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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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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

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This second edition cancels and replaces the first edition (ISO/IEC 23090-2:2019), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Multiple viewpoints have been added. Viewpoints can be used for example to provide several user-switchable camera positions to view the content or to express a storyline where the user is given the choice to select which storyline path is followed.

— Sphere-relative and viewport-relative video and image overlays have been added.

— Mesh omnidirectional video where the video is projected on an indicated set of mesh elements has been added.

— Two tiling OMAF video profiles for viewport-dependent streaming have been added.

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

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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 forms of omnidirectional media applications is omnidirectional video, also known as 360° video. Omnidirectional video is typically captured by multiple cameras that cover the entire sphere or at least a large part of the sphere. 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):

— 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;

— 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;

— storage of omnidirectional media and the associated metadata using the ISO Base Media File Format (ISOBMFF) as specified in ISO/IEC 14496-12;

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— storage of video or image overlays and the associated metadata using ISOBMFF;

— encapsulation, signalling, and streaming of omnidirectional media and overlays 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;

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— media profiles and presentation profiles that provide 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;

— toolset brands that provide conformance points for functionalities beyond plain 360° video, images and audio.

This document is organized as follows:

a) Clause 1 specifies the scope of this document.

b) Clause 2 contains the normative references.

c) Clause 3 specifies the terms, definitions, abbreviated terms, arithmetic operations, mathematical functions and other conventions used in this document.

d) Clause 4 contains an overview of this document.

e) Clause 5 specifies a coordinate system used in this document and the equations for the equirectangular and cubemap omnidirectional projection formats, the conversion from the local coordinate axes to the global coordinate axes, and the rectangular region-wise packing.

f) Clause 6 specifies syntax structures that are common for fisheye video and fisheye images.

g) Clause 7 specifies extensions to the ISOBMFF for omnidirectional media as well as for timed metadata for sphere regions. It also specifies generic extensions to ISO/IEC 14496-12 and ISO/IEC 14496-15, which may be used also for other purposes than for omnidirectional media.

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h) Clause 8 specifies extensions to DASH for omnidirectional media.

i) Clause 9 specifies extensions to MMT for omnidirectional media.

j) Clause 10 specifies OMAF media profiles.

k) Clause 11 specifies OMAF presentation profiles based on some of the OMAF media profiles specified in Clause 10.

l) Clause 12 specifies OMAF toolset brands.

m) Annex A contains the OMAF DASH XML schema.

n) Annex B specifies the DASH integration of all the OMAF media profiles for timed media specified in Clause 10.

o) Annex C specifies the CMAF integration of some of the OMAF media profiles specified in Clause 10.

p) Annex D describes some schemes for viewport-dependent omnidirectional video processing.

q) Annex E contains some DASH MPD examples.

r) Annex F contains some MMT signalling examples.

s) Annex G specifies the expected OMAF player behaviour for rendering overlays.

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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. Omnidirectional image or video can contain graphics elements generated by computer graphics but encoded as image or video. Multiple viewpoints, each corresponding to an omnidirectional camera, are supported. The document also specifies storage and delivery of overlay images or video intended to be rendered over the omnidirectional background image or video.

2 Normative references

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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.

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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 14496-3:2019, *Information technology — Coding of audio-visual objects — Part 3: Advanced audio coding*

Rec. ITU-T H.264 (06/19) | ISO/IEC 14496-10:2014, *Information technology — Coding of audio-visual objects — Part 10: Advanced video coding*

ISO/IEC 14496-12:2020, *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 14496-15:2019, *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 23000-19:2020, *Information technology — Multimedia application format (MPEG-A) — Part 19: Common media application format (CMAF) for segmented media*

ISO/IEC 23000-22:2019, *Information technology — Multimedia application format —Part 22 Multi-image application format (MIAF)*

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ISO/IEC 23003-3:2020, *Information technology — MPEG audio technologies — Part 3: Unified speech and audio coding*

ISO/IEC 23003-4:2020, *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)*

Rec. ITU-T H.265 | ISO/IEC 23008-2:2020, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 2: High efficiency video coding*

ISO/IEC 23008-3:2019, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 3: 3D audio*

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

ISO/IEC 23009-1:2019, *Information technology — Dynamic adaptive streaming over HTTP (DASH) — Part 1: Media presentation description and segment formats*

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

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

IETF BCP 47, *Tags for Identifying Languages*

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IETF Internet Standard 66, *Uniform Resource Identifier (URI): Generic Syntax*

IETF RFC 6381, *MIME Codecs and Profiles*

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W3C Candidate Recommendation, *WebVTT, The Web Video Text Tracks Format*

W3C Recommendation, *TTML Profiles for Internet Media Subtitles and Captions 1.0.1 (IMSC1)*

W3C Recommendation, *XML schema part 1: Structures*

W3C Recommendation, *XML schema part 2: Datatypes*

W3C Recommendation, *XML Path Language (XPath) 2.0 (Second Edition)*

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 and the following apply.

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.

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

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

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

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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* (3.1.22).

3.1.3
background visual media

piece of *visual media* (3.1.62) on which an *overlay* (3.1.31) is superimposed

3.1.4
circular image

image captured with a *fisheye lens* (3.1.18)

3.1.5
closed scheme type

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scheme type (3.1.46) that clearly specifies which transformations are allowed and does not allow future extensions

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3.1.6
common reference coordinate system

3D Cartesian coordinate system with the centre being (X, Y, Z) equal to (0, 0, 0), used as the reference coordinate system for all *viewpoints* (3.1.59) within a *viewpoint group* (3.1.60)

3.1.7
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

3.1.8
composition picture

picture that is suitable to be presented and is obtained from the decoding outputs of *composition-aligned samples* (3.1.7) of all tracks of a 2D spatial relationship track group by arranging them spatially as specified by the semantics of the 2D spatial relationship track group

3.1.9
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

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3.1.10
content coverage

one or more *sphere regions* (3.1.48) that are covered by the content represented by the track, an image item, or a *composition picture* (3.1.8)

3.1.11
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.

3.1.12
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* (3.1.22). This coincides with the equator on Earth.

3.1.13
encoded tile sequence

coded representation of a *tile sequence* (3.1.52) that has the capability to be merged with other encoded tile sequences in coded domain without decoding mismatch by rewriting only header data

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3.1.14
extractor track

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

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3.1.15
field of view

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

3.1.16
file decoder

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

3.1.17
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 a decoded pictures or audio samples, and rendering metadata for them; or a fully rendered audio scene in the reference system

3.1.18
fisheye lens

wide-angle camera lens that usually captures an approximately hemispherical *field of view* (3.1.15) and projects it as a *circular image* (3.1.4)

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3.1.19
fisheye omnidirectional video
fisheye omnidirectional image

omnidirectional media (3.1.29) where *circular images* (3.1.4) of *fisheye lenses* (3.1.18) are spatially arranged onto picture(s)

3.1.20
fisheye video

video captured by *fisheye lenses* (3.1.18)

3.1.21
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.

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.

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3.1.22
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.

3.1.23
guard band

area that is not rendered but may be used to improve the rendering quality to avoid or mitigate visual artifacts such as seams

Note 1 to entry: Guard bands in *packed pictures* (3.1.34) are associated with *packed regions* (3.1.35) as described in subclause 7.5.3.

3.1.24
local coordinate axes

coordinate axes obtained after applying rotation to the *global coordinate axes* (3.1.21)

3.1.25
mesh omnidirectional video

omnidirectional media (3.1.29) where rectangular regions of two-dimensional pictures are mapped to mesh elements of a three-dimensional mesh

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