
**Information technology — Coded
representation of immersive media —
Part 5:
Visual volumetric video-based coding
(V3C) and video-based point cloud
compression (V-PCC)**

*Technologie de l'information — Représentation codée de média
immersifs —*

*Partie 5: Codage basé sur la vidéo volumétrique (V3C) et compression
de nuage de points basée sur la vidéo (V-PCC)*

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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

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 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.

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

Advances in 3D capturing and rendering technologies have unleashed a new wave of innovation in virtual/augmented/mixed reality (VR/AR/MR) content creation and communication, of which visual volumetric video is an integral part.

Visual volumetric video, a sequence of visual volumetric frames, if uncompressed, can be represented by a large amount of data, which can be costly in terms of storage and transmission. This has led to the need for a high coding efficiency standard for the compression of visual volumetric data.

Visual volumetric frames can be coded by converting the 3D volumetric information into a collection of 2D images and associated data. The converted 2D images can be coded using widely available video and image coding specifications, such as ISO/IEC 14496-10 and ISO/IEC 23008-2 and the associated data can be coded with mechanisms specified in this document. The coded images and the associated data can then be decoded and used to reconstruct the 3D volumetric information. This document specifies a generic mechanism for visual volumetric video coding, i.e. visual volumetric video-based coding. The generic mechanism can be used by applications targeting volumetric content, such as point clouds, immersive video with depth, mesh representations of visual volumetric frames, etc.

In addition to the generic mechanism of coding volumetric content, this document specifies one of the applications of visual volumetric video-based coding targeting point cloud representations of visual volumetric frames. In a point cloud sequence, each point cloud frame contains a collection of points. Each point has a 3D position, i.e., geometry information, and each point can also be associated with a number of attributes, such as colour, reflectance, surface normal, etc.

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Information technology — Coded representation of immersive media —

Part 5:

Visual volumetric video-based coding (V3C) and video-based point cloud compression (V-PCC)

1 Scope

This document specifies the syntax, semantics and decoding for visual volumetric media using video-based coding methods. This document also specifies processes that can be needed for reconstruction of visual volumetric media, which can also include additional processes such as post-decoding, pre-reconstruction, post-reconstruction and adaptation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitute 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.

IEEE 754-2019, *IEEE Standard for Floating-Point Arithmetic*

IETF RFC 1321 *The MD5 Message-Digest Algorithm*

IETF RFC 5646 *Tags for Identifying Languages*

ISO/IEC 10646, *Information technology — Universal Coded Character Set (UCS)*

ISO/IEC 14496-10:2020, *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 14496-15, *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 23008-2:2020, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 2: High efficiency video coding*

ISO/IEC 23090-3, *Information technology — Coded representation of immersive media — Part 3: Versatile video coding*

ISO/IEC 23091-2, *Coding-independent code points for video signal type identification*

Rec. ITU-T T.35:2000, *Procedure for the allocation of ITU-T defined codes for non standard facilities*

Rec. ITU-T H.271:2006, *Video back-channel messages for conveyance of status information and requests from a video receiver to a video sender*

3 Terms and definitions

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

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/>

3.1

3D bounding box

volume defined as a cuboid solid having six rectangular faces placed at right angles

3.2

associated non-ACL NAL unit

non-ACL NAL unit (3.78) that is associated with an *ACL NAL unit* (3.6) for the purpose of decoding or other operations specified by this document

3.3

associated ACL NAL unit

preceding *ACL NAL unit* (3.6) in decoding order for a *non-ACL NAL unit* (3.78) with *nal_unit_type* equal to NAL_EOS, NAL_EOB, NAL_FD, NAL_SUFFIX_NSEI, or NAL_SUFFIX_ESEI, or in the ranges of NAL_RSV_NACL_48..NAL_RSV_NACL_52 or NAL_UNSPEC_53..NAL_UNSPEC_63; or otherwise the next *ACL NAL unit* (3.6) in decoding order

3.4

atlas

collection of 2D bounding boxes and their associated information placed onto a rectangular frame and corresponding to a volume in 3D space on which volumetric data is rendered

3.5

atlas bitstream

sequence of bits that forms the representation of *atlas frames* (3.8) and associated data forming one or more *CASs* (3.36)

3.6

atlas coding layer NAL unit

ACL NAL unit

collective term for coded atlas tile layer *NAL units* (3.76) and the subset of *NAL units* (3.76) that have reserved values of *nal_unit_type* that are classified as being of type class equal to ACL in this document

3.7

atlas coordinates

two scalars (x, y) with finite precision and dynamic range that indicate the location of an atlas sample relative to the top left corner of an atlas frame, with x and y indicating the horizontal and vertical direction, respectively

3.8

atlas frame

2D rectangular array of atlas samples onto which *patches* (3.85) are projected and additional information related to the *patches* (3.85), corresponding to a *volumetric frame* (3.138)

3.9

atlas frame parameter set

AFPS

syntax structure (3.120) containing *syntax elements* (3.119) that apply to zero or more entire coded *atlas frames* (3.8) as determined by the content of a *syntax element* (3.119) found in each tile header

3.10**atlas sample**

position on the rectangular frame onto which *patches* (3.85) that are associated with an *atlas* (3.4) are projected

3.11**atlas sequence**

collection of *atlas frames* (3.8)

3.12**atlas sequence parameter set****ASPS**

syntax structure (3.120) containing *syntax elements* (3.119) that apply to zero or more entire *coded atlas sequences* (3.35) as determined by the content of a *syntax element* (3.119) found in the AFPS referred to by a syntax element found in each tile header

3.13**atlas sub-bitstream**

extracted *sub-bitstream* (3.108) from the *V3C bitstream* (3.128) containing a part of an atlas NAL bitstream

3.14**atlas unit**

set of *NAL units* (3.76) that contain all *ACL NAL units* (3.6) of a *coded atlas* (3.34) and their *associated non-ACL NAL units* (3.2)

3.15**attribute**

scalar or vector property optionally associated with each point in a *volumetric frame* (3.138) such as colour, reflectance, surface normal, transparency, material ID, etc.

3.16**attribute access unit**

collection of *attribute maps* (3.18) and auxiliary attribute frames, if available, for a specific *attribute* (3.15) that correspond to the same time instance

3.17**attribute frame**

2D rectangular array created through the aggregation of *patches* (3.85) containing values of a specific *attribute* (3.15)

3.18**attribute map**

attribute frame (3.17) containing *attribute patch* (3.85) information projected at a particular depth indicated by the corresponding *geometry map* (3.59)

3.19**auxiliary attribute frame**

2D rectangular array that is associated with *RAW patches* (3.103) and *EOM patches* (3.51), and contains values of a specific *attribute* (3.15)

3.20**auxiliary geometry frame**

2D rectangular array that is associated with *RAW patches* (3.103) and contains *geometry* (3.56) values

3.21**auxiliary video component**

video component (3.125) indicated as being of auxiliary type through an appropriate flag in the VPS (3.134) and containing data only associated with *RAW patches* (3.103) or *EOM patches* (3.51), or both

3.22

auxiliary video sub-bitstream

video sub-bitstream (3.127) indicated as being of auxiliary type through an appropriate flag in the *VPS* (3.134) and containing data only associated with *RAW patches* (3.103) or *EOM patches* (3.51), or both

3.23

bitstream

ordered series of bits that forms the coded representation of the data

3.24

byte

sequence of 8 bits, within which, when written or read as a sequence of bit values, the left-most and right-most bits represent the most and least significant bits, respectively

3.25

broken link access access unit

BLA access unit

access unit in which the *coded atlas* (3.34) with *nal_layer_id* equal to 0 is a *BLA coded atlas* (3.26)

3.26

broken link access coded atlas

BLA coded atlas

IRAP coded atlas (3.73) frame for which each *ACL NAL unit* (3.6) has *nal_unit_type* equal to *NAL_BLA_W_LP*, *NAL_GBLA_W_LP*, *NAL_BLA_W_RADL*, *NAL_GBLA_W_RADL*, *NAL_BLA_N_LP* or *NAL_GBLA_N_LP*.

Note 1 to entry: A BLA coded atlas does not use inter prediction in its decoding process, and could be the first coded atlas in the bitstream in decoding order, or could appear later in the bitstream. Each BLA coded atlas begins a new CAS, and has the same effect on the decoding process as an instantaneous decoding refresh (IDR) coded atlas. However, a BLA coded atlas contains syntax elements that specify a non-empty DAB. When a BLA coded atlas frame for which each ACL NAL unit has *nal_unit_type* equal to *NAL_BLA_W_LP* or *NAL_GBLA_W_LP*, it may have associated random access skipped leading (RASL) coded atlas frames, which are not output by the decoder and may not be decodable, as they may contain references to atlas frames that are not present in the bitstream. When a BLA coded atlas frame for which each ACL NAL unit has *nal_unit_type* equal to *NAL_BLA_W_LP* or *NAL_GBLA_W_LP*, it may also have associated RADL coded atlas frames, which are specified to be decoded. When a BLA coded atlas frame for which each ACL NAL unit has *nal_unit_type* equal to *NAL_BLA_W_RADL* or *NAL_GBLA_W_RADL*, it does not have associated RASL coded atlas frames but may have associated random access decodable leading (RADL) coded atlas frames. When a BLA coded atlas frame for which each ACL NAL unit has *nal_unit_type* equal to *NAL_BLA_N_LP* or *NAL_GBLA_N_LP*, it does not have any associated leading coded atlas frames.

3.27

byte-aligned

positioned as an integer multiple of 8 bits from the position of the first bit in the *bitstream* (3.23)

3.28

byte-aligned position

position in a *bitstream* (3.23) that is *byte-aligned* (3.27)

3.29

byte-aligned byte

byte (3.24) that appears in a position in a *bitstream* (3.23) that is *byte-aligned* (3.27)

3.30

Cartesian coordinates

three scalars (x, y, z) with finite precision and dynamic range that indicate the location of a point relative to a fixed reference point (the origin)

3.31

clean random access access unit

CRA access unit

access unit in which the *coded atlas* (3.34) with *nal_layer_id* equal to 0 is a *CRA coded atlas* (3.32)

3.32**clean random access coded atlas****CRA coded atlas**

IRAP coded atlas (3.73) for which each *ACL NAL unit* (3.6) has *nal_unit_type* equal to *NAL_CRA* or *NAL_GCRA*

Note 1 to entry: A CRA coded atlas does not use inter prediction in its decoding process, and could be the first coded atlas in the bitstream in decoding order, or could appear later in the bitstream. A CRA coded atlas could have associated RADL or RASL coded atlas frames. When a CRA coded atlas has *NoOutputBeforeRecoveryFlag* equal to 1, the associated RASL coded atlas frames are not output by the decoder, because they might not be decodable, as they could contain references to coded atlas frames that are not present in the bitstream.

3.33**codec**

specification, device, or system that specifies or uses well defined instructions for encoding or decoding a digital data, i.e. image or video, stream or signal

3.34**coded atlas****coded atlas frame**

coded representation of an *atlas* (3.4)

3.35**coded atlas access unit**

set of *atlas NAL units* (3.76) that are associated with each other according to a specified classification rule, are consecutive in decoding order, and contain all *atlas NAL units* (3.76) pertaining to one particular output time

3.36**coded atlas sequence****CAS**

sequence of *coded atlas access units* (3.35), in decoding order, of an *IRAP coded atlas access unit* (3.74), followed by zero or more *coded atlas access units* (3.35) that are not *IRAP coded atlas access units* (3.74), including all subsequent *access units* (3.35) up to but not including any subsequent *coded atlas access unit* (3.35) that is an *IRAP coded atlas access unit* (3.74)

3.37**coded volumetric frame**

collection of coded representations of an *atlas* (3.4), *occupancy* (3.83), *geometry access unit* (3.57), and, for each available *attribute* (3.15), *attribute access unit* (3.16), pertaining to one particular time instance

3.38**coded V3C sequence****CVS**

sequence of *V3C sub-bitstreams* (3.133) identified and separated by appropriate delimiters, required to start with a *VPS* (3.134), included in at least one *V3C unit* (3.135) or provided through external means, and contains one or more V3C units that can be factored into *V3C composition units* (3.131), where the first V3C composition unit is a *V3C IRAP composition unit* (3.132)

3.39**coded representation**

data element as represented in its coded form

3.40**coded sub-bitstream sequence**

sub-bitstream IRAP composition unit (3.110) followed by zero or more sub-bitstream composition units (3.109)

3.41**coded V3C component**

coded representation of a *V3C component* (3.129)

3.42

component bitstream

bitstream (3.23) representing a *V3C component* (3.129)

3.43

component sub-bitstream

portion of *component bitstream* (3.42)

3.44

composition time

time or time period at which a frame needs to be composed, used for reconstruction, or presented

3.45

composition time index

index to an ordered list of *composition times* (3.44)

3.46

composition unit

partition of a *bitstream* (3.23) that has a certain *composition time* (3.44)

3.47

decoder under test

DUT

decoder that is tested for conformance to this document by operating the hypothetical stream scheduler to deliver a conforming *bitstream* (3.23) to the decoder and to the hypothetical reference decoder and comparing the values and timing or order of the output of the two decoders

3.48

decoding unit

sub-set of a *coded atlas access unit* (3.35) consisting of one or more ACL NAL units in a *coded atlas access unit* (3.35) and the *associated non-ACL NAL units* (3.2)

3.49

enhanced occupancy mode

EOM

patch coding mode where a *patch* (3.85) is associated with enhanced occupancy information

3.50

EOM coded points

coded representation of 3D points located at intermediate depth positions for which *geometry* (3.56) values are stored as codewords in the *occupancy frame* (3.84) and their corresponding attributes values are stored in additional patches, referred to as *EOM patches* (3.51), in the *attribute frames* (3.17)

3.51

EOM patch

patch (3.85) with *patch mode* (3.87) equal to I_EOM, P_EOM, or P_SKIP associated with *EOM coded points* (3.50)

3.52

EOM patch type

patch type (3.88) indicating an *EOM patch* (3.51)

3.53

essential supplemental enhancement information

ESEI

SEI (3.117) that is deemed as essential by the decoding process and should not be ignored or discarded

3.54**essential supplemental enhancement information NAL unit****ESEI NAL unit**

NAL unit (3.76) corresponding to an *ESEI* (3.53) and has *nal_unit_type* equal to *NAL_PREFIX_ESEI* or *NAL_SUFFIX_ESEI*

3.55**flag**

variable or single-bit syntax element that can take one of the two possible values: 0 and 1

3.56**geometry**

set of *Cartesian coordinates* (3.30) associated with a *volumetric frame* (3.138)

3.57**geometry access unit**

collection of *geometry maps* (3.59) and auxiliary geometry frames, if present, corresponding to the same time instance

3.58**geometry frame**

2D array created through the aggregation of the *geometry* (3.56) information associated with each *patch* (3.85)

3.59**geometry map**

geometry frame (3.58) containing *geometry patch* (3.85) information projected at a particular depth

3.60**global broken link access access unit****GBLA access unit**

access unit in which the *coded atlas* (3.34) with *nal_layer_id* equal to 0 is a *GBLA coded atlas* (3.61)

3.61**global broken link access coded atlas****GBLA coded atlas**

IRAP coded atlas (3.73) frame for which each *ACL NAL unit* (3.6) has *nal_unit_type* equal to *NAL_GBLA_W_LP*, *NAL_GBLA_W_RADL*, or *NAL_GBLA_N_LP* respectively

3.62**global clean random access access unit****GCRA access unit**

access unit in which the *coded atlas* (3.34) with *nal_layer_id* equal to 0 is a *GCRA coded atlas* (3.63)

3.63**global clean random access coded atlas****GCRA coded atlas**

IRAP coded atlas (3.73) frame for which each *ACL NAL unit* (3.6) has *nal_unit_type* equal to *NAL_GCRA*

3.64**global instantaneous decoding refresh access unit****GIDR access unit**

access unit in which the *coded atlas* (3.34) with *nal_layer_id* equal to 0 is a *GIDR coded atlas* (3.65)

3.65**global instantaneous decoding refresh coded atlas access unit****GIDR-coded atlas**

coded atlas (3.34) for which each *ACL NAL unit* (3.6) has *nal_unit_type* equal to *NAL_GIDR_W_RADL*, *NAL_GBLA_N_LP*, or *NAL_GCRA*, or in the range of *NAL_GBLA_W_LP* to *NAL_GBLA_N_LP*, inclusive, and specify a random access association between the current *coded atlas* and its corresponding coded video frames at the same composition time

3.66

global intra random access point coded atlas

GIRAP coded atlas

IRAP coded atlas (3.73) for which each *ACL NAL unit* (3.6) has *nal_unit_type* equal to *NAL_GIDR_W_RADL*, *NAL_GBLA_N_LP*, or *NAL_GCRA*, or in the range of *NAL_GBLA_W_LP* to *NAL_GBLA_N_LP*, inclusive, and specify a random access association between the current coded atlas and the corresponding coded video frames at the same composition time

3.67

hypothetical reference decoder

HRD

hypothetical decoder model that specifies constraints on the variability of conforming atlas *NAL unit* (3.76) streams or conforming *coded atlas* (3.34) sample streams that an encoding process can produce

3.68

hypothetical stream scheduler

HSS

hypothetical delivery mechanism used for checking the conformance of an *atlas sub-bitstream* (3.13) or a decoder with regards to the timing and data flow of the input of an *atlas sub-bitstream* (3.13) into the *hypothetical reference decoder* (3.67)

3.69

instantaneous decoding refresh coded atlas access unit

IDR coded atlas access unit

access unit in which the *coded atlas* (3.34) with *nal_layer_id* equal to 0 is an *IDR coded atlas* (3.70)

3.70

instantaneous decoding refresh coded atlas

IDR coded atlas

IRAP coded atlas (3.73) for which each *ACL NAL unit* (3.6) has *nal_unit_type* equal to *NAL_IDR_W_RADL*, or *NAL_IDR_N_LP*, *NAL_GIDR_W_RADL*, or *NAL_GIDR_N_LP*

Note 1 to entry: An IDR coded atlas does not refer to any atlases other than itself for inter prediction in its decoding process, and may be the first atlas in the bitstream in decoding order, or may appear later in the bitstream. Each IDR coded atlas is the first atlas of a CAS in decoding order. When an IDR coded atlas for which each ACL NAL unit has *nal_unit_type* equal to *NAL_IDR_W_RADL* or *NAL_GIDR_W_RADL*, it may have associated RADL coded atlases. When an IDR coded atlas for which each ACL NAL unit has *nal_unit_type* equal to *NAL_IDR_N_LP* or *NAL_GIDR_N_LP*, it does not have any associated leading coded atlases. An IDR coded atlas does not have associated RASL coded atlases.

3.71

inter atlas tile

atlas tile that can be decoded using both intra or inter prediction methods

3.72

intra atlas tile

atlas tile that is decoded using only intra prediction methods

3.73

intra random access point coded atlas

IRAP coded atlas

IRAP coded atlas frame

coded atlas (3.34) for which each *ACL NAL unit* (3.6) has *nal_unit_type* in the range of *NAL_BLA_W_LP* to *NAL_RSV_IRAP_ACL_29*, inclusive

Note 1 to entry: An IRAP coded atlas does not refer to any coded atlases other than itself for prediction in its decoding process, and may be a BLA coded atlas, a CRA coded atlas, or an IDR coded atlas. Provided the necessary parameter sets are available when they need to be activated, the IRAP coded atlas and all subsequent non-RASL coded atlas in decoding order can be correctly decoded without performing the decoding process of any coded atlases that precede the IRAP coded atlas in decoding order.