
**Information technology — Biometric data
interchange formats —**

**Part 2:
Finger minutiae data**

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

Partie 2: Données du point caractéristique 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 19794-2 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 19794-2:2005). It reflects the harmonization across the second generation of ISO/IEC 19794. A new Clause 7 has been added to describe the finger minutiae format types; Clause 8 contains descriptions of the harmonized general and representation headers; and Clauses 8 and 9 have been technically revised. All annexes have been technically revised. Annex A is under development and will contain an amendment for conformance testing methodology for this part of ISO/IEC 19794. The former Annex B "Fingerprint Image Quality Specifications" has been removed. Annex E contains three examples of capture device certifications. Annex F provides descriptions of fingerprint minutiae location, direction, and type.

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

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 ISO/IEC 19794 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.

In the interest of implementing interoperable biometric recognition systems, this part of ISO/IEC 19794 establishes a data interchange format for minutiae. It is relevant for systems or components dealing with generating, processing, and storing minutiae data. Representation of fingerprint data using minutiae is a widely used technique in many application areas.

This part of ISO/IEC 19794 defines specifics of the extraction of key points (called *minutiae*) from fingerprint ridge patterns. These specifics include a description of the types of minutiae identified, the method used for the placement of minutiae on an image, a definition of the coordinate system used, and the methods used to calculate the angle associated with each minutia.

Information technology — Biometric data interchange formats —

Part 2: Finger minutiae data

1 Scope

This part of ISO/IEC 19794 specifies a concept and data formats for representation of fingerprints using the fundamental notion of minutiae. It is generic, in that it may be applied and used in a wide range of application areas where automated fingerprint recognition is involved. This part of ISO/IEC 19794 contains definitions of relevant terms, a description of how minutiae are to be determined, data formats for containing the data for both general use and for use with cards, and conformance information. Guidelines and values for comparing and decision parameters are provided.

NOTE Although ISO/IEC 19794-4 covers both finger and palm image data, this part of ISO/IEC 19794 only covers finger minutiae and is not applicable to palms.

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 minutiae record format and Clause 9 for the finger minutiae on-card biometric comparison 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 minutiae record format and Clause 9 for the finger minutiae on-card biometric comparison 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 19785-3:2007, *Information technology — Common Biometric Exchange Formats Framework — Part 3: Patron format specifications*

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

ISO/IEC 7816-11:2004, *Identification cards — Integrated circuit cards — Part 11: Personal verification through biometric methods*

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 algorithm

sequence of instructions that tell a biometric system how to solve a particular problem

NOTE An algorithm will have a finite number of steps and is typically used by the biometric engine (i.e., the biometric system software) to compute whether a biometric sample and template are the same.

4.2 end user

person who interacts with a biometric system to enrol or have his/her identity checked

NOTE Compare with the definition of “user” in ISO/IEC 19794-1.

4.3 live-scan print

fingerprint image that is produced by scanning or imaging a live finger to generate an image of the friction ridges

4.4 population

set of end users for the application

4.5 ridge skeleton endpoint

minutia assigned to the location at which a ridge skeleton ends

NOTE A ridge skeleton endpoint is defined as the ending of the skeleton of a ridge.

4.6 template/reference template

data, which represents the biometric measurement of an enrollee, used by a biometric system for comparison against subsequently submitted biometric samples

NOTE This term is not restricted to mean only data used in any particular recognition method, such as template comparison.

4.7 valley bifurcation

point at which a valley splits into two valleys or, alternatively, where two separate valleys combine into one

5 Abbreviated terms

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

BIT	biometric information template
DO	data object
FAR	false acceptance rate
FRR	false rejection rate
RCE	ridge count extraction
RFU	reserved for future use

6 Minutiae extraction

6.1 Purpose

This clause defines the placement of minutiae on the fingerprint. Compatible minutiae extraction is required for interoperability between different finger comparators for the purposes of comparing an individual against a previously collected and stored finger record. Interoperability is based on the definition of the finger minutiae extraction rules, variations of the record format (Clause 7.2), and the on-card biometric comparison format (Clause 7.3) that are common to many finger comparators for acceptable comparing accuracy, while allowing for extended data to be attached for use with equipment that is compatible with it.

6.2 Minutia description

Establishment of a common feature-based representation shall rest on agreement on the fundamental notion for representing a fingerprint. Minutiae are points located at the places in the fingerprint image where friction ridges end or split into two ridges. Describing a fingerprint in terms of the location and direction of these ridge endings and bifurcations provides sufficient information to reliably determine whether two fingerprint records are from the same finger.

The specifications of minutia location and minutia direction described below accomplish this. See Figures 2 through 4 for an illustration of the definitions below.

6.3 Minutia type

6.3.1 General

Each minutia has a “type” associated with it. There are two major types of minutiae: a “ridge skeleton end point” and a “ridge skeleton bifurcation point” or split point. There are other types of “points of interest” in the friction ridges that occur much less frequently and are more difficult to define precisely. More complex types of minutiae are usually a combination of the basic types defined above. Some points are neither a ridge ending nor a bifurcation. This part of ISO/IEC 19794 therefore defines an additional type named “other”, which shall be used for such a case. The “other” minutiae type shall not be used for minutiae that are ridge endings or ridge bifurcations.

Therefore, the following types are distinguished:

- ridge ending
- ridge bifurcation
- other.

A ridge ending may — alternatively — be referred to as a valley bifurcation depending on the method to determine its position (Clause 6.4.3 and 6.4.5). The format type of the biometric information template indicates the use of ridge endings or valley bifurcations.

6.3.2 Unique minutia

A minutia point shall be encoded once. A minutia point is uniquely identified by the location and angle.

6.3.3 Encoding trifurcations

The location at which a ridge splits into three separate ridges is a trifurcation. If it is encoded, it shall be encoded as two bifurcations with identical (x,y) values and different orientation angle values.

6.4 Minutia location

6.4.1 General

The minutia location is represented by its horizontal and vertical position. The minutiae determination strategy considered in this document relies on skeletons derived from a digital fingerprint image. The ridge skeleton is computed by thinning down the ridge area to single pixel wide lines. The valley skeleton is computed by thinning down the valley area to single pixel wide lines. If other methods are applied, they should approximate the skeleton method, i.e. location and angle of the minutia should be equivalent to the skeleton method.

6.4.2 Coordinate system

The coordinate system used to express the minutiae of a fingerprint shall be a Cartesian coordinate system. Points shall be represented by their X and Y coordinates. The origin of the coordinate system shall be the upper left corner of the original image with X increasing to the right and Y increasing downward. Note that this is in agreement with most imaging and image processing use. When viewed on the finger, X increases from right to left as shown in Figure 1. All X and Y values are non-negative.

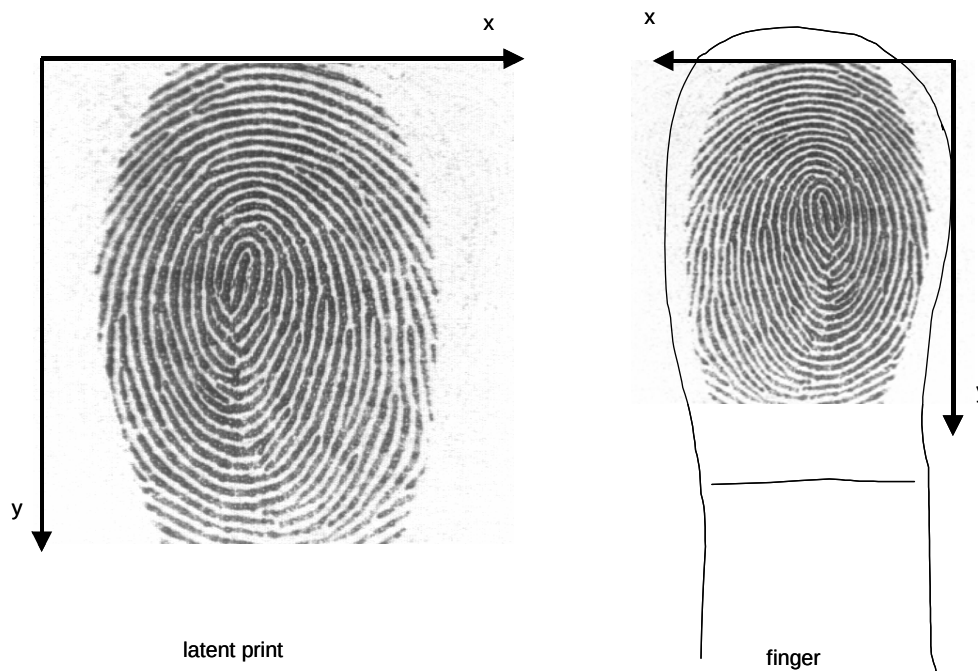


Figure 1 — Coordinate system

For the finger minutiae record format, clause 7.2, the X and Y coordinates of the minutiae shall be measured in pixel units, with the spatial sampling rate of a pixel given in the "X Spatial sampling rate" and "Y Spatial sampling rate" fields of the record header. The spatial sampling rates are stated separately as described in clauses 8.4.11 and 8.4.12.

For the on-card biometric comparison format, clause 7.3, the X and Y coordinates shall be measured in fixed metrical units of one bit per one tenth of a millimetre or 10^{-1} mm as described in clause 9.2.3.

6.4.3 Minutia placement on a ridge ending (encoded as valley skeleton bifurcation point)

The minutia for a ridge ending shall be defined as the point of forking of the medial skeleton of the valley area immediately in front of the ridge ending. If the valley area were thinned down to a single-pixel-wide skeleton, the point where the three skeletal line intersect is the location of the minutia. In simpler terms, it is the point where the valley bifurcates, or (equivalently) where the three thinned valley lines intersect (see Figure 2).

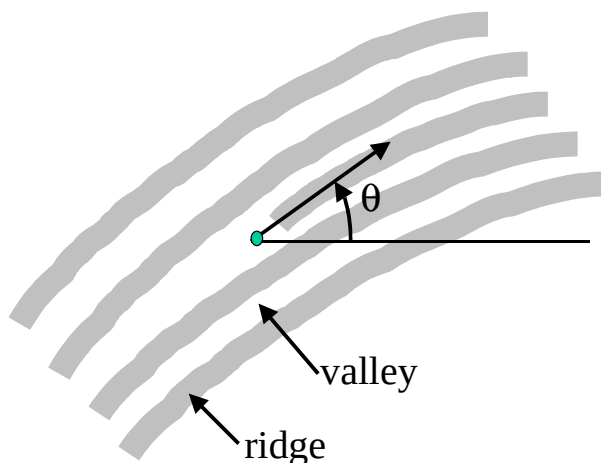


Figure 2 — Location and direction of a ridge ending (encoded as valley skeleton bifurcation point)

6.4.4 Minutia placement on a ridge bifurcation (encoded as a ridge skeleton bifurcation point)

The minutia for a ridge bifurcation shall be defined as the point of forking of the medial skeleton of the ridge. If the ridges were thinned down to a single-pixel-wide skeleton, the point where the three skeletal lines intersect is the location of the minutia. In simpler terms, it is the point where the ridge bifurcates, or (equivalently) where the three skeletal lines of the thinned ridge intersect (see Figure 3).

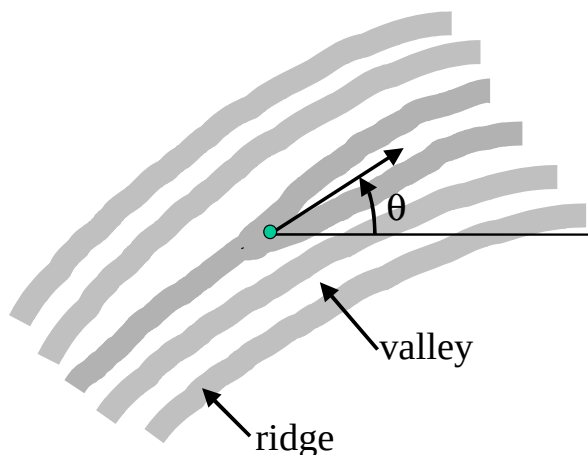


Figure 3 — Location and direction of a ridge bifurcation (encoded as ridge skeleton bifurcation point)

6.4.5 Minutia placement on a ridge skeleton endpoint

The minutia for a ridge skeleton endpoint shall be defined as the center point of the ending ridge. If the ridges in the digital fingerprint image were thinned down to a single-pixel-wide skeleton, the position of the minutia would be the coordinates of the skeleton point with only one neighbour pixel belonging to the skeleton (see Figure 4).

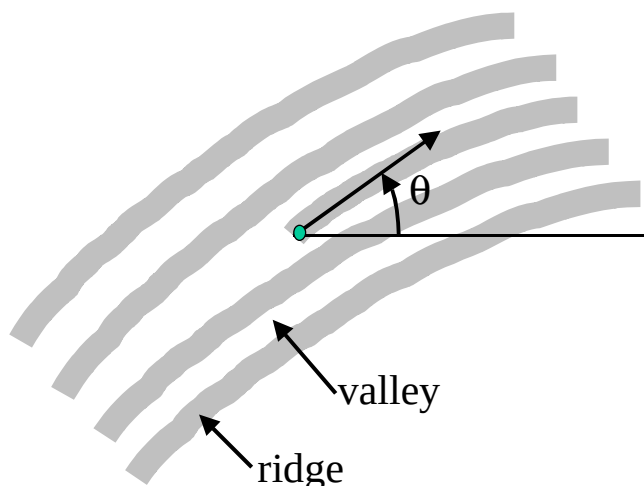


Figure 4 — Location and direction of a ridge skeleton endpoint

6.4.6 Usage of the minutia placement by the record and on-card biometric comparison formats

Depending on the specific algorithms implemented, both the record format and the on-card biometric comparison format use

- valley skeleton bifurcations or ridge skeleton endpoints for locating minutiae on ridge endings, and
- ridge skeleton bifurcations for locating minutiae on ridge bifurcations

For on-card biometric comparison, a card will request from the card usage system biometric verification data in the format compliant to its algorithm. The requested format is either implicitly known to the card usage system or can be retrieved in the Biometric Information Template (see ISO/IEC 19785-3 and ISO/IEC 7816-11).

6.5 Minutiae direction

6.5.1 Angle conventions

The minutia angle is measured increasing counter-clockwise starting from the horizontal axis to the right.

In the finger minutiae record format, the angle of a minutia is scaled to fit the granularity of 1.40625 (360/256) degrees per least significant bit as described in clause 8.4.19.1.4.

The angle coding for the on-card biometric comparison formats is scaled to fit the granularity of 5.625 (360/64) degrees per least significant bit as described in clause 9.2.5.

6.5.2 Minutia direction of a ridge ending (encoded as valley skeleton bifurcation point)

A ridge ending (encoded as valley skeleton bifurcation point) has three arms of valleys meeting in one point. Two valleys enclosing the ridge ending line encompass an acute angle. The direction of a valley bifurcation is defined by the mean direction of their tangents and is measured as the angle the tangent of the ending ridge forms with the horizontal axis to the right (see Figure 2).

6.5.3 Minutia direction of a ridge bifurcation (encoded as ridge skeleton bifurcation point)

A ridge bifurcation (encoded as ridge skeleton bifurcation point) has three arms of ridges meeting in one point. Two ridges enclosing the ending valley encompass an acute angle. The direction of a valley bifurcation is defined by the mean direction of their tangents and is measured as the angle the tangent of the ending valley forms with the horizontal axis to the right (see Figure 3).

6.5.4 Minutia direction of a ridge skeleton end point

The direction of a ridge skeleton endpoint is defined as the angle that the tangent to the ending ridge encompasses with the horizontal axis to the right (see Figure 4).

6.6 Core and delta placement

Core and delta points are designated points of interest in a fingerprint. A fingerprint may have 0, 1 or more cores and 0, 1 or more deltas. The core and delta are defined in ISO/IEC 19794-1. The location of the core and delta positions are defined as follows:

Core position: If there are ridge endings enclosed by the innermost recurving ridgeline, the ending nearest to the maximal curvature of the recurving ridgeline defines the core position. If the core is a u-turn of a ridgeline not enclosing ridge endings, the valley end defines the core position.

Delta position: Three points of divergence are each placed between the two ridges at the location where the ridges begin to diverge; that is, where the ridges that have been parallel or nearly parallel begin to spread apart as they approach the delta. The position of the delta is defined by the spatial mean of these three points. The position is at the point on a ridge at or in front of and nearest the center of the divergence of the ridges that start parallel, diverge, and surround or tend to surround the pattern area of the fingerprint image.

Core and delta point placement is illustrated in Figure 5.

NOTE Cores and deltas represent singularities in the ordinary direction field of the fingerprint image. Hence, angle information of cores and deltas cannot fit smoothly into the direction values of all points in the neighbourhood.

6.7 Encoding of multibyte quantities

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 (and are transmitted before) less significant bytes. All numeric values are fixed-length integer quantities, and are unsigned quantities.

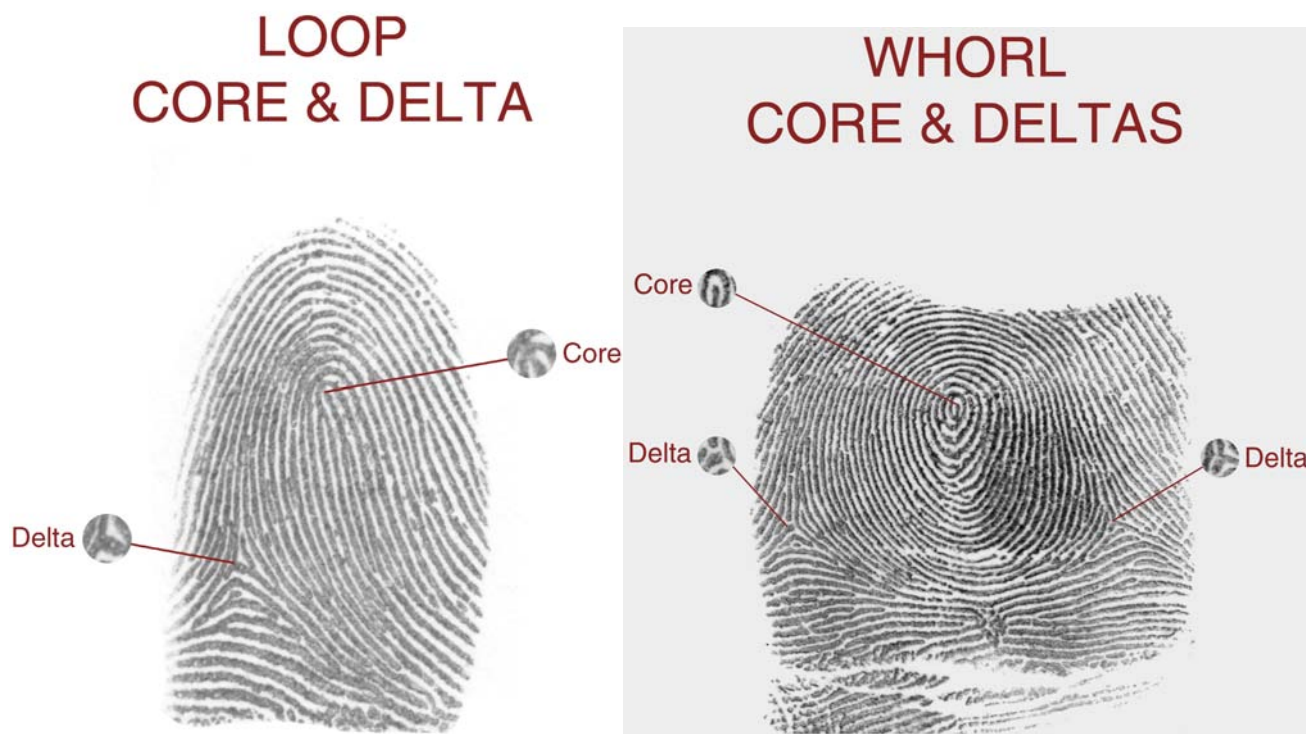


Figure 5 — Example core and delta placement

7 Finger minutiae format types

7.1 Overview

This part of 19794 defines two format types for minutiae encoding. These format types have been derived from those listed in Version 2 of this part of ISO/IEC 19794 (ISO/IEC 19794-2:2005). The first record format is designed for general storage, data interchange, or card based system. The second is an on-card biometric comparison format intended for the comparison-on-card application as described in ISO/IEC 24787. Table 1 provides a tabular illustration of the two format types and the options available for each type.

7.2 Record format

This record format (Clause 8) requires the use of a general header for each finger record and a representation header for each representation of the finger. This format is also designed to accommodate ridge count data, core and delta data, zonal quality data, or vendor-defined extended data. Within the representation header parameters shall be set to indicate whether five or six bytes are needed for each minutiae (the latter includes a 1 byte quality field for each minutia). A second field in the representation header is used to differentiate between ridge ending minutiae determined by ridge skeleton end points, and those determined using valley bifurcations. A third field encodes the vendor of the minutiae extraction algorithm. The fourth field is a vendor-assigned identification of the feature extraction algorithm used by the vendor.

7.3 On-card comparison format

This on-card biometric comparison format (Clause 9) precludes the use of a general or representation header. Unlike the record format, the on-card biometric comparison format does not have a header and only has provision for a single representation record of the finger. This corresponds to the compact-size card format types that existed in ISO/IEC 19794-2:2005, which require three bytes to describe each minutiae. This format locates ridge endings using either the ridge skeleton end-points or valley bifurcation points. As with the record

Table 1 — Format type options

Format		Extended data (Option)	Ridge ending	Ridge bifurcation	minutiae size (per minutiae)
Finger Minutiae Record Format	Finger Minutia Qualified Pixel Record Format	Supported	Ridge valley bifurcation	Ridge bifurcation	6 byte
			Ridge Skeleton end point		
	Finger Minutia Pixel Record Format	Supported	Ridge valley bifurcation	Ridge bifurcation	5 byte
			Ridge Skeleton end point		
Finger Minutiae On-Card Biometric Comparison Format		Supported with DOs	Ridge valley bifurcation	Ridge bifurcation	3 byte
			Ridge skeleton end point	Ridge bifurcation	3 byte

format, bifurcations are located using ridge skeleton bifurcation points. Whether the ridge endings are represented by ridge skeleton end-points or valley skeleton bifurcation points shall be indicated by different CBEFF BDB format type identifiers (see Clause 10).

8 Finger minutiae record format

8.1 Introduction

The finger minutiae record format shall be used to achieve interoperability between finger minutiae extraction and comparison subsystems. The record format requires a general header. The minutiae data are represented by different variations and may contain extended data in addition to the basic data. The formats differ in two respects: the size of the encoded minutia, and whether ridge endings are determined by valley skeleton bifurcation or ridge skeleton end points. With the exception of the Format Identifier and the Version number for the standard, which are null-terminated ASCII character strings, all data is represented in binary format. There are no record separators or field tags; fields are parsed by byte count.

8.2 Record organization

The organization of the record is as follows:

- A single fixed-length (15-byte) general header containing information about the overall record, including the number of finger representations and the overall record length in bytes;
- A single finger record for each finger representation, consisting of:
 - o A variable-length finger minutiae representation header containing information about the data for a single finger representation, including the number of minutiae;

Note 1 For each quality block of information recorded the length will be increased by 5 bytes

Note 2 When capture device certification information is present, one byte for the count of certifications is required plus an additional 3 bytes for each specific certification

- o A variable-length finger minutiae representation body containing
 - A series of fixed-length (6-byte, or 5-byte) minutia descriptions, including the position, type, and angle (quality of the minutia is also included for the 6-byte record format);
 - and
 - One required extended data block for each finger representation containing zero or more extended data areas describing optional or vendor specific information.

8.3 General header

There shall be one and only one general header for the minutiae record. Table 2 contains a summary of the general record header fields.

Table 2 — General header

One per Record	Field	Size	Valid Values	Notes
	Format Identifier	4 bytes	464D5200 _{Hex} (‘F’ ‘M’ ‘R’ 00 _{Hex})	“FMR ” – finger minutiae record
	Version Number	4 bytes	30333000 _{Hex} (‘0’ ‘3’ ‘0’ 00 _{Hex})	Version = 030
	Length of record	4 bytes	36 _{Hex} to FFFFFFF _{Hex}	Minimum length is 15 for the general header plus 39 for each representation (1 minutiae) = 54 to 2 ³² -1
	Number of Finger Representations	2 bytes	0001 _{Hex} to 0160 _{Hex}	(10 fingers + 1 unknown + 11 multiple finger combinations) times 16 = 352
	Device Certification Block Flag	1 byte	00 _{Hex} or 01 _{Hex}	Indicates the presence of any device certification blocks within the representation headers

8.3.1 Format identifier

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

8.3.2 Version number

The number for the version of this part of ISO/IEC 19794 used for constructing the finger minutiae BDIR shall be placed in four bytes. This version number shall consist of three ASCII numerals followed by a zero byte as a NULL string terminator. 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 “030” – Version 3 revision 0.

8.3.3 Length of record

The length (in bytes) of the entire finger minutiae 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.

8.3.4 Number of finger representations

The total number of representations 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, this number will be greater than the number of fingers.

8.3.5 Device certification block 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).

8.4 Finger minutiae representation format

8.4.1 Finger minutiae representation header

A finger minutiae representation header shall precede each representation of finger minutiae data providing information for that finger representation. There shall be one finger representation header for each finger representation contained in the finger minutiae record. The finger representation header will occupy a minimum of 39 bytes as described below. As the number of finger image quality blocks, capture device certification blocks, and extended data areas are added, the length of the finger header will increase. Table 3 contains a summary of the fields for the finger representation format. Table 4 describes the contents of extended data areas. These two tables list the header fields, and all fields that may occur in a representation including the finger minutiae data fields and extended data fields.

NOTE It is permissible to have multiple finger representations of the same finger in the same finger minutia record provided that each representation's data is derived from a unique capture of the same finger.

8.4.2 Representation length

The representation-length field denotes the length in bytes of the representation including the representation header fields.

8.4.3 Capture date-time

The capture date and time field shall indicate when the capture of this representation started in Coordinated Universal Time (UTC). This field is not intended to encode the time the record was instantiated. The capture date and time field shall be encoded in accordance to the requirements given in ISO/IEC 19794-1.

8.4.4 Capture device technology ID

The capture device technology ID shall be encoded in one byte. This field shall indicate the class of capture device technology used to acquire the captured biometric sample. A value of 00_{Hex} indicates unknown or unspecified technology. See Table 5 for the list of possible values.

8.4.5 Capture device vendor identifier

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.

Table 3 — Finger minutiae representation format

Field	Size	Valid Values	Notes
Representation length	4 bytes	27 _{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 5 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.
Capture device type identifier	2 bytes	0000 _{Hex} to FFFF _{Hex}	The capture device type identifier shall identify the product type that created the BDIR. It shall be assigned by the registered product owner or other approved registration authority. A value of all zeros shall indicate that the capture device type is unreported. If the capture device vendor identifier is 0000 _{Hex} , then also the capture device type identifier shall be 0000 _{Hex} .
Quality record	1 to 1,276 bytes (1 to 1 + (255 * 5))	See ISO/IEC 19794-1	A quality record shall consist of a length field followed by zero or more quality blocks. The length field shall consist of one byte. It shall represent the number of quality blocks as an unsigned integer. Each quality block shall consist of – a quality score, – a quality algorithm vendor identifier, and – a quality algorithm identifier. A quality score should express the predicted comparison performance of a representation. A quality score shall be encoded in one byte as an unsigned integer. Allowed values are – 0 to 100 with higher values indicating better quality, – 255, i.e. ff_{Hex}, for indicating that an attempt to calculate a quality score failed. The quality algorithm vendor identifier shall identify the provider of the quality algorithm. The quality algorithm vendor identifier shall be encoded in two bytes carrying a CBEFF biometric organization identifier (registered by IBIA or other approved registration authority). A value of all zeros shall indicate that the value for this field is unreported.

Field	Size	Valid Values	Notes
			The quality algorithm identifier shall identify the vendor's quality algorithm that created the quality score. It shall be assigned by the provider of the quality algorithm or an approved registration authority. The quality algorithm identifier shall be encoded in two bytes. A value of all zeros shall indicate that the value for this field is unreported.
Certification record	0 to 766 bytes (1 to 1 + (255 * 3))	See ISO/IEC 19794-1	The certification record only exists if the certification flag in the general header has a value of 1. A certification record shall consist of a length field followed by zero or more certification blocks. The length field shall consist of one byte. It shall represent the number of unique certification blocks as an unsigned integer. Each certification block shall consist of – a certification authority identifier and – a certification scheme identifier. The certification authority identifier shall identify a certification authority that has carried out a certification according to a certification scheme. The certification authority identifier shall be encoded in two bytes carrying a CBEFF biometric organization identifier (registered by IBIA or other approved registration authority). The certification scheme identifier shall identify a certification scheme according to which a certification has been carried out. The certification scheme identifier shall be encoded in one byte. See Table 6 for the list of certification scheme identifiers.
Finger position	1 byte	0 to 10; 13 to 15; 40 to 50	See Table 7
Representation number	1 byte	0 to 15	Up to 16 representations for each finger
Image spatial sampling rate (horiz)	2 bytes	0062 _{Hex} to FFFF _{Hex}	In pixels/cm (minimum of 98 pp/cm)
Image spatial sampling rate (vert)	2 bytes	0062 _{Hex} to FFFF _{Hex}	In pixels/cm (minimum of 98 pp/cm)
Impression type	1 byte	0 to 9; 24; 28 to 29	See Table 8
Size of scanned image in X-Dir	2 bytes	0000 _{Hex} to 3FFF _{Hex}	In pixels
Size of Scanned image in Y-dir	2 bytes	0000 _{Hex} to 3FFF _{Hex}	In pixels
Minutiae field length	4 bits	5, 6	6 byte format includes a quality byte
Ridge ending type	4 bits	0,1	0 – intersection of valley bifurcation lines 1 – ridge skeleton endpoints
Number of minutiae	1 byte	1 to 255	

Field		Size	Valid Values	Notes
One per minutia	Minutia type	2 bits	0 _{Hex} to 3 _{Hex}	00 other 01 ridge ending 10 ridge bifurcation 11 reserved by SC 37 for future use
	Minutia X	14 bits	0000 _{Hex} to 3FFF _{Hex}	Expressed in pixels
	Reserved by SC 37 for future use	2 bits	0 _{Hex}	
	Minutia Y	14 bits	0000 _{Hex} to 3FFF _{Hex}	Expressed in pixels
	Angle Ø	1 byte	0 to 255	Resolution is 1.40625 degrees
	Minutia Quality	0 or 1 byte	0 to 100; 254; 255	Minutia quality field does not exist for the 5-byte format, 254 means quality score is not reported and 255 indicates failure to compute quality.
Extended data block length		2 bytes	0000 _{Hex} 0004 _{Hex} to FFFF _{Hex}	0000 _{Hex} indicates that there is no extended data
+	Extended data area type Code	2 bytes	0000 _{Hex} to FFFF _{Hex}	Only if Extended data block length ≠0 See Table 11
	Extended data area length	2 bytes	0004 _{Hex} to FFFF _{Hex}	Only if Extended data block length ≠0. If this field is present, its value includes the count of the length and type identification fields (four bytes total).
	Extended data	00 _{Hex} to FFFB _{Hex} bytes	See clause 8.5.1.4	Only if Extended data block length ≠0 The minimum size in bytes of the Extended Data is 00 _{Hex} because clause 8.5.1 provides no specific guidance for vendor-defined extended data. The maximum size in bytes of the Extended Data is FFFB _{Hex} , which is FFFF _{Hex} minus the 2-byte length of the Extended Data Area Type Code field and the 2-byte length of the Extended Data Area Length field.

Table 4 — Extended data areas

Each extended data area may contain vendor-specific data, or one or more of the following (in any order)					
Ridge count data	0+	Field	Size	Valid Values	Notes
		Ridge count extraction method	1 byte	0 to 2	Non-specific, 4-neighbour quadrants, or 8-neighbour octants
		Ridge count data – idx #1	1 byte	1 to 255	Starting minutia
		Ridge count data – idx #2	1 byte	0 to 255	Neighbouring minutia
		Count of ridges	1 byte	0 to 255	Intersecting ridges
Delta and Core Data	0+	Reserved	4 bits	0 _{Hex}	Reserved by SC 37 for future use
		Number of cores	4 bits	0 to 15	
		Core information type	2 bits	00, 01	01 - 1 core angle present
		X location	14 bits	0000 _{Hex} to 3FFF _{Hex}	
		Reserved	2 bits	0 _{Hex}	Reserved by SC 37 for future use
		Y location	14 bits	0000 _{Hex} to 3FFF _{Hex}	
		Core angle	1 byte	00 _{Hex} to FF _{Hex}	Angle present if Core information type = '01'
	0+	Reserved	4 bits	0 _{Hex}	Reserved by SC 37 for future use
		Number of deltas	4 bits	0 to 15	
		Delta information type	2 bits	00, 01	01 – 3 delta angles present
		X location	14 bits	0000 _{Hex} to 3FFF _{Hex}	
		Reserved	2 bits	0 _{Hex}	Reserved by SC 37 for future use
		Y location	14 bits	0000 _{Hex} to 3FFF _{Hex}	
		Delta angle # 1	1 byte	00 _{Hex} to FF _{Hex}	These angles present if Delta information type = '01'
		Delta angle # 2	1 byte	00 _{Hex} to FF _{Hex}	
		Delta angle # 3	1 byte	00 _{Hex} to FF _{Hex}	
Zonal quality data		Zonal quality vendor ID	2 bytes	0000 _{Hex} to FFFF _{Hex}	ID registered with IBIA
		Zonal quality algorithm	2 bytes	0000 _{Hex} to FFFF _{Hex}	Assigned by vendor
		Cell width	1 byte	1 to 255	Number of pixels
		Cell height	1 byte	1 to 255	Number of pixels
		Cell information bit depth	1 byte	1 to 8	
		Cell quality data	Cell Data Length	0 to 2 ^{depth} -1	

8.4.6 Capture device type identifier

The capture device type identifier shall identify the product type that created the BDIR. It shall be assigned by the registered product owner or other approved registration authority. A value of all zeros shall indicate that the capture device type is unreported.

Table 5 — Capture device technology ID

ID	Capture device technology
0	Unknown or unspecified
1	White light optical TIR
2	White light optical direct view on platen <i>Note: Card scanner should encode their technology type as "white light optical direct view on platen".</i>
3	White light optical touchless
4	Monochromatic visible optical TIR
5	Monochromatic visible optical direct view on platen
6	Monochromatic visible optical touchless
7	Monochromatic IR optical TIR
8	Monochromatic IR optical direct view on platen
9	Monochromatic IR optical touchless
10	Multispectral optical TIR
11	Multispectral optical direct view on platen
12	Multispectral optical touchless
13	Electro luminescent
14	Semiconductor capacitive
15	Semiconductor RF
16	Semiconductor thermal
17	Pressure sensitive
18	Ultrasound
19	Mechanical
20	Glass fiber

8.4.7 Finger image quality

8.4.7.1 General

The quality information of the overall finger image data, if present, shall be recorded in one or more five-byte blocks when the number of quality blocks field is greater than 0. Each of these blocks shall pertain to a specific quality/vendor/algorithm evaluation. Figure 6 illustrates the placement and recording of multiple quality blocks.

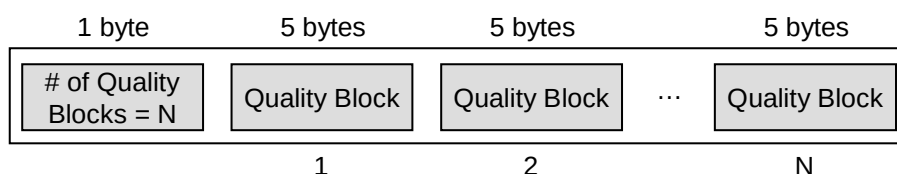


Figure 6 — Image quality layout

8.4.7.2 Number of quality Blocks

The first byte is mandatory and shall contain the number of blocks of quality information of the overall finger image data. Subsequent 5-byte blocks shall contain the specific quality/vendor/algorithm information for each quality/vendor/algorithm evaluation. A value of zero (0) means that no attempt was made to assign a quality score. In this case, no Quality Blocks are present.

8.4.7.3 Quality score

The quality score, as defined in ISO/IEC 29794-1, shall be recorded in the first byte of each of the five-byte blocks. It shall be a quantitative expression of the predicted verification performance of the biometric sample. Valid values for Quality Score are integers between 0 and 100, where higher values indicate better quality. A value of 255 is to handle a special case that indicates a failed attempt to calculate a quality score.

8.4.7.4 Quality algorithm vendor ID

To enable the recipient of the quality score to differentiate between quality scores generated by different algorithms, the provider of quality scores shall be uniquely identified by the next two bytes. This Vendor ID shall be registered with the International Biometrics Industry Association (IBIA).

8.4.7.5 Quality algorithm ID

The remaining two bytes shall specify an integer product code assigned by the vendor of the Quality Algorithm ID. It indicates which of the vendor's algorithms (and version) was used in the calculation of the quality score and shall be within the range of 0000_{Hex} to FFFF_{Hex}. Multiple quality scores calculated by the same algorithm (same vendor ID and algorithm ID) shall not be present in a single representation.

8.4.8 Capture device certifications

8.4.8.1 General

This multi-byte block contains information to indicate the compliant certification procedures that were used to test the biometric capture equipment used. The certification record shall consist of a length field followed by zero or more 3-byte certification blocks. Each certification block shall consist of a certification authority identifier, and a certification scheme identifier.

If the device certification flag in the general header has a value of 00_{Hex}, no capture device certification information shall be present in any of the representation header records for that finger minutiae record.

8.4.8.2 Number of certifications

The first byte is mandatory and shall contain the number of certification blocks as an unsigned integer for the capture device.

8.4.8.3 Certification authority identifier

The first two bytes of each block contain the CBEFF biometric organization identifier of the certification authority (registered by IBIA or other approved registration authority). This is the agency that certifies a device according to a particular certification scheme identifier.

8.4.8.4 Certification scheme identifier

This last byte of the block shall identify a certification scheme used to certify the capture device. A list of current certification scheme identifiers is contained in Table 6.

8.4.9 Finger position

The finger position shall be recorded in one byte. The codes for this byte shall be chosen from Table 7 which lists single finger and multiple finger combinations.

NOTE The capability to compare minutiae from un-segmented fingers (i.e. finger-position codes 13 and above) has not been demonstrated, and will require dedicated research and development.

Table 6 — Identifiers for certification schemes specified in the annexes

Certification scheme Identifier	Annex
00 _{Hex}	Reserved by SC 37 for future use
01 _{Hex}	E.1 — Image quality specification for AFIS systems
02 _{Hex}	E.2 — Image quality specification for personal verification
03 _{Hex}	E.3 — Requirements and test procedures for optical fingerprint scanners
04 _{Hex} to FF _{Hex}	Reserved by SC 37 for future use

8.4.10 Representation number

This one byte field shall contain the specific image representation number associated with the finger. If there is more than one finger minutiae representation from the same finger in a finger minutiae record, each minutiae record shall have a unique representation number. The combination of finger location and representation number shall uniquely identify a particular minutiae representation within a minutiae record. Multiple finger minutiae representations from the same finger shall be numbered with increasing representation numbers, beginning with zero. Where only one finger minutiae record is taken from each finger, this field shall be set to 0.

8.4.11 Image spatial sampling rate (horizontal)

The horizontal spatial sampling rate of the minutiae coordinate system shall be recorded in two bytes having the units of pixels per centimeter. The value of the X spatial sampling rate shall not be less than 98.45 pixels per centimeter (250 pixels per inch).

8.4.12 Image spatial sampling rate (vertical)

The vertical spatial sampling rate of the minutiae coordinate system shall be recorded in two bytes having the units of pixels per centimeter. The value of the Y spatial sampling rate shall not be less than 98.45 pixels per centimeter (250 pixels per inch).

8.4.13 Impression type

The impression type of the finger images from which the minutiae data was derived shall be recorded in this one byte field. The codes for this byte are shown in Table 8 — Finger impression codes. These codes are compatible with Table 8 — Finger impression codes of the ANSI/NIST-ITL 1-2007, "Data Format for the Interchange of Fingerprint Information".

8.4.14 Size of scanned image in X-direction

This two-byte binary field shall be used to specify the number of pixels contained on a single horizontal line of the transmitted image. The range of allowed values is 0000_{Hex} to 3FFF_{Hex} for compatibility with the Minutia, Core, and Delta Position fields.

8.4.15 Size of scanned image in Y-direction

This two-byte binary field shall be used to specify the number of horizontal lines contained in the transmitted image. The range of allowed values is 0000_{Hex} to 3FFF_{Hex} for compatibility with the Minutia, Core, and Delta Position fields.

Table 7 — Finger position codes

Finger position	Code
Unknown finger	0
Right thumb	1
Right index finger	2
Right middle finger	3
Right ring finger	4
Right little finger	5
Left thumb	6
Left index finger	7
Left middle finger	8
Left ring finger	9
Left little finger	10
Plain right four fingers	13
Plain left four fingers	14
Left thumb and right thumb	15
Right Index and middle	40
Right middle and ring	41
Right ring and little	42
Left Index and middle	43
Left middle and ring	44
Left ring and little	45
Right index and Left index	46
Right index and middle and ring	47
Right middle and ring and little	48
Left index and middle and ring	49
Left middle and ring and little	50

Table 8 — Finger impression codes

Code	Description
0	Live-scan plain
1	Live-scan rolled
2	Nonlive-scan plain
3	Nonlive-scan rolled
4	Latent impression
5	Latent tracing
6	Latent photo
7	Latent lift
8	Live-scan swipe
9	Vertical roll
10 to 23	Reserved by SC 37 for future use
24	Live-scan optical contactless plain
25 to 27	Reserved by SC 37 for future use
28	Other
29	Unknown

8.4.16 Minutia field length

The number of bytes required to describe each minutia shall be recorded in four high-order (most significant) bits of the byte. The contents of this field shall be either 6 to indicate a 6-byte minutia format (including a 1-byte quality field) or a 5 to indicate a 5-byte minutia format (with no quality information). The low-order four bits of the byte shall contain the "Ridge Ending Type".

8.4.17 Ridge ending type

The method used to determine the location of a ridge ending shall be recorded in four low-order (least significant) bits of the byte. A value of 0 shall indicate that the minutia was located using the intersection of three valleys. A value of 1 shall indicate that the minutia was located using ridge skeleton endpoints. The high-order four bits of the byte shall contain the length of minutiae field.

8.4.18 Number of minutiae

The number of minutiae extracted and encoded for the finger shall be recorded in this one byte.

8.4.19 Finger minutiae data

The finger minutiae data for a single finger shall be recorded in blocks of six or five bytes per minutia. This is dependent on the minutiae field length as encoded in the above in clause 8.4.16. The method used to locate ridge endings is independent of the number of bytes required to represent a minutia. The order of the minutiae is not specified.

8.4.19.1 Qualified finger minutia pixel record format

8.4.19.1.1 Overview

Using the qualified finger minutia pixel record format, six bytes are needed to encode each minutia. Table 9 illustrates the layout of the bits and bytes for minutiae type, location, angle, and quality descriptors for the 6-byte minutiae format.

Table 9 — Qualified finger minutia pixel record format

type t	x-coordinate	Reserved	y-coordinate	angle θ	Quality
2 bits	14 bits	2 bits	14 bits	1 byte	1 byte

8.4.19.1.2 Minutia type

The type of minutia (type t) will be recorded in the first two bits of the upper byte of the X coordinate. The bits “00” will represent a minutia of “other” type, “01” will represent a ridge ending and “10” will represent a ridge bifurcation. Type “11” is reserved by SC 37 for future use. Minutia type “other” shall not be used for minutiae that are either ridge endings or ridge bifurcations. Ridge endings may either be encoded as valley skeleton bifurcation points or ridge skeleton end points.

8.4.19.1.3 Minutia position

The X coordinate of the minutia shall be recorded in the rest of the first two bytes (fourteen bits). The Y coordinate shall be placed in the lower fourteen bits of the following two bytes. The upper two bits are reserved by SC 37 for future use and shall be set to ‘00’. The coordinates shall be expressed in pixels at the spatial sampling rate indicated in the representation header. Position information shall be present for each minutia, regardless of type, although position for minutiae of type “other” is vendor-defined.

8.4.19.1.4 Minutia angle

The angle of the minutia shall be recorded in one byte in units of 1.40625 (360/256) degrees. The value shall range from 0 to 255, inclusive. For example, an angle value of 16 represents 22.5 degrees. Note that angle information shall be present for each minutia, regardless of type, although angle for minutiae of type “other” is vendor defined.

8.4.19.1.5 Minutia quality

Minutia quality is the confidence that the minutia is a true minutia. The quality value shall range from 100 as a maximum to 0 as a minimum. A value of 254 indicates the quality was not reported and a value of 255 indicates failure to acquire a quality score.

8.4.19.2 Finger minutia pixel record format

8.4.19.2.1 Overview

Using the minutia pixel record format, only five bytes are needed to encode each minutia. Table 10 illustrates the layout of the bits and bytes for minutiae type, location, and angle descriptors.

Table 10 — Finger minutia pixel record format

type <i>t</i>	x-coordinate	reserved	y-coordinate	angle θ
2 bits	14 bits	2 bits	14 bits	1 byte

8.4.19.2.2 Minutia type, position, and angle

The 5-byte minutia non-qualified pixel format is the same as the 6-byte minutia qualified pixel format without the quality byte. The same field descriptions as in the 6-byte minutia qualified pixel format are applicable to this format also.

8.5 Extended data

The extended data section of the finger minutiae record format is provided for the storage of additional data that may be used by the comparison equipment. The size of this section shall be kept as small as possible, augmenting the data stored in the standard minutiae section. The extended data for each finger representation shall immediately follow the standard minutiae data for that finger representation and shall begin with the Extended Data Block Length field. More than one extended data area may be present for each finger and the extended data block length field will be the summation of the lengths of each extended data segment. The data block length is used as a signal for the existence of the extended data while the individual extended data length fields are used as indices to parse the extended data. Note that the extended data area shall not be used alone, without the standard portion of the minutiae record.

While the extended data area allows for inclusion of vendor-defined data within the minutiae format, this is not intended to allow for alternate representations of data that can be represented in an open manner as defined in this part of ISO/IEC 19794. In particular, ridge count data, core and delta data or zonal quality information shall not be represented in vendor-defined manner to the exclusion of the publicly defined formats in this part of ISO/IEC 19794. Additional ridge count, core and delta or zonal quality information may be placed in a vendor-defined extended data area if the standard fields defined below are also populated. The intention of this part of ISO/IEC 19794 is to provide interoperability.

8.5.1 Common extended data fields

8.5.1.1 Extended data block length

All finger records shall contain the extended data block length. This field will signify the existence of extended data. A value of all zeros (0000_{Hex}) will indicate that there is no extended data and that the record will end or continue with the next finger representation. A nonzero value will indicate the length of all extended data starting with the next byte. The block length will then be followed by the type identification code (8.5.1.2), length of data field (8.5.1.3) and the data area (8.5.1.4).

8.5.1.2 Extended data area type code

The type identification code shall be recorded in two bytes, and shall distinguish the format of the extended data area. A value of zero in both bytes is reserved by SC 37 for future use and shall not be used. A value of zero in the first byte, followed by a non-zero value in the second byte, shall indicate that the extended data section has a format defined in this part of ISO/IEC 19794. A non-zero value in the first byte shall indicate a vendor specified format, with a code maintained by the vendor. Refer to Table 11 for a summary of the type identification codes. If the Extended Data Block Length (8.5.1.1) for the finger representation is zero, indicating no extended data, this field shall not be present.

Table 11 — Extended data area type codes

First byte	Second byte	Identification
00 _{Hex}	00 _{Hex}	Reserved by SC37 for future use
00 _{Hex}	01 _{Hex}	ridge count data (8.5.2)
00 _{Hex}	02 _{Hex}	core and delta data (8.5.3)
00 _{Hex}	03 _{Hex}	zonal quality data (8.5.4)
00 _{Hex}	04 _{Hex} to FF _{Hex}	Reserved by SC37 for future use
01 _{Hex} to FF _{Hex}	00 _{Hex}	Reserved by SC37 for future use
01 _{Hex} to FF _{Hex}	01 _{Hex} to FF _{Hex}	Vendor specific extended data

8.5.1.3 Extended data area length

The length of the extended data section shall be recorded in two bytes. This value is used to skip to the next extended data if the comparator cannot decode and use this data. If the Extended Data Block Length (8.5.1.1) for the finger representation is zero, indicating no extended data, this field shall not be present. If the field is present, this length field includes the count of the length and type identification fields (four bytes total).

8.5.1.4 Data section

The data field of the extended data is defined by the equipment that is generating the finger minutiae record, or by common extended data formats contained in this part of ISO/IEC 19794; see clauses 8.5.2, 8.5.3, and 8.5.4. If the Extended Data Block Length (8.5.1.1) for the finger representation is zero, indicating no extended data, this field shall not be present.

8.5.2 Ridge count data format

If the extended data area type code is 0001_{Hex}, the extended data area contains ridge count information. The minimum value for the Extended Data Area Length field of a Ridge Count Extended Data area is 5 bytes. This consists of 2 bytes for type, 2 bytes for length, and one byte to identify a ridge count extraction method. This format provides optional information about the number of fingerprint ridges between pairs of minutiae. Each ridge count is associated with a pair of minutiae contained in the minutiae data area defined in clause 8.4.19. No ridge information may be contained that is associated with minutiae not included in the corresponding minutiae area. Ridge counts shall not include the ridges represented by either of the associated minutiae. Refer to Figure 7 for clarification; the ridge count between minutiae A and B is 1, while the ridge count between minutiae B and C is 2.

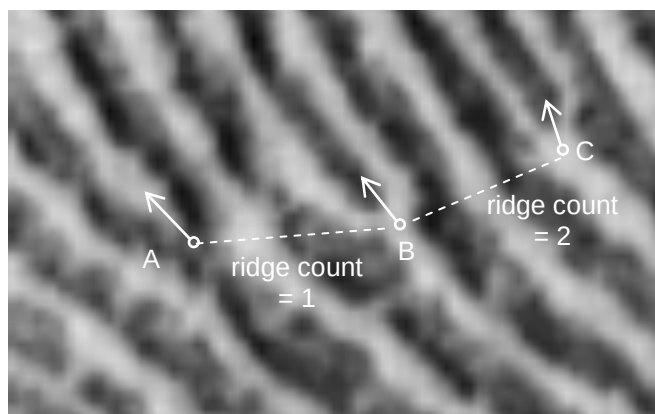


Figure 7 — Example ridge count data

8.5.2.1 Ridge count extraction method

The ridge count data area shall begin with a single byte indicating the ridge count extraction method. Ridge counts associated with a particular central minutia (a minutiae used as the reference to generate the subsequent ridge counts relevant for the ridge count extraction method) are frequently extracted in one of two ways: by extracting the ridge count to the nearest neighbouring minutia in each of four angular regions (or quadrants), or by extracting the ridge count to the nearest neighbouring minutia in each of eight angular regions (or octants). The ridge count extraction method field shall indicate the extraction method used, as shown in Table 12. It is not necessary for all minutiae in the minutiae data area to have ridge count data associated with each minutia.

If either of these specific extraction methods are used, the ridge counts shall be listed in the following way:

- all ridge counts for a particular central minutia shall be listed together;
- the central minutia shall be the first minutia referenced in the three-byte ridge count data;
- the listing of the central minutiae of each 3-byte data block shall be ordered and the order of the listing of neighbouring minutiae for each central minutia are not defined by the standard.

Table 12 — Ridge count extraction method codes

RCE method field value	Extraction method	Comments
00 _{Hex}	Non-specific	No assumption shall be made about the method used to extract ridge counts, nor their order in the record; in particular, the counts may not be between nearest-neighbour minutiae
01 _{Hex}	Four-neighbour (quadrants)	For each central minutia used, ridge count data was extracted to the nearest neighbouring minutia in four quadrants, and ridge counts for each central minutia are listed together
02 _{Hex}	Eight-neighbour (octants)	For each central minutia used, ridge count data was extracted to the nearest neighbouring minutia in eight octants, and ridge counts for each central minutia are listed together

8.5.2.1.1 Eight-neighbour ridge count extraction method

Ridge count information for the eight-neighbour ridge count extraction method shall be extracted as follows

- Each central minutia used shall be assigned its own unique “neighbourhood” consisting of eight octants (angular sectors of 45 degrees) of a (theoretical) circle centered on the location of the minutia. The octants shall be numbered counterclockwise from zero to seven with octant number zero locally center