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Information technology — JPEG 2000 image coding system —

Part 5: Reference software

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Foreword

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This document was prepared by ITU-T (as ITU-T REC. T.803) and drafted in accordance with its editorial rules, in collaboration with Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

This third edition cancels and replaces the second edition (ISO/IEC 15444-5:2015), which has been technically revised.

The main changes are as follows:

— addition of a software reference implementation of a High Throughput (HT) block coding algorithm specified in Rec. ITU-T T.814 | ISO/IEC 15444-15; and

— addition of a software reference implementation of a JPH file format specified in Rec. ITU-T T.814 | ISO/IEC 15444-15.

A list of all parts in the ISO/IEC 15444 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.

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INTERNATIONAL STANDARD
ITU-T RECOMMENDATION

Information technology – JPEG 2000 image coding system: Reference software

1 Scope

Rec. ITU-T T.800 | ISO/IEC 15444-1[1] defines a set of lossless and lossy compression methods for coding continuous-tone, bi-level, greyscale or colour digital still images. This Recommendation | International Standard provides three independently created software reference implementations of Rec. ITU-T T.800 | ISO/IEC 15444-1, in order to assist implementers of Rec. ITU-T T.800 | ISO/IEC 15444-1 in testing and understanding its content. The packages are JASPER, JJ2000 and OPENJPEG.

This Recommendation | International Standard also provides an independently created software reference implementation of Rec. ITU-T T.814 | ISO/IEC 15444-15, which specifies a high-throughput (HT) block coding algorithm that can be used in place of the block coding algorithm of Rec. ITU-T T.800 | ISO/IEC 15444-1, in order to assist implementers of Rec. ITU-T T.814 | ISO/IEC 15444-15 in testing and understanding its content. The package is TT.

This Recommendation | International Standard additionally provides an independently created software reference implementation for parsing of a JP2 file format specified in Rec. ITU-T T.800 | ISO/IEC 15444-1 and a JPH file format specified in Rec. ITU-T T.814 | ISO/IEC 15444-15, The package is Codestream-parser.

This Recommendation | International Standard does not define any additional part of the JPEG 2000 image coding system.

Each version of the J2K reference software contains source code, which can be compiled to provide the following functionality:

- Transcoding from selected, widely available image formats into a JPEG 2000 codestream.
- Transcoding from selected, widely available image formats into the JP2 file format.
- Selection of a wide range of JPEG 2000 encoding options (as documented in each reference software).
- Decoding from a JPEG 2000 codestream to a range of selected widely available image formats.
- Processing of a JP2 file to extract a JPEG 2000 codestream for decoding and conversion to a range of selected widely available image formats.
- The ability to extract metadata from a JP2 file, including the contents of the Image Header box and the colour space.
- The decoding of JP2 files that use the three-component matrix-based form of the restricted ICC method for the specification of colour space and the conversion of the decoded image data to the sRGB colour space for display, including limited upsampling of all decoded components to the same resolution.
- The decoding of JP2 files that use the monochrome form of the restricted ICC method for the specification of colour space and the conversion of the decoded image data to the sRGB based greyscale space as defined within the JP2 file format.
- The decoding of JP2 files that use the sYCC colour space and the conversion of the decoded image data to the sRGB colour space for display, including upsampling of all decoded components to the same resolution.
- Some additional tools to help with evaluation and testing.

The TT HTJ2K reference software contains source code, which can be compiled to provide the following functionality:

- Decoding from a HTJ2K codestream to a range of selected widely available image formats.

The codestream-parser reference software contains source code, which can provide the following functionality:

- Parsing of JP2 file format;
- Parsing of JPH file format.

The reference software is intended for use as a testing and validation tool for other implementations of JPEG 2000, and to help in the understanding of Rec. ITU-T T.800 | ISO/IEC 15444-1 and Rec. ITU-T T.814 | ISO/IEC 15444-15.

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[1] This Specification includes an electronic attachment containing the JASPER, JJ2000, OPENJPEG, TT, Codestream-parser reference packages.

2 Normative references

The following Recommendations and International Standards contain provisions which, through reference in this text, constitute provisions of this Recommendation | International Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. At the time of publication, the editions indicated in dated references were valid. All Recommendations and Standards are subject to revision, and parties to agreements based on this Recommendation | International Standard are encouraged to investigate the possibility of applying the most recent edition of the Recommendations and Standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards. The Telecommunication Standardization Bureau of the ITU maintains a list of currently valid ITU-T Recommendations.

2.1 Identical Recommendations | International Standards

- Recommendation ITU-T T.800 | ISO/IEC 15444-1, *Information technology – JPEG 2000 Image Coding System: Core coding system*.
- Recommendation ITU-T T.814 | ISO/IEC 15444-15, *Information technology – JPEG 2000 image coding system – Part 15: High Throughput JPEG 2000*.

2.2 Additional references

- ISO/IEC 9899:1999, *Programming languages – C*.
- ISO/IEC 9945-1:1996, *Information technology – Portable Operating System Interface (POSIX) – Part 1: System Application Program Interface (API) (C language)*.
- ISO/IEC 9945-2:1993, *Information technology – Portable Operating System Interface (POSIX) – Part 2: Shell and utilities*.
- ISO/IEC 14882:2011, *Programming languages – C++*.

3 Definitions

For the purposes of this Recommendation | International Standard, the following definitions apply:

3.1 **big endian**: The bits of a value representation occur in order from most significant to least significant.

3.2 **bit**: A contraction of the term "binary digit"; a unit of information represented by a zero or a one.

3.3 **bit-plane**: A two-dimensional array of bits. In this Recommendation | International Standard, a bit-plane refers to all the bits of the same magnitude in all coefficients or samples. This could refer to a bit-plane in a component, tile-component, code-block, region of interest, or other.

3.4 **bit stream**: The actual sequence of bits resulting from the coding of a sequence of symbols. It does not include the markers or marker segments in the main and tile-part headers or the EOC marker. It does include any packet headers and in stream markers and marker segments not found within the main or tile-part headers.

3.5 **box**: A portion of the file format defined by a length and unique box type. Boxes of some types may contain other boxes.

3.6 **box contents**: Refers to the data wrapped within the box structure. The contents of a particular box are stored within the DBox field within the Box data structure.

3.7 **byte**: Eight bits.

3.8 **channel**: One logical component of the image. A channel may be a direct representation of one component from the codestream, or may be generated by the application of a palette to a component from the codestream.

3.9 **code-block**: A rectangular grouping of coefficients from the same subband of a tile-component.

3.10 **coder**: An embodiment of either an encoding or decoding process.

3.11 **codestream**: A collection of one or more bit streams and the main header, tile-part headers, and the EOC required for their decoding and expansion into image data. This is the image data in a compressed form with all of the signalling needed to decode.

3.12 **coefficient**: The values that are the result of a transformation.

3.13 **component**: A two-dimensional array of samples. An image typically consists of several components, for instance representing red, green and blue.

3.14 **compressed image data**: Part or all of a bit stream. Can also refer to a collection of bit streams in part or all of a codestream.

3.15 **decoder**: An embodiment of a decoding process, and optionally a colour transformation process.

3.16 **decoding process**: A process which takes as its input all or part of a codestream and outputs all or part of a reconstructed image.

3.17 **discrete wavelet transformation (DWT)**: A transformation that iteratively transforms one signal into two or more filtered and decimated signals corresponding to different frequency bands. This transformation operates on spatially discrete samples.

3.18 **encoder**: An embodiment of an encoding process.

3.19 **encoding process**: A process that takes as its input all or part of a source image data and outputs a codestream.

3.20 **file format**: A codestream and additional support data and information not explicitly required for the decoding of codestream. Examples of such support data include text fields providing titling, security and historical information, data to support placement of multiple codestreams within a given data file, and data to support exchange between platforms or conversion to other file formats.

3.21 **header**: Either a part of the codestream that contains only markers and marker segments (main header and tile-part header) or the signalling part of a packet (packet header).

3.22 **image**: The set of all components.

3.23 **image area**: A rectangular part of the reference grid, registered by offsets from the origin and the extent of the reference grid.

3.24 **image area offset**: The number of reference grid points down and to the right of the reference grid origin where the origin of the image area can be found.

3.25 **image data**: The components and component samples making up an image. Image data can refer to either the source image data or the reconstructed image data.

3.26 **irreversible**: A transformation, progression, system, quantization, or other process that, due to systemic or quantization error, disallows lossless recovery. An irreversible process can only lead to lossy compression.

3.27 **JP2**: The name of the file format defined by Rec. ITU-T T.800 | ISO/IEC 15444-1.

3.28 **JPEG**: Used to refer globally to the encoding and decoding process of the following Recommendations | International Standards:

- Recommendation ITU-T T.81 (1992) | ISO/IEC 10918-1:1994, Information technology – Digital compression and coding of continuous-tone still images: Requirements and guidelines.
- Recommendation ITU-T T.83 (1994) | ISO/IEC 10918-2:1995, Information technology – Digital compression and coding of continuous-tone still images: Compliance testing.
- Recommendation ITU-T T.84 (1996) | ISO/IEC 10918-3:1997, Information technology – Digital compression and coding of continuous-tone still images: Extensions.
- Recommendation ITU-T T.84 (1996)/Amd. 1 (1999), Information technology – Digital compression and coding of continuous-tone still images: Extensions – Amendment 1: Provisions to allow registration of new compression types and versions in the SPIFF header.
- Recommendation ITU-T T.86 (1998) | ISO/IEC 10918-4, Information technology – Digital compression and coding of continuous-tone still images: Registration of JPEG Profiles, SPIFF Profiles, SPIFF Tags, SPIFF colour Spaces, APPn Markers, SPIFF Compression types and Registration authorities (REGAUT).

3.29 **JPEG 2000**: Used to refer globally to the encoding and decoding processes in this Recommendation | International Standard and their embodiment in applications.

3.30 **layer**: A collection of compressed image data from coding passes of one, or more, code-blocks of a tile-component. Layers have an order for encoding and decoding that is required to be preserved.

3.31 **lossless**: A descriptive term for the effect of the overall encoding and decoding processes in which the output of the decoding process is identical to the input to the encoding process. Distortion free restoration can be assured. All of the coding processes or steps used for encoding and decoding are reversible.

3.32 **lossy**: A descriptive term for the effect of the overall encoding and decoding processes in which the output of the decoding process is not identical to the input to the encoding process. There is distortion (measured mathematically). At least one of the coding processes or steps used for encoding and decoding is irreversible.

3.33 **marker**: A two-byte code in which the first byte is hexadecimal FF (0xFF) and the second byte is a value between 1 (0x01) and hexadecimal FE (0xFE).

3.34 **marker segment**: A marker and associated (not empty) set of parameters.

3.35 **packet**: A part of the bit stream comprising a packet header and the compressed image data from one layer of one precinct of one resolution level of one tile-component.

3.36 **packet header**: Portion of the packet that contains signalling necessary for decoding that packet.

3.37 **precinct**: A one rectangular region of a transformed tile-component, within each resolution level, used for limiting the size of packets.

3.38 **precision**: Number of bits allocated to a particular sample, coefficient, or other binary numerical representation.

3.39 **progression**: The order of a codestream where the decoding of each successive bit contributes to a "better" reconstruction of the image. What metrics make the reconstruction "better" is a function of the application. Some examples of progression are increasing resolution or improved sample fidelity.

3.40 **quantization**: A method of reducing the precision of the individual coefficients to reduce the number of bits used to entropy code them. This is equivalent to division while compressing and multiplying while decompressing. Quantization can be achieved by an explicit operation with a given quantization value or by dropping (truncating) coding passes from the codestream.

3.41 **raster order**: A particular sequential order of data of any type within an array. The raster order starts with the top left data point and moves to the immediate right data point, and so on, to the end of the row. After the end of the row is reached, the next data point in the sequence is the left-most data point immediately below the current row. This order is continued to the end of the array.

3.42 **reconstructed image**: An image that is the output of a decoder.

3.43 **reconstructed sample**: A sample reconstructed by the decoder. This always equals the original sample value in lossless coding but may differ from the original sample value in lossy coding.

3.44 **reference grid**: A regular rectangular array of points used as a reference for other rectangular arrays of data. Examples include components and tiles.

3.45 **reference tile**: A rectangular sub-grid of any size associated with the reference grid.

3.46 **region of interest (ROI)**: A collection of coefficients that are considered of particular relevance by some user defined measure.

3.47 **resolution level**: Equivalent to decomposition level with one exception: the LL subband is also a separate resolution level.

3.48 **reversible**: A transformation, progression, system, or other process that does not suffer systemic or quantization error and, therefore, allows lossless signal recovery.

3.49 **sample**: One element in the two-dimensional array that comprises a component.

3.50 **source image**: An image used as input to an encoder.

3.51 **subband**: A group of transform coefficients resulting from the same sequence of low-pass and high-pass filtering operations, both vertically and horizontally.

3.52 **subband coefficient**: A transform coefficient within a given subband.

3.53 **tile**: A rectangular array of points on the reference grid, registered with and offset from the reference grid origin and defined by a width and height. The tiles which overlap are used to define tile-components.

3.54 **tile-component**: All the samples of a given component in a tile.

3.55 **tile index**: The index of the current tile ranging from zero to the number of tiles minus one.

3.56 **transformation**: A mathematical mapping from one signal space to another.

3.57 **J2K**: Used to refer to the encoding and decoding processes in Rec. ITU-T T.800 | ISO/IEC 15444-1.

3.58 **HTJ2K**: Used to refer to the encoding and decoding processes in Rec. ITU-T T.814 | ISO/IEC 15444-15.

3.59 **JPH**: The name of the file format defined by Rec. ITU-T T.814 | ISO/IEC 15444-15.