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Second edition
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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.

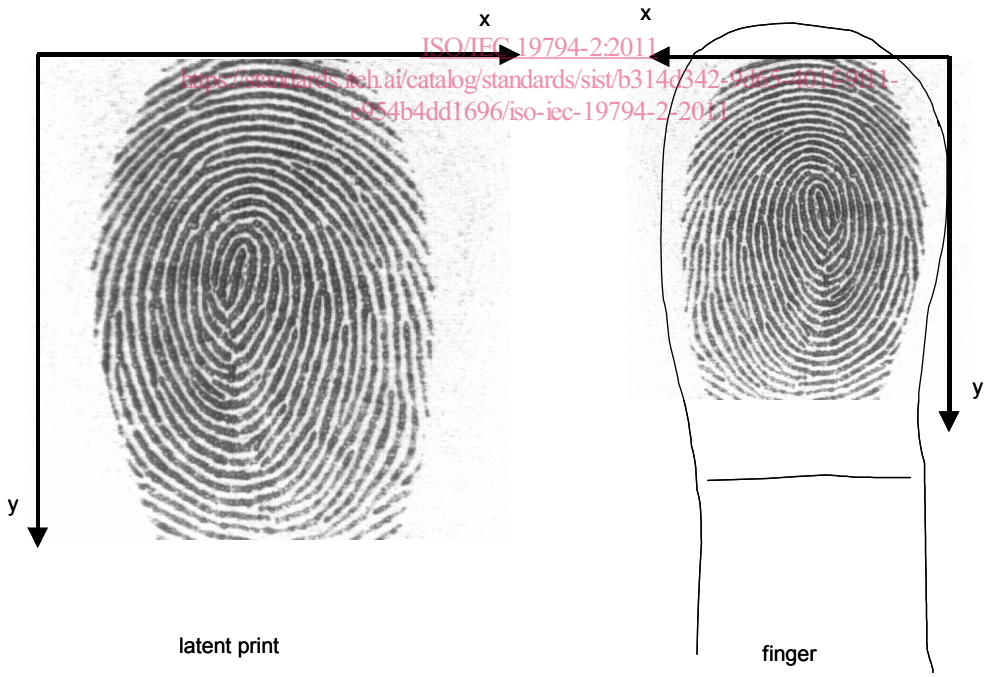

Figure 1 — Coordinate system

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).

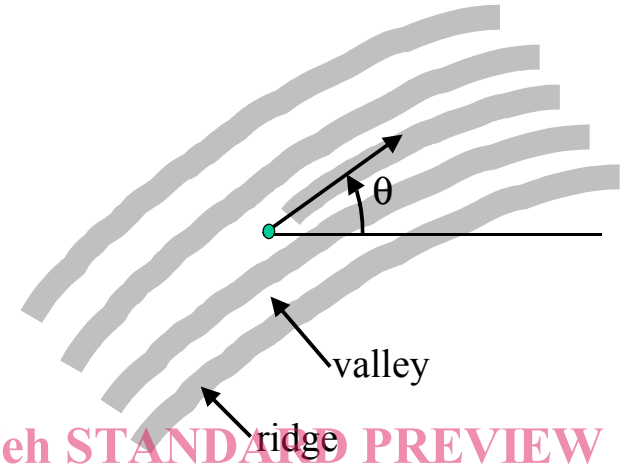

Figure 2 — Location and direction of a ridge ending (encoded as valley skeleton bifurcation point)

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).

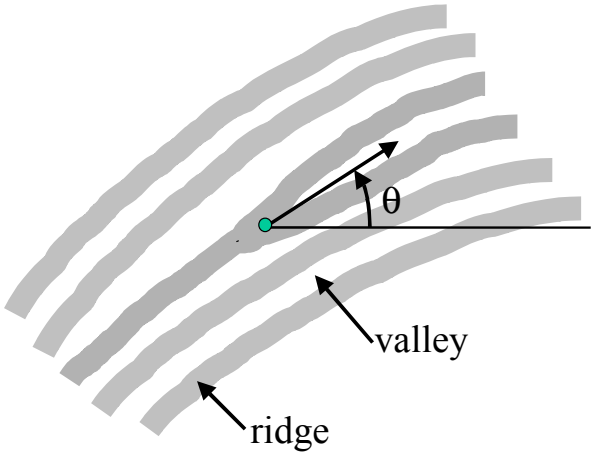

Figure 3 — Location and direction of a ridge bifurcation (encoded as ridge skeleton bifurcation point)

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).

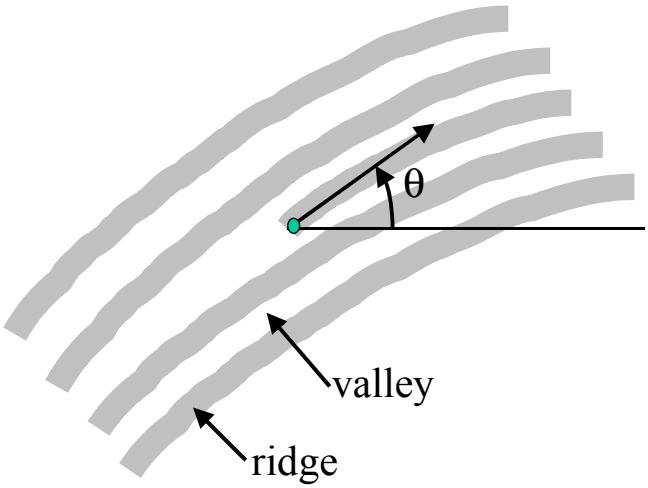

Figure 4 — Location and direction of a ridge skeleton endpoint

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.