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

**Part 4:
Reference software**

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents) or the IEC list of patent declarations received (see <https://patents.iec.ch>).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 approaches. It specifies tools for coding these approaches 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 reference software implementations of ISO/IEC 21794-1 and ISO/IEC 21794-2 that demonstrate the features and capabilities of JPEG Pleno for coding light field data. Its purpose is to act as a guideline for implementations and as a reference for conformance testing. As such, the implementations are conforming to ISO/IEC 21794-1, i.e. it implements the structure of a JPL file which includes the concepts of boxes. In addition, the reference software implementations also cover ISO/IEC 21794-2, i.e. light-field coding.

This document includes the source code for reference implementations of ISO/IEC 21794-1 and ISO/IEC 21794-2 as electronic attachments. They have been successfully compiled and tested on Linux^{®1)} operating system at the time of writing.

Instructions for unpacking and building the software are found in [Annexes A](#). Instructions for its use are listed in [Annexes B](#) and [C](#).

1) Linux[®] is the trademark of a product supplied by Linus Torvalds. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO/IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

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Part 4: Reference software

1 Scope

This document provides reference implementations of ISO/IEC 21794-1 and ISO/IEC 21794-2, 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, *Information technology — Plenoptic image coding system (JPEG Pleno) — Part 2: Light field coding*

ISO/IEC 21794-3, *Information technology — Plenoptic image coding system (JPEG Pleno) — Part 3: Conformance testing*

3 Terms and definitions

For the purposes of this document the terms and definitions given in ISO/IEC 21794-1, in ISO/IEC 21794-2, in ISO/IEC 21794-3, 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 codestream

sequence of bytes that conforms to or is to be checked for conformance with the codestream syntax specified in ISO/IEC 21794-1 and/or ISO/IEC 21794-2

3.2 JSON

data interchange format that represents data objects using attribute–value pairs and array data types specified in ISO/IEC 21778

4 Abbreviated terms

JPLM JPEG Pleno Model

PPM	Portable pixmap format
PSNR	Peak signal-to-noise ratio
RDO	Rate-distortion optimization
RGB	Red, Green, Blue

5 Conventions

Monospaced text indicates program input or output as necessary to either run the software, or as generated by the software on the console.

6 Reference software

The following reference software is provided:

- Reference decoder software capable of decoding codestreams that conform to ISO/IEC 21794-1 and/or ISO/IEC 21794-2.
- Sample encoder software capable of producing codestreams that conform to ISO/IEC 21794-1 and/or ISO/IEC 21794-2.

The use of the reference software is not required for making an implementation of an encoder or decoder in conformance to any of the parts of the ISO/IEC 21794 series. Requirements established in ISO/IEC 21794-1 and ISO/IEC 21794-2 take precedence over the behaviour of the reference software.

7 Examples of use

Some examples of use for the reference decoder software implementations are as follows:

- As an illustration of how to perform the decoding processes.
- As the starting basis for the implementation of a decoder that conforms to one or multiple parts of the ISO/IEC 21794 series.
- For (non-exhaustive) testing of the conformance of a codestream (or file) as specified in ISO/IEC 21794-1 or ISO/IEC 21794-2.

NOTE The lack of detection of any conformance violation by any reference software implementation is not to be considered as definitive proof that the codestream under test conforms to all constraints required for the codestream to conform to one of the ISO/IEC 21794 series.

Some examples of use for a reference encoder software are as follows:

- As an illustration of how to implement an encoding process that produces codestreams that are, depending on the settings of the software, conforming to one or multiple members of the software of ISO/IEC 21794 series.
- As a starting point for an implementation of an encoder that conforms to one or multiple members of the ISO/IEC 21794 series.
- As a means of generating codestreams conforming to one or multiple parts of the ISO/IEC 21794 series for testing purposes.
- As a means of demonstrating and evaluating examples of the quality that can be achieved by an encoding process that conforms to multiple parts of the ISO/IEC 21794 series.

No guarantee of the quality that will be achieved by an encoder is provided by its conformance to one or multiple parts of the ISO/IEC 21794 series as the conformance is defined only in terms of specific

constraints imposed on the syntax of the generated codestream. In particular, while sample encoder software implementations may suffice to provide some illustrative examples of which quality can be achieved within the ISO/IEC 21794 series, they provide neither an assurance of minimum guaranteed image encoding quality nor maximum achievable image encoding quality.

Similarly, the computation resource characteristics in terms of program or data memory usage, execution speed, etc. of sample software encoder or decoder implementations should not be construed as a representative of the typical, minimal or maximal computational resource characteristics to be exhibited by implementations of some parts of the ISO/IEC 21794 series.

8 Warranty disclaimer

Regardless of any and all statements made herein or elsewhere regarding the possible uses of the reference software, the following disclaimers of warranty apply to the provided reference software implementations:

- ISO and IEC disclaim any and all warranties, whether express, implied, or statutory, including any implied warranties of merchantability or fitness for a particular purpose.
- In no event shall the contributor(s) or ISO or IEC be liable for any incidental, punitive or consequential damages of any kind whatsoever arising from the use of these programs.
- This disclaimer of warranty extends to the user of these programs and the user's customers, employees, agents, transferees, successors, and assignees.
- ISO and IEC do not represent or warrant that the software is free of infringements of any patents.
- Commercial applications of ISO/IEC International Standards, including shareware, may be subject to royalty fees to patent holders.

9 General

The reference software implementations for the ISO/IEC 21794 series are available at <https://standards.iso.org/iso-iec/21794/-4/ed-1/en/>.

The file "jpeg-pleno-refsw-bbbp.zip" contains a reference implementation for ISO/IEC 21794-1 and ISO/IEC 21794-2 that currently encodes and decodes codestreams conformant to the baseline block-based profile. Unpacking and compilation of this software is explained in [Annex A](#), guidance on how to use this software is given in [Annex B](#).

The file "jpeg-pleno-refsw-bvbp.zip" contains a reference implementation for ISO/IEC 21794-1 and ISO/IEC 21794-2 that currently encodes and decodes codestreams conformant to the baseline view-based profile. Unpacking and compilation of this software is explained in [Annex A](#), guidance on how to use this software is given in [Annex C](#).

10 Building the reference software

The whole build system is managed by CMake^{®2)}. The reference software has been compiled on a machine with Internet access, configured with the following operating system and packages:

- Linux[®] environment with kernel 4.15.0 or above.
- GCC 9.2.1 or above.
- CMake3.10 or above.

2) CMake[®] is the trademark of a product supplied by Kitware. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO/IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

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- Doxygen 1.8.13 or above (optional to build binaries but required to build documentation).
- TeX Live (optional).

Internet access is required to build the reference software because CMake downloads packages to resolve library dependencies.

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Annex A (informative)

Building the reference software for ISO/IEC 21794-1 and ISO/IEC 21794-2

A.1 Building baseline block-based profile reference software

Unpacking a ZIP file is operating system specific. Under POSIX compliant operating systems, open a command line window and enter

```
~$ unzip jpeg-pleno-refsw-bbbp.zip
```

This will extract the source-code into the `jpeg-pleno-refsw-bbbp` directory.

To compile the software, please follow these steps:

```
~$ cd jpeg-pleno-refsw-bbbp
~/jpeg-pleno-refsw-bbbp$ mkdir; cd build
~/jpeg-pleno-refsw-bbbp/build$ cmake -DVISUALIZATION_TOOL=OFF ..
~/jpeg-pleno-refsw-bbbp/build$ make
```

After performing the above commands, the build can be verified via the following command:

```
~/jpeg-pleno-refsw-bbbp/build$ ctest --verbose
```

The built binaries will be stored in `~/jpeg-pleno-refsw-bbbp/bin`.

A.2 Building baseline view-based profile reference software

Unpacking a ZIP file is operating system specific. Under POSIX compliant operating systems, open a command line window and enter

```
~$ unzip jpeg-pleno-refsw-bvbp.zip
```

This will extract the source-code into the `jpeg-plm-4dpm` directory.

To compile the software, please follow these steps:

```
~$ cd jpeg-pleno-refsw-bvbp
~/jpeg-pleno-refsw-bvbp$ mkdir; cd build
~/jpeg-pleno-refsw-bvbp/build$ cmake ..
~/jpeg-pleno-refsw-bvbp/build$ make -j
```

After performing the above commands, the build can be verified via the following command:

```
~/jpeg-pleno-refsw-bvbp/build$ make test
```

The built binaries will be stored in `~/jpeg-pleno-refsw-bvbp/build/bin`.