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Corresponding Author	Family Name	**Sanchez-Reillo**
	Particle	
	Given Name	**Raul**
	Suffix	
	Division	GUTI (University Group for Identification Technologies)
	Organization	University Carlos III of Madrid
	Address	28911, Avda. Universidad, 30, Leganes, Madrid, Spain
	Email	rsreillo@ing.uc3m.es
	Email	raul.sanchezreillo@gmail.com

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Finger Data Interchange Format, Standardization

Raul Sanchez-Reillo*[a] and Robert Mueller[b]
[a]GUTI (University Group for Identification Technologies), University Carlos III of Madrid, Leganes, Madrid, Spain
[b]NEXT Biometrics, Nesoya, Norway

Synonyms

Encoded finger data; Fingerprint data interchange format

Definition

Set of ISO standards that define common formats to encode information related to finger-based biometrics. These formats are defined to allow interoperability among different vendors globally and have been developed by the international scientific biometrics community taking part in ISO/IEC JTC1/SC37 standardization subcommittee. Those documents define the encoding of not only a fingerprint image but also syntax and semantics of feature vectors composed of *minutiae* points for storage, transmission, and comparison. Furthermore, formats for the fingerprint *spectral data* and fingerprint skeletal data are defined.

Introduction

Standardization is essential for the widespread adoption of technologies in open mass applications. Fingerprint recognition is not only the most prominent biometric measure but also the biometric trait with the largest databases and the best long-term experience. Fingerprints are used in applications such as physical access control and digital signature creation and also national ID card schemes and other governmental projects. The need for standardization is conspicuous in every single area where it was not applied.

The SC37 subcommittee of ISO/IEC JTC1 deals with the standardization of biometrics. Among the many aspects of its work, SC37's Working Group 3 is devoted to defining Interchange Data Formats for a variety of biometric modalities. To accomplish this, a multipart International Standard has been developed, covering several biometric modalities. Such multipart standard is known as ISO/IEC 19794, and currently two different generations of those data formats have been defined, one published in 2005–2006 and the 2nd one published in 2011. The 2nd generation of ISO/IEC 19794 is not backwards compatible with the 1st generation, although there is a common way of identifying the generation, so that the client can parse the information from one generation to the other and then process it. Main differences between both generations have to deal with creating common header structures for all biometric modalities, allowing the inclusion of more header fields and correcting some errors or ambiguities.

*E-mail: rsreillo@ing.uc3m.es, raul.sanchezreillo@gmail.com

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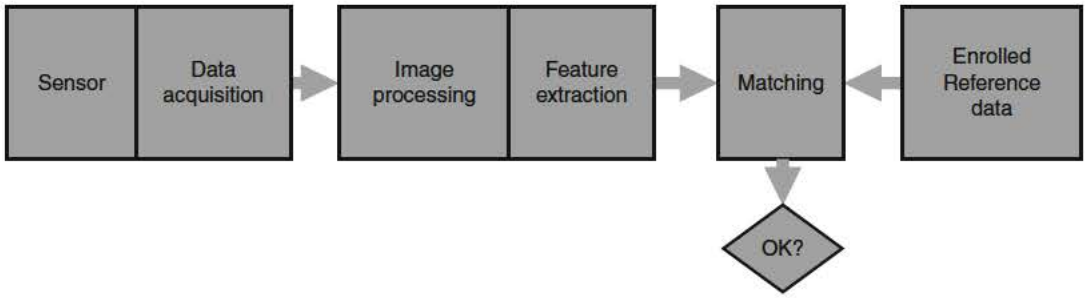

Fig. 1 Typical biometric verification system

There are four parts in this standard which cover finger-based biometrics, or what can be better understood as fingerprint biometrics:

1. Part 2 of the standard series deals with the way a minutiae-based feature vector or template has to be coded.
2. Part 3 standardizes encoding of information referring to the spectral information of a fingerprint.
3. Part 4 specifies the coding of a fingerprint raw image.
4. Part 8 establishes a way to code a fingerprint by its skeletal data.

Figure 1 shows the basic architecture of a typical Fingerprint Verification system. A finger is presented to a sensor and a raw image acquired. Image processing techniques enhance the image quality before a feature vector of characteristic features can be extracted. The features are compared with a previously recorded reference data set to determine the similarity between the two sets. The authentication of the user presenting the finger is completed with the decision whether the similarity meets the security requirements of the application. Feature comparison and decision is also referred to as "matching." The reference data may be stored in a database or on a portable data carrier.

The following subsections explain the basic characteristics of each type of finger-based standard. The image standard (Part 4) is presented first as it is the first step in the fingerprint comparison process as shown in the architecture in Fig. 1. This is followed by other finger-based standards, each of which deal with samples already processed.

Finger Images (ISO/IEC 19794-4:2005: 1st Generation)

The encoding of fingerprint image is defined in ISO/IEC 19794-4 International Standard [1], titled "Information technology – Biometric data interchange formats – Part 4: Finger image data." The way the finger image is captured is out of the scope of the standard, but after image acquisition, the image shall represent a finger in an upright position, i.e., vertical and with the tip of the finger in the upper part of the image. The way to code such an image is represented in Fig. 2, where the top line is the first to be stored and/or transmitted. This is in contradiction to mathematical graphing practice but in conjunction with typical digital image processing. For images requiring two or more bytes per pixel intensity, the most significant byte is stored/transmitted first, and bytes follow the most significant bit coding.

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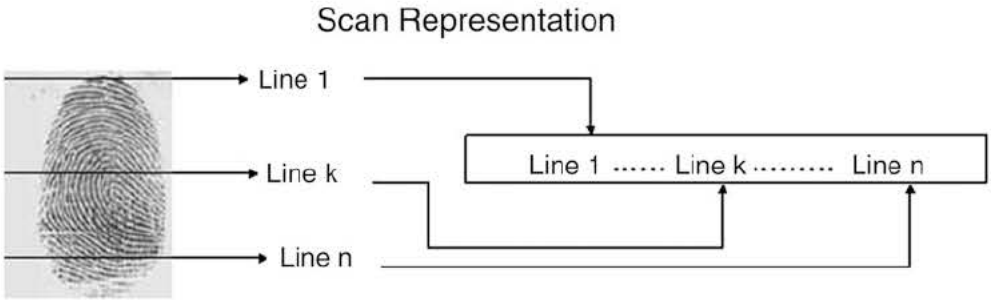

Fig. 2 Coding structure of a fingerprint image (Image taken from [1])

Table 1 Image acquisition levels for finger biometrics (Extract from Table 1 in [1])

Setting level	Scan resolution (dpi)	Pixel depth (bits)	Gray levels
10	125	1	2
20	250	3	5
30	500	8	80
31	500	8	200
35	750	8	100
40	1,000	8	120
41	1,000	8	200

This International Standard also includes a set of constraints for image acquisition. It determines the pixel aspect ratio, which shall be between 0.99 and 1.01 (horizontal/vertical sizes), as well as several image acquisition levels, as stated in Table 1. Fingerprint images generated with some scanners may have to undergo scaling or mapping to eliminate, e.g., optical distortion before satisfying the requirements laid down in this part of ISO/IEC 19794.

Besides the requirements for the image to be stored or transmitted, this International Standard also defines the structure of the data record representing one or more finger images. Following CBEFF specifications [2] (see entry "▸ mon Biometric Exchange Formats Framework, Standardization"), a record referring to a finger image has the following structure [1]: Q2

- A single fixed-length (32-byte) general record header containing information about the overall record, with the following fields:
  - Format identifier (4 bytes with the hexadecimal value 0 × 46495200) and version number (coded in 4 bytes)
  - Record length (in bytes) including all finger images within that record (coded in 6 bytes)
  - Capture device ID (2 bytes) and image acquisition level (2 bytes)
  - Number of fingers (1 byte), scale units used (1 byte), and scan resolution used (2 bytes for horizontal and 2 bytes for vertical resolution)
  - Image resolution, coded the same way as the scan resolution and whose value shall be less or equal to the scan resolution
  - Pixel depth (1 byte) and image compression algorithm used (coded in 1 byte)
  - 2 bytes reserved for future use

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- A single finger record for each finger/view, multi-finger image, or palm consisting of:
  - A fixed-length (14-byte) finger header containing information pertaining to the data for a single or multi-finger image, which gives information about:
    - Length of the finger data block (in 4 bytes)
    - Finger/palm position (in 1 byte)
    - Count of views (1 byte) and view number (1 byte)
    - Finger/palm image quality (1 byte) and impression type (1 byte)
    - Number of pixels per horizontal line (2 bytes) and number of horizontal lines (2 bytes)
    - 1 byte reserved for future use
  - Compressed or uncompressed image data view for a single, multi-finger, or palm image

The raw finger format is used, for example, in databases containing standard fingerprints. Law enforcement agencies are typical applicants of the standard. The largest fingerprint image databases are maintained by the FBI in the United States and are encoded with a national counterpart of this standard.

Finger Images (ISO/IEC 19794-4:2011–2nd Generation)

When the 2nd generation of the data formats was developed, both the general record header (now called general header) and the finger record header (now called representation header) changed, but the meaning of most of the fields kept intact. The new data format has now the following structure [3]:

- A single fixed-length (now only 16 bytes) general header, with the following fields:
  - Format identifier (4 bytes with the same value as in the 1st generation) and version number (which in this 2nd generation now has the value of 0×30323000)
  - Record length (as in 1st generation)
  - Number of finger/palm representations, coded in 2 bytes and containing at least 1
  - Certification flag, coded in 1 byte and having the number 0 if none of the representations included in the record have certification information and stating with the number 1 that all of the representations have certification information
  - Number of distinct fingers/palm positions, coded in 1 byte and having at least the value of 1
- For each of the finger/palm representations, there is the following sequential information:
  - A representation header consisting of:
    - Length of the representation (in 4 bytes)
    - Capture date and time, coded in 9 bytes
    - Capture device technology identifier, coded in 1 byte and with the values stated in the standard, which details if the capture device is, for example, optical scanner or semiconductor capacitive sensor
    - Capture device vendor ID (in 2 bytes) and type (in another 2 bytes), which identifies the product using registered vendor and types IDs

Q3

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- A sequence of bytes containing quality information. This quality information is given by:
  - 1 byte indicating the number of quality blocks (a value of 0 indicates that no quality information is provided).
  - For each of the quality blocks, 5 bytes are provided, indicating in the first byte the quality score (from 0 to 100), the quality algorithm vendor (in 2 bytes), and the quality algorithm used from that vendor (also coded in 2 bytes).
- If the certification flag at the header has the value of 1, then the following field is a sequence of bytes indicating certification information:
  - The first byte indicates the number of certification blocks.
  - For each certification block, 2 bytes indicate the certification authority ID, and the 3rd byte indicates the certification identifier for that certification authority.
- Finger/palm position (in 1 byte, as in the 1st generation).
- The representation number (in 1 byte, starting with 1 for the first representation).
- The scale units (in 1 byte) indicating if the information is to be provided in pixels/inch or in pixels/cm.
- 2 bytes for each of the spatial sampling rates, being the different sampling rates, the scan horizontal, the scan vertical, the image horizontal, and the image vertical.
- The bit depth of the pixels in the image (coded in 1 byte, indicating the number of bits used for coding each of the pixels).
- The image compression algorithm, coded in 1 byte, with the values specified in the standard.
- The impression type (e.g., live scan, latent, etc.) coded in 1 byte as indicated in the standard.
- Horizontal and vertical line lengths, each of them coded in 2 bytes.
- And 4 bytes indicating the length of the image data.

– Compressed or uncompressed image data view for a single, multi-finger, or palm image.
– Optional extended data blocks containing information about the representation finger (e.g., if segmentation was made). For each of the extended data blocks, 2 bytes indicate the type of extended data, another 2 bytes indicate the length of the data, and then the extended data follows. This is repeated for all extended information.

In addition to these changes in the binary format of finger image records, an XML coding for the finger image representation has been added to the 2nd generation, being developed as the 2nd amendment to ISO/IEC 19794-4:2011.

Fingerprint Minutiae (ISO/IEC 19794-2:2005–1st Generation)

While Part 4 of the ISO/IEC 19794 series of standards is dedicated to raw biometric sample data, Part 2 refers to the format in which a minutiae-based feature vector or template has to be coded. Therefore, ISO/IEC 19794-2 "Information Technology Biometric data interchange Formats Part 2: Finger minutiae data" [4] deals with processed biometric data, ready to be sent to a comparison block in order to obtain a matching score.

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Finger minutiae are local point patterns present in a fingerprint image. The comparison of these characteristic features is sufficient to positively identify a person. Sir Francis Galton first defined the features of a fingerprint [5].

In order to reach interoperability, this International Standard defines not only the record format but also the rules for fingerprint minutiae extraction. Regarding record formats, due to the application of fingerprint biometrics to systems based on smart cards, compact record formats are also defined to cope with memory and transmission speed limitations of such devices.

Fingerprint scientists have defined more than 150 different types of minutiae [6]. Within this standard, minutiae types are simplified to the following: (a) ridge ending, (b) ridge bifurcation, and (c) others. The location of each minutiae is determined by its horizontal and vertical position within the image. To determine such location, a coordinate system is to be defined. Figure 3 shows how such coordinate system is chosen. Granularity to be taken to determine location is of one-hundredth of millimeter for the normal format, while just one-tenth of a millimeter for card compact formats.

Figure 4 shows the different ways to consider the location of a minutia. (a) represents a ridge ending, encoded as a valley skeleton bifurcation point. (b) shows how to locate a ridge bifurcation, encoded as a ridge skeleton bifurcation point. Finally, (c) illustrates how to locate a ridge ending encoded as a ridge skeleton end point. How to determine the encoding of a ridge ending that is actually used in a specific dataset is a subject currently under revision in the standard. The other types of minutia have to be coded consistent with the standards (see details in [4]).

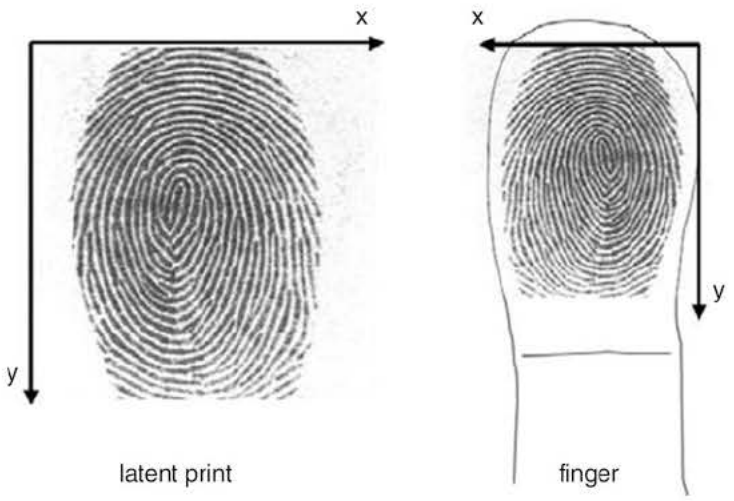

Fig. 3 Coordinate system for minutiae location (Image taken from [4])

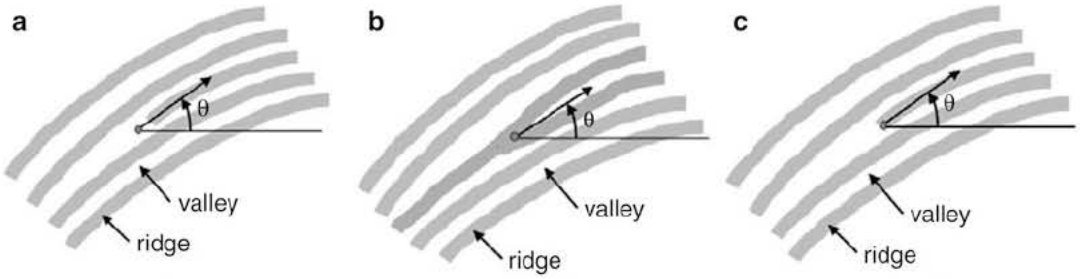

Fig. 4 Illustration of location of minutia (Image taken from [4])

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To define the minutiae direction, its angle has to be determined. This International Standard specifies that the angle is increasing in a counterclockwise rotation starting from the horizontal axis to the right of the location of the minutiae point. The angle is encoded in an unsigned single byte, so the granularity is 1.40625° per bit (360/256). Figure 4 also illustrates how the angle is determined.

Additional information that may be included in a minutiae-based record are cores, deltas, and ridge crossings to neighboring minutiae.

With all these definitions, the two major format types defined by this International Standard are (a) record format and (b) card format. The structure of the record format is summarized in the following paragraphs, but for additional details, refer to the standard [4]:

- A fixed-length (24-byte) record header containing information about the overall record, including the number of fingers represented and the overall record length in bytes:
  - Format identifier (4 bytes with the hexadecimal value $0 \times 464D5200$) and version number (coded in 4 bytes)
  - Record length (in bytes) including all finger images within that record (coded in 4 bytes)
  - Capture device ID (2 bytes)
  - Size of the image in pixels (2 bytes for X-dimension and 2 bytes for Y-dimension)
  - Image resolution in pixels per centimeter (2 bytes for X and 2 bytes for Y)
  - Number of finger views included in the record
  - 1 byte reserved for future use
- A single finger record for each finger/view, consisting of:
  - A fixed-length (4-byte) header containing information about the data for a single finger, including the number of minutiae:
    - Finger position (1 byte)
    - View number (4 bits) and impression type (4 bits to make a 1 byte in total)
    - Finger quality (1 byte)
    - Number of minutia (1 byte)
  - A series of fixed-length(6-byte) minutia descriptions:
    - Minutia type (2 bits) and X-location in pixels (14 bits)
    - 2 bits reserved and Y-location in pixels (14 bits)
    - Minutiae angle (1 byte)
    - Quality of minutiae (1 byte)
  - One or more "extended" data areas for each finger/view, containing optional or vendor-specific information. Extended data always starts with 2 bytes specifying the length of extended data block. If this is 0×0000, no extended data is included. If it has a nonzero value, then it is followed by vendor-specific data, which may include information about ridge counts, cores and deltas, cell information, pore positions, or other proprietary and vendor-specific data.

Regarding the card formats, the current version of the standard allows 2 sub-formats: (a) normal format (also referred as 5-byte minutiae) and (b) compact format (also known as 3-byte minutiae). The way minutiae are coded in each format is:

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- Card normal format (like the record format, but removing quality information):
  - Minutia type (2 bits) and X-location in pixels (14 bits)
  - 2 bits reserved and Y-location in pixels (14 bits)
  - Minutiae angle (1 byte)

- Card compact format:
  - X-coordinate (8 bits) considering a unit of 10^{-1} mm
  - Y-coordinate (8 bits) considering a unit of 10^{-1} mm
  - Minutia type (2 bits) using the same coding as with the card normal format
  - Angle (6 bits) having a granularity of 360/64

Another important aspect related to card formats is that as they are intended to be used with devices with limited memory and processing power, the number of minutia may be restricted, and in such case, truncation is needed. Additionally, in systems implementing on-card biometric comparison in order to reduce algorithm complexity, minutiae may need to be sorted in a certain way. And finally, the way data is exchanged differs from the traditional CBEFF format. This International Standard covers all such cases. The reader is suggested to refer to the last version of the standard [4] for further details.

The minutia standard is used, e.g., by the ILO (International Labour Organization) in its seafarers identity card and in several national ID card implementations including Thailand and Spain [7].

Fingerprint Minutiae (ISO/IEC 19794-2:2011–2nd Generation)

As with the finger images, the 2nd generation of the data formats also changed the record information from the 1st generation, in changing both the general header and the representation header. These changes follow the ones for the finger image, and the main differences with 19794-4 2nd generation are [8]:

- A single fixed-length general header (coded in 15 bytes) containing the same information than the general header of the finger image, but with the following differences:
  - The format identifier is identical to the 19794-2 one (i.e., the 1st generation for finger minutiae).
  - The version number for this 2nd generation of finger minutiae is 0 × 30333000
  - There is not a field for coding the number of distinct fingers/palm positions.
- For each finger minutiae representation, the included information is:
  - A representation header consisting of:
    - Length of the representation, capture date and time, capture device technology identifier, capture device vendor and type, quality information, certification information, finger position, and representation number, all coded in the same way as in the 2nd generation of 19794-4
    - 2 bytes for each of the image spatial sampling rates (horizontal and vertical), coded in pixels/cm

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  - 1 byte for coding the impression type (as coded in the finger image standard)
  - The size of the scanned image in pixels, both for the horizontal and the vertical dimension, and with 2 bytes per dimension
  - The length of the coding of each minutiae (either 5 or 6 bytes per minutiae)
  - The way the ridge ending is located (in 1 byte)
  - The number of minutiae (coded in 1 byte)
- For each of the minutiae, the minutia information is coded in the same way as in the 1st generation.
- Optional extended data blocks as indicated in the 1st generation.

The card format, now called on-card comparison format, is kept in the standard, and, as with the 2nd generation of the finger image, also an XML coding for the finger minutiae representation has been added, being also developed as the 2nd amendment to ISO/IEC 19794-2:2011.

Spectral Data of a Fingerprint (ISO/IEC 19794-3:2006)

Part 3 of the 19794 series of standards deals with a format suitable to process fingerprints when using morphological approaches. As seen in additional fingerprint entries in this encyclopedia, there are other approaches to perform biometric identification using fingerprints. Some of these approaches relate to the spectral information of the fingerprint. Algorithms using spectral data look at the global structure of a finger image rather than certain local point patterns. In such cases, 19794-2 is of no use, and the only possibility would be to use the whole image, as stated in 19794-4, which has the inconvenience of requiring the storage and/or transmission of a large amount of data. This could be inconvenient if not blocking for some applications.

In order to provide a new data format that could increase interoperability among spectral-based solutions, reducing the amount of data to be used 19794-3 has been developed under the title of "Information technology – Biometric data interchange formats – Part 3: Finger pattern spectral data" [9]. This part of the standard has not been demanded to develop a 2nd generation standard, so it has been kept only in the 1st generation. This International Standard deals with three major approaches in spectral-based biometrics (wavelet-based approaches are not supported by this standard):

1. Quantized co-sinusoidal triplets
2. Discrete Fourier transform
3. Gabor filters

Some of the formats may be subject to international patents and require a license agreement with the owner organization.

After declaring the basic requirements for the original image in order to be considered for these algorithms (same coordinate system as in 19794-2, 255 levels of gray with 0 representing black and 255 being white, and dark colors corresponding to ridges while light pixels corresponding to valleys) and describing all the abovementioned technologies, this part focuses on the record structure (for details refer to [9]), which is:

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- A variable-length record header containing information about the overall record, including:
  - Format identifier (4 bytes with the hexadecimal value 0 × 46535000) and version number (coded in 4 bytes).
  - Record length (in bytes) including all fingers within that record (coded in 4 bytes).
  - Number of finger records included (1 byte).
  - Image resolution in pixels per centimeter (2 bytes for X-direction and 2 bytes for Y-direction).
  - Number of cells (2 bytes for X-direction and 2 bytes for Y-direction).
  - Number of pixels in cells (2 bytes for X-direction and 2 bytes for Y-direction).
  - Number of pixels between cells centers (2 bytes for X-direction and 2 bytes for Y-direction).
  - SCSM (spectral component selection method −1 byte), which can be 0, 1, or 2. Depending on the value of this field, the following fields could refer to type of window, standard deviation, number of frequencies, frequencies, number of orientations and spectral components per cell, and bit depths (propagation angle, wavelength, phase, and/or magnitude).
  - Bit depth of quality score (1 byte).
  - Cell quality group granularity (1 byte).
  - 2 bytes reserved for future use.
- A single finger record for each finger, consisting of:
  - A fixed-length (6-byte) header containing information about the data for a single finger:
    - Finger location (1 byte)
    - Impression type (1 byte)
    - Number of views in single finger record (1 byte)
    - Finger pattern quality (1 byte)
    - Length of finger pattern spectral data block (2 bytes)
  - A finger pattern spectral data block:
    - View number (1 byte)
    - Finger pattern spectral data
    - Cell quality data
  - An extended data block containing vendor-specific data composed of block length (2 bytes), area type code (2 bytes), area length, and area

As in 19794-2, this International Standard also defines the data objects to be included for a card format, with the reduction in granularity recommended (for further details, see [9]).

Some of the leading Fingerprint Verification algorithms rely on spectral data or a combination of spectral data and minutiae. This standard could enhance the interoperability and performance of large-scale identification systems such as criminal or civil automatic fingerprint identification systems (AFIS).

Skeletal Data of a Fingerprint (ISO/IEC 19794-8:2006–1st Generation)

Finally, 19794-8 titled "Information technology Biometric data interchange formats Part 8: Finger pattern skeletal data" [8] deals with the format for representing fingerprint images by a skeleton with ridges represented by a sequence of lines. Skeletonization is a standard procedure in image

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processing and generates a single-pixel wide skeleton of a binary image. Moreover, the start and end points of the skeleton ridge lines are included as real or virtual minutiae, and the line from start to end point is encoded by successive direction changes.

For minutiae location and coding, much of the 19794-2 card format is used, but here the position of a ridge bifurcation minutia shall be defined as the point of forking of the skeleton of the ridge and the position of a ridge end minutia shall be the point of ending of the ridge skeleton. In other words, the point where three or more ridges intersect or a ridge ends is the location of the minutia, respectively. No valley representation is accepted under this International Standard to determine the exact minutia position. Another difference with 19794-2 card formats is that in this standard, no other-type minutiae is considered (if a minutia has more than three arms, like a trifurcation, it is considered a bifurcation) and that along this standard codes for "virtual minutiae" are used.

Skeleton lines are coded as polygons. Every line starts with a minutia, and it is followed by a chain of direction changes (coded with the granularity stated in the record header), until it reaches the terminal minutia of the specific line. Several rules are defined in the standard (see [10] for further reference) including virtual minutiae where a polygon segment ends without a true minutia.

All information is coded in a record with the following structure (limiting values as well as recommended values can be found in [10]):

- A fixed-length (24-byte) record header containing:
  - Format identifier (4 bytes with the hexadecimal value $0 \times 46534B00$) and version number (coded in 4 bytes)
  - Record length (in bytes) including all finger images within that record (coded in 4 bytes)
  - Capture device ID (2 bytes)
  - Number of finger views in record (1 byte)
  - Resolution of finger pattern in pixels per centimeter (1 byte)
  - Bit depth of direction code start and stop point coordinates (1 byte)
  - Bit depth of direction code start and stop direction (1 byte)
  - Bit depth of direction in direction code (1 byte)
  - Step size of direction code (1 byte)
  - Relative perpendicular step size (1 byte)
  - Number of directions on 180° (1 byte)
  - 2 bytes reserved for future use

- A single finger record for each finger/view, consisting of:
  - A fixed-length (10 bytes) header:
    - View number (1 byte)
    - Finger position (1 byte)
    - Impression type (1 byte)
    - Finger quality (1 byte)
    - Skeleton image size in pixels (2 bytes for X-direction, 2 bytes for Y-direction)
    - Length of finger pattern skeletal data block (2 bytes)
  - The variable-length fingerprint pattern skeletal description:
    - Length of finger pattern skeletal data (2 bytes)
    - Finger pattern skeletal data

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  - Length of skeleton line neighborhood index data (2 bytes)
  - Skeleton line neighborhood index data
- An extended data block containing the extended data block length and zero or more extended data areas for each finger/view, defining length (2 bytes), area type code (2 bytes), area length (2 bytes), and data.

This International Standard also defines two card formats, a normal one and a compact one. As with other parts, this means more limiting constraints to code data tighter and the definition of the data objects needed (for details refer to [10]).

The skeleton format is used in scientific research [11] and by some vendors implementing on-card biometric comparison.

Skeletal Data of a Fingerprint (ISO/IEC 19794-8:2011–2nd Generation)

Q6 As with the finger images, the 2nd generation of the data formats also changed the record information from the 1st generation, changing both the general header and the representation header. These changes are similar to the finger image standard, and the main differences with 19794-4 2nd generation are [12]:

- A single fixed-length general header (coded in 15 bytes) containing the same information than the general header of the finger image, but with the following differences:
  - The format identifier is identical to ISO/IEC 19794-8:2006 (i.e., the 1st generation for finger skeletal data).
  - There is no field for coding the number of distinct fingers/palm positions.
- For each of representation, the included information is:
  - A representation header consisting of:
    - Length of the representation, capture date and time, capture device technology identifier, capture device vendor and type, quality information, certification information, finger position, and representation number, all coded in the same way as in the 2nd generation of 19794-4
    - 1 byte for the resolution of finger pattern, being recommended a resolution of 100 ppcm
    - 1 byte for coding the impression type (as coded in the finger image standard)
    - The size of the scanned image in pixels, both for the horizontal and the vertical dimension, and with 2 bytes per dimension
    - 1 byte for coding each of the following bit depths:
      - Start and stop point coordinates
      - Start and stop direction
      - Direction
    - Step size of direction code (1 byte)
    - Relative perpendicular step size related to S_2 (1 byte)
    - Relative perpendicular step size related to S (1 byte)

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  - Number of N directions (1 byte)
  - Length of finger pattern skeletal data block (2 bytes)

- For each pattern skeletal data block, the information is coded in the same way as in the 1st generation.
- Optional extended data blocks as indicated in the 1st generation.

As in the 2nd generation of 19794-4, also an XML coding for the finger skeletal representation has been added, being also developed as the 2nd amendment to ISO/IEC 19794-8:2011.

Summary

To provide interoperability in storing and transmitting finger-related biometric information, four International Standards have already been published by ISO defining the formats for raw images, minutia-based feature vectors, spectral information, and skeletal representation of a fingerprint. Beyond that, other standards deal with conformance testing and sample quality data, as well as profiles and interfaces or performance evaluation and reporting (see Related Entries below for further information).

Related Entries

Q7

- Biometric Data Interchange Format
- Common Biometric Exchange Formats Framework
- Fingerprint Recognition
- International Standardization of Biometrics
- Standardization of Conformance Testing Methodologies for Biometric Data Interchange Formats

Q8

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Author Queries

Query Refs.	Details Required
Q1	Please check if edit to sentence starting "Those documents define..." is okay.
Q2	Entry title "Common Biometric Exchange Formats Framework, Standardization" is mismatching with ToC. Please check if we can change the title as per ToC or retain as in MS.
Q3	Please provide opening parenthesis for "capacitive sensor)" in the sentence starting "Capture device technology...".
Q4	Please provide opening parenthesis for "minutiae is 0 × 30333000)" in the sentence starting "The version number for...".
Q5	Please check if "automatic" should be changed to "automated".
Q6	Please check if edit to sentence starting "As with the finger images..." is okay.
Q7	Entry title "Biometric Data Interchange Format", "Common Biometric Exchange Formats Framework", and "Fingerprint Recognition" are mismatching with ToC. Please check if we can change the title as per ToC or retain as in MS.
Q8	Entry titles "International Standardization of Biometrics" and "Standardization of Conformance Testing Methodologies for Biometric Data Interchange Formats" are not listed in the ToC. Please check.