversion

Image data between the inner and outer iris boundaries shall be converted to polar coordinates, with each pixel's intensity represented by eight or more bits per colour. The inner and outer boundaries, which need not be concentric, shall each be divided into m angular intervals. The image segment extending from the ith inner boundary segment to the ith outer boundary segment shall be divided into n radial samples. The intensity of each polar image sample $p(r,\theta)$ shall be computed using bilinear interpolation applied to the four pixels closest to the calculated sample coordinates in the rectilinear input image. The zero degree angular value shall be at the six o'clock position, directly downward from the estimated pupil centre, and angular values shall increase in the counter-clockwise direction. The pixel with the lowest address shall be adjacent to the inner boundary at zero degrees. Subsequent addresses shall be occupied by pixels at the same radius but increasing angles until the first ring is completed. This shall be followed by m samples at radius = 1, etc. as shown in Figure 1 (for m=256). The entire uncompressed image shall consist of n x m samples for a monochrome image or 3 x n x m samples for a colour image. Figure 2 is a representative iris image showing the results of pre-processing steps that extract the inner and outer iris boundaries using the circular models. The extracted pupil, iris, and eyelid boundaries are shown along with the iris centre.

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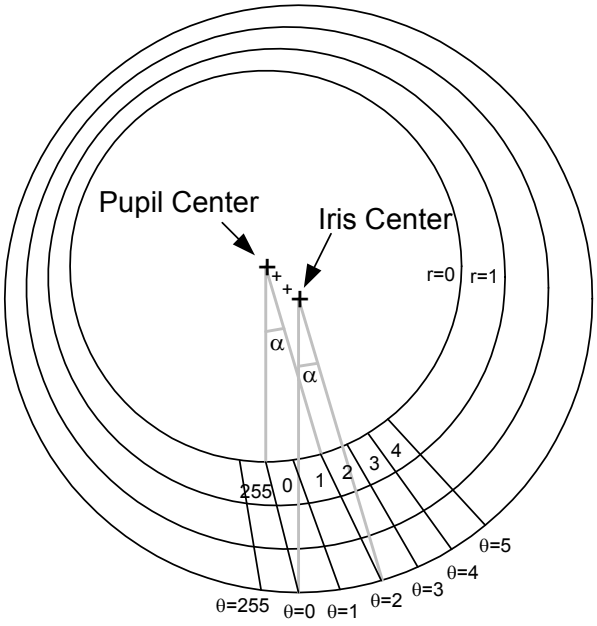

Figure 1 — Polar image sample sequence

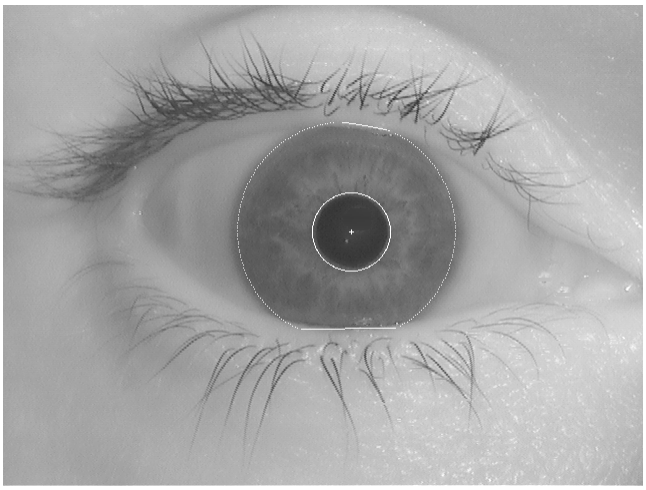

Figure 2 — Iris image with features

6.3.2.8 Polar image rotation correction

Rotation angle is not recorded for polar images and should be set to ROT_ANGLE_UNDEF. If the rotation angle is available when the polar image is produced, it shall be used to correct for rotation, so that the zero degree radial is perpendicular to the line between the pupil centres. If such correction is performed the rotation uncertainty shall be set to a nonzero value indicating the expected accuracy of the correction. If rotation correction is not performed the rotation uncertainty shall be set to ROT_UNCERTAIN_UNDEF.

6.4 Iris image biometric data block

Table 1 illustrates the structure of the iris image biometric data block. Every data block shall have an iris record header that contains information about the image capture device and conditions. The record shall

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contain images from one or two eyes, which are designated iris biometric subtypes, and the iris record header shall indicate how many such biometric subtypes were recorded (one or two). Each iris biometric subtype shall have an iris biometric subtype header that identifies it as a right or left eye, and contains information on the number of images recorded from that eye. If the capture device is unable to determine which eye was presented, then the eye designation shall be entered as "unknown", and all captured images shall be saved with a single biometric subtype header. Each iris image shall be accompanied by an iris image header that contains an image sequence number plus information about quality and rotation for that image. Each image shall be padded with extra bits, if necessary, to end on an integral byte boundary. 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. A single record header structure shall be used for both rectilinear and polar formats. An iris image data record shall contain either rectilinear format images or polar format images; the two formats shall not be intermixed within a data record. The CBEFF_BDB_format_type value in the CBEFF header shall indicate the format used, with the value 0x0009 used to indicate rectilinear coordinates and 0x0011 to indicate polar coordinates as specified in clause 6.1.

Table 1 — Iris image biometric data block

Bytes	Type	Content	Description
1 - 45		Iris record header	Information pertaining to capture device, number of biometric subtypes (eyes) included in the record, and total record size in bytes
46 - 48		Iris biometric subtype header	Header for biometric subtype indicating right or left eye, if known, and number of images
49 - 59		Iris image header	Header for first image containing image number for first eye, quality, rotation angle and uncertainty, and image length
60 – (image length-1)	Unsigned char	Image	First image, this eye
		Iris image header	Image header, second image, first eye
	Unsigned char	Image	Second image, first eye
		• • •	• • •
		Iris image header	Image header, last image, first eye
	Unsigned char	Image	Last image, first eye
		Iris biometric subtype header	Biometric subtype header indicating right or left eye and number of images (used only if eye type is known)
		Iris image header	Image header, first image, second eye
	Unsigned char	Image	First image, second eye
		Iris image header	Image header, second image, second eye
	Unsigned char	Image	Second image, second eye
		• • •	• • •
		Iris image header	Image header, last image, second eye
	Unsigned char	Image	Last image, second eye

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6.5 Iris header structures

6.5.1 Iris record header structure

The iris record header shall contain data values that identify the record as containing iris image data, specify properties of the image capture device and the image format, and designate a unique identifier for the data capture event. The record header format is shown in Table 2.

6.5.2 Iris biometric subtype header structure

The iris biometric subtype header shall contain data values that indicate which eye was presented, if known, and the number of images captured for that eye. The iris biometric subtype header format is shown in Table 3.

6.5.3 Iris image header structure

The iris image header shall indicate an image sample number, quality value, eye rotation information (if available), and image data length. The image quality value shall be recorded as a number between 0 and 100 equivalent to CBEFF_BDB_quality specified in ISO/IEC 19785-1. The image data length shall be followed by the image data. The iris image header format is shown in Table 4.

Table 2 — Iris record header

Bytes	Type	Content	Description
1-4	Unsigned char	Format identifier	0x49495200 ('I' 'I' 'R' 0x00), 'IIR' for iris image record
5-8	Unsigned char	Format version	'n' 'n' 'n' 0x00 Header format version. This version number shall consist of three ASCII numbers followed by a zero byte as the NULL string terminator. The first and second characters shall represent the major revision number and the third character shall represent the minor revision number.
9-12	Unsigned long	Record length	Total length of data record in bytes
13-14	Unsigned short	Capture device ID	Capture device ID assigned by vendor of equipment used to capture image data CAPTURE_DEVICE_UNDEF = 0
15	Unsigned char	No. of iris biometric subtypes	Number of eyes imaged, 1 or 2.
16-17	Unsigned short	Record header length	Currently 45 bytes

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Table 2 (*continued*)

Bytes	Type	Content	Description
18-19	Unsigned short	Iris image properties bitfield	1-2: Horizontal orientation ORIENTATION_UNDEF = 0 ORIENTATION_BASE = 1 ORIENTATION_FLIPPED = 2 3-4: Vertical orientation ORIENTATION_UNDEF = 0 ORIENTATION_BASE = 1 ORIENTATION_FLIPPED = 2 5-6: Scan type (rectilinear only) SCAN_TYPE_CORRECTED = 0 SCAN_TYPE_PROGRESSIVE = 1 SCAN_TYPE_INTERLACE_FRAME = 2 SCAN_TYPE_INTERLACE_FIELD = 3 7: Iris occlusions (polar only) IROCC_UNDEF = 0 IROCC_PROCESSED = 1 8: Occlusion filling (polar only) IROCC_ZEROFILL = 0 IROC_UNITFILL = 1 9: Boundary extraction (polar only) IRBNDY_UNDEF = 0 IRBNDY_PROCESSED = 1
20-21	Unsigned short	Iris diameter	Expected iris diameter in pixels (rectilinear only)
22-23	Unsigned short	Image format	Image format of data blob (JPEG, raw, etc.): IMAGEFORMAT_MONO_RAW = 2 (0x0002) IMAGEFORMAT_RGB_RAW = 4 (0x0004) IMAGEFORMAT_MONO_JPEG = 6 (0x0006) IMAGEFORMAT_RGB_JPEG = 8 (0x0008 IMAGEFORMAT_MONO_JPEG_LS = 10 (0x000A) IMAGEFORMAT_RGB_JPEG_LS = 12 (0x000C) IMAGEFORMAT_MONO_JPEG2000 = 14 (0x000E) IMAGEFORMAT_RGB_JPEG2000 = 16 (0x0010)
24-25	Unsigned short	Raw image width	Raw image width, pixels WIDTH_UNDEF = 0
26-27	Unsigned short	Raw image height	Raw image height, pixels HEIGHT_UNDEF = 0
28	Unsigned char	Intensity depth	Intensity depth, bits, per colour INTENSITY_DEPTH_UNDEF = 0

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Table 2 (*continued*)

Bytes	Type	Content	Description
29	Unsigned char	Image transformation	Transformation to polar image (polar only) TRANS_UNDEF = 0 TRANS_STD = 1
30-45	Unsigned char	Device unique identifier	A 16 character string uniquely identifying the device or source of the data. This data can be one of: Device Serial number, identified by the first character “D” Host PC Mac address, identified by the first character “M” Host PC processor ID, identified by the first character “P” No serial number, identified by all zero’s

Table 3 — Iris biometric subtype header

Bytes	Type	Content	Description
1	Unsigned char	Biometric subtype	1: biometric subtype identifier EYE_UNDEF = 0 (0x00) EYE_RIGHT = 1 (0x01) EYE_LEFT = 2 (0x02)
2 - 3	Unsigned short	No. images	Number of iris images for this biometric subtype, 1-65,535
NOTE: The biometric subtype identifier is equivalent to the CBEFF_BDB_biometric_subtype data element specified in ISO/IEC 19785-1. The CBEFF_BDB_biometric_subtype data element may be used to indicate the biometric subtype if the iris data record contains samples from only one biometric subtype.			

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Table 4 — Iris image header

Bytes	Type	Content	Description
1 - 2	Unsigned short	Image number	Image sequence number, 1 – No. Images
3	Unsigned char	Quality	Image quality value
4 - 5	Signed short	Rotation angle of eye	Rotation angle = (signed short) round (65536*angle/360) modulo 65536 ROT_ANGLE_UNDEF = 0xFFFF Where angle is measured in degrees from horizontal Used only for rectilinear images. For polar images entry shall be ROT_ANGLE_UNDEF
6 - 7	Unsigned short	Rotation uncertainty	Rotation uncertainty = (unsigned short) round (65536*uncertainty/180) Where 0 ≤ uncertainty < 180 ROT_UNCERTAIN_UNDEF = 0xFFFF Where uncertainty is measured in degrees and is the absolute value of maximum error
8 - 11	Unsigned long	Image length	Size of image data, bytes, 0 - 4294967295
NOTE: The Quality field is equivalent to the CBEFF_BDB_quality data element specified in ISO/IEC 19785-1. The CBEFF_BDB_quality data element may be used to indicate the quality if the iris data record contains only one image.			

6.5.4 Header constants

Significance of specific constants within the header structures are as follows:

- UNDEF – usage in any constant indicates that the parameter is undefined.
- ORIENTATION_BASE - superior edge of eye is at top of image and left side of eye facing subject (i.e. nasal side of subject's left eye) is on left side of image.
- ORIENTATION_FLIPPED - horizontal or vertical orientation is opposite from that described for ORIENTATION_BASE.
- SCAN_TYPE_PROGRESSIVE - the image was captured using progressive scanning, in which case all image lines are generated sequentially.
- SCAN_TYPE_INTERLACE_FRAME - the image was captured using interlaced scanning, in which two fields are generated in sequence, the first composed of odd-numbered lines and the second of even-numbered lines.
- SCAN_TYPE_INTERLACE_FIELD - the image was captured using interlaced scanning, in which only one field is generated, and then each line is duplicated to produce a full size image.
- SCAN_TYPE_CORRECTED – image artifacts introduced by progressive or interlaced scanning have been corrected.
- IMAGEFORMAT_MONO_RAW - image is raw format, with width and height in pixels specified by Raw image width and Raw image height, respectively. This format has no header; each pixel is one intensity value and the lowest address corresponds to the upper left corner of the image, in row-major order.

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- IMAGEFORMAT_RGB_RAW - image is raw format, with width and height in pixels specified by Raw image width and Raw image height, respectively. This format has no header; each pixel is three consecutive bytes, representing values of red, green, and blue intensity. The lowest address corresponds to the upper left corner of the image, row-major order.

- IMAGEFORMAT_MONO_JPEG - image is monochrome and compressed using JPEG algorithm as specified in ISO/IEC 10918.

- IMAGEFORMAT_RGB_JPEG – image is colour and compressed using JPEG algorithm as specified in ISO/IEC 10918.

- IMAGEFORMAT_MONO_JPEG_LS - image is monochrome and compressed using JPEG-LS algorithm as specified in ISO/IEC 14495.

- IMAGEFORMAT_RGB_JPEG_LS - image is colour and compressed using JPEG-LS lossless compression algorithm as specified in ISO/IEC 14495.

- IMAGEFORMAT_MONO_JPEG2000 – image is monochrome and compressed using JPEG2000 algorithm as specified in ISO/IEC 15444.

- IMAGEFORMAT_RGB_JPEG2000 – image is colour and compressed using JPEG2000 algorithm as specified in ISO/IEC 15444.

- IROCC_UNDEF - iris occlusions from reflections, eyelids, etc. have not been identified and marked with a reserved pixel intensity value.

- IROCC_PROCESSED - iris occlusions from reflections, eyelids, etc. have been identified and marked with a reserved pixel intensity value.

- IROCC_ZEROFILL - iris occlusions have been marked with pixel intensity value zero.

- IROCC_UNITFILL - iris occlusions have been marked with the maximum possible pixel intensity value.

- IRBNDY_UNDEF - precise inner and outer iris boundaries have not been defined and post-processing steps must be used to define these boundaries in accordance with sub-clause 5.3.2.2.

- IRBNDY_PROCESSED - the inner and outer iris boundaries have been determined by approximating the pupil and outer iris boundaries as circles in accordance with sub-clause 5.3.2.1.

- TRANS_STD - the transformation from rectilinear to polar coordinates uses linear interpolation of radial samples along a line from the ith angular point on the pupil boundary to the ith angular sample on the iris boundary, where the boundaries are defined by best-fit circles that are not necessarily concentric.

- TRANS_UNDEF – the transformation from rectilinear to polar coordinates is not defined.

- ROT_ANGLE_UNDEF – rotation angle information is not available. Polar image format does not use this value.

- ROT_UNCERTAIN_UNDEF – rotation angle information is not available or, in the case of polar image format, rotation angle correction has not been performed.

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Annex A
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Iris image capture

A.1 Image quality

A.1.1 General

The spatial resolution of the iris imaging system should be at least 2 lp/mm at the object plane with 60% modulation. The digital image that is captured from the iris should have pixel resolution equal to at least 8,3 pixels per mm. Image suppliers may indicate higher levels of resolution by specifying in the CBEFF image header an image quality value corresponding to acceptable or good quality in accordance with Table A.1. Typical iris diameter values, corresponding pixel resolution in pixels per mm, and optical resolution specified for 60% modulation, are listed in Table A.1. Specific recommended values are defined in the following sub-clauses.

Table A.1 — Image quality levels

Image quality level	Image quality value	Expected iris diameter, pixels	Minimum pixel resolution, pixels per mm	Optical resolution at 60% modulation, lp/mm	Comment
Poor	0 – 25	-	-	-	Unacceptable quality
Low	26-50	100 - 149	8,3	2,0	Marginal quality
Medium	51 - 75	150 - 199	12,5	3,0	Acceptable quality
High	76 - 100	200 or more	16,7	4,0	Good quality

A.1.2 Unacceptable quality

Image quality values between 0 and 25 may be used to indicate that the image does not meet the minimum quality standards set by the entity that produced the data.

A.1.3 Low quality

Images identified as having minimum or low quality should be collected using cameras having minimum spatial resolution of 2,0 lp/mm at 60 percent or higher contrast, and pixel resolution at least 8,3 pixels per mm at the object plane. Expected iris diameter is 100 to 149 pixels. Image quality value is between 26 and 50. Value selected within this range may reflect other factors such as focus, contrast, signal-to-noise ratio, visible iris, etc.

A.1.4 Medium quality

Images identified as having medium quality should be collected using cameras having spatial resolution of at least 3,0 lp/mm at 60 percent or higher contrast, and pixel resolution at least 12,5 pixels per mm at the object plane. Expected iris diameter is 150 to 199 pixels. Image quality value is between 51 and 75. Value selected within this range may reflect other factors such as focus, contrast, signal-to-noise ratio, visible iris, etc.

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A.1.5 High quality

Images identified as having high quality should be collected using cameras having spatial resolution of at least 4,0 lp/mm at 60 percent or higher contrast, and pixel resolution at least 16,7 pixels per mm at the object plane. Expected iris diameter is 200 or more pixels. Image quality value is between 76 and 100. Value selected within this range may reflect other factors such as focus, contrast, signal-to-noise ratio, visible iris, etc.

A.1.6 Focus quality

Images should have focus quality adequate to preserve the specified spatial resolution. Figure A.1 illustrates a representative iris image with adequate resolution and focus quality. Any image compression process used to reduce the size of the stored image should preserve this resolution. If JPEG (ISO/IEC 10918) or JPEG 2000 (ISO/IEC 15444) compression is used, a compression factor of 6:1 or less is recommended.

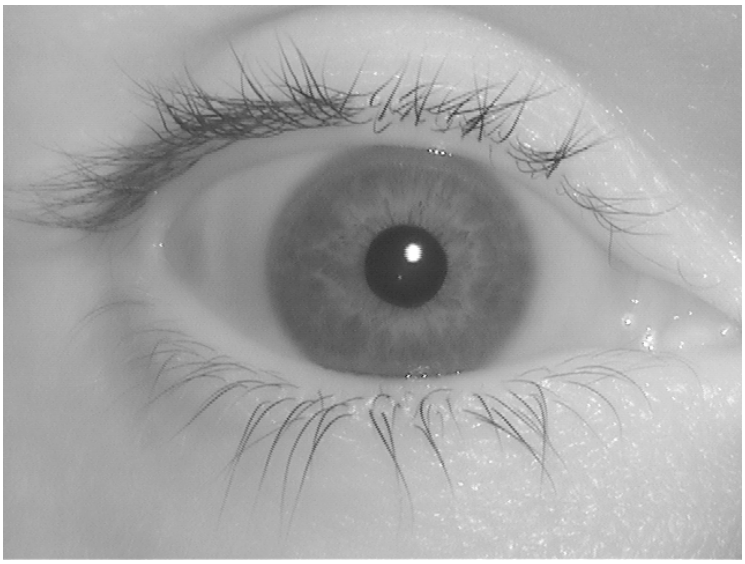

Figure A.1 — Iris image

A.2 Greyscale density

The image should have a dynamic range spanning at least 256 grey levels, allocating at least one byte (8 bits) per intensity value and providing at least 7 bits of useful intensity information. The image may utilize eight or more bits per grey value. 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 may be amended based on availability of performance data that documents the impact of the proposed change.

A.3 Illumination

The eye should be illuminated using near-infrared wavelengths between approximately 700 and 900 nanometers (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.

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A.4 Contrast

The iris image should have a minimum of 70 grey levels separation between the iris and sclera and a minimum of 50 grey levels separation between iris and pupil for all colour eyes. See Figure A.2. This recommendation may be amended based on availability of performance data that documents the impact of the proposed change.

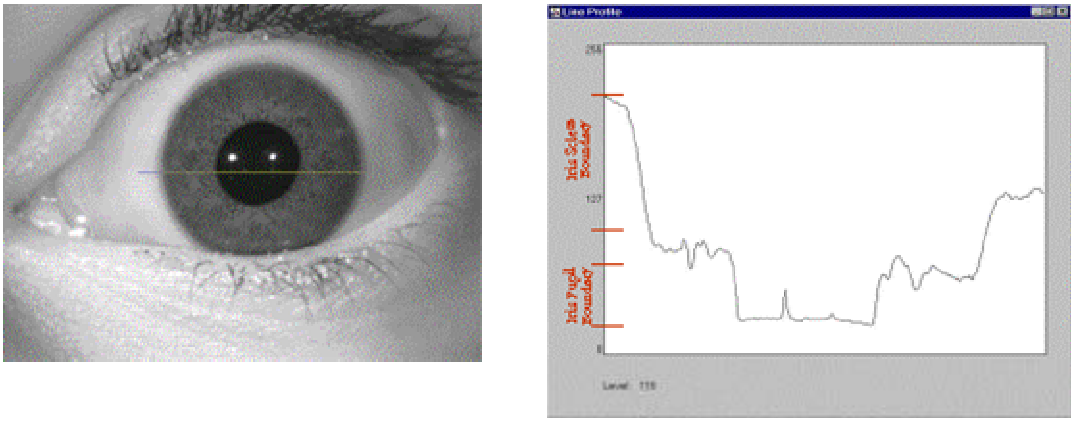

Figure A.2 — Iris image and grey level profile

A.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 may be difficult to achieve among some ethnic populations. This recommendation may be amended based on availability of performance data that documents the impact of the proposed change.

A.6 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.

A.7 Image scale

The image scale should be such that an iris with naturally occurring iris diameter range of 9,5 mm to 13,7 mm has a minimum digital iris diameter of at least 100 pixels as described in clause A.1.1 above. The image should be large enough to include at least 70 pixels between the left or right edge of the iris and the closest edge of the image, and at least 70 pixels between the upper or lower edges of the iris and the closest edge of the image. See Figure A.3. This recommendation may be amended based on availability of performance data that documents the impact of the proposed change.

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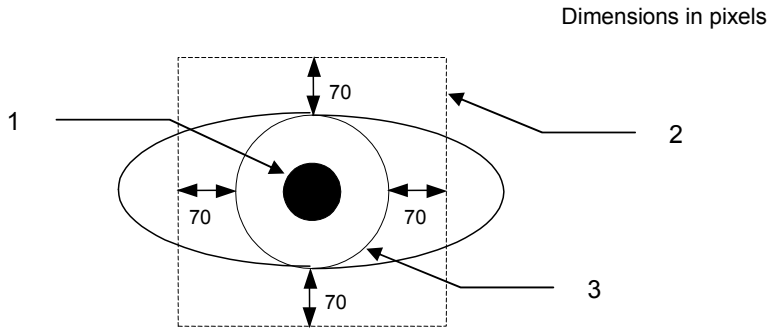

Key

1 pupil boundary

2 image border

3 iris boundary

Figure A.3 — Image size specification

A.8 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[4].

A.9 Noise

The image signal-to-noise ratio (SNR) should not be less than 40 dB inclusive of any noise introduced by image compression techniques. This recommendation may be amended based on availability of performance data that documents the impact of the proposed change.

A.10 Image orientation

The image should contain either the left or right eye and should be presented in the following canonical form. If it must be flipped either horizontally or vertically to attain this form, then parameters in the header structure 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.

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A.11 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 tilted 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 rotation 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 may affect the quality of enrollment and pupil size of 7 mm or less should be presented.

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

- Hard contact lenses and patterned soft contact lenses should be removed.

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Annex B
(informative)

Sample image data records

B.1 Rectilinear data record sample, single eye, single image

Table B.1 — Rectilinear iris image biometric data block, single eye, single image

Bytes	Value	Description
Iris Record Header		
1 - 4	49 49 52 00	Format ID 'IIR'
5 – 8	xx xx xx 00	Format version
9 - 12	00 00 2E 91	Length of entire record, 11921 bytes
13 - 14	xx xx	Capture Device ID
15	01	No. of iris biometric subtypes = 1
16 - 17	00 2D	Record header length – 0x2D = 45 bytes
18 - 19	00 16	Image property bitfield = 0x16 Horizontal orientation = ORIENTATION_FLIPPED Vertical orientation = ORIENTATION_BASE Scan type = SCAN_TYPE_PROGRESSIVE Iris occlusions = IROCC_UNDEF Occlusion filling = IROCC_ZEROFILL Boundary extraction = IRBNDY_UNDEF
20 - 21	00 BE	Expected iris diameter = 0xBE = 190 pixels
22 - 23	00 06	Image format = 0x0006 = IMAGEFORMAT_MONO_JPEG
24 - 25	00 00	Image width = 0x00 = WIDTH_UNDEF
26 - 27	00 00	Image height = 0x00 = HEIGHT_UNDEF
28	08	Image intensity depth = 0x08 = 8 bits
29	00	Transformation to polar image = TRANS_UNDEF
30 - 45	4D 30 30 63 30 34 66 31 62 37 65 63 66 00 00 00	Device unique identifier (DUID), 16 bytes, “M00c04f1b7ecf”
Iris Biometric Subtype Header		
46	00	Biometric subtype identifier = 0 = EYE_UNDEF
47 - 48	00 01	Number of iris images, this feature = 1
Iris Image Header		
49 - 50	00 01	Image sequence number = 1

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Table B.1 (*continued*)

Bytes	Value	Description
51	40	Image quality medium = 0x40 = 64 decimal
52 - 53	FF FF	Rotation angle = ROT_ANGLE_UNDEF = 0xFFFF
54 - 55	FF FF	Rotation uncertainty = ROT_UNCERTAIN_UNDEF = 0xFFFF
56 - 59	00 00 2E 56	Size of image data, bytes = 11,862 bytes = 0x00002E56
Image Data		
60 – 11,921	xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx . . .	Image data, 11,862 bytes

Table B.2 — CBEFF header for rectilinear image data record, single eye, single image

CBEFF Field	Type	Content	Description
CBEFF_BDB_quality	Unsigned char	Iris image quality	Image quality value = 0x40 = 64 decimal (medium quality)
CBEFF_BDB_format_ owner	Unsigned short	Format owner	0x0101
CBEFF_BDB_format_ type	Unsigned short	Format type	Type = 0x0009 (rectilinear)
CBEFF_BDB_biometric_type	Various	Biometric type code	Iris type code specified in patron format
CBEFF_BDB_biometric_subtype	Unsigned short	Right or left eye	Biometric subtype = 0x00 (No information given)

B.2 Rectilinear data record sample, multiple eyes, multiple images

Table B.3 — Rectilinear image biometric data block, multiple eyes, multiple images

Byte	Value	Description
Iris Record Header		
1 – 4	49 49 52 00	Format ID 'IIR'
5 – 8	xx xx xx 00	Format version
9 – 12	00 00 CB F4	Length of entire record = 0x0000CC04 = 52,212 bytes
13 - 14	xx xx	Capture Device ID

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Table B.3 (*continued*)

Byte	Value	Description
15	02	No. of iris biometric subtypes = 2
16 - 17	00 2D	Record header length – 0x2D = 45 bytes
18 - 19	00 16	Image property bitfield = 0x16 Horizontal orientation = ORIENTATION_FLIPPED Vertical orientation = ORIENTATION_BASE Scan type = SCAN_TYPE_PROGRESSIVE Iris occlusions = IROCC_UNDEF Occlusion filling = IROCC_ZEROFILL Boundary extraction = IRBNDY_UNDEF
20 – 21	BE	Expected iris diameter = 0xBE = 190 decimal
22 – 23	00 06	Image format = IMAGEFORMAT_MONO_JPEG
24 – 25	00 00	Image width = WIDTH_UNDEF
26 – 27	00 00	Image height = HEIGHT_UNDEF
28	08	Image intensity depth = 0x08 = 8 bits
29	00	Transformation to polar image = TRANS_UNDEF
30 - 45	4D 30 30 63 30 34 66 31 62 37 65 63 66 00 00 00	Device unique identifier (DUID), 16 bytes, “M00c04f1b7ecf”
Iris Biometric Subtype Header		
46	01	Biometric subtype identifier = 0x01 = EYE_RIGHT
47 - 48	00 02	Number of iris images, this biometric subtype = 2
Iris Image Header		
49 - 50	00 01	Image sequence number = 1
51	38	Image quality medium = 0x38 = 56 decimal
52 - 53	FF FF	Rotation angle = ROT_ANGLE_UNDEF = 0xFFFF
54 - 55	FF FF	Rotation uncertainty = ROT_UNCERTAIN_UNDEF = 0xFFFF
56 - 59	00 00 2E 56	Size of image data, bytes = 11,862 bytes = 0x00002E56
Image Data		
60 – 11,921	xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx . . .	Image data, 11,862 bytes
Iris Image Header		
11,922 - 11923	00 02	Image sequence number = 2

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Table B.3 (*continued*)

Byte	Value	Description
11,924	3A	Image quality medium = 0x3A = 58 decimal
11,925 - 11,926	FF FF	Rotation angle = ROT_ANGLE_UNDEF = 0xFFFF
11,927 – 11,928	FF FF	Rotation uncertainty = ROT_UNCERTAIN_UNDEF = 0xFFFF
11,929 – 11,932	00 00 37 21	Size of image data, bytes = 14,113 bytes = 0x00003721
Image Data		
11,933 – 26,045	xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx . . .	Image data, 14,113 bytes
Iris Biometric Subtype Header		
26,046	02	Biometric subtype identifier = 0x02 = EYE_LEFT
26,047 – 26,048	00 02	Number of iris images, this biometric subtype = 2
Iris Image Header		
26,049 – 26,050	00 01	Image sequence number = 1
26,051	35	Image quality medium = 0x35 = 53 decimal
26,052 – 26,053	FF FF	Rotation angle = ROT_ANGLE_UNDEF = 0xFFFF
26,054 – 26,055	FF FF	Rotation uncertainty = ROT_UNCERTAIN_UNDEF = 0xFFFF
26,056 – 26,059	00 00 33 CE	Size of image data, bytes = 13,262 bytes = 0x000033CE
26,060 – 39,321	xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx . . .	Image data, 13,262 bytes
Iris Image Header		
39,322 – 39,323	00 02	Image sequence number = 2
39,324	4B	Image quality medium = 0x4B = 75 decimal
39,325 – 39,326	FF FF	Rotation angle = ROT_ANGLE_UNDEF = 0xFFFF
39,327 – 39,328	FF FF	Rotation uncertainty = ROT_UNCERTAIN_UNDEF = 0xFFFF
39,329 – 39,332	00 00 32 50	Size of image data, bytes = 12,880 bytes = 0x00003250

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Table B.3 (*continued*)

Byte	Value	Description
Image Data		
39,333 – 52,212	xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx . . .	Image data, 12,880 bytes

Table B.4 — CBEFF header for rectilinear image data record, multiple eyes, multiple images

CBEFF Field	Type	Content	Description
CBEFF_BDB_quality	Unsigned char	Iris image quality	Image quality value = 0x00 (no information given)
CBEFF_BDB_format_ owner	Unsigned short	Format owner	0x0101
CBEFF_BDB_format_ type	Unsigned short	Format type	Type = 0x0009 (rectilinear)
CBEFF_BDB_biometric_type	Various	Biometric type code	Iris type code specified in patron format
CBEFF_BDB_biometric_ subtype	Unsigned short	Right or left eye	Biometric subtype = 0x00 (no information given)

B.3 Polar image biometric data block, single eye, single image

Table B.5 — Polar image biometric data block, single eye, single image

Byte	Value	Description
Iris Record Header		
1 – 4	49 49 52 00	Format ID 'IIR'
5 – 8	xx xx xx 00	Format version
9 – 12	00 00 08 3B	Length of entire record = 0x0000083B = 2107 bytes
13 - 14	xx xx	Capture Device ID
15	01	No. of iris features = 1
16 - 17	00 2D	Record header length – 0x2D = 45 bytes

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Table B.5 (*continued*)

Byte	Value	Description
18 - 19	01 05	Image property bitfield = 0x01 0x05 Horizontal orientation = ORIENTATION_BASE Vertical orientation = ORIENTATION_BASE Scan type = SCAN_TYPE_CORRECTED Iris occlusions = IROCC_PROCESSED Occlusion filling = IROCC_UNITFILL Boundary extraction = IRBNDY_PROCESSED
20 - 21	00 00	Expected iris diameter = 0
22 - 23	00 02	Image format = IMAGEFORMAT_MONO_RAW
24 - 25	01 00	Raw image width = 0x0100 = 256 pixels
26 - 27	00 08	Raw Image height = 0x08 = 8 pixels
28	08	Image intensity depth = 0x08 = 8 bits
29	01	Image transformation = TRANS_STD
30 - 45	4D 30 30 63 30 34 66 31 62 37 65 63 66 00 00 00	Device unique identifier (DUID), 16 bytes, “M00c04f1b7ecf”
Iris Biometric Subtype Header		
46	01	Biometric subtype identifier = EYE_RIGHT = 0x1
47 - 48	00 01	Number of iris images, this biometric subtype = 0x1
Iris Image Header		
49 - 50	00 01	Image sequence number = 0x1
51	38	Image quality medium = 0x38 = 56 decimal
52 - 53	FF FF	Rotation angle = ROT_ANGLE_UNDEF = 0xFFFF
54 - 55	05 B0	Rotation uncertainty = 4 degrees and 65536 x 4/180 = 1456 = 0x05B0
56 - 59	00 00 08 00	Data length, 2048 bytes
Image Data		
60 – 2107	xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx xx . . .	Image data

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Table B.6 — CBEFF header for polar image biometric data block, single eye, single image

CBEFF Field	Type	Content	Description
CBEFF_BDB_quality	Unsigned char	Iris image quality	Image quality value = 0x38 = 56 decimal (medium quality)
CBEFF_BDB_format_owner	Unsigned short	Format owner	0x0101
CBEFF_BDB_format_type	Unsigned short	Format type	Type = 0x0011 (polar)
CBEFF_BDB_biometric_type	Various	Biometric type code	Iris type code specified in patron format
CBEFF_BDB_biometric_subtype	Unsigned short	Right or left eye	Biometric subtype = 0x01 (right eye)

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