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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.

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*

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:

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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*

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

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.

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

± 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 i^{th} inner boundary segment to the i^{th} 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.

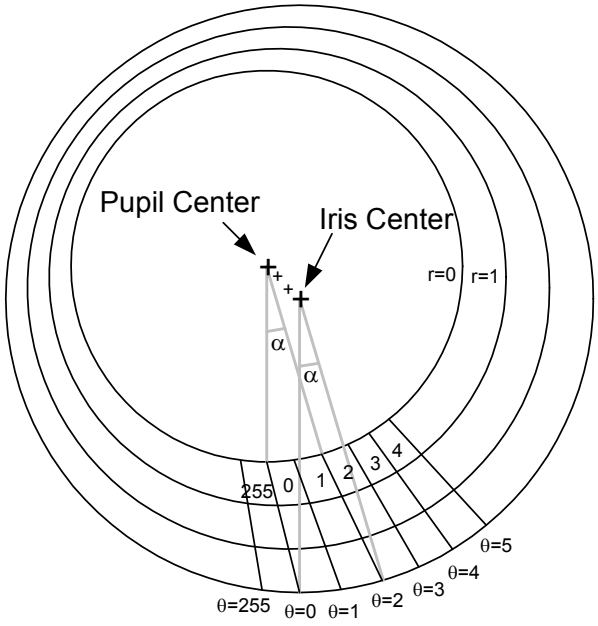

Figure 1 — Polar image sample sequence

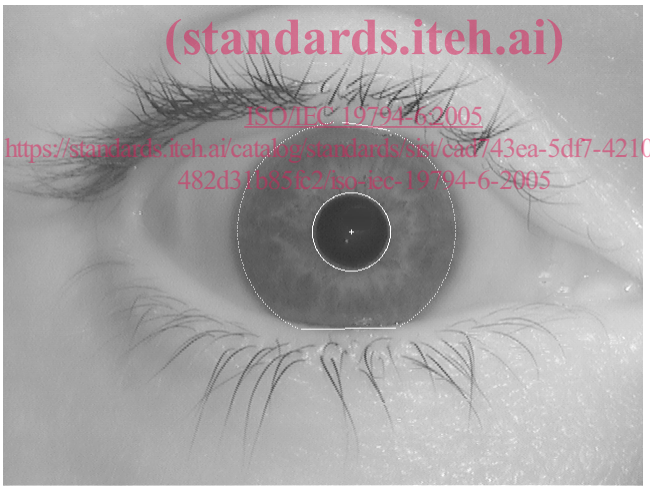

Figure 2 — Iris image with features

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