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Information technology — Biometric data interchange formats —

Part 4: Finger image data

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

Partie 4: Données d'image du doigt

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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 19794-4 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 19794-4:2005). It reflects the harmonization across the second generation of ISO/IEC 19794. Clause 8 has been technically revised and contains descriptions of the harmonized general and representation headers. Annex A is under development and will contain an amendment for conformance testing methodology for this part of ISO/IEC 19794. Annex B contains capture device certifications for capturing finger image data. Annex B has been technically revised. Annex D describes conditions for capturing finger image data, and Annex E contains the WSQ Gray-scale fingerprint image compression specification. The former Annex A “Image Quality Specification” has been removed.

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

In the forensic community, the capture and transmission of fingerprint images has been a common choice for the exchange of fingerprint information used by Automatic Fingerprint Identification Systems (AFIS) for the identification of individuals. However, little to no fingerprint information is being exchanged between equipment from different vendors in the biometric user verification and access community. This has been due in part to the lack of agreement between vendors on the amount and type of information to capture, the method of capture, and the information to be exchanged.

ISO/IEC 19794 is a series of International Standards being developed by ISO/IEC JTC 1/SC 37 that supports interoperability and data interchange among biometric applications and systems. The series specifies requirements that solve the complexities of applying biometrics to a wide variety of personal recognition applications, whether such applications operate in an open systems environment or consist of a single, closed system. Additional information regarding the series is provided in ISO/IEC 19794-1.

This part of ISO/IEC 19794 is intended for those applications requiring the exchange of raw or processed fingerprint and palm images that may not necessarily be limited by the amount of resources required for data storage or transmitting time. It can be used for the exchange of scanned fingerprints containing detailed image pixel information. This part of ISO/IEC 19794 can also be used to exchange processed fingerprint image data containing considerably fewer pixels per inch and/or a lesser number of grayscale levels. This is in contrast to other parts of ISO/IEC 19794 used for exchanging lists of fingerprint characteristics such as minutiae, patterns, or other variants. These formats require considerably less storage than a fingerprint image. However, by using any of the other parts of ISO/IEC 19794, information recorded in one standard format cannot be used by algorithms designed to operate with another type of information. In other words, minutiae data records cannot be compared with pattern skeletal data comparison subsystems.

Although the minutiae, pattern, or other approaches produce different intermediate outputs, all shall initially capture a reasonably high quality fingerprint image before reducing the size of the image (in bytes) or developing a list of characteristic data from the image. Use of the captured or processed image can provide interoperability among vendors relying on minutiae-based, pattern-based or other algorithms. As a result, data from the captured finger image offers the developer more freedom in choosing or combining comparison algorithms. For example, an enrolment image may be stored on a contactless chip located on an identification document. This will allow future verification of the holder of the document with systems that rely on either minutiae-based or pattern-based algorithms. Establishment of an image-based representation of fingerprint information will not rely on pre-established definitions of minutiae, patterns or other types. It will provide implementers with the flexibility to accommodate images captured from dissimilar devices, varying image sizes, spatial sampling rates, and different grayscale depths. Use of the fingerprint image will allow each vendor to implement their own algorithms to determine whether two fingerprint records are from the same finger.

Information technology — Biometric data interchange formats —

Part 4: Finger image data

1 Scope

This part of ISO/IEC 19794 specifies a data record interchange format for storing, recording, and transmitting the information from one or more finger or palm image areas. This can be used for the exchange and comparison of finger image data. It defines the content, format, and units of measurement for the exchange of finger image data that may be used for enrolment, verification, or identification of a subject. The information consists of a variety of mandatory and optional items, including scanning parameters, compressed or uncompressed images and vendor-specific information. This information is intended for interchange among organizations that rely on automated devices and systems for identification or verification purposes based on the information from finger image areas. Information compiled and formatted in accordance with this part of ISO/IEC 19794 can be recorded on machine-readable media or may be transmitted by data communication facilities.

2 Conformance

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

a) its data structure, data values, and the relationships between its data elements, as specified throughout Clause 8 for the finger image record format of this part of ISO/IEC 19794;

b) the relationship between its data values and the input biometric data from which the biometric data record was generated, as specified throughout Clause 8 for the finger image record format 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.

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 10918-1, *Information technology — Digital compression and coding of continuous-tone still images: Requirements and guidelines*

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

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

ISO/IEC 19794-1:2011, *Information technology — Biometric data interchange formats — Part 1: Framework*

ISO/IEC 29794-1, *Information technology — Biometric sample quality — 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
capture device spatial sampling rate
number of pixels per unit distance used by a sensor or scanning device to initially capture an image

4.2
fingerprint image
area of friction skin on the fleshy surface of a finger located horizontally between the two edges of the fingernail and vertically between the first joint and the tip of a finger

NOTE It contains a unique pattern of friction ridge and valley information commonly referred to as a “fingerprint”.

4.3
image spatial sampling rate
number of pixels per unit distance in the image

NOTE This may be the result of processing a captured image. The original captured scanned image may have been subsampled, scaled, down-sampled, or otherwise processed.

4.4
palm
friction ridge skin on the side and underside of the hand

4.5
plain fingerprint image
image captured from a finger placed on a platen without any rolling movement

4.6
rolled fingerprint image
image captured that is located between the two edges of the fingernail

NOTE This type of image is typically acquired using a rolling motion from one edge of the fingernail to the other.

4.7
vertical rolls
fingerprint images that have been captured by rolling a finger vertically from the slap position over the finger tip to the nail

NOTE This is in contrast to horizontal rolls, which are captured by horizontal rolling from the nail over the slap position to the other side of the nail as described in the definition for “rolled fingerprint image”.

5 Abbreviated terms

For the purposes of this document the following abbreviations and those given in ISO/IEC 19794-1 apply.

ppcm	pixels per centimetre
ppi	pixels per inch
TIR	Total Internal Reflection

6 Data conventions

6.1 Byte and bit ordering

Each item of information, field, or logical record shall contain one or more bytes of data. Within a record all multibyte quantities are represented in Big-Endian format. That is, the more significant bytes of any multibyte quantity are stored at lower addresses in memory than less significant bytes. The order for transmission shall also be the most significant byte first and least significant byte last. Within a byte, the order of transmission shall be the most significant bit first and the least significant bit last. All numeric values are fixed-length unsigned integer quantities.

6.2 Scan sequence

It is not the purpose of this part of ISO/IEC 19794 to specify the orientation of the finger (or palm), the method of scanning, or the order of scanning used to capture the image. However, each image as presented in accordance with this format standard shall appear to have been captured in an upright position and approximately centered horizontally in the field of view. The recorded image data shall appear to be the result of a scanning of an impression of a fingerprint. The scanning sequence (and recorded data) shall appear to have been captured from left-to-right, progressing from top-to-bottom of the fingerprint or palm print. Figure 1 illustrates the recording order for the scanned image. For the purpose of describing the position of each pixel within an image to be exchanged, a pair of reference axes shall be used. The origin of the axes, pixel location (0,0), shall be located at the upper left-hand corner of each image. The x-coordinate (horizontal) position shall increase positively from the origin to the right side of the image. The y-coordinate (vertical) position shall increase positively from the origin to the bottom of the image.

7 Image acquisition requirements

7.1 General

Image capture requirements are dependent on various factors including the application, the available amount of raw pixel information to retain or exchange, and targeted performance metrics. As a result of these factors, the image capture operation will be associated with a combination of image acquisition parameters settings described below.

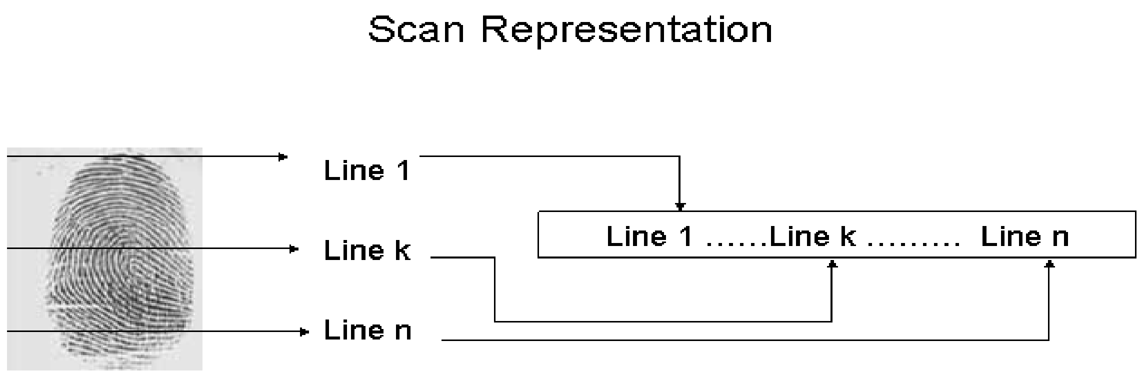

Figure 1 — Order of scanned lines

7.2 Pixel aspect ratio

The finger image shall be represented using square pixels, in which the horizontal and vertical dimensions of the pixels are equal. Any difference between these two dimensions should be within 1%. That is, the ratio of horizontal to vertical pixel dimensions should be between 0,99 and 1,01.

7.3 Bit-depth

The grayscale precision of the pixel data shall be specified in terms of the bit-depth or the number of bits used to represent the grayscale value of a pixel. A bit-depth of 3 provides 8 levels of grayscale; a depth of 8 provides 256 levels of gray. For grayscale data, the minimum value that can be assigned to a "black" pixel shall be zero. The maximum value that can be assigned to a "white" pixel shall be the grayscale value with all of its bits of precision set to "1". However, the "blackest" pixel in an image may have a value greater than "0" and the "whitest" pixel may have a value less than its maximum value. For example, the range of values for a "white" pixel with 5 bits of precision shall be 31 or less. The range of values for a "white" pixel using 8 bits of precision shall be 255 or less. The bit-depth may range from 1 to 16 bits.

7.4 Grayscale data

Grayscale finger image data shall be stored, recorded, or transmitted in either compressed or uncompressed form. The image data portion of a record for an uncompressed grayscale image shall contain a set of raw pixel information. Using a bit-depth of 8 bits (256 grayscale levels) each pixel shall be contained in a single byte. Pixel values with a depth of less than eight bits shall be stored and transmitted in a packed binary format. Increased precision for pixel values greater than 255 shall use two unsigned bytes to hold up to sixteen-bit pixels with values in the range of 0-65535. The encoding of a compressed grayscale image shall be the output of the appropriate grayscale compression algorithm specified in Table 9. Upon decompression the grayscale value for each pixel shall be represented in the same manner as pixels in an uncompressed image.

7.5 Dynamic range

The image grayscale shall be encoded using the agreed precision necessary to meet the dynamic range requirement for a specific application. It is assumed that the precise requirements of the application are known.

7.6 Capture device spatial sampling rate

Grayscale fingerprint images to be captured shall be acquired by an image capture device operating at a specific scanning spatial sampling rate. As the spatial sampling rate used in the image capture process is increased, more detailed ridge and structure information for processing becomes available. For minutiae and small feature based algorithms, use of the higher spatial sampling rate enhances the detection of more closely spaced features that may not be detected using the minimum spatial sampling rate.

7.7 Image spatial sampling rate

The spatial sampling rate of the image data formatted and recorded for interchange may be the scan spatial sampling rate of the image or it may have been sub-sampled, scaled, down-sampled, or otherwise processed to produce a form for representing the ridge and valley structure areas of the fingerprint.

7.8 Fingerprint image location

This part of ISO/IEC 19794 is designed to accommodate both plain (flat) or rolled fingerprint images. Biometric systems perform better if the volar pad of the finger is centered both horizontally and vertically in the image capture area. Therefore, when capturing a fingerprint image, the center of the fingerprint image should be located in the approximate center of the image capture area.

For multiple finger verification and/or identification purposes, there are currently fingerprint scanner devices that will acquire images of multiple fingers during a single capture cycle. These devices are capable of capturing the plain impressions from two, three, or four adjacent fingers of either hand during a single scanning. The plain impressions from the two thumbs or two index fingers can also be captured at one time. Therefore, with three placements of the fingers on a device's scanning surface all ten fingers from an individual shall be acquired in three scans – right four fingers, left four fingers, and two thumbs. For these multi-finger captures, half of the captured fingers should be located to the left of the image center and the other half of the fingers to the right of the image center.

7.9 Palm image location

This part of ISO/IEC 19794 is also designed to accommodate images from the palm of the hand or from the side of the hand opposite the thumb also known as the "writer's palm". Most comparison subsystems perform better if the flat or fleshy part of the palm or writer's palm is centered both horizontally and vertically in the image capture area. Therefore, when capturing a palmprint image, the center of the palm or writer's palm image area should be located in the approximate center of the image capture area. The palm itself may be captured as one entity, or various pieces of it can be captured as single images such as the thenar (fleshy part behind the thumb), hyperthenar (fleshy area opposite the thumb), or interdigital (area of the palm directly beneath the four fingers).

8 Finger image record format

8.1 Record structure

This part of ISO/IEC 19794 defines the composition of the finger image record. Each record shall pertain to a single subject and shall contain at least one representation for each of one or more fingers, multiple fingers (single image records), or palms. Figure 2 illustrates the record structure for the finger image record format.

Figure 3 details the order of fields in the record and the length of each field. The fields in white indicate mandatory fields. Shaded fields indicate optional information.

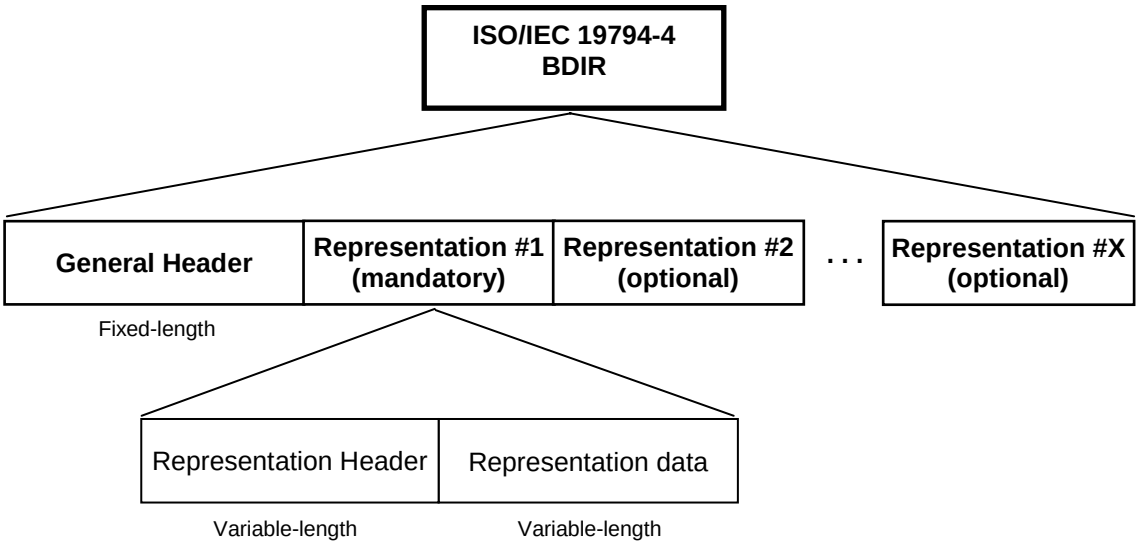

Figure 2 — Finger image record structure

The organization of the record format is as follows:

- A single fixed-length (16-byte) general record header containing information about the overall record, including the number of finger/palm images represented and the overall record length in bytes;
- A single finger record for each single finger, multi-finger, or palm image representation consisting of:
  - A variable length finger image representation header containing information pertaining to the data for a single finger, multi-finger, or palm image;

    NOTE1 For each quality block of information recorded, the length will be increased by 5 bytes.
    NOTE2 If any of the finger image representations contain a device certification block, then the length of each finger representation header shall be a minimum of a 42-byte header.
    NOTE3 For each device certification block of information recorded the length will be increased by 3 bytes.

  - A variable-length finger image representation body containing
    - Compressed or uncompressed image data representation for a single, multi-finger, or palm image; and
    - Optional extended data describing finger segmentation (in the case of multi-finger images), annotation, and comments.

Annex C provides an example of the application of this part of ISO/IEC 19794. It illustrates the completion of required data fields for both the general record header and the finger image record.

8.2 Finger image general header

8.2.1 Required fields

Table 1 lists the fields included in the general record header. As this is a fixed-length header, information shall be included for each field within the header.

General Header	Format identifier	Version number	Length of record	Number of finger/palm representations	Certification flag	Number of distinct finger/palm positions
	4	4	4	2	1	1

Representation Header	Representation length	Capture date & time	Capture device technology identifier	Capture device vendor Identifier	Capture device type identifier	Number of quality blocks
	4	9	1	2	2	1

Quality block data	Number of certification blocks	Certification block data	Finger/palm position	Representation number	Scale units	Capture device spatial sampling rate (horiz)	Capture device spatial sampling rate (vert)
5x	1	3x	1	1	1	2	2

Image spatial sampling rate (horiz)	Image spatial sampling rate (vert)	Bit-depth	Image compression algorithm	Impression type	Horizontal line length	Vertical line length	Image data length
2	2	1	1	1	2	2	4

Quality block data	Quality score	Quality algorithm vendor ID	Quality algorithm ID
	1	2	2

Certification block data	Certification authority identifier	Certification scheme identifier
	2	1

Representation Body	Image data	Extended data blocks
	Variable	Variable

Extended data block	Type identification code	Length of data	Data section
	2	2	Variable

Figure 3 — Order and size of fields in the finger image record

8.2.2 Format identifier

The format identifier shall be recorded in four bytes. The format identifier shall consist of three characters "FIR" followed by a zero byte as a NULL string terminator.

8.2.3 Version number

The number for the version of this part of ISO/IEC 19794 used for constructing the BDIR shall be placed in four bytes. This version number shall consist of three ASCII numerals followed by a zero byte as a NULL

Table 1 — General record header

Field	Size	Valid values	Notes
Format identifier	4 bytes	464952_{Hex} (‘F’ ‘I’ ‘R’ 00_{Hex})	“FIR” – Finger Image Record
Version number	4 bytes	30323000_{Hex} (‘0’ ’2’ ’0’ 00_{Hex})	“020”
Length of record	4 bytes	57 to (2^{32}-1)	Includes all finger/palm representations, quality blocks and certification blocks[1)]
Number of finger/palm representations	2 bytes	1 to 672	[(14 finger positions) + (11 multiple finger positions) + (17 palm codes)]* 16 = 672 possible representations
Certification flag	1 byte	0, 1	Indicates the presence of any device certification blocks within the representation headers
Number of distinct fingers/palm positions	1 byte	>=1	Number of fingers or palms represented

string terminator. The first and second character will represent the major version number and the third character will represent the minor revision number. Upon approval of this specification, the version number shall be “020” – Version 2 revision 0.

8.2.4 Length of record

The length (in bytes) of the entire BDIR shall be recorded in four bytes. This count shall be the total length of the BDIR including the general record header and one or more representation records. The length of the record is dependent on several factors.

8.2.5 Number of finger/palm representations

The total number of representation records contained in the BDIR shall be recorded in two bytes. A minimum of one representation is required. In cases where there is more than one representation of any finger or palm, this number will be greater than the number of fingers or palms.

8.2.6 Device certification flag

The one-byte certification flag shall indicate whether each representation header includes a certification record. A value of 00_{Hex} shall indicate that none of the representations contains a certification record. A value of 01_{Hex} shall indicate that all representations contain a certification record.

NOTE A certification record that is present may contain 0 certifications (in that case the number-of-certifications field in the certification record has the value 0).

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1) If Certification flag (General Header) = 0

$$\text{Length} = 16 + \sum_{1}^{\text{Number of Representations}} (41 + 5*(\#\text{QualityBlocks}) + \text{SizeOfImageData} + \text{SizeOfExtendedData})$$

If Device Certification Flag (General Header) = 1

$$\text{Length} = 16 + \sum_{1}^{\text{Number of Representations}} (42 + 5*(\#\text{QualityBlocks}) + 3*(\#\text{Certification blocks}) + \text{SizeOfImageData} + \text{SizeOfExtendedData})$$

8.2.7 Number of distinct finger/palm positions

The number of fingers or palms included in the record shall be recorded in one byte. Multiple fingers acquired by a single capture and contained in the same image are counted as a single finger image.

EXAMPLE 1 If a record contains two images of a right index finger (position code 2 in Table 6) and two images of a left index finger (position code 7 in Table 6) then the value encoded by this clause would be 2. The number of representations encoded by clause 8.2.5 would be 4.

EXAMPLE 2 If a record contains two images of a right index finger (position code 2 in Table 6), one image of the left index and middle fingers (position code 43 in Table 7), and one image of the right four fingers (position code 13 in Table 6) then the value encoded by this clause would be 3. The number of representations encoded by clause 8.2.5 would be 4.

8.3 Finger/palm image representation header

8.3.1 Required fields

A finger or palm representation header shall start each section of finger data providing information for that representation of a single finger image, multi-finger image, or palm image. For each such image there shall be one finger header record accompanying the representation of the image data. The finger header shall occupy a minimum of 41 or 42 bytes as described below (depending on the certification flag in the general header). The compressed or uncompressed image data for that image representation shall immediately follow the header portion. Additional representations (including the header portion) will be concatenated to the end of the previous representation data. Table 2 is a list of the entries contained in the header preceding each block of finger/palm image data. Table 3 lists the finger/palm image data and various types of extended data associated with a finger representation.

Table 2 — Finger image representation header record

Field	Size	Valid values	Notes
Representation length	4 bytes	41 $_{Hex}$ to FFFFFFFF $_{Hex}$	Denotes the length in bytes of the representation including the representation header fields
Capture date and time	9 bytes	See ISO/IEC 19794-1	The capture date and time field shall indicate when the capture of this representation stated 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.
Capture device technology identifier	1 byte	0 to 20	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 00Hex indicates unknown or unspecified technology. See Table 4 for the list of possible values.
Capture device vendor identifier	2 bytes	0000 $_{Hex}$ to FFFF $_{Hex}$	The capture device vendor identifier shall identify the biometric organization that owns the product that created the BDIR. The capture device 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 capture device vendor is unreported.