

AS ISO/IEC 39794.4:2023
ISO/IEC 39794-4:2019



STANDARDS
Australia



Information technology — Extensible biometric data interchange formats

Part 4: Finger image data



AS ISO/IEC 39794.4:2023

This Australian Standard ® was prepared by IT-032, Biometrics and Identification. It was approved on behalf of the Council of Standards Australia on 27 September 2023.

This Standard was published on 13 October 2023.

The following are represented on Committee IT-032:

- Australian Information Industry Association
- Australian Retailers Association
- Department of Defence (Australian Government)
- Department of Foreign Affairs and Trade (DFAT)
- Department of Home Affairs — Digital and Technology Policy Division
- Photo Marketing Association
- SITA

This Standard was issued in draft form for comment as DR AS ISO/IEC 39794.4:2023.

Keeping Standards up-to-date

Ensure you have the latest versions of our publications and keep up-to-date about Amendments, Rulings, Withdrawals, and new projects by visiting:

www.standards.org.au

ISBN 978 1 76139 360 0

Information technology — Extensible biometric data interchange formats

Part 4: Finger image data

First published as AS ISO/IEC 3979.4:2023.

COPYRIGHT

© ISO/IEC 2023 — All rights reserved
© Standards Australia Limited 2023

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of the publisher, unless otherwise permitted under the Copyright Act 1968 (Cth).

Preface

This Standard was prepared by the Standards Australia Committee IT-032, Biometrics and Identification, to supersede AS ISO/IEC 19794.4:2007, *Information technology — Biometric data interchange formats, Part 4: Finger image data*.

The objective of this document is to specify:

- (a) generic extensible data interchange formats for the representation of friction ridge image data: a tagged binary data format based on an extensible specification in ASN.1 and a textual data format based on an XML schema definition that are both capable of holding the same information;
- (b) examples of data record contents;
- (c) application specific requirements, recommendations, and best practices in data acquisition; and
- (d) conformance test assertions and conformance test procedures applicable to this document.

This document is identical with, and has been reproduced from, ISO/IEC 39794-4:2019, *Information technology — Extensible biometric data interchange formats — Part 4: Finger image data*.

As this document has been reproduced from an International document, a full point substitutes for a comma when referring to a decimal marker.

Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an “informative” appendix or annex is only for information and guidance.

Contents

Preface	ii
Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Abbreviated terms	5
5 Conformance	6
6 Modality specific information	6
6.1 Capture recommendations	6
6.1.1 Fingerprint image	6
6.1.2 Palm image	6
6.2 Image coordinate system considerations	6
6.3 Image representation requirements	7
6.3.1 General	7
6.3.2 Colorspace	7
6.3.3 Pixel aspect ratio	7
6.3.4 Bit-depth	7
6.3.5 Image spatial sampling rate	8
7 Abstract data elements	8
7.1 Purpose and overall structure	8
7.2 Finger image data block	9
7.3 Version block	9
7.4 Representation blocks	9
7.5 Position	10
7.6 Impression	10
7.7 Image data format	11
7.7.1 Supported data format	11
7.7.2 PGM encoding definition	11
7.8 Image data	11
7.9 Capture date/time block	12
7.10 Capture device block	12
7.10.1 Model identifier block	12
7.10.2 Capture device technology identifier	12
7.10.3 Certification identifier blocks	13
7.11 Quality blocks	13
7.12 Spatial sampling rate block	14
7.13 Position computed by capture device	14
7.14 Original rotation	14
7.15 Image rotated to vertical	14
7.16 Image has been lossily compressed	14
7.17 Segmentation blocks	14
7.18 Annotation blocks	15
7.19 PAD data block	15
7.20 Comment blocks	15
7.21 Vendor specific data blocks	15
8 Encoding	16
8.1 Tagged binary encoding	16
8.2 XML encoding	16
9 Registered BDB format identifiers	16

Annex A	(normative) Formal specifications	17
Annex B	(informative) Encoding examples	29
Annex C	(normative) Conformance testing methodology	33
Annex D	(normative) Capture device certifications	38
Annex E	(informative) Conditions for capturing fingerprint image data	62
Annex F	(normative) WSQ greyscale finger image compression specification	71
Bibliography		97

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents) or the IEC list of patent declarations received (see <http://patents.iec.ch>).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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

A list of all parts in the ISO/IEC 39794 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

The purchase of this ISO/IEC document carries a copyright licence for the purchaser to use ISO/IEC copyright in the schemas in the annexes to this document for the purpose of developing, implementing, installing and using software based on those schemas, subject to ISO/IEC licensing conditions set out in the schemas.

Introduction

Biometric data interchange formats enable the interoperability of different biometric systems. The first generation of biometric data interchange formats has been published between 2005 and 2007 in the first edition of the ISO/IEC 19794 series. From 2011 onwards, the second generation of biometric data interchange formats was published in the second edition of the established parts and the first edition of some new parts of the ISO/IEC 19794 series. In the second generation of biometric data interchange formats, new useful data elements such as data elements related to biometric sample quality have been added, the header data structures were harmonized across all parts of the ISO/IEC 19794 series, and XML encoding has been added in addition to the binary encoding.

In anticipation of the future need for additional data elements and to avoid future compatibility issues, ISO/IEC JTC 1/SC 37 has developed the ISO/IEC 39794 series as a third generation of biometric data interchange formats, defining extensible biometric data interchange formats capable of including future extensions in a defined way. Extensible specifications in ASN.1 (Abstract Syntax Notation One) and the distinguished encoding rules of ASN.1 form the basis for encoding biometric data in binary tag-length-value formats. XML schema definitions form the basis for encoding biometric data in XML (eXtensible Markup Language).

This third generation of finger image data interchange formats complements ISO/IEC 19794-4 (both the 2005 and 2011 editions). The first generation of biometric data interchange formats, which has been adopted, e.g. by ICAO for the biometric data stored in machine readable travel documents, is expected to be retained in the standards catalogue as long as needed.

This document is intended for those applications requiring the exchange of raw or processed fingerprint and other friction ridge images (for example, palm images) that may not necessarily be limited in the amount of resources available for data storage or transmitting time. It can be used for the exchange of scanned fingerprints containing detailed image pixel information.

Use of the captured or processed image allows interoperability among biometric systems relying on minutiae-based, pattern-based or other algorithms. Thus, data from the captured finger image offers the developer more freedom in choosing or combining comparison algorithms. For example, an enrolment image may be stored on a contactless chip located on an identification document. This will allow future verification of the holder of the document with systems that rely on either minutiae-based or pattern-based algorithms. Establishment of an image-based representation of fingerprint information will not rely on pre-established definitions of minutiae, patterns or other types. It will provide implementers with the flexibility to accommodate images captured from dissimilar devices, varying image sizes, spatial sampling rates and different greyscale depths. Use of the finger image will allow each vendor to implement their own algorithms to determine whether two fingerprint records are from the same finger.

This document supports both binary and XML encoding, to support a spectrum of user requirements. With XML, this document meets the requirements of modern IT architectures. With binary encoding this document is also able to be used in bandwidth or storage constrained environments.

Australian Standard[®]

Information technology — Extensible biometric data interchange formats Part 4: Finger image data

1 Scope

This document specifies:

- generic extensible data interchange formats for the representation of friction ridge image data: a tagged binary data format based on an extensible specification in ASN.1 and a textual data format based on an XML schema definition that are both capable of holding the same information;
- examples of data record contents;
- application specific requirements, recommendations, and best practices in data acquisition; and
- conformance test assertions and conformance test procedures applicable to this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 2382-37, *Information technology — Vocabulary — Part 37: Biometrics*

ISO/IEC 8824-1, *Information technology — Abstract Syntax Notation One (ASN.1): Specification of basic notation — Part 1*

ISO/IEC 8825-1, *Information technology — ASN.1 encoding rules — Part 1: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER), and Distinguished Encoding Rules (DER)*

ISO/IEC 14495-1, *Information technology — Lossless and near-lossless compression of continuous-tone still images: Baseline*

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

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

ISO/IEC 39794-1, *Information technology — Extensible biometric data interchange formats — Part 1: Framework*

W3C Recommendation, *XML Schema Part 1: Structures* (Second Edition), 28 October 2004

W3C Recommendation, *XML Schema Part 2: Datatypes* (Second Edition), 28 October 2004

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 2382-37, ISO/IEC 39794-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardisation at the following addresses:

- IEC Electropedia available at <http://www.electropedia.org/>
- ISO Online Browsing Platform available at <http://www.iso.org/obp>.

3.1**spatial sampling rate**

number of pixels per unit distance used by a sensor or scanning device to initially capture an image

3.2**coding model**

procedure used to convert input data into symbols to be coded

3.3**coding process**

general term for referring to an encoding process, a decoding process, or both

3.4**column**

samples per line in an image

3.5**compressed data**

either compressed image data or table specification data or both

3.6**compressed image data**

coded representation of an image

Note 1 to entry: As specified in [Annex F](#).

3.7**compression**

reduction in the number of bits used to represent source image data

3.8**decoder**

embodiment of a decoding process

3.9**decoding process**

process which takes as its input compressed image data and outputs a continuous-tone image

3.10**dequantization**

inverse procedure to quantization by which the decoder recovers a representation of the DWT coefficients

3.11**reconstructed image**

<data>continuous-tone image which is the output of the decoder

Note 1 to entry: As defined in [Annex F](#).

3.12**source image**

<data>continuous-tone image used as input to any encoder

Note 1 to entry: As defined in [Annex F](#).

3.13**digital image**

<data>two-dimensional array of data

3.14**downsampling**

procedure by which the spatial resolution of an image is reduced

3.15**DWT****discrete wavelet transform**

linear transformation, implemented by a multirate filter bank, that maps a digital input signal to a collection of output subbands

3.16**encoder**

embodiment of an encoding process

3.17**encoding process**

process which takes as its input a continuous-tone image and outputs compressed image data

3.18**entropy-coded data segment**

independently decodable sequence of entropy encoded bytes of compressed image data

3.19**entropy decoder**

embodiment of an entropy decoding procedure

3.20**entropy decoding**

lossless procedure which recovers the sequence of symbols from the sequence of bits produced by the entropy coder

3.21**entropy encoder**

embodiment of an entropy encoding procedure

3.22**entropy encoding**

lossless procedure which converts a sequence of input symbols into a sequence of bits such that the average number of bits per symbol approaches the entropy of the input symbols

3.23**fingerprint image**

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

Note 1 to entry: It contains a unique pattern of friction ridge and valley information commonly referred to as a "fingerprint".

3.24**Huffman decoder**

embodiment of a Huffman decoding procedure

3.25**Huffman decoding**

entropy decoding procedure which recovers the symbol from each variable length code produced by the Huffman encoder

3.26**Huffman encoder**

embodiment of a Huffman encoding procedure

3.27**Huffman encoding**

entropy encoding procedure which assigns a variable length code to each input symbol

3.28**Huffman table**

set of variable length codes required in a Huffman encoder and Huffman decoder

3.29**image data**

either source image data or reconstructed image data

3.30**image spatial sampling rate**

number of pixels per unit distance in the image

Note 1 to entry: This may be the result of processing a captured image. The original captured scanned image may have been subsampled, scaled, downsampled, or otherwise processed.

3.31**interchange format**

representation of compressed image data for exchange between application environments

3.32**lossless**

descriptive term for encoding and decoding processes and procedures in which the output of the decoding procedure(s) is identical to the input to the encoding procedure(s)

3.33**marker**

two-byte code in which the first byte is FF_{Hex} and the second byte is a value between 1 and FE_{Hex}

3.34**marker segment**

marker and associated set of parameters

3.35**palm**

friction ridge skin on the side and underside of the hand

3.36**parameter**

fixed length integers 8, 16, or 32 bits in length, used in the compressed data format

3.37**plain fingerprint image**

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

3.38**procedure**

set of steps which accomplishes one of the tasks which comprise an encoding or decoding process

3.39**progressive**

<coding>separation of data segments into blocks that can be transmitted successively to allow the compressed image data to be decoded at successively higher levels of resolution

3.40**quantization table**

set of quantization values (i.e., bin widths) used to quantize DWT coefficients within the subbands

3.41**quantize**

act of performing the quantization procedure for a DWT coefficient

3.42**restart interval**

number of coefficients processed as an independent sequence within an image

3.43**restart marker**

marker that separates two restart intervals in an image

3.44**rolled fingerprint image**

image captured that is located between the two edges of the fingernail

Note 1 to entry: This type of image is typically acquired using a rolling motion from one edge of the fingernail to the other.

3.45**run length**

number of consecutive symbols of the same value

3.46**SWT****symmetric wavelet transform**

linear transform implemented by applying a DWT to a periodized symmetric extension of the input signal

3.47**sample**

one element in the two-dimensional array which comprises a finger image

3.48**table specification data**

coded representation from which the tables, used in the encoder and decoder, are generated

3.49**upsampling**

procedure by which the spatial resolution of an image is increased

4 Abbreviated terms

For the purposes of this document, the abbreviated terms given in ISO/IEC 39794-1 and the following apply.

ppcm	pixels per centimetre
ppi	pixels per inch
CTF	contrast transfer function
JPEG	joint photographic experts group
MTF	modulation transfer function
PGM	portable gray map
PNG	portable network graphics
TIR	total internal reflection
WSQ	wavelet scalar quantization

5 Conformance

A biometric data block (BDB) conforms to this document if it satisfies all of the requirements related to:

- its data structure, data values and the relationships between its data elements as specified throughout [Clauses 6, 7, 8](#), and [Annex A](#), and
- the relationship between its data values and the input biometric data from which the biometric data record was generated as specified throughout [Clauses 6, 7, 8](#), and [Annex A](#).

A system that produces biometric data records conforms to this document if all biometric data records that it outputs conform to this document (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 document, but only those that are claimed to be supported by the system in the ICS.

A system that uses biometric data records conforms to this document if it can read, and use for the purpose intended by that system, all biometric data records that conform to this document (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 document, but only those that are claimed to be supported by the system in an ICS.

6 Modality specific information

6.1 Capture recommendations

6.1.1 Fingerprint image

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

For multiple finger verification and/or identification purposes, there exist fingerprint capture devices that will acquire images of multiple fingers during a single capture cycle. These devices are capable of capturing the plain impressions from two, three or four adjacent fingers of either hand during a single scanning. The plain impressions from the two thumbs or two index fingers can also be captured at one time. Therefore, with three placements of the fingers on a device's scanning surface all ten fingers from an individual would 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 centre and the other half of the fingers to the right of the image centre.

6.1.2 Palm image

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

6.2 Image coordinate system considerations

The recorded image data shall appear to be the result of a scanning of an impression of a friction ridge image. For the purpose of describing the position of each pixel within an image to be exchanged, a pair of reference axes shall be used. The origin of the axes, pixel location (0,0), shall be located at the upper

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

To assure that friction ridge images are interoperable with existing fingerprint images in legacy datasets, care shall be taken to assure that the orientation of the fingerprint is correct. [Figure 1](#) shows how this shall be achieved.

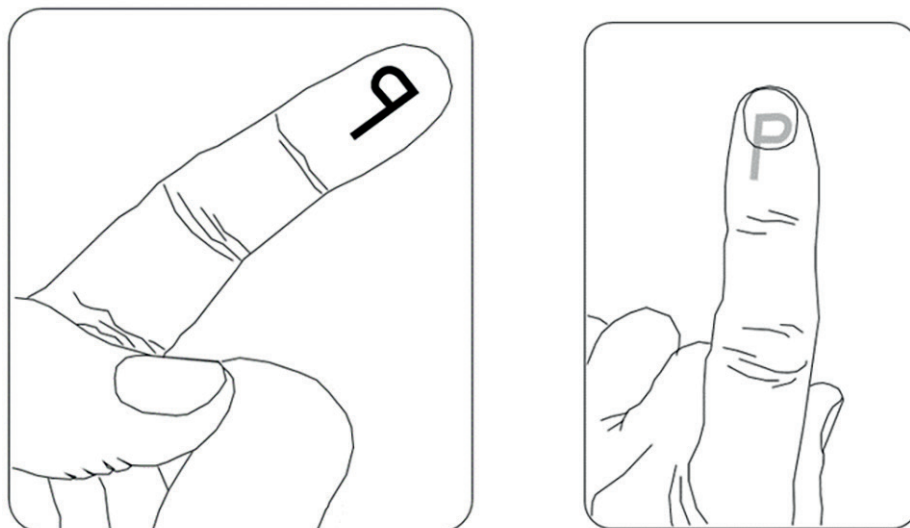


Figure 1 — Illustration of fingerprint orientation

6.3 Image representation requirements

6.3.1 General

Image representation requirements are dependent on various factors including the application, the available amount of raw pixel information to retain or exchange, and targeted performance metrics. Because of these factors, the images represented will have characteristics based on the aspects described in [6.3.2](#) through [6.3.5](#).

6.3.2 Colourspace

Finger images shall be represented as greyscale image data.

6.3.3 Pixel aspect ratio

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

6.3.4 Bit-depth

The greyscale precision of the pixel data shall be specified in terms of the bit-depth or the number of bits used to represent the greyscale value of a pixel. A bit-depth of 8 provides 256 levels of grey. For greyscale 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 greyscale 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.

6.3.5 Image spatial sampling rate

The spatial sampling rate of the image data formatted and recorded for interchange establishes the number of pixels for a given distance over the fingerprint object. A finger image may be represented with a certain number of pixels per cm (ppcm) or pixels per inch (ppi). A finger image with a sampling rate of 197 ppcm is practically equivalent to a finger image with a sampling rate of 500 ppi. For example, if a spatial sampling rate of 500 ppi is established for a fingerprint sensor with a width of 0.635 cm (corresponding to a quarter inch), there will be 125 pixels across the width of the image.

7 Abstract data elements

7.1 Purpose and overall structure

This clause describes the contents of data elements defined in this document. The description is independent of the encoding of the data elements.

The full naming conventions for ASN.1 module components and component types definitions, naming conventions for XML schema elements and element types definitions also ASN.1 and XML schema definition extensions applied per the ISO/IEC 39794 series are specified in ISO/IEC 39794-1.

The tagged binary encoding as well as the XML encoding is given in [Clause 8](#) and [Annex A](#).

The structure of the abstract data elements is described in [Figure 2](#).

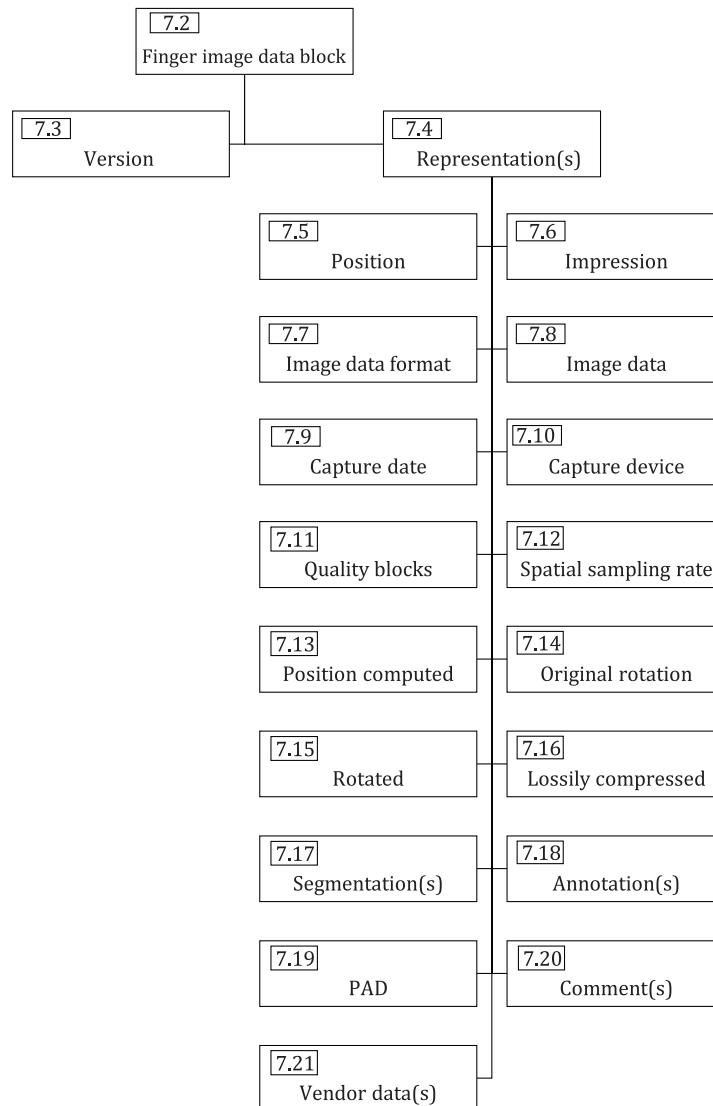


Figure 2 — Fingerprint image data block

NOTE Figure 2 is not automatically generated and can only be viewed as an overview of the structure.

7.2 Finger image data block

Abstract values: See [Figure 2](#) – Fingerprint image data block.

Contents: This data element is the container for all the data associated with the finger image.

7.3 Version block

Abstract values: See ISO/IEC 39794-1.

Contents: The generation number of this document shall be 3. The year shall be the year of the publication of this document.

7.4 Representation blocks

Abstract values: See [Figure 2](#) – Fingerprint image data block.

Contents: This data element is the container for all the data associated with the finger image, except for the version block information.

7.5 Position

Abstract values: See [Annex A](#). As the number of positions is long and duplicative, it is best to understand the possible positions by examining the schema directly.

Contents: This data element establishes which friction ridge region is encoded in the image data. For example, a right index finger image is described with a position of “rightIndexFinger” in an ASN.1 encoding. Note that the position encodings are specified to improve interoperability with existing standards, notably ANSI/NIST ITL standards[\[3\]](#).

7.6 Impression

Abstract values: See [Table 1](#).

Contents: This data element establishes how the friction ridge interacted with the capture system at the time of capture. Note that the impression encodings are specified to improve interoperability with existing standards, notably ANSI/NIST ITL standards[\[3\]](#).

Table 1 — Description for finger impression values

Abstract value	Description
plainContact	A stationary subject's friction ridge in contact with a fixed scanning surface (or platen).
rolledContact	A laterally rolled subject's friction ridge in contact with a fixed scanning surface (or platen).
latentImage	A residue from a subject's friction ridge left on a surface that has been captured.
swipeContact	A moving subject's friction ridge (typically vertically) in contact with a fixed thin scanning bar.
stationarySubjectContactlessPlain	A subject's friction ridge captured without contact in such a way that the image is not representative of a roll or other 3D structure, and in which the subject is expected to remain mostly motionless.
stationarySubjectContactlessRolled	A subject's friction ridge captured without contact in such a way that the image is representative of a roll or other 3D structure, and in which the subject is expected to remain mostly motionless. A multi-camera system that captures many views of a fingerprint and stitches them together to create a rolled image would fall into this category.
movingSubjectContactlessPlain	A subject's friction ridge captured without contact in such a way that the image is not representative of a roll or other 3D structure, and in which the subject is expected to move to perform an effective capture. A contactless “swipe” sensor in which the subject slides their fingers above a capture system would fall into this category.
movingSubjectContactlessRolled	A subject's friction ridge captured without contact in such a way that the image is representative of a roll or other 3D structure, and in which the subject is expected to move to perform an effective capture. A system in which a subject performs a rolling action above or inside a capture system (without platen contact) would fall into this category.
unknownImpression	Impression information was not captured or has been lost.
otherImpression	Impression information is known, but does not correspond to any specified values.

7.7 Image data format

7.7.1 Supported data format

Abstract values: See [Table 2](#).

Contents: Finger images shall be encoded using uncompressed or compressed formats. The format used to encode the finger image data shall match the format specified in this data element. [Table 2](#) lists the supported data formats and associated parameters that may be used.

Table 2 — Image data format

Abstract value	Image data format	Normative reference	Allowed spatial sampling	Maximum compression ratio
pgm	None	None	All	None
wsq	WSQ	IAFIS_IC-0110, Annex F	197 ppcm	15:1
Jpeg2000Lossy	JPEG 2000 (lossy)	ISO/IEC 15444	394 ppcm	15:1
Jpeg2000Lossless	JPEG 2000 (lossless)	ISO/IEC 14495-1	197 ppcm or 394 ppcm	None
png	PNG	ISO/IEC 15948	All	None

7.7.2 PGM encoding definition

A finger image may be encoded in the Netpbm portable grayscale binary image format. The format definition is [\[15\]](#):

- 1) a "magic number" = "P5" for identifying the file type followed by:
- 2) any whitespace (blanks, TABs, CRs, LFs);
- 3) a width formatted as ASCII characters in decimal;
- 4) any whitespace (blanks, TABs, CRs, LFs);
- 5) a height in ASCII decimal;
- 6) any whitespace (blanks, TABs, CRs, LFs);
- 7) the maximum grayscale value (Maxval), again in ASCII decimal: the Maxval shall be less than 65536, and more than zero;
- 8) a single whitespace character (usually a newline);
- 9) a raster of height rows, in order from top to bottom. Each row consists of width grayscale values, in order from left to right. Each grayscale value is a number from 0 through Maxval, with 0 being black and Maxval being white. Each grayscale value is represented in pure binary by either 1 or 2 bytes. If the Maxval is less than 256, it is 1 byte. Otherwise, it is 2 bytes. The most significant byte is first.

7.8 Image data

Contents: This data element contains the encoded friction ridge image data.

NOTE The finger image data does not necessarily represent a finger. In general, any position specified in [7.5](#) may be collected and would be encoded into the finger image data element.

7.9 Capture date/time block

See ISO/IEC 39794-1.

7.10 Capture device block

7.10.1 Model identifier block

See ISO/IEC 39794-1.

7.10.2 Capture device technology identifier

Abstract Values: See [Table 3](#).

Contents: This data element establishes the class of capture device technology used to acquire the captured biometric sample. Note that the technology encodings are specified to improve interoperability with existing standards, notably ANSI/NIST ITL standards[\[3\]](#).

Table 3 — Description for finger image capture device technology identifier

Abstract value	Description
unknownTechnology	Capture device technology information was not captured or has been lost.
otherTechnology	Capture device technology information is known, but does not correspond to any specified values.
scannedInkOnPaper	Subjects ink their fingerprints and apply them to paper (cardstock) which can then be imaged/scanned. NOTE Card scanners would encode their technology type as scannedInkOnPaper.
opticalTIRBrightField	Contact prism such that ridges absorb light from the illumination system.
opticalTIRDarkField	Contact prism such that ridges reflect light from the illumination system.
opticalImage	Differences in the ridge detail are captured by an optical capture system.
opticalLowFrequency3DMapped	A 3D model of the shape of the finger is used to project reflected light from ridges onto a flattened (2D) model of the finger.
opticalHighFrequency3DMapped	A 3D model that is sensitive to the 3D distances between ridges and valleys is used to project reflected light from ridges onto a flattened (2D) model of the finger.
capacitive	A contact sensor that utilizes the difference in charge between touching ridges and non-touching valleys. The sensor acts as one plate of the capacitor, the non-conducting epidermis as a dielectric, and the conducting dermis as the other plate. There are active and passive versions of the technology.
capacitiveRF	A low radio frequency (RF) signal is applied to the ridge detail and reflections are sensed by the detector array, with each pixel operating like a tiny antenna.
electroLuminescence	A contact technology in which the ridges and an alternating current (AC) signal cause an EL panel to emit light which is captured by an imaging system.
reflectedUltrasonic	High frequency sound signals are applied to the ridge detail and the acoustic response is sensed by the detector array, with each pixel operating like a tiny microphone.
impediographicUltrasonic	A contact technology in which the absorption of ultrasonic energy is measured by changes in the impedance of a piezo-electric material.

Table 3 (continued)

Abstract value	Description
thermal	Thermal differences between contact ridges and ambient temperature in valleys are used by a detector array, with each pixel operating like a tiny thermometer.
directPressure	These sensors operate by measuring the pressure difference between ridges and valleys, as the valleys are not involved in any direct force on the surface of the sensor. The pressure is measured by a detector array, with each pixel operating like a tiny scale. In practice, these sensors are electronic binary switches that use time and/or spatial diversity to achieve grayscale detail.
indirectPressure	A contact technology in which the pressure of the fingerprint ridge skin against a deformable material is assessed optically to produce a friction ridge image.
liveTape	A technology in which one-time use tape is used on live friction ridge skin to collect friction ridge detail and the tape is then subsequently imaged by traditional photography.
latentImpression	A powder is applied to a surface that a fingerprint has touched. The oil residue of the finger attaches to the powder. This is then photographed and post-processed to produce a latent finger image.
latentPhoto	A printed photograph of a latent impression is subsequently imaged (with a scanner or camera).
latentMolded	A mold of a latent is fabricated and utilized to construct an artificial finger which is then used with a PAD-disabled scanner to produce a latent finger image.
latentTracing	An older legacy latent friction ridge capture process in which a hand-drawn or computer-drawn tracing is subsequently imaged by a flatbed scanner or photographed.
latentLift	A powder is applied to a surface that a fingerprint has touched. The oil residue of the finger attaches to the powder. Transparent tape is then placed over the latent and is photographed after the tape is removed or lifted.

7.10.3 Certification identifier blocks

Abstract Values: See ISO/IEC 39794-1 and [Table 4](#).

Contents: This data element establishes the certification scheme as specified in [Annex D](#). The certification authority is ISO/IEC JTC1/SC 37 with the registered biometric organization identifier 257 (0101_{Hex}). The Certification identifier structure conforms to ISO/IEC 39794-1.

Table 4 — Certification scheme identifiers for certification schemes specified in [Annex D](#)

Certification scheme identifier	Annex
1	Annex D.1 — Image quality specification for AFIS systems.
2	Annex D.2 — Image quality specification for personal verification.
3	Annex D.3 — Requirements and test procedures for optical fingerprint scanners.
4 to 65535	Reserved by SC 37 for future use.

7.11 Quality blocks

See ISO/IEC 39794-1.

7.12 Spatial sampling rate block

Abstract values: See [Annex A](#). As it consists of two elements, it is best to understand the possible positions by examining the schema directly.

Contents: This data element establishes the resolution of the friction ridge image. It consists of two elements, the unit of samples or pixels per unit distance and the unit of measure for which the number of samples are related (either inch or cm). If this element is not present, the image's spatial sampling rate is established at 500 pixels per inch (ppi), or equivalently 197 pixels per centimetre (ppcm).

7.13 Position computed by capture device

Abstract values: True or False.

Contents: This Boolean data element establishes whether the capture device determined the friction ridge position automatically. If false, then the position encoded was established by the user or operator at the time of capture.

7.14 Original rotation

Abstract values: an angle from 0 to 359.

Contents: This data element establishes the original rotation of the finger image. The finger image is modelled as a rough ellipse, and the major axis of that ellipse is vertical when the rotation is 0. The rotation of the fingerprint is measured counter clockwise with increasing rotation angles.

7.15 Image rotated to vertical

Abstract values: True or False.

Contents: This Boolean data element establishes whether the represented finger image has been rotated to make its major axis vertical.

7.16 Image has been lossily compressed

Abstract values: True or False.

Contents: This Boolean data element establishes whether the finger image is or has been lossily compressed. It is useful to provide this information for images that may have been previously compressed with a lossy compression algorithm (WSQ, JPEG 2000 Lossy).

7.17 Segmentation blocks

Abstract values: See [Annex A](#). As it consists of multiple internal data elements, it is best to understand the possible positions by examining the schema directly.

Contents: This data elements contains the segmentation algorithm identifier block and one or more segment blocks.

The segment block data element contains n-sided polygon coordinates that enclose segments of the friction ridge image data.

For example, a right four slap position may be acquired by a fingerprint capture device, and the slap image can be processed by fingerprint segmentation software. The software may provide bounding

boxes that enclose the fingerprint regions. A bounding box can be described by 2 vertices: a top-left vertex coordinate and a bottom-right vertex coordinate. Alternatively, the segment could be defined by 4 points that specify a tetragon that encloses a single fingerprint region. The x-y values of the coordinate are relative to the image coordinates of the origin image.

The order of the vertex coordinates (when >2) shall be in their consecutive order around the perimeter of the polygon, either clockwise or counter clockwise. No two vertices may occupy the same location. The polygon side defined by the last coordinate and the first coordinate shall complete the polygon. The polygon shall be a simple, plane figure with no sides crossing and no interior holes.

As there are finger positions that encompass multiple finger regions, a single finger image can have multiple segmentation blocks from different segmentation algorithm providers, which encapsulate multiple finger region segment blocks, each described by both a set of coordinates and a position, with optional information about orientation, quality, and segment confidence. The confidence value is a measure of estimated correctness regarding the accuracy of the enclosing coordinates.

7.18 Annotation blocks

Abstract Values: See [Table 5](#).

Contents: This data element contains the annotations that describe reasons why appropriate position (see [7.5](#)) friction ridges are not captured as expected. For example, a capture subject might be missing the right index finger, and the capture device captured a right four finger slap image. The segmentation software performs much better when it knows that the right index finger is missing. Furthermore, there are applications use cases that drive different reasons. The generic reasons that are supported by this document are specified in [Table 5](#).

Table 5 — Annotation reasons

Abstract value	Description
amputated	The friction ridge region has been amputated, or is anatomically missing.
unableToPrint	The friction ridge region is unable to be captured for undescribed reasons.
bandaged	The friction ridge region has a bandage on it rendering it not capturable.
physicallyChallenged	Physical ailments, like extreme arthritis, prevent the capture of the friction ridge region.
diseased	The friction ridge region suffers from the effects of a disease, rendering it not capturable.
unknown	Annotation information was not captured or has been lost.
other	Annotation information is known, but does not correspond to any specified values.

7.19 PAD data block

See ISO/IEC 39794-1.

7.20 Comment blocks

Abstract values: Any string value (see [Annex A](#) for details).

Contents: This data element contains comment data associated with friction ridge image data.

7.21 Vendor specific data blocks

Abstract values: See [Annex A](#). As it consists of multiple internal data elements, it is best to understand the possible positions by examining the schema directly.

Contents: This data element contains the vendor data type identifier block along with vendor specific proprietary data associated with the friction ridge. The former specifies the biometric organization (vendor) and data type identifier assigned by biometric organization for possible data interpretation.

As this is an interoperable data interchange format, this data element shall not be used to contain data that can be provided with other elements of this document.

8 Encoding

8.1 Tagged binary encoding

The ASN.1 types (as defined in [Clause A.1](#)) which encode the abstract elements of [Clause 7](#) shall conform to ISO/IEC 8824-1 and to ISO/IEC 39794-1.

The tagged binary encoding of friction ridge image data shall be obtained by applying the ASN.1 distinguished encoding rules (DER) defined within ISO/IEC 8825-1 to a value of the type FingerImageDataBlock defined in the given ASN.1 module. The DER encoding of each data object has three parts: tag octets that identify the data object, length octets that give the number of subsequent value octets, and the value octets.

The ASN.1 module in [Clause A.1](#) can be retrieved from <http://standards.iso.org/iso-iec/39794/-4/ed-1/en>.

8.2 XML encoding

The XSD types as defined in [Clause A.2](#) which encode the abstract elements of [Clause 7](#) shall conform to the W3C Recommendations, *XML Schema Parts 1 and 2* and to ISO/IEC 39794-1.

An XML document encoding friction ridge image data shall obey the given XSD.

The XSD in [Clause A.2](#) is available at <http://standards.iso.org/iso-iec/39794/-4/ed-1/en>.

9 Registered BDB format identifiers

The registrations listed in [Table 6](#) have been made in accordance with ISO/IEC 19785-1[13] to identify the finger image data interchange formats defined in document. The format owner is ISO/IEC JTC 1/SC 37 with the registered biometric organization identifier 257 (0101_{Hex}).

Table 6 — BDB format identifiers

BDB format identifier	Short name	Full object identifier
40 (0028 _{Hex})	g3-binary-finger-image	{ iso(1) registration-authority(1) cbeff(19785) biometric-organization(0) jtc1-sc37(257) bdb(0) g3-binary-finger-image(40) }
41 (0029 _{Hex})	g3-xml-finger-image	{ iso(1) registration-authority(1) cbeff(19785) biometric-organization(0) jtc1-sc37(257) bdb(0) g3-xml-finger-image(41) }

Annex A (normative)

Formal specifications

A.1 ASN.1 module for tagged binary encoding

```
ISO-IEC-39794-4-ed-1-v1 {iso(1) standard(0) iso-iec-39794(39794) part-4(4) ed-1(1) v1(1)
iso-iec-39794-4(0)}
```

```
-- Use of ISO/IEC copyright in this Schema is licensed for the purpose of
-- developing, implementing, and using software based on this Schema, subject
-- to the following conditions:
```

```
--
-- * Software developed from this Schema must retain the Copyright Notice,
--   this list of conditions and the disclaimer below ("Disclaimer").
--
-- * Neither the name or logo of ISO or of IEC, nor the names of specific
--   contributors, may be used to endorse or promote software derived from
--   this Schema without specific prior written permission.
--
-- * The software developer shall attribute the Schema to ISO/IEC and
--   identify the ISO/IEC standard from which it is taken. Such attribution
--   (e.g., "This software makes use of the Schema from ISO/IEC 39794-4
--   within modifications permitted in the relevant ISO/IEC standard.
--   Please reproduce this note if possible."), may be placed in the
--   software itself or any other reasonable location.
--
```

```
-- The Disclaimer is:
-- THE SCHEMA ON WHICH THIS SOFTWARE IS BASED IS PROVIDED BY THE COPYRIGHT
-- HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES,
-- INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY
-- AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL
-- THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT,
-- INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT
-- NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE,
-- DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY
-- THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT
-- (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF
-- THE CODE COMPONENTS, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
```

```
DEFINITIONS IMPLICIT TAGS ::= BEGIN
```

```
IMPORTS
    QualityBlocks,
    ScoreOrError,
    RegistryIdBlock,
    CertificationIdBlocks,
    CaptureDateTimeBlock,
    PADDataBlock,
    VersionBlock,
    CoordinateCartesian2DUnsignedShortBlock,
    ExtendedDataBlock
FROM ISO-IEC-39794-1-ed-1-v1;
```

```
PositionCode ::= ENUMERATED {
    unknownPosition(0),
    rightThumbFinger(1),
    rightIndexFinger(2),
    rightMiddleFinger(3),
    rightRingFinger(4),
    rightLittleFinger(5),
    leftThumbFinger(6),
    leftIndexFinger(7),
```

leftMiddleFinger(8),
leftRingFinger(9),
leftLittleFinger(10),
rightFourFingers(13),
leftFourFingers(14),
bothThumbFingers(15),
rightExtraDigitFinger(16),
leftExtraDigitFinger(17),
unknownFrictionRidge(18),
entireJointImage(19),
unknownPalm(20),
rightFullPalm(21),
rightWritersPalm(22),
rightLowerPalm(23),
rightUpperPalm(24),
rightOtherPalm(25),
rightInterdigital(26),
rightThenar(27),
rightHypothenar(28),
leftFullPalm(29),
leftWritersPalm(30),
leftLowerPalm(31),
leftUpperPalm(32),
leftOtherPalm(33),
leftInterdigital(34),
leftThenar(35),
leftHypothenar(36),
rightGrasp(37),
leftGrasp(38),
rightIndexMiddleFingers(40),
rightMiddleRingFingers(41),
rightRingLittleFingers(42),
leftIndexMiddleFingers(43),
leftMiddleRingFingers(44),
leftRingLittleFingers(45),
rightIndexLeftIndexFingers(46),
rightIndexMiddleRingFingers(47),
rightMiddleRingLittleFingers(48),
leftIndexMiddleRingFingers(49),
leftMiddleRingLittleFingers(50),
rightFourFingertips(51),
leftFourFingertips(52),
rightFingertips(53),
leftFingertips(54),
leftMiddleIndexRightIndexMiddleFingers(55),
unknownSole(60),
rightSole(61),
leftSole(62),
unknownToe(63),
rightBigToe(64),
rightSecondToe(65),
rightMiddleToe(66),
rightFourthToe(67),
rightLittleToe(68),
leftBigToe(69),
leftSecondToe(70),
leftMiddleToe(71),
leftFourthToe(72),
leftLittleToe(73),
rightFrontBallFoot(74),
rightBackHeelFoot(75),
leftFrontBallFoot(76),
leftBackHeelFoot(77),
rightMiddleFoot(78),
leftMiddleFoot(79),
rightCarpalDelta(81),
leftCarpalDelta(82),
rightFullWithWriterPalm(83),
leftFullWithWriterPalm(84),
rightBracelet(85),
leftBracelet(86),

```

        otherPosition(999)
    }

    PositionExtensionBlock ::= SEQUENCE {
        fallback [0] PositionCode,
        ...
    }

    Position ::= CHOICE {
        code [0] PositionCode,
        extensionBlock [1] PositionExtensionBlock
    }

    ImpressionCode ::= ENUMERATED {
        plainContact(0),
        rolledContact(1),
        latentImage(4),
        swipeContact(8),
        stationarySubjectContactlessPlain(24),
        stationarySubjectContactlessRolled(25),
        movingSubjectContactlessPlain(41),
        movingSubjectContactlessRolled(42),
        otherImpression(28),
        unknownImpression(29)
    }

    ImpressionExtensionBlock ::= SEQUENCE {
        fallback [0] ImpressionCode,
        ...
    }

    Impression ::= CHOICE {
        code [0] ImpressionCode,
        extensionBlock [1] ImpressionExtensionBlock
    }

    CaptureDeviceTechnologyIdCode ::= ENUMERATED {
        unknownCaptureDeviceTechnology(0),
        otherCaptureDeviceTechnology(1),
        scannedInkOnPaper(2),
        opticalTIRBrightField(3),
        opticalTIRDarkField(4),
        opticalImage(5),
        opticalLowFrequency3DMapped(6),
        opticalHighFrequency3DMapped(7),
        capacitive(9),
        capacitiveRF(10),
        electroLuminescence(11),
        reflectedUltrasonic(12),
        impediographicUltrasonic(13),
        thermal(14),
        directPressure(15),
        indirectPressure(16),
        liveTape(17),
        latentImpression(18),
        latentPhoto(19),
        latentMolded(20),
        latentTracing(21),
        latentLift(22)
    }

    CaptureDeviceTechnologyIdExtensionBlock ::= SEQUENCE {
        fallback [0] CaptureDeviceTechnologyIdCode,
        ...
    }

    CaptureDeviceTechnologyId ::= CHOICE {
        code [0] CaptureDeviceTechnologyIdCode,
        extensionBlock [1] CaptureDeviceTechnologyIdExtensionBlock
    }

```

```

ImageDataFormatCode ::= ENUMERATED {
    pgm(0),
    wsq(1),
    jpeg2000Lossy(2),
    jpeg2000Lossless(3),
    png(4)
}

ImageDataFormatExtensionBlock ::= SEQUENCE {
    ...
}

ImageDataFormat ::= CHOICE {
    code [0] ImageDataFormatCode,
    extensionBlock [1] ImageDataFormatExtensionBlock
}

CoordinateBlock ::= CoordinateCartesian2DUnsignedShortBlock

CoordinatesBlock ::= SEQUENCE (SIZE(2..MAX)) OF CoordinateBlock

SegmentBlock ::= SEQUENCE {
    position [0] Position,
    enclosingCoordinatesBlock [1] CoordinatesBlock,
    orientation [2] INTEGER (0..255) OPTIONAL,
    qualityBlocks [3] QualityBlocks OPTIONAL,
    confidence [4] ScoreOrError OPTIONAL,
    ...
}

SegmentBlocks ::= SEQUENCE OF SegmentBlock

SegmentationBlock ::= SEQUENCE {
    algorithmIdBlock [0] RegistryIdBlock,
    segmentBlocks [1] SegmentBlocks,
    ...
}

AnnotationReasonCode ::= ENUMERATED {
    unknown(0),
    other(1),
    amputated(2),
    unableToPrint(3),
    bandaged(4),
    physicallyChallenged(5),
    diseased(6)
}

AnnotationReasonExtensionBlock ::= SEQUENCE {
    fallback [0] AnnotationReasonCode,
    ...
}

AnnotationReason ::= CHOICE {
    code [0] AnnotationReasonCode,
    extensionBlock [1] AnnotationReasonExtensionBlock
}

AnnotationBlock ::= SEQUENCE {
    position [0] Position,
    reason [1] AnnotationReason,
    ...
}

UnitDimensionCode ::= ENUMERATED {
    inch(0),
    cm(1)
}

SpatialSamplingRateBlock ::= SEQUENCE {
    samplesPerUnit [0] INTEGER (0..65535),

```

```

        unitDimension [1] UnitDimensionCode
    }

    CaptureDeviceBlock ::= SEQUENCE {
        modelIdBlock [0] RegistryIdBlock,
        technologyId [1] CaptureDeviceTechnologyId OPTIONAL,
        certificationIdBlocks [2] CertificationIdBlocks OPTIONAL,
        ...
    }

    FingerRotation ::= INTEGER (0..359)

    SegmentationBlocks ::= SEQUENCE OF SegmentationBlock

    AnnotationBlocks ::= SEQUENCE OF AnnotationBlock

    CommentBlock ::= VisibleString

    CommentBlocks ::= SEQUENCE OF CommentBlock

    VendorSpecificDataBlock ::= ExtendedDataBlock

    VendorSpecificDataBlocks ::= SEQUENCE OF VendorSpecificDataBlock

    RepresentationBlock ::= SEQUENCE {
        position [0] Position,
        impression [1] Impression,
        imageDataFormat [2] ImageDataFormat,
        imageData [3] OCTET STRING,
        captureDateTimeBlock [4] CaptureDateTimeBlock OPTIONAL,
        captureDeviceBlock [5] CaptureDeviceBlock OPTIONAL,
        qualityBlocks [6] QualityBlocks OPTIONAL,
        spatialSamplingRateBlock [7] SpatialSamplingRateBlock OPTIONAL,
        positionComputedByCaptureSystem [8] BOOLEAN OPTIONAL,
        originalRotation [9] FingerRotation OPTIONAL,
        imageRotatedToVertical [10] BOOLEAN OPTIONAL,
        imageHasBeenLossilyCompressed [11] BOOLEAN OPTIONAL,
        segmentationBlocks [12] SegmentationBlocks OPTIONAL,
        annotationBlocks [13] AnnotationBlocks OPTIONAL,
        pADDataBlock [14] PADDataBlock OPTIONAL,
        commentBlocks [15] CommentBlocks OPTIONAL,
        vendorSpecificDataBlocks [16] VendorSpecificDataBlocks OPTIONAL,
        ...
    }

    RepresentationBlocks ::= SEQUENCE OF RepresentationBlock

    FingerImageDataBlock ::= [APPLICATION 4] SEQUENCE {
        versionBlock [0] VersionBlock,
        representationBlocks [1] RepresentationBlocks,
        ...
    }

END

```

A.2 XML schema definition for XML encoding

```
<?xml version="1.0" encoding="utf-8" ?>
<!--Use of ISO/IEC copyright in this Schema is licensed for the purpose of developing,
implementing, and using software based on this Schema, subject to the following
conditions:
```

* Software developed from this Schema must retain the Copyright Notice, this list of conditions and the disclaimer below ("Disclaimer").

* Neither the name or logo of ISO or of IEC, nor the names of specific contributors, may be used to endorse or promote software derived from this Schema without specific prior written permission.

* The software developer shall attribute the Schema to ISO/IEC and identify the ISO/IEC standard from which it is taken. Such attribution (e.g., "This software makes use of the Schema from ISO/IEC 39794-4 within modifications permitted in the relevant ISO/IEC standard. Please reproduce this note if possible."), may be placed in the software itself or any other reasonable location.

The Disclaimer is:

```
THE SCHEMA ON WHICH THIS SOFTWARE IS BASED IS PROVIDED BY THE COPYRIGHT HOLDERS AND
CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO,
THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE
DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY
DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT
NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR
PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER
IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY
WAY OUT OF THE USE OF THE CODE COMPONENTS, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH
DAMAGE.-->
```

```
<xs:schema
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:vc="http://www.w3.org/2007/XMLSchema-versioning"
  xmlns:cmn="http://standards.iso.org/iso-iec/39794/-1"
  xmlns="http://standards.iso.org/iso-iec/39794/-4"
  vc:minVersion="1.0"
  targetNamespace="http://standards.iso.org/iso-iec/39794/-4"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">

  <xs:import schemaLocation="iso-iec-39794-1-ed-1-v1.xsd" namespace="http://standards.iso.
org/iso-iec/39794/-1" />

  <xs:complexType name="PositionCodeType">
    <xs:choice>
      <xs:element name="unknownPosition" type="xs:int" fixed="0" />
      <xs:element name="rightThumbFinger" type="xs:int" fixed="1" />
      <xs:element name="rightIndexFinger" type="xs:int" fixed="2" />
      <xs:element name="rightMiddleFinger" type="xs:int" fixed="3" />
      <xs:element name="rightRingFinger" type="xs:int" fixed="4" />
      <xs:element name="rightLittleFinger" type="xs:int" fixed="5" />
      <xs:element name="leftThumbFinger" type="xs:int" fixed="6" />
      <xs:element name="leftIndexFinger" type="xs:int" fixed="7" />
      <xs:element name="leftMiddleFinger" type="xs:int" fixed="8" />
      <xs:element name="leftRingFinger" type="xs:int" fixed="9" />
      <xs:element name="leftLittleFinger" type="xs:int" fixed="10" />
      <xs:element name="rightFourFingers" type="xs:int" fixed="13" />
      <xs:element name="leftFourFingers" type="xs:int" fixed="14" />
      <xs:element name="bothThumbFingers" type="xs:int" fixed="15" />
      <xs:element name="rightExtraDigitFinger" type="xs:int" fixed="16" />
      <xs:element name="leftExtraDigitFinger" type="xs:int" fixed="17" />
      <xs:element name="unknownFrictionRidge" type="xs:int" fixed="18" />
      <xs:element name="entireJointImage" type="xs:int" fixed="19" />
      <xs:element name="unknownPalm" type="xs:int" fixed="20" />
      <xs:element name="rightFullPalm" type="xs:int" fixed="21" />
      <xs:element name="rightWritersPalm" type="xs:int" fixed="22" />
      <xs:element name="rightLowerPalm" type="xs:int" fixed="23" />
      <xs:element name="rightUpperPalm" type="xs:int" fixed="24" />
      <xs:element name="rightOtherPalm" type="xs:int" fixed="25" />
```

```

<xs:element name="rightInterdigital" type="xs:int" fixed="26" />
<xs:element name="rightThenar" type="xs:int" fixed="27" />
<xs:element name="rightHypothenar" type="xs:int" fixed="28" />
<xs:element name="leftFullPalm" type="xs:int" fixed="29" />
<xs:element name="leftWritersPalm" type="xs:int" fixed="30" />
<xs:element name="leftLowerPalm" type="xs:int" fixed="31" />
<xs:element name="leftUpperPalm" type="xs:int" fixed="32" />
<xs:element name="leftOtherPalm" type="xs:int" fixed="33" />
<xs:element name="leftInterdigital" type="xs:int" fixed="34" />
<xs:element name="leftThenar" type="xs:int" fixed="35" />
<xs:element name="leftHypothenar" type="xs:int" fixed="36" />
<xs:element name="rightGrasp" type="xs:int" fixed="37" />
<xs:element name="leftGrasp" type="xs:int" fixed="38" />
<xs:element name="rightIndexMiddleFingers" type="xs:int" fixed="40" />
<xs:element name="rightMiddleRingFingers" type="xs:int" fixed="41" />
<xs:element name="rightRingLittleFingers" type="xs:int" fixed="42" />
<xs:element name="leftIndexMiddleFingers" type="xs:int" fixed="43" />
<xs:element name="leftMiddleRingFingers" type="xs:int" fixed="44" />
<xs:element name="leftRingLittleFingers" type="xs:int" fixed="45" />
<xs:element name="rightIndexLeftIndexFingers" type="xs:int" fixed="46" />
<xs:element name="rightIndexMiddleRingFingers" type="xs:int" fixed="47" />
<xs:element name="rightMiddleRingLittleFingers" type="xs:int" fixed="48" />
<xs:element name="leftIndexMiddleRingFingers" type="xs:int" fixed="49" />
<xs:element name="leftMiddleRingLittleFingers" type="xs:int" fixed="50" />
<xs:element name="rightFourFingertips" type="xs:int" fixed="51" />
<xs:element name="leftFourFingertips" type="xs:int" fixed="52" />
<xs:element name="rightFingertips" type="xs:int" fixed="53" />
<xs:element name="leftFingertips" type="xs:int" fixed="54" />
<xs:element name="leftMiddleIndexRightIndexMiddleFingers" type="xs:int" fixed="55"
/>
<xs:element name="unknownSole" type="xs:int" fixed="60" />
<xs:element name="rightSole" type="xs:int" fixed="61" />
<xs:element name="leftSole" type="xs:int" fixed="62" />
<xs:element name="unknownToe" type="xs:int" fixed="63" />
<xs:element name="rightBigToe" type="xs:int" fixed="64" />
<xs:element name="rightSecondToe" type="xs:int" fixed="65" />
<xs:element name="rightMiddleToe" type="xs:int" fixed="66" />
<xs:element name="rightFourthToe" type="xs:int" fixed="67" />
<xs:element name="rightLittleToe" type="xs:int" fixed="68" />
<xs:element name="leftBigToe" type="xs:int" fixed="69" />
<xs:element name="leftSecondToe" type="xs:int" fixed="70" />
<xs:element name="leftMiddleToe" type="xs:int" fixed="71" />
<xs:element name="leftFourthToe" type="xs:int" fixed="72" />
<xs:element name="leftLittleToe" type="xs:int" fixed="73" />
<xs:element name="rightFrontBallFoot" type="xs:int" fixed="74" />
<xs:element name="rightBackHeelFoot" type="xs:int" fixed="75" />
<xs:element name="leftFrontBallFoot" type="xs:int" fixed="76" />
<xs:element name="leftBackHeelFoot" type="xs:int" fixed="77" />
<xs:element name="rightMiddleFoot" type="xs:int" fixed="78" />
<xs:element name="leftMiddleFoot" type="xs:int" fixed="79" />
<xs:element name="rightCarpalDelta" type="xs:int" fixed="81" />
<xs:element name="leftCarpalDelta" type="xs:int" fixed="82" />
<xs:element name="rightFullWithWriterPalm" type="xs:int" fixed="83" />
<xs:element name="leftFullWithWriterPalm" type="xs:int" fixed="84" />
<xs:element name="rightBracelet" type="xs:int" fixed="85" />
<xs:element name="leftBracelet" type="xs:int" fixed="86" />
<xs:element name="otherPosition" type="xs:int" fixed="999" />
</xs:choice>
</xs:complexType>

<xs:complexType name="PositionExtensionBlockType">
  <xs:sequence>
    <xs:element name="fallback" type="PositionCodeType"/>
    <xs:any namespace="##other" processContents="lax"/>
  </xs:sequence>
</xs:complexType>

<xs:complexType name="PositionType">
  <xs:choice>
    <xs:element name="code" type="PositionCodeType" />
    <xs:element name="extensionBlock" type="PositionExtensionBlockType" />
  </xs:choice>

```

```

    </xs:choice>
</xs:complexType>

<xs:complexType name="ImpressionCodeType">
  <xs:choice>
    <xs:element name="plainContact" type="xs:int" fixed="0" />
    <xs:element name="rolledContact" type="xs:int" fixed="1" />
    <xs:element name="latentImage" type="xs:int" fixed="4" />
    <xs:element name="swipeContact" type="xs:int" fixed="8" />
    <xs:element name="stationarySubjectContactlessPlain" type="xs:int" fixed="24" />
    <xs:element name="stationarySubjectContactlessRolled" type="xs:int" fixed="25" />
    <xs:element name="movingSubjectContactlessPlain" type="xs:int" fixed="41" />
    <xs:element name="movingSubjectContactlessRolled" type="xs:int" fixed="42" />
    <xs:element name="otherImpression" type="xs:int" fixed="28" />
    <xs:element name="unknownImpression" type="xs:int" fixed="29" />
  </xs:choice>
</xs:complexType>

<xs:complexType name="ImpressionExtensionBlockType">
  <xs:sequence>
    <xs:element name="fallback" type="ImpressionCodeType"/>
    <xs:any namespace="##other" processContents="lax"/>
  </xs:sequence>
</xs:complexType>

<xs:complexType name="ImpressionType">
  <xs:choice>
    <xs:element name="code" type="ImpressionCodeType" />
    <xs:element name="extensionBlock" type="ImpressionExtensionBlockType" />
  </xs:choice>
</xs:complexType>

<xs:complexType name="CaptureDeviceTechnologyIdCodeType">
  <xs:choice>
    <xs:element name="unknownCaptureDeviceTechnology" type="xs:int" fixed="0" />
    <xs:element name="otherCaptureDeviceTechnology" type="xs:int" fixed="1" />
    <xs:element name="scannedInkOnPaper" type="xs:int" fixed="2" />
    <xs:element name="opticalTIRBrightField" type="xs:int" fixed="3" />
    <xs:element name="opticalTIRDarkField" type="xs:int" fixed="4" />
    <xs:element name="opticalImage" type="xs:int" fixed="5" />
    <xs:element name="opticalLowFrequency3DMapped" type="xs:int" fixed="6" />
    <xs:element name="opticalHighFrequency3DMapped" type="xs:int" fixed="7" />
    <xs:element name="capacitive" type="xs:int" fixed="9" />
    <xs:element name="capacitiveRF" type="xs:int" fixed="10" />
    <xs:element name="electroLuminescence" type="xs:int" fixed="11" />
    <xs:element name="reflectedUltrasonic" type="xs:int" fixed="12" />
    <xs:element name="impediographicUltrasonic" type="xs:int" fixed="13" />
    <xs:element name="thermal" type="xs:int" fixed="14" />
    <xs:element name="directPressure" type="xs:int" fixed="15" />
    <xs:element name="indirectPressure" type="xs:int" fixed="16" />
    <xs:element name="liveTape" type="xs:int" fixed="17" />
    <xs:element name="latentImpression" type="xs:int" fixed="18" />
    <xs:element name="latentPhoto" type="xs:int" fixed="19" />
    <xs:element name="latentMolded" type="xs:int" fixed="20" />
    <xs:element name="latentTracing" type="xs:int" fixed="21" />
    <xs:element name="latentLift" type="xs:int" fixed="22" />
  </xs:choice>
</xs:complexType>

<xs:complexType name="CaptureDeviceTechnologyIdExtensionBlockType">
  <xs:sequence>
    <xs:element name="fallback" type="CaptureDeviceTechnologyIdCodeType"/>
    <xs:any namespace="##other" processContents="lax"/>
  </xs:sequence>
</xs:complexType>

<xs:complexType name="CaptureDeviceTechnologyIdType">
  <xs:choice>
    <xs:element name="code" type="CaptureDeviceTechnologyIdCodeType" />
    <xs:element name="extensionBlock" type="CaptureDeviceTechnologyIdExtensionBlockType" />
  </xs:choice>
</xs:complexType>

```

/>

```

    </xs:choice>
  </xs:complexType>

  <xs:complexType name="ImageDataFormatCodeType">
    <xs:choice>
      <xs:element name="pgm" type="xs:int" fixed="0" />
      <xs:element name="wsq" type="xs:int" fixed="1" />
      <xs:element name="jpeg2000Lossy" type="xs:int" fixed="2" />
      <xs:element name="jpeg2000Lossless" type="xs:int" fixed="3" />
      <xs:element name="png" type="xs:int" fixed="4" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="ImageDataFormatExtensionBlockType">
    <xs:sequence>
      <xs:any namespace="##other" processContents="lax"/>
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="ImageDataFormatType">
    <xs:choice>
      <xs:element name="code" type="ImageDataFormatCodeType" />
      <xs:element name="extensionBlock" type="ImageDataFormatExtensionBlockType" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name = "CoordinateBlockType" >
    <xs:complexContent>
      <xs:extension base="cmn:CoordinateCartesian2DUnsignedShortBlockType"/>
    </xs:complexContent>
  </xs:complexType>

  <xs:complexType name="CoordinatesBlockType">
    <xs:sequence>
      <xs:element name="coordinateBlock" type="CoordinateBlockType" minOccurs="2"
maxOccurs="unbounded" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="SegmentBlockType">
    <xs:sequence>
      <xs:element name="position" type="PositionType" />
      <xs:element name="enclosingCoordinatesBlock" type="CoordinatesBlockType" />
      <xs:element name="orientation" type="xs:unsignedByte" minOccurs="0" />
      <xs:element name="qualityBlocks" type="cmn:QualityBlocksType" minOccurs="0" />
      <xs:element name="confidence" type="cmn:ScoreOrErrorType" minOccurs="0" />
      <xs:any minOccurs="0" namespace="##other" processContents="lax" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="SegmentBlocksType">
    <xs:sequence>
      <xs:element name="segmentBlock" type="SegmentBlockType" maxOccurs="unbounded" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="SegmentationBlockType">
    <xs:sequence>
      <xs:element name="algorithmIdBlock" type="cmn:RegistryIdBlockType" />
      <xs:element name="segmentBlocks" type="SegmentBlocksType" />
      <xs:any minOccurs="0" namespace="##other" processContents="lax" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="AnnotationReasonCodeType">
    <xs:choice>
      <xs:element name="unknown" type="xs:int" fixed="0" />
      <xs:element name="other" type="xs:int" fixed="1" />
      <xs:element name="amputated" type="xs:int" fixed="2" />
      <xs:element name="unableToPrint" type="xs:int" fixed="3" />
      <xs:element name="bandaged" type="xs:int" fixed="4" />
    </xs:choice>
  </xs:complexType>

```