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Information technology — Biometric data interchange formats —

Part 4: Finger image data

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

Partie 4: Données d'image du doigt

Reference number
ISO/IEC 19794-4:2005(E)

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 19794-4 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 37, *Biometrics*.

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*

The following parts are under preparation:

— *Part 7: Signature/sign behavioral data*

— *Part 8: Finger pattern skeletal data*

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Introduction

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

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

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

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Information technology — Biometric data interchange formats —

Part 4: Finger image data

1 Scope

This part of the ISO/IEC 19794 standard specifies a data record interchange format for storing, recording, and transmitting the information from one or more finger or palm image areas within an ISO/IEC 19785-1 CBEFF data structure. This can be used for the exchange and comparison of finger image data. It defines the content, format, and units of measurement for the exchange of finger image data that may be used in the verification or identification process of a subject. The information consists of a variety of mandatory and optional items, including scanning parameters, compressed or uncompressed images and vendor-specific information. This information is intended for interchange among organizations that rely on automated devices and systems for identification or verification purposes based on the information from finger image areas. Information compiled and formatted in accordance with this part of the ISO/IEC 19794 standard can be recorded on machine-readable media or may be transmitted by data communication facilities.

2 Conformance

Systems claiming conformance with this part of the ISO/IEC 19794 standard shall be capable of encoding and decoding finger image data and the associated parameter data used in the transmitting and/or receiving of fingerprint images as defined by this part of the ISO/IEC 19794 standard. At a minimum, conformance shall require the ability to capture, exchange, and compare interoperable fingerprint image information.

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.

IAFIS-IC-0110 (V3), WSQ Gray-scale Fingerprint Image Compression Specification 1997

ISO/IEC 19785.1, *Information technology — Common biometric exchange formats framework — Part 1: Data element specification*

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

MTR 04B0000022 (Mitre Technical Report), Margaret Lepley, Profile for 1000ppi Fingerprint Compression, Version 1.1, April 2004. Available at:
http://www.mitre.org/work/tech_papers/tech_papers_04/lepley_fingerprint/lepley_fingerprint.pdf

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1
biometric sample
raw data representing a biometric characteristic of an end-user as captured by a biometric system

EXAMPLE The image of a fingerprint.

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4.2
capture
the method of taking a biometric sample from an end user

4.3
core
the approximate center of a fingerprint image area

NOTE The exact location of the core is generally placed near the topmost point of the innermost recurving ridgeline of the fingerprint provided there are no ridges inside the recurving ridge. For those instances where there are one or more ridges within the recurving ridge, the placement of the core will be dependent upon the specific combination of ridges.

4.4
fingerprint image area
the area of friction skin on the fleshy surface of a finger located horizontally between the two edges of the fingernail and vertically between the first joint and the tip of a finger. It contains a unique pattern of friction ridge and valley information commonly referred to as a “fingerprint”

4.5
friction ridge
the ridges present on the skin of the finger which makes contact with an incident surface under normal touch

4.6
grayscale
the method used to represent a continuous tone image that has only a single component or variable to represent each pixel; also referred to as monochrome or black and white

4.7
image resolution
the number of pixels per unit distance in the interchanged image

NOTE This may be the result of processing a captured image. The original captured scanned image may have been subsampled, scaled, interpolated, or otherwise processed to produce a form for representing the ridge and valley structure areas of the fingerprint.

4.8
latent
an impression of a fingerprint image collected from an intermediate surface, rather than directly via a live scan capture device or a traditional inked fingerprint card

NOTE The term latent print is generally used to describe any type of print found at the scene of a crime or on evidence associated with a crime.

4.9
live capture
the process of capturing a biometric sample through an interaction between and end user and a biometric system

4.10
pixel
a picture element – located on an n by m matrix of picture elements, where n is the horizontal component and m is the vertical component

4.11
plain fingerprint image
image captured from a finger placed on a platen without any rolling movement – the center portion of a rolled image

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4.12
rolled fingerprint image
image area captured that is located between the two edges of the fingernail. Acquired using a rolling motion from one edge of the fingernail to the other

4.13
scan resolution
the number of pixels per unit distance used by a sensor or scanning device to initially capture a fingerprint or palmprint image

4.14
swipe fingerprint image
a method of fingerprint collection where the finger is manually slid across a one-dimensional sensor resulting in multiple readings or partial impressions from the same fingerprint. These readings are then combined to produce an accurate two-dimensional image of the fingerprint

4.15
transaction
a command, message, or input record that explicitly or implicitly calls for a processing action. Information contained in a transaction shall be applicable to a single subject

4.16
valley
the area surrounding a friction ridge, which does not make contact with an incident surface under normal touch; the area of the finger image area between two frictions ridges

5 Abbreviated terms

ppcm pixels per centimetre

ppi pixels per inch

ppmm pixels per millimetre

6 Data conventions

6.1 Byte and bit ordering

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

6.2 Scan sequence

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

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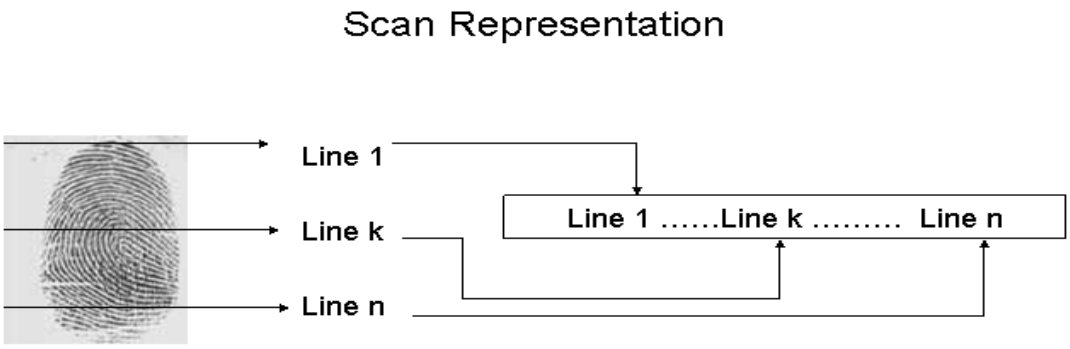


Figure 1 Order of scanned lines

(horizontal) position shall increase positively from the origin to the right side of the image. The y-coordinate (vertical) position shall increase positively from the origin to the bottom of the image.

7 Image acquisition requirements

7.1 General

Image capture requirements are dependent on various factors including the application, the available amount of raw pixel information to retain or exchange, and targeted performance metrics. As a result of these factors, numeric values for specific image capture parameters will be associated with one of several combinations of image acquisition parameters settings. The choice of the image acquisition settings level should therefore be commensurate with the system and application requirements.

Table 1 lists the minimum requirements for selected image acquisition parameters as a function of the image acquisition settings level desired. A tolerance of plus or minus 1% is applicable to the minimum numeric values stated for the scan resolution and dynamic range parameters. The last column indicates compliance with established certification procedures. Values for setting levels 40 or 41 are intended for applications requiring the greatest amount of detailed information. Scanners capable of level 30 and 31 performance are currently available and are being deployed for law enforcement purposes. Level 30 or 31 applications primarily include law enforcement agencies. Both level 41 and 31 systems should be certified using these and other requirements contained in Appendix F of the FBI's Electronic Fingerprint Transmission Specification (EFTS/F). Annex A lists the requirements from the EFTS/Appendix F that are pertinent to fingerprint image input devices. The remaining levels are designed for commercial access control and verification systems. The overall quality level of a biometric system will be limited to that level at which all of the minimums are met.

Note – Setting levels not listed are reserved for future definition by SC37, including indication of compliance with future ISO standards for image capture. Compliance with future certifications will be indicated by additional entries in the certifications columns.

7.2 Pixel aspect ratio

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

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Table 1 — Image acquisition settings levels

Setting level	Scan resolution pixels/centimeter (ppcm)	Scan resolution pixels/inch (ppi)	Pixel depth (bits)	Dynamic range (gray levels)	Certification
10	49	125	1	2	None
20	98	250	3	5	None
30	197	500	8	80	None
35	295	750	8	100	None
31	197	500	8	200	EFTS/F
40	394	1000	8	120	None
41	394	1000	8	200	EFTS/F

Note – Manufacturers generally express the rated scan resolution of their devices in pixels per inch (ppi). Table 1 also lists the resolutions in pixels per centimetre (ppcm). These are the rounded values of each ppi resolution divided by 2.54. The ppi and ppcm values are therefore consistent with, but not exactly equal to, each other. Either system may be used, but the two should not be intermixed or re-converted.

7.3 Pixel depth

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

7.4 Grayscale data

Grayscale finger image data may be stored, recorded, or transmitted in either compressed or uncompressed form. The image data portion of a record for an uncompressed grayscale image shall contain a set of raw pixel information. Using a pixel depth of 8 bits (256 grayscale levels) each pixel shall be contained in a single byte. Pixel values with a depth of less than eight bits can be stored and transmitted in a packed binary format. Increased precision for pixel values greater than 255 shall use two unsigned bytes to hold up to sixteen-bit pixels with values in the range of 0-65635. The encoding of a compressed grayscale image shall be the output of the appropriate grayscale compression algorithm specified. Upon decompression the grayscale value for each pixel shall be represented in the same manner as pixels in an uncompressed image.

7.5 Dynamic range

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

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7.6 Scan resolution

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

7.7 Image resolution

The resolution of the image data formatted and recorded for interchange may be the scan resolution of the image or it may have been subsampled, scaled, interpolated, or otherwise processed to produce a form for representing the ridge and valley structure areas of the fingerprint.

7.8 Fingerprint image location

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

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

8 Finger image record format

8.1 Record structure

This part of the ISO/IEC 19794 standard defines the composition of the finger image record. Each record shall pertain to a single subject and shall contain an image record (consisting of one or more views) for each of one or more fingers, multiple fingers (single image records), or palms.

The biometric data record specified in this standard shall be embedded in a CBEFF-compliant structure in the CBEFF Biometric Data Block (BDB). The CBEFF BDB_biometric organization shall be assigned by the International Biometric Industry Association (IBIA) to JTC 1 SC 37 shall be used. This is the sixteen bit value 0x0101 (hexadecimal 101 or decimal 257). There is one CBEFF BDB_format code assigned to this standard. This code shall be included in the CBEFF Header. The associated sixteen-bit CBEFF BDB_format code shall have a value of 0x0007. The BDB_PID recorded shall be defined by CBEFF.

The organization of the record format is as follows:

- A single fixed-length (32-byte) general record header containing information about the overall record, including the number of finger/palm images represented and the overall record length in bytes;
- A single finger record for each 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;
  - Compressed or uncompressed image data view for a single, multi-finger, or palm image.

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

8.2 General record header

8.2.1 Required fields

Table 2 lists the fields included in the general record header. As this is a fixed-length header, information must be included for each field within the header.

Table 2 — General record header

Field	Size	Valid values	Notes
Format identifier	4 bytes	0x464952 (‘F’ ‘I’ ‘R’ 0x0)	“FIR” – Finger Image Record
Version number	4 bytes	0x30313000 (‘0’ ’1’ ’0’ 0x0)	“010”
Record length	6 bytes	32+ Number Views * (14 bytes + Data length)	Includes all finger views
Capture device ID	2 bytes		Vendor specified
Image acquisition level	2 bytes	See Table 1	Combination of parameters
Number of fingers/palms	1 byte	>=1	
Scale units	1 byte	1-2	Pixels/Inch or pixels/cm
Scan resolution (horiz)	2 bytes	See Table 1	Up to 39.37 ppmm or 1000 ppi
Scan resolution (vert)	2 bytes	See Table 1	Up to 39.37 ppmm or 1000 ppi
Image resolution (horiz)	2 bytes	<= Scan Resolution (horiz)	Quality level dependent
Image resolution (vert)	2 bytes	<= Scan Resolution (vert)	Quality level dependent
Pixel depth	1 byte	1 -16 bits	2 – 65536 gray levels
Image compression Algorithm	1 byte	See Table 3	Uncompressed or algorithm used
Reserved	2 bytes		Bytes set to '0x0'

8.2.2 Format identifier

The Format Identifier for the finger image standard record shall consist of the three ASCII characters "FIR" followed by the null character (0x0).

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8.2.3 Version number

The number for the version of this standard used for constructing the image record 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 “010” – Version 1 revision 0.

8.2.4 Record length

The combined length in bytes for the entire record shall be recorded in these six bytes. This count shall be the sum of the lengths of all finger records (including all finger headers), the views for each finger, multiple finger record, and palms.

8.2.5 Capture device ID

The (2 byte) capture device ID field denotes the vendor specific capture device ID. A value of all zeros will be acceptable and will indicate that the capture device ID is unspecified. Application developers may obtain the values for these codes from the vendor.

8.2.6 Image acquisition level

This two-byte field shall specify the image acquisition setting level chosen from table 1. The value used shall indicate the level at which all of the minimum acquisition parameters were satisfied during the capture of the image.

8.2.7 Number of finger/palm images

The number of finger or palm images included in the record shall be recorded in one byte. Multiple fingers acquired by a single capture and contained in the same image are counted as a single finger image. The number of views is not part of the count for this field.

8.2.8 Scale units

This field shall specify the units used to describe the scanning and image resolutions of the image. A ‘0x01’ in this field indicates pixels per inch, or a ‘0x02’ indicates pixels per centimeter.

8.2.9 Scan resolution (horizontal)

This 2-byte field shall specify the rounded scanning resolution used in the horizontal direction. The scale units field will determine whether the value is pixels per inch or pixels per centimeter.

8.2.10 Scan resolution (vertical)

This 2-byte field shall specify the rounded scanning resolution used in the vertical direction. The scale units field will determine whether the value is pixels per inch or pixels per centimeter.

8.2.11 Image resolution (horizontal)

This 2-byte field shall specify the rounded image resolution used in the horizontal direction. The scale units field will determine whether the value is pixels per inch or pixels per centimeter. It should be noted that certain combinations of scan and image pixel resolution values may result in the overlapping pixels or spaces between pixels in the captured image.

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8.2.12 Image resolution (vertical)

This 2-byte field shall specify the rounded image resolution used in the vertical direction. The scale units field will determine whether the value is pixels per inch or pixels per centimetre. It should be noted that certain combinations of scan and image pixel resolution values may result in the overlapping pixels or spaces between pixels in the captured image.

8.2.13 Pixel depth

This 1-byte field shall contain the number of bits used to represent a pixel. This field shall contain an entry of '0x1' to '0x10'.

8.2.14 Image compression algorithm

This 1-byte field shall specify the method used to record the uncompressed or compressed grayscale images. Table 3 lists the available storage options and compression algorithms that may be used. Uncompressed

Table 3 — Compression algorithm codes

Code	Compression algorithm
0	Uncompressed – no bit packing
1	Uncompressed – bit packed
2	Compressed – WSQ
3	Compressed – JPEG
4	Compressed – JPEG2000
5	PNG

image data can be recorded in an unpacked or packed form. When using the unpacked option for grayscale pixels greater than eight bits, each pixel shall be recorded in a pair of bytes right justified. A certified version of the Wavelet Scalar Quantization (WSQ) algorithm as specified by IAFIS-IC-0110 can be used for lossy compression of 8-bit, 19.69 ppmm (500 ppi) grayscale images, and shall be limited to a 15:1 compression ratio. WSQ shall not be used to compress images scanned at 39.37 ppmm (1000 ppi). Fingerprint/palmprint images scanned at 39.37 ppmm (1000 ppi), if compressed, shall be compressed using the JPEG 2000 algorithm as described in the ISO Standard 15444. When this algorithm is used, then the JPEG 2000 profile settings as specified in the "Profile for 1000ppi Fingerprint Compression" normative reference are required to be incorporated.

NOTE – The recommendation is that JPEG 2000 compression be limited to 15:1 for 39.37 ppmm (1000 ppi) images. Images scanned at 19.69 ppmm (500 ppi), if compressed should use WSQ compression and the compression ratio shall be limited to 15:1; above 19.69 ppmm (500 ppi), JPEG 2000 compression is recommended. No recommendations are being made for compression of other image resolutions.

8.2.15 Reserved

Two bytes are reserved for future revisions of this part of the ISO/IEC 19794 standard. For this version of the standard this field shall be set to all '0x0'.

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8.3 Finger record header

8.3.1 Required fields

A finger header shall start each section of finger data providing information for that view of a single finger image, multi-finger image, or palm. For each such image there shall be one finger header record accompanying the view of the image data. The finger header shall occupy a total of 14 bytes as described below. The compressed or uncompressed image data for that image view shall immediately follow the header portion. Subsequent image views (including the header portion) will be concatenated to the end of the previous image view. Table 4 is a list of the entries contained in the header preceding each set of finger image data.

8.3.2 Length of finger/palm data block

This four-byte field shall contain the length in bytes of the finger segment. It will specify the total number of bytes including the length of the header and the size of the compressed or uncompressed image data.

Table 4 — Finger image header record

Field	Size	Valid values	Notes
Length of finger data block (bytes)	4 bytes		Includes header, and largest image data block
Finger/palm position	1 byte	0-15; 20-36	See Table 5 and 6
Count of views	1	1-256	
View number	1	1-256	
Finger/palm image quality	1 byte	1-100	BioAPI specification
Impression type	1 byte		Table 7
Horizontal line length	2 bytes		Number of pixels per horizontal line
Vertical line length	2 bytes		Number of horizontal lines
Reserved	1 byte	_____	Byte set to '0x0'
Finger/palm image data	< $43x10^{8}$ bytes	_____	Compressed or uncompressed image data

8.3.3 Finger/palm position

This 1-byte field shall contain the finger position. The codes for this byte as well as the maximum size of the recorded image are defined in Table 6 and Table 19 of the ANSI/NIST-ITL 1-2000 standard, “Data Format for the Interchange of Fingerprint, Facial, & Scar Mark & Tattoo (SMT) Information”. The tables are reproduced here as tables 5 and 6 for convenience. Codes 0-10 from table 5 should be used for single fingers. Codes 13 and 14 are used for the images containing four fingers from the right hand and left hand respectively. Code 15 is an additional code for accommodating the simultaneous capture of the two thumbs. Codes 11 and 12 should be avoided. Codes for palm images are found in table 6. For full palms the captured area should

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extend from the "wrist bracelet" through the second joint of the fingers. Similarly, the captured area of the upper palm should extend from immediately below the interdigital area through the second joint of the fingers. The lower palm will cover the area from the "wrist bracelet" through the interdigital area.

Table 5 — Finger position codes, areas, and maximum dimensions

Finger position	Finger code	Max image area (mm^2)	Width		Length	
			(mm)	(in)	(mm)	(in)
Unknown	0	1745	40,6	1,6	38,1	1,5
Right thumb	1	1745	40,6	1,6	38,1	1,5
Right index finger	2	1640	40,6	1,6	38,1	1,5
Right middle finger	3	1640	40,6	1,6	38,1	1,5
Right ring finger	4	1640	40,6	1,6	38,1	1,5
Right little finger	5	1640	40,6	1,6	38,1	1,5
Left thumb	6	1745	40,6	1,6	38,1	1,5
Left index finger	7	1640	40,6	1,6	38,1	1,5
Left middle finger	8	1640	40,6	1,6	38,1	1,5
Left ring finger	9	1640	40,6	1,6	38,1	1,5
Left little finger	10	1640	40,6	1,6	38,1	1,5
Plain right four fingers	13	6800	83,8	3,3	76,2	3,0
Plain left four fingers	14	6800	83,8	3,3	76,2	3,0
Plain thumbs (2)	15	4800	50,8	2,0	76,2	3,0

Table 6 — Palm codes, areas, and maximum dimensions

Palm position	Palm code	Image area (cm^2)	Width		Height	
			(cm)	(in)	(cm)	(in)
Unknown palm	20	283,87	13,97	5,5	20,32	8,0
Right full palm	21	283,87	13,97	5,5	20,32	8,0
Right writer's palm	22	58,06	4,57	1,8	12,70	5,0
Left full palm	23	283,87	13,97	5,5	20,32	8,0
Left writer's palm	24	58,06	4,57	1,8	12,70	5,0
Right lower palm	25	195,16	13,97	5,5	13,97	5,5
Right upper palm	26	195,16	13,97	5,5	13,97	5,5
Left lower palm	27	195,16	13,97	5,5	13,97	5,5
Left upper palm	28	195,16	13,97	5,5	13,97	5,5
Right other	29	283,87	13,97	5,5	20,32	8,0
Left other	30	283,87	13,97	5,5	20,32	8,0
Right interdigital	31	106,45	13,97	5,5	7,62	3,0
Right thenar	32	77,42	7,62	3,0	10,16	4,0
Right hypothenar	33	106,45	7,62	3,0	13,97	5,5
Left interdigital	34	106,45	13,97	5,5	7,62	3,0
Left thenar	35	77,42	7,62	3,0	10,16	4,0
Left hypothenar	36	106,45	7,62	3,0	13,97	5,5

8.3.4 Count of views

This one byte field shall contain the total number of specific views available for this finger.

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8.3.5 View number

This one byte field shall contain the specific image view number associated with the finger.

8.3.6 Finger/palm image quality

The quality of the overall scanned finger/palm image shall be between 0 and 100 and recorded in one byte. A value of 0 shall represent the lowest possible quality and the value of 100 shall represent the highest possible quality. The numeric values in this field will be set in accordance with the general guidelines contained in Section 2.1.42 of ANSI/NCITS 358-2002, "BioAPI H-Level Specification Version 1.1". A matcher may use this value to determine its certainty of verification.

8.3.7 Impression type

The impression type of the finger or palm image shall be recorded in this one byte field. The codes for this byte shall be as defined as contained in Tables 5 & 18 the ANSI/NIST-ITL 1-2000 standard, "Data Format for the Interchange of Fingerprint, Facial, & Scar Mark & Tattoo (SMT) Information". The tables have been shortened and are reproduced here as table 7 for convenience. Nonlive entries refer to images scanned from cards or other media. Live-scan contactless refers to image capture devices that do not depend upon the surface of a finger making contact with a scanner platen.

Table 7 — Finger and palm impression types

Description	Code
Live-scan plain	0
Live-scan rolled	1
Nonlive-scan plain	2
Nonlive-scan rolled	3
Latent	7
Swipe	8
Live-scan Contactless	9

8.3.8 Horizontal line length

This two-byte binary field shall be used to specify the number of pixels contained on a single horizontal line of the transmitted image.

8.3.9 Vertical line length

This two-byte binary field shall be used to specify the number of horizontal lines contained in the transmitted image.

8.3.10 Finger/palm image data

This field shall contain of the grayscale image data formatted and recorded in accordance with the image compression algorithm.

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Annex A
(normative)

Image quality specifications

A.1 Scope and purpose

These specifications apply to fingerprint scanner systems that supply fingerprint data to the major advanced Automated Fingerprint Identification System (AFIS).

Electronic images must be of sufficient quality to allow for: (l) conclusive fingerprint comparisons (identification or non-identification decision); (2) fingerprint classification; (3) automatic feature detection; and (4) overall Automated Fingerprint Identification System (AFIS) search reliability.

The fingerprint comparison process requires a high fidelity image without any banding, streaking or other visual defects. Finer detail such as pores and incipient ridges are needed since they can play an important role in the comparison. Additionally, the gray-scale dynamic range must be captured with sufficient depth to support image enhancement and restoration algorithms.

The image quality requirements have associated test procedures to show compliance. These procedures will be used in acceptance testing to ensure compliance with the requirements, and in performance capability demonstrations as an indication of capability to perform. Equipment shall be tested to meet the requirements in normal operating modes, e.g., scanners shall not be tested at slower than normal operating speeds to meet modulation transfer function specifications. A vendor may recommend alternate testing methods.

A.2 Fingerprint scanners

The following subsections describe the image quality performance characteristics required for a fingerprint scanner (live scan and card scan). These specifications require that the scanner capture fingerprints at a minimum resolution in both the detector row and detector column directions (also known as 'along-scan' and 'cross-scan' directions) of 19,69 ppmm plus or minus 0,1969 ppmm (500 ppi, plus or minus 5 ppi). The final output delivered image from the scanner system shall have a resolution of 19,69 ppmm plus or minus 0,1969 ppmm (500 ppi, plus or minus 5 ppi), and each pixel shall be gray level quantized to 8 bits. [Requirement described in the ANSI standard: *Data Format for the Interchange of Fingerprint Information*, ANSI/NIST- ITL 1-2000.]

A.2.1 Geometric image accuracy

The absolute value of the difference "D", between the actual distance "X" between any two points on a target and the distance "Y" between those same two points as measured on the output scanned image of that target, shall meet the following requirements for the value D, where D = absolute value of (Y – X) :

where: D, X, Y are in millimetres	(where: D, X, Y are in inches)
D **.LE.** 0,01778, for 0 **.LE.** X **.LE.** 1,778	(D **.LE.** 0,0007, for 0 **.LE.** X **.LE.** 0,07)
D **.LE.** 0,01X, for 1,778 **.LE.** X **.LE.** 38,1	(D **.LE.** 0,01X, for 0,07 **.LE.** X **.LE.** 1,50)

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The requirement corresponds to a positional accuracy of plus or minus 1% for distances between 1,778 mm (0.07inches) and 38.1mm (1.5 inches), and a constant plus or minus 0,01778 mm (0.0007 inches) or 1/3 pixel for distances less than or equal to 1,778 mm (0.07 inches). The geometric image accuracy shall be measured using precision 1 cycle per millimetre Ronchi targets on white polyethylene terephthalate (mylar) reflective base.

A.2.2 Modulation transfer function

The measured modulation transfer function (MTF) of the scanner, in both the detector row and detector column directions, and over any region of the scanner's field of view, shall have modulation values which fall within the ranges given in the following MTF table, at the given spatial frequencies:

cyc/mm	MTF
1	0,905 to 1,00
2	0,797 to 1,00
3	0,694 to 1,00
4	0,598 to 1,00
5	0,513 to 1,00
6	0,437 to 1,00
8	0,312 to 1,00
10	0,200 to 1,00

The MTF shall be measured using a test chart containing a single, representative sine wave modulation in each imaged sine wave frequency pattern that is determined from the sample modulation values collected from within that pattern. The sample modulation values are computed from the maximum and minimum levels corresponding to the 'peak' and adjacent 'valley' in each sine wave period. These maximum and minimum levels represent the corresponding locally averaged image gray levels mapped through a calibration curve into target reflectance space, where the local average of gray levels is computed in a direction orthogonal to the sinusoidal variation direction. Sample image modulation is then defined as:

(maximum - minimum) / (maximum + minimum)

The calibration curve is constructed by performing a least squares linear regression curve fit between the image gray levels of the 14 density patches in the test target and the corresponding target reflectance values. The scanner MTF at each frequency is then defined as:

MTF = representative image modulation / target modulation

[Target modulations and target density patch values are supplied with the test target by the manufacturer.]

A.2.3 Signal-to-noise ratio

Both the ratio of signal to white noise standard deviation and the ratio of signal to black noise standard deviation of the digital scanner shall be greater than or equal to 125 using the following procedure:

1) A random 6,35 mm x 6,35 mm (0,25 inch x 0,25 inch) test field within the image area is chosen and a white reference target is placed in the test field.

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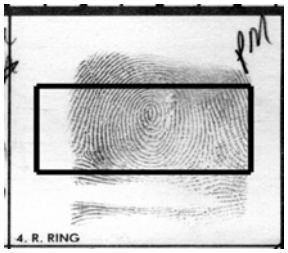
2) A white test population of 8-bit reflectance values from at least 1000 samples within the test field are collected. The average value and standard deviation are computed from this test population.

3) Steps 1 and 2 are repeated for a black matte reference target.

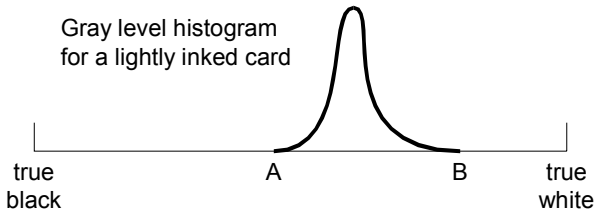
4) The signal to noise ratio (SNR) is computed as the difference between average white and average black values, alternately divided by the white noise standard deviation ('white SNR') and the black noise standard deviation ('black SNR').

Note: The scanner shall be set up such that the white reference target is below scanner saturation level, and the black reference target is above scanner dark current level. Also, care should be taken, via direct visual or visual display observation, to avoid areas of dust, pinholes, scratches, or other imperfections on the target when selecting the sub-area for the 1000 samples.

A.2.4 Grayscale range of image data



At least 80% of the captured individual fingerprint images shall have a gray-scale dynamic range of at least 200 gray levels and at least 99% shall have a dynamic range of at least 128 gray levels. For this requirements section, 'dynamic range' is defined as the total number of gray levels that have signal content from the fingerprint image. Fingerprint card format lines, boxes, and text shall be excluded from the dynamic range computation and white surround in the immediate vicinity of a given fingerprint shall be included in the dynamic range computation (dashed box at right). Compliance with these dynamic range requirements shall be verified using a stratified sample of fingerprint cards.



The intent is to avoid excessively low contrast images. Live-scan systems and card scanners at a booking station can control dynamic range by rolling the prints properly. However, with central site or file conversion systems, where a variety of card types and image qualities are encountered, adaptive processing may be necessary. The 8-bit quantization of the gray-scale values for very low contrast fingerprints needs to more optimally represent the reduced gray-scale range of such fingerprints. In the example histogram accompanying this section, the gray-scale values divide up the range from A to B. The parameters A and B are stored with the image to provide an audit trail.

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A.2.5 Grayscale linearity

Using 14 gray patches in a test target as the scanner input (independent variable), with their manufacture-supplied reflectance values, none of the corresponding 14 scanner output gray levels (dependent variable) shall deviate by more than 7.65 gray levels from a linear, least squares regression line fitted between the two variables. The output sample values within an area of at least 6,35 mm x 6,35 mm (0,25 inch x 0,25 inch) shall be utilized to compute the average output gray level for each patch.

A.2.6 Output gray level uniformity

Output gray level uniformity shall be determined by scanning both a white reference target, white matte, and a black matte reference target. The scanner shall be set up such that the white reference target is below scanner saturation level, and the black reference target is above scanner dark current level in the respective tests.

Using the white target as the scanner input, the following three requirements shall be met:

(1) The outputs of any two adjacent rows or columns of length 9 pixels or greater shall not have mean gray levels that differ by more than 2.5 gray levels.

(2) For all pixels within a 6,35 mm x 6,35 mm (0,25 inch x 0,25 inch - 'quarter inch area') located in any region of the total scanner field of view, no individual pixel's gray level shall vary from the mean gray level by more than 22.0 gray levels.

(3) For any two non-contiguous quarter inch areas located anywhere in the total scanner field of view, the mean gray levels of the two quarter inch areas shall not differ by more than 12.0 gray levels.

And, using the black target as the scanner input, the following three requirements shall be met:

(1) The outputs of any two adjacent rows or columns of length 9 pixels or greater shall not have mean gray levels that differ by more than 1.0 gray levels.

(2) For all pixels within a 6,35 mm x 6,35 mm (0,25 inch x 0,25 inch - 'quarter inch area') located in any region of the total scanner field of view, no individual pixel's gray level shall vary from the mean gray level by more than 8.0 gray levels.

(3) For any two non-contiguous 6,35 mm x 6,35 mm (0,25 inch x 0,25 inch - 'quarter inch') areas located anywhere in the total scanner field of view, the mean gray levels of the two 6,35 mm x 6,35 mm (0,25 inch x 0,25 inch - 'quarter inch') areas shall not differ by more than 3.0 gray levels.

A.3 Latent print scanners

The following subsections describe the image quality performance characteristics required for a latent print scanner operating in a 39,37 ppmm (1000 ppi) mode. These specifications require that the scanner shall capture fingerprints at a minimum resolution in both the detector row and detector column directions (also known as 'along-scan' and 'cross-scan' directions) of 39,37 ppmm (1000 ppi). The final output delivered image from the scanner system (at the this setting) shall have a resolution of 39,37 ppmm plus or minus 0,3937 ppmm (1000 ppi plus or minus 10 ppi), and each pixel shall be gray level quantized to a minimum of 8 bits. The complete latent print specification consists of all requirements given in this Section, plus all non-conflicting requirements given in Section 2.0 Fingerprint Scanners.

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A.3.1 Geometric image accuracy

The absolute value of the difference "D", between the actual distance "X" between any two points on a target and the distance "Y" between those same two points as measured on the output scanned image of that target, shall meet the following requirements for the value D, where D = absolute value of (Y – X) :

where: D, X, Y are in millimetres	(where: D, X, Y are in inches)
D **.LE.** 0,0127, for 0 **.LE.** X **.LE.** 1,778	(D **.LE.** 0,0005, for 0 **.LE.** X **.LE.** 0,07)
D **.LE.** 0,071X, for 1,778 **.LE.** X **.LE.** 38,1	(D **.LE.** 0,0071X, for 0,07 **.LE.** X **.LE.** 1,50)

The requirement corresponds to a positional accuracy of ∀ .71% for distances between 1,778 and 38.1 mm (0.07 and 1.5 in), and a constant plus or minus 0,0127 mm (0.0005 in) or 1/2 pixel for distances less than or equal to 1,778 mm (0.07 in). The geometric image accuracy shall be measured using precision 1 cycle per millimeter Ronchi targets on white polyethylene terephthalate (mylar) reflective base

A.3.2 Modulation transfer function

The measured modulation transfer function (MTF) of the scanner, in both the detector row and detector column directions, and over any region of the scanner's field of view, shall have modulation values which fall within the ranges given in the following MTF table, at the given spatial frequencies:

cyc/mm	MTF
1	0,925 to 1,00
2	0,856 to 1,00
3	0,791 to 1,00
4	0,732 to 1,00
5	0,677 to 1,00
6	0,626 to 1,00
8	0,536 to 1,00
10	0,458 to 1,00
12	0,392 to 1,00
14	0,336 to 1,00
16	0,287 to 1,00
18	0,246 to 1,00
20	0,210 to 1,00

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The MTF shall be measured using test chart. The single, representative sine wave modulation in each imaged sine wave frequency pattern is determined from the sample modulation values collected from within that pattern. The sample modulation values are computed from the maximum and minimum levels corresponding to the 'peak' and adjacent 'valley' in each sine wave period. These maximum and minimum levels represent the corresponding locally averaged image gray levels mapped through a calibration curve into target reflectance space, where the local average of gray levels is computed in a direction orthogonal to the sinusoidal variation direction. Sample image modulation is then defined as:

(maximum - minimum) / (maximum + minimum)

The calibration curve is constructed by performing a least squares linear regression curve fit between the image gray levels of the 14 density patches in the test target and the corresponding target reflectance values. The scanner MTF at each frequency is then defined as:

MTF = representative image modulation / target modulation

[Target modulations and target density patch values are supplied with the test target by the manufacturer.]

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Annex B
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Finger image data record example

The fingerprint image area that appears in Figure 1 will serve as example of the data encoding process and will be formatted according to this standard. Assume it originated from a left index finger and that the image was captured using a live-scan device that conformed to the parameters listed under level '31' in table 1. The image has pixel dimensions of 375x625 and will be formatted as uncompressed for the purpose of illustration. The required fields for this example are illustrated in Table B-1 and Table B-2.

Table B-1 General record header example

Field	Bytes	Value	Notes
Format identifier	1-4	46 49 52 00	"FIR" – Finger Image Record
Version number	5-8	30 31 30 00	"010"
Record length	9-14	00 00 00 03 93 b5	One finger view 32+1*(14+234,375)
Device ID	15-16	01 02	Vendor Supplied
Image Acquisition Level	17-18	00 1F	Level 31
Number of fingers/palms	19	01	
Scale units	20	01	Pixels/inch
Scan resolution (horiz)	21-22	01 F4	500 pixels per inch
Scan resolution (vert)	23-24	01 F4	500 pixels/inch
Image resolution (horiz)	25-26	01 F4	500 pixels/inch
Image resolution (vert)	27-28	01 F4	500 pixels/inch
Pixel depth	29	08	256 gray levels
Image compression Algorithm	30	00	Uncompressed (no bit packing)
Reserved	31-32	00 00	

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Table B-2 Finger image header record example

Field	Bytes	Values	Notes
Length of finger data block (bytes)	1-4	00 03 93 95	Includes header, and largest image data block
Finger/palm position	5	07	Left index finger
Count of views	6	01	
View number	7	01	
Finger/palm image quality	7	00	Undefined
Impression type	9	00	Live-scan plain
Horizontal line length	10-11	01 77	375 pixels per horizontal line
Vertical line length	12-13	02 71	625 horizontal lines
Reserved	14	00	Byte set to '0x0'
Finger/palm image data	15- 234,389	_____	Uncompressed image data

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