
**Information technology — Coded
representation of immersive media —
Part 2:
Omnidirectional media format**

*Technologies de l'information — Représentation codée de média
immersifs — Partie 2: Format de média omnidirectionnel*

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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 Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

A list of all parts in the ISO/IEC 23090 series can be found on the ISO website.

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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.

Introduction

When omnidirectional media content is consumed with a head-mounted display and headphones, only the parts of the media that correspond to the user's viewing orientation are rendered, as if the user were in the spot where and when the media was captured. One of the most popular forms of omnidirectional media applications is omnidirectional video, also known as 360° video. Omnidirectional video is typically captured by multiple cameras that cover up to 360° of the scene. Compared to traditional media application formats, the end-to-end technology for omnidirectional video (from capture to playback) is more easily fragmented due to various capturing and video projection technologies. From the capture side, there exist many different types of cameras capable of capturing 360° video, and on the playback side there are many different devices that are able to playback 360° video with different processing capabilities. To avoid fragmentation of omnidirectional media content and devices, a standardized format for omnidirectional media applications is specified in this document.

This document defines a media format that enables omnidirectional media applications, focusing on 360° video, images, and audio, as well as associated timed text. What is specified in this document includes (but is not limited to):

- 1) a coordinate system that consists of a unit sphere and three coordinate axes, namely the X (back-to-front) axis, the Y (lateral, side-to-side) axis, and the Z (vertical, up) axis,
- 2) projection and rectangular region-wise packing methods that may be used for conversion of a spherical video sequence or image into a two-dimensional rectangular video sequence or image, respectively,
- 3) storage of omnidirectional media and the associated metadata using the ISO base media file format (ISOBMFF) as specified in ISO/IEC 14496-12,
- 4) encapsulation, signalling, and streaming of omnidirectional media in a media streaming system, e.g., dynamic adaptive streaming over HTTP (DASH) as specified in ISO/IEC 23009-1 or MPEG media transport (MMT) as specified in ISO/IEC 23008-1, and
- 5) media profiles and presentation profiles that provide interoperable and conformance points for media codecs as well as media coding and encapsulation configurations that may be used for compression, streaming, and playback of the omnidirectional media content.

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Information technology — Coded representation of immersive media —

Part 2: Omnidirectional media format

1 Scope

This document specifies the omnidirectional media format for coding, storage, delivery, and rendering of omnidirectional media, including video, images, audio, and timed text.

In an OMAF player the user's viewing perspective is from the centre of the sphere looking outward towards the inside surface of the sphere.

NOTE 1 In this document, only 3 degrees of freedom (3DOF) is supported. In other words, purely translational movement of the user does not result in different omnidirectional media being rendered to the user. For 3DOF support with stereoscopic video, when the user rolls his/her head, there could be a stereoscopic rendering issue.

NOTE 2 Omnidirectional video could contain graphics elements generated by computer graphics but encoded as video.

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 10918-1, *Information technology — Digital compression and coding of continuous-tone still images — Part 1: Requirements and guidelines*

ISO/IEC 14496-1, *Information technology — Coding of audio-visual objects — Part 1: Systems*

ISO/IEC 14496-3:2009, *Information technology — Coding of audio-visual objects — Part 3: Audio*

ISO/IEC 14496-10:2014, *Information technology — Coding of audio-visual objects — Part 10: Advanced video coding*

ISO/IEC 14496-12, *Information technology — Coding of audio-visual objects — Part 12: ISO base media file format*

ISO/IEC 14496-14, *Information technology — Coding of audio-visual objects — Part 14, MP4 file format*

ISO/IEC 14496-15:2017, *Information technology — Coding of audio-visual objects — Part 15, Carriage of network abstraction layer (NAL) unit structured video in the ISO base media file format*

ISO/IEC 14496-30:2018, *Information technology — Coding of audio-visual objects — Part 30: Timed text and other visual overlays in ISO base media file format*

ISO/IEC 23000-19:2018, *Information technology — Multimedia application format (MPEG-A) — Part 19: Common media application format (CMAF) for segmented media*

ISO/IEC 23003-4:2015, *Information technology — MPEG audio technologies — Part 4: Dynamic range control*

ISO/IEC 23008-1:2017, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 1: MPEG media transport (MMT)*

ISO/IEC 23008-2:2017, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 2: High efficiency video coding*

ISO/IEC 23008-3:2015, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 3: 3D audio*

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ISO/IEC 23008-12, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 12: Image file format*

ISO/IEC 23009-1, *Information technology — Dynamic adaptive streaming over HTTP (DASH) — Part 1: Media presentation description and segment formats*

ISO/IEC 23091-2¹, *Information technology — Coding-independent code points — Part 2: Video*

ISO/IEC 23091-3, *Information technology — Coding-independent code points — Part 3: Audio*

W3C Recommendation, *TTML profiles for Internet media subtitles and captions 1.0 (IMSC1)*

WebVTT: *The web video text tracks format*, W3C (Working Draft, 08 August 2017)

W3C Recommendation, *XML schema part 1: Structures*

W3C Recommendation, *XML schema part 2: Datatypes*

IETF BCP 47, *Tags for Identifying Languages*

IETF RFC 6381, *MIME Codecs and Profiles*

3 Terms, definitions, abbreviated terms, and conventions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions in ISO/IEC 14496-12, ISO/IEC 23008-12, ISO/IEC 23009-1 and the following apply. If terms defined in ISO/IEC 14496-12, ISO/IEC 23008-12 and ISO/IEC 23009-1 are also defined in this document, the definitions in this document are applicable.

NOTE In particular, the terms coded image, coded image item, derived image, derived image item, image item, reconstructed image, and source image item are defined in ISO/IEC 23008-12.

The terminological databases for use in standardization maintained by ISO and IEC at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/ards/sist/6be3da4c-182a-48ee-a941-f8876a0d3373/iso-iec-23090-2-2019>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1.1

azimuth

first of the two sphere coordinates describing the location of a point on the sphere

Note 1 to entry: Azimuth and elevation are specified in subclause 5.1.

3.1.2

azimuth circle

circle on the sphere connecting all points with the same azimuth value

Note 1 to entry: An azimuth circle is always a *great circle* (3.1.17).

3.1.3

circular image

image captured with a *fisheye lens* (3.1.14)

3.1.4

closed scheme type

scheme type (3.1.35) that clearly specifies which transformations are allowed and does not allow future extensions

¹ Under preparation. Stage at time of FDIS ballot: ISO/IEC DIS 23091-2, 40.99.

3.1.5**composition-aligned sample**

sample in a track that is associated with another track, the sample has the same composition time as a particular sample in the another track, or, when a sample with the same composition time is not available in the another track, the closest preceding composition time relative to that of a particular sample in the another track

3.1.6**constituent picture**

such part of a spatially frame-packed stereoscopic picture that corresponds to one view, or a picture itself when frame packing is not in use or the temporal interleaving frame packing arrangement is in use

3.1.7**content coverage**

one or more sphere regions that are covered by the content represented by the track or by an image item

3.1.8**elevation**

second of the two sphere coordinates describing the location of a point on the sphere

Note 1 to entry: Azimuth and elevation are specified in subclause 5.1.

3.1.9**elevation circle**

circle on the sphere connecting all points with the same elevation value

Note 1 to entry: When the elevation is zero, an elevation circle is also a *great circle* (3.1.17). This coincides with the equator on Earth.

3.1.10**extractor track**

track that has *untransformed sample entry type* (3.1.44) equal to 'hvc2', 'avc2', or 'avc4' and contains one or more 'scal' track references

3.1.11**field of view**

extent of the observable world in captured/recorded content or in a physical display device

3.1.12**file decoder**

collective term for file/segment decapsulation and decoding of video, audio or image bitstreams

3.1.13**file decoding process**

process specified as a part of a media profile specification that takes as input a set of ISOBMFF tracks or items and derives either of the following:

- decoded pictures or audio samples, and rendering metadata for them;
- a fully rendered audio scene in the reference system

3.1.14**fisheye lens**

wide-angle camera lens that usually captures an approximately hemispherical *field of view* (3.1.11) and projects it as a *circular image* (3.1.3)

3.1.15**fisheye video**

video captured by *fisheye lenses* (3.1.14)

3.1.16**global coordinate axes**

coordinate axes that are associated with audio, video, and images representing the same acquisition position and intended to be rendered together

Note 1 to entry: Coordinate axes are specified in subclause 5.1.

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Note 2 to entry: The origin of the global coordinate axes is usually the same as the centre point of a device or rig used for omnidirectional audio/video acquisition as well as the position of the observer's head in the three-dimensional space in which the audio and video tracks are located.

Note 3 to entry: In the absence of the initial viewing orientation metadata (see subclause 7.7.4 for tracks or subclause 7.9.9 for image items), the initial viewing orientation should be inferred to be equal to (0, 0, 0) for (*centre_azimuth*, *centre_elevation*, *centre_tilt*) relative to the global coordinate axes.

3.1.17

great circle

intersection of the sphere and a plane that passes through the centre point of the sphere

Note 1 to entry: A great circle is also known as an orthodrome or Riemannian circle.

Note 2 to entry: The centre of the sphere and the centre of a great circle are co-located.

3.1.18

guard band

area in a *packed picture* (3.1.23) that is not rendered but may be used to improve the rendered part of the packed picture to avoid or mitigate visual artifacts such as seams

Note to entry: Guard bands are associated with *packed regions* (3.1.24) as described in subclause 7.5.3.

3.1.19

local coordinate axes

coordinate axes obtained after applying rotation to the *global coordinate axes* (3.1.16)

3.1.20

OMAF player

collective term for

- file/segment reception or file access;
- file/segment decapsulation;
- decoding of audio, video, image, or timed text bitstreams;
- rendering of audio, images, or timed text; and
- viewport selection

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3.1.21

omnidirectional media

media such as image or video and its associated audio that enable rendering according to the user's *viewing orientation* (3.1.45), if consumed with a head-mounted device, or according to user's desired *viewport* (3.1.46), otherwise, as if the user was in the spot where and when the media was captured

3.1.22

open-ended scheme type

scheme type (3.1.35) that allows future extensions

3.1.23

packed picture

picture that is represented as a coded picture in the coded video bitstream

Note 1 to entry: A packed picture may result from *region-wise packing* (3.1.31) of a *projected picture* (3.1.25).

3.1.24

packed region

region in a *packed picture* (3.1.24) that is mapped to a *projected region* (3.1.26) as specified by the *region-wise packing* (3.1.31) signalling

3.1.25

projected picture

picture that has a representation format specified by an omnidirectional video projection format

Note 1 to entry: Omnidirectional projection formats are specified in subclause 5.2.

3.1.26**projected region**

region in a *projected picture* (3.1.25) that is mapped to a *packed region* (3.1.24) as specified by the region-wise packing signalling

3.1.27**projection**

inverse of the process by which the samples of a *projected picture* (3.1.25) are mapped to a set of positions identified by a set of azimuth and elevation coordinates on a unit sphere

3.1.28**quality ranking region**

region that is associated with a quality ranking value and is specified relative to a decoded picture or a sphere

3.1.29**quality ranking 2D region**

quality ranking region (3.1.28) that is specified relative to a decoded picture

3.1.30**quality ranking sphere region**

quality ranking region (3.1.28) that is specified relative to a sphere

3.1.31**region-wise packing**

inverse of the process of transformation, resizing, and relocating of *packed regions* (3.1.24) of a *packed picture* (3.1.23) to remap to *projected regions* (3.1.26) of a *projected picture* (3.1.25)

3.1.32**rendering**

process of generating audio-visual content for playback from the decoded audio-visual data according to the user's *viewing orientation* (3.1.45), if consumed with a head-mounted device, or according to user's desired *viewport* (3.1.46), otherwise

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3.1.33**sample**

all the data associated with a single time or single element in one of the three sample arrays that represent a picture

<https://standards.iteh.ai/catalog/standards/sist/6be3da4c-182a-48ee-a941-f8876a0d3373/iso-iec-23090-2-2019>

Note 1 to entry: When the term sample is used in the context of a track, it refers to all the data associated with a single time of that track, where a time is either a decoding time or a composition time. When the term sample is used in the context of a picture, e.g., in the phrase "luma sample", it refers to a single element in one of the three sample arrays that represent the picture.

3.1.34**sample entry type**

four-character code that is either the value of the *format* field of a *SampleEntry* directly contained in *SampleDescriptionBox* or the *data_format* value of an instance of *OriginalFormatBox*

3.1.35**scheme type**

type that parameterizes an encrypted, restricted, or incomplete media track

3.1.36**sphere coordinates**

azimuth (ϕ) and *elevation* (θ) that identify a location of a point on the unit sphere

3.1.37**sphere region**

region on a sphere, specified either by four *great circles* (3.1.17) or by two *azimuth circles* (3.1.2) and two *elevation circles* (3.1.9), or such a region on the rotated sphere after applying certain amount of yaw, pitch, and roll rotations

3.1.38**sub-picture**

picture that represents a spatial subset of the original video content, which has been split into spatial subsets before video encoding at the content production side

3.1.39

sub-picture bitstream

bitstream that represents a spatial subset of the original video content, which has been split into spatial subsets before video encoding at the content production side

3.1.40

sub-picture track

track that represents a *sub-picture bitstream* (3.1.39)

3.1.41

tilt angle

angle indicating the amount of tilt of a *sphere region* (3.1.37), measured as the amount of rotation of the sphere region along the axis originating from the sphere origin passing through the centre point of the sphere region, where the angle value increases clockwise when looking from the origin towards the positive end of the axis

3.1.42

time-parallel sample

sample in a track that is associated with another track, and either has the same decoding time as a particular sample in the other track, or, when a sample with the same decoding time in the other track is not available, the closest preceding decoding time relative to that of a particular sample in the other track

3.1.43

track sample entry type

sample entry type (3.1.34) of a `SampleEntry` directly contained in `SampleDescriptionBox`

3.1.44

untransformed sample entry type

track sample entry type (3.1.43) that would apply if no transformations had been performed to a transformed media track

3.1.45

viewing orientation

triplet of azimuth, elevation, and tilt angle characterizing the orientation that a user is consuming the audio-visual content; in case of image or video, characterizing the orientation of the *viewport* (3.1.46)

3.1.46

viewport

region of omnidirectional image or video suitable for display and viewing by the user

3.2 Abbreviated terms

| | |
|---------|---|
| 2D | two-dimensional |
| CICP | coding-independent code points (specified in ISO/IEC 23091-1, 23091-2, and 23091-3) |
| CMAF | common media application format (specified in ISO/IEC 23000-19) |
| DASH | MPEG dynamic adaptive streaming over HTTP (specified in ISO/IEC 23009-1) |
| ERP | equiangular projection |
| FOV | field of view |
| ISOBMFF | ISO base media file format (specified in ISO/IEC 14496-12) |
| HEVC | high efficiency video coding (specified in ISO/IEC 23008-2) |
| HMD | head-mounted display |
| HOA | higher-order ambisonics |

| | |
|------|---|
| MCTS | motion-constrained tile set |
| MMT | MPEG media transport (specified in ISO/IEC 23008-1) |
| OMAF | omnidirectional media format (specified in ISO/IEC 23090-2) |
| SRD | spatial relationship description |
| URN | uniform resource name |
| VR | virtual reality |

3.3 Arithmetic operators and mathematical functions

| | |
|---------------------|--|
| + | addition |
| - | subtraction (as a two-argument operator) or negation (as a unary prefix operator) |
| * | multiplication, including matrix multiplication |
| x^y | exponentiation, specifies x to the power of y (In other contexts, such notation is used for superscripting not intended for interpretation as exponentiation.) |
| / | integer division with truncation of the result toward zero EXAMPLE $7 / 4$ and $-7 / 4$ are truncated to 1 and $-7 / 4$ and $7 / -4$ are truncated to -1 . |
| ÷ | denotes division in mathematical equations where no truncation or rounding is intended |
| $\frac{x}{y}$ | denotes division in mathematical equations where no truncation or rounding is intended |
| $\sum_{i=x}^y f(i)$ | summation of $f(i)$ with i taking all integer values from x up to and including y |
| $x \% y$ | modulus (Remainder of x divided by y , defined only for integers x and y with $x \geq 0$ and $y > 0$.) |
| Asin(x) | trigonometric inverse sine function, operating on an argument x that is in the range of -1.0 to 1.0 , inclusive, with an output value in the range of $-\pi/2$ to $\pi/2$, inclusive, in units of radians |
| Atan(x) | trigonometric inverse tangent function, operating on an argument x that is any real number, with an output value in the range of $-\pi/2$ to $\pi/2$, inclusive, in units of radians |
| Atan2(y, x) | $\begin{cases} \text{Atan}\left(\frac{y}{x}\right) & ; \text{ if } x > 0 \\ \text{Atan}\left(\frac{y}{x}\right) + \pi & ; \text{ if } x < 0 \ \&\& \ y \geq 0 \\ \text{Atan}\left(\frac{y}{x}\right) - \pi & ; \text{ if } x < 0 \ \&\& \ y < 0 \\ +\frac{\pi}{2} & ; \text{ if } x = 0 \ \&\& \ y \geq 0 \\ -\frac{\pi}{2} & ; \text{ otherwise} \end{cases}$ |
| Cos(x) | trigonometric cosine function operating on an argument x in units of radians |