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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 Cen-tring	Margins		Width and Height	Data Size	Compression	
		Hori-zontal	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.