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Information technology — Extensible biometric data interchange formats —

Part 5:
Face image data

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Foreword

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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).

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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.

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Introduction

Face images have been used for many decades to verify the identity of individuals. In recent years, digital face images have been used in many applications including human examination as well as computer-automated face recognition. Photographic formats are standardized, e.g., for passports and driver licences. There is also a need for a standard data format for digital face images to enable interoperability. A prominent case where such interoperability is essential is the electronic passport system, where face images are stored for several purposes including Automated Border Control.

Biometric data interchange formats enable the interoperability of different biometric systems. The first generation of biometric data interchange formats was 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 were added, the header data structures were harmonized across all parts of the ISO/IEC 19794 series, and XML encoding was been added in addition to the binary encoding.

In anticipation of the need for additional data elements, and in order to avoid future compatibility issues, the ISO/IEC 39794 series provides standard biometric data interchange formats capable of being extended in a defined way. Extensible specifications in ASN.1 (Abstract Syntax Notation One) and the distinguished encoding rules (DER) of ASN.1 form the basis for encoding biometric data in binary tag-length-value formats. XSDs (XML schema definitions) form the basis for encoding biometric data in XML (eXtensible Markup Language).

This third generation of face image data interchange formats complements ISO/IEC 19794-5:2005 and ISO/IEC 19794-5:2011. 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 to provide a generic face image data format for face recognition applications requiring exchange of face image data. Typical applications are:

— automated face biometric verification (one-to-one comparison) and identification (one-to-many comparison), and

— human verification of a biometric claim by comparison of data subjects against face images, including examination of face images with sufficient detail.

In addition to the data format, this document specifies application specific profiles including scene constraints, photographic properties and digital image attributes like image spatial sampling rate, image size, etc. These application profiles are contained in Annex D.

The structure of the data format in this document is not compatible with the previous generations. However, this new revision addresses, for the first time, a mechanism to maintain future extensions in a backwards- and forwards-compatible manner. This will mean that a parser is able to read data records and understand data items that are formatted according to versions of the standard that are older, the same or newer than the parser is developed to. All newer data items will not disrupt the parsing process and can be ignored. Newer versions of this document will at least include the mandatory data items of the previous standards.

The 3D encoding types 3D point map and range image are not supported by this edition of this document.

Information technology — Extensible biometric data interchange formats —

Part 5: Face image data

1 Scope

This document specifies:

— generic extensible data interchange formats for the representation of face 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: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER) — Part 1*

ITU-T Rec. T.81 | ISO/IEC 10918-1, *Information technology — Digital compression and coding of continuous-tone still images — Part 1: Requirements and guidelines*

ISO 11664-2:2007, *Colorimetry — Part 2: CIE standard illuminants*

ISO/IEC 14496-2:2004, *Information technology — Coding of audio-visual objects — Part 2: Visual*

ITU-T Rec. T.800 | ISO/IEC 15444-1, *Information technology — JPEG 2000 image coding system— Part 1: Core 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*

Doc ICAO 9303: *Machine Readable Travel Documents*

W3C Recommendation, *XML Schema Part 1: Structures* (Second Edition), 28 October 2004, http://www.w3.org/TR/xmlschema-1/

W3C Recommendation, *XML Schema Part 2: Datatypes* (Second Edition), 28 October 2004, http://www.w3.org/TR/xmlschema-2/

3 Terms and definitions

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

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
1:1 application case
biometric verification

Note 1 to entry: Biometric verification is defined in ISO/IEC 2382-37 as a process of confirming a biometric claim through biometric comparison.

3.2
1:N application case
biometric identification

Note 1 to entry: Biometric identification is defined in ISO/IEC 2382-37 as a process of searching against a biometric enrolment database to find and return the biometric reference identifier(s) attributable to a single individual.

3.3
2D face image
two-dimensional face representation that encodes the luminance and/or colour texture of the face of a capture subject in a given lighting environment

3.4
3D face image
three-dimensional face representation that encodes a surface in a 3D space

3.5
3D vertex
representation using 3D vertices and triangles between these points for coding of a 3D surface

3.6
RGB
colour space designed to encompass most of the colours achievable on CMYK colour printers, but by using red, green and blue primary colours on a device such as a computer display

3.7
anthropometric landmark
landmark on the face used for identification and classification of humans

3.8
landmark code
<anthropometric> two-part code that uniquely defines an anthropometric landmark

3.9
camera to subject distance
CSD
distance between the eyes plane of a capture subject and the and the sensor/image plane of the camera

3.10
Cartesian coordinate system
3D orthogonal coordinate system

3.11
chin
central forward portion of the lower jaw

3.12
CIE standard illuminant D65
commonly used standard illuminant defined by the International Commission on Illumination (CIE) that is intended to represent average daylight and has a correlated colour temperature of approximately 6500 K

Note 1 to entry: CIE standard illuminant D65 is specified in ISO 11664-2.

3.13
colour image
continuous tone image (3.16) that has more than one channel, each of which is coded with one or multiple bits

3.14
colour space
way of representing colours of pixels in an image

EXAMPLE RGB and YUV colour spaces are typically used in this document.

3.15
common biometric exchange formats framework
CBEFF
data format specifically for exchanging biometric data that provides for the encompassing of any biometric type into a standard format

3.16
continuous tone image
image whose channels have more than one bit per pixel

3.17
crop factor
ratio of the diagonal of the full frame camera (43,3 mm) to that of a selected camera's image sensor

Note 1 to entry: The determination of an appropriate focal length lens for a field of view equivalent to a full frame camera can be made by considering the crop factor.

3.18
crown
top of the head ignoring any hair

3.19
dots per inch
DPI
individual printed dots in a line or column within a span of 25,4 mm (1 inch)

3.20
exposure value
EV
number that represents a combination of a camera's shutter speed and f-number, such that all combinations that yield the same exposure have the same description value

3.21
eye centre
centre of the line connecting the inner and the outer corner of the eye

Note 1 to entry: The eye centres are the feature points 12.1 and 12.2 as defined in ISO/IEC 14496-2:2004, Annex C.

Note 2 to entry: The inner and the outer corner of the eye are defined by ISO/IEC 14496-2-2:2004: feature points 3.12 and 3.8 for the right eye, and 3.11 and 3.7 for the left eye.

3.22
eye-to-mouth distance
EMD
distance between the face centre and the mouth midpoint

Note 1 to entry: The mouth midpoint is the feature point 2.3 as defined in ISO/IEC 14496-2:2004, Annex C.

3.23
eye visibility zone
EVZ
zone covering a rectangle having a margin to any part of the visible eyeball

Note 1 to entry: The margin is defined in D.1.4.3.3.

3.24
face centre
M
midpoint of the line connecting the two eye centres

3.25
face image kind
category of *face images* (3.27) that satisfy specific requirements

Note 1 to entry: Application specific requirements are specified in one of the application profiles in Annex D.

3.26
facial animation parameter
FAP
standard for the virtual representation, which includes visual speech intelligibility, mood and gesture by using feature points

Note 1 to entry: Visual representation as specified in ISO/IEC 14496-1 and ISO/IEC 14496-2.

3.27
face image
electronic image-based representation of the face of a capture subject

3.28
face portrait
visual representation of the capture subject, which includes the full-frontal part of the head, including hair in most cases, as well as neck and possibly top of shoulders

3.29
face texture
2D sampling face representation that encodes one or a combination of several spectral spatial modulations received by 3D imaging systems of a face in a given lighting system having a 2D coordinate link to the face shape

3.30
feature point
reference point in a face image as used by face recognition algorithms

Note 1 to entry: Commonly referred to as a landmark, an example being the position of the eyes.

3.31
fish eye
type of distortion where central objects of the image erroneously appear closer than those at the edge

3.32
Frankfurt Horizon
standard plane for orientation of the head defined by a line passing through the right tragion (the front of the ear) and the lowest point of the right eye socket

Note 1 to entry: The Frankfurt Horizon may be hard to define, as it is related to the ear position that may be covered by hair.

Note 2 to entry: The Frankfurt Horizon has been defined in the Frankfurt-am-Main (anthropological) Agreement of 1882.

3.33
greyscale image
continuous tone image (3.16) encoded with one luminance channel

Note 1 to entry: If the luminance channel is coded with 8 bits, the greyscale image is also referred to as a monochrome or black and white image.

3.34
horizontal deviation angle
HD
maximal allowed deviation from the horizontal of the imaginary line between the nose of a capture subject and the lens of the camera

3.35
human examination
process of human comparison of a face image with an individual or another face image through detailed examination of face characteristics and structures for the purposes of biometric verification or identification

3.36
human identification
process of human searching through a list of face images to match against an input image(s)

Note 1 to entry: Also known as one-to-many (1:N) searching.

Note 2 to entry: Identification can be performed by human (experts) as well, and human identification may consider more than biometric data.

3.37
human verification
process of confirming a specific biometric claim by human comparison of a face image with an individual or another face image

Note 1 to entry: Also known as one-to-one (1:1) comparison.

Note 2 to entry: Verification can be performed by human (experts) as well, and human verification may consider more than biometric data.

3.38
implementation under test
IUT
Implementation of a technical system currently tested

3.39
inner region
pixels of a face image carrying data of the central region of a face

3.40
inter-eye distance
IED
length of the line connecting the eye centres of the left and right eye

3.41
issuer
organization that issues Machine Readable Travel Documents (MRTDs)

3.42
lower camel-case notation
naming convention in which compound words are joined together without spaces, where the first letter of the entire word is lowercase, but the first letter of subsequent words is uppercase

3.43
magnification distortion
image imperfection where the degree of magnification varies with the distance from the camera and the depth of the face

3.44
modus
manner in which a particular property is acquired

3.45
near infrared
section of infrared band with wavelength from 780 nm to 3000 nm

3.46
outer region
pixels of a face image outside of the inner region

3.47
photo booth
automated system for digitally capturing 2D images in either public or office environments

Note 1 to entry: A photo booth encloses the subject in a highly-controlled lighting environment and consists of a camera, lighting and peripheral devices such as printers. It has entrances on one or both sides with reflective curtains protecting against ambient light.

3.48
photo kiosk
semi-automated system for digitally capturing 2D images in an office-environment

Note 1 to entry: A photo kiosk consists of camera and lighting and usually has a separate panel placed behind the subject to provide the required background but is otherwise open.

3.49
pixel
picture element on a two-dimensional array that comprises an image

3.50
pixel per inch
PPI
individual pixels in a line or column of a digital image within a span of 25,4 mm (1 inch)

3.51
presentation attack
presentation of an artefact or human characteristic to the biometric capture subsystem in a fashion that could interfere with the intended policy of the biometric system

3.52
presentation attack detection
PAD
automated determination of a presentation attack

3.53
radial distortion
image imperfection where the degree of magnification varies with the distance from the optical axis

3.54
red eye effect
red glow from a subject's eye caused by light from flash reflecting from blood vessels behind the retina

3.55
subject
individual who is to be displayed on the face portrait

Note 1 to entry: If the face portrait is part of a Machine Readable Travel Document (MRTD), this individual is intended to be the holder of the MRTD.

3.56
upper camel-case notation
naming convention in which compound words are joined together without spaces and the first letter of every word is uppercase

3.57
wavelength
distance between repeating units of a wave pattern

Note 1 to entry: Commonly designated by the Greek letter lambda (λ).

3.58
white light
apparently colourless light on human perception

EXAMPLE Ordinary daylight, standard lights as D50, D65, etc.

Note 1 to entry: For many purposes it is assumed that white light contains all wavelengths of the visible spectrum at equal intensity based on human perception. Strong deviations from equal intensity usually lead to deviations in the perception of colours.

4 Abbreviated terms

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

ABC Automated Border Control

CCD charge-coupled device

CMOS complementary metal-oxide-semiconductor

CSD camera to subject distance

DOVID diffractive optically variable image device

DPI dots per inch

EMD eye-to-mouth distance

EV	exposure value
EVZ	eye visibility zone
FAP	facial animation parameter
FH	Frankfurt Horizon
HD	horizontal deviation angle
ICAO	International Civil Aviation Organization
IED	Inter-eye distance
JPEG	image compression standard specified as ISO/IEC 10918; the JPEG baseline standard was published as ITU-T Rec. T.81 | ISO/IEC 10918-1
JPEG2000	image compression standard specified as ISO/IEC 15444; the JPEG2000 baseline standard was published as ITU-T Rec. T.800 | ISO/IEC 15444-1
LDS	logical data structure as defined in ICAO Doc 9303
M	face centre
MP	intensity measurement pattern side length
MRTD	machine readable travel document, the term also includes electronic MRTD's, electronic machine readable travel document using a contactless integrated circuit
MTF	modulation transfer function
MTF20	highest spatial frequency where the MTF is 20 % or above
NIR	near infrared
PPCM	pixel per centimetre
PPI	pixel per inch
PNG	portable network graphics format specified as ISO/IEC 15948
RFID	radio-frequency identification
RGB	red green blue colour representation
SFR	spatial frequency response
SNR	signal to noise ratio
sRGB	standard RGB colour space created for use on monitors, printers and the Internet using the ITU-R BT.709 primaries

5 Conformance

A BDB conforms to this document if it satisfies all the relevant requirements related to:

— its data structure, data values and the relationships between its data elements as specified throughout Clauses 7, 8 and Annex A,

— the relationship between its data values and the input biometric data from which the BDB was generated as specified throughout Clauses 7, 8, and Annex A, and

— application profile specific compliance specifications given in Annex C.4.

A system that produces biometric data records is conformant to this document if all biometric data records that it outputs 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 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 BDBs is conformant to this document if it can read, and use for the purpose intended by that system, all BDBs 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 BDBs 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

The recorded image data shall appear to be the result of a capture process of a face. 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, which corresponds to the upper right-hand side of the forehead from the perspective of the capture subject. The x-coordinate (horizontal) position shall increase positively from the origin to the right side of the image (i.e. left-hand forehead). The y-coordinate (vertical) position shall increase positively from the origin to the bottom of the image.

7 Abstract data elements

7.1 Overview

7.1.1 Content and notation

This clause describes the contents of data elements defined in this document. These semantic descriptions are independent of the encoding of the data elements.

The presence of data elements is specified in Annex A. Certain data elements are optional. Such data elements need not be included in a BDB. An optional data element may be omitted altogether from the encoding.

Application profiles as defined in Annex D may further restrict the presence of data elements. Such profiles may make optional elements mandatory, and they may exclude optional elements.

In an ASN.1 module, optional data elements are marked with the keyword OPTIONAL. When such an element is not present, then the tag, length and value octets of this data element are omitted from the tagged binary encoding.

A data element in an XML schema definition is optional if the value of its minOccurs attribute is 0. When such an element is not present, the opening and closing tags as well as the value of this data element are omitted from the XML encoding.

If all child elements of a data element are optional, this data element shall be marked optional as well.

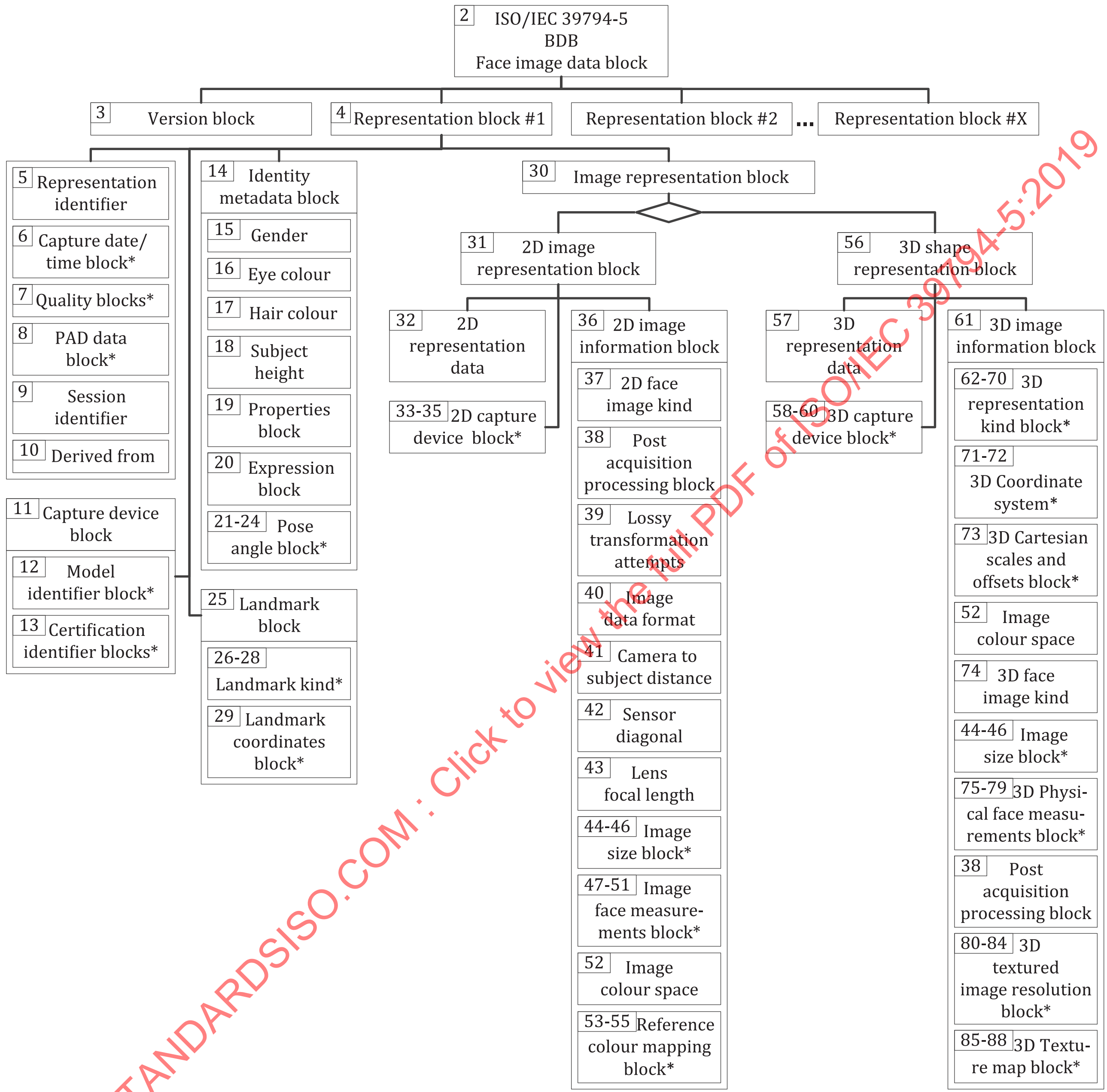
Type names are in upper camel-case notation derived from subclause titles in this clause. Element names are in lower camel-case notation derived from these subclause titles. If the generic name starts with a number, then this component is set to the end of the base name. In the XSD, type names will end with the word “Type”.

EXAMPLE 1 The Image Colour Space element has the encoding name imageColourSpace and the type ImageColourSpace (in ASN.1) and ImageColourSpaceType (in XML).

EXAMPLE 2 An element value with the abstract name colour coded light has the value colourCodedLight. An element value with the abstract name 48 bit RGB has the encoding value rgb48Bit.

7.1.2 Structure overview

The order of the abstract data elements in 7.2 and beyond is derived from traversing the tree in Figure 1 from left to right, depth first. A formal description of the structure is given in Annex A.1 for ASN.1 and in Annex A.2 for the XML encoding of these abstract data elements.



Key

* elements which can be divided in sub-elements, not shown in this Figure

◇ Exclusive Or (XOR), one, and only one, option shall be chosen

[n] denotes that this element is defined in Clause 7.n

The Figure has been manually generated, its content is informative. The normative structure is given in A.1 for ASN.1 and A.2 for XML.

Figure 1 — Face image data block

7.1.3 Data conventions

For value measurement the following units are used:

— physical measurement: millimetres;

— image measurement: pixels;

— left/right: from perspective of the subject.

Unless otherwise specified, all other numeric values are unsigned integer quantities.

The conversion of a numeric value to integer is given by rounding down if the fractional portion is less than 0,5 and rounding up if the fractional value is greater than or equal to 0,5.

The absence of an optional element means that the encoder does not provide any statement about the value of the element.

7.2 Face image data block

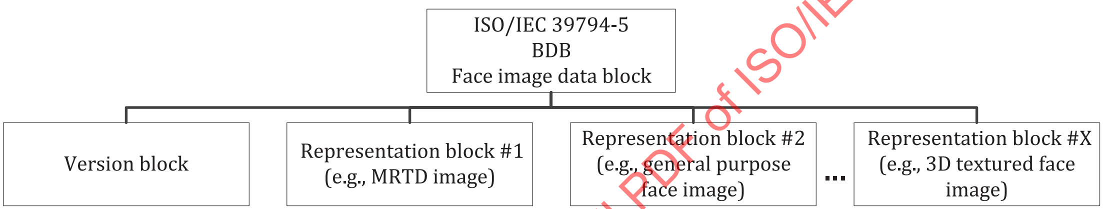


Figure 2 — Example of embedding multiple representations in the same Face image data block

Abstract values: None

Contents: Each BDB shall pertain to a single subject and shall contain one or more representations of a human face. Together with the Version block, each BDB can contain one or more geometric representations in Representation blocks. The record structure is depicted in Figure 2.

7.3 Version block

Abstract values: The abstract values for the Version block are defined in 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.

If a BDB contains representations encoded using different versions of an extensible biometric data interchange format, then the version number of the most recent version of the encoding versions shall be used.

7.4 Representation block

Abstract values: None.

Contents: A Representation block consists of a unique Representation identifier characterizing this Representation block, an Image representation block, a Capture date/time block, Quality blocks, a PAD data block, a Session identifier, an identifier to define a relationship to another record, called Derived from, a Capture device block, a Identity metadata block describing discernible characteristics of the subject, and the Landmark blocks. The structure of this element is shown in Figure 1.

Multiple face image representations of the same biometric data subject may be described in the same Face image data block. This is accomplished by including multiple Representation blocks. Face image representations containing 2D data may be combined with face image representations containing 3D data.

EXAMPLE The structure of a possible storage of Respresentaton blocks containing 2D and 3D data is illustrated in Figure 2.

7.5 Representation identifier

Abstract values: Integer.

Contents: This element shall obtain a unique identifier for the Representation block. Each representation shall have its unique Representation identifier.

NOTE Unlike other parts of the ISO/IEC 39794 series, this document requires Representation identifiers to link processed data to its original source.

7.6 Capture date/time block

Abstract values: See Capture date/time block in ISO/IEC 39794-1.

Contents: The Capture date/time block shall indicate when the capture of this representation started in Coordinated Universal Time (UTC).

7.7 Quality blocks

Abstract values: See Quality blocks in ISO/IEC 39794-1.

Contents: This element contains information on the biometric sample quality.

7.8 PAD data block

Abstract values: See PAD data block in ISO/IEC 39794-1.

Contents: This element shall convey the mechanism used in biometric presentation attack detection and the results of the presentation attack detection mechanism.

7.9 Session identifier

Abstract values: Integer.

Contents: This element shall map the Representation block to the photo session where the face image was recorded.

7.10 Derived from

Abstract values: Integer.

Contents: This element shall denote interdependencies when multiple representations are stored in a Face image data block. This is of particular interest in the case where post-processing has been used but may be used in case of all other image types, too. The value shall be the Representation identifier number of the original representation.

To give an example for an application of this specification, assume that there are two Representations in the overall record. Their identifiers are 1 and 2. The first representation has been post-processed and resulted in the second representation. Then, the second representation shall have the Derived from element set to 1.

7.11 Capture device block

Abstract values: See Capture device block in ISO/IEC 39794-1.

Contents: The Capture device block contains the Model identifier block and the Certification identifier blocks.

7.12 Model identifier block

Abstract values: See Model identifier block in ISO/IEC 39794-1.

Contents: The Model identifier block shall identify the biometric organization that manufactures the product that created the BDB. It shall carry a CBEFF biometric organization identifier (see ISO/IEC 39794-1). Additionally, it shall identify the product type that created the BDB. It shall be assigned by the registered product manufacturer or other approved registration authority (see ISO/IEC 39794-1).

7.13 Certification identifier blocks

Abstract values: See Certification identifier blocks in ISO/IEC 39794-1.

Contents: This document does not contain details of certification schemes.

NOTE Currently, no certification schemes are available for this document.

7.14 Identity metadata block

Abstract values: For the structure see Figure 1.

Contents: The Identity metadata block is intended to describe properties of the subject pictured in the image. The Identity metadata block consists of the Gender, Eye colour, Hair colour, and Subject height elements, the Properties block, the Expression block, and the Pose angle block.

If all elements of this element are absent, the element itself shall be absent, too.

7.15 Gender

Abstract values: The value of this element shall be one of the following:

— unknown;

— other;

— male;

— female.

Contents: The Gender element shall represent the gender of the subject.

7.16 Eye colour

Abstract values: The value of this element shall be one of the following:

— unknown;

— other;

— black;

— blue;

— brown;

— grey;

— green;

— hazel;

— multi-coloured;

— pink.

Contents: The Eye colour element shall represent the colour of the irises of the eyes. If the eyes have different colours, then the colour of the right eye shall be encoded.

7.17 Hair colour

Abstract values: The value of this element shall be one of the following.

Contents:
- — unknown;
- — other;
- — bald;
- — black;
- — blonde;
- — brown;
- — grey;
- — white;
- — red;
- — known coloured (it is known that the hair colour has been changed from the natural one of that capture subject).

Contents: The Hair colour element shall represent the colour of the hair of the subject.

7.18 Subject height

Abstract values: Integer.

Contents: The Subject height element shall represent the height of the subject in millimetres. The minimum value for this element shall be 1 mm and the maximum value shall be 65535 mm.

NOTE This value in most cases can only be used as a rough estimate of the subject height. Shoes, age, and even time of the day influence this measure.

7.19 Properties block

Abstract values: This element contains one or several of the following elements:

- glasses;
- moustache;
- beard;
- teeth visible;
- pupil or iris not visible (e.g. either or both eyes closed or half closed);
- mouth open;
- left eye patch;
- right eye patch;
- dark glasses (medical);
- biometric absent (conditions which could impact landmark detection);
- head coverings present (e.g., hats, scarves, toupees).

Contents: The Properties block indicates which properties are present. There may be restrictions for different Face image kinds (see the profiles in Annex D). Each element may be true, false or absent. False elements do not need to be listed unless those elements are mandatory.

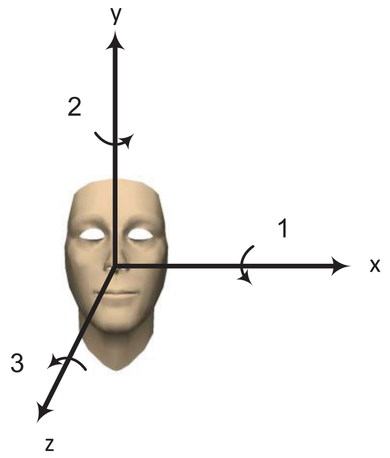
7.20 Expression block

Abstract values: This element contains one or several of the following items:

- neutral (non-smiling) with both eyes open and mouth closed;
- smile;
- raised eyebrows;
- eyes looking away from the camera;
- squinting;
- frowning.

Contents: The Expression block indicates which expressions are shown. Each element may be true, false or absent. False elements do not need to be listed unless those elements are mandatory. Neutral and smile shall not be both true for the same image.

7.21 Pose angle block



Key

1 pitch (P)

2 yaw (Y)

3 roll (R)

The three elements together define the pose (Y, P, R).

Figure 3 — Definition of pose angles with respect to the frontal view of the subject

Abstract values: The Pose angle block contains Angle blocks for yaw, pitch, and roll.

Contents: The Pose angle block shall represent the estimated or measured pose of the subject in the image.

The angles encoded in this element are:

Yaw angle block (Y): Rotation about the vertical (y) axis. The yaw angle Y is the rotation in degrees about the y-axis (vertical axis) shown in Figure 3. Frontal poses have a yaw angle of 0°. Positive angles represent faces looking to their left (a counter-clockwise rotation around the y-axis).

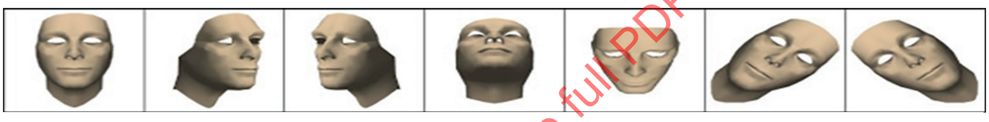
Pitch angle block (P): Rotation about the horizontal side-to-side (x) axis. The pitch angle P is the rotation in degrees about the x-axis (horizontal axis) shown in Figure 3. Frontal poses have a pitch angle of 0°. Positive angles represent faces looking down (a counter-clockwise rotation around the x-axis).

Roll angle block (R): Rotation about the horizontal back to front (z) axis. The roll angle R is the rotation in degrees about the z-axis (the horizontal axis from front to back) shown in Figure 3. Frontal poses have a roll angle of 0°. Positive angles represent faces tilted toward their right shoulder (counter-clockwise rotation around the z-axis). A roll angle of 0° denotes that the left and right eye centres have identical y coordinates.

The angles are defined relative to the frontal pose of the subject, which has angles (Y = P = R = 0) as shown in Figure 3. The frontal pose is defined by the Frankfurt Horizon as the xz plane and the vertical symmetry plane as the yz plane with the z axis oriented in the direction of the face sight. Examples are shown in Figure 4.

As order of the successive rotation around the different axes does matter, the encoded rotation angle shall correspond to an order of execution starting from the frontal view. This order shall be given by roll (about the front axis), then pitch (about the horizontal axis) and finally yaw (about the vertical axis). The (first executed) roll transformation will therefore always be in the image xy plane.

From the point of view of executing a transformation from the observed view to a frontal view, the transformation order will therefore be in the opposite order: Yaw, pitch, and then roll. The encoded angles are from the frontal view to the observed view. The conversion to integer is specified in 7.1.



(Y,P,R) = (0, 0, 0)   (+45, 0, 0)   (-45, 0, 0)   (0, -45, 0)   (0, +45, 0)   (0, 0, -45)   (0, 0, 45)

Figure 4 — Examples of pose angles in the form (Y, P, R)

7.22 Angle data block

Abstract values: Angle value and Angle uncertainty.

Contents: The Angle data block element contains an Angle value and its corresponding Angle uncertainty.

7.23 Angle value

Abstract values: Integer, the minimum value is −180, the maximum value is 180.

Contents: The Angle value is given by Tait-Bryan angles (in degrees).

7.24 Angle uncertainty

Abstract values: The minimum value of an Angle uncertainty variable is 0, the maximum value is 180.

Contents: The Angle uncertainty represents the expected degree of uncertainty of the associated pose angle. The more uncertain, the value of the uncertainty shall become larger. The Angle uncertainty allows storing an uncertainty or tolerance value for an angle. The true angle should be in a range of Angle value ± Angle uncertainty. If the associated pose angle is absent, the Angle uncertainty for this angle shall be absent, too.

7.25 Landmark block

Abstract values: None.

Contents: The Landmark block specifies the type, code and position of landmarks in the face image. If the Landmark blocks element is present, it shall contain at least one Landmark block. A Landmark block consists of the Landmark kind element and the Landmark coordinates block. The structure of this element is shown in Figure 1.

Landmarks can be specified as MPEG-4 feature points as given by ISO/IEC 14496-2:2004, Annex C or as anthropometric landmarks. The description of the anthropometric landmarks[2] and their relation with the set of MPEG4 feature points is discussed in Table 2.

7.26 Landmark kind

Abstract values: MPEG4 feature point or anthropometric landmark.

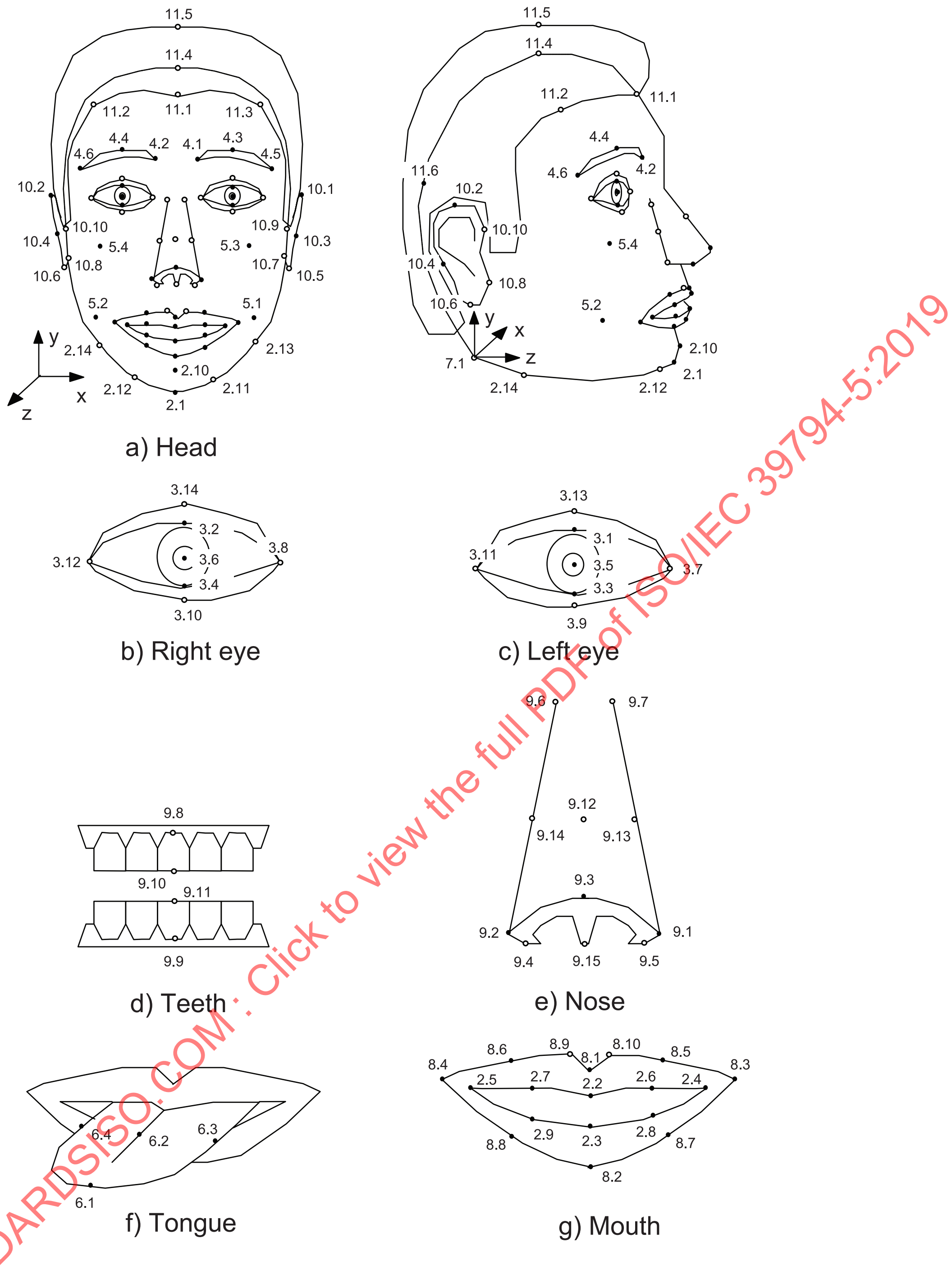
Contents: The Landmark kind shall either be MPEG4 feature point or anthropometric landmark. The Landmark code shall specify the landmark that is stored in the Landmark block element. The MPEG4 feature points are extended by eye and nostril landmarks

References to right and left shall be taken from the perspective of the subject contained within an image. References to right shall mean the right side of the body from the perspective of the subject. References to the left shall mean the left side of the body from the perspective of the subject.

7.27 MPEG4 feature point

Abstract values: See Figure 5 and Figure 6.

Contents: Figure 5 denotes the landmark codes associated with feature points as given by ISO/IEC 14496-2:2004, Annex C. Each landmark can be written in the form A.B using a major (A) and a minor (B) value. Eye and nostril landmarks are contained as an addition to the MPEG4 feature points.



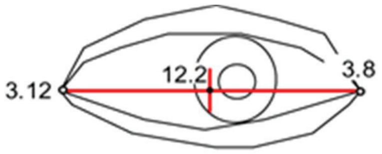
Key

● feature points affected by face animation parameters (FAPs) as specified in ISO/IEC 14496-2

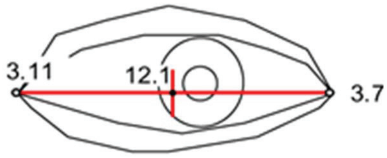
○ other feature points

Figure 5 — Feature points as specified in ISO/IEC 14496-2

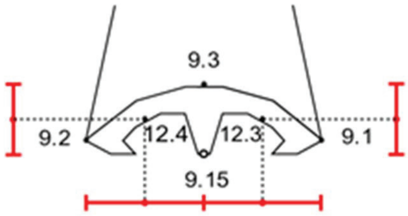
The eye centre landmarks 12.1 (left) and 12.2 (right) are defined to be the horizontal and vertical midpoints of the eye corners (3.7, 3.11) and (3.8, 3.12) respectively. The left nostril centre landmark 12.3 is defined to be the midpoint of the nose landmarks (9.1, 9.15) in the horizontal direction and (9.3, 9.15) in the vertical direction. Similarly, the right nostril centre landmark 12.4 is defined to be the midpoint of the nose landmarks (9.2, 9.15) in the horizontal direction and (9.3, 9.15) in the vertical direction. Both the eye centre and nostril centre landmarks are shown in Figure 6 and values given in Table 1.



a) Right eye



b) Left eye



c) Nostrils

Key

- ● feature points affected by FAPs
- ○ other feature points

The landmarks 12.1, 12.2, 12.3, and 12.4 are defined to be the midpoints of MPEG features.

Figure 6 — Eye and nostril centre landmarks

Table 1 — Eye and nostril centre landmark codes

Centre landmark	Midpoint of landmarks		Landmark code
Left eye	3.7, 3.11		12.1
Right eye	3.8, 3.12		12.2
Left nostril	Horizontal	Vertical	12.3
	9.1, 9.15	9.3, 9.15	
Right nostril	Horizontal	Vertical	12.4
	9.2, 9.15	9.3, 9.15	

7.28 Anthropometric landmark

Abstract values: See Table 2.

Contents: Anthropometric landmarks denote feature points that are used in forensics and anthropology for recognition of individuals via two face images or image and skull over a long time. They also allow specification of points that are in use by criminal examiners and anthropologists[2].

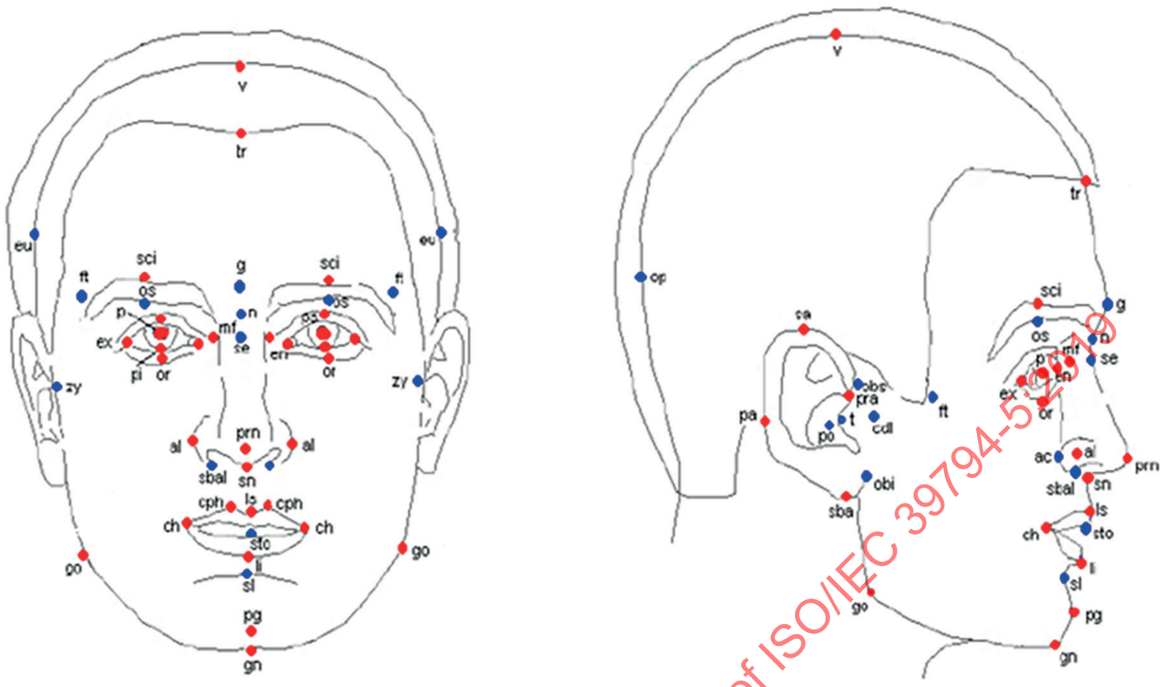
Figure 7 and Table 2 show the definition of the Anthropometric landmarks. The set of points represents the craniofacial landmarks of the head and face. The latter are used in forensics for “face to face” and “skull to face” identification. Some of these points have MPEG 4 counterparts, others not.

There are three different possibilities to encode an Anthropometric landmark:

Firstly, each Anthropometric landmark may be notated in the form A.B. A specifies the global landmark of the face to which this landmark belongs such as nose, mouth, etc. B specifies the particular point. In case a landmark has two symmetrical entities (left and right) the right entity always has a greater and even minor code value. Hence, all landmarks from the left part of the face have odd minor codes, and from the right part – even minor codes.

Secondly, each Anthropometric landmark may be notated by its name. In case a landmark has two symmetrical entities (left and right) a "left" or "right" shall be added to the names in Table 2.

Thirdly, each Anthropometric landmark may be notated by its point identifier. In case a landmark has two symmetrical entities (left and right) a "left" or "right" shall be added to the names in Table 2.



Key

- ● landmarks without MPEG4 counterpart
- ● landmarks with MPEG4 counterpart

Figure 7 — Anthropometric landmarks

Table 2 — Definitions of the anthropometric landmarks

Anthropometric landmark point identifier	Anthropometric landmark point name	MPEG4	Anthropometric landmark name	How to point
v	1.1	11.4	vertex	The highest point of head when the head is oriented in Frankfurt Horizon
g	1.2		glabella	The most prominent middle point between the eyebrows
op	1.3		opisthocranion	Situated in the occipital region of the head is most distant from the glabella
eu	1.5, 1.6		eurion	The most prominent lateral point on each side of the skull in the area of the parietal and temporal bones
ft	1.7, 1.8		frontotemporale	The point on each side of the forehead, laterally from the elevation of the linea temporalis
tr	1.9	11.1	trichion	The point on the hairline in the midline of the forehead
zy	2.1, 2.2		zygion	The most lateral point of each of the zygomatic
go	2.3,2.4	2.13, 2.14	gonion	The most lateral point on the mandibural angle close to the bony gonion

Table 2 *(continued)*

Anthropometric landmark point identifier	Anthropometric landmark point name	MPEG4	Anthropometric landmark name	How to point
sl	2.5		sublabiale	Determines the lower border of the lower lip or the upper border of the chin
pg	2.6	2.10	pogonion	The most anterior midpoint of the chin, located on the skin surface in the front of the identical bony landmark of the mandible
gn	2.7	2.1	menton (or gnathion)	The lowest median landmark on the lower border of the mandible
cdl	2.9, 2.10		condylion laterale	The most lateral point on the surface of the condyle of the mandible
en	3.1, 3.2	3.11, 3.8	endocanthion	The point at the inner commissure of the eye fissure
ex	3.3, 3.4	3.7, 3.12	exocanthion (or ectocanthion)	The point at the outer commissure of the eye fissure
p	3.5, 3.6	3.5, 3.6	centre point of pupil	Is determined when the head is in the rest position and the eye is looking straight forward
or	3.7, 3.8	3.9, 3.10	orbitale	The lowest point on the lower margin of each orbit
ps	3.9, 3.10	3.1, 3.2	palpebrale superius	The highest point in the midportion of the free margin of each upper eyelid
pi	3.11, 3.12	3.3, 3.4	palpebrale inferius	The lowest point in the midportion of the free margin of each lower eyelid
os	4.1, 4.2		orbitale superius	The highest point on the lower border of the eyebrow
sci	4.3, 4.4	4.3, 4.4	superciliare	The highest point on the upper border in the midportion of each eyebrow
n	5.1		nasion	The point in the middle of both the nasal root and nasofrontal suture
se	5.2		sellion (or subnasion)	Is the deepest landmark located on the bottom of the nasofrontal angle
al	5.3, 5.4	9.1, 9.2	alare	The most lateral point on each alar contour
prn	5.6	9.3	pronasale	The most protruded point of the apex nasi
sn		9.15	subnasale	The craniometric point at the base of the nasal (nose) spine
sbal			subalare	
ac		9.1, 9.2	alar curvature (or alar crest) point	The nasal alar crest
mf		9.6, 9.7	maxillofrontale	
cph		8.9, 8.10	christa philtra landmark	The point on the crest of the philtrum, the vertical groove in the median portion of the upper lip, just above the vermillion border (sharp demarcation between the lip and the adjacent normal skin)

Table 2 *(continued)*

Anthropometric landmark point identifier	Anthropometric landmark point name	MPEG4	Anthropometric landmark name	How to point
ls		8.1	labiale (or labrale) superius	The mid point of the vermillion border of the upper lip
li		8.2	labiale (or labrale) inferius	The mid point of the vermillion border of the lower lip
ch		8.3, 8.4	cheilion	The outer corner of the mouth where the outer edges of the upper and lower vermillions meet
sto			stomion	The median point of the oral slit when the lips are closed
sa		10.1, 10.2	superaurale	The furthermost point of the ear lobe when measured from the sba landmark
sba		10.5, 10.6	subaurale	The lowest point on the inferior (lower) border of the ear lobule when the subject is looking straight ahead
pra		10.9, 10.10	preaurale	The point between obs and abi opposite to pa
pa			postaurale	The most posterior point on the free margin of the ear
obs		10.3, 10.4	otobasion superius	The highest point of attachment of the external ear to the head
obi			obotasion inferius	The lowest point of attachment of the external ear to the head
po			porion (soft)	The central point on the upper margin of the external auditory meatus (passage in the ear)
t			tragion	A cephalometric point in the notch just above the tragus (small tongue-like projection of the auricular cartilage) of the ear

7.29 Landmark coordinates block

Abstract values: None.

Contents: The Landmark coordinates block shall contain the coordinates of the associated landmark in the 2D Cartesian coordinate system (in case of 2D image representation block existence), in a Coordinate texture image block, or in a 3D Cartesian coordinate system (in case of 3D image representation block existence).

In 2D Image representation blocks, the Z coordinate of the Cartesian coordinate system is not used. This element shall then contain the horizontal and vertical position of the associated landmark. They are measured in pixels with values from 0 to width-1 and from 0 to height-1. The Coordinate texture image block consists of the two integer values uInPixel and vInPixel. In 3D Shape representation blocks, the X, Y, and Z coordinates are mandatory and defined in the 3D Cartesian coordinate system. The X, Y, and Z coordinates are non-negative integers. The landmarks are converted to metric Cartesian coordinates using the Cartesian scales and offsets block. The error of the Z coordinate of an anthropometric landmark location should be no greater than 3 mm. The point shall withstand from the nearest point on the surface no further than 3 mm.

7.30 Image representation block

Abstract values: Either 2D image representation block, or 3D shape representation block.

Contents: The Image representation block contains the image data and metadata. It is either a 2D image representation block or a 3D shape representation block.

7.31 2D image representation block

Abstract values: None.

Contents: The 2D image representation block contains the 2D representation data, the 2D image information block, and the 2D capture device block.

7.32 2D representation data

Abstract values: Octet string.

Contents: The 2D representation data element shall contain the encoded image data in accordance with the value of the Image data format element.

7.33 2D capture device block

Abstract values: None.

Contents: The 2D capture device block consists of the 2D capture device spectral block and the 2D capture device technology identifier.

7.34 2D capture device spectral block

Abstract values: The possible values are:

— near infrared;

— thermal;

— white light.

Contents: Many different types of capture devices work in the near infrared, thermal, or white light spectral range. The 2D capture device spectral block indicates whether the capture device technology uses one or more of these spectral ranges.

7.35 2D capture device technology identifier

Abstract values: The possible values are:

- unknown;
- static photograph from an unknown source;
- static photograph from a digital still-image camera;
- static photograph from a scanner;
- video frame(s) from an unknown source;
- video frame(s) from an analogue video camera;
- video frame(s) from a digital video camera.

Contents: The 2D capture device technology identifier shall indicate the device technology used to acquire the captured biometric sample.

7.36 2D image information block

Abstract values: None.

Contents: The 2D image information block element is intended to describe digital properties of the 2D representation data.

The 2D image information block consists of the Image data format, the 2D face image kind, the Post-acquisition processing block, the Lossy transformation attempts element, the Camera to subject distance, the Sensor diagonal, the Lens focal length, the Image size block, the Image face measurements block, the Image colour space element, and the Reference colour mapping block. The structure of this element is shown in Figure 1.

7.37 2D face image kind

Abstract values: See Table 3 for a list of allowed 2D face image kinds and their normative requirements. Other application specific image types may be added in the future.

Contents: The 2D face image kind element shall represent the type of the face image stored in the 2D representation data. There are several types according to the chosen application specific profile (see Annex D), additional profiles may be included in future versions of this document.

Table 3 — 2D face image kinds

Value	Definition and normative requirements
MRTD	Annex D.1
General purpose	Annex D.2

7.38 Post acquisition processing block

Abstract values: The values of this block shall be one or more of the following:

— rotated (in- plane);

— cropped;

— down-sampled;

— white balance adjusted;

— multiply compressed;

— interpolated;

— contrast stretched;

— pose corrected;

— multi view image;

— age progressed;

— super-resolution processed;

— normalised.

There may be restrictions on the allowed values by the choice of the 2D face image kind.

Contents: This element contains notifications on potential post acquisition processing steps.

While the alteration of face image data is discouraged, there are cases when no alternative may exist:

— Legacy database of ¾ frontal face images which shall be rotated to full frontal prior to biometric comparison.

— From a frontal image artificial non-frontal face images are automatically generated at predetermined non-frontal poses (multi-view images) using an implicit head model or similar. These images can be beneficial during the comparison process or a manual review process as they show a more similar pose than the original frontal image.

— A single image is to be age progressed and used for verification of a passport holder.

— A short video stream is super-resolved to a single face image for comparison against a watch list.

The Post acquisition processing block allows the specification of the kind of post processing that has been applied to the original captured image.

On the one hand a captured image might need some post-processing so that the resulting representation conforms to the requirements of this document. On the other hand, these processing steps should be minimal and not distort the characteristics of the original image.

7.39 Lossy transformation attempts

Abstract values: Unknown, 0, 1, more than 1.

Contents: This element counts the number of previous lossy transformation steps.

7.40 Image data format

Abstract values: The values shall be specified according to Table 4.

Contents: The Image data format denotes the encoding type of the 2D representation data and of the 3D texture map.

For lossless compression PNG or JPEG2000 lossless shall be used. For lossless representation of images using more than 8 bits per channel PNG or JPEG2000 lossless shall be used. For lossy representation of images using more than eight bit per channel JPEG2000 shall be used. For an encoding in Netpbm portable binary the image formats P5 (grey, PGM) and P6 (colour, PPM) shall be used.

Table 4 — Image data format codes

<table>
<tr><th>Value</th><th>Specified in</th></tr>
<tr><td>unknown</td><td></td></tr>
<tr><td>other</td><td></td></tr>
<tr><td>jpeg</td><td>ITU-T Rec. T.81 | ISO/IEC 10918-1 and Reference [3]</td></tr>
<tr><td>jpeg2000 lossy</td><td rowspan="2">ISO/IEC 15444-1</td></tr>
<tr><td>jpeg2000 lossless</td></tr>
<tr><td>png</td><td>ISO/IEC 15948</td></tr>
<tr><td>pgm</td><td>Reference [33]</td></tr>
<tr><td>ppm</td><td>Reference [34]</td></tr>
</table>

If the Image data format value is unknown or other or a later-version extension code, then the Image size block (with width and height) shall be included.

In the event that a greyscale face image is encoded in the Netpbm portable greyscale binary image format (PGM), the format definition is as follows:

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, formatted as ASCII characters in decimal;
6. any Whitespace (blanks, TABs, CRs, LFs);
7. the maximum grey value (Maxval), formatted as ASCII characters in decimal – the value shall be smaller than 256, and larger 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 grey values, in order from left to right. Each grey value is a number from 0 through Maxval, with 0 being black and Maxval being white. Each grey 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.

A PGM encoded greyscale face image shall be encoded in a P5 format.

In the event that a colour face image is encoded in the Netpbm portable colour binary image format (PPM), the format definition is as follows:

1. a "magic number" = “P6” 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, formatted as ASCII characters in decimal;
6. any Whitespace (blanks, TABs, CRs, LFs);
7. the maximum channel value (Maxval), formatted as ASCII characters in decimal – the value shall be smaller than 256, and larger 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 pixel values, in order from left to right. Each pixel value is represented by 1 number for red, 1 number for green and 1 number for blue, each from 0 through Maxval; thus each pixel value is represented in pure binary by 3 bytes.

A PPM encoded colour face image shall be encoded in a P6 format.

7.41 Camera to subject distance

Abstract values: Integer.

Contents: The Camera to subject distance (CSD) element contains the camera to subject distance of the photographical setup used for capturing the photo in millimetres. The maximum CSD to be encoded is 50000 mm. All larger distances shall by encoded using that maximum value.

7.42 Sensor diagonal

Abstract values: Integer.

Contents: The Sensor diagonal element contains the diagonal length of the camera sensor used for capturing the photo in millimetres. The maximum Sensor diagonal to be encoded is 2000 mm. All larger distances shall by encoded using that maximum value. If a zoom lens is used, this data element shall encode the actual focal length used to capture the image.

Figure 8 illustrates the relative sizes of some commonly available image sensors. Table 5 provides the approximate widths, heights, areas, diagonals, and crop factors for these sensors. The dimensions in Table 5 are approximates and serve as examples.

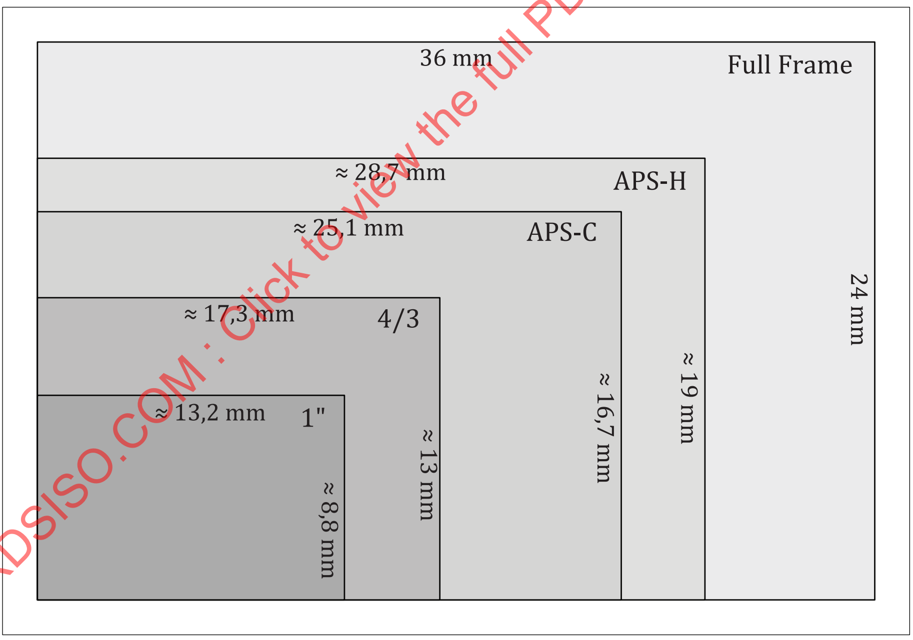


Figure 8 — Typical sensors and their relation in size to the traditional full frame

It might be noted that, by gathering more light, a larger image sensor will provide typically lower image noise, and a fixed focal length lens will generally provide a higher image quality than a zoom lens of the same focal length. Moreover, by using a fixed focal length lens, the problem of inadvertent change to the zoom ratio (i.e., the field of view) can be avoided.

Table 5 — Typical image sensor sizes and corresponding crop factors

Sensor type	Width (mm)	Height (mm)	Area (mm^2)	Diagonal (mm)	Crop factor
Full frame	36	24	864	43,3	1
APS-H	28,7	19	545	34,4	1,26
APS-C	25,1	16,7	419	30,1	1,44
Four thirds system (4/3)	17,3	13	225	21,6	2,00
1 inch (1")	13,2	8,8	116	15,9	2,73

7.43 Lens focal length

Abstract values: Integer.

Contents: The Lens focal length element contains the focal length of the camera lens used for capturing the photo in millimetres. The maximum Lens focal length to be encoded is 2000 mm. All larger distances shall by encoded using that maximum value.

7.44 Image size block

Abstract values: None.

Contents: The Image size block consists of the Width and the Height element.

7.45 Width

Abstract values: Integer.

Contents: The Width element shall specify the number of pixels of the 2D representation data in the horizontal direction.

7.46 Height

Abstract values: Integer.

Contents: The Height element shall specify the number of pixels of the 2D representation data in the vertical direction.

7.47 Image face measurements block

Abstract values: None.

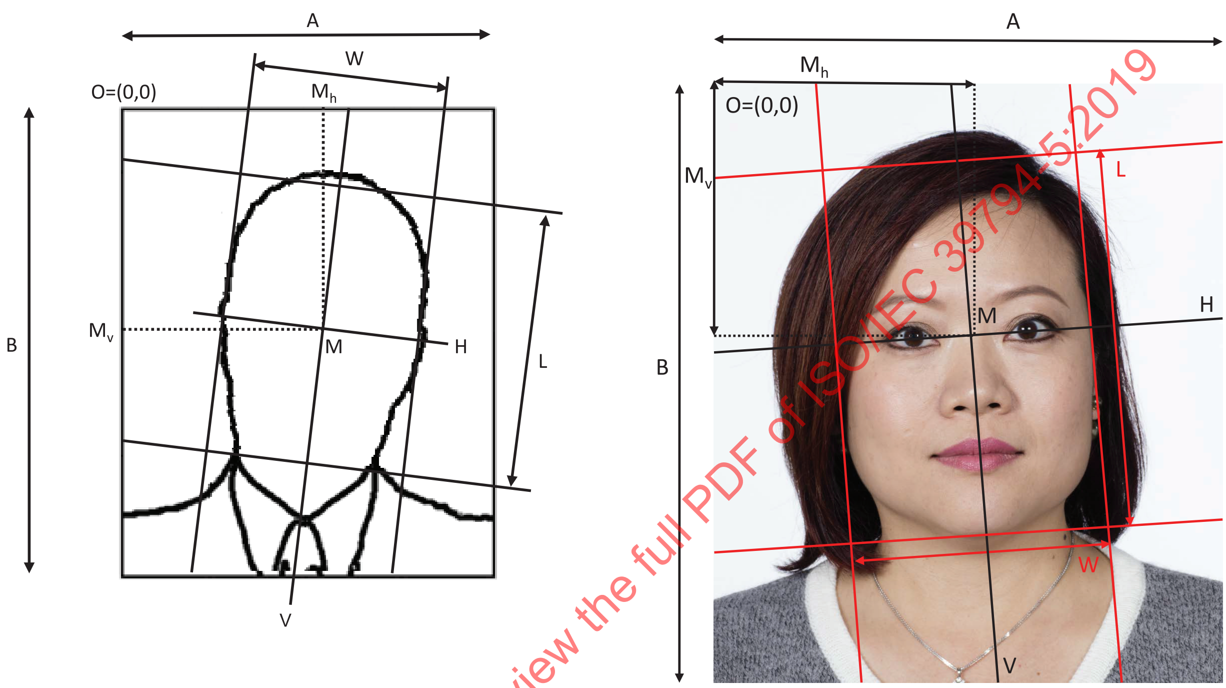
Contents: For specific application domains different minimal spatial sampling rates of the interchange data may be required. For example, using higher spatial sampling rate images allow for specific human as well as machine inspection methods that depend on the analysis of very small details.

The Image face measurements block consists of four elements. If the number of pixels across the width of the head shall be encoded the Image head width may be used. If the number of pixels across the length of the head shall be encoded the Image head length may be used. If the inter-eye distance shall be encoded the Image inter-eye distance data element may be used. If the eye-to-mouth distance shall be encoded the Image eye-to-mouth distance data element may be used. If necessary, all four elements may be used.

7.48 Image head width

Abstract values: Integer.

Contents: The Image head width element provides information on the number of pixels in the image across the width of the head. The head width (W) is defined in Figure 9.



a) Abstract geometric characteristics

b) Sample

Key

A image width

B image height

W head width

L head length

V vertical centre line

H horizontal centre line

M face centre

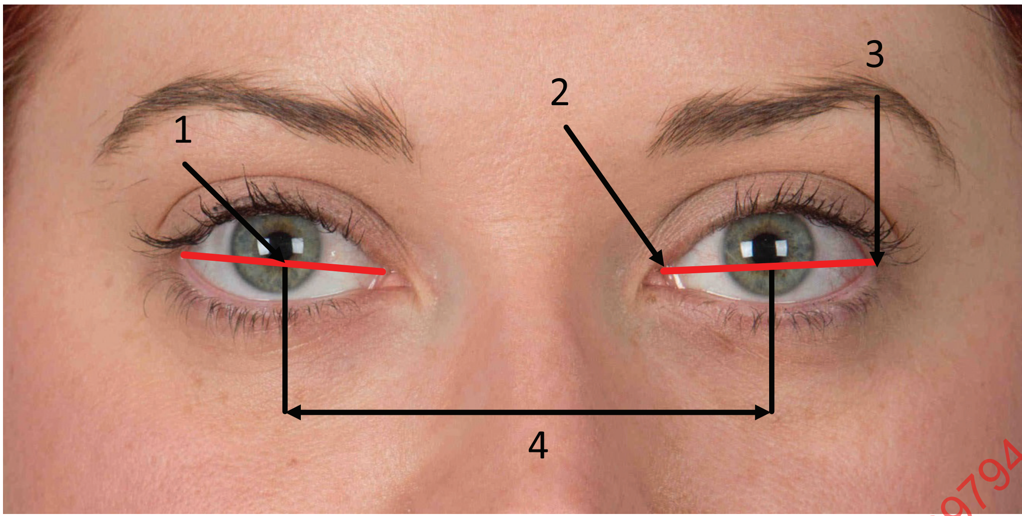
Figure 9 — Abstract geometric characteristics of a portrait applied to a sample

NOTE The typical inter-eye distance is approximately half of the head width.

7.49 Image inter-eye distance

Abstract values: Integer.

Contents: The Image inter-eye distance element provides information on the number of pixels in the image between the eye centres (feature points 12.1 and 12.2). For an explanation of the inter-eye distance see Figure 10. The value of this element shall be the number of pixels between the eye centres.



Key

1 eye centre

2 inner canthus

3 outer canthus

4 Inter-eye distance

Figure 10 — Inter-eye distance (IED) measurement

NOTE Be aware that the eye centre is not necessarily the centre of the pupil.

NOTE A typical real IED (distance measured at the face) is between 60 mm and 65 mm.

7.50 Image eye-to-mouth distance

Abstract values: Integer.

Contents: The Image eye-to-mouth distance element provides information on the number of pixels in the image between the mouth and the eyes. The value of this element shall be the number of pixels between the midpoint of the line connecting the eye centres (feature points 12.1 and 12.2) and the mouth (feature point 2.3).

7.51 Image head length

Abstract values: Integer.

Contents: The Image head length element provides information on the number of pixels in the image from the chin to crown, or length, of the head. The head length (L) is defined in Figure 9. The value of this element shall be the number of pixels across the length of the head.

7.52 Image colour space

Abstract values: The value of this element shall be one of the following:

- unknown;
- other;
- 24 bit RGB;
- 48 bit RGB;
- YUV422;
- 8 bit greyscale;
- 16 bit greyscale.

Contents: The Image colour space element indicates the colour space used in the encoded 2D or 3D image information block. RGB encoding is recommended. The ICC profile should be embedded inside the Texture map data (if applicable), as JPEG and PNG formats allow ICC profile encoding.

7.53 Reference colour mapping block

Abstract values: None.

Contents: Mapping of reference colours like in IEC 61966-8. This data element contains the name of the applied Reference colour schema, like IEC 61966-8, and a list of Reference colour definition and value blocks.

7.54 Reference colour schema

Abstract values: Octet string.

Contents: This data element contains the name of the applied Reference colour schema, like IEC 61966-8.

7.55 Reference colour definition and value block

Abstract values: Two octet strings.

Contents: These data elements contain pairs of elements consisting of a Reference colour definition like "J 14" in the IEC case, and the respective Reference colour value in the given face portrait.

7.56 3D shape representation block

Abstract values: None.

Contents: The 3D shape representation block contains the 3D representation data, the 3D image information block, and the 3D capture device block. The structure of the 3D shape representation block is shown in Figure 1.

7.57 3D representation data

Abstract values: Octet string.

Contents: The 3D representation data element shall contain the image data in a vertex representation. The 3D representation kind (vertex) shall be specified in the 3D representation kind element.

7.58 3D capture device block

Abstract values: None.

Contents: In analogy to the 2D capture device block in the 2D image representation block, where the source of the 2D data can be coded, the 3D capture device block should be used to indicate the device that was used to acquire the 3D data.

The 3D capture device block consists of the 3D modus element and the 3D capture device technology identifier 3D element.

If all elements of the 3D capture device block are absent the 3D capture device block element shall be absent.

7.59 3D modus

Abstract values: The value of this element shall be one of the following:

— unknown;

— active;

— passive.

Contents: This element describes the manner in which the 3D image is acquired.

7.60 3D capture device technology identifier

Abstract values: The value of this element shall be one of the following:

— unknown;

— stereoscopic scanner;

— moving (monochromatic) laser line;

— structured light;

— colour coded light;

— ToF (time of flight);

— shape from shading.

Contents: This element contains information on the technology used in the capture device used.

NOTE Some of the listed 3D capture device technology identifier abstract values are incompatible with a 3D modus value of passive.

7.61 3D image information block

Abstract values: None.

Contents: The 3D image information block consists of the the 3D representation kind block, the 3D coordinate system, the 3D Cartesian scales and offsets block, the Image colour space (see 7.52), the 3D face image kind, the Image size block (see 7.44), the 3D physical face measurements block, the Post acquisition processing block (see 7.38), and the 3D texture map block. The structure of this element is shown in Figure 1.

7.62 3D representation kind block

Abstract values: Vertex.

Contents: The 3D representation kind block shall contain the name of the encoding schema used for the 3D representation data, which is 3D vertex block for this version of this document.

3D vertex block codes 3D points based on a non-regular sampling interval, typically resulting in a sparse coding. Due to variable sampling of the vertex points the vertex representation on the one hand can result in very compact representations or in a very exact representation when using many vertices.

7.63 3D vertex block

Abstract values: None.

Contents: The 3D vertex block consists of at one or more 3D vertex information blocks, and one or more 3D vertex triangle data blocks.

The Coordinate system type for vertex data shall be Cartesian. All Cartesian coordinates shall be non-negative integer. After application of Cartesian scales and offsets, the Cartesian coordinates become metric Cartesian coordinates which can be negative and positive and decimal.

The origin of the metric Cartesian coordinates is defined. For example, this origin is linked to landmarks like the middle of the 2 eyes for the 3D textured image application profile, or like to the top of the nose.

The scale is defined to be in conformity with the 3D textured image resolution block.

7.64 3D vertex information block

Abstract values: None.

Contents: The 3D vertex information block consists of the 3D vertex coordinates block, the 3D vertex identifier, the 3D vertex normals block, the 3D vertex textures block, and the 3D error map elements.

7.65 3D vertex coordinate block

Abstract values: 3D coordinate Cartesian unsigned short block, see ISO/IEC 39794-1.

Contents: The location of each vertex is represented by its X coordinate, Y coordinate, and Z coordinate.

7.66 3D vertex identifier

Abstract values: Integer.

Contents: This element shall obtain a unique identifier for the associated vertex. Each two vertices in a record shall have different identifiers.

NOTE If the 3D vertex identifier is absent for a vertex, it is impossible to refer to it in the 3D vertex triangle data block.

7.67 3D vertex normals block

Abstract values: 3D coordinate Cartesian unsigned short block, see ISO/IEC 39794-1.

Contents: The 3D vertex normals block contains the normal X, normal Y and normal Z coordinate elements.

7.68 3D vertex textures block

Abstract values: 2D coordinate Cartesian unsigned short block, see ISO/IEC 39794-1.

Contents: The vertex texture X and vertex texture Y fields represent the corresponding x and y pixel position in the 3D texture map block with (0, 0) denoting the upper left corner.

7.69 3D error map

Abstract values: Octet string.

Contents: The 3D error map can be used to give further information on how the 3D data has been processed before it was stored in the 3D representation. The 3D error map shall be coded in the PNG format using an 8 bit per pixel greyscale image. The length of the map is variable, as it depends on the lossless compression algorithm.

Pixel values t in the range of 0 to 199 and 206 to 255 are reserved for future use. A value of $t = 200$ codes that the depth value is considered to be correct. Values of $t \geq 201$ code a specific potential or corrected defect of the 3D data or the corresponding texture image. See Table 6 for an enumerated list of possible values.

Table 6 — 3D error map values

Description	Value
Reserved for future use	0 to 199
Depth value is considered correct	200
Depth value is interpolated, interpolation type isn't specified	201
Depth value is interpolated, linear interpolation has been used	202
Depth value is interpolated, bi-cubic interpolation has been used	203
Value of optional texture image potentially wrong (texture noisy, overexposure, etc.)	204
Value of optional texture image has been corrected by post processing (image processing)	205
Reserved for future use	206 to 255

7.70 3D vertex triangle data block

Abstract values: None.

Contents: The 3D vertex triangle data block contains a list of triangle descriptions. Each triangle is specified by the three indices (Triangle index 1, Triangle index 2, and Triangle index 3) of the vertices in the vertex data list forming the triangle. The order of the vertex indices shall be counter clock wise to indicate the external face of the triangle.

7.71 3D coordinate system

Abstract values: 3D Cartesian coordinate system.

Contents: This element contains information on the coordinate system used.

Originally, 3D data is acquired in a device dependent coordinate system. Based on the knowledge about several device parameters the 3D data can be transformed in Cartesian coordinates. This transformation may involve rotation, translation and resampling. Efforts must be made to preserve the precision of the original data as intended by this document and defined by the 3D textured image resolution block.

This document supports the Cartesian coordinate system for all encodings.

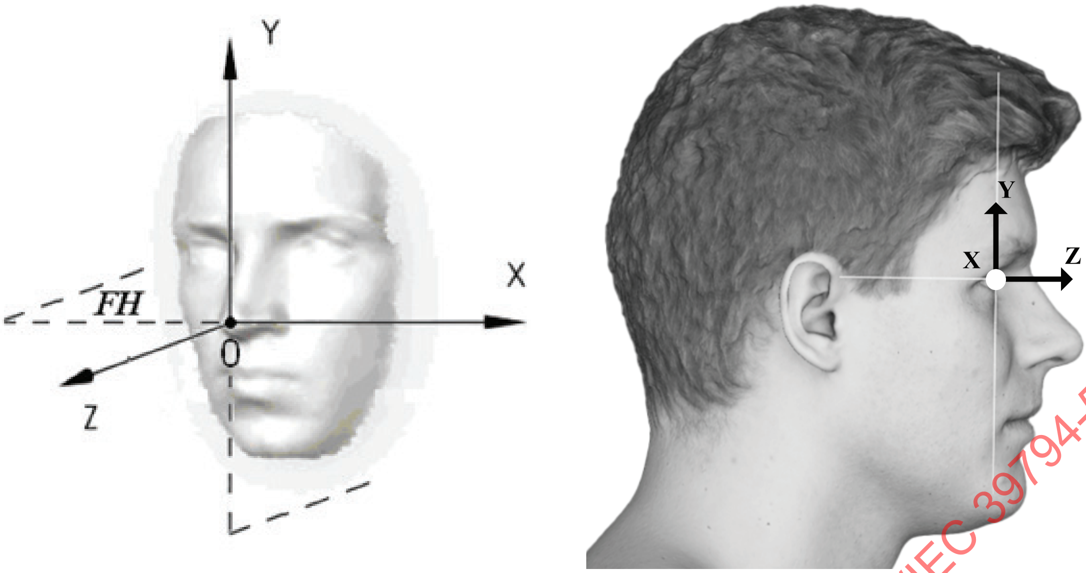
The transformation to metric world coordinates is described by appropriate scaling factors and implicit rules (e.g. as used in the anthropometric landmark type).

7.72 3D Cartesian coordinate system

Abstract values: None.

Contents: In the 3D Cartesian coordinate system, the point of origin must be defined in order to get positive encoding of XYZ coordinates.

Figure 11 shows two examples of a metric Cartesian coordinate system. In the left, a sample of a Cartesian coordinate system with the origin on the tip of the nose is shown. The XZ plane is defined parallel to the Frankfurt Horizon. In the right, a sample of a metric Cartesian coordinate system with the origin at the middle of the two eyes is given. The XZ plane passes the horizontal gaze axis. This metric Cartesian coordinate system is used by the 3D textured face image application profile. The X axis leads from right eye to left eye, the Z axis is in Horizontal eye direction, looking straight forward in rest position.



Key

X, Y, Z	coordinate axes
FH	Frankfurt Horizon
0	coordinate origin

Figure 11 — Samples of Cartesian coordinate systems

7.73 3D Cartesian scales and offsets block

Abstract values: Real.

Contents: ScaleX, ScaleY, ScaleZ, OffsetX, OffsetY and OffsetZ are needed to transform digital coordinates to metric coordinates. The scale values have no dimension, the offset values are given in millimetres.

The transformation from Cartesian coordinates to metric Cartesian coordinates is derived as follows:

— $X = x * ScaleX + OffsetX;$

— $Y = y * ScaleY + OffsetY;$

— $Z = z * ScaleZ + OffsetZ.$

There is a strong relation between anthropometric landmarks and the metric Cartesian coordinate system, as the landmarks define the origin and the orientation.

For certain 3D face image kinds, the origin of the metric Cartesian coordinate system can be the midpoint between the left eye centre (12.1) and the right eye centre (12.2), or can be also the nose (prn).

For certain 3D face image kinds, the orientation of the Cartesian system is linked to the pose of the head. One example is the frontal pose which is defined by the Frankfurt Horizon as the xz plane and the vertical symmetry plane as the yz plane with the z axis oriented in the direction of the face sight. Another example is the rest position (gaze looking straight forward) with the xz plane passing the two eye centres, and the horizontal gaze axis, vertical symmetry plane as the yz plane with the z axis oriented in the direction of the face sight.

Large values of ScaleX, ScaleY or ScaleZ indicate a low spatial sampling rate in the respective dimension. Boundary values of ScaleX, ScaleY and ScaleZ may be strongly restricted for different 3D face image kinds.

7.74 3D face image kind

Abstract values: None.

Contents: The 3D face image kind element shall represent the type of the face image stored in the 3D representation data. See Table 7 for a list of allowed image types and their normative requirements.

Table 7 — 3D Face image kind codes

Value	Definition and normative requirements
3D Textured face images	Annex D.3

7.75 3D physical face measurements block

Abstract values: None.

Contents: For specific application domains different minimal spatial sampling rates of the interchange data may be required. For example, using higher spatial sampling rate images allow for specific human as well as machine inspection methods that depend on the analysis of very small details.

The 3D physical face measurements block consists of four elements. If the width of the head shall be encoded the 3D physical head width may be used. If the length of the head shall be encoded the 3D physical head length may be used. If the inter-eye distance shall be encoded the Physical inter-eye distance may be used. If the eye-to-mouth distance shall be encoded the 3D physical eye-to-mouth distance may be used. If necessary, all four elements may be used. All measures shall be given in millimetres. See 7.48 for equivalent definitions for pixel measurements in 2D images.

7.76 3D physical head width

Abstract values: Integer.

Contents: The 3D physical head width element provides information on the width of the head in millimetres.

7.77 3D physical inter-eye distance

Abstract values: Integer.

Contents: The 3D physical inter-eye distance element provides information on the distance between the eye midpoints in millimetres.

7.78 3D physical eye-to-mouth distance

Abstract values: Integer.

Contents: The 3D physical eye-to-mouth distance element provides information on the distance between the mouth and the eyes in millimetres, more precise, between the midpoint of the line connecting the eye centres (feature points 12.1 and 12.2) and the mouth (feature point 2.3).

7.79 3D physical head length

Abstract values: Integer.

Contents: The 3D physical head length element provides information on the distance from the chin to crown, or length, of the head, in millimetres.

7.80 3D textured image resolution block

Abstract values: None.

Contents: The 3D textured image resolution block consists of MM shape [X/Y/Z] resolution, 3D MM texture resolution, 3D texture acquisition period, and 3D face area scanned.

7.81 3D MM shape [X/Y/Z] resolution

Abstract values: Real (Decimal).

Contents: The 3D MM shape X resolution, the 3D MM shape Y resolution, and the 3D MM shape Z resolution define the minimal distance acquired by the shape acquisition system in millimetres. These resolutions may be different compared with the MM texture resolution value.

7.82 3D MM texture resolution

Abstract values: Real (Decimal).

Contents: The 3D MM texture resolution defines the minimal distance acquired by the texture acquisition system in mm. This resolution may be different compared with the 3D MM shape [X/Y/Z] resolution values.

7.83 3D texture acquisition period

Abstract values: Real (Decimal).

Contents: The 3D texture acquisition period defines the time in milliseconds used for shape and texture acquisition. During this period neither the acquisition system nor the subject shall move or be moved.

7.84 3D face area scanned block

Abstract values: The value of this element shall be one or more of the following:

— Front of the head;

— Chin;

— Ears;

— Neck;

— Back of the head;

— Full head.

Contents: The 3D face area scanned shall indicate the area scanned of the face. The minimum allowed 3D face area scanned is Front of the head.

7.85 3D texture map block

Abstract values: None.

Contents: The 3D texture map block consists of the 3D texture map data, the Image data format, the 3D texture capture device spectral block, the 3D texture standard illuminant, and the 3D error map (See 7.70) elements.

The 3D texture map block should only be used to store face texture data that is acquired by a scanning device during the 3D acquisition process, and therefore may have a different geometry than the 2D representation data stored in the same BDB. It is not a substitute for the 2D representation data. The 3D texture map shall be coded in 8 bit or 16 bit greyscale or as a 24 bit colour image. The length of the map is variable as it depends on the applied compression algorithm.

7.86 3D texture capture device spectral block

Abstract values: The value of this element shall be one of the following:

— unknown;

— other;

— white (380 nm–780 nm);

— very near infrared (photographic) (780 nm–1000 nm);

— short wave infrared (1000 nm–1400 nm).

Contents: The 3D texture capture device spectral block denotes the kind of spectrum that has been used for acquiring the 3D texture map. This spectrum may differ from the one used for 2D image representation data.

7.87 3D texture standard illuminant

Abstract values: The value of this element shall be one of the following:

— D30;

— D35;

— D40;

— D45;

— D50;

— D55;

— D60;

— D65;

— D70;

— D75;

— D80.

Contents: Illumination according to one of the standard illuminants defined in ISO 11664-2 or similar.

7.88 3D texture map data

Abstract values: Octet string.

Contents: The 3D texture map data shall contain the face texture data acquired by a capture device during the 3D acquisition process. The 3D texture map data element shall have the format specified in the Image data format element.

8 Encoding

8.1 Overview

The tagged binary encoding as well as the XML encoding is given in this clause and Annex A, respectively. In order to aid recognition of abstract values, the same lower camel-case notation is used for abstract data elements in the ASN.1 module and in the XSD. The lower camel-case names are derived from the abstract values given here.

The names of the ASN.1 module and of the XML schema definition (available at http://standards.iso.org/iso-iec/39794/-5/ed-1/en) are iso-iec-39794-5-ed-1-v1.asn and iso-iec-39794-5-ed-1-v1.xsd, respectively.

Content and semantics of parameters of ISO/IEC 19794-5 (2011 edition) served as starting point for this document. The syntax has been modified to accommodate new requirements, and many parameters have been added allowing the encoding of many more properties of face images than before.

Most of the face image data record parameters are considered as optional to allow application specific profiles and efficient storage of the available data.

The 3D encoding types 3D point map and range image are not supported by this version of this document.

8.2 Tagged binary encoding

This clause specifies the ASN.1 module implementing the abstract data elements specified in Clause 7. It describes the parameters of face image data as they are encoded in ASN.1. These ASN.1 definitions are based on the following design decisions:

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

— The tagged binary encoding of face image data shall be obtained by applying the ASN.1 distinguished encoding rules (DER) defined in ISO/IEC 8825-1 to a value of the type FaceImageDataBlock 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 ISO/IEC 39794 ASN.1 modules are defined independently, i.e. no re-use or imports of definitions outside the ISO/IEC 39794 series area in order to avoid interdependencies to other standardization bodies even if this might be useful (e.g., considering X.509/PKIX definitions).

— Any face image data specific definition is fully included in the ASN.1 module in this document, any re-usable header field that is defined in the ISO/IEC 39794-1 framework is part of the separate ISO/IEC 39794-1 ASN.1 module.

— The entry point for any ISO/IEC 39794 series biometric type definition is the BiometricDataBlock defined in the ISO/IEC 39794-1 ASN.1 module. This module includes the ASN.1 definition of all modality specific parts of the ISO/IEC 39794 series. This allows modifying or extending both the generic header information and the supported set of biometric data types at one place without impacting the other parts of the ISO/IEC 39794 series. For example, the ISO/IEC 39794-1 ASN.1 module includes the definitions of face image data and fingerprint image data and is extended later on by iris data. In this case, the ASN.1 definitions of ISO/IEC 39794-4 and this document do not need to be modified.

— Extension markers are included in all data elements to ensure extensibility and forward/backward compatibility when new parameters need to be added to existing containers/blocks.

— The latest version of the ASN.1 standard is employed, namely ISO/IEC 8824-1:2015.

— The distinguished encoding rules (DER) as specified in ISO/IEC 8825-1 are utilized to represent the data in binary format. Other options such as XML encoding rules shall not be used. The syntax of face image XML documents shall be based on the XML schema definition in A.2, not on the ASN.1 module in A.1.

The ASN.1 module in A.1 is available at http://standards.iso.org/iso-iec/39794/-5/ed-1/en.

Additional explanations on the mapping between the specifications in Clause 7 and the ASN.1 module given in A.1 apply:

— The ASN.1 schema does not guarantee that if all elements that could be contained in an element are absent, the whole element is absent too.

— If in the propertiesBlock element a property is set to TRUE, the respective property is present in the image. Otherwise if its set to FALSE, that property is absent in the image. If a property is omitted no statement has been made.

— If in the expressionBlock element one of the components is set to TRUE, the respective attribute is present in the image. Otherwise if its set to FALSE, it is absent in the image. If an element is omitted no statement has been made. The ASN.1 schema does not prevent from choosing the expressions neutral and smile for the same face image. However, neutral and smile shall not be both true for the same image.

— At least one of the elements of the poseAngleBlock element shall be present; otherwise the whole poseAngleBlock element shall be absent. This requirement is not covered by the ASN.1 schema.

— MPEG4 feature points with the abstract name <1>.<2> are encoded as mpeg4PointCode-<01>-<02>. AnthropometricLandmarkPointCode elements with the abstract name <1>.<2> are encoded as pointCode-<01>-<02>.

Encoding examples are contained in Annex B.

8.3 XML encoding

Annex A.2 specifies an XSD schema, in which the abstract data elements of Clause 7 are constrained by XML types defined within one of the following standards: W3C Recommendations, *XML Schema Parts 1 and 2*, ISO/IEC 39794-1, or this document.

Binary data shall only be encoded as base 64 and stored as a text string in an element, which itself has the underlying type of xs:base64Binary, for example: <xs:element name="data" type="xs:base64Binary"/>

For avoidance of doubt other methods of encoding binary data such as xs:hexBinary or proprietary extensions which support binary data encoding (i. e.: XOP) are not permitted.

Additional explanations on the mapping between the specifications in Clause 7 and the XSD given in A.2 apply:

— The XML schema does not guarantee that if all elements that could be contained in an element are absent, the whole element is absent, too.

— If a property in a propertiesBlock element is set to TRUE, this property is present in the image. Otherwise if its set to FALSE, the property is absent in the image. If a property is omitted no statement has been made.

— If an expression in an expressionBlock element is set to TRUE, this expression is present in the image. Otherwise if its set to FALSE, the expression is absent in the image. If an expression is omitted no statement has been made.

— The XML schema does not prevent from choosing the expressions neutral and smile for the same face image. However, neutral and smile shall not be both true for the same image.

— At least one of the elements of the poseAngleBlock element shall be present; otherwise the whole poseAngleBlock element shall be absent. This requirement is not covered by the XML schema.

— MPEG4 feature points with the abstract name <1>.<2> are encoded as MPEG4PointCode-<01>-<02>.

— AnthropometricLandmarkPointCode elements with the abstract name <1>.<2> are encoded as PointCode-<01>-<02>.

The XSD module in A.2 can be retrieved from http://standards.iso.org/iso-iec/39794/-5/ed-1/en.

Encoding examples are contained in Annex B.

9 Registered BDB format identifiers

The registrations listed in Table 8 have been made in accordance with ISO/IEC 19785 (all parts)[31] to identify the face image data interchange formats defined in this document. The format owner is ISO/IEC JTC 1/SC 37 with the registered biometric organization identifier 257 (0101Hex).

Table 8 — BDB format identifiers

BDB format identifier	Short name	Full object identifier
42 (002AHex)	g3-binary-face-image	{ iso(1) registration-authority(1) cbeff(19785) biometric-organization(0) jtc1-sc37(257) bdbs(0) g3-binary-face-image(42) }
43 (002BHex)	g3-xml-face-image	{ iso(1) registration-authority(1) cbeff(19785) biometric-organization(0) jtc1-sc37(257) bdbs(0) g3-xml-face-image(43) }

Annex A
(normative)

Formal specifications

A.1 ASN.1 module for tagged binary encoding

This ASN.1 module is available at http://standards.iso.org/iso-iec/39794/-5/ed-1/en

```
ISO-IEC-39794-5-ed-1-v1 {iso(1) standard(0) iso-iec-39794(39794) part-5(5) ed-1(1) v1(1)
iso-iec-39794-5(0)}

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-- 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
      VersionBlock,
      CaptureDateTimeBlock,
      QualityBlocks,
      PADDataBlock,
      CoordinateCartesian2DUnsignedShortBlock,
      CoordinateCartesian3DUnsignedShortBlock,
      RegistryIdBlock,
      CertificationIdBlocks
   FROM ISO-IEC-39794-1-ed-1-v1;

   FaceImageDataBlock ::= [APPLICATION 5] SEQUENCE {
      versionBlock [0] VersionBlock,
      representationBlocks [1] RepresentationBlocks,
      ...
   }
```

```
RepresentationBlocks ::= SEQUENCE OF RepresentationBlock

RepresentationBlock ::= SEQUENCE {
   representationId [0] INTEGER (0..MAX),
   imageRepresentation [1] ImageRepresentation,
   captureDateTimeBlock [2] CaptureDateTimeBlock OPTIONAL,
   qualityBlocks [3] QualityBlocks OPTIONAL,
   padDataBlock [4] PADDataBlock OPTIONAL,
   sessionId [5] INTEGER (0..MAX) OPTIONAL,
   derivedFrom [6] INTEGER (0..MAX) OPTIONAL,
   captureDeviceBlock [7] CaptureDeviceBlock OPTIONAL,
   identityMetadataBlock [8] IdentityMetadataBlock OPTIONAL,
   landmarkBlocks [9] LandmarkBlocks OPTIONAL,
   ...
}

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

IdentityMetadataBlock ::= SEQUENCE {
   gender [0] Gender OPTIONAL,
   eyeColour [1] EyeColour OPTIONAL,
   hairColour [2] HairColour OPTIONAL,
   subjectHeight [3] SubjectHeight OPTIONAL,
   propertiesBlock [4] PropertiesBlock OPTIONAL,
   expressionBlock [5] ExpressionBlock OPTIONAL,
   poseAngleBlock [6] PoseAngleBlock OPTIONAL,
   ...
}

GenderCode ::= ENUMERATED {
   unknown (0),
   other (1),
   male (2),
   female (3)
}

GenderExtensionBlock ::= SEQUENCE {
   fallback [0] GenderCode,
   ...
}

Gender ::= CHOICE {
   code [0] GenderCode,
   extensionBlock [1] GenderExtensionBlock
}

EyeColourCode ::= ENUMERATED {
   unknown (0),
   other (1),
   black (2),
   blue (3),
   brown (4),
   grey (5),
   green (6),
   hazel (7),
   multi-coloured (8),
   pink (9)
}

EyeColourExtensionBlock ::= SEQUENCE {
   fallback [0] EyeColourCode,
   ...
}

EyeColour ::= CHOICE {
   code [0] EyeColourCode,
   extensionBlock [1] EyeColourExtensionBlock
```

```
}

HairColourCode ::= ENUMERATED {
   unknown (0),
   other (1),
   bald (2),
   black (3),
   blonde (4),
   brown (5),
   grey (6),
   white (7),
   red (8),
   knownColoured (9)
}

HairColourExtensionBlock ::= SEQUENCE {
   fallback [0] HairColourCode,
   ...
}

HairColour ::= CHOICE {
   code [0] HairColourCode,
   extensionBlock [1] HairColourExtensionBlock
}

SubjectHeight ::= INTEGER (1..65535)

PropertiesBlock ::= SEQUENCE {
   glasses [0] BOOLEAN OPTIONAL,
   moustache [1] BOOLEAN OPTIONAL,
   beard [2] BOOLEAN OPTIONAL,
   teethVisible [3] BOOLEAN OPTIONAL,
   pupilOrIrisNotVisible [4] BOOLEAN OPTIONAL,
   mouthOpen [5] BOOLEAN OPTIONAL,
   leftEyePatch [6] BOOLEAN OPTIONAL,
   rightEyePatch [7] BOOLEAN OPTIONAL,
   darkGlasses [8] BOOLEAN OPTIONAL,
   biometricAbsent [9] BOOLEAN OPTIONAL,
   headCoveringsPresent [10] BOOLEAN OPTIONAL,
   ...
}

ExpressionBlock ::= SEQUENCE {
   neutral [0] BOOLEAN OPTIONAL,
   smile [1] BOOLEAN OPTIONAL,
   raisedEyebrows [2] BOOLEAN OPTIONAL,
   eyesLookingAwayFromTheCamera [3] BOOLEAN OPTIONAL,
   squinting [4] BOOLEAN OPTIONAL,
   frowning [5] BOOLEAN OPTIONAL,
   ...
}

PoseAngleBlock ::= SEQUENCE {
   yawAngleBlock [0] AngleDataBlock OPTIONAL,
   pitchAngleBlock [1] AngleDataBlock OPTIONAL,
   rollAngleBlock [2] AngleDataBlock OPTIONAL
}

AngleDataBlock ::= SEQUENCE {
   angleValue [0] AngleValue,
   angleUncertainty [1] AngleUncertainty OPTIONAL,
   ...
}

AngleValue ::= INTEGER (-180..180)

AngleUncertainty ::= INTEGER (0..180)

LandmarkBlocks ::= SEQUENCE OF LandmarkBlock

LandmarkBlock ::= SEQUENCE {
```

```
   landmarkKind [0] LandmarkKind,
   landmarkCoordinates [1] LandmarkCoordinates OPTIONAL,
   ...
}

LandmarkKind ::= CHOICE {
   base [0] LandmarkKindBase,
   extensionBlock [1] LandmarkKindExtensionBlock
}

LandmarkKindBase ::= CHOICE {
   mpeg4FeaturePoint [0] MPEG4FeaturePoint,
   anthropometricLandmark [1] AnthropometricLandmark
}

LandmarkKindExtensionBlock ::= SEQUENCE {
   ...
}

MPEG4FeaturePointCode ::= ENUMERATED {
   mpeg4PointCode-02-01 (0),
   mpeg4PointCode-02-02 (1),
   mpeg4PointCode-02-03 (2),
   mpeg4PointCode-02-04 (3),
   mpeg4PointCode-02-05 (4),
   mpeg4PointCode-02-06 (5),
   mpeg4PointCode-02-07 (6),
   mpeg4PointCode-02-08 (7),
   mpeg4PointCode-02-09 (8),
   mpeg4PointCode-02-10 (9),
   mpeg4PointCode-02-11 (10),
   mpeg4PointCode-02-12 (11),
   mpeg4PointCode-02-13 (12),
   mpeg4PointCode-02-14 (13),
   mpeg4PointCode-03-01 (14),
   mpeg4PointCode-03-02 (15),
   mpeg4PointCode-03-03 (16),
   mpeg4PointCode-03-04 (17),
   mpeg4PointCode-03-05 (18),
   mpeg4PointCode-03-06 (19),
   mpeg4PointCode-03-07 (20),
   mpeg4PointCode-03-08 (21),
   mpeg4PointCode-03-09 (22),
   mpeg4PointCode-03-10 (23),
   mpeg4PointCode-03-11 (24),
   mpeg4PointCode-03-12 (25),
   mpeg4PointCode-03-13 (26),
   mpeg4PointCode-03-14 (27),
   mpeg4PointCode-04-01 (28),
   mpeg4PointCode-04-02 (29),
   mpeg4PointCode-04-03 (30),
   mpeg4PointCode-04-04 (31),
   mpeg4PointCode-04-05 (32),
   mpeg4PointCode-04-06 (33),
   mpeg4PointCode-05-01 (34),
   mpeg4PointCode-05-02 (35),
   mpeg4PointCode-05-03 (36),
   mpeg4PointCode-05-04 (37),
   mpeg4PointCode-06-01 (38),
   mpeg4PointCode-06-02 (39),
   mpeg4PointCode-06-03 (40),
   mpeg4PointCode-06-04 (41),
   mpeg4PointCode-07-01 (42),
   mpeg4PointCode-08-01 (43),
   mpeg4PointCode-08-02 (44),
   mpeg4PointCode-08-03 (45),
   mpeg4PointCode-08-04 (46),
   mpeg4PointCode-08-05 (47),
   mpeg4PointCode-08-06 (48),
   mpeg4PointCode-08-07 (49),
   mpeg4PointCode-08-08 (50),
```

```
      mpeg4PointCode-08-09 (51),
      mpeg4PointCode-08-10 (52),
      mpeg4PointCode-09-01 (53),
      mpeg4PointCode-09-02 (54),
      mpeg4PointCode-09-03 (55),
      mpeg4PointCode-09-04 (56),
      mpeg4PointCode-09-05 (57),
      mpeg4PointCode-09-06 (58),
      mpeg4PointCode-09-07 (59),
      mpeg4PointCode-09-08 (60),
      mpeg4PointCode-09-09 (61),
      mpeg4PointCode-09-10 (62),
      mpeg4PointCode-09-11 (63),
      mpeg4PointCode-09-12 (64),
      mpeg4PointCode-09-13 (65),
      mpeg4PointCode-09-14 (66),
      mpeg4PointCode-09-15 (67),
      mpeg4PointCode-10-01 (68),
      mpeg4PointCode-10-02 (69),
      mpeg4PointCode-10-03 (70),
      mpeg4PointCode-10-04 (71),
      mpeg4PointCode-10-05 (72),
      mpeg4PointCode-10-06 (73),
      mpeg4PointCode-10-07 (74),
      mpeg4PointCode-10-08 (75),
      mpeg4PointCode-10-09 (76),
      mpeg4PointCode-10-10 (77),
      mpeg4PointCode-11-01 (78),
      mpeg4PointCode-11-02 (79),
      mpeg4PointCode-11-03 (80),
      mpeg4PointCode-11-04 (81),
      mpeg4PointCode-11-05 (82),
      mpeg4PointCode-11-06 (83),
      mpeg4PointCode-12-01 (84),
      mpeg4PointCode-12-02 (85),
      mpeg4PointCode-12-03 (86),
      mpeg4PointCode-12-04 (87)
   }

   MPEG4FeaturePointExtensionBlock ::= SEQUENCE {
      fallback [0] MPEG4FeaturePointCode,
      ...
   }

   MPEG4FeaturePoint ::= CHOICE {
      code [0] MPEG4FeaturePointCode,
      extensionBlock [1] MPEG4FeaturePointExtensionBlock
   }

   AnthropometricLandmark ::= CHOICE {
      base [0] AnthropometricLandmarkBase,
      extensionBlock [1] AnthropometricLandmarkExtensionBlock
   }

   AnthropometricLandmarkBase ::= CHOICE {
      anthropometricLandmarkName [0] AnthropometricLandmarkName,
      anthropometricLandmarkPointName [1] AnthropometricLandmarkPointName,
      anthropometricLandmarkPointId [2] AnthropometricLandmarkPointId
   }

   AnthropometricLandmarkExtensionBlock ::= SEQUENCE {
      ...
   }

   AnthropometricLandmarkNameCode ::= ENUMERATED {
      vertex                      (0),
      glabella                    (1),
      opisthocranion              (2),
      eurionLeft                  (3),
      eurionRight                 (4),
      frontotemporaleLeft         (5),
```

```
   frontotemporaleRight        (6),
   trichion                    (7),
   zygionLeft                  (8),
   zygionRight                 (9),
   gonionLeft                  (10),
   gonionRight                 (11),
   sublabiale                  (12),
   pogonion                    (13),
   menton                      (14),
   condylionLateraleLeft       (15),
   condylionLateraleRight      (16),
   endocanthionLeft            (17),
   endocanthionRight           (18),
   exocanthionLeft             (19),
   exocanthionRight            (20),
   centerPointOfPupilLeft      (21),
   centerPointOfPupilRight     (22),
   orbitaleLeft                (23),
   orbitaleRight               (24),
   palpebraleSuperiusLeft      (25),
   palpebraleSuperiusRight     (26),
   palpebraleInferiusLeft      (27),
   palpebraleInferiusRight     (28),
   orbitaleSuperiusLeft        (29),
   orbitaleSuperiusRight       (30),
   superciliareLeft            (31),
   superciliareRight           (32),
   nasion                      (33),
   sellion                     (34),
   alareLeft                   (35),
   alareRight                  (36),
   pronasale                   (37),
   subnasale                   (38),
   subalare                    (39),
   alarCurvatureLeft           (40),
   alarCurvatureRight          (41),
   maxillofrontale             (42),
   christaPhiltraLandmarkLeft  (43),
   christaPhiltraLandmarkRight (44),
   labialeSuperius             (45),
   labialeInferius             (46),
   cheilionLeft                (47),
   cheilionRight               (48),
   stomion                     (49),
   superauraleLeft             (50),
   superauraleRight            (51),
   subauraleLeft               (52),
   subauraleRight              (53),
   preaurale                   (54),
   postaurale                  (55),
   otobasionSuperiusLeft       (56),
   otobasionSuperiusRight      (57),
   otobasionInferius           (58),
   porion                      (59),
   tragion                     (60)
}

AnthropometricLandmarkNameExtensionBlock ::= SEQUENCE {
   fallback [0] AnthropometricLandmarkNameCode,
   ...
}

AnthropometricLandmarkName ::= CHOICE {
   code [0] AnthropometricLandmarkNameCode,
   extensionBlock [1] AnthropometricLandmarkNameExtensionBlock
}

AnthropometricLandmarkPointNameCode ::= ENUMERATED {
   pointCode-01-01 (0),
   pointCode-01-02 (1),
   pointCode-01-05 (2),
```

```
    pointCode-01-06 (3),
    pointCode-01-07 (4),
    pointCode-01-08 (5),
    pointCode-01-09 (6),
    pointCode-02-01 (7),
    pointCode-02-02 (8),
    pointCode-02-03 (9),
    pointCode-02-04 (10),
    pointCode-02-05 (11),
    pointCode-02-06 (12),
    pointCode-02-07 (13),
    pointCode-02-09 (14),
    pointCode-02-10 (15),
    pointCode-03-01 (16),
    pointCode-03-02 (17),
    pointCode-03-03 (18),
    pointCode-03-04 (19),
    pointCode-03-05 (20),
    pointCode-03-06 (21),
    pointCode-03-07 (22),
    pointCode-03-08 (23),
    pointCode-03-09 (24),
    pointCode-03-10 (25),
    pointCode-03-11 (26),
    pointCode-03-12 (27),
    pointCode-04-01 (28),
    pointCode-04-02 (29),
    pointCode-04-03 (30),
    pointCode-04-04 (31),
    pointCode-05-01 (32),
    pointCode-05-02 (33),
    pointCode-05-03 (34),
    pointCode-05-04 (35),
    pointCode-05-06 (36)
}

AnthropometricLandmarkPointNameExtensionBlock ::= SEQUENCE {
    fallback [0] AnthropometricLandmarkPointNameCode,
    ...
}

AnthropometricLandmarkPointName ::= CHOICE {
    code [0] AnthropometricLandmarkPointNameCode,
    extensionBlock [1] AnthropometricLandmarkPointNameExtensionBlock
}

AnthropometricLandmarkPointIdCode ::= ENUMERATED {
    v          (0),
    g          (1),
    op         (2),
    eu-left    (3),
    eu-right   (4),
    ft-left    (5),
    ft-right   (6),
    tr         (7),
    zy-left    (8),
    zy-right   (9),
    go-left    (10),
    go-right   (11),
    sl         (12),
    pg         (13),
    gn         (14),
    cdl-left   (15),
    cdl-right  (16),
    en-left    (17),
    en-right   (18),
    ex-left    (19),
    ex-right   (20),
    p-left     (21),
    p-right    (22),
    or-left    (23),
```

```
   or-right  (24),
   ps-left   (25),
   ps-right  (26),
   pi-left   (27),
   pi-right  (28),
   os-left   (29),
   os-right  (30),
   sci-left  (31),
   sci-right (32),
   n         (33),
   se        (34),
   al-left   (35),
   al-right  (36),
   prn       (37),
   sn        (38),
   sbal      (39),
   ac-left   (40),
   ac-right  (41),
   mf-left   (42),
   mf-right  (43),
   cph-left  (44),
   cph-right (45),
   ls        (46),
   li        (47),
   ch-left   (48),
   ch-right  (49),
   sto       (50),
   sa-left   (51),
   sa-right  (52),
   sba-left  (53),
   sba-right (54),
   pra-left  (55),
   pra-right (56),
   pa        (57),
   obs-left  (58),
   obs-right (59),
   obi       (60),
   po        (61),
   t         (62)
}

AnthropometricLandmarkPointIdExtensionBlock ::= SEQUENCE {
   fallback [0] AnthropometricLandmarkPointIdCode,
   ...
}

AnthropometricLandmarkPointId ::= CHOICE {
   code [0] AnthropometricLandmarkPointIdCode,
   extensionBlock [1] AnthropometricLandmarkPointIdExtensionBlock
}

LandmarkCoordinates ::= CHOICE {
   base [0] LandmarkCoordinatesBase,
   extensionBlock [1] LandmarkCoordinatesExtensionBlock
}

LandmarkCoordinatesBase ::= CHOICE {
   coordinateCartesian2DBlock [0] CoordinateCartesian2DUnsignedShortBlock,
   coordinateTextureImageBlock [1] CoordinateTextureImageBlock,
   coordinateCartesian3DBlock [2] CoordinateCartesian3DUnsignedShortBlock
}

LandmarkCoordinatesExtensionBlock ::= SEQUENCE {
   ...
}

CoordinateTextureImageBlock ::= SEQUENCE {
   uInPixel [0] INTEGER (0..MAX),
   vInPixel [1] INTEGER (0..MAX)
}
```

```
ImageRepresentation ::= CHOICE {
   base [0] ImageRepresentationBase,
   extensionBlock [1] ImageRepresentationExtensionBlock
}

ImageRepresentationBase ::= CHOICE {
   imageRepresentation2DBlock [0] ImageRepresentation2DBlock,
   shapeRepresentation3DBlock [1] ShapeRepresentation3DBlock
}

ImageRepresentationExtensionBlock ::= SEQUENCE {
   ...
}

ImageRepresentation2DBlock ::= SEQUENCE {
   representationData2D [0] OCTET STRING,
   imageInformation2DBlock [1] ImageInformation2DBlock,
   captureDevice2DBlock [2] CaptureDevice2DBlock OPTIONAL,
   ...
}

CaptureDevice2DBlock ::= SEQUENCE {
   captureDeviceSpectral2DBlock [0] CaptureDeviceSpectral2DBlock OPTIONAL,
   captureDeviceTechnologyId2D [1] CaptureDeviceTechnologyId2D OPTIONAL,
   ...
}

CaptureDeviceSpectral2DBlock ::= SEQUENCE {
   whiteLight [0] BOOLEAN OPTIONAL,
   nearInfrared [1] BOOLEAN OPTIONAL,
   thermal [2] BOOLEAN OPTIONAL,
   ...
}

CaptureDeviceTechnologyId2DCode ::= ENUMERATED {
   unknown (0),
   staticPhotographFromUnknownSource (1),
   staticPhotographFromDigitalStillImageCamera (2),
   staticPhotographFromScanner (3),
   videoFrameFromUnknownSource (4),
   videoFrameFromAnalogueVideoCamera (5),
   videoFrameFromDigitalVideoCamera (6)
}

CaptureDeviceTechnologyId2DExtensionBlock ::= SEQUENCE {
   fallback [0] CaptureDeviceTechnologyId2DCode,
   ...
}

CaptureDeviceTechnologyId2D ::= CHOICE {
   code [0] CaptureDeviceTechnologyId2DCode,
   extensionBlock [1] CaptureDeviceTechnologyId2DExtensionBlock
}

ImageInformation2DBlock ::= SEQUENCE {
   imageDataFormat [0] ImageDataFormat,
   faceImageKind2D [1] FaceImageKind2D OPTIONAL,
   postAcquisitionProcessingBlock [2] PostAcquisitionProcessingBlock OPTIONAL,
   lossyTransformationAttempts [3] LossyTransformationAttempts OPTIONAL,
   cameraToSubjectDistance [4] CameraToSubjectDistance OPTIONAL,
   sensorDiagonal [5] SensorDiagonal OPTIONAL,
   lensFocalLength [6] LensFocalLength OPTIONAL,
   imageSizeBlock [7] ImageSizeBlock OPTIONAL,
   imageFaceMeasurementsBlock [8] ImageFaceMeasurementsBlock OPTIONAL,
   imageColourSpace [9] ImageColourSpace OPTIONAL,
   referenceColourMappingBlock [10] ReferenceColourMappingBlock OPTIONAL,
   ...
}

FaceImageKind2DCode ::= ENUMERATED {
   mrtd (0),
```



```
   generalPurpose (1)
}

FaceImageKind2DExtensionBlock ::= SEQUENCE {
   fallback [0] FaceImageKind2DCode,
   ...
}

FaceImageKind2D ::= CHOICE {
   code [0] FaceImageKind2DCode,
   extensionBlock [1] FaceImageKind2DExtensionBlock
}

PostAcquisitionProcessingBlock ::= SEQUENCE {
   rotated [0] BOOLEAN OPTIONAL,
   cropped [1] BOOLEAN OPTIONAL,
   downSampled [2] BOOLEAN OPTIONAL,
   whiteBalanceAdjusted [3] BOOLEAN OPTIONAL,
   multiplyCompressed [4] BOOLEAN OPTIONAL,
   interpolated [5] BOOLEAN OPTIONAL,
   contrastStretched [6] BOOLEAN OPTIONAL,
   poseCorrected [7] BOOLEAN OPTIONAL,
   multiViewImage [8] BOOLEAN OPTIONAL,
   ageProgressed [9] BOOLEAN OPTIONAL,
   superResolutionProcessed [10] BOOLEAN OPTIONAL,
   normalised [11] BOOLEAN OPTIONAL,
   ...
}

LossyTransformationAttemptsCode ::= ENUMERATED {
   unknown (0),
   zero (1),
   one (2),
   moreThanOne (3)
}

LossyTransformationAttemptsExtensionBlock ::= SEQUENCE {
   fallback [0] LossyTransformationAttemptsCode,
   ...
}

LossyTransformationAttempts ::= CHOICE {
   code [0] LossyTransformationAttemptsCode,
   extensionBlock [1] LossyTransformationAttemptsExtensionBlock
}

ImageDataFormatCode ::= ENUMERATED {
   unknown (0),
   other (1),
   jpeg (2),
   jpeg2000Lossy (3),
   jpeg2000Lossless (4),
   png (5),
   pgm (6),
   ppm (7)
}

ImageDataFormatExtensionBlock ::= SEQUENCE {
   ...
}

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

CameraToSubjectDistance ::= INTEGER (0..50000)

SensorDiagonal ::= INTEGER (0..2000)

LensFocalLength ::= INTEGER (0..2000)
```

```
   ImageSizeBlock ::= SEQUENCE {
      width [0] ImageSize,
      height [1] ImageSize
   }

   ImageSize ::= INTEGER (0..65535)

   ImageFaceMeasurementsBlock ::= SEQUENCE {
      imageHeadWidth [0] INTEGER (0..MAX) OPTIONAL,
      imageInterEyeDistance [1] INTEGER (0..MAX) OPTIONAL,
      imageEyeToMouthDistance [2] INTEGER (0..MAX) OPTIONAL,
      imageHeadLength [3] INTEGER (0..MAX) OPTIONAL,
      ...
   }

   ImageColourSpaceCode ::= ENUMERATED {
      unknown (0),
      other (1),
      rgb24Bit (2),
      rgb48Bit (3),
      yuv422 (4),
      greyscale8Bit (5),
      greyscale16Bit (6)
   }

   ImageColourSpaceExtensionBlock ::= SEQUENCE {
      fallback [0] ImageColourSpaceCode,
      ...
   }

   ImageColourSpace ::= CHOICE {
      code [0] ImageColourSpaceCode,
      extensionBlock [1] ImageColourSpaceExtensionBlock
   }

   ReferenceColourMappingBlock ::= SEQUENCE {
      referenceColourSchema [0] OCTET STRING OPTIONAL,
      referenceColourDefinitionAndValueBlocks [1] ReferenceColourDefinitionAndValueBlocks
OPTIONAL,
      ...
   }

   ReferenceColourDefinitionAndValueBlocks ::= SEQUENCE OF ReferenceColourDefinitionAndVal
ueBlock

   ReferenceColourDefinitionAndValueBlock ::= SEQUENCE {
      referenceColourDefinition [0] OCTET STRING OPTIONAL,
      referenceColourValue [1] OCTET STRING OPTIONAL,
      ...
   }

   ShapeRepresentation3DBlock ::= SEQUENCE {
      representationData3D [0] OCTET STRING,
      imageInformation3DBlock [1] ImageInformation3DBlock,
      captureDevice3DBlock [2] CaptureDevice3DBlock OPTIONAL,
      ...
   }

   CaptureDevice3DBlock ::= SEQUENCE {
      modus3D [0] Modus3D OPTIONAL,
      captureDeviceTechnologyId3D [1] CaptureDeviceTechnologyId3D OPTIONAL,
      ...
   }

   Modus3DCode ::= ENUMERATED {
      unknown (0),
      active (1),
      passive (2)
   }
```

```
Modus3DExtensionBlock ::= SEQUENCE {
   fallback [0] Modus3DCode,
   ...
}

Modus3D ::= CHOICE {
   code [0] Modus3DCode,
   extensionBlock [1] Modus3DExtensionBlock
}

CaptureDeviceTechnologyId3DCode ::= ENUMERATED {
   unknown (0),
   stereoscopicScanner (1),
   movingLaserLine (2),
   structuredLight (3),
   colourCodedLight (4),
   timeOfFlight (5),
   shapeFromShading (6)
}

CaptureDeviceTechnologyId3DExtensionBlock ::= SEQUENCE {
   fallback [0] CaptureDeviceTechnologyId3DCode,
   ...
}

CaptureDeviceTechnologyId3D ::= CHOICE {
   code [0] CaptureDeviceTechnologyId3DCode,
   extensionBlock [1] CaptureDeviceTechnologyId3DExtensionBlock
}

ImageInformation3DBlock ::= SEQUENCE {
   representationKind3D [0] RepresentationKind3D,
   coordinateSystem3D [1] CoordinateSystem3D,
   cartesianScalesAndOffsets3DBlock [2] CartesianScalesAndOffsets3DBlock,
   imageColourSpace [3] ImageColourSpace OPTIONAL,
   faceImageKind3D [4] FaceImageKind3D OPTIONAL,
   imageSizeBlock [5] ImageSizeBlock OPTIONAL,
   physicalFaceMeasurements3DBlock [6] PhysicalFaceMeasurements3DBlock OPTIONAL,
   postAcquisitionProcessingBlock [7] PostAcquisitionProcessingBlock OPTIONAL,
   texturedImageResolution3DBlock [8] TexturedImageResolution3DBlock OPTIONAL,
   textureMap3DBlock [9] TextureMap3DBlock OPTIONAL,
   ...
}

RepresentationKind3D ::= CHOICE {
   base [0] RepresentationKind3DBase,
   extensionBlock [1] RepresentationKind3DExtensionBlock
}

RepresentationKind3DBase ::= CHOICE {
   vertex3DBlock [0] Vertex3DBlock
}

RepresentationKind3DExtensionBlock ::= SEQUENCE {
   ...
}

Vertex3DBlock ::= SEQUENCE {
   vertexInformation3DBlocks [0] VertexInformation3DBlocks OPTIONAL,
   vertexTriangleData3DBlocks [1] VertexTriangleData3DBlocks OPTIONAL,
   ...
}

VertexInformation3DBlocks ::= SEQUENCE OF VertexInformation3DBlock

VertexInformation3DBlock ::= SEQUENCE {
   vertexCoordinates3DBlock [0] CoordinateCartesian3DUnsignedShortBlock,
   vertexId3D [1] INTEGER (0..MAX) OPTIONAL,
   vertexNormals3DBlock [2] CoordinateCartesian3DUnsignedShortBlock OPTIONAL,
   vertexTextures3DBlock [3] CoordinateCartesian2DUnsignedShortBlock OPTIONAL,
   errorMap3D [4] OCTET STRING OPTIONAL,
```

```
    ...
}

VertexTriangleData3DBlocks ::= SEQUENCE OF VertexTriangleData3DBlock

VertexTriangleData3DBlock ::= SEQUENCE {
    triangleIndex1 [0] INTEGER (0..MAX),
    triangleIndex2 [1] INTEGER (0..MAX),
    triangleIndex3 [2] INTEGER (0..MAX)
}

CoordinateSystem3DCode ::= ENUMERATED {
    cartesianCoordinateSystem3D (0)
}

CoordinateSystem3DExtensionBlock ::= SEQUENCE {
    fallback [0] CoordinateSystem3DCode,
    ...
}

CoordinateSystem3D ::= CHOICE {
    code [0] CoordinateSystem3DCode,
    extensionBlock [1] CoordinateSystem3DExtensionBlock
}

CartesianScalesAndOffsets3DBlock ::= SEQUENCE {
    scaleX [0] REAL,
    scaleY [1] REAL,
    scaleZ [2] REAL,
    offsetX [3] REAL,
    offsetY [4] REAL,
    offsetZ [5] REAL
}

FaceImageKind3DCode ::= ENUMERATED {
    texturedFaceImage3d (0)
}

FaceImageKind3DExtensionBlock ::= SEQUENCE {
    fallback [0] FaceImageKind3DCode,
    ...
}

FaceImageKind3D ::= CHOICE {
    code [0] FaceImageKind3DCode,
    extensionBlock [1] FaceImageKind3DExtensionBlock
}

PhysicalFaceMeasurements3DBlock ::= SEQUENCE {
    physicalHeadWidth3D [0] INTEGER OPTIONAL,
    physicalInterEyeDistance3D [1] INTEGER OPTIONAL,
    physicalEyeToMouthDistance3D [2] INTEGER OPTIONAL,
    physicalHeadLength3D [3] INTEGER OPTIONAL,
    ...
}

TexturedImageResolution3DBlock ::= SEQUENCE {
    mMShapeXResolution3D [0] REAL OPTIONAL,
    mMShapeYResolution3D [1] REAL OPTIONAL,
    mMShapeZResolution3D [2] REAL OPTIONAL,
    mMTextureResolution3D [3] REAL OPTIONAL,
    textureAcquisitionPeriod3D [4] REAL OPTIONAL,
    faceAreaScanned3DBlock [5] FaceAreaScanned3DBlock OPTIONAL,
    ...
}

FaceAreaScanned3DBlock ::= SEQUENCE {
    frontOfTheHead [0] BOOLEAN OPTIONAL,
    chin [1] BOOLEAN OPTIONAL,
    ears [2] BOOLEAN OPTIONAL,
    neck [3] BOOLEAN OPTIONAL,
```

```
      backOfTheHead [4] BOOLEAN OPTIONAL,
      fullHead [5] BOOLEAN OPTIONAL,
      ...
   }

   TextureMap3DBlock ::= SEQUENCE {
      textureMapData3D [0] OCTET STRING,
      imageDataFormat [1] ImageDataFormat,
      textureCaptureDeviceSpectral3D [2] TextureCaptureDeviceSpectral3D OPTIONAL,
      textureStandardIlluminant3D [3] TextureStandardIlluminant3D OPTIONAL,
      errorMap3D [4] OCTET STRING OPTIONAL,
      ...
   }

   TextureCaptureDeviceSpectral3DCode ::= ENUMERATED {
      unknown (0),
      other (1),
      white (2),
      veryNearInfrared (3),
      shortWaveInfrared (4)
   }

   TextureCaptureDeviceSpectral3DExtensionBlock ::= SEQUENCE {
      fallback [0] TextureCaptureDeviceSpectral3DCode,
      ...
   }

   TextureCaptureDeviceSpectral3D ::= CHOICE {
      code [0] TextureCaptureDeviceSpectral3DCode,
      extensionBlock [1] TextureCaptureDeviceSpectral3DExtensionBlock
   }

   TextureStandardIlluminant3DCode ::= ENUMERATED {
      d30 (0),
      d35 (1),
      d40 (2),
      d45 (3),
      d50 (4),
      d55 (5),
      d60 (6),
      d65 (7),
      d70 (8),
      d75 (9),
      d80 (10)
   }

   TextureStandardIlluminant3DExtensionBlock ::= SEQUENCE {
      fallback [0] TextureStandardIlluminant3DCode,
      ...
   }

   TextureStandardIlluminant3D ::= CHOICE {
      code [0] TextureStandardIlluminant3DCode,
      extensionBlock [1] TextureStandardIlluminant3DExtensionBlock
   }
END
```


A.2 XML schema definition for XML encoding

The XSD module below can be retrieved from http://standards.iso.org/iso-iec/39794/-5/ed-1/en

```
<?xml version="1.0" encoding="utf-8"?>
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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/-5"
   vc:minVersion="1.0"
   targetNamespace="http://standards.iso.org/iso-iec/39794/-5"
   elementFormDefault="qualified"
   attributeFormDefault="unqualified">

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

  <xs:element name="faceImageData" type="FaceImageDataBlockType">
    <xs:annotation>
      <xs:documentation>root element</xs:documentation>
    </xs:annotation>
  </xs:element>

  <xs:complexType name="FaceImageDataBlockType">
    <xs:sequence>
      <xs:element name="versionBlock" type="cmn:VersionBlockType" />
      <xs:element name="representationBlocks" type="RepresentationBlocksType" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
   </xs:sequence>
  </xs:complexType>

  <xs:complexType name="RepresentationBlocksType">
    <xs:sequence>
      <xs:element name="representationBlock" type="RepresentationBlockType"
maxOccurs="unbounded" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="RepresentationBlockType">
    <xs:sequence>
      <xs:element name="representationId" type="xs:unsignedInt" />
      <xs:element name="imageRepresentation" type="ImageRepresentationType" />
      <xs:element name="captureDateTimeBlock" type="cmn:CaptureDateTimeBlockType"
minOccurs="0" />
      <xs:element name="qualityBlocks" type="cmn:QualityBlocksType" minOccurs="0" />
      <xs:element name="padDataBlock" type="cmn:PADDataBlockType" minOccurs="0" />
      <xs:element name="sessionId" type="xs:unsignedInt" minOccurs="0" />
      <xs:element name="derivedFrom" type="xs:unsignedInt" minOccurs="0" />
      <xs:element name="captureDeviceBlock" type="CaptureDeviceBlockType" minOccurs="0" />
      <xs:element name="identityMetadataBlock" type="IdentityMetadataBlockType"
minOccurs="0" />
      <xs:element name="landmarkBlocks" type="LandmarkBlocksType" minOccurs="0" />
```



```
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="CaptureDeviceBlockType">
    <xs:sequence>
      <xs:element name="modelIdBlock" type="cmn:RegistryIdBlockType" minOccurs="0" />
      <xs:element name="certificationIdBlocks" type="cmn:CertificationIdBlocksType"
minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="IdentityMetadataBlockType">
    <xs:sequence>
      <xs:element name="gender" type="GenderType" minOccurs="0" />
      <xs:element name="eyeColour" type="EyeColourType" minOccurs="0" />
      <xs:element name="hairColour" type="HairColourType" minOccurs="0" />
      <xs:element name="subjectHeight" type="SubjectHeightType" minOccurs="0" />
      <xs:element name="propertiesBlock" type="PropertiesBlockType" minOccurs="0" />
      <xs:element name="expressionBlock" type="ExpressionBlockType" minOccurs="0" />
      <xs:element name="poseAngleBlock" type="PoseAngleBlockType" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="GenderCodeType">
    <xs:choice>
      <xs:element name="unknown" type="xs:int" fixed="0" />
      <xs:element name="other" type="xs:int" fixed="1" />
      <xs:element name="male" type="xs:int" fixed="2" />
      <xs:element name="female" type="xs:int" fixed="3" />
    </xs:choice>
  </xs:complexType>

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

  <xs:complexType name="GenderType">
    <xs:choice>
      <xs:element name="code" type="GenderCodeType" />
      <xs:element name="extensionBlock" type="GenderExtensionBlockType" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="EyeColourCodeType">
    <xs:choice>
      <xs:element name="unknown" type="xs:int" fixed="0" />
      <xs:element name="other" type="xs:int" fixed="1" />
      <xs:element name="black" type="xs:int" fixed="2" />
      <xs:element name="blue" type="xs:int" fixed="3" />
      <xs:element name="brown" type="xs:int" fixed="4" />
      <xs:element name="grey" type="xs:int" fixed="5" />
      <xs:element name="green" type="xs:int" fixed="6" />
      <xs:element name="hazel" type="xs:int" fixed="7" />
      <xs:element name="multi-coloured" type="xs:int" fixed="8" />
      <xs:element name="pink" type="xs:int" fixed="9" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="EyeColourExtensionBlockType">
    <xs:sequence>
      <xs:element name="fallback" type="EyeColourCodeType" />
      <xs:any namespace="##other" processContents="lax" />
    </xs:sequence>
  </xs:complexType>
```



```
<xs:complexType name="EyeColourType">
  <xs:choice>
    <xs:element name="code" type="EyeColourCodeType" />
    <xs:element name="extensionBlock" type="EyeColourExtensionBlockType" />
  </xs:choice>
</xs:complexType>

<xs:complexType name="HairColourCodeType">
  <xs:choice>
    <xs:element name="unknown" type="xs:int" fixed="0" />
    <xs:element name="other" type="xs:int" fixed="1" />
    <xs:element name="bald" type="xs:int" fixed="2" />
    <xs:element name="black" type="xs:int" fixed="3" />
    <xs:element name="blonde" type="xs:int" fixed="4" />
    <xs:element name="brown" type="xs:int" fixed="5" />
    <xs:element name="grey" type="xs:int" fixed="6" />
    <xs:element name="white" type="xs:int" fixed="7" />
    <xs:element name="red" type="xs:int" fixed="8" />
    <xs:element name="knownColoured" type="xs:int" fixed="9" />
  </xs:choice>
</xs:complexType>

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

<xs:complexType name="HairColourType">
  <xs:choice>
    <xs:element name="code" type="HairColourCodeType" />
    <xs:element name ="extensionBlock" type="HairColourExtensionBlockType" />
  </xs:choice>
</xs:complexType>

<xs:simpleType name="SubjectHeightType">
  <xs:restriction base="xs:unsignedInt">
    <xs:minInclusive value="1" />
    <xs:maxInclusive value="65535" />
  </xs:restriction>
</xs:simpleType>

<xs:complexType name="PropertiesBlockType">
  <xs:sequence>
    <xs:element name="glasses" type="xs:boolean" minOccurs="0" />
    <xs:element name="moustache" type="xs:boolean" minOccurs="0" />
    <xs:element name="beard" type="xs:boolean" minOccurs="0" />
    <xs:element name="teethVisible" type="xs:boolean" minOccurs="0" />
    <xs:element name="pupilOrIrisNotVisible" type="xs:boolean" minOccurs="0" />
    <xs:element name="mouthOpen" type="xs:boolean" minOccurs="0" />
    <xs:element name="leftEyePatch" type="xs:boolean" minOccurs="0" />
    <xs:element name="rightEyePatch" type="xs:boolean" minOccurs="0" />
    <xs:element name="darkGlasses" type="xs:boolean" minOccurs="0" />
    <xs:element name="biometricAbsent" type="xs:boolean" minOccurs="0" />
    <xs:element name="headCoveringsPresent" type="xs:boolean" minOccurs="0" />
    <xs:any namespace="##other" processContents="lax" minOccurs="0" />
  </xs:sequence>
</xs:complexType>

<xs:complexType name="ExpressionBlockType">
  <xs:sequence>
    <xs:element name="neutral" type="xs:boolean" minOccurs="0" />
    <xs:element name="smile" type="xs:boolean" minOccurs="0" />
    <xs:element name="raisedEyebrows" type="xs:boolean" minOccurs="0" />
    <xs:element name="eyesLookingAwayFromTheCamera" type="xs:boolean" minOccurs="0" />
    <xs:element name="squinting" type="xs:boolean" minOccurs="0" />
    <xs:element name="frowning" type="xs:boolean" minOccurs="0" />
    <xs:any namespace="##other" processContents="lax" minOccurs="0" />
  </xs:sequence>
</xs:complexType>
```

```
  <xs:complexType name="PoseAngleBlockType">
    <xs:sequence>
      <xs:element name="yawAngleBlock" type="AngleDataBlockType" minOccurs="0" />
      <xs:element name="pitchAngleBlock" type="AngleDataBlockType" minOccurs="0" />
      <xs:element name="rollAngleBlock" type="AngleDataBlockType" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="AngleDataBlockType">
    <xs:sequence>
      <xs:element name="angleValue" type="AngleValueType" />
      <xs:element name="angleUncertainty" type="AngleUncertaintyType" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:simpleType name="AngleValueType">
    <xs:restriction base="xs:integer">
      <xs:minInclusive value="-180" />
      <xs:maxInclusive value="180" />
    </xs:restriction>
  </xs:simpleType>

  <xs:simpleType name="AngleUncertaintyType">
    <xs:restriction base="xs:integer">
      <xs:minInclusive value="0" />
      <xs:maxInclusive value="180" />
    </xs:restriction>
  </xs:simpleType>

  <xs:complexType name="LandmarkBlocksType">
    <xs:sequence>
      <xs:element name="landmarkBlock" type="LandmarkBlockType" maxOccurs="unbounded" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="LandmarkBlockType">
    <xs:sequence>
      <xs:element name="landmarkKind" type="LandmarkKindType" />
      <xs:element name="landmarkCoordinates" type="LandmarkCoordinatesType" minOccurs="0"
/>
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="LandmarkKindBaseType">
    <xs:choice>
      <xs:element name="mpeg4FeaturePoint" type="MPEG4FeaturePointType" />
      <xs:element name="anthropometricLandmark" type="AnthropometricLandmarkType" />
    </xs:choice>
  </xs:complexType>

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

  <xs:complexType name="LandmarkKindType">
    <xs:choice>
      <xs:element name="base" type="LandmarkKindBaseType"/>
      <xs:element name="extensionBlock" type="LandmarkKindExtensionBlockType"/>
    </xs:choice>
  </xs:complexType>

 <xs:complexType name="MPEG4FeaturePointCodeType">
    <xs:choice>
      <xs:element name="mpeg4PointCode-02-01" type="xs:int" fixed="0" />
      <xs:element name="mpeg4PointCode-02-02" type="xs:int" fixed="1" />
      <xs:element name="mpeg4PointCode-02-03" type="xs:int" fixed="2" />
```

```
<xs:element name="mpeg4PointCode-02-04" type="xs:int" fixed="3" />
<xs:element name="mpeg4PointCode-02-05" type="xs:int" fixed="4" />
<xs:element name="mpeg4PointCode-02-06" type="xs:int" fixed="5" />
<xs:element name="mpeg4PointCode-02-07" type="xs:int" fixed="6" />
<xs:element name="mpeg4PointCode-02-08" type="xs:int" fixed="7" />
<xs:element name="mpeg4PointCode-02-09" type="xs:int" fixed="8" />
<xs:element name="mpeg4PointCode-02-10" type="xs:int" fixed="9" />
<xs:element name="mpeg4PointCode-02-11" type="xs:int" fixed="10" />
<xs:element name="mpeg4PointCode-02-12" type="xs:int" fixed="11" />
<xs:element name="mpeg4PointCode-02-13" type="xs:int" fixed="12" />
<xs:element name="mpeg4PointCode-02-14" type="xs:int" fixed="13" />
<xs:element name="mpeg4PointCode-03-01" type="xs:int" fixed="14" />
<xs:element name="mpeg4PointCode-03-02" type="xs:int" fixed="15" />
<xs:element name="mpeg4PointCode-03-03" type="xs:int" fixed="16" />
<xs:element name="mpeg4PointCode-03-04" type="xs:int" fixed="17" />
<xs:element name="mpeg4PointCode-03-05" type="xs:int" fixed="18" />
<xs:element name="mpeg4PointCode-03-06" type="xs:int" fixed="19" />
<xs:element name="mpeg4PointCode-03-07" type="xs:int" fixed="20" />
<xs:element name="mpeg4PointCode-03-08" type="xs:int" fixed="21" />
<xs:element name="mpeg4PointCode-03-09" type="xs:int" fixed="22" />
<xs:element name="mpeg4PointCode-03-10" type="xs:int" fixed="23" />
<xs:element name="mpeg4PointCode-03-11" type="xs:int" fixed="24" />
<xs:element name="mpeg4PointCode-03-12" type="xs:int" fixed="25" />
<xs:element name="mpeg4PointCode-03-13" type="xs:int" fixed="26" />
<xs:element name="mpeg4PointCode-03-14" type="xs:int" fixed="27" />
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<xs:element name="mpeg4PointCode-04-02" type="xs:int" fixed="29" />
<xs:element name="mpeg4PointCode-04-03" type="xs:int" fixed="30" />
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<xs:element name="mpeg4PointCode-04-05" type="xs:int" fixed="32" />
<xs:element name="mpeg4PointCode-04-06" type="xs:int" fixed="33" />
<xs:element name="mpeg4PointCode-05-01" type="xs:int" fixed="34" />
<xs:element name="mpeg4PointCode-05-02" type="xs:int" fixed="35" />
<xs:element name="mpeg4PointCode-05-03" type="xs:int" fixed="36" />
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<xs:element name="mpeg4PointCode-06-02" type="xs:int" fixed="39" />
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<xs:element name="mpeg4PointCode-08-02" type="xs:int" fixed="44" />
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<xs:element name="mpeg4PointCode-08-06" type="xs:int" fixed="48" />
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<xs:element name="mpeg4PointCode-08-08" type="xs:int" fixed="50" />
<xs:element name="mpeg4PointCode-08-09" type="xs:int" fixed="51" />
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<xs:element name="mpeg4PointCode-09-02" type="xs:int" fixed="54" />
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<xs:element name="mpeg4PointCode-09-10" type="xs:int" fixed="62" />
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<xs:element name="mpeg4PointCode-09-12" type="xs:int" fixed="64" />
<xs:element name="mpeg4PointCode-09-13" type="xs:int" fixed="65" />
<xs:element name="mpeg4PointCode-09-14" type="xs:int" fixed="66" />
<xs:element name="mpeg4PointCode-09-15" type="xs:int" fixed="67" />
<xs:element name="mpeg4PointCode-10-01" type="xs:int" fixed="68" />
<xs:element name="mpeg4PointCode-10-02" type="xs:int" fixed="69" />
<xs:element name="mpeg4PointCode-10-03" type="xs:int" fixed="70" />
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<xs:element name="mpeg4PointCode-10-05" type="xs:int" fixed="72" />
<xs:element name="mpeg4PointCode-10-06" type="xs:int" fixed="73" />
```



```
      <xs:element name="mpeg4PointCode-10-07" type="xs:int" fixed="74" />
      <xs:element name="mpeg4PointCode-10-08" type="xs:int" fixed="75" />
      <xs:element name="mpeg4PointCode-10-09" type="xs:int" fixed="76" />
      <xs:element name="mpeg4PointCode-10-10" type="xs:int" fixed="77" />
      <xs:element name="mpeg4PointCode-11-01" type="xs:int" fixed="78" />
      <xs:element name="mpeg4PointCode-11-02" type="xs:int" fixed="79" />
      <xs:element name="mpeg4PointCode-11-03" type="xs:int" fixed="80" />
      <xs:element name="mpeg4PointCode-11-04" type="xs:int" fixed="81" />
      <xs:element name="mpeg4PointCode-11-05" type="xs:int" fixed="82" />
      <xs:element name="mpeg4PointCode-11-06" type="xs:int" fixed="83" />
      <xs:element name="mpeg4PointCode-12-01" type="xs:int" fixed="84" />
      <xs:element name="mpeg4PointCode-12-02" type="xs:int" fixed="85" />
      <xs:element name="mpeg4PointCode-12-03" type="xs:int" fixed="86" />
      <xs:element name="mpeg4PointCode-12-04" type="xs:int" fixed="87" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="MPEG4FeaturePointExtensionBlockType">
    <xs:sequence>
      <xs:element name="fallback" type="MPEG4FeaturePointCodeType" />
      <xs:any namespace="##other" processContents="lax" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="MPEG4FeaturePointType">
    <xs:choice>
      <xs:element name="code" type="MPEG4FeaturePointCodeType" />
      <xs:element name="extensionBlock" type="MPEG4FeaturePointExtensionBlockType" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="AnthropometricLandmarkBaseType">
    <xs:choice>
      <xs:element name="anthropometricLandmarkName" type="AnthropometricLandmarkNameType"
/>
      <xs:element name="anthropometricLandmarkPointName" type="AnthropometricLandmarkPoint
NameType" />
      <xs:element name="anthropometricLandmarkPointId" type="AnthropometricLandmarkPointId
Type" />
    </xs:choice>
  </xs:complexType>

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

  <xs:complexType name="AnthropometricLandmarkType">
    <xs:choice>
      <xs:element name="base" type="AnthropometricLandmarkBaseType"/>
      <xs:element name="extensionBlock" type="AnthropometricLandmarkExtensionBlockType"/>
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="AnthropometricLandmarkNameCodeType">
    <xs:choice>
      <xs:element name="vertex" type="xs:int" fixed="0" />
      <xs:element name="glabella" type="xs:int" fixed="1" />
      <xs:element name="opisthocranion" type="xs:int" fixed="2" />
      <xs:element name="eurionLeft" type="xs:int" fixed="3" />
      <xs:element name="eurionRight" type="xs:int" fixed="4" />
      <xs:element name="frontotemporaleLeft" type="xs:int" fixed="5" />
      <xs:element name="frontotemporaleRight" type="xs:int" fixed="6" />
      <xs:element name="trichion" type="xs:int" fixed="7" />
      <xs:element name="zygionLeft" type="xs:int" fixed="8" />
      <xs:element name="zygionRight" type="xs:int" fixed="9" />
      <xs:element name="gonionLeft" type="xs:int" fixed="10" />
      <xs:element name="gonionRight" type="xs:int" fixed="11" />
      <xs:element name="sublabiale" type="xs:int" fixed="12" />
      <xs:element name="pogonion" type="xs:int" fixed="13" />
```



```
      <xs:element name="menton" type="xs:int" fixed="14" />
      <xs:element name="condylionLateraleLeft" type="xs:int" fixed="15" />
      <xs:element name="condylionLateraleRight" type="xs:int" fixed="16" />
      <xs:element name="endocanthionLeft" type="xs:int" fixed="17" />
      <xs:element name="endocanthionRight" type="xs:int" fixed="18" />
      <xs:element name="exocanthionLeft" type="xs:int" fixed="19" />
      <xs:element name="exocanthionRight" type="xs:int" fixed="20" />
      <xs:element name="centerPointOfPupilLeft" type="xs:int" fixed="21" />
      <xs:element name="centerPointOfPupilRight" type="xs:int" fixed="22" />
      <xs:element name="orbitaleLeft" type="xs:int" fixed="23" />
      <xs:element name="orbitaleRight" type="xs:int" fixed="24" />
      <xs:element name="palpebraleSuperiusLeft" type="xs:int" fixed="25" />
      <xs:element name="palpebraleSuperiusRight" type="xs:int" fixed="26" />
      <xs:element name="palpebraleInferiusLeft" type="xs:int" fixed="27" />
      <xs:element name="palpebraleInferiusRight" type="xs:int" fixed="28" />
      <xs:element name="orbitaleSuperiusLeft" type="xs:int" fixed="29" />
      <xs:element name="orbitaleSuperiusRight" type="xs:int" fixed="30" />
      <xs:element name="superciliareLeft" type="xs:int" fixed="31" />
      <xs:element name="superciliareRight" type="xs:int" fixed="32" />
      <xs:element name="nasion" type="xs:int" fixed="33" />
      <xs:element name="sellion" type="xs:int" fixed="34" />
      <xs:element name="alareLeft" type="xs:int" fixed="35" />
      <xs:element name="alareRight" type="xs:int" fixed="36" />
      <xs:element name="pronasale" type="xs:int" fixed="37" />
      <xs:element name="subnasale" type="xs:int" fixed="38" />
      <xs:element name="subalare" type="xs:int" fixed="39" />
      <xs:element name="alarCurvatureLeft" type="xs:int" fixed="40" />
      <xs:element name="alarCurvatureRight" type="xs:int" fixed="41" />
      <xs:element name="maxillofrontale" type="xs:int" fixed="42" />
      <xs:element name="christaPhiltraLandmarkLeft" type="xs:int" fixed="43" />
      <xs:element name="christaPhiltraLandmarkRight" type="xs:int" fixed="44" />
      <xs:element name="labialeSuperius" type="xs:int" fixed="45" />
      <xs:element name="labialeInferius" type="xs:int" fixed="46" />
      <xs:element name="cheilionLeft" type="xs:int" fixed="47" />
      <xs:element name="cheilionRight" type="xs:int" fixed="48" />
      <xs:element name="stomion" type="xs:int" fixed="49" />
      <xs:element name="superauraleLeft" type="xs:int" fixed="50" />
      <xs:element name="superauraleRight" type="xs:int" fixed="51" />
      <xs:element name="subauraleLeft" type="xs:int" fixed="52" />
      <xs:element name="subauraleRight" type="xs:int" fixed="53" />
      <xs:element name="preaurale" type="xs:int" fixed="54" />
      <xs:element name="postaurale" type="xs:int" fixed="55" />
      <xs:element name="otobasionSuperiusLeft" type="xs:int" fixed="56" />
      <xs:element name="otobasionSuperiusRight" type="xs:int" fixed="57" />
      <xs:element name="otobasionInferius" type="xs:int" fixed="58" />
      <xs:element name="porion" type="xs:int" fixed="59" />
      <xs:element name="tragion" type="xs:int" fixed="60" />
    </xs:choice>
  </xs:complexType>

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

  <xs:complexType name="AnthropometricLandmarkNameType">
    <xs:choice>
      <xs:element name="code" type="AnthropometricLandmarkNameCodeType" />
      <xs:element name="extensionBlock" type="AnthropometricLandmarkNameExtensionBlockT
ype" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="AnthropometricLandmarkPointNameCodeType">
    <xs:choice>
      <xs:element name="pointCode-01-01" type="xs:int" fixed="0" />
      <xs:element name="pointCode-01-02" type="xs:int" fixed="1" />
      <xs:element name="pointCode-01-05" type="xs:int" fixed="2" />
      <xs:element name="pointCode-01-06" type="xs:int" fixed="3" />
```



```
      <xs:element name="pointCode-01-07" type="xs:int" fixed="4" />
      <xs:element name="pointCode-01-08" type="xs:int" fixed="5" />
      <xs:element name="pointCode-01-09" type="xs:int" fixed="6" />
      <xs:element name="pointCode-02-01" type="xs:int" fixed="7" />
      <xs:element name="pointCode-02-02" type="xs:int" fixed="8" />
      <xs:element name="pointCode-02-03" type="xs:int" fixed="9" />
      <xs:element name="pointCode-02-04" type="xs:int" fixed="10" />
      <xs:element name="pointCode-02-05" type="xs:int" fixed="11" />
      <xs:element name="pointCode-02-06" type="xs:int" fixed="12" />
      <xs:element name="pointCode-02-07" type="xs:int" fixed="13" />
      <xs:element name="pointCode-02-09" type="xs:int" fixed="14" />
      <xs:element name="pointCode-02-10" type="xs:int" fixed="15" />
      <xs:element name="pointCode-03-01" type="xs:int" fixed="16" />
      <xs:element name="pointCode-03-02" type="xs:int" fixed="17" />
      <xs:element name="pointCode-03-03" type="xs:int" fixed="18" />
      <xs:element name="pointCode-03-04" type="xs:int" fixed="19" />
      <xs:element name="pointCode-03-05" type="xs:int" fixed="20" />
      <xs:element name="pointCode-03-06" type="xs:int" fixed="21" />
      <xs:element name="pointCode-03-07" type="xs:int" fixed="22" />
      <xs:element name="pointCode-03-08" type="xs:int" fixed="23" />
      <xs:element name="pointCode-03-09" type="xs:int" fixed="24" />
      <xs:element name="pointCode-03-10" type="xs:int" fixed="25" />
      <xs:element name="pointCode-03-11" type="xs:int" fixed="26" />
      <xs:element name="pointCode-03-12" type="xs:int" fixed="27" />
      <xs:element name="pointCode-04-01" type="xs:int" fixed="28" />
      <xs:element name="pointCode-04-02" type="xs:int" fixed="29" />
      <xs:element name="pointCode-04-03" type="xs:int" fixed="30" />
      <xs:element name="pointCode-04-04" type="xs:int" fixed="31" />
      <xs:element name="pointCode-05-01" type="xs:int" fixed="32" />
      <xs:element name="pointCode-05-02" type="xs:int" fixed="33" />
      <xs:element name="pointCode-05-03" type="xs:int" fixed="34" />
      <xs:element name="pointCode-05-04" type="xs:int" fixed="35" />
      <xs:element name="pointCode-05-06" type="xs:int" fixed="36" />
    </xs:choice>
  </xs:complexType>

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

  <xs:complexType name="AnthropometricLandmarkPointNameType">
    <xs:choice>
      <xs:element name="code" type="AnthropometricLandmarkPointNameCodeType" />
      <xs:element name="extensionBlock" type="AnthropometricLandmarkPointNameExtensionBloc
kType" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="AnthropometricLandmarkPointIdCodeType">
    <xs:choice>
      <xs:element name="v" type="xs:int" fixed="0" />
      <xs:element name="g" type="xs:int" fixed="1" />
      <xs:element name="op" type="xs:int" fixed="2" />
      <xs:element name="eu-left" type="xs:int" fixed="3" />
      <xs:element name="eu-right" type="xs:int" fixed="4" />
      <xs:element name="ft-left" type="xs:int" fixed="5" />
      <xs:element name="ft-right" type="xs:int" fixed="6" />
      <xs:element name="tr" type="xs:int" fixed="7" />
      <xs:element name="zy-left" type="xs:int" fixed="8" />
      <xs:element name="zy-right" type="xs:int" fixed="9" />
      <xs:element name="go-left" type="xs:int" fixed="10" />
      <xs:element name="go-right" type="xs:int" fixed="11" />
      <xs:element name="sl" type="xs:int" fixed="12" />
      <xs:element name="pg" type="xs:int" fixed="13" />
      <xs:element name="gn" type="xs:int" fixed="14" />
      <xs:element name="cdl-left" type="xs:int" fixed="15" />
      <xs:element name="cdl-right" type="xs:int" fixed="16" />
      <xs:element name="en-left" type="xs:int" fixed="17" />
```

```
      <xs:element name="en-right" type="xs:int" fixed="18" />
      <xs:element name="ex-left" type="xs:int" fixed="19" />
      <xs:element name="ex-right" type="xs:int" fixed="20" />
      <xs:element name="p-left" type="xs:int" fixed="21" />
      <xs:element name="p-right" type="xs:int" fixed="22" />
      <xs:element name="or-left" type="xs:int" fixed="23" />
      <xs:element name="or-right" type="xs:int" fixed="24" />
      <xs:element name="ps-left" type="xs:int" fixed="25" />
      <xs:element name="ps-right" type="xs:int" fixed="26" />
      <xs:element name="pi-left" type="xs:int" fixed="27" />
      <xs:element name="pi-right" type="xs:int" fixed="28" />
      <xs:element name="os-left" type="xs:int" fixed="29" />
      <xs:element name="os-right" type="xs:int" fixed="30" />
      <xs:element name="sci-left" type="xs:int" fixed="31" />
      <xs:element name="sci-right" type="xs:int" fixed="32" />
      <xs:element name="n" type="xs:int" fixed="33" />
      <xs:element name="se" type="xs:int" fixed="34" />
      <xs:element name="al-left" type="xs:int" fixed="35" />
      <xs:element name="al-right" type="xs:int" fixed="36" />
      <xs:element name="prn" type="xs:int" fixed="37" />
      <xs:element name="sn" type="xs:int" fixed="38" />
      <xs:element name="sbal" type="xs:int" fixed="39" />
      <xs:element name="ac-left" type="xs:int" fixed="40" />
      <xs:element name="ac-right" type="xs:int" fixed="41" />
      <xs:element name="mf-left" type="xs:int" fixed="42" />
      <xs:element name="mf-right" type="xs:int" fixed="43" />
      <xs:element name="cph-left" type="xs:int" fixed="44" />
      <xs:element name="cph-right" type="xs:int" fixed="45" />
      <xs:element name="ls" type="xs:int" fixed="46" />
      <xs:element name="li" type="xs:int" fixed="47" />
      <xs:element name="ch-left" type="xs:int" fixed="48" />
      <xs:element name="ch-right" type="xs:int" fixed="49" />
      <xs:element name="sto" type="xs:int" fixed="50" />
      <xs:element name="sa-left" type="xs:int" fixed="51" />
      <xs:element name="sa-right" type="xs:int" fixed="52" />
      <xs:element name="sba-left" type="xs:int" fixed="53" />
      <xs:element name="sba-right" type="xs:int" fixed="54" />
      <xs:element name="pra-left" type="xs:int" fixed="55" />
      <xs:element name="pra-right" type="xs:int" fixed="56" />
      <xs:element name="pa" type="xs:int" fixed="57" />
      <xs:element name="obs-left" type="xs:int" fixed="58" />
      <xs:element name="obs-right" type="xs:int" fixed="59" />
      <xs:element name="obi" type="xs:int" fixed="60" />
      <xs:element name="po" type="xs:int" fixed="61" />
      <xs:element name="t" type="xs:int" fixed="62" />
    </xs:choice>
  </xs:complexType>

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

  <xs:complexType name="AnthropometricLandmarkPointIdType">
    <xs:choice>
      <xs:element name="code" type="AnthropometricLandmarkPointIdCodeType" />
      <xs:element name="extensionBlock" type="AnthropometricLandmarkPointIdExtensionBlockT
ype" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="LandmarkCoordinatesBaseType">
    <xs:choice>
      <xs:element name="coordinateCartesian2DBlock" type="cmn:CoordinateCartesian2DUnsigne
dShortBlockType" />
      <xs:element name="coordinateTextureImageBlock" type="CoordinateTextureImageBlockT
ype" />
      <xs:element name="coordinateCartesian3DBlock" type="cmn:CoordinateCartesian3DUnsigne
dShortBlockType" />
```

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

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

  <xs:complexType name="LandmarkCoordinatesType">
    <xs:choice>
      <xs:element name="base" type="LandmarkCoordinatesBaseType"/>
      <xs:element name="extensionBlock" type="LandmarkCoordinatesExtensionBlockType"/>
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="CoordinateTextureImageBlockType">
    <xs:sequence>
      <xs:element name="uInPixel" type="xs:unsignedInt" />
      <xs:element name="vInPixel" type="xs:unsignedInt" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="ImageRepresentationType">
    <xs:choice>
      <xs:element name="base" type="ImageRepresentationBaseType" />
      <xs:element name="extensionBlock" type="ImageRepresentationExtensionBlockType" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="ImageRepresentationBaseType">
    <xs:choice>
      <xs:element name="imageRepresentation2DBlock" type="ImageRepresentation2DBlockType"
/>
      <xs:element name="shapeRepresentation3DBlock" type="ShapeRepresentation3DBlockType"
/>
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="ImageRepresentationExtensionBlockType">
    <xs:sequence>
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="ImageRepresentation2DBlockType">
    <xs:sequence>
      <xs:element name="representationData2D" type="xs:base64Binary" />
      <xs:element name="imageInformation2DBlock" type="ImageInformation2DBlockType" />
      <xs:element name="captureDevice2DBlock" type="CaptureDevice2DBlockType"
minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="CaptureDevice2DBlockType">
    <xs:sequence>
      <xs:element name="captureDeviceSpectral2DBlock" type="CaptureDeviceSpectral2DBlockT
ype" minOccurs="0" />
      <xs:element name="captureDeviceTechnologyId2D" type="CaptureDeviceTechnologyId2DT
ype" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="CaptureDeviceSpectral2DBlockType">
    <xs:sequence>
      <xs:element name="whiteLight" type="xs:boolean" minOccurs="0" />
      <xs:element name="nearInfrared" type="xs:boolean" minOccurs="0" />
      <xs:element name="thermal" type="xs:boolean" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
```

```
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="CaptureDeviceTechnologyId2DCodeType">
    <xs:choice>
      <xs:element name="unknown" type="xs:int" fixed="0" />
      <xs:element name="staticPhotographFromUnknownSource" type="xs:int" fixed="1" />
      <xs:element name="staticPhotographFromDigitalStillImageCamera" type="xs:int"
fixed="2" />
      <xs:element name="staticPhotographFromScanner" type="xs:int" fixed="3" />
      <xs:element name="videoFrameFromUnknownSource" type="xs:int" fixed="4" />
      <xs:element name="videoFrameFromAnalogueVideoCamera" type="xs:int" fixed="5" />
      <xs:element name="videoFrameFromDigitalVideoCamera" type="xs:int" fixed="6" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="CaptureDeviceTechnologyId2DExtensionBlockType">
    <xs:sequence>
      <xs:element name="fallback" type="CaptureDeviceTechnologyId2DCodeType" />
      <xs:any namespace="##other" processContents="lax" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="CaptureDeviceTechnologyId2DType">
    <xs:choice>
      <xs:element name="code" type="CaptureDeviceTechnologyId2DCodeType" />
      <xs:element name ="extensionBlock" type="CaptureDeviceTechnologyId2DExtensionBlockT
ype" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="ImageInformation2DBlockType">
    <xs:sequence>
      <xs:element name="imageDataFormat" type="ImageDataFormatType" />
      <xs:element name="faceImageKind2D" type="FaceImageKind2DType" minOccurs="0" />
      <xs:element name="postAcquisitionProcessingBlock" type="PostAcquisitionProcessingBlo
ckType" minOccurs="0" />
      <xs:element name="lossyTransformationAttempts" type="LossyTransformationAttemptsT
ype" minOccurs="0" />
      <xs:element name="cameraToSubjectDistance" type="CameraToSubjectDistanceType"
minOccurs="0" />
      <xs:element name="sensorDiagonal" type="SensorDiagonalType" minOccurs="0" />
      <xs:element name="lensFocalLength" type="LensFocalLengthType" minOccurs="0" />
      <xs:element name="imageSizeBlock" type="ImageSizeBlockType" minOccurs="0" />
      <xs:element name="imageFaceMeasurementsBlock" type="ImageFaceMeasurementsBlockType"
minOccurs="0" />
      <xs:element name="imageColourSpace" type="ImageColourSpaceType" minOccurs="0" />
      <xs:element name="referenceColourMappingBlock" type="ReferenceColourMappingBlockT
ype" minOccurs="0" />
     <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="FaceImageKind2DCodeType">
    <xs:choice>
      <xs:element name="mrtd" type="xs:int" fixed="0" />
      <xs:element name="generalPurpose" type="xs:int" fixed="1" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="FaceImageKind2DExtensionBlockType">
    <xs:sequence>
      <xs:element name="fallback" type="FaceImageKind2DCodeType" />
      <xs:any namespace="##other" processContents="lax" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="FaceImageKind2DType">
    <xs:choice>
      <xs:element name="code" type="FaceImageKind2DCodeType" />
      <xs:element name="extensionBlock" type="FaceImageKind2DExtensionBlockType" />
```

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

  <xs:complexType name="PostAcquisitionProcessingBlockType">
    <xs:sequence>
      <xs:element name="rotated" type="xs:boolean" minOccurs="0" />
      <xs:element name="cropped" type="xs:boolean" minOccurs="0" />
      <xs:element name="downSampled" type="xs:boolean" minOccurs="0" />
      <xs:element name="whiteBalanceAdjusted" type="xs:boolean" minOccurs="0" />
      <xs:element name="multiplyCompressed" type="xs:boolean" minOccurs="0" />
      <xs:element name="interpolated" type="xs:boolean" minOccurs="0" />
      <xs:element name="contrastStretched" type="xs:boolean" minOccurs="0" />
      <xs:element name="poseCorrected" type="xs:boolean" minOccurs="0" />
      <xs:element name="multiViewImage" type="xs:boolean" minOccurs="0" />
      <xs:element name="ageProgressed" type="xs:boolean" minOccurs="0" />
      <xs:element name="superResolutionProcessed" type="xs:boolean" minOccurs="0" />
      <xs:element name="normalised" type="xs:boolean" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="LossyTransformationAttemptsCodeType">
    <xs:choice>
      <xs:element name="unknown" type="xs:int" fixed="0" />
      <xs:element name="zero" type="xs:int" fixed="1" />
      <xs:element name="one" type="xs:int" fixed="2" />
      <xs:element name="moreThanOne" type="xs:int" fixed="3" />
    </xs:choice>
  </xs:complexType>

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

  <xs:complexType name="LossyTransformationAttemptsType">
    <xs:choice>
      <xs:element name="code" type="LossyTransformationAttemptsCodeType" />
      <xs:element name="extensionBlock" type="LossyTransformationAttemptsExtensionBlockT
ype" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="ImageDataFormatCodeType">
    <xs:choice>
      <xs:element name="unknown" type="xs:int" fixed="0" />
      <xs:element name="other" type="xs:int" fixed="1" />
      <xs:element name="jpeg" type="xs:int" fixed="2" />
      <xs:element name="jpeg2000Lossy" type="xs:int" fixed="3" />
      <xs:element name="jpeg2000Lossless" type="xs:int" fixed="4" />
      <xs:element name="png" type="xs:int" fixed="5" />
      <xs:element name="pgm" type="xs:int" fixed="6" />
      <xs:element name="ppm" type="xs:int" fixed="7" />
    </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>
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```
<xs:simpleType name="CameraToSubjectDistanceType">
  <xs:restriction base="xs:unsignedInt">
    <xs:minInclusive value="0" />
    <xs:maxInclusive value="50000" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="SensorDiagonalType">
  <xs:restriction base="xs:unsignedInt">
    <xs:minInclusive value="0" />
    <xs:maxInclusive value="2000" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="LensFocalLengthType">
  <xs:restriction base="xs:unsignedInt">
    <xs:minInclusive value="0" />
    <xs:maxInclusive value="2000" />
  </xs:restriction>
</xs:simpleType>

<xs:complexType name="ImageSizeBlockType">
  <xs:sequence>
    <xs:element name="width" type="ImageSizeType" />
    <xs:element name="height" type="ImageSizeType" />
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="ImageSizeType">
  <xs:restriction base="xs:integer">
    <xs:minInclusive value="0" />
    <xs:maxInclusive value="65535" />
  </xs:restriction>
</xs:simpleType>

<xs:complexType name="ImageFaceMeasurementsBlockType">
  <xs:sequence>
    <xs:element name="imageHeadWidth" type="xs:unsignedInt" minOccurs="0" />
    <xs:element name="imageInterEyeDistance" type="xs:unsignedInt" minOccurs="0" />
    <xs:element name="imageEyeToMouthDistance" type="xs:unsignedInt" minOccurs="0" />
    <xs:element name="imageHeadLength" type="xs:unsignedInt" minOccurs="0" />
   <xs:any namespace="##other" processContents="lax" minOccurs="0" />
  </xs:sequence>
</xs:complexType>

<xs:complexType name="ImageColourSpaceCodeType">
  <xs:choice>
    <xs:element name="unknown" type="xs:int" fixed="0" />
    <xs:element name="other" type="xs:int" fixed="1" />
    <xs:element name="rgb24Bit" type="xs:int" fixed="2" />
    <xs:element name="rgb48Bit" type="xs:int" fixed="3" />
    <xs:element name="yuv422" type="xs:int" fixed="4" />
    <xs:element name="greyscale8Bit" type="xs:int" fixed="5" />
    <xs:element name="greyscale16Bit" type="xs:int" fixed="6" />
  </xs:choice>
</xs:complexType>

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

<xs:complexType name="ImageColourSpaceType">
  <xs:choice>
    <xs:element name="code" type="ImageColourSpaceCodeType" />
    <xs:element name="extensionBlock" type="ImageColourSpaceExtensionBlockType" />
  </xs:choice>
</xs:complexType>
```



```
  <xs:complexType name="ReferenceColourMappingBlockType">
    <xs:sequence>
      <xs:element name="referenceColourSchema" type="xs:base64Binary" minOccurs="0" />
      <xs:element name="referenceColourDefinitionAndValueBlocks" type="ReferenceColourDefi
nitionAndValueBlocksType" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="ReferenceColourDefinitionAndValueBlocksType">
    <xs:sequence>
      <xs:element name="referenceColourDefinitionAndValueBlock" type="ReferenceColourDefin
itionAndValueBlockType" maxOccurs="unbounded" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="ReferenceColourDefinitionAndValueBlockType">
    <xs:sequence>
      <xs:element name="referenceColourDefinition" type="xs:base64Binary" minOccurs="0" />
      <xs:element name="referenceColourValue" type="xs:base64Binary" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="ShapeRepresentation3DBlockType">
    <xs:sequence>
      <xs:element name="representationData3D" type="xs:base64Binary" />
      <xs:element name="imageInformation3DBlock" type="ImageInformation3DBlockType" />
      <xs:element name="captureDevice3DBlock" type="CaptureDevice3DBlockType"
minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="CaptureDevice3DBlockType">
    <xs:sequence>
      <xs:element name="modus3D" type="Modus3DType" minOccurs="0" />
      <xs:element name="captureDeviceTechnologyId3D" type="CaptureDeviceTechnologyId3DT
ype" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="Modus3DCodeType">
    <xs:choice>
      <xs:element name="unknown" type="xs:int" fixed="0" />
      <xs:element name="active" type="xs:int" fixed="1" />
      <xs:element name="passive" type="xs:int" fixed="2" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="Modus3DExtensionBlockType">
    <xs:sequence>
      <xs:element name="fallback" type="Modus3DCodeType" />
      <xs:any namespace="##other" processContents="lax" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="Modus3DType">
    <xs:choice>
      <xs:element name="code" type="Modus3DCodeType" />
      <xs:element name="extensionBlock" type="Modus3DExtensionBlockType" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="CaptureDeviceTechnologyId3DCodeType">
    <xs:choice>
      <xs:element name="unknown" type="xs:int" fixed="0" />
      <xs:element name="stereoscopicScanner" type="xs:int" fixed="1" />
      <xs:element name="movingLaserLine" type="xs:int" fixed="2" />
      <xs:element name="structuredLight" type="xs:int" fixed="3" />
```

```
      <xs:element name="colourCodedLight" type="xs:int" fixed="4" />
      <xs:element name="timeOfFlight" type="xs:int" fixed="5" />
      <xs:element name="shapeFromShading" type="xs:int" fixed="6" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="CaptureDeviceTechnologyId3DExtensionBlockType">
    <xs:sequence>
      <xs:element name="fallback" type="CaptureDeviceTechnologyId3DCodeType" />
      <xs:any namespace="##other" processContents="lax" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="CaptureDeviceTechnologyId3DType">
    <xs:choice>
      <xs:element name="code" type="CaptureDeviceTechnologyId3DCodeType" />
      <xs:element name="extensionBlock" type="CaptureDeviceTechnologyId3DExtensionBlockT
ype" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="ImageInformation3DBlockType">
    <xs:sequence>
      <xs:element name="representationKind3D" type="RepresentationKind3DType" />
      <xs:element name="coordinateSystem3D" type="CoordinateSystem3DType" />
      <xs:element name="cartesianScalesAndOffsets3DBlock" type="CartesianScalesAndOffsets3
DBlockType" />
      <xs:element name="imageColourSpace" type="ImageColourSpaceType" minOccurs="0" />
      <xs:element name="faceImageKind3D" type="FaceImageKind3DType" minOccurs="0" />
      <xs:element name="imageSizeBlock" type="ImageSizeBlockType" minOccurs="0" />
     <xs:element name="physicalFaceMeasurements3DBlock" type="PhysicalFaceMeasurements3DBl
ockType" minOccurs="0" />
      <xs:element name="postAcquisitionProcessingBlock" type="PostAcquisitionProcessingBlo
ckType" minOccurs="0" />
      <xs:element name="texturedImageResolution3DBlock" type="TexturedImageResolution3DBlo
ckType" minOccurs="0" />
      <xs:element name="textureMap3DBlock" type="TextureMap3DBlockType" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="RepresentationKind3DBaseType">
    <xs:choice>
      <xs:element name="vertex3DBlock" type="Vertex3DBlockType" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="RepresentationKind3DExtensionBlockType">
    <xs:sequence>
      <xs:any namespace="##other" processContents="lax"/>
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="RepresentationKind3DType">
    <xs:choice>
      <xs:element name="base" type="RepresentationKind3DBaseType"/>
      <xs:element name="extensionBlock" type="RepresentationKind3DExtensionBlockType"/>
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="Vertex3DBlockType">
    <xs:sequence>
      <xs:element name="vertexInformation3DBlocks" type="VertexInformation3DBlocksType"
minOccurs="0" />
      <xs:element name="vertexTriangleData3DBlocks" type="VertexTriangleData3DBlocksType"
minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="VertexInformation3DBlocksType">
```

```
    <xs:sequence>
      <xs:element name="vertexInformation3DBlock" type="VertexInformation3DBlockType"
maxOccurs="unbounded" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="VertexInformation3DBlockType">
    <xs:sequence>
      <xs:element name="vertexCoordinates3DBlock" type="cmn:CoordinateCartesian3DUnsignedS
hortBlockType" />
      <xs:element name="vertexId3D" type="xs:unsignedInt" minOccurs="0" />
      <xs:element name="vertexNormals3DBlock" type="cmn:CoordinateCartesian3DUnsignedShort
BlockType" minOccurs="0" />
      <xs:element name="vertexTextures3DBlock" type="cmn:CoordinateCartesian2DUnsignedShor
tBlockType" minOccurs="0" />
      <xs:element name="errorMap3D" type="xs:base64Binary" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="VertexTriangleData3DBlocksType">
    <xs:sequence>
      <xs:element name="vertexTriangleData3DBlock" type="VertexTriangleData3DBlockType"
maxOccurs="unbounded" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="VertexTriangleData3DBlockType">
    <xs:sequence>
      <xs:element name="triangleIndex1" type="xs:unsignedInt" />
      <xs:element name="triangleIndex2" type="xs:unsignedInt" />
      <xs:element name="triangleIndex3" type="xs:unsignedInt" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="CoordinateSystem3DCodeType">
    <xs:choice>
      <xs:element name="cartesianCoordinateSystem3D" type="xs:int" fixed="0" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="CoordinateSystem3DExtensionBlockType">
    <xs:sequence>
      <xs:element name="fallback" type="CoordinateSystem3DCodeType" />
      <xs:any namespace="##other" processContents="lax" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="CoordinateSystem3DType">
    <xs:choice>
      <xs:element name="code" type="CoordinateSystem3DCodeType" />
      <xs:element name="extensionBlock" type="CoordinateSystem3DExtensionBlockType" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="CartesianScalesAndOffsets3DBlockType">
    <xs:sequence>
      <xs:element name="scaleX" type="xs:decimal" />
      <xs:element name="scaleY" type="xs:decimal" />
      <xs:element name="scaleZ" type="xs:decimal" />
      <xs:element name="offsetX" type="xs:decimal" />
      <xs:element name="offsetY" type="xs:decimal" />
      <xs:element name="offsetZ" type="xs:decimal" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="FaceImageKind3DCodeType">
    <xs:choice>
      <xs:element name="texturedFaceImage3d" type="xs:int" fixed="0" />
    </xs:choice>
  </xs:complexType>
```

```
  <xs:complexType name="FaceImageKind3DExtensionBlockType">
    <xs:sequence>
      <xs:element name="fallback" type="FaceImageKind3DCodeType" />
      <xs:any namespace="##other" processContents="lax" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="FaceImageKind3DType">
    <xs:choice>
      <xs:element name="code" type="FaceImageKind3DCodeType" />
      <xs:element name="extensionBlock" type="FaceImageKind3DExtensionBlockType" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="PhysicalFaceMeasurements3DBlockType">
    <xs:sequence>
      <xs:element name="physicalHeadWidth3D" type="xs:int" minOccurs="0" />
      <xs:element name="physicalInterEyeDistance3D" type="xs:int" minOccurs="0" />
      <xs:element name="physicalEyeToMouthDistance3D" type="xs:int" minOccurs="0" />
      <xs:element name="physicalHeadLength3D" type="xs:int" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="TexturedImageResolution3DBlockType">
    <xs:sequence>
      <xs:element name="mMShapeXResolution3D" type="xs:decimal" minOccurs="0" />
      <xs:element name="mMShapeYResolution3D" type="xs:decimal" minOccurs="0" />
      <xs:element name="mMShapeZResolution3D" type="xs:decimal" minOccurs="0" />
      <xs:element name="mMTextureResolution3D" type="xs:decimal" minOccurs="0" />
      <xs:element name="textureAcquisitionPeriod3D" type="xs:decimal" minOccurs="0" />
      <xs:element name="faceAreaScanned3DBlock" type="FaceAreaScanned3DBlockType"
minOccurs="0" />
     <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="FaceAreaScanned3DBlockType">
    <xs:sequence>
      <xs:element name="frontOfTheHead" type="xs:boolean" minOccurs="0" />
      <xs:element name="chin" type="xs:boolean" minOccurs="0" />
      <xs:element name="ears" type="xs:boolean" minOccurs="0" />
      <xs:element name="neck" type="xs:boolean" minOccurs="0" />
      <xs:element name="backOfTheHead" type="xs:boolean" minOccurs="0" />
      <xs:element name="fullHead" type="xs:boolean" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="TextureMap3DBlockType">
    <xs:sequence>
      <xs:element name="textureMapData3D" type="xs:base64Binary" />
      <xs:element name="imageDataFormat" type="ImageDataFormatType" />
      <xs:element name="textureCaptureDeviceSpectral3D" type="TextureCaptureDeviceSpectral
3DType" minOccurs="0" />
      <xs:element name="textureStandardIlluminant3D" type="TextureStandardIlluminant3DT
ype" minOccurs="0" />
      <xs:element name="errorMap3D" type="xs:base64Binary" minOccurs="0" />
      <xs:any namespace="##other" processContents="lax" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="TextureCaptureDeviceSpectral3DCodeType">
    <xs:choice>
      <xs:element name="unknown" type="xs:int" fixed="0" />
      <xs:element name="other" type="xs:int" fixed="1" />
      <xs:element name="white" type="xs:int" fixed="2" />
      <xs:element name="veryNearInfrared" type="xs:int" fixed="3" />
      <xs:element name="shortWaveInfrared" type="xs:int" fixed="4" />
    </xs:choice>
```

```
  </xs:complexType>

  <xs:complexType name="TextureCaptureDeviceSpectral3DExtensionBlockType">
    <xs:sequence>
      <xs:element name="fallback" type="TextureCaptureDeviceSpectral3DCodeType" />
      <xs:any namespace="##other" processContents="lax" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="TextureCaptureDeviceSpectral3DType">
    <xs:choice>
      <xs:element name="code" type="TextureCaptureDeviceSpectral3DCodeType" />
      <xs:element name="extensionBlock" type="TextureCaptureDeviceSpectral3DExtensionBlock
Type" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="TextureStandardIlluminant3DCodeType">
    <xs:choice>
      <xs:element name="d30" type="xs:int" fixed="0" />
      <xs:element name="d35" type="xs:int" fixed="1" />
      <xs:element name="d40" type="xs:int" fixed="2" />
      <xs:element name="d45" type="xs:int" fixed="3" />
      <xs:element name="d50" type="xs:int" fixed="4" />
      <xs:element name="d55" type="xs:int" fixed="5" />
      <xs:element name="d60" type="xs:int" fixed="6" />
      <xs:element name="d65" type="xs:int" fixed="7" />
      <xs:element name="d70" type="xs:int" fixed="8" />
      <xs:element name="d75" type="xs:int" fixed="9" />
      <xs:element name="d80" type="xs:int" fixed="10" />
    </xs:choice>
  </xs:complexType>

  <xs:complexType name="TextureStandardIlluminant3DExtensionBlockType">
    <xs:sequence>
      <xs:element name="fallback" type="TextureStandardIlluminant3DCodeType" />
      <xs:any namespace="##other" processContents="lax" />
    </xs:sequence>
  </xs:complexType>

  <xs:complexType name="TextureStandardIlluminant3DType">
    <xs:choice>
      <xs:element name="code" type="TextureStandardIlluminant3DCodeType" />
      <xs:element name="extensionBlock" type ="TextureStandardIlluminant3DExtensionBlockT
ype" />
    </xs:choice>
  </xs:complexType>

</xs:schema>
```


Annex B
(informative)

Encoding examples

B.1 Binary encoding example

A binary TLV encoding example based on the ASN.1 schema in Annex A.1 is given below. This example encoding is available at http://standards.iso.org/iso-iec/39794/-5/ed-1/en.

```
<65 83 0D A3 B8 A0 07 80 01 03 81 02 07 E3 A1 83 0D A3 AA 30 83 0D A3 A5>
     0 893880: [APPLICATION 5] {
<A0 07 80 01 03 81 02 07 E3>
     5       7:   [0] {
<80 01 03>
     7       1:     [0] 03
<81 02 07 E3>
    10       2:     [1] 07 E3
             :     }
<A1 83 0D A3 AA 30 83 0D A3 A5 80 01 01 A1 83 0D A2 97 A0 83 0D A2 92 A0>
    14 893866:   [1] {
<30 83 0D A3 A5 80 01 01 A1 83 0D A2 97 A0 83 0D A2 92 A0 83 0D A2 8D 80>
    19 893861:     SEQUENCE {
<80 01 01>
    24       1:       [0] 01
<A1 83 0D A2 97 A0 83 0D A2 92 A0 83 0D A2 8D 80 83 0D A2 75 FF D8 FF E0>
    27 893591:       [1] {
<A0 83 0D A2 92 A0 83 0D A2 8D 80 83 0D A2 75 FF D8 FF E0 00 10 4A 46 49>
    32 893586:         [0] {
<A0 83 0D A2 8D 80 83 0D A2 75 FF D8 FF E0 00 10 4A 46 49 46 00 01 01 00>
    37 893581:           [0] {
<80 83 0D A2 75 FF D8 FF E0 00 10 4A 46 49 46 00 01 01 00 00 01 00 01 00>
    42 893557:             [0]
             :               FF D8 FF E0 00 10 4A 46 49 46 00 01 01 00 00 01
             :               00 01 00 00 FF DB 00 43 00 01 01 01 01 01 01 01
             :               01 01 01 01 01 01 01 01 01 01 01 01 01 01 01 01
             :               01 01 01 01 01 01 01 01 01 01 01 01 01 02 02 01
             :               01 02 01 01 01 02 02 02 02 02 02 02 02 02 01 02
             :               02 02 02 02 02 02 02 02 02 FF DB 00 43 01 01 01
             :               01 01 01 01 01 01 01 01 02 01 01 01 02 02 02 02
             :               02 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02
             :                       [ Another 893429 bytes skipped ]
<A1 0A A0 03 80 01 02 A1 03 80 01 01>
893604      10:             [1] {
<A0 03 80 01 02>
893606       3:               [0] {
<80 01 02>
893608       1:                 [0] 02
             :                 }
<A1 03 80 01 01>
893611       3:               [1] {
<80 01 01>
893613       1:                 [0] 01
             :                 }
             :               }
<A2 05 A1 03 80 01 01>
893616       5:             [2] {
<A1 03 80 01 01>
893618       3:               [1] {
<80 01 01>
893620       1:                 [0] 01
             :                 }
```

```
             :               }
             :             }
             :           }
             :         }
<A2 0A 80 02 07 E3 81 01 07 82 01 08>
893623     10:       [2] {
<80 02 07 E3>
893625      2:         [0] 07 E3
<81 01 07>
893629      1:         [1] 07
<82 01 08>
893632      1:         [2] 08
             :         }
<A3 23 30 0E A0 07 80 01 2A 81 02 12 67 A1 03 80 01 32 30 11 A0 08 80 02>
893635     35:       [3] {
<30 0E A0 07 80 01 2A 81 02 12 67 A1 03 80 01 32>
893637     14:         SEQUENCE {
<A0 07 80 01 2A 81 02 12 67>
893639      7:           [0] {
<80 01 2A>
893641      1:             [0] 2A
<81 02 12 67>
893644      2:             [1] 12 67
             :             }
<A1 03 80 01 32>
893648      3:           [1] {
<80 01 32>
893650      1:             [0] 32
             :             }
             :           }
<30 11 A0 08 80 02 1E 3F 81 02 06 72 A1 05 A1 03 80 01 00>
893653     17:         SEQUENCE {
<A0 08 80 02 1E 3F 81 02 06 72>
893655      8:           [0] {
<80 02 1E 3F>
893657      2:             [0] 1E 3F
<81 02 06 72>
893661      2:             [1] 06 72
             :             }
<A1 05 A1 03 80 01 00>
893665      5:           [1] {
<A1 03 80 01 00>
893667      3:             [1] {
<80 01 00>
893669      1:               [0] 00
             :               }
             :             }
             :           }
             :         }
<A4 55 A0 03 80 01 01 A1 10 30 0E A0 07 80 01 2A 81 02 12 67 A1 03 80 01>
893672     85:       [4] {
<A0 03 80 01 01>
893674      3:         [0] {
<80 01 01>
893676      1:           [0] 01
             :           }
<A1 10 30 0E A0 07 80 01 2A 81 02 12 67 A1 03 80 01 2A>
893679     16:         [1] {
<30 0E A0 07 80 01 2A 81 02 12 67 A1 03 80 01 2A>
893681     14:           SEQUENCE {
<A0 07 80 01 2A 81 02 12 67>
893683      7:             [0] {
<80 01 2A>
893685      1:               [0] 2A
<81 02 12 67>
893688      2:               [1] 12 67
             :               }
<A1 03 80 01 2A>
893692      3:             [1] {
<80 01 2A>
893694      1:               [0] 2A
```

```
             :               }
             :             }
             :           }
<A3 03 80 01 00>
893697      3:         [3] {
<80 01 00>
893699      1:           [0] 00
             :           }
<A4 03 80 01 04>
893702      3:         [4] {
<80 01 04>
893704      1:           [0] 04
             :           }
<85 01 64>
893707      1:         [5] 64
<A6 03 80 01 02>
893710      3:         [6] {
<80 01 02>
893712      1:           [0] 02
             :           }
<87 13 50 41 44 20 70 61 72 61 6D 65 74 65 72 20 62 79 74 65 73>
893715     19:         [7] 'PAD parameter bytes'
<A8 15 04 13 50 41 44 20 63 68 61 6C 6C 65 6E 67 65 20 62 79 74 65 73>
893736     21:         [8] {
<04 13 50 41 44 20 63 68 61 6C 6C 65 6E 67 65 20 62 79 74 65 73>
893738     19:           OCTET STRING 'PAD challenge bytes'
             :           }
             :         }
<85 03 06 8E C3>
893759      3:       [5] 06 8E C3
<A7 0B A1 09 30 07 80 01 2A 81 02 12 67>
893764     11:       [7] {
<A1 09 30 07 80 01 2A 81 02 12 67>
893766      9:         [1] {
<30 07 80 01 2A 81 02 12 67>
893768      7:           SEQUENCE {
<80 01 2A>
893770      1:             [0] 2A
<81 02 12 67>
893773      2:             [1] 12 67
             :             }
             :           }
             :         }
<A8 2E A0 03 80 01 02 A1 03 80 01 07 A2 03 80 01 05 83 02 00 B4 A4 03 82>
893777     46:       [8] {
<A0 03 80 01 02>
893779      3:         [0] {
<80 01 02>
893781      1:           [0] 02
             :           }
<A1 03 80 01 07>
893784      3:         [1] {
<80 01 07>
893786      1:           [0] 07
             :           }
<A2 03 80 01 05>
893789      3:         [2] {
<80 01 05>
893791      1:           [0] 05
             :           }
<83 02 00 B4>
893794      2:         [3] 00 B4
<A4 03 82 01 00>
893798      3:         [4] {
<82 01 00>
893800      1:           [2] 00
             :           }
<A5 03 81 01 FF>
893803      3:         [5] {
<81 01 FF>
893805      1:           [1] FF
```



```
             :         }
<A6 0F A0 03 80 01 00 A1 03 80 01 0F A2 03 80 01 1E>
893808     15:         [6] {
<A0 03 80 01 00>
893810      3:           [0] {
<80 01 00>
893812      1:             [0] 00
             :             }
<A1 03 80 01 0F>
893815      3:           [1] {
<80 01 0F>
893817      1:             [0] 0F
             :             }
<A2 03 80 01 1E>
893820      3:           [2] {
<80 01 1E>
893822      1:             [0] 1E
             :             }
             :           }
             :         }
<A9 3A 30 1B A0 0B A0 09 A1 07 A0 05 A0 03 80 01 15 A1 0C A0 0A A0 08 80>
893825     58:       [9] {
<30 1B A0 0B A0 09 A1 07 A0 05 A0 03 80 01 15 A1 0C A0 0A A0 08 80 02 01>
893827     27:         SEQUENCE {
<A0 0B A0 09 A1 07 A0 05 A0 03 80 01 15>
893829     11:           [0] {
<A0 09 A1 07 A0 05 A0 03 80 01 15>
893831      9:             [0] {
<A1 07 A0 05 A0 03 80 01 15>
893833      7:               [1] {
<A0 05 A0 03 80 01 15>
893835      5:                 [0] {
<A0 03 80 01 15>
893837      3:                   [0] {
<80 01 15>
893839      1:                     [0] 15
             :                     }
             :                   }
             :                 }
             :               }
             :             }
<A1 0C A0 0A A0 08 80 02 01 81 81 02 01 E0>
893842     12:           [1] {
<A0 0A A0 08 80 02 01 81 81 02 01 E0>
893844     10:             [0] {
<A0 08 80 02 01 81 81 02 01 E0>
893846      8:               [0] {
<80 02 01 81>
893848      2:                 [0] 01 81
<81 02 01 E0>
893852      2:                 [1] 01 E0
             :                 }
             :               }
             :             }
             :           }
<30 1B A0 0B A0 09 A1 07 A0 05 A0 03 80 01 16 A1 0C A0 0A A0 08 80 02 02>
893856     27:         SEQUENCE {
<A0 0B A0 09 A1 07 A0 05 A0 03 80 01 16>
893858     11:           [0] {
<A0 09 A1 07 A0 05 A0 03 80 01 16>
893860      9:             [0] {
<A1 07 A0 05 A0 03 80 01 16>
893862      7:               [1] {
<A0 05 A0 03 80 01 16>
893864      5:                 [0] {
<A0 03 80 01 16>
893866      3:                   [0] {
<80 01 16>
893868      1:                     [0] 16
             :                     }
             :                   }
```

```
             :                 }
             :               }
             :             }
<A1 0C A0 0A A0 08 80 02 02 80 81 02 01 DB>
893871     12:           [1] {
<A0 0A A0 08 80 02 02 80 81 02 01 DB>
893873     10:             [0] {
<A0 08 80 02 02 80 81 02 01 DB>
893875      8:               [0] {
<80 02 02 80>
893877      2:                 [0] 02 80
<81 02 01 DB>
893881      2:                 [1] 01 DB
             :                 }
             :               }
             :             }
             :           }
             :         }
             :       }
             :     }
             :   }
```

B.2 Example encodings for a face image XML document

An encoding example based on the XSD schema in Annex A.2 is given below. This example encoding is available at http://standards.iso.org/iso-iec/39794/-5/ed-1/en.

NOTE The example available at http://standards.iso.org/iso-iec/39794/-5/ed-1/en possesses full contents of the 2D face JPEG image data encoded within the base64Binary type value field of the “representationData2D” element. The value is replaced below in a truncated version (with full length in the brackets) for simplicity.

```
<?xml version="1.0" encoding="utf-8"?>
<fac:faceImageData xmlns:cmn="http://standards.iso.org/iso-iec/39794/-1"
xmlns:fac="http://standards.iso.org/iso-iec/39794/-5">
  <fac:versionBlock>
    <cmn:generation>3</cmn:generation>
    <cmn:year>2019</cmn:year>
  </fac:versionBlock>
  <fac:representationBlocks>
    <fac:representationBlock>
      <fac:representationId>1</fac:representationId>
      <fac:imageRepresentation>
        <fac:base>
          <fac:imageRepresentation2DBlock>
            <fac:representationData2D>
              /9j/4AAQSkZJRgABAQ… (191412 bytes)
            </fac:representationData2D>
            <fac:imageInformation2DBlock>
              <fac:imageDataFormat>
                <fac:code>
                  <fac:jpeg>2</fac:jpeg>
                </fac:code>
              </fac:imageDataFormat>
              <fac:faceImageKind2D>
                <fac:code>
                  <fac:generalPurpose>1</fac:generalPurpose>
                </fac:code>
              </fac:faceImageKind2D>
            </fac:imageInformation2DBlock>
            <fac:captureDevice2DBlock>
              <fac:captureDeviceTechnologyId2D>
                <fac:code>
                  <fac:staticPhotographFromUnknownSource>1</fac:staticPhotographFromUnknow
nSource>
                </fac:code>
              </fac:captureDeviceTechnologyId2D>
            </fac:captureDevice2DBlock>
          </fac:imageRepresentation2DBlock>
        </fac:base>
```

```
</fac:imageRepresentation>
<fac:captureDateTimeBlock>
  <cmn:year>2019</cmn:year>
  <cmn:month>7</cmn:month>
  <cmn:day>8</cmn:day>
</fac:captureDateTimeBlock>
<fac:qualityBlocks>
  <cmn:qualityBlock>
    <cmn:algorithmIdBlock>
      <cmn:organization>42</cmn:organization>
      <cmn:id>4711</cmn:id>
    </cmn:algorithmIdBlock>
    <cmn:scoreOrError>
      <cmn:score>50</cmn:score>
    </cmn:scoreOrError>
  </cmn:qualityBlock>
  <cmn:qualityBlock>
    <cmn:algorithmIdBlock>
      <cmn:organization>7743</cmn:organization>
      <cmn:id>1650</cmn:id>
    </cmn:algorithmIdBlock>
    <cmn:scoreOrError>
      <cmn:error>
        <cmn:code>
          <cmn:failureToAssess>0</cmn:failureToAssess>
        </cmn:code>
      </cmn:error>
    </cmn:scoreOrError>
  </cmn:qualityBlock>
</fac:qualityBlocks>
<fac:padDataBlock>
  <cmn:decision>
    <cmn:code>
      <cmn:attack>1</cmn:attack>
    </cmn:code>
  </cmn:decision>
  <cmn:scoreBlocks>
    <cmn:scoreBlock>
      <cmn:mechanismIdBlock>
        <cmn:organization>42</cmn:organization>
        <cmn:id>4711</cmn:id>
      </cmn:mechanismIdBlock>
      <cmn:scoreOrError>
        <cmn:score>42</cmn:score>
      </cmn:scoreOrError>
    </cmn:scoreBlock>
  </cmn:scoreBlocks>
  <cmn:captureContext>
    <cmn:code>
      <cmn:enrolment>0</cmn:enrolment>
    </cmn:code>
  </cmn:captureContext>
  <cmn:supervisionLevel>
    <cmn:code>
      <cmn:unattended>4</cmn:unattended>
    </cmn:code>
  </cmn:supervisionLevel>
  <cmn:riskLevel>100</cmn:riskLevel>
  <cmn:criteriaCategory>
    <cmn:code>
      <cmn:common>2</cmn:common>
    </cmn:code>
  </cmn:criteriaCategory>
  <cmn:parameter>
    UEFEIHBhcmFtZXRlciBieXRlcw==
  </cmn:parameter>
  <cmn:challenges>
    <cmn:challenge>
      UEFEIGNoYWxsZW5nZSBieXRlcw==
    </cmn:challenge>
  </cmn:challenges>
```

```
    </fac:padDataBlock>
    <fac:sessionId>429763</fac:sessionId>
    <fac:captureDeviceBlock>
      <fac:certificationIdBlocks>
        <cmn:certificationIdBlock>
          <cmn:organization>42</cmn:organization>
          <cmn:id>4711</cmn:id>
        </cmn:certificationIdBlock>
      </fac:certificationIdBlocks>
    </fac:captureDeviceBlock>
    <fac:identityMetadataBlock>
      <fac:gender>
        <fac:code>
          <fac:male>2</fac:male>
        </fac:code>
      </fac:gender>
      <fac:eyeColour>
        <fac:code>
          <fac:hazel>7</fac:hazel>
        </fac:code>
      </fac:eyeColour>
      <fac:hairColour>
        <fac:code>
          <fac:brown>5</fac:brown>
        </fac:code>
      </fac:hairColour>
      <fac:subjectHeight>180</fac:subjectHeight>
      <fac:propertiesBlock>
        <fac:beard>false</fac:beard>
      </fac:propertiesBlock>
      <fac:expressionBlock>
        <fac:smile>1</fac:smile>
      </fac:expressionBlock>
      <fac:poseAngleBlock>
        <fac:yawAngleBlock>
          <fac:angleValue>0</fac:angleValue>
        </fac:yawAngleBlock>
        <fac:pitchAngleBlock>
          <fac:angleValue>15</fac:angleValue>
        </fac:pitchAngleBlock>
        <fac:rollAngleBlock>
          <fac:angleValue>30</fac:angleValue>
        </fac:rollAngleBlock>
      </fac:poseAngleBlock>
    </fac:identityMetadataBlock>
    <fac:landmarkBlocks>
      <fac:landmarkBlock>
        <fac:landmarkKind>
        <fac:base>
            <fac:anthropometricLandmark>
           <fac:base>
                <fac:anthropometricLandmarkName>
                  <fac:code>
                    <fac:centerPointOfPupilLeft>21</fac:centerPointOfPupilLeft>
                  </fac:code>
                </fac:anthropometricLandmarkName>
           </fac:base>
            </fac:anthropometricLandmark>
       </fac:base>
        </fac:landmarkKind>
        <fac:landmarkCoordinates>
        <fac:base>
            <fac:coordinateCartesian2DBlock>
              <cmn:x>385</cmn:x>
              <cmn:y>480</cmn:y>
            </fac:coordinateCartesian2DBlock>
       </fac:base>
        </fac:landmarkCoordinates>
      </fac:landmarkBlock>
      <fac:landmarkBlock>
        <fac:landmarkKind>
```

```
          <fac:base>
              <fac:anthropometricLandmark>
             <fac:base>
                  <fac:anthropometricLandmarkName>
                    <fac:code>
                      <fac:centerPointOfPupilRight>22</fac:centerPointOfPupilRight>
                    </fac:code>
                  </fac:anthropometricLandmarkName>
             </fac:base>
              </fac:anthropometricLandmark>
         </fac:base>
          </fac:landmarkKind>
          <fac:landmarkCoordinates>
          <fac:base>
              <fac:coordinateCartesian2DBlock>
                <cmn:x>640</cmn:x>
                <cmn:y>475</cmn:y>
              </fac:coordinateCartesian2DBlock>
         </fac:base>
          </fac:landmarkCoordinates>
        </fac:landmarkBlock>
      </fac:landmarkBlocks>
    </fac:representationBlock>
  </fac:representationBlocks>
</fac:faceImageData>
```

Annex C
(normative)

Conformance testing methodology

C.1 General

This annex specifies elements of the conformance testing methodology, test assertions, and test procedures as applicable to this document. Specifically it establishes:

— test assertions of the structure of the face image data format as specified in this document (Type A Level 1),

— test assertions of internal consistency by checking the types of values that may be contained within each element (Type A Level 2),

— tests of semantic assertions (Type A Level 3).

This conformance testing methodology does not establish:

— tests of conformance of CBEFF structures required by ISO/IEC 39794-1,

— tests of conformance of the image data to the quality-related specifications,

— tests of conformance of the image data blocks to the respective JPEG or JPEG 2000 standards,

— tests of other characteristics of biometric products or other types of testing of biometric products (e.g., acceptance, performance, robustness, security).

To provide sufficient information about the IUT for the testing laboratory to properly conduct a conformance test and for an appropriate declaration of conformity to be made, the supplier of the IUT shall provide the identification of the supplier and the IUT information in Table C.1 and also complete the columns IUT support and supported range in Table C.2 that applies to tested face image extensible BDB format(s). All tables shall be provided to the testing laboratory prior to, or at the same time as, the IUT is provided to the testing laboratory.

NOTE W3C maintains a list of tools that can be used to work with xml documents and schemas[35]. ITU-T maintains a list of tools that can be used to work with ASN.1 documents and schemas[36]. Validating documents with the schemas will assure all Level 1 conformance issues.

Table C.1 — Identification of the supplier and the IUT

Supplier name and address	
Contact point for queries about the ICS	
Implementation name	
Implementation version	
Any other information necessary for full identification of the implementation	
Registered BDB format identifier of the format that conformance is claimed to	
Are any mandatory requirements of the standard not fully supported (Yes or No)	
Date of statement	

C.2 Requirements and options

Table C.2 lists the syntactic options and semantic conformance requirements specified in this document. The supplier of the IUT can explain which optional components are supported and the testing laboratory can note the results of the test. Support is defined as the ability of the used structure to fulfil the requirements automatically without further testing. Support does not mean that the requirement can't be fulfilled when using the structure, all requirements in this table can be fulfilled for both ASN.1 and XML.

Table C.2 details the Level 2 conformance tests that a testing organization should perform on an IUT. These Level 2 tests are necessary as the schema validation does not perform those checks. All other Level 1 and Level 2 conformance requirements are tested by schema validation.

Table C.2 — Requirements and options of the data format specification

Provision identifier	Reference in data format specification	Provision summary	Level	Status	Format type applicability		IUT support	Supported range	Test result
					Tagged binary encoding	XML encoding			
P1	Annex A	A face-image data block may contain unknown extensions.	1 and 2	O	Y	Y			
P2	Annex A	A representation block may contain a capture date/time block.	1 and 2	O	Y	Y			
P3	Annex A	A representation block may contain quality blocks.	1 and 2	O	Y	Y			
P4	ISO/IEC 39794-1	A quality block may contain unknown extensions.	1 and 2	O	Y	Y			
P5	Annex A	A representation block may contain a PAD data block.	1 and 2	O	Y	Y			
P6	ISO/IEC 39794-1	A PAD data block may contain a PAD decision.	1 and 2	O	Y	Y			
P7	ISO/IEC 39794-1	A PAD data block may contain PAD score blocks.	1 and 2	O	Y	Y			
P8	ISO/IEC 39794-1	A PAD data block may contain extended data blocks.	1 and 2	O	Y	Y			
P9	ISO/IEC 39794-1	A PAD data block may contain a context-of-capture field.	1 and 2	O	Y	Y			
P10	ISO/IEC 39794-1	A PAD data block may contain a level-of-supervision/surveillance field.	1 and 2	O	Y	Y			
P11	ISO/IEC 39794-1	A PAD data block may contain a risk level field.	1 and 2	O	Y	Y			
P12	ISO/IEC 39794-1	A PAD data block may contain a category-of-criteria field.	1 and 2	O	Y	Y			
P13	ISO/IEC 39794-1	A PAD data block may contain a PAD parameters field.	1 and 2	O	Y	Y			
P14	ISO/IEC 39794-1	A PAD data block may contain PAD challenges.	1 and 2	O	Y	Y			
P15	ISO/IEC 39794-1	A PAD data block may contain a PAD capture date/time field.	1 and 2	O	Y	Y			
P16	Annex A	A representation block may contain a session identifier.	1 and 2	O	Y	Y			
P17	Annex A	A representation block may contain a derived-from identifier.	1 and 2	O	Y	Y			
P18	Annex A	A representation block may contain a capture device block.	1 and 2	O	Y	Y			
P19	Annex A	A capture device block may contain a model identifier block.	1 and 2	O	Y	Y			
P20	Annex A	A capture device block may contain certification identifier blocks.	1 and 2	O	Y	Y			
P21	Annex A	A capture device block may contain unknown extensions.	1 and 2	O	Y	Y			
P22	Annex A	A representation block may contain an identity metadata block.	1 and 2	O	Y	Y			
P23	Annex A	An identity metadata block may contain a gender field.	1 and 2	O	Y	Y			

Table C.2 *(continued)*

Provi-sion identifier	Reference in data format specification	Provision summary	Level	Status	Format type applicability		IUT sup-port	Support-ed range	Test result
					Tagged binary encoding	XML encod-ing			
P24	Annex A	An identity metadata block may contain an eye colour field.	1 and 2	O	Y	Y			
P25	Annex A	An identity metadata block may contain a hair colour field.	1 and 2	O	Y	Y			
P26	Annex A	An identity metadata block may contain a subject height field.	1 and 2	O	Y	Y			
P27	Annex A	An identity metadata block may contain a properties block.	1 and 2	O	Y	Y			
P28	Annex A	A properties block may contain a glasses field.	1 and 2	O	Y	Y			
P29	Annex A	A properties block may contain a moustache field.	1 and 2	O	Y	Y			
P30	Annex A	A properties block may contain a beard field.	1 and 2	O	Y	Y			
P31	Annex A	A properties block may contain a teeth-visible field.	1 and 2	O	Y	Y			
P32	Annex A	A properties block may contain a pupil-or-iris-not-visible field.	1 and 2	O	Y	Y			
P33	Annex A	A properties block may contain a mouth-open field.	1 and 2	O	Y	Y			
P34	Annex A	A properties block may contain a left-eye-patch field.	1 and 2	O	Y	Y			
P35	Annex A	A properties block may contain a right-eye-patch field.	1 and 2	O	Y	Y			
P36	Annex A	A properties block may contain a dark-glasses field.	1 and 2	O	Y	Y			
P37	Annex A	A properties block may contain a biometric-absent field.	1 and 2	O	Y	Y			
P38	Annex A	A properties block may contain a head-coverings-present field.	1 and 2	O	Y	Y			
P39	Annex A	A properties block may contain unknown extensions.	1 and 2	O	Y	Y			
P40	Annex A	An identity metadata block may contain an expression block.	1 and 2	O	Y	Y			
P41	Annex A	An expression block may contain a neutral field.	1 and 2	O	Y	Y			
P42	Annex A	An expression block may contain a smile field.	1 and 2	O	Y	Y			
P43	Annex A	An expression block may contain a raised-eyebrows field.	1 and 2	O	Y	Y			
P44	Annex A	An expression block may contain an eyes-looking-away-from-the-camera field.	1 and 2	O	Y	Y			
P45	Annex A	An expression block may contain a squinting field.	1 and 2	O	Y	Y			
P46	Annex A	An expression block may contain a frowning field.	1 and 2	O	Y	Y			

Table C.2 *(continued)*

Provision identifier	Reference in data format specification	Provision summary	Level	Status	Format type applicability		IUT support	Supported range	Test result
					Tagged binary encoding	XML encoding			
P47	Annex A	An expression block may contain unknown extensions.	1 and 2	O	Y	Y			
P48	Annex A	An identity metadata block may contain a pose angle block.	1 and 2	O	Y	Y			
P49	Annex A	A pose angle block may contain a yaw angle block.	1 and 2	O	Y	Y			
P50	Annex A	A yaw angle block may contain an angle value field.	1 and 2	O	Y	Y			
P51	Annex A	A yaw angle block may contain an angle uncertainty field.	1 and 2	O	Y	Y			
P52	Annex A	A yaw angle block may contain unknown extensions.	1 and 2	O	Y	Y			
P53	Annex A	A pose angle block may contain a pitch angle block.	1 and 2	O	Y	Y			
P54	Annex A	A pitch angle block may contain an angle value field.	1 and 2	O	Y	Y			
P55	Annex A	A pitch angle block may contain an angle uncertainty field.	1 and 2	O	Y	Y			
P56	Annex A	A pitch angle block may contain unknown extensions.	1 and 2	O	Y	Y			
P57	Annex A	A pose angle block may contain a roll angle block.	1 and 2	O	Y	Y			
P58	Annex A	A roll angle block may contain an angle value field.	1 and 2	O	Y	Y			
P59	Annex A	A roll angle block may contain an angle uncertainty field.	1 and 2	O	Y	Y			
P60	Annex A	A roll angle block may contain unknown extensions.	1 and 2	O	Y	Y			
P61	Annex A	An identity metadata block may contain unknown extensions.	1 and 2	O	Y	Y			
P62	Annex A	A representation block may contain landmarks blocks.	1 and 2	O	Y	Y			
P63	Annex A	A landmark block may contain a landmark kind value.	1 and 2	O	Y	Y			
P64	Annex A	A landmark block may contain a landmark coordinates block.	1 and 2	O	Y	Y			
P65	Annex A	A landmark co-ordinates block may contain a 2D Cartesian co-ordinates block.	1 and 2	O	Y	Y			
P66	Annex A	A landmark co-ordinates block may contain a texture image coordinates block.	1 and 2	O	Y	Y			
P67	Annex A	A landmark coordinates block may contain a 3D Cartesian coordinates block.	1 and 2	O	Y	Y			
P68	Annex A	A landmark coordinates block may contain unknown extensions.	1 and 2	O	Y	Y			
P69	Annex A	A landmark block may contain unknown extensions.	1 and 2	O	Y	Y			

Table C.2 *(continued)*

Provision identifier	Reference in data format specification	Provision summary	Level	Status	Format type applicability		IUT support	Supported range	Test result
					Tagged binary encoding	XML encoding			
P70	Annex A	A representation block may contain unknown extensions.	1 and 2	O	Y	Y			
P71	Annex A	An image representation may contain a 2D image representation block.	1 and 2	O	Y	Y			
P72	Annex A	A 2D image representation block may contain a 2D capture device block.	1 and 2	O	Y	Y			
P73	Annex A	A 2D capture device block may contain a 2D capture device spectral block.	1 and 2	O	Y	Y			
P74	Annex A	A 2D capture device spectral block may contain a white-light field.	1 and 2	O	Y	Y			
P75	Annex A	A 2D capture device spectral block may contain a near-infrared field.	1 and 2	O	Y	Y			
P76	Annex A	A 2D capture device spectral block may contain a thermal field.	1 and 2	O	Y	Y			
P77	Annex A	A 2D capture device spectral block may contain unknown extensions.	1 and 2	O	Y	Y			
P78	Annex A	A 2D capture device block may contain a 2D capture device technology identifier field.	1 and 2	O	Y	Y			
P79	Annex A	A 2D capture device block may contain unknown extensions.	1 and 2	O	Y	Y			
P80	Annex A	A 2D image information block may contain a 2D face image kind field.	1 and 2	O	Y	Y			
P81	Annex A	A 2D image information block may contain a post-acquisition processing block.	1 and 2	O	Y	Y			
P82	Annex A	A post-acquisition processing block within a 2D image information block may contain a rotated field.	1 and 2	O	Y	Y			
P83	Annex A	A post-acquisition processing block within a 2D image information block may contain a cropped field.	1 and 2	O	Y	Y			
P84	Annex A	A post-acquisition processing block within a 2D image information block may contain a down-sampled field.	1 and 2	O	Y	Y			
P85	Annex A	A post-acquisition processing block within a 2D image information block may contain a white-balance-adjusted field.	1 and 2	O	Y	Y			
P86	Annex A	A post-acquisition processing block within a 2D image information block may contain a multiply-compressed field.	1 and 2	O	Y	Y			

Table C.2 *(continued)*

Provision identifier	Reference in data format specification	Provision summary	Level	Status	Format type applicability		IUT support	Supported range	Test result
					Tagged binary encoding	XML encoding			
P87	Annex A	A post-acquisition processing block within a 2D image information block may contain an interpolated field.	1 and 2	O	Y	Y			
P88	Annex A	A post-acquisition processing block within a 2D image information block may contain a contrast-stretched field.	1 and 2	O	Y	Y			
P89	Annex A	A post-acquisition processing block within a 2D image information block may contain a pose-corrected field.	1 and 2	O	Y	Y			
P90	Annex A	A post-acquisition processing block within a 2D image information block may contain a multi-view image field.	1 and 2	O	Y	Y			
P91	Annex A	A post-acquisition processing block within a 2D image information block may contain an age-progressed field.	1 and 2	O	Y	Y			
P92	Annex A	A post-acquisition processing block within a 2D image information block may contain a super-resolution processed field.	1 and 2	O	Y	Y			
P93	Annex A	A post-acquisition processing block within a 2D image information block may contain a normalised field.	1 and 2	O	Y	Y			
P94	Annex A	A post-acquisition processing block within a 2D image information block may contain unknown extensions.	1 and 2	O	Y	Y			
P95	Annex A	A 2D image information block may contain a lossy-transformation attempts field.	1 and 2	O	Y	Y			
P96	Annex A	A 2D image information block may contain a camera-to-subject distance field.	1 and 2	O	Y	Y			
P97	Annex A	A 2D image information block may contain sensor diagonal field.	1 and 2	O	Y	Y			
P98	Annex A	A 2D image information block may contain a lens focal length field.	1 and 2	O	Y	Y			
P99	Annex A	A 2D image information block may contain an image size block.	1 and 2	O	Y	Y			
P100	Annex A	If the 2D image data format is unknown or other or a later version extension code, then an image size block (width and height) shall be included.	1 and 2	O	Y	Y			
P101	Annex A	An image size block may contain a width field.	1 and 2	O	Y	Y			
P102	Annex A	An image size block may contain a height field.	1 and 2	O	Y	Y			
P103	Annex A	A 2D image information block may contain an image face measurements block.	1 and 2	O	Y	Y			

Table C.2 *(continued)*

Provision identifier	Reference in data format specification	Provision summary	Level	Status	Format type applicability		IUT support	Supported range	Test result
					Tagged binary encoding	XML encoding			
P104	Annex A	An image face measurements block may contain an image head-width field.	1 and 2	O	Y	Y			
P105	Annex A	An image face measurements block may contain an image inter-eye distance field.	1 and 2	O	Y	Y			
P106	Annex A	An image face measurements block may contain an image eye-to-mouth distance field.	1 and 2	O	Y	Y			
P107	Annex A	An image face measurements block may contain an image head-length field.	1 and 2	O	Y	Y			
P108	Annex A	An image face measurements block may contain unknown extensions.	1 and 2	O	Y	Y			
P109	Annex A	A 2D image information block may contain an image colour space field.	1 and 2	O	Y	Y			
P110	Annex A	A 2D image information block may contain a reference colour mapping block.	1 and 2	O	Y	Y			
P111	Annex A	A reference colour mapping block may contain a reference colour scheme field.	1 and 2	O	Y	Y			
P112	Annex A	A reference colour mapping block may contain reference colour definition-and-value blocks.	1 and 2	O	Y	Y			
P113	Annex A	A reference colour definition-and-value block may contain a reference colour definition field.	1 and 2	O	Y	Y			
P114	Annex A	A reference colour definition-and-value block may contain a reference colour value field.	1 and 2	O	Y	Y			
P115	Annex A	A reference colour definition-and-value block may contain unknown extensions.	1 and 2	O	Y	Y			
P116	Annex A	A reference colour mapping block may contain unknown extensions.	1 and 2	O	Y	Y			
P117	Annex A	A 2D image information block may contain unknown extensions.	1 and 2	O	Y	Y			
P118	Annex A	A 2D image representation block may contain unknown extensions.	1 and 2	O	Y	Y			
P119	Annex A	An image representation may contain a 3D shape representation block.	1 and 2	O	Y	Y			

Table C.2 *(continued)*

Provision identifier	Reference in data format specification	Provision summary	Level	Status	Format type applicability		IUT support	Supported range	Test result
					Tagged binary encoding	XML encoding			
P120	Annex A	A 3D shape representation block may contain a 3D capture device block.	1 and 2	O	Y	Y			
P121	Annex A	A 3D capture device technology block may contain a 3D modus field.	1 and 2	O	Y	Y			
P122	Annex A	A 3D capture device technology block may contain a 3D capture device technology kind field.	1 and 2	O	Y	Y			
P123	Annex A	A 3D capture device technology block may contain unknown extensions.	1 and 2	O	Y	Y			
P124	Annex A	A 3D image information block may contain an image colour space field.	1 and 2	O	Y	Y			
P125	Annex A	A 3D image information block may contain a 3D face image kind field.	1 and 2	O	Y	Y			
P126	Annex A	A 3D image information block may contain an image size block.	1 and 2	O	Y	Y			
P127	Annex A	If the 3D image data format is unknown or other or a later version extension code, then an image size block (width and height) shall be included.	1 and 2	O	Y	Y			
P128	Annex A	A 3D image information block may contain a 3D physical face measurements block.	1 and 2	O	Y	Y			
P129	Annex A	A physical face measurements block may contain a 3D physical head-width field.	1 and 2	O	Y	Y			
P130	Annex A	A physical face measurements block may contain a 3D physical inter-eye distance field.	1 and 2	O	Y	Y			
P131	Annex A	A physical face measurements block may contain a 3D physical eye-to-mouth distance field.	1 and 2	O	Y	Y			
P132	Annex A	A physical face measurements block may contain a 3D physical head-length field.	1 and 2	O	Y	Y			
P133	Annex A	A physical face measurements block may contain unknown extensions.	1 and 2	O	Y	Y			
P134	Annex A	A 3D image information block may contain a post-acquisition processing block.	1 and 2	O	Y	Y			
P135	Annex A	A post-acquisition processing block within a 3D image information block may contain a rotated field.	1 and 2	O	Y	Y			

Table C.2 *(continued)*

Provision identifier	Reference in data format specification	Provision summary	Level	Status	Format type applicability		IUT support	Supported range	Test result
					Tagged binary encoding	XML encoding			
P136	Annex A	A post-acquisition processing block within a 3D image information block may contain a cropped field.	1 and 2	O	Y	Y			
P137	Annex A	A post-acquisition processing block within a 3D image information block may contain a down-sampled field.	1 and 2	O	Y	Y			
P138	Annex A	A post-acquisition processing block within a 3D image information block may contain a white-balance-adjusted field.	1 and 2	O	Y	Y			
P139	Annex A	A post-acquisition processing block within a 3D image information block may contain a multiply-compressed field.	1 and 2	O	Y	Y			
P140	Annex A	A post-acquisition processing block within a 3D image information block may contain an interpolated field.	1 and 2	O	Y	Y			
P141	Annex A	A post-acquisition processing block within a 3D image information block may contain a contrast-stretched field.	1 and 2	O	Y	Y			
P142	Annex A	A post-acquisition processing block within a 3D image information block may contain a pose-corrected field.	1 and 2	O	Y	Y			
P143	Annex A	A post-acquisition processing block within a 3D image information block may contain a multi-view image field.	1 and 2	O	Y	Y			
P144	Annex A	A post-acquisition processing block within a 3D image information block may contain an age-progressed field.	1 and 2	O	Y	Y			
P145	Annex A	A post-acquisition processing block within a 3D image information block may contain a super-resolution processed field.	1 and 2	O	Y	Y			
P146	Annex A	A post-acquisition processing block within a 3D image information block may contain a normalised field.	1 and 2	O	Y	Y			
P147	Annex A	A post-acquisition processing block within a 3D image information block may contain unknown extensions.	1 and 2	O	Y	Y			
P148	Annex A	A 3D image information block may contain a 3D textured image resolution block.	1 and 2	O	Y	Y			
P149	Annex A	A 3D textured image resolution block may contain a 3D mm shape x resolution field.	1 and 2	O	Y	Y			
P150	Annex A	A 3D textured image resolution block may contain a 3D mm shape y resolution field.	1 and 2	O	Y	Y			

Table C.2 *(continued)*

Provision identifier	Reference in data format specification	Provision summary	Level	Status	Format type applicability		IUT support	Supported range	Test result
					Tagged binary encoding	XML encoding			
P151	Annex A	A 3D textured image resolution block may contain a 3D mm shape z resolution field.	1 and 2	O	Y	Y			
P152	Annex A	A 3D textured image resolution block may contain a 3D mm texture resolution field.	1 and 2	O	Y	Y			
P153	Annex A	A 3D textured image resolution block may contain a 3D texture acquisition period field.	1 and 2	O	Y	Y			
P154	Annex A	A 3D textured image resolution block may contain a 3D face area scanned block.	1 and 2	O	Y	Y			
P155	Annex A	A 3D face area scanned block may contain a front-of-the-head field.	1 and 2	O	Y	Y			
P156	Annex A	A 3D face area scanned block may contain a chin field.	1 and 2	O	Y	Y			
P157	Annex A	A 3D face area scanned block may contain an ears field.	1 and 2	O	Y	Y			
P158	Annex A	A 3D face area scanned block may contain a neck field.	1 and 2	O	Y	Y			
P159	Annex A	A 3D face area scanned block may contain a back-of-the-head field.	1 and 2	O	Y	Y			
P160	Annex A	A 3D face area scanned block may contain a full-head field.	1 and 2	O	Y	Y			
P161	Annex A	A 3D face area scanned block may contain unknown extensions.	1 and 2	O	Y	Y			
P162	Annex A	A 3D textured image resolution block may contain unknown extensions.	1 and 2	O	Y	Y			
P163	Annex A	A 3D image information block may contain a 3D texture map block.	1 and 2	O	Y	Y			
P164	Annex A	A 3D texture map block may contain an image data format field.	1 and 2	O	Y	Y			
P165	Annex A	A 3D texture map block may contain a 3D texture capture device spectral block spectrum field.	1 and 2	O	Y	Y			
P166	Annex A	A 3D texture map block may contain a texture 3D texture standard illuminant field.	1 and 2	O	Y	Y			
P167	Annex A	A 3D texture map block may contain a 3D error map field.	1 and 2	O	Y	Y			
P168	Annex A	A 3D texture map block may contain unknown extensions.	1 and 2	O	Y	Y			
P169	Annex A	A 3D image information block may contain unknown extensions.	1 and 2	O	Y	Y			
P170	Annex A	A 3D shape representation block may contain unknown extensions.	1 and 2	O	Y	Y			

Table C.2 *(continued)*

Provision identifier	Reference in data format specification	Provision summary	Level	Status	Format type applicability		IUT support	Supported range	Test result
					Tagged binary encoding	XML encoding			
P171	Annex A	A 3D representation kind block may contain a 3D vertex block.	1 and 2	O	Y	Y			
P172	Annex A	A 3D vertex block may contain a 3D vertex information block.	1 and 2	O	Y	Y			
P173	Annex A	A 3D vertex information block may contain a 3D vertex identifier.	1 and 2	O	Y	Y			
P174	Annex A	A 3D vertex information block may contain a 3D vertex normals block.	1 and 2	O	Y	Y			
P175	Annex A	A 3D vertex information block may contain a 3D textures block.	1 and 2	O	Y	Y			
P176	Annex A	A 3D vertex information block may contain a 3D error map field.	1 and 2	O	Y	Y			
P177	Annex A	A 3D vertex information block may contain unknown extensions.	1 and 2	O	Y	Y			
P178	Annex A	A 3D vertex block may contain a 3D vertex triangle data block.	1 and 2	O	Y	Y			
P179	Annex A	A 3D representation kind may contain unknown extensions.	1 and 2	O	Y	Y			

IUT support notes

To be filled in by the supplier of the IUT on the copy of this table provided to the testing laboratory and to be included in the copy of this table that forms part of the test report.

Test result notes

To be filled in by the testing laboratory, if necessary, during the execution of the conformance test and to be included in the copy of this table that forms part of the test report.

C.3 Conformance test assertions

Level 1 and 2 requirements and options shall be tested by:

— decoding tagged binary data blocks under test based on the ASN.1 module that specifies the tagged binary data format; or

— validation of XML documents under test against the XML schema definition that specifies the textual data format, respectively.

C.4 Conformance testing for profiles given in Annex D

This clause specifies conformance testing methodologies for the specific requirements according to the application profiles as given in Annex D.

NOTE Currently, no conformance testing methodologies for the application profiles in Annex D are available for this document.

Annex D
(normative)

Application profiles

D.1 Reference face image for Machine Readable Travel Documents (MRTD)

D.1.1 General

ICAO Doc 9303 provides the basic functional specification for MRTDs and describes all relevant properties of MRTDs.

The face portrait printed on the ICAO compliant MRTD is an essential element of that document and one of the most important information carriers binding the document to the holder. A standardized face portrait produced at a high quality helps issuing agencies to screen identity and border agencies to inspect the travel document manually or via automated processing.

After the introduction of the digitally stored image in 2005, ABC (Automated Border Control) systems have been introduced to perform automated comparison of the individual and the electronically stored image. Those ABC systems compare, whether it is manually or automated, the printed image and/or the electronically stored image and the image taken live while crossing a border.

This annex contains significant content from Reference [38].

D.1.2 Overview

This annex describes the requirements and best practice recommendations to be applied for face portrait capturing in the application case of enrolment of biometric reference data for electronic MRTD. In this sense, this annex is an application profile.

This annex:

— shares the lessons learned using the stored and displayed face portrait in an MRTD,

— describes how the face portraits should be captured that serve as the content of this document and its data structures,

— provides the experiences made applying face recognition technology in ABC gates, manual border control, identity screening, and other applications based on the face portraits provided by electronic MRTDs. It also gives guidance on the requirements for capturing and processing face portraits contained in MRTDs to support the inspection process, and

— provides comprehensive recommendations for face portrait capturing including scene, photographic and digital requirements.

The following topics are not in scope of this annex, requirements on them are given in ICAO Doc 9303:

— image printing and scanning as well as on digital image processing,

— face portraits printed on MRTDs to ensure good visibility for inspection,

— guidance for reader system manufacturers on the use of unified reflection free illumination and view angles, and

— image capturing for verification and/or identification applications like ABC, even if many of the requirements listed in this document apply to such images, too.

The following topics are not in scope of this annex:

— Definition of image data formats like JPEG, JPEG2000, PNG,

— Security aspects like digital image electronic signature, presentation attack detection (PAD), and morphing prevention.

For certain criteria, there may be two different levels given in a table form: A minimum requirement and a best practice recommendation. The requirement gives the minimum acceptable values or value ranges in order to reach compliance. The best practice recommendation gives values that will result in better overall performance or quality, and users are encouraged to adopt best practice values whenever possible. See Table D.1.

Table D.1 — Sample table summarizing minimum requirements and best practice recommendations

Criterion	Requirement	The criterion shall be ...
	Best practice	The criterion should be ...

D.1.3 Face portraits

D.1.3.1 Uses of face portrait images

Face portraits appear in several places on and in an MRTD:

— As a printed image on the data page (Zone V as defined in ICAO Doc 9303),

— As a digital image stored in the RFID chip,

— Optionally, as a secondary image on the data and/or observation page, e.g., as a changeable laser image, as a micro-perforation, or as a background print.

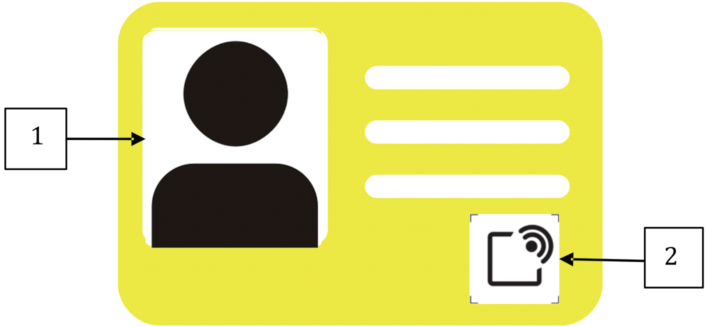
All the images used shall be derived from the same captured face portrait. However, the technical requirements of each of the images may differ depending on the applied technology.

The intended use for a printed face portrait is to give a good physical representation of the document holder and to allow for a human comparison of the face portrait and the holder of the MRTD. Physical security features and the printing technology may interact or influence the face portrait which needs to be considered as part of the comparison process.

The intended use of the face portrait image digitally stored in the chip is such that the image can be compared to the printed face portrait and the human via manual processes or compared to a live image via automated processes in a 1:1 od 1:N application case. Because of the way the image is stored on the MRTD (see Doc 9303 Part 11), border agencies can confirm that the image has been stored on the MRTD by the issuing authority and remains unaltered or unsubstituted. The digital image is the primary image used for biometric comparison.

The secondary images serve as physical security features protecting the printed face portrait. Therefore their appearance shall be the same as the printed face portrait. However, size and production technology determine the technical requirements of the face portrait derivative used here.

Figure D.1 displays the appearance of the face portrait as a printed image and as a digitally stored image.



Key

1 printed image

2 digitally stored image

Figure D.1 — Face portraits to be used on/in an MRTD

Two main types of application processes are considered, those based on:

— submission of printed photographs provided by the citizen to the passport authority, and on

— electronic face portrait submission.

There are two sub-types of the second type:

— live capture where the applicant has the photo taken during an interview or application submission, and

— upload, where the image is provided electronically by the applicant, by an enrolment bureau or by an accredited ID photo service.

These two sub-types are subject to the same requirements. Depending on the process type, different clauses of this document apply, as defined below. Both main types are shown in Figure D.2.

The production of the printed as well as of the electronic face portraits may be done by automated photo kiosks, officers of passport authorities, photo booths or photographers. It is essential that the quality requirements are met. Photographic experts should be consulted before introducing a new enrolment solution.

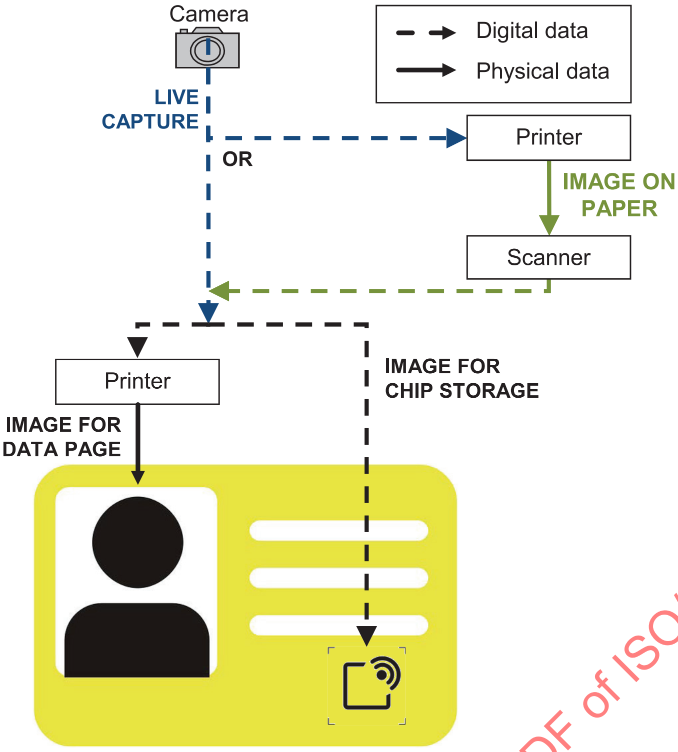


Figure D.2 — Face portrait enrolment process variations

D.1.3.2 Passport application using printed face portraits

For a passport application process that uses printed face portraits the citizen typically visits a photographer or photo booth to obtain such a face portrait. In all cases the citizen receives printed photos, and there is no electronic submission or linkage to an electronically stored image available. Then the citizen submits such a photo to the passport issuing authority as part of their application. To establish a passport application process using printed face portraits, D.1.4 and D.1.5 apply. Additional requirements on image printing for submission purposes, scanning of printed images and image printing on MRTD data pages specified in ICAO Doc 9303 apply.

D.1.3.3 Passport application using electronic face portrait submission

Enrolment data providers, such as photographers, photo booths or kiosks can be linked electronically to the issuing authorities. For a passport application that uses electronic submission, the intermediate steps dealing with a printed photo are skipped. In most cases, the photo is digitally captured and electronically stored or directly transmitted to the passport issuing authority. There are many ways the face portrait may be transferred to the passport issuing authority. Such schemas include direct transmission to the authority, a data carrier submitted by the citizen, and temporary storage on a server and submission of a reference to the uploaded/stored photo provided by the citizen. Live capture where the applicant has the photo taken during an interview or application submission is covered here, too. To establish a passport application process using electronic face portraits, D.1.4 and D.1.5 apply. Additional requirements on image printing on MRTD data pages specified in ICAO Doc 9303 apply. The IED requirement for electronically submitted images follows the same requirement for chip images as in D.1.5 and Tables D.4 and D.10.

D.1.3.4 Non-professional photographs

Passport applicants should not be encouraged to submit face portraits captured by amateur photographers or captured on amateur equipment such as mobile phones or tablets or printed on consumer printers (home-made face portraits) as they typically do not achieve the required quality level as specified in D.1.4. If an issuer decides to accept homemade face portraits, the issuer shall ensure, based on an appropriate level of expertise, that the printing quality and all of the requirements specified in D.1.4 are maintained, and that the risks of photo manipulation and morphing inherent with such an uncontrolled process are suitably mitigated.

D.1.4 Enrolment live face portrait capturing

D.1.4.1 General

This clause describes the requirements for the environment that is used for face portrait capturing. Additionally, it gives recommendations on best practice. The requirements on the environment are derived from experiences made in face recognition applications including ABC gates, and they consider the methods used by professional photographers.

Before introducing new equipment and defining processes for enrolment data capturing, an experienced face portrait photographer and/or an optics expert should be asked for advice. The requirements apply to all installations including photo booths and kiosks.

This clause specifies requirements for the photograph being captured as well as for the photographic equipment being used. Figure D.3 shows the content of D.1.4 in the MRTD production process chain.

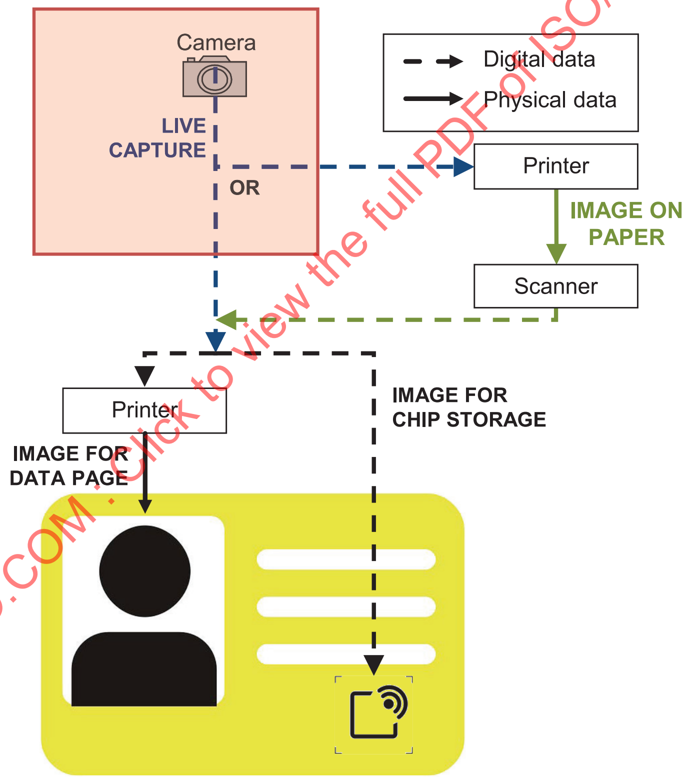


Figure D.3 — Content of D.1.4 in the MRTD production process chain (boxed in red)

NOTE Pose constraints are very difficult to evaluate on the acquired 2D image, even for experts in this field. Numeric values have been provided in this document to support a consistent subject positioning in the full-frontal pose.

D.1.4.2 Camera and scene

D.1.4.2.1 Selection of camera and focal length

In addition to choosing an appropriate camera-to-subject distance (CSD), as described in D.1.4.2.2, the selection of a camera and its lens is a major factor affecting the quality of face portrait images. To ensure high image quality and a standards-compliant inter-eye distance (IED), the camera's sensor must have sufficient pixel dimensions and its lens must be chosen to match its image sensor's physical dimensions.

For example, for a camera using an APS-C sensor (having a crop factor of 1,44), photographers should consider using a lens of focal length between 50/1,44 and 130/1,44, or roughly 35 mm to 90 mm.

For face portrait photos, photographers using a conventional 35 mm film camera (having a 36 mm × 24 mm frame, with a 43,3 mm diagonal) often select a normal to moderate telephoto lens, with a focal length between 50 and 130 mm (or an equivalent zoom lens). For digital cameras employing typically smaller size CMOS or CCD image sensors, the lens selected for face portrait photography should have a proportionally decreased focal length.

For further explanations on sensor diagonal and sensor diagonal encoding see 7.42 and 7.43.

Figure D.4 illustrates the typical optical arrangement and terminology for face portrait image acquisition, as well as some of the variables in the arrangement.

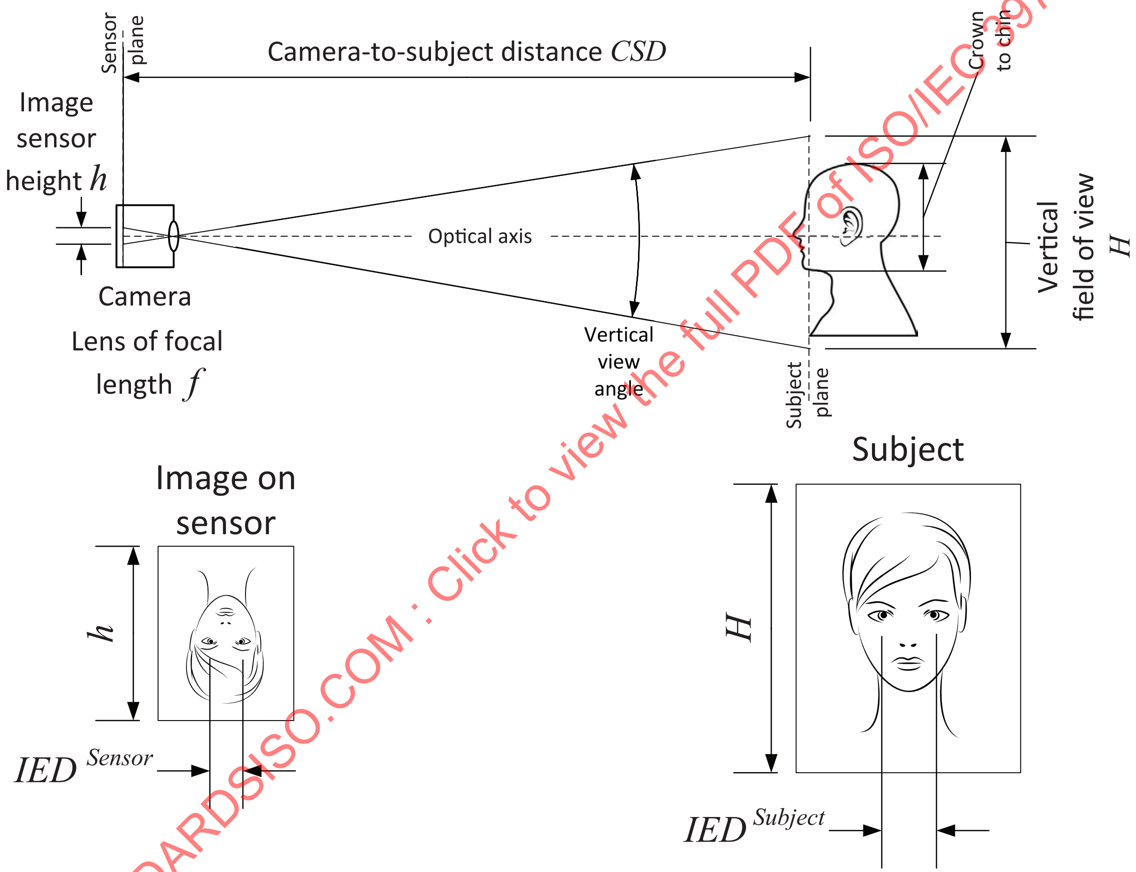


Figure D.4 — Illustration of optical arrangement and terminology

For a selected CSD (in millimetres), and camera image sensor with a vertical dimension in millimetres h, a requested field of view of $H_{FieldOfViewmm}$, the focal length f (in millimetres) can be computed using the following relationships in order to optimise the requested field of view of the subject into the sensor dimensions:

$$f \cong h_{mm} \frac{CSD}{H_{FieldOfViewmm}}$$

In case of homemade face portraits, the lens optimization is not done due to the large camera angle.

For the same camera image sensor with vertical pixel count of h pixels, the inter-eye distance on the sensor in pixels IED_{px}^{Sensor} may be computed using the following relation-ships, where $IED_{mm}^{Subject}$ is inter-eye distance in millimetres on the subject.

$$IED_{mm}^{Sensor} \cong IED_{mm}^{Subject} \times \frac{f}{CSD}$$

and

$$IED_{px}^{Sensor} = IED_{mm}^{Sensor} \times \frac{h_{px}}{h_{mm}}$$

EXAMPLE 1 A commercially available, digital single lens reflex (DSLR) camera has the following specifications: sensor APS-C, 22,3 mm × 14,9 mm, 5184 px × 3456 px, 18 megapixels. For a CSD of 1200 mm, a typical $H_{FieldOfViewmm}$ of 500 mm, a typical IED of the subject of about 62 mm the calculations below show that the focal length f will be about 50 mm (equivalent to 80 mm full frame).

$$f \cong 22{,}3\,mm \times \frac{1200\,mm}{500\,mm} \cong 53{,}5\,mm \cong 50\,mm$$

The calculations below show that IED_{px}^{Sensor} will be about 598 pixels, well above the best practice value suggested in Table D.4.

$$IED_{mm}^{Sensor} \cong 62\,mm \times \frac{50\,mm}{1200\,mm} \cong 2{,}58\,mm$$

and

$$IED_{px}^{Sensor} \cong 2{,}58\,mm \times \frac{3456\,px}{14{,}9\,mm} = 598 \text{ pixels}$$

EXAMPLE 2 For a sensor of 5 megapixels (2592 px × 1944 px) with an optimized focal length lens, the IED_{px}^{Sensor} will be about 336 pixels, well above the best practice value suggested in Table D.4:

$$IED_{px}^{Sensor} \cong 2{,}58\,mm \times \frac{1944\,px}{14{,}9\,mm} = 336 \text{ pixels}$$

D.1.4.2.2 Magnification distortion and camera subject distance

All images captured by a photographic system will contain image distortion. Every face portrait is a compromise between different requirements like camera and lens costs or available space and illumination. In this document requirements and recommendations are given to ensure global interoperability in the sense that the most important properties of every face portrait used for MRTD purposes reach the correct quality requirements and therefore ensure similar performance in face image-based authentication applications like border control systems.

The CSD requirements are listed in Table D.2. For sample face portraits illustrating possible effects of the optical system see Figures D.6 and D.7. Table D.4 lists different camera subject distances and their corresponding magnification distortions.

Magnification distortion can only be evaluated by measuring tools. See E.2. It is not possible to evaluate magnification distortion value from human vision. For information, ears start to be masked around a magnification distortion of 14 % or higher.

NOTE 1 Selfie-style face portraits are likely not to maintain the minimal distance requirement.

Table D.2 — CSD requirements and recommendations

Criterion: CSD for 1:1	Requirement	0,7 m ≤ CSD ≤ 4 m
	Best practice	1,0 m ≤ CSD ≤ 2,5 m
Criterion: CSD for 1:N	Requirement	1 m ≤ CSD ≤ 4 m
	Best practice	1,2 m ≤ *CSD* ≤ 2,5 m

The camera shall be at the subject's eye-level. The line between camera and centre of subject's face shall be horizontal within a maximum HD of ±5°. Height alignment should be done by vertical adjustment of either subject or camera. See Figure D.5.

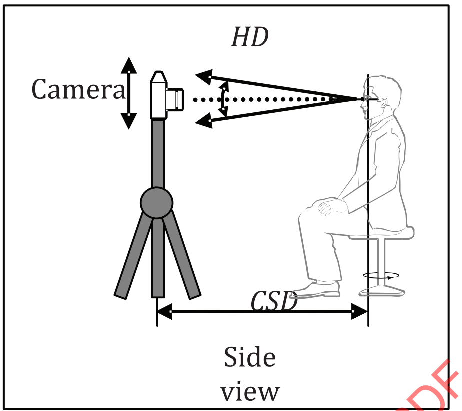


Figure D.5 — Alignment of camera and subject

These recommendations and requirements apply for all capturing setups including photo booths and kiosks.

a) Good appearance **b) Good appearance** **c) Good appearance**

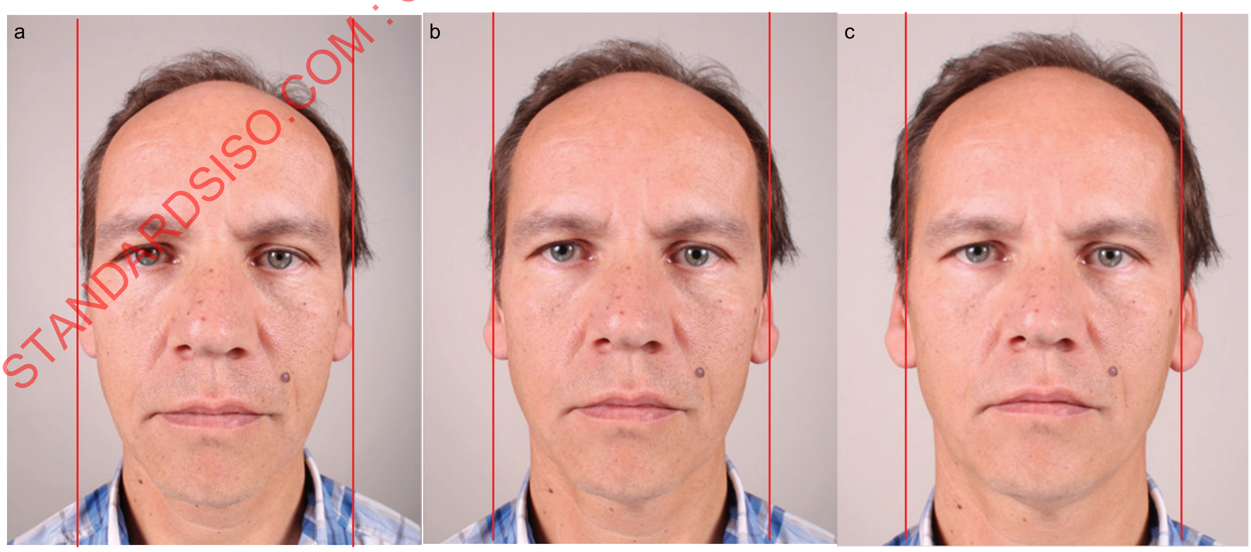
d) Too strong magnification distortion | e) Too strong magnification distortion | f) Too strong magnification distortion

Figure D.6 — Appearance with and without strong magnification distortion

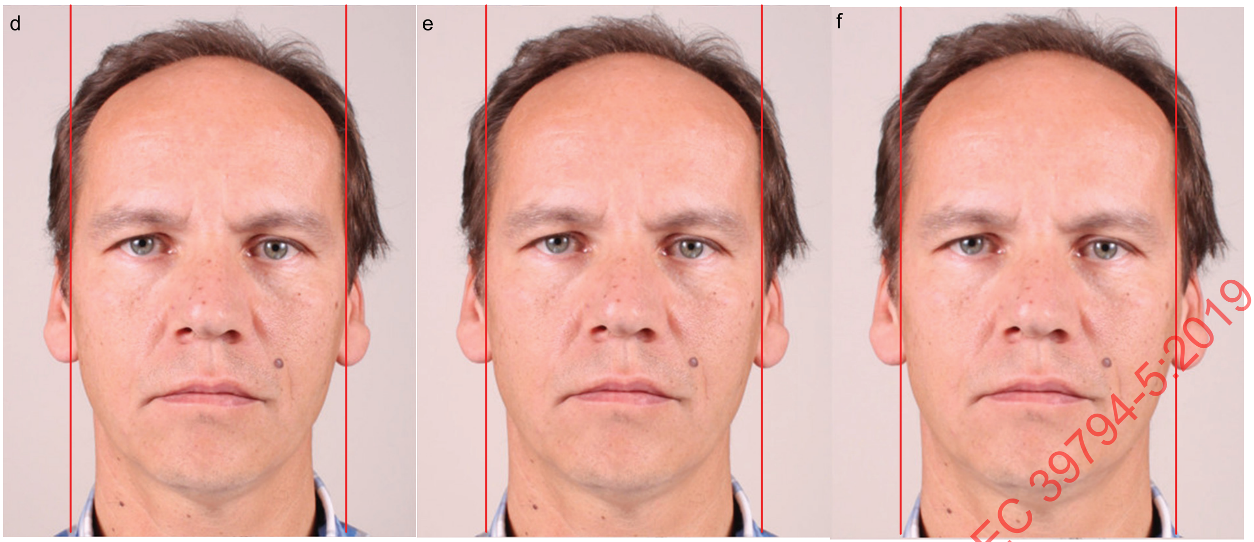
One of the important factors that influence the appearance of the facial features is the distance between subject and camera lens.

The magnification distortion due to camera subject distance can be noticeable to human examiners but shall be within defined limits that allow effective face recognition.

Acceptable distortion rate tolerances depend on the performance capacity of state of the art face recognition technology, and on the capability of typical human inspection staff to recognize people, even those coming from varying ethnic origin.



a) Distance of 300 mm | b) Distance of 400 mm | c) Distance of 600 mm



d) Distance of 700 m | **e) Distance of 800 mm** | **f) Distance of 1000 mm**

g) Distance of 1500 mm | **h) Distance of 2000 mm** | **i) Distance of 2500 mm**

Figure D.7 — Sample face portraits taken with a full-size sensor camera at focal length 50 mm from different distances

These images have been captured using the enrolment bench described in E.6. All images have been normalized to a constant IED. The red bars mark the distance between the feature points 10.7 and 10.8 according to ISO/IEC 14496-2:2004, Annex C measured in Figure D.7 i).

Rulers at nose and ear may be used to measure the geometric effect to the face, i.e., a millimetre at nose level is larger than a millimetre at ear level on the image of the rulers.

The maximum level of magnification distortion of the capturing process shall be set depending on the appropriate application case:

— **1:1 application case:** At the border, an automatic and/or human face verification/comparison is progressed. This is the case in most automated border control applications. The maximum magnification distortion rate of the picture in the passport **shall not be greater than 7 %** and ideally **should not be greater than 5 %**.

— **1:N application case:** At the enrolment or issuance time of the document, a 1:N face identification is done on a database to help verifying the uniqueness of the identity associated to the new image provided. N is as large as the number of images searched. This application case requires higher quality enrolment. The maximum magnification distortion rate **shall not be greater than 5 %** and ideally **should not be greater than 4 %**.

The study presented in E.6 has shown that, for a large range of enrolment and verification distances the influence of magnification distortion on automatic face recognition system performance is low.

The magnification distortion is considered to be noticeable if the distance between units on a ruler at the nose tip level measured in pixels is more than 5 % larger than the distance between units on a ruler at the outer canthus level measured in pixels. The elevation of the nose compared to the outer canthus of the test subject is assumed to be 50 mm. It is sufficient to measure this properly once whenever a photographic setup is introduced or modified. An example photo is given in Figure D.8. Examples of face portraits with good appearance and too strong magnification distortion are given in Figure D.7. The general case of the optical system is discussed in E.2.

a) Ruler at nose/eye level **b) Ruler at nose level** **c) Ruler at eye level**

Figure D.8 — Magnification distortion measurement with rulers at nose and eye level

There are several possible strategies for decreasing the magnification distortion. The general assessment of an optical system is discussed in E.2. Assuming a telecentric lens, the distance between sensor and subject does not introduce any magnification distortion. Real systems need specific considerations and measurements like those described in E.2. Another strategy to decrease the magnification distortion is to increase the distance between subject and camera, or to fold the optical path. The principle of a folded optical path is illustrated in Figure D.9. These strategies are not limitative. Camera subject distance and corresponding magnification distortion examples are listed in Table D.3. Sample images taken with a high quality camera with several magnification distortion rates are given in Figure D.7.

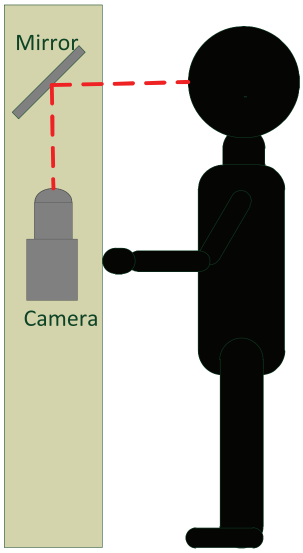


Figure D.9 — Principle sketch of a folded optical path

Table D.3 — Camera subject distance and corresponding magnification distortion

Camera subject distance in mm	Magnification distortion Δd/d for a standard (i.e. not telecentric) lens
300	16,7 %
400	12,5 %
500	10,0 %
600	8,3 %
700	7,1 %
1000	5,0 %
1200	4,2 %
1500	3,3 %
2000	2,5 %
2500	2,0 %
3000	1,7 %

NOTE 2 This magnification distortion only applies for standard (i. e. non-telecentric lens) lenses.

Homemade face portraits are also affected by magnification distortion tolerance. Issuers who accept homemade face portraits should be aware that there is no scientific solution that allows checking the tolerance compliancy. Therefore, the acceptance of homemade face portrait is not recommended.

The issuer should allow for a transition period in which enrolment systems, e.g., photo booths and kiosks may be updated to fulfil the magnification distortion requirements considering economic and feasibility reasons. The duration of such transition period is at the discretion of the issuer.

D.1.4.2.3 Radial distortion

The radial distortion due to lens properties can be noticeable to human examiners but shall be within defined limits that allow effective face recognition. In particular, fish eye effects caused by wide angle lenses combined with camera placement too close to the face shall not be present.

Acceptable distortion rate tolerances depend on the performance capacity of state of the art face recognition technology, and on the capability of typical human inspection staff to recognize people, even those coming from varying ethnic origin.

If the radial distortion is less than 2 %, the human eye will not easily perceive it. It is recommended that radial distortion is less than 2,5 %.

The general assessment of an optical system is discussed in E.2.

D.1.4.2.4 Pixel count, focus and depth of field

Digital cameras used to capture face portraits shall produce images where the vertical and horizontal pixel density is the same.

Live captured face portraits of a subject:

— Shall be captured in one of the following formats: PNG, JPEG, JPEG2000, RAW formats supported by the camera, lossless formats should be preferred,

— Should be captured at a minimum dimension of 1200 pixels width × 1600 pixels height (cropped image),

— Shall be captured in colour.

One of the four possible encodings shall be used:

— The JPEG sequential baseline (ISO/IEC 10918-1) mode of operation and encoded in the JFIF file format (the JPEG file format).

— The JPEG-2000 Part-1 code stream format (ISO/IEC 15444-1), lossy, and encoded in the JP2 file format (the JPEG2000 file format).

— The JPEG-2000 Part-1 code stream format (ISO/IEC 15444-1), lossless, and encoded in the JP2 file format (the JPEG2000 file format).

— The PNG specification (ISO/IEC 15948). PNG shall not be used in its interlaced mode and not for images that have been JPEG compressed before.

For the use of RAW images see 7.40. The encoding into one of the four formats above can be done in a later process step before MRTD production.

The IED in the captured photo shall be at least 90 pixels for legacy applications. If an issuer considers the design of a new passport application process, the new IED should be at least 240 pixels. Examples for a new process could be live capturing, digital submission without analogue intermediate steps, or increasing the size of the printed photograph to be scanned, see Table D.4. See Figure 10 for an illustration of the IED measurement.

Table D.4 — IED capturing requirements and recommendations.

Criterion: live capture IED	Requirement	IED ≥ 90 pixels
	Best practice	IED ≥ 240 pixels
Criterion: scanned image IED	Requirement	IED ≥ 90 pixels
	Best practice	IED ≥ 240 pixels
Criterion: electronic submission IED	Requirement	IED ≥ 90 pixels
	Best practice	IED ≥ 240 pixels
Criterion: issuer repository IED	Requirement	IED ≥ 90 pixels
	Best practice	IED ≥ 240 pixels
Criterion: MRTD chip storage IED	Requirement	IED ≥ 90 pixels
	Best practice	IED ≥ 120 pixels

NOTE This pixel count is specified for the live captured face portrait only. For stored images on the chip, see D.1.5 and Table D.10 as well.

All images shall have sufficient focus and depth of field to maintain the required level of details. The camera shall be capable of accurately rendering fine contrasted face details, such as wrinkles and moles, as small as 1 mm in diameter on the face.

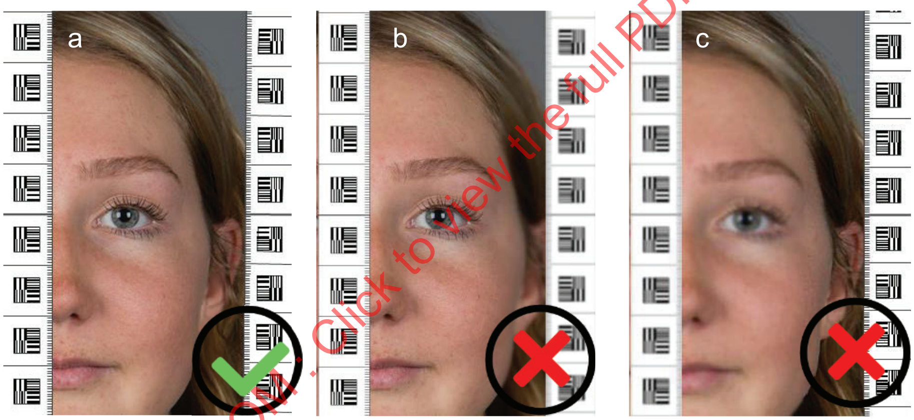
The focus and depth of field of the camera shall be set so that the subject's captured image is in focus from nose to ears. In most cases, a depth of field of 150 mm will be sufficient. See Table D.5. The background behind the subject may be out of focus. Proper focus and depth-of-field will be assured by either using the camera auto focus function with manual aperture settings or by pre-focusing the lens at the distance of the subject's eyes and by selecting an appropriate aperture (F-stop) to ensure a depth-of-field of the distance from a subject's nose to ears. See E.5.

Table D.5 — Depth of field requirements and recommendations

Criterion: Depth of field	Requirement	Nose to ears
	Best practice	150 mm from nose level

EXAMPLE An aperture of f/8 for an 80 mm lens at a distance of 2500 mm provides a depth of field of 150 mm. An aperture of f/16 for a 50 mm lens at a distance of 1200 mm provides a depth of field of about 180 mm.

A simplified visual compliance check method requires that the individual millimetre markings of rulers placed on the subject's nose and ear facing the camera can be seen simultaneously in a captured test image. See Figure D.10. This quality assurance method should be used for quality assurance field checks from time to time. A more systematic test method is described in E.2.



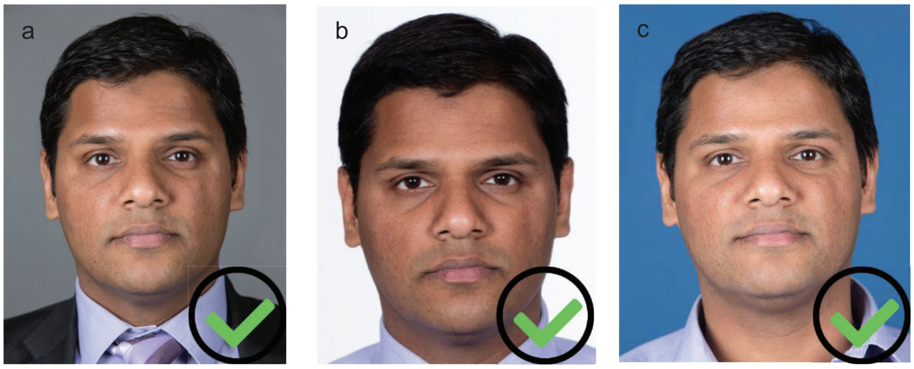
a) Part of a compliant image **b) Sharp at nose only** **c) Sharp at the ears only**

Figure D.10 — Examples for sharpness at nose and ear level

D.1.4.2.5 Background

The background surface behind the subject shall be plain, and shall have no texture containing spots, lines or curves that will be visible in the captured image. The background shall have a uniform colour. There may be gradual changes from light to dark luminosity in a single direction, although this may make it more difficult to remove the background during the document production process.

A typical background for the scene is grey with a plain, dull flat surface. Plain light-coloured backgrounds such as light blue or white may be used as long as there is sufficient distinction between the face/hair area and the background. Camera colour settings should not be shifted depending on the background colour, see Figure D.11.



a) Grey background b) Light grey background c) Blue background

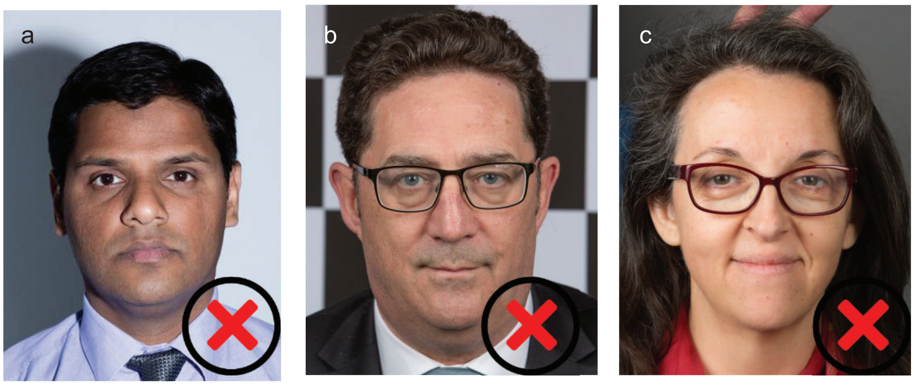
Figure D.11 — Examples of compliant portrait backgrounds

The boundary between the head and the background should be clearly identifiable around the entire subject with the exception of very large hair volume. See Figure D.12. A boundary that is not clearly visible can have a negative impact on the production process which often requires background removal.

a) Compliant image b) Low contrast c) Low background contrast

Figure D.12 — Contrast examples

Shadows should not be visible on the background behind the face image. In particular, there shall not be asymmetric shadows. There shall not be any objects visible in the background like supporting persons, chair backs, furniture, carpets, patterned wall papers or plants. For examples, see Figure D.13.



a) Asymmetric shadow on the left | b) Inhomogenous background | c) Body parts visible behind the head

Figure D.13 — Examples for non-compliant backgrounds

D.1.4.2.6 Lighting

Face portraits shall have adequate and uniform illumination. Lighting shall be equally distributed on the face, in particular symmetrically, i.e., there is no difference between the brightness of the right and left side of the face. There shall not be significant direction of the light visible from the point of view of the camera.

The measured EV at four spots on a subject's face; the left and right cheeks, forehead, and chin, should be the same. An EV difference of at most one F-stop or one shutter speed step is acceptable. If one or some of these four spots are covered by hair, e.g., the forehead by the hairstyle or the chin by a beard, these spots can't be evaluated. The appropriate illumination setup of the scene should be verified from time to time. The subject being used for these tests should not have a hairstyle covering the forehead or the cheeks, or a beard.

The uniformity measurement should be done as specified below. It is not intended to be used for every single image. See Figure D.14 for a visualization of that measurement. Automated quality assurance software, e.g., for registration offices or photo kiosks, should be implemented accordingly. However, such software should also consider exceptions due to hair on the forehead, beard, face anomalies and the like.

1. Determine the four measurement zones on the forehead, the cheeks and the chin. These locations are determined as follows:

   a) Connect the two eye centres (feature points 12.1 and 12.2 from ISO/IEC 14496-2:2004, Annex C). The IED is the length of the connecting line H. The point M is the midpoint of this line.

   b) Connect M with the mouth midpoint (feature point 2.3 from ISO/IEC 14496-2:2004, Annex C). EMD is the length of the connecting line V. Note that the two lines do not need to be rectangular.

   c) MP, the side length of the four squared measurement zones, is defined to be 0,3 IED.

   d) The centre of the forehead measurement zone F is located at a distance of 0,5 EMD upwards from M on V.

   e) The centre of the chin measurement zone C is located at a distance of 1,5 EMD downwards from M on V.

   f) The top left corner of the right (from the capture subject) cheek measurement zone R is located at a distance of 0,5 EMD downwards from M on V and 0,5 IED to the left of M on H (looking at the capture subject).

g) The top right corner of the left (from the capture subject) cheek measurement zone L is located at a distance of 0,5 EMD downwards from M on V and 0,5 IED to the right of M on H (looking at the capture subject).

2. For all colour channels, measure the mean intensity values MI for the measurement zones F, C, L and R.

3. For all channels separately, the lowest MI (of F, C, L and R) in that channel shall not be lower than 50 % of the highest MI (of F, C, L and R).

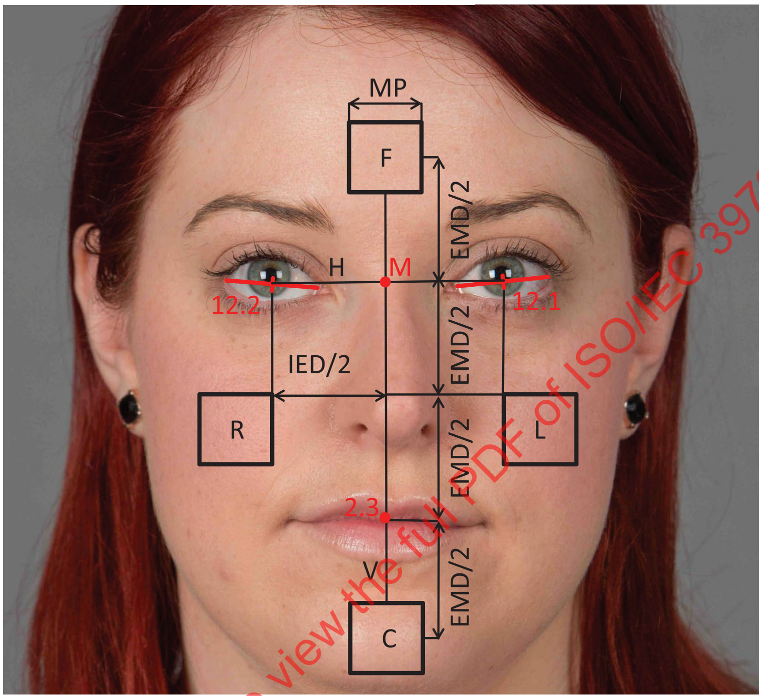


Figure D.14 — Location and size of the intensity measurement zones

The measures for the illumination intensity and requirements to them are listed in Table D.6.

Table D.6 — Measures for the illumination intensity compliance check

Term	Description	Requirement
12.1	Feature point at left eye centre	
12.2	Feature point at right eye centre	
H	Line connecting 12.1 and 12.2	
IED	Length of H between 12.1 and 12.2	IED ≥ 90 pixels
M	Midpoint of H between 12.1 and 12.2	
2.3	Feature point at mouth centre (with closed mouth the same as 2.2)	
V	Line connecting M and 2.3, V and H do not need to be orthogonal	
EMD	Length of V between M and 2.3	
MP	Side length of the squared measurement zones	MP = 0,3 IED
F	Forehead measurement zone, located at a distance of 0,5 EMD upwards from M on V	
C	Chin measurement zone C, located at a distance of 1,5 EMD downwards from M on V	
R	Right (from the capture subject) cheek measurement zone R, its top left corner is located at a distance of 0,5 EMD downwards from M on V and 0,5 IED to the left of M on H	

Table D.6 *(continued)*

Term	Description	Requirement
L	Left (from the capture subject) cheek measurement zone L, its top right corner is located at a distance of 0,5 EMD downwards from M on V and 0,5 IED to the right of M on H	
MI	Mean intensity value measured for every channel separately	$max \leq 2 \times min$ (per channel)

While it is understood that massive shadows on parts of the face will obscure face details important for identification, having no shadows at all will result in a non-natural appearance. In such a case, the face will appear flat and without surface features. Appropriate shadows help distinguish the shape of the nose, eye areas, forehead, cheeks, chin and so on. Furthermore, lighting and shadows are necessary to show details around the eyes, wrinkles and scars. There shall not be extreme dark shadow visible on the face, especially around the nose, in the eye sockets, around the mouth, and between mouth and chin that obscure face details important for inspection. The brightness shall be nearly the same on both sides of the face, left and right. All features in the face shall be clearly recognizable, and the volume effect especially around nose and eyes shall render the reality, see Figure D.15.

EXAMPLE To comply with this requirement, the illumination elements can be aligned in an angle of approximately 35° off the axis between camera lens and face centre. Descriptions of sample illumination layouts are given in E.1.

a) Side illumination **b) Top illumination** **c) Bottom illumination**

Figure D.15 — Examples for non-compliant illumination

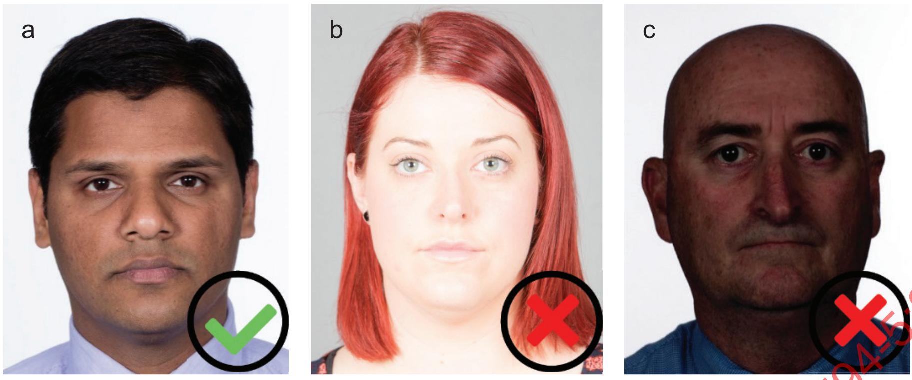
Flashes should only be used for indirect illumination. Issuers may exclude the use of flashes. If face portraits are captured using flashes, care should be taken to verify that the eyes of the subject are open. As long as the requirements for the face portrait from D.1.4 are maintained, one or more flashes or a large surface flash may be used. There shall not be any shadows at the face or in the background of the face portrait that obscure face details important for inspection. Illumination shall not cause any red eye effect visible in the eyes or other lighting artefacts such as spots from a ring flash reducing the visibility of the eyes.

A high colour rendering index is recommended for illumination. See D.1.4.2.9 for details.

The captured image shall contain minimal reflections or bright spots. Diffused lighting, multiple balanced sources or other appropriate lighting methods should be used. A single bare point light source like a camera mounted direct flash shall not be used for imaging. Lamp reflectors or other technologies that provide non-point illumination should be used.

D.1.4.2.7 Contrast

For each patch of skin on the capture subject's face, the gradations in textures shall be clearly visible, i.e., being of reasonable contrast. Whites of eyes shall be clearly light or white (when appropriate) and dark hair or face features (when appropriate) shall be clearly dark. Generally, the face portrait shall have appropriate brightness and good contrast between face, hair and background. See Figure D.16.



a) Correct exposure   b) Over exposure   c) Under exposure

Figure D.16 — Examples for compliant and non-compliant exposure

D.1.4.2.8 Dynamic range

The dynamic range of the image should have at least 50 % of intensity variation in the face region of the image. The face region is defined as the region from crown to chin and from the left ear to the right ear. This recommendation may require an adjustment of the equipment settings on an individual basis when the skin tone is excessively light or dark. In the rectangle between the ISO/IEC 14496-2 feature points:

— 2.1: Bottom of the chin,

— 10.9: Upper contact point between left ear and face,

— 10.10: Upper contact point between right ear and face, and

— 11.1: Middle border between hair and forehead.

All colour channels should have at least 50 % of intensity variation. As this may be difficult to achieve, best efforts should be made to get as close as possible to that requirement. See Figure D.17 for an illustration of the recommended measuring zone and Figure D.18 for examples of good and bad quality images.

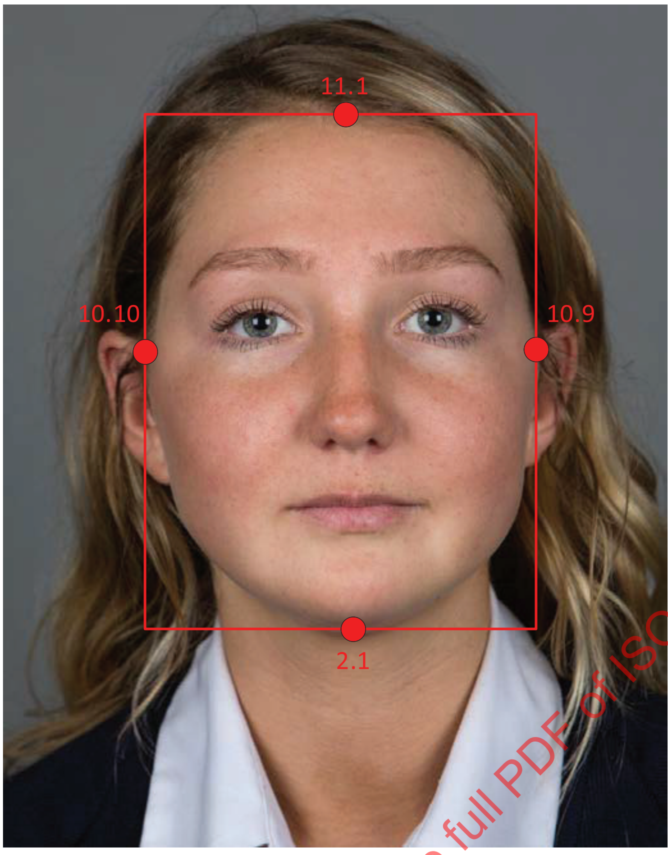
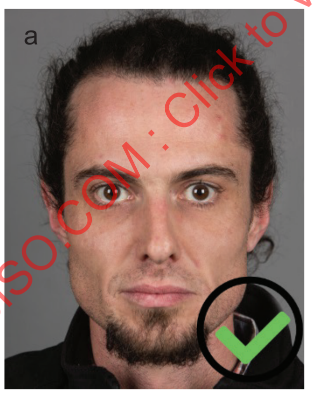


Figure D.17 — Recommended dynamic range measuring zone



a) Compliant face portrait

b) Too low dynamic range

Figure D.18 — Compliant and non-compliant dynamic range

D.1.4.2.9 Colour

All images should be captured in colour. Newly designed enrolment processes should capture colour images only.

The captured face portrait shall be a true-colour representation of the holder in a typical colour space such as sRGB as specified in IEC 61966-2. Other true-colour representations may be used as long as the colour profile is embedded in the image.

The sensor of the camera shall capture the entire visible wavelength, basically the wavelength between 400 nm and 700 nm. It allows rendering correctly the natural colours seen by humans. Unnaturally coloured lighting, i.e., yellow, red, etc., shall not be used. Care should be taken to correct the white balance of image capture devices. The lighting shall produce a face image with naturally looking flesh tones when viewed in typical examination environments. See Figure D.19.

a) Correct colour

b) Colour deviations

c) Excessive saturation in hue, saturation and luminance (HSL) colour space

Figure D.19 — Examples for compliant and non-compliant colour setups

The RGB values from the capturing device should be converted to an appropriate RGB space as required by the data format.

Dedicated near infra-red cameras shall not be used for image acquisition.

Colour calibration using an 18 % grey background or other method such as white balancing should be applied.

White balance shall be properly set in order to achieve high fidelity skin tones. Quality assurance measurements of light conditions and camera system response should be made when a recommended CIE Standard Illuminant D65 illuminant (see ISO 11664-2) or a similar continuous spectrum daylight illuminant and a camera and/or camera control software are used to take pictures. In practice it is necessary to reduce the ambient light emanating from uncontrolled daylight sources, fluorescent or similar light sources and reflections from surfaces.

Imaging fidelity measurements for photo studio and stationary registration office installations may be done either using a light spectrum analyser to define the spectral characteristics of the illuminants or analysing measurement target images using software applications.

Annex E.3 contains a methodology for measuring colour quality and recommended values.

Colour quality should be measured in terms of colour error using the CIEDE2000 formula (deltaE2000) of a standardized test pattern according to the methodology in E.3. The average deltaE2000 of all colour patches should not exceed 4 for scanners and 10 for camera systems. The maximum deltaE2000 for any colour patch should not exceed 15 for scanners and 20 for camera systems. Measured CIELAB L*a*b* human skin tone a* and b* values shall be positive as shown in E.3. See References [25] and [26] for explanations. Negative a* and b* values are acceptable for medical reasons only.

D.1.4.2.10 Noise

The enrolment should be made in a controlled scene; the picture should be captured with high signal-to-noise ratio. Noise is not information contained in the original scene but is created by the electronics due to a too high level of amplification. ISO sensitivity settings at values of ISO 100 and ISO 200 typically reduce noise; for high-quality cameras ISO 400 and ISO 800 may also be used. Noise can be minimized by correct exposure at a low ISO setting.

The ratio of signal to noise (SNR) is one indicator of the overall ability of a collection system to accurately capture a subject's appearance. Unwanted variations in the response of an imaging system (i. e., noise) are inherent in the capture process of a digital representation of a physical scene and arise from the interplay between the system components (e.g., sensor and lens) and the capture environment (e. g., subject illumination). Reducing overall noise to improve the SNR benefits human examiners and automated face analysis systems which rely on high-quality subject images. SNR should be computed as prescribed in ISO 15739:2017, 4.7, which incorporates a human visual model to calculate the human observable (i. e., perceived) SNR of the overall collection system.

Commercial software designed for use by photo studios and registration office imaging systems are available with accompanying standard test targets for computing SNR.

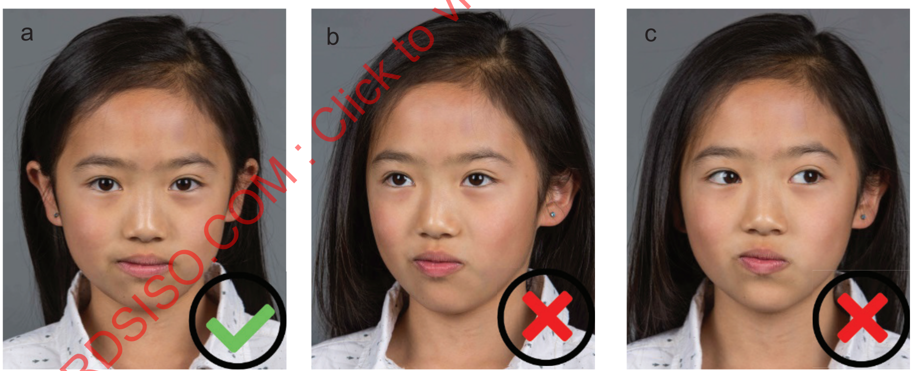
D.1.4.2.11 Filters

Polarization filters shall not be used in front of the light sources. Linear polarization filters shall not be used in front of the camera lens as they interfere with autofocus cameras and thus reduce or remove skin texture information which might be used by face image comparison algorithms. Circular polarizing filters decrease reflections that show up in eyeglasses and may be used in front of the camera lens.

D.1.4.3 Subject conditions

D.1.4.3.1 Pose

The subject should be instructed to look directly at the camera and to keep his or her head erect. Typically people are able to adopt such a position if instructed. Care should be taken to maintain the full frontal pose as well as possible. See Figure D.20.



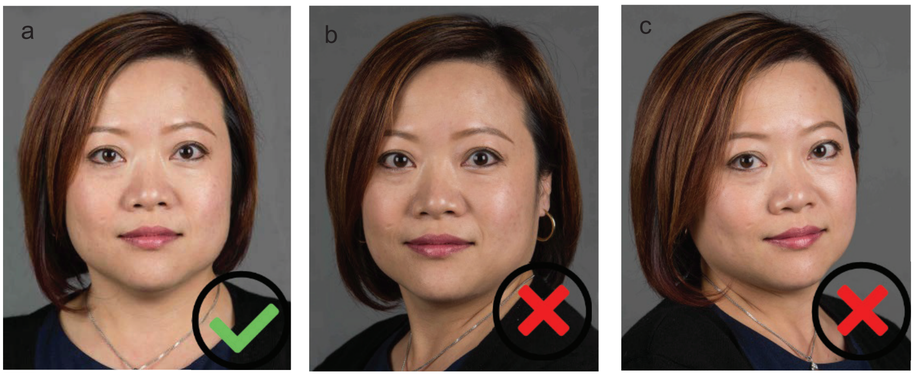
a) Compliant pose

b) Head not aligned toward the camera

c) Eyes not aligned toward the camera

Figure D.20 — Pose examples

The shoulders shall be square on to the camera, parallel to the camera imaging plane. Portrait style photographs where the subject is looking over the shoulder shall not be used. See Figure D.21.



a) Compliant pose **b) Shoulders not aligned toward the camera** **c) Shoulders not aligned toward the camera, head tipped to the side**

Figure D.21 — Pose examples

The pitch of the head shall be less than ±5° from frontal. The yaw of the head shall be less than ±5° from frontal. The roll of the head shall be less than ±8°, it is recommended to keep it below ±5°. Any stronger pose deviation may have negative impact on face recognition error rates. Therefore, effort should be spent to ensure that all angles are as small as possible. See Table D.7. For an illustration of the angles see Figure 3. For samples showing correct pose and pose deviations see Figure D.22.

Table D.7 — Pose angle requirements and recommendations

Criterion: Pose angle	Requirement	Pitch ≤ ±5°, yaw ≤ ±5°, roll ≤ ±8°
	Best Practice	Pitch ≤ ±5°, yaw ≤ ±5°, roll ≤ ±5°

a) Too large pitch up

b) Too large roll angle

c) Compliant image

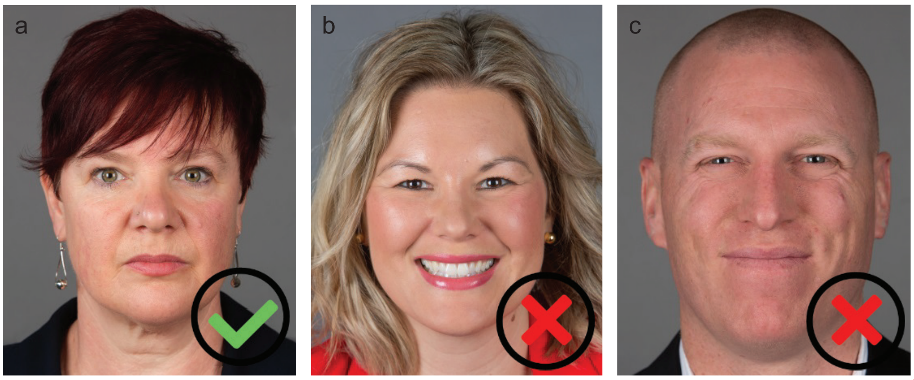
d) Too large yaw angle

e) Too large pitch down

Figure D.22 — Pose angle examples

D.1.4.3.2 Expression

The face shall have a neutral expression; in particular the capture subject shall not smile. The mouth shall be closed; the teeth shall not be visible. A smile is not allowed, even with closed jaw. The eyebrows shall not be raised. Squinting and frowning shall not be visible. See Figure D.23.



a) Compliant portrait b) Smiling subject c) Subject smiling with closed mouth

Figure D.23 — Expression examples

The mouth is considered to be closed if the distance A between the inner borders of the lips (distance between feature points 2.2 and 2.3) is less than 50 % of the thickness of the lower lip B (distance between the feature points 2.3 and 8.2). See Figure D.24.

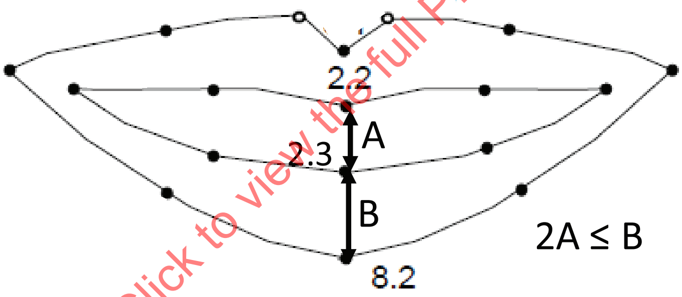
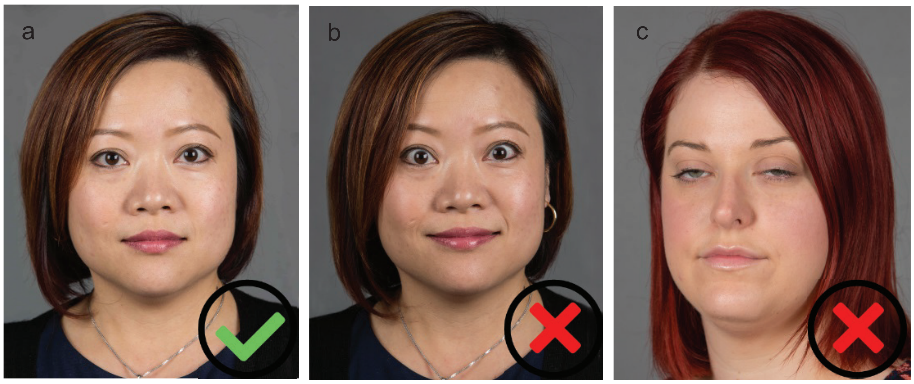


Figure D.24 — Definition of a closed mouth

D.1.4.3.3 Eye visibility

Both eyes shall be opened naturally, but not forced wide-opened. Pupils and irises, including iris colour, shall be completely visible, although there may be exceptions due to ethnicity or other individually specific reasons. The eyes shall look into the camera unless there are medical conditions preventing this. There should not be strong shadows in the eye-sockets. See Figure D.25 for examples.



a) Compliant portrait **b) Unnaturally wide opened eyes** **c) Eyes not fully opened**

Figure D.25 — Eye visibility examples

Any lighting artefacts present on the region of the eyes shall not obscure eye details such that identification becomes difficult. Lighting artefacts shall not be larger than 15 % of the area of the iris. If there are unacceptable reflections, the illumination should be relocated appropriately. The pitch shall not be increased by moving the head forward.

Examples of setups preventing or at least reducing lighting artefacts are given in E.1.

The eye visibility zone (EVZ) is defined as the covering rectangle having a distance V of at least 5 % of the IED to any part of the visible eye ball. Figure D.26 indicates the distance V of the covering rectangle to the visible parts of the eye ball. The EVZ shall be completely visible and unobscured.

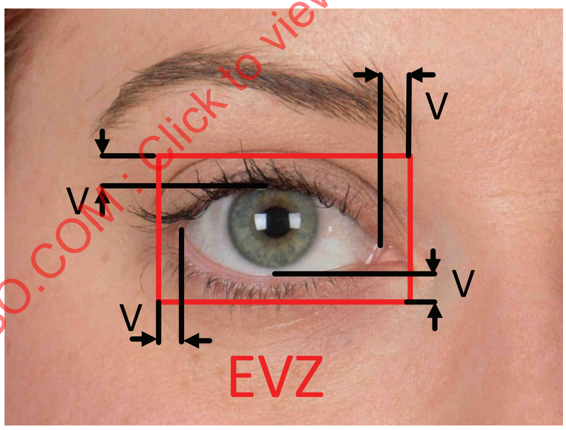


Figure D.26 — Illustration of the EVZ

Contact lenses changing the appearance of the iris including the size and the shape shall not be worn. The pattern of the lens shall not exceed the limbus.

D.1.4.3.4 Accessories: Glasses

If glasses are permitted by the issuer, subjects may wear glasses during image capture if they typically do so. Glasses other than those worn due to ametropia shall not be worn. Reading glasses shall not be worn during image capture. The lens area of glasses shall be made of fully transparent material. Tinted glasses, sunglasses, and glasses with polarization filters shall not be worn. An exception applies when the subject asserts a medical reason to retain glasses which are not fully transparent. If glasses are worn that tint automatically under illumination, they shall be photographed without tint by tuning the direct illumination or background lighting. In cases where the tint cannot be reduced the glasses shall be removed or the subject should be asked to use other glasses. See Figure D.27. A circled yellow "P" in the Figure indicates compliance depending on the acceptance policy of the issuer.

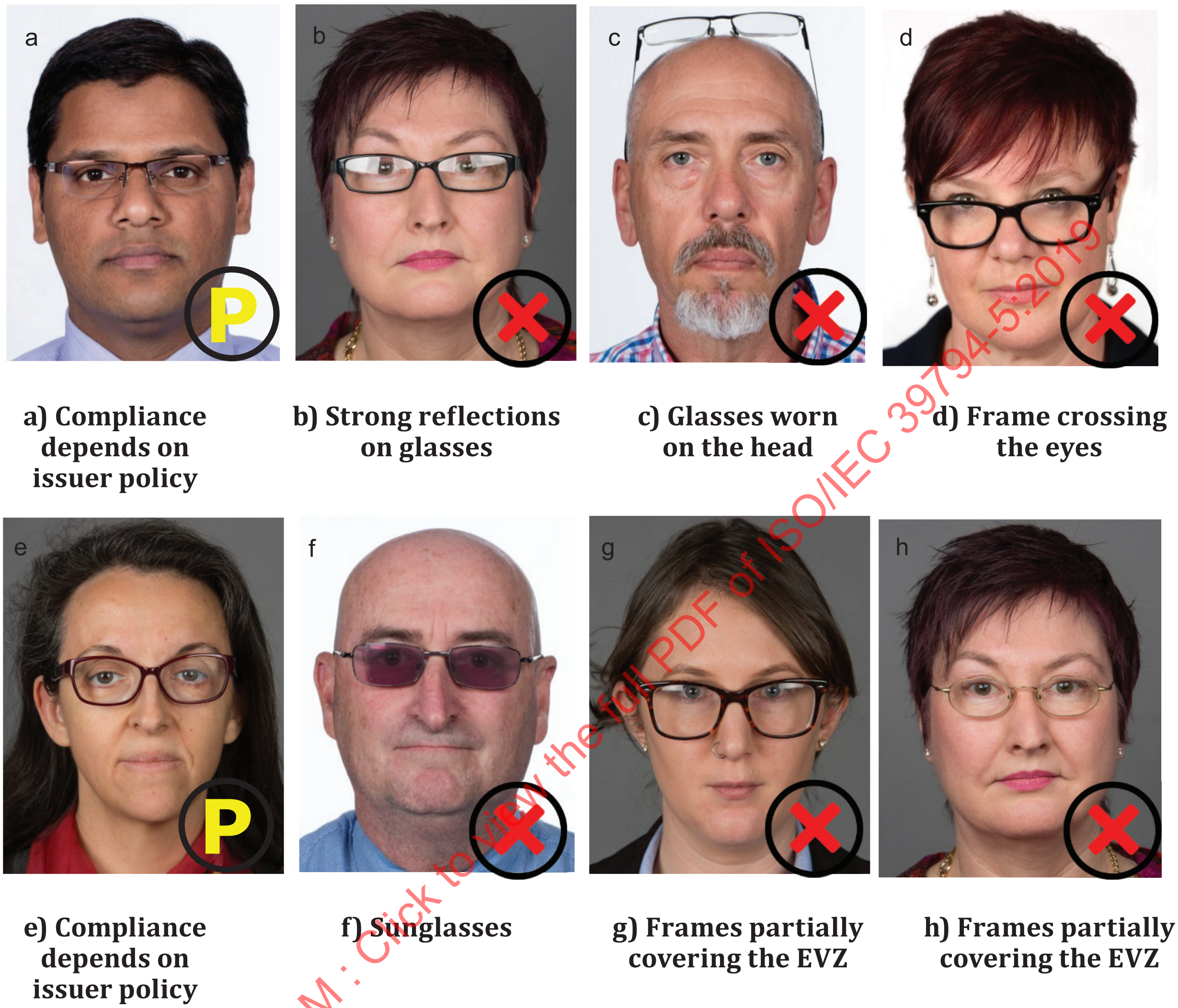


Figure D.27 — Examples for compliance of glasses

Any lighting artefacts present on the region of the glasses shall not obscure eye details such that identification becomes difficult. Glasses may be repositioned to eliminate lighting artefacts, but frames shall not obscure eye details. The pitch shall not be increased by moving the head forward.

Rims and frames of glasses shall not obscure the eyes as well as the EVZ. The irises of both eyes shall be visible to the same extent as without glasses. Frames should not be thicker than 5 % of the IED (typically 3–4 mm). A subject wearing heavier frames should be asked to use other glasses or to remove their glasses.

D.1.4.3.5 Accessories: Head coverings

The region of the face, from the crown to the base of the chin, and from ear-to-ear, shall be clearly visible. Special care shall be taken in cases when veils, scarves or head covering cannot be removed for religious reasons to ensure these coverings do not obscure any face features and do not generate shadow. Head coverings shall not be accepted except in circumstances specifically approved by the issuing state of the MRTD. Such circumstances may be religious, medical or cultural. If head coverings are allowed, they shall be firm fitting and of a plain uniform colour with no pattern and no visible perforations and the region between hair lines, both forwards of the ears and chin including cheeks, mouth, eyes, and eyebrows shall be visible without any distortion or shadows. For examples, see Figure D.28.

The elliptically shaped region between the following face feature points as defined in ISO/IEC 14496-2 shall be visible without any intensive shadows:

— 2.1: Bottom of the chin,

— 10.9: Upper contact point between left ear and face,

— 10.10: Upper contact point between right ear and face, and

— 11.1: Middle border between hair and forehead.

An issuer may or may not require that the ears are visible. The capture process should minimize shadows and obscuration of features in the face region. This might involve adjustment of the head coverings. See Figure D.28.

a) Compliance depends on issuer policy

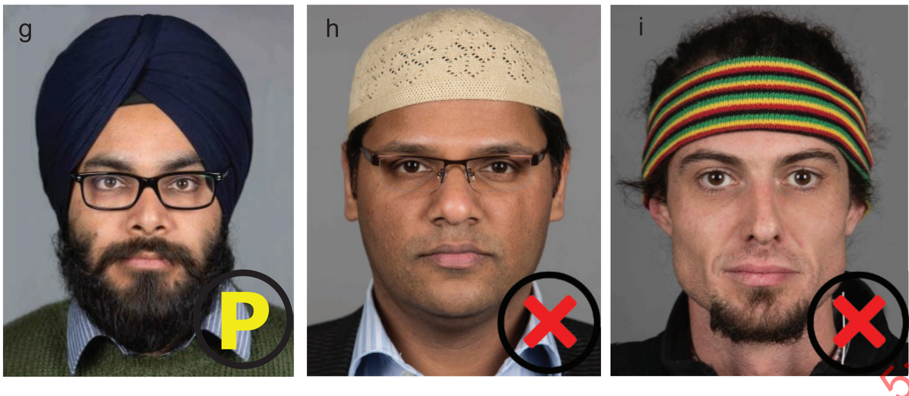
b) Compliance depends on issuer policy

c) Face not completely visible

d) Non-uniform head covering

e) Low background contrast

f) Low background contrast



g) Compliance depends on issuer policy | h) Visible perforation | i) Non-religious head covering

Figure D.28 — Head covering examples

D.1.4.3.6 Accessories: Face ornamentation

Face ornamentation which obscures the face shall not be present. Concerning face ornaments not obscuring the face, the issuer may use its discretion as to the extent to which face ornaments may appear in the face portrait. In any case, only permanently worn face ornaments may appear in the face portrait. See Figure D.29.

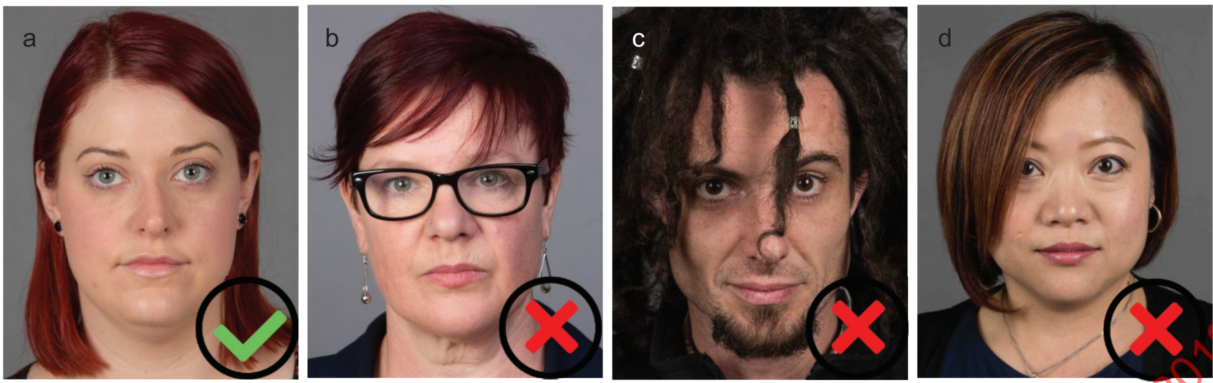
a) Compliant face ornamentation | b) Compliant face ornamentation | c) Compliant face ornamentation

Figure D.29 — Face ornamentation examples

D.1.4.3.7 Style: Make-up, hair style

People usually try to look better than normal in an ID photo. In some extreme cases an excessive use of make-up affects computerized as well as human face recognition capabilities. Therefore, the subject should only wear typical every day make-up.

There shall be no dirt visible on the face in a captured face portrait. It should be considered that dermatological problems could cause skin properties that look like dirt. The hair of the subject shall not cover any part of the eyes. The hair should not cover any part of the EVZ. See Figure D.30. Eye patches shall not be worn unless required for a medical reason.



a) Compliant face portrait	b) Hairs and glasses close to the EVZ	c) Hair partly covering the EVZ	d) Hair partly covering the EVZ

Figure D.30 — Hair style examples

D.1.4.4 Face portrait dimensions and head location

The head shall be centred in the final face portrait as described in this clause. The referenced feature points are defined in ISO/IEC 14496-2. See Figure 9, Figure D.32, and Table D.8.

The image width A to image height B aspect ratio should be between 74 % and 80 %. The imaginary line H is defined as the (almost horizontal) line through the eye centres of the left (feature point 12.1) and the right eye (feature point 12.2).

The centre of H is the face midpoint M. The horizontal distance M_h between the left image border and M shall be between 45 % and 55 % of A. The vertical distance M_v between the top image border and M shall be between 30 % and 50 % of B. The mouth centre (feature point 2.3) and M define the imaginary (almost vertical) line V. Note, that V and H are not necessarily perpendicular.

The head width W is defined as the distance between the two imaginary lines parallel to the line V; each imaginary line is drawn between the upper and lower lobes of each ear (feature points 10.2/10.6 for the right and 10.1/10.5 for the left ear). The W to A ratio shall be between 50 % and 75 %. This constraint is more important than including the entire hairline in the photograph for subjects with large hair volume.

The head length L is defined as the distance between the base of the chin (feature point 2.1) and the crown (feature point 11.4) measured on the imaginary line V. If these feature points are not exactly located at V, the vertical projection of them to V shall be used. The L to B ratio shall be between 60 % and 90 %.

Often, the location of crown, chin or ears cannot be determined precisely. In such a case, a good guess shall be made.

For examples see Figure D.31.

a) Compliant face portrait | b) Invisible crown | c) Invisible chin | d) Invisible crown and chin

Figure D.31 — Face portrait dimensions and head location examples

Table D.8 — Geometric face portrait requirements

Term	Description	Requirement
A	Image width	
B	Image height	74 % ≤ A/B ≤ 80 %
H	Line through the centres of the left (feature point 12.1) and the right eye (feature point 12.2)	
M	Face centre (midpoint of H)	
M_h	Distance from the left side of the image to M	45 % ≤ M_h /A ≤ 55 %
M_v	Distance from the top of the image to M	30 % ≤ M_v /B ≤ 50 %
V	Line through mouth centre (feature point 2.3) and M	
W	Head width: Distance between the two imaginary lines parallel to the line V; each imaginary line is drawn between the upper and lower lobes of each ear (feature points 10.2/10.6 for the right and 10.1/10.5 for the left ear)	50 % ≤ W/A ≤ 75 %
L	Head length: Distance between the base of the chin (feature point 2.1) and the crown (feature point 11.4) measured on the imaginary line V, if these feature points are not exactly located at V, the vertical projection of them to V shall be used	60 % ≤ L/B ≤ 90 %

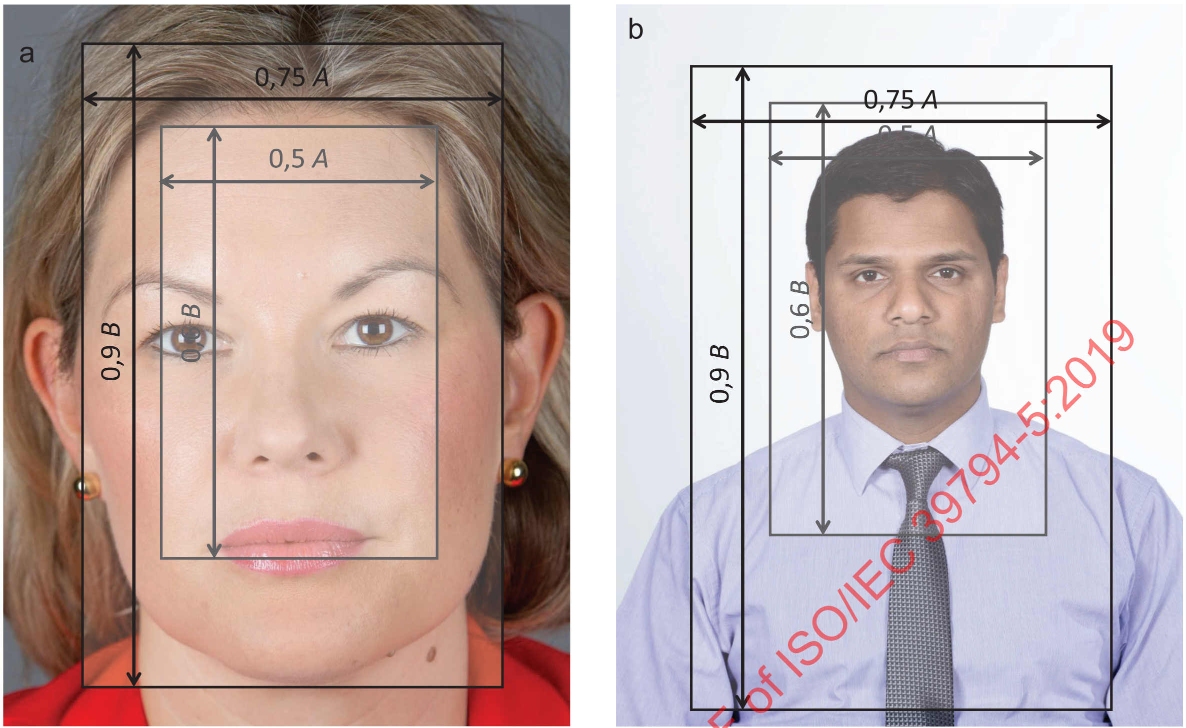
NOTE Both ISO/IEC 19794-5:2005 (edition 1) and ISO/IEC 19794-5:2011 (edition 2) comply with Table D.8 geometric requirements for Full Frontal image type and Token Face image type.

Figure D.32 shows a typical example of a face portrait. In Figure D.32 a) the intersection of the two rectangles marks the region where the centre point M shall be located. In Figure D.32 b) the smaller rectangle in the face portrait shall be completely included in the head; the head itself shall be completely included in the larger rectangle. Note that the locations of these two rectangles do not depend on the location of M, the rectangles can be moved freely and independently from each other as long as they stay parallel to the borders of the image. Figure D.33 gives samples where the faces do not fit into the larger rectangle or do not fill the smaller rectangle.

a) True location and allowed region for the centre point M

b) Minimal size (inner rectangle) and maximal size (outer rectangle) of W and L depending on A and B

Figure D.32 — Sample face portraits with the respective minimal and maximal head dimensions



a) Face too large and doesn't fit into the larger rectangle

b) Face too small and does not cover the entire smaller rectangle

Figure D.33 — Sample face portraits not complying with minimal and maximal head dimensions

D.1.4.5 Children

D.1.4.5.1 General

This subclause specifies additional guidance for capturing face portraits of children. Care should be taken to capture such images according to the specifications; however, sometimes this is not possible or would cause huge discomfort. Therefore, some requirements may be relaxed for children as specified below. See Figure D.34, Figure D.35 and Figure D.36 for sample images.

D.1.4.5.2 Children below one year

Deviating from the specifications in D.1.4, babies under one year should be in an upright position, but it is acceptable to capture the face portrait with the baby lying on a white or plain light-coloured blanket which conforms to the requirements in D.1.4.2.5 and D.1.4.2.9. Alternatively, the baby may be placed in a baby seat as long as the background behind the head of the baby conforms to the requirements above and no portions of the baby seat are visible in the face portrait.

Deviating from the specifications in D.1.4.3.3, it is not necessary that babies under one year have their eyes open.

Hands, arms and other body parts of an assisting person used to support the positioning of the subject, e.g., parents supporting their child, shall not be visible in the image. Shadows of these assistant parts shall not be visible on the face portrait or in the background.

D.1.4.5.3 Children below six years

Deviating from the specifications in D.1.4.3.1, children aged six and under shall face the camera within an angle of ±15° in pitch, yaw, and roll. Deviating from the specifications in D.1.4.3.2, children aged six and under do not need to have a neutral expression. For infants under the age of six, images are acceptable as long as the infant is awake, has his or her eyes open, there are no other people or objects in the photo and the background is uniform and face portrait meets the colour requirements in D.1.4.2.9.

D.1.4.5.4 Children below eleven years

Deviating from the specifications in D.1.4.4 for children of up to eleven years, L/B shall be between 50 % and 90 %. Furthermore, M_y /B shall be between 30 % and 60 %.

a) Compliant photo b) Compliant photo c) Compliant photo d) Compliant photo

Figure D.34 — Compliant child face portraits

a) Toy visible b) Supporting person c) Non-neutral background d) Supporting hands

Figure D.35 — Examples of additional objects visible in the image

a) Not looking into the camera

b) Eyes closed

c) Cap

d) No neutral expression

Figure D.36 — Examples of non-compliant poses and expressions

D.1.5 Image storage in the chip

D.1.5.1 General

This subclause specifies properties of the face portrait to be electronically stored in a MRTD. Figure D.37 shows the content of D.1.5 in the MRTD production process chain.

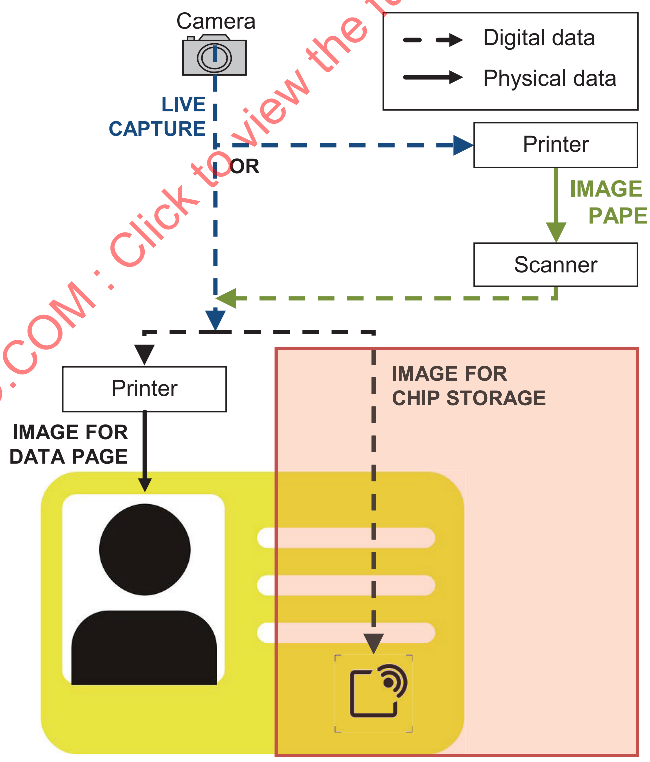


Figure D.37 — Content of D.1.5 in the MRTD production process chain (boxed in red)

The requirements and recommendations given in this subclause shall ensure that the photographic requirements given in D.1.4.2 are retained in the face portrait that is finally stored in a MRTD, with the exception of the pixel count. The minimal requirements specified in this subclause apply to the image finally stored in Data Group 2 as defined in ICAO Doc 9303.

A submitted face portrait shall have been captured within the last six months before application. Face portraits with a capture time dating back more than three months should not be accepted. Issuers should consider the use of the metadata encoded with the digital image to assure that the photograph is recent. See Table D.9.

Table D.9 — Capture time requirements and recommendations

Criterion: Capture time	Requirement	At most six months before application.
	Best practice	At most three months before application.

D.1.5.2 Data format

Face portraits of a subject to be stored in the MRTD chip

— Shall be stored in one of the following formats: JPEG, JPEG2000,

— Should have a minimum IED of 90 pixels, preferably of 120 pixels (see Table D.10),

— Shall be in colour.

These specifications provide adequate spatial sampling rate for use on the MRTD while maintaining an adequate quality for human and machine face recognition purposes.

Table D.10 — IED requirements and recommendations for the chip image

Criterion: IED	Requirement	IED ≥ 90 pixels
	Best Practice	IED ≥ 120 pixels

The pixel count specified in D.1.4.2.4 applies to the originally captured face portrait and not to the images to be stored in a passport. The processing steps between capturing and passport production might lead to information losses. It is therefore recommended that a higher resolution version of the image is stored in the issuer's repository.

One of the three possible encodings shall be used:

— The JPEG sequential baseline (ISO/IEC 10918-1) mode of operation and encoded in the JFIF file format (the JPEG file format).

— The JPEG-2000 Part-1 code stream format (ISO/IEC 15444-1), lossy, and encoded in the JP2 file format (the JPEG2000 file format).

— The JPEG-2000 Part-1 code stream format (ISO/IEC 15444-1), lossless, and encoded in the JP2 file format (the JPEG2000 file format).

The coordinate origin shall be at the upper left given by coordinate (0,0) with positive entries from left to right (first dimension) and top to bottom (second dimension).

D.1.5.3 Property mask

The positions of the Properties element in the data structure described in this document should be set for:

— (medical) dark glasses;

— head coverings;

— left and right eye patches;

— glasses;

— biometric absence (conditions which could impact landmark detection).

Additionally, the Subject height element should be encoded.

D.1.5.4 Post-acquisition processing

No other post processing than:

— in-plane rotation and/or;

— cropping and/or;

— down sampling and/or;

— white balance adjustment and/or;

— ICC colour management transformation and/or;

— processing RAW images into the target encoding (once) and/or;

— compression as described in D.1.5.5,

shall be applied on the captured image to create the face portrait. Any processing shall maintain the requirements given in D.1.3 and D.1.4. Any processing shall render skin and hair colours realistically enough to allow straightforward human identification of the MRTD holder. The face images shall not be modified locally, e.g., for removal of scars, pimples or other skin impurities or to modify the shape or location of the nose, the eyes, the eyebrows or any other face landmarks. The image shall not be modified locally by editing clothes (e.g., a turban).

In particular, any image processing targeting at background removal shall not be implemented. If necessary, the MRTD issuing authority may remove or alter the background in the printed image later in the MRTD production process.

D.1.5.5 Compression

Captured face portraits of a subject should not sacrifice image quality by overly compressing the image.

For maximum effect in human and automated face recognition, the raw image or an image with limited compression should be retained. The JPEG compression ratio shall not exceed 15:1.

EXAMPLE In many cases, such images have a size of at least 12 kBytes for JPEG and JPEG2000 for storage in the chip of an electronic MRTD. The upper limit is defined by the available storage space available on the chip and reading time requirements.

The image used for the printing process on the MRTD and for storage in the chip will give better results if not compressed beyond a ratio creating visible artefacts on the image when viewed at 100 % magnification – where a single pixel in an image file is displayed by a single pixel on a monitor or viewing device. This allows for electronic judging of whether an image is overly compressed.

Lossy compressions can only be applied once per each of the following steps:

— one initial compression by the camera itself,

— one compression done by the photographer or citizen, and

— one compression done by the issuer.

JPEG 2000 enables compressing to a target file size. If using JPEG compression must be done iteratively to the target file size while reverting back to the original image rather than successive compressions.

D.2 General purpose face image

D.2.1 General

This annex describes a profiled face image that meets minimal requirements to acquire an image for general face recognition usage.

One of the following encodings shall be used:

— The JPEG sequential baseline (ISO/IEC 10918-1) mode of operation and encoded in the JFIF file format (the JPEG file format)

— The JPEG-2000 Part-1 code stream format (ISO/IEC 15444-1), lossy or lossless, and encoded in the JP2 file format (the JPEG2000 file format)

— The PNG specification (ISO/IEC 15948). PNG shall not be used in its interlaced mode and not for images that have been JPEG compressed before.

Landmarks should be determined on images before compression is applied. Landmarks should be included in the record format if they have been accurately determined, thereby providing the option that these parameters do not have to be re-determined when the image is processed for face recognition tasks. The landmarks should be determined by computer-automated detection mechanisms followed by human validation. It is recommended to encode the following landmarks: the middle point of the eyes (12.1 and 12.2), the base of the nose (9.4, 9.5, and 9.15) and the upper lip of the mouth (8.4, 8.1 and 8.3).

The 2D Image representation block shall be present. The value of the 2D face image kind shall be General purpose.

D.2.2 Image data compression requirements and recommendations

Best practice on compression without a region of interest is:

a) The compressed file size should not be smaller than 11KB on average.

b) JPEG2000 should be preferred over JPEG.

JPEG2000 can be used to implement region of interest (ROI) compression, as it is a technique specified in the JPEG2000 standard and well defined for JPEG2000 software libraries. JPEG2000 ROI encoding can be used to achieve smaller file sizes.

The inner region of an image are the pixels having X and Y coordinates with −1,5 w ≤ X ≤ 1,5 w and −1,8 w ≤ Y ≤ 1,8 w in the Cartesian coordinate system with the landmark Prn as origin, where w is the inter-eye distance. The outer region of an image consists of all pixels of the image that are not in the inner region of that image.

The inner region of a face image used for comparison can be compressed to a low ratio, while the outer region of the image is compressed to a higher ratio. The resulting image is smaller in size, but those parts of the image used for comparison retain high quality while the remainder of the image maintains their usefulness for visual inspection. A standard compliant JPEG2000 decoder with ROI support will decode an ROI image regardless of the location of ROI regions.

The use of region of interest compression for situations where computer alignment is performed without human verification is not recommended. It is important to note that additional compression can be achieved by defining inner and outer regions that are based on the face area.

When derived from a 300 dpi image, an inner region can be defined as including the entire face from crown to chin and ear to ear. Best practice indicates that a compression ratio of 60:1 using JPEG2000 preserves comparison performance. If a 50:1 ratio is used for the inner region, 200:1 can be used on the outer region with an acceptable level of degradation for visual inspection purposes. For a colour, 300 dpi, 35 mm × 45 mm JPEG2000 image (413 pixels × 531 pixels, 658 KB uncompressed), with a 240 pixels × 320 pixels (230,4 KB) inner region, the sizes after compression are:

— 200:1 outer region: (658 KB - 230,4 KB)/200 = 2,14 KB;

— 50:1 inner region: (230,4 KB)/50 = 4,61 KB;

— total file size: 2,14 KB + 4,61 KB = 6,75 KB. File size reduction: ~40 %.

D.2.3 Scene requirements and recommendations

D.2.3.1 Pose

Pose is known to strongly affect performance of automated face recognition systems. Thus, the frontal pose shall be used. Rotation of the head shall be less than ±5° from frontal in pitch and yaw. Pose variations that lead to an in-plane rotation of the head can be more easily compensated by automated face recognition systems. Therefore, the rotation of the head shall be less than ±8° from frontal in roll.

The best practice is that the rotation of the head should be less than ±5° from frontal in every direction, roll, pitch and yaw. The optimum height of the camera is at the subject's eye-level. Height adjustment can be done by either using a height-adjustable stool or adjusting the tripod's height. The subject should be instructed to look directly at the camera and to keep his or her head erect and shoulders square to the camera.

D.2.3.2 Expression

Expression is known to strongly affect the performance of automated face recognition systems. It is recommended that the Expression element is present.

The expression should be neutral (non-smiling) with both eyes open normally (i.e. not wide-open), and mouth closed (mouth is closed if the distance between landmark 2.2 and 2.3 is less than 50 % of the distance of landmark 2.3 and 8.2). Every effort should be made to have the supplied images to comply with this specification. A smile with closed or open jaw, raised eyebrows, eyes looking away from the camera, squinting or frowning are not recommended.

D.2.3.3 Shoulders

Shoulders shall be square on to the camera. Portrait style photographs where the subject is looking over one shoulder are not acceptable.

D.2.3.4 Backgrounds

The specification of a certain background is not normative for the creation of general purpose face images. A consideration of the background is important for computer-based face recognition because the first step in the computer face recognition process is the segmentation of the face from the background.

D.2.3.5 Subject and scene lighting

Lighting shall be equally distributed on the face. There shall be no significant direction of the light from the point of view of the photographer. The ratio between the median intensity on a square region centred around Landmarks 5.3 and 5.4 with side length 20 % of the inter-eye distance shall be between 0,5 and 2,0.

D.2.3.6 Hot spots, specular reflections, and other lighting artefacts

Hot spots (i. e., bright regions that results from light shining directly on the face) shall be absent. These artefacts typically occur when a high intensity focused light source is used for illumination. Diffused lighting, multiple balanced sources or other lighting methods shall be used.

There shall be no lighting artefacts or flash reflections on glasses. Lighting artefacts covering any region of the eyes shall not be present. This applies to any region in the polygon between landmarks 3.8, 3.2, 3.12 and 3.4 for the right eye and between landmarks 3.11, 3.1, 3.7 and 3.3 for the left eye.

D.2.3.7 Eye visibility and eye glasses

The eye pupils and irises shall be visible. There should be no shadows in the eye-sockets due to the brow. In cases where pupils or irises are not visible the pupil or iris not visible element in the Properties element shall be true.

Eye patches shall not be worn. An exception applies when the subject asserts a need to retain the patch (e.g., a medical reason); in these cases, the left eye patch or the right eye patch element in the Properties element shall be true.

Hair should not cover any part of the eyes. It is recommended that hair should not cover landmarks 3.2, 3.8, 3.12 for the right eye and Landmarks 3.1, 3.7 and 3.11 for the left eye, as well as region above these points that measures 5 % of inter-eye distance.

If the subject normally wears glasses, they may wear glasses if permitted for the intended application when their photograph is taken.

Glasses should be clear and transparent. This requirement is intended to exclude dark or otherwise opaque glasses. Tinted glasses or sunglasses shall not be worn. An exception applies when the subject asserts a medical reason to retain tinted glasses; in these cases, the dark glasses element in the Properties element shall be true.

If glasses are worn that tint automatically under illumination, they should be photographed without tint by tuning the direct illumination or background lighting. In cases where the tint cannot be reduced, the glasses shall be removed unless the subject asserts a medical reason to retain the glasses. In cases where tinted glasses are worn, the specification of dark glasses in the Properties element is recommended.

The frames of glasses shall not obscure the eyes. The frames shall not be thicker than 5 % of the inter-eye distance. Rims of glasses are covering part of the eye if any part of rims covers any part of the area enclosed by landmarks 3.2, 3.4, 3.8 and 3.12 for the right eye and landmarks 3.1, 3.3, 3.7 and 3.11 for the left eye, as well as region around these points that measures 5 % of inter-eye distance. If rims of glasses are not visible or are completely transparent, it is assumed that they do not cover any part of the eye.

Lighting artefacts can typically be avoided by increasing the angle between the lighting, subject and camera to 45° or more.

D.2.3.8 Head coverings

In cases where head coverings are present the head coverings element in the Properties element shall be true.

Head coverings and shadows should be absent. An exception applies to cases in which a subject cannot remove a headdress, veil or scarf (e.g, for religious reasons). In such cases the capture process should minimize shadows and obscuration of the face features in the face region. This might involve adjustment of the head coverings.

D.2.4 Photographic requirements and recommendations

D.2.4.1 Purpose

Rather than impose a particular hardware and lighting capture system, this subclause specifies the desired output image properties. The requirements and recommendations apply to film as well as to digital photography.

This subclause describes the minimum relative dimensions of the full image with respect to the face. The requirements can be met by images taken in both face portrait and landscape mode, and Figure 9 shows a face portrait image and head outline to display lines H and V and dimensions A, B, W, and L which are referenced in the subclauses below. In addition to the requirements in D.2.4.2 through D.2.4.14, the face shall be entirely visible from crown to chin and ear to ear in the image.

NOTE For digital images the requirements related to the minimum inter-eye distance impose further requirements on the minimum head size.

D.2.4.2 Contrast and saturation

For each patch of skin on the capture subject's face, the gradations in textures shall be clearly visible, i.e., being of reasonable contrast. In this sense, there will be no saturation (over or under exposure) on the face.

The colour saturation of a 24-bit colour image should be such that after conversion to greyscale, there are 7 bits of intensity variation in the face region of the image.

D.2.4.3 Focus and depth of field

The subject's captured image shall always be in focus from nose to ears and chin to crown. Although this may result in the background behind the subject being out of focus, this is not a problem.

All images shall have sufficient depth of focus to maintain visibility of all of the subject's face features greater than one milimetre in size (at the face) at time of capture. This is considered accomplished, if, e.g., the individual millimetre markings of rulers placed on the subject's nose and ear facing the camera can be seen simultaneously in a captured test image.

In a typical photographic situation, for optimum quality of the captured face, the f-stop of the lens should be set at two (or more) f-stops below the maximum aperture opening when possible to obtain enough depth of field.

If the camera lacks auto focus all subject positions will need to be maintained in a defined area for all image captures.

D.2.4.4 Greyscale density

The dynamic range of the image should have at least 7 bits of intensity variation (span a range of at least 128 unique values) in the face region of the image. The face region is defined as the region from crown to chin and from the left ear to the right ear. This recommendation may require camera, video digitizer or scanner settings to be changed on an individual basis when the skin tone is excessively lighter or darker than the average (present) population.

D.2.4.5 Unnatural colour

Unnaturally coloured lighting (yellow, red, etc.) is not allowed. Care shall be taken to correct the white balance of image capture devices. The lighting shall produce a face image with natural looking flesh tones when viewed in typical examination environments. Images showing a red eye effect, i.e., the common appearance of red eyes on photographs taken with a photographic flash when the flash is too close to the lens, are not acceptable. The iris and the iris colour shall be visible.

Greyscale photographs should be produced from common incandescent light sources. Colour photographs should use colour-balancing techniques such as using high colour-temperature flash with standard film or tungsten-balanced film with incandescent lighting.

D.2.4.6 Colour or greyscale enhancement

A process that overexposes or under-develops a colour or greyscale image for purposes of beauty enhancement or artistic pleasure is not allowed. The full spectrum shall be represented on the face image where appropriate. Teeth and whites of eyes shall be clearly light or white (when appropriate) and dark hair or features (when appropriate) shall be clearly dark.

D.2.4.7 Colour calibration

Colour calibration using an 18 % grey background or other method (such as white balancing) is recommended.

D.2.4.8 Radial distortion of the camera lens

The fish eye effect associated with wide angle lenses which can result in the subject appearing to have an unusually large nose in the image shall not be present.

While some distortion is almost always present during face portrait photography, the distortion should not be noticeable by human examination.

D.2.4.9 Horizontally centred face

The approximate horizontal midpoints of the mouth and of the bridge of the nose define the imaginary line V (usually the symmetry axis of the face). Furthermore, the imaginary line H is defined as the line through the centres of the left and the right eye. The intersection of V and H defines the point M as the centre of the face. The X-coordinate M_x of M shall be between 45 % and 55 % of the image width.

D.2.4.10 Vertical position of the face

The Y-coordinate M_y of M shall be between 30 % and 50 % of the image height. A single exception is allowed for children under the age of 11 years, in which case the higher limit shall be modified to 60 % (i. e., the centre point of the head is allowed to be lower in the image for children under the age of 11). The origin O of the coordinate system is defined to be in the upper left corner of the image.

D.2.4.11 Width of the image

To ensure that the entire face is visible in the image, the IED shall be between 25 % and 37,5 % of the image width A.

D.2.4.12 Height of the image

In order to assure that the entire face is visible in the image, the minimum image height shall be specified by requiring that the eye-to-mouth distance (segment between M and (feature point 2.3 from ISO/IEC 14496-2:2004, Annex C) of the image shall be between 20 % and 30 % of the vertical height of the image B. A single exception is allowed for children under the age of 11 years, in which case the lower limit shall be modified to 15 %.

D.2.4.13 Image aspect ratio

The (image width: image height) aspect ratio should be between 1:1,25 and 1:1,34.

D.2.4.14 Summary of photographic requirements

Table D.11 below summarizes the photographic requirements for general purpose face images.

Table D.11 — Summary of photographic requirements for general purpose face images

Clause	Definition	Requirements
D.2.4.1	General requirement	Head entirely visible in the image
D.2.4.9	Horizontal position of the face	$0{,}45\ A \le M_x \le 0{,}55\ A$
D.2.4.10	Vertical position of the face	$0{,}3\ B \le M_y \le 0{,}5\ B$

Table D.11 *(continued)*

Clause	Definition	Requirements
D.2.4.10	Vertical position of the face (children below 11)	0,3 B ≤ M_y ≤ 0,6 B
D.2.4.11	Width of head	0,25 A ≤ IED ≤ 0,375 A
D.2.4.12	Length of head	0,2 B ≤ EMD ≤ 0,3 B
D.2.4.12	Length of head (children below 11)	0,15 B ≤ EMD ≤ 0,3 B

D.2.5 Digital requirements and recommendations

D.2.5.1 Geometry

Digital cameras and scanners used to capture face images shall produce images with a pixel aspect ratio of 1:1. That is, the number of pixels per inch in the vertical dimension shall equal the number of pixels per inch in the horizontal direction.

The origin of coordinates shall be at the upper left given by coordinate (0,0) with positive entries from left to right (first dimension) and top to bottom (second dimension).

D.2.5.2 Colour profile

General purpose face images shall be represented as one of the following:

a) 24-bit RGB colour space where for every pixel, eight (8) bits will be used to represent each of the Red, Green, and Blue components.

b) 8-bit monochrome colour space where for every pixel, (8) bits will be used to represent the luminance component.

c) YUV422 colour space where twice as many bits are dedicated to luminance as to each of the two colour components. YUV422 images typically contain two 8-bit Y samples along with one 8-bit sample of each of U and V in every four bytes.

Interlaced video frames are not allowed for the general purpose face image kind. All interlacing shall be absent (not removed, but absent).

D.2.5.3 Use of near infrared cameras

Dedicated near-infrared cameras shall not be used for acquisition of image of the general purpose face image kind.

D.2.5.4 Pixel count

For an image for optimal human examination and permanent storage, the head width shall be at least 180 pixels, or roughly 90 pixels from eye centre to eye centre.

D.2.5.5 Post acquisition processing

No other post processing than in-plane rotation and/or cropping and/or down sampling and/or multiple compressions shall be applied to derive a general purpose face image from a captured image. Multiple (i.e., repeated) compressions should be avoided when generating general purpose face images.

D.3 3D Textured face image

D.3.1 General

This annex contains the description of an application profile for a 3D textured face image that meets the requirements of this document to acquire an image for 3D face recognition.

The purpose of the 3D textured application profile is to encode the shape and the texture of the face (see Figure D.38) with high precision. For some use cases, the texture of the face is optional. By an optical backward projection of the 3D presentation to a virtual camera with defined lighting, similar image quality of the skin rendering compared to a 2D representation data with different viewing angles should be obtained.

The 3D shape representation block shall be present. The value of the 3D face image kind shall be textured face image 3D.

The 3D representation data element shall contain only the vertex representation, that means range image and 3D point map shall not be used.

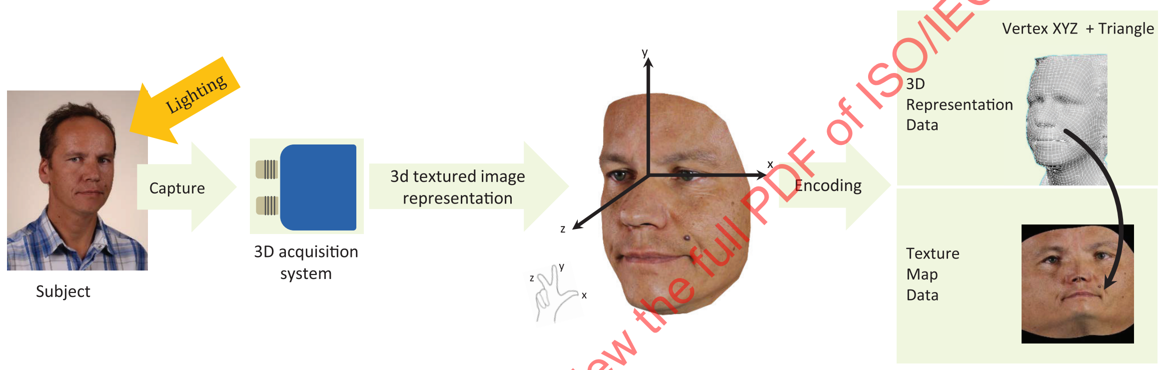


Figure D.38 — Example of a 3D textured image representation data which is composed of the 3D data representation (a list of triangles consisting of 3 vertices) and a Texture map data

Each vertex of the 3D representation data has a 2D UV spatial reference to the Texture data. The data defined by the textured vertex representation is encoded in two different data structures:

— The mandatory 3D representation data for the shape of the face, where the 3D representation data is defined by a set of:

a) a Vertex block defined by the 3D coordinates X, Y, and Z and by the spatial coordinates U and V which refer to the Texture map, and

b) a Vertex triangle data block referring to the ordered list of vertices.

— The optional Texture map data for the texture image of the face, where one of the following possible encodings for the texture map data (which is a 2D image) shall be used:

a) JPEG sequential baseline (ISO/IEC 10918-1) mode of operation and encoded in the JFIF file format (the JPEG file format),

b) JPEG-2000 Part-1 code stream format (ISO/IEC 15444-1), lossy or lossless, and encoded in the JP2 file format (the JPEG2000 file format), or

c) PNG specification (ISO/IEC 15948). PNG shall not be used in its interlaced mode and not for images that have been JPEG compressed before.

The formats unknown and other shall not be used. The specification of the Texture map image is stored inside of the image header, i.e., the image width, image height, channel numbers, number of bits per channel and ICC profile.

Landmarks shall be defined with 3D coordinates.

Landmarks should be determined on images before compression is applied. Landmarks should be included in the record format if they have been accurately determined, thereby providing the option that these parameters do not have to be re-determined when the image is processed for face recognition tasks. The landmarks may be determined by computer-automated detection mechanisms. If necessary, a human validation can be applied in such case. It is recommended to add the following landmarks to the encoding of a 3D image:

— the eye centres (12.1 and 12.2),

— the base of the nose (9.4, 9.5, and 9.15), and

— the upper lip of the mouth (8.4, 8.1 and 8.3).

D.3.2 Image data compression requirements and recommendations

Best practice on compression without region of interest is:

a) The compressed file size should not be smaller than 100 KB on average.

b) JPEG2000 should be preferred over JPEG.

NOTE For the Textured 3D representation, the texture map data refer only to the face texture description and not, e.g., to the background or the shoulders. As a consequence, there is no significant gain to use the implement region of interest (ROI) compression of JPEG2000.

D.3.3 Scene requirements and recommendations

D.3.3.1 Pose of the 3D representation

Pose is known to strongly affect performance of automated face recognition systems. However, this sensibility is less important for 3D representation which can be rotated without losing information after acquisition.

For the pose of the Textures 3D face image representation the following requirements on the subject position, and on the 3D acquisition system geometry apply:

— Subject position:

  The pose of the subject shall be with the head in the rest position. The eyes shall be looking straight forward according to the horizontal axis. The with shoulder position shall be perpendicular to the gaze axis.

  Rotation of the head shall be less than ±5° in pitch, yaw and roll.

— 3D acquisition system geometry:

  The optical axis of the 3D acquisition system shall be horizontal, at the same height of the eye subject, and perpendicular to the support line passing by the two eyes. Height adjustment may be done by either using a height-adjustable stool or by adjusting the acquisition system height.

  The subject should be instructed to orient his or her gaze paralleled to the optical axis via a visible sign. The subject should be instructed to keep his or her head erect and shoulders square to the 3D acquisition system.

  The subject shall not move during the acquisition. In particular, no instruction shall request a subject movement during capturing.

D.3.3.2 Expression

Expression is known to strongly affect the performance of automated face recognition systems. It is recommended that the Expression element is present.

The expression should be neutral (non-smiling) with both eyes open normally (i.e., not wide-open), and mouth closed (the mouth is closed if the distance between landmarks 2.2 and 2.3 is less than 50 % of the distance of landmarks 2.3 and 8.2.) Every effort should be made supply images complying with this specification. To smile with closed or open jaw is not recommended, neither are raised eyebrows, eyes looking away from camera, squinting or frowning.

The 3D textured face image acquisition system shall not allow expression change. The 3D face image acquisition process should be fast enough to ensure that expression does not change. Morphing and interpolation after the acquisition should not change the expression.

D.3.3.3 Shoulders

Shoulders shall be square on to the camera. Portrait style photographs where the subject is looking over one shoulder are not acceptable.

D.3.3.4 Background

The background shall not be stored inside the 3D vertex encoding. A 3D acquisition system shall be able to differentiate the background from the face, based on the depth data along the *Z* axis.

The minimal distance between face and background should be 400 mm.

The colour of the background should be uniform and should have a contrast to skin and hairs.

NOTE Some configurations of the background can improve the segmentation of the head such as background far behind the subject, very dark or very light background, and appropriately coloured background.

Reflexion on the face caused by the background should not affect the texture rendering of the face skin.

D.3.3.5 Subject and scene lighting

Lighting shall be equally distributed on the skin of the face. There shall be no significant direction of the light from the point of view of the subject. The ratio between the median intensity on a square region centred around landmarks 5.3 and 5.4 with side length 20 % of the inter-eye distance shall be between 0,5 and 2,0.

Lighting cannot be perfectly uniform and diffuse on the face during acquisition. In order to not create face texture inconstancy by a head movement during the 3D face image acquisition, any head movement should be avoided.

In case of pattern projection during the acquisition, the projected patterns should not be perceivable by the subject in order to not perturbate the subject expression.

For RGB acquisition, the sensor of the camera shall capture the entire visible wavelength, basically the wavelength between 400 nm and 700 nm. This allows correct rendering of the natural colours as seen by humans. Unnaturally coloured lighting, i. e., yellow, red, etc., shall not be used. Care should be taken to adjust the white balance. A high colour rendering index is recommended for illumination.

Illumination shall not cause any red eye effect visible in the eyes and should not cause other lighting artefacts such as spots from a ring flash reducing the visibility of the eyes.

The enrolment should be made in a controlled scene; the image should be captured with high signal-to-noise ratio. Noise is not information contained in the original scene but is created by the electronics due to a too high level of amplification. ISO sensitivity settings at values of ISO 100 and ISO 200 typically reduce noise; for high-quality cameras ISO 400 and ISO 800 may also be used. Noise can be minimized by correct exposure at a low ISO setting.

D.3.3.6 Hot spots and specular reflections

Hot spots (i.e., bright regions that result from light shining directly on the face) shall be absent. These artefacts typically occur when a high intensity focused light source is used for illumination. Diffused lighting, multiple balanced sources or other lighting methods shall be used.

A single bare point shaped light source like a flash mounted on the 3D acquisition system is not acceptable for imaging. Instead, the illumination should be accomplished using other methods that meet the requirements specified in this clause.

D.3.3.7 Eye glasses

Enrollees shall not wear eye glasses during acquisition. Enrolment systems shall provide a smart user interface for enrollees who usually wear glasses considering their temporarily reduced reading capabilities.

NOTE Eye glasses interfere with the 3D sensor with respect to several aspects. They hide some parts of the face. The lens might not be completely transparent for the capturing illumination leading to potentially wrong volume determination. The light direction emitted or captured by the 3D system acquisition is perturbed by the lenses.

An exception applies when the subject asserts a medical reason to retain the glasses; in these cases, the dark glasses element in the Properties element shall be set to true, even if the glasses are not dark.

D.3.3.8 Shadows in eye-sockets

There should be no shadows in the eye-sockets caused by the eyebrows. The iris and pupil of the eyes should be visible.

NOTE This recommendation is intended to exclude images in which the eyes are closed (e.g. during a blink) or half closed.

D.3.3.9 Head coverings

In cases where head coverings are present the head coverings element in the Properties block shall be set to true.

Head coverings and shadows caused by head coverings should be absent. An exception applies to cases in which a subject cannot remove a headdress, veil or scarf (e.g., for religious reasons). In such cases the capture process should minimize shadows and obscuration of the face features in the face region. This might involve adjustment of the head coverings.

D.3.3.10 Visibility of pupils and irises

In cases where pupils or irises are not visible the pupil or iris not visible element in the Properties block shall be set to true.

D.3.3.11 Lighting artefacts

There shall be no lighting artefacts visible on the skin of the face.

D.3.3.12 Eye patches

Eye patches shall not be worn. An exception applies when the subject asserts a need to retain the patch (e.g., for a medical reason); in this case, the left eye patch or the right eye patch element in the Properties block shall be true.