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Information technology — Plenoptic image coding system (JPEG Pleno) —

Part 3: Conformance testing

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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 or www.iec.ch/members_experts/refdocs).

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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. In the IEC, see www.iec.ch/understanding-standards.

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 21794 series can be found on the ISO and IEC websites.

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 and www.iec.ch/national-committees.

Introduction

This document is part of a series of standards for a system known as JPEG Pleno. The ISO/IEC 21794 series aims to provide a standard framework for representing new imaging modalities. It facilitates the capture, representation, exchange and visualization of plenoptic imaging modalities. A plenoptic image modality can be a light field, point cloud or hologram, which are sampled representations of the plenoptic function in the form of, respectively, a vector function that represents the radiance of a discretized set of light rays, a collection of points with position and attribute information, or a complex wavefront. The plenoptic function describes the radiance in time and in space obtained by positioning a pinhole camera at every viewpoint in 3D spatial coordinates, every viewing angle and every wavelength, resulting in a 7D function.

JPEG Pleno is designed primarily to facilitate the capture, representation, exchange and visualization of point cloud, light field and holographic imaging modalities. It specifies tools for coding these modalities while providing advanced functionality at the system level, such as support for data and metadata manipulation, editing, random access and interaction, protection of privacy and ownership rights, as well as other security mechanisms.

This document provides the framework, concepts and methodology for testing codestreams and implementations, and the criteria to be achieved to claim conformance to the ISO/IEC 21794 series. The objective of this document is to promote interoperability between JPEG Pleno decoders, and to test these systems for conformance to one or multiple specifications that are part of the JPEG Pleno. Conformance testing is the testing of a candidate implementation for the existence of specific characteristics required by a standard. It involves testing the capabilities of an implementation against the conformance requirements in the relevant standard.

The purpose of this document is to define a common test methodology, to provide a framework for specific test cases and to define the procedures to be followed during conformance testing.

Any organization contemplating the use of the test methods defined in this document should carefully consider the constraints on their applicability. Conformance testing does not include robustness testing, acceptance testing or performance testing, all of which are outside the scope of this document.

Information technology — Plenoptic image coding system (JPEG Pleno) —

Part 3: Conformance testing

1 Scope

This document provides the conformance testing of the ISO/IEC 21794 series, also known as JPEG Pleno.

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 21794-1, *Information technology — Plenoptic image coding system (JPEG Pleno) — Part 1: Framework*

ISO/IEC 21794-2:2021, *Information technology — Plenoptic image coding system (JPEG Pleno) — Part 2: Light field coding*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 21794-1 and ISO/IEC 21794-2 and the following apply.

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

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

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

3.1
baseline block-based profile
BBBP
4D transform mode coding tools

3.2
baseline view-based profile
BVBP
4D prediction mode coding tools

3.3
box
structured collection of data describing a portion of the file format defined by a length and unique box type

3.4
conformance
fulfilment of the specified requirements for a given profile

Note 1 to entry: The specified requirements are those defined in this document.

3.5
conformance test procedure
steps for assessing *conformance* (3.4)

3.6
executable test suite
ETS
set of executable test cases that support the abstract test cases

3.7
file format
codestream and its additional support information encoded for storage in a computer file

3.8
header
part of the codestream that contains only markers and marker segments

3.9
image
set of all components

3.10
implementation
realization of a specification

3.11
mean squared error
MSE
average squared difference between the decoded values and the pristine value

3.12
parser
program for syntax analysis

3.13
precision
number of binary digits allocated to a given sample

3.14
prediction mode codestream
ISO/IEC 21794-2 codestream obtained using the 4DPM coding tools

3.15
peak signal-to-noise ratio
PSNR
fidelity measurement between the original and decompressed signal

3.16
test codestream
TCS
available codestream designed to test specific tools

3.17
testing
process of evaluating conformance

3.18
transform mode codestream
ISO/IEC 21794-2 codestream obtained using the 4DTM coding tools

4 Abbreviated terms

4DPM four-dimensional prediction mode

4DTM four-dimensional transform mode

ASCII American Standard Code for Information Interchange

5 General description

5.1 Overview

JPEG Pleno encoders will possibly employ only a fraction of the features specified by ISO/IEC 21794-2. Likewise, some decoders might not implement all the features specified by ISO/IEC 21794-2. It is impossible to provide test cases for all possible configurations of tools that an encoder or decoder can implement. This document provides abstract test procedures for JPEG Pleno encoders and decoders. A developer may designate the features that have been implemented and determine a set of test cases that applies to those features. This document specifies explicit decoder test procedures that aim to ensure the greatest level of interoperability between various implementations of encoders and decoders. These test procedures are used to derive tests that are run for a particular profile. Passing the explicit tests for a given profile allows a decoder to be labelled as "conforming to a given profile".

Even with the explicit decoder tests, it is expected that some decoders will not decode all of the information that was originally incorporated into the codestream by an encoder. Since ISO/IEC 21794-2 defines many auxiliary boxes, it is desirable to allow decoders to ignore information that is not of interest to their target application.

This document describes conformance for JPEG Pleno decoders in terms of a system of assurance. These assurances serve to discourage encoders from producing codestreams that will be exceedingly difficult or impossible for a decoder to process, to encourage decoders to provide quality images from any reasonable codestream, and to encourage the use of the flexibility and scalability of JPEG Pleno codestreams.

5.2 Profiles and levels

Profiles define a subset of coding techniques, from the ISO/IEC 21794 series, that meet the needs of a given application. Levels provide information about resolution and memory constraints in conforming decoder implementations. Decoders implement the capabilities for all bitstreams encoded for a particular profile. Encoders achieve quality guarantees for particular decoders by encoding bitstreams which meet a particular profile and level definition.

If a JPEG Pleno encoder produces a codestream with certain properties, then a decoder of a certain profile and level will be able to produce an image with some defined level of quality. The tests in this document are designed to require a conforming decoder to be capable of decoding all codestreams.

Two profiles are labelled as baseline block-based profile (BBBP) and baseline view-based profile (BVBP). These two profiles describe bitstream constraints for an encoder implementing ISO/IEC 21794-1 and ISO/IEC 21794-2. BBBP corresponds to the 4DTM coding tools. Specifically, this profile considers the tools described in Annexes A and B but excludes the tools detailed in ISO/IEC 21794-2:2021, Annexes C, D and E. BVBP corresponds to the 4DPM tools and requires the implementation of all annexes but Annex B. These profiles do not define a hierarchy, and hence are not subsets of each other. In other words, they are independent of each other and no other simple relation holds between the other profiles.

Levels define the complexity of the decoding tools and serve as guidance for encoders to produce codestreams that are easily decodable by decoders conforming to a given profile and level. A lower level is a subset of a higher level. Hence, any implementation capable of decoding a higher-level test codestream (TCS) shall be capable of passing the conformance tests for a lower-level codestream of the same profile.

5.3 Objective metrics

Maximum absolute error and peak signal-to-noise ratio (PSNR) are the objective metrics used for computing the distortions obtained from the conformance test procedure.

The maximum absolute error, $E_{\max}$, between the original component, I, and the reconstructed component, I', both with size $M \times N$ samples, is computed as follows:

$$E_{\max} = \max_{0 \le i < M,\ 0 \le j < N} (|I(i,j) - I'(i,j)|)$$

The maximum absolute error of the whole light field is the maximum value obtained for all sub-aperture images.

The PSNR between the original component, I, and the reconstructed component, I', (both n-bit) is computed as follows:

$$S_{\text{PSNR}} = 10 \times log_{10}\left(\frac{(2^n - 1)^2}{E_{\text{MSE}}}\right)$$

where E_{MSE} is the mean squared error (MSE) between the two $M \times N$ images, I and I':

$$E_{\text{MSE}} = \frac{1}{M \times N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (I(i,j) - I'(i,j))^2$$

Once the PSNR of the Y-channel ($S_{\text{PSNR,Y}}$), the PSNR of the Cb-channel ($S_{\text{PSNR,Cb}}$) and the PSNR of the Cr-channel ($S_{\text{PSNR,Cr}}$) are computed, the PSNR of all three channels ($S_{\text{PSNR,YCbCr}}$) should be computed as follows:

$$S_{\text{PSNR},YCbCr} = \frac{6 \times S_{\text{PSNR},Y} + S_{\text{PSNR},Cb} + S_{\text{PSNR},Cr}}{8}$$

The PSNRs for the whole light field ($S_{\text{PSNR,LF}}$) are computed by averaging the PSNRs for all sub-aperture images.

5.4 Test procedures to test decoders for conformance to ISO/IEC 21794-2

The test procedure specified in Annex A shall be used for testing whether a decoder under test conforms to a particular profile and level from ISO/IEC 21794-2. Annex B specifies the test suites and the references and tolerances allowed for each TCS.

5.5 File format syntax testing

The procedures defined in Annex C shall be used for testing JPEG Pleno files for conformity to the file format specified in ISO/IEC 21794-1 and ISO/IEC 21794-2. They depend on a codestream syntax parsing tool whose source code is available as a machine-readable file at https://standards.iso.org/iso-iec/21794/-3/ed-1/en.