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Information technology — JPEG XL Image Coding System —

Part 3:
Conformance testing

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Foreword

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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*.

A list of all parts in the ISO/IEC 18181 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

The ISO/IEC 18181 series, also known as "JPEG XL", supports lossless and lossy compression of images and image sequences.

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 18181 series. The objective of this standard is to promote interoperability between JPEG XL decoders, and to test these systems for conformance. Conformance testing is the testing of a candidate implementation for the existence of specific characteristics required by a standard.

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

Information technology — JPEG XL Image Coding System —

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1 Scope

This document specifies the conformance testing of the ISO/IEC 18181 series, also known as JPEG XL. Other desirable aspects of implementation (including robustness and performance) are outside the scope of 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 18181-1, *Information technology — JPEG XL image coding system — Part 1: Core coding system*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 18181-1 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/

4 Testing procedure

4.1 Structure of the test corpora

4.1.1 General

NOTE JPEG XL specifies infinite-precision arithmetic, whereas practical implementations are likely to use finite-precision arithmetic. Allowing each intermediate operation to round the result to a floating-point representation might not give sufficient freedom for alternate implementation strategies, or conversely too much freedom to be useful. This document therefore specifies tolerances for the decoded samples.

A description of the test corpora is provided in Annex A and the following files are available from https://standards.iso.org/iso-iec/18181/-3/ed-1/en/:

— a testcases/ subdirectory, containing

    — multiple subdirectories, each of which contains a single test case for conformance testing

    — multiple .txt files, each line of which contains the name of a folder corresponding to a test case

— a conformance.py file that provides a possible implementation of the testing procedure described in this document

— a lcms2.py file, which is a supporting file for conformance.py

Each subdirectory contains:

— exactly one JSON file[2], named test.json

— exactly one JXL file, named input.jxl

— up to two NPY files, named reference_image.npy or reference_preview.npy

— up to two ICC profile files, named reference.icc or original.icc

— zero or one JPEG files, named reconstructed.jpeg

If a NPY file is present, then the ICC profile named reference.icc is also present.

Collectively, the NPY, ICC and JPEG files are known as the reference for this test case.

The JSON file specifies the tests to be performed as part of this test case.

The NPY files contain sample values for either the main frames or the preview frames, represented as a four-dimensional array with dimensions (num_frames, height, width, num_channels) respectively. `num_frames` is always 1 for the preview frames. The data format stored in these arrays is one of float (32 or 64 bits), uint8 and uint16.

"`reference.icc`" represents the colour space of the data in the NPY files.

"`original.icc`" represents the ICC profile of the samples that were used to create the JPEG XL file; this is metadata that may be present in the JPEG XL file.

"`reconstructed.jpg`" contains the original JPEG1 file that produced a recompressed JPEG1 (i.e. with a "jbrd" box) JPEG XL file.

4.1.2 Numpy File Format

A NPY file begins with the sequence of bytes "93 4e 55 4d 50 59" (byte 93 followed by "NUMPY" in ASCII), followed by the sequence of bytes "01 00", followed by two bytes representing a 16-bit little-endian integer LEN that represents the length of the rest of the header.

The rest of the header contains the newline-terminated ASCII string "{'descr': '<f4', 'fortran_order': False, 'shape': (X, Y, Z, W), }", where *X*, *Y*, *Z*, *W* represent integers in their usual base-10 textual representation.

The NPY file represents an array with dimensions (*X*, *Y*, *Z*, *W*). The rest of the file contains *X* x *Y* x *Z* x *W* little endian, 32-bit floating point numbers (as specified in IEEE 754-2019), in raster order with the *W* dimension varying faster, i.e. floating point number in position (*x*, *y*, *z*, *w*) is stored in the 4 bytes starting at position $4 \cdot (x \cdot Y \cdot Z \cdot W + y \cdot Z \cdot W + z \cdot W + w)$ after the header.

NOTE This is a subset of the format specified in https://numpy.org/devdocs/reference/generated/numpy.lib.format.html

4.2 Image similarity

Samples are compared in the colour space specified by the reference ICC profile "`reference.icc`", with nominal values in the interval [0, 1] (no clipping is to be applied to values outside this range). An image is similar to the reference image if and only if the following three conditions are met:

1) The image dimensions, number of frames and number of channels are identical.

2) Each of their samples are similar, i.e. the peak error is bounded. A decoded sample *D* and reference sample *R* are similar if and only if $|D - R|$ is smaller or equal to a given threshold.

3) For all channels (components), the root mean square error (the root of the sum of $(D - R)^2$ over all samples) is smaller or equal to a given threshold.

For the purposes of this comparison, the channels are assumed to be ordered as follows: the first three channels are the RGB channels (in the order R, G, B); then, channel 3+i is the i-th extra channel (ISO/IEC 18181-1:2022, C.4.10).

In the case of greyscale images, the reference is given in RGB, where the RGB channels are equal (R = G = B).

4.3 Conformance on a single test case

The JSON file for a given test case represents the configuration of the given test case.

The JSON file represents this configuration using a key-value format, where keys are strings and values are strings, numbers, arrays or nested key-value pairs.

If the "`frames`" key is present, its corresponding value is an array of per-frame information. Its length equals the number of frames in "`reference_image.npy`". For each array entry, conformance is tested by checking similarity of the i-th decoded frame with the i-th frame in "`reference_image.npy`". For the purposes of this document, the i-th decoded frame is defined to be the i-th frame with a FrameType of either "kRegular" or "kSkipProgressive" and either a non-zero duration or is_last set to true, after any blending and orientation is applied (ISO/IEC 18181-1:2022, C.1, C.2). This corresponds to frames that are meant to be displayed to the end user. If the total number of decoded frames is not equal to the length of the array, the decoder is non-conforming. The keys in the i-th entry of the array influence conformance testing at follows:

— The key "`rms_error`" specifies the threshold for the root mean square error of any channel.

— The key "`peak_error`" specifies the threshold for the peak error of any channel.

— The value of the key "`duration`", if present, specifies the amount of time (in seconds) that the frame should be displayed for (ISO/IEC 18181-1:2022, C.2). The decoder is not conformant if this duration differs from the duration reported by the decoder by more than 0.0001 seconds.

— The value of the key "`name`", if present, is a string that specifies the name of the frame (ISO/IEC 18181-1:2022, C.2). If it differs in either content or length from the decoded value, the decoder is not conformant.

— The value of the key "`timecode`", if present, is an integer that specifies the timecode of the frame (ISO/IEC 18181-1:2022, C.2). If it differs from the decoded value, the decoder is not conformant.

If the "`preview`" key is present, its corresponding value is a single instance of the per-frame information that is used for the "`frames`" key. It is to be interpreted in the same way, except that it refers to the "`reference_preview.npy`" file and the decoded preview image.

If the "`original_icc`" key is present, its value is ignored. The decoder is not conformant if it reports that the original ICC profile of the samples represented by the JPEG XL file (ISO/IEC 18181-1:2022, Annex B) differs from "`original.icc`", either in length or in contents.

If the "`reconstructed_jpeg`" key is present, its value is ignored. The decoder is not conformant if the process of reconstructing an ISO/IEC 18477-1 JPEG bitstream (as described in ISO/IEC 18181-2) differs from "`reconstructed.jpg`", either in length or in contents.

If the "`intensity_target`" key is present , its value is a number that defines the intensity target of the decoded image (ISO/IEC 18181-1:2022, Table A.18). If the decoded value differs by more than 0.0001, the decoder is not conformant. The "`min_nits`", "`relative_to_max_display`" and "`linear_below`" keys are defined in a similar way.

If the "`extra_channel_type`" key is present, its value is an array of strings that has a length of "`num_channels`-3" (i.e. equal to the number of extra channels). The i-th entry of the array corresponds to the "type" value of the ExtraChannelInfo (ISO/IEC 18181-1:2022, A.9) bundle corresponding to that extra channel. If any of those values differs from the decoded ones, the decoder is not conformant.

If the "`bits_per_channel`" key is present, its value is an array of integers representing the original bit depth. Its length is "`num_channels`-2"; the first value corresponds to the `bit_depth.bits_per_sample` value of the color channels (ISO/IEC 18181-1:2022, Table A.16), and the other values correspond to the `bit_depth.bits_per_sample` value of the extra channels (ISO/IEC 18181-1:2022, Table A.22).

If the "`exp_bits_per_channel`" key is present, its value is an array of integers. Its length is "`num_channels`-2"; the first value corresponds to the `bit_depth.exp_bits` value of the color channels (ISO/IEC 18181-1:2022, Table A.16), and the other values correspond to the `bit_depth.exp_bits` value of the extra channels (ISO/IEC 18181-1:2022, Table A.22).

4.4 Encoder test

As specified in ISO/IEC 18181-1, any encoding process is acceptable so long as it produces a valid codestream. Thus, an encoder shall be considered conforming if it produces output files which are successfully decoded by a conforming decoder. More precisely, the steps for testing encoder conformance are as follows:

a) Select a test image that represents the type of imagery that the encoder is designed to compress. The reference decoded images provided for decoder conformance tests are acceptable but not required.

b) Encode with the encoder under test.

c) Send the codestream to the reference decoder.

d) An encoder is found to be compliant if the reference decoder can fully decode the image.

e) Repeat steps a) through d) for all parameters for which the encoder is designed. These parameters should be varied to the extent to which the encoder will be used.

f) Repeat steps a) through e) for several test images, sampling the breadth of imagery types (small image size, large image size, odd image sizes, number of components, component bit depths, component sampling) the encoder is designed to compress.

4.5 Decoder

A decoder shall be considered conforming to Level 5 of the Main profile if it is conforming to all the testcases specified in the `main_level5.txt` file available from https://standards.iso.org/iso-iec/18181/-3/ed-1/en/.

A decoder shall be considered conforming to Level 10 of the Main profile if it is conforming to all the testcases specified in the `main_level10.txt` file available from https://standards.iso.org/iso-iec/18181/-3/ed-1/en/.

Annex A
(informative)

Description of the test corpora

Table A.1 describes what combinations of coding tools and peak/mean error values are found in each of the test corpora. Coding tools and values are considered on a per-channel basis; for example, in the Level 5 test corpus it is possible to find an image with the three colour channel encoded with VarDCT and a peak/average error bound of 0.06 and 0.02, plus one extra channel encoded with 8-bit Modular (with no filters) and a peak/average error bound of $1/2^{10}$.

In this table, "no filters" means that all the coding tools from ISO/IEC 18181-1:2022, Annexes J and K, as well as L.7 and L.8 are not enabled for that channel. In contrast, "with filters" means that some of those tools are enabled. An X is present in the "Level 5"/"Level 10" columns if images with this configuration can be found in the corresponding corpora.

Table A.1 — Summary of parameters in test corpora

	Level 5	Level 10	Peak error	RMSE
VarDCT, Modular with filters	X	X	0.06	0.02
VarDCT, Modular no filters	X	X	0.06	0.02
VarDCT, Modular with filters		X	0.004	$1/10^4$
VarDCT with no filters		X	0.004	$1/10^5$
Modular 8-bit, no filters, RGB	X	X	$1/2^{10}$	$1/2^{10}$
Modular 10-bit, no filters, RGB	X	X	$1/2^{12}$	$1/2^{12}$
Modular 12-bit, no filters, RGB	X	X	$1/2^{14}$	$1/2^{14}$
Modular 16-bit, no filters, RGB		X	$1/2^{18}$	$1/2^{18}$

Table A.2 lists the test cases and the relevant coding tools that are tested with them. The `main_level5.txt` file contains all the test cases that are indicated to be level 5 in the rightmost column; the `main_level10.txt` file contains all the test cases.

Table A.2 — Summary of test cases and relevant coding tools

test case	*what it tests*	*level*
`alpha_nonpremultiplied`	Modular mode, alpha channel, 12-bit	5
`alpha_premultiplied`	VarDCT mode, premultiplied alpha channel, 12-bit color, 16-bit alpha	10
`alpha_triangles`	Modular mode, alpha channel, 9-bit	5
`animation_icos4D`	VarDCT mode, alpha channel, animation	5
`animation_newtons_cradle`	Modular mode, Palette, animation	5
`animation_spline`	Splines, animation	5
`bench_oriented_brg`	Container, VarDCT mode, JPEG reconstruction, Orientation, ICC profile	5
`bicycles`	Modular mode, Squeeze, XYB	5
`bike`	VarDCT mode	5
`blendmodes`	Modular mode, various blend modes, 12-bit	5
`cafe`	Container, VarDCT mode, JPEG reconstruction, chroma upsampling	5