
**Information technology — JPEG XS
low-latency lightweight image coding
system —**

**Part 1:
Core coding system**

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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Introduction

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INTOPIX SA

Rue Emile Francqui 9

B-1435 Mont-Saint-Guibert, Belgium

Fraunhofer-Gesellschaft zur Foerderung der angewandten Forschung e.V. for its Fraunhofer Institute for Integrated Circuits IIS

Am Wolfsmantel 33

91058 Erlangen, Germany

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Information technology — JPEG XS low-latency lightweight image coding system —

Part 1: Core coding system

1 Scope

This document defines a syntax (and an accompanying decompression process) that is capable to represent continuous-tone grey-scale, or continuous-tone colour digital images without visual loss at moderate compression rates. Typical compression rates are between 2:1 and 6:1 but can also be higher depending on the nature of the image. In particular, the syntax and the decoding process specified in this document allow lightweight encoder and decoder implementations that limit the end-to-end latency to a fraction of the frame size. However, the definition of transmission channel buffer models necessary to ensure such latency is beyond the scope of this document.

This document:

- specifies a decoding process for converting compressed image data to reconstructed image data;
- specifies a codestream syntax containing information for interpreting the compressed image data;
- provides guidance on encoding processes for converting source image data to compressed image data.

2 Normative references

There are no normative references in this document.

3 Terms and definitions, abbreviated terms and symbols

3.1 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/>

3.1.1

band

input data to a specific *wavelet filter type* (3.1.49) that contributes to the generation of one of the *components* (3.1.13) of the image

3.1.2

band type

single number collapsing the information on the *component* (3.1.13), and horizontal and vertical *wavelet filter types* (3.1.49) that are applied in the filter cascade reconstructing spatial image *samples* (3.1.42) from inversely quantized wavelet *coefficients* (3.1.10)

3.1.3

bit

binary choice encoded as either 0 or 1

3.1.4

bitplane

array of *bits* (3.1.3) having all the same *significance* (3.1.31)

3.1.5

bitplane count

number of significant *bitplanes* (3.1.4) of a *code group* (3.1.9), counting from the LSB up to the most significant, non-empty bitplane

3.1.6

bitplane count subpacket

subset of a *packet* (3.1.34) which decodes to the *bitplane counts* (3.1.5) of all *code groups* (3.1.9) within a packet, followed by *padding* (3.1.35) and optional *filler bytes* (3.1.24)

Note 1 to entry: See subclause C.5.3.

3.1.7

byte

group of 8 *bits* (3.1.3)

3.1.8

codestream

compressed image data representation that includes all necessary data to allow a (full or approximate) reconstruction of the *sample* (3.1.42) values of a digital image

3.1.9

code group

group of *quantization indices* (3.1.40) in sign-magnitude representation before *inverse quantization* (3.1.25)

3.1.10

coefficient

input value to the inverse wavelet transformation resulting from *inverse quantization* (3.1.25)

3.1.11

column

set of vertically aligned *precincts* (3.1.36)

3.1.12

compression

process of reducing the number of *bits* (3.1.3) used to represent source image data

3.1.13

component

two-dimensional array of *samples* (3.1.42) having the same designation such as red, green or blue in the output or display device

3.1.14

continuous-tone image

image whose *components* (3.1.13) have more than one *bit* (3.1.3) per *sample* (3.1.42)

3.1.15

data subpacket

subset of a *packet* (3.1.34) which consists of the *quantization index magnitudes* (3.1.41), followed by *padding* (3.1.35) and optional *filler bytes* (3.1.24)

Note 1 to entry: See subclause C.5.4.

3.1.16**deadzone quantizer**

quantizer whose zero bucket has a size different from all other buckets

Note 1 to entry: Based on this, inverse deadzone quantizers can be defined as inverse quantizers whose zero bucket has a size different from all other buckets.

3.1.17**decoder**

embodiment of a *decoding process* ([3.1.18](#))

3.1.18**decoding process**

process which takes as its input a *codestream* ([3.1.8](#)) and outputs a *continuous-tone image* ([3.1.14](#))

3.1.19**decomposition level**

set of wavelet *coefficients* ([3.1.10](#)) resulting from a particular level of recursive application of a wavelet transform

3.1.20**encoder**

embodiment of an *encoding process* ([3.1.23](#))

3.1.21**encoding process**

process which outputs compressed image data in the form of a *codestream* ([3.1.8](#))

3.1.22**entropy decoding**

lossless ([3.1.28](#)) *procedure* ([3.1.38](#)) which recovers the sequence of symbols from the sequence of *bits* ([3.1.3](#)) produced by an *entropy encoding* ([3.1.23](#)) procedure

3.1.23**entropy encoding**

lossless ([3.1.28](#)) *procedure* ([3.1.38](#)) which converts a sequence of input symbols into a sequence of *bits* ([3.1.3](#)) such that the average number of bits per symbol approaches the entropy of the input symbols

3.1.24**filler bytes**

integer number of *bytes* ([3.1.7](#)) a *decoder* ([3.1.17](#)) will skip over on decoding without interpreting the values of the bytes itself

3.1.25**inverse quantization**

inverse *procedure* ([3.1.38](#)) to *quantization* ([3.1.39](#)) by which the *decoder* ([3.1.17](#)) recovers a representation of the *coefficients* ([3.1.10](#))

3.1.26**inverse reversible multi component transformation****inverse RCT**

inverse transformation across multiple *component* ([3.1.13](#)) *sample* ([3.1.42](#)) values located at the same *sample grid* ([3.1.43](#)) point that is invertible without loss

Note 1 to entry: See subclauses [F.3](#) and [F.4](#).

3.1.27**LL band**

input to a series of wavelet filters where only inverse low-pass filters are applied in horizontal and vertical direction

3.1.28

lossless

being such that, for encoding and decoding *procedures* (3.1.38), the output of the decoding procedure(s) is identical to the input to the encoding procedure(s)

3.1.29

lossless coding

mode of operation which refers to any one of the coding processes defined in this document in which all of the *procedures* (3.1.38) are *lossless* (3.1.28)

3.1.30

sign subpacket

subset of a *packet* (3.1.34) that consists of the sign information of all non-zero *quantization indices* (3.1.40) within a packet, followed by *padding* (3.1.35) and optional *filler bytes* (3.1.24)

Note 1 to entry: See subclause C.5.5.

3.1.31

significance

attribute of *code groups* (3.1.9) that applies if, depending on the Run Mode flag in the picture header, either at least one of *coefficients* (3.1.10) in the code group is non-zero, or the *bitplane count* (3.1.5) prediction residual of the code group is non-zero

3.1.32

significance group

group of horizontally adjacent *code groups* (3.1.9) sharing the same *significance* (3.1.31) information in the *significance subpacket* (3.1.33)

3.1.33

significance subpacket

subset of a *packet* (3.1.34) that identifies which *significance groups* (3.1.32) within a packet are insignificant, followed by *padding* (3.1.35) and optional *filler bytes* (3.1.24)

Note 1 to entry: See subclause C.5.2.

3.1.34

packet

segment of the *codestream* (3.1.8) containing entropy coded information on a single *precinct* (3.1.36), line and a subset of the *bands* (3.1.1) within this precinct and line

3.1.35

padding

bits (3.1.3) within the *codestream* (3.1.8) whose only purpose is to align syntax elements to *byte* (3.1.7) boundaries and that carry no information

3.1.36

precinct

collection of *quantization indices* (3.1.40) of all *bands* (3.1.1) contributing to a given spatial region of the image

3.1.37

precision

number of *bits* (3.1.3) allocated to a particular *sample* (3.1.42), *coefficient* (3.1.10), or other binary numerical representation

3.1.38

procedure

set of steps which accomplishes one of the tasks which comprise an *encoding* (3.1.23) or *decoding process* (3.1.18)

3.1.39**quantization**

method of reducing the *precision* (3.1.37) of the individual *coefficients* (3.1.10)

3.1.40**quantization index**

input to the *inverse quantization* (3.1.25) process which reconstructs a *wavelet coefficient* (3.1.10)

3.1.41**quantization index magnitude**

absolute value of a *quantization index* (3.1.40)

3.1.42**sample**

single element in the two-dimensional image array which comprises a *component* (3.1.13)

3.1.43**sample grid**

common coordinate system for all *samples* (3.1.42) of an image, where the samples at the top left edge of the image have the coordinates (0,0), the first coordinate increases towards the right, the second towards the bottom

3.1.44**slice**

integral number of *precincts* (3.1.36) whose *wavelet coefficients* (3.1.10) can be entropy-decoded independently

3.1.45**subpacket**

substructure of a *packet* (3.1.34) containing information of one or multiple *bands* (3.1.1) of one line of a single *precinct* (3.1.36)

3.1.46**truncation position**

number of least significant *bitplanes* (3.1.4) not included in the *quantization index* (3.1.40) of a *wavelet coefficient* (3.1.10)

3.1.47**uniform quantizer**

quantizer whose buckets are all of equal size

Note 1 to entry: Based in this, inverse uniform quantizers can be defined as inverse quantizers whose buckets are all of equal size.

3.1.48**upsampling**

procedure (3.1.38) by which the spatial resolution of a *component* (3.1.13) is increased

3.1.49**wavelet filter type**

single number that uniquely identifies each element of the wavelet filter with regard to the number and type of horizontal and vertical decompositions

Note 1 to entry: Unlike the band type, the wavelet filter type does not include component information.

3.2 Abbreviated terms

LSB least significant bit

MSB most significant bit

3.3 Symbols

$B[c]$	bit precision of component c
β	wavelet filter type
b	band type
B_w	nominal overall bit precision of the wavelet data
B_r	number of bits required to encode a bitplane count in raw
C_{pih}	colour transformation type
$c[p,\lambda,b,x]$	wavelet coefficient in precinct p , line λ , band b and position x
C_s	width of precincts other than the rightmost precinct in sample grid positions
C_w	width of precincts in multiples of 8 LL subsampled band sample grid positions
$D[p,b]$	bitplane count coding mode of band b in precinct p
$D_r[p,s]$	raw coding mode override flag for packet s in precinct p
F_s	sign packing flag
F_{slc}	slice coding mode
F_q	number of fractional bits in the representation of wavelet coefficients
$G[b]$	gain of subband b
$H_b[a]$	height of subband a in wavelet coefficients
$H_c[i]$	height of the component i in sample points
H_f	height of the image in sampling grid points
H_p	height of a precinct in lines
H_{sl}	height of a slice in precincts
$I[p,b,\lambda,s]$	line inclusion flag, set if line λ of band b and precinct p is included in packet s , reset otherwise
$L_0[p,b]$	first line of band b in precinct p
$L_1[p,b]$	last line + 1 of band b in precinct p
L_{cod}	codestream length in bytes
$L_{dat}[p,s]$	size of the data subpacket of precinct p and packet s in bytes
$L_{cnt}[p,s]$	size of the bitplane count subpacket of precinct p and packet s in bytes
$L_{sgn}[p,s]$	size of the sign subpacket of precinct p and packet s in bytes
$L_{prc}[p]$	length of the entropy coded data in precinct p
L_{slc}	slice length in bytes

$M[p,\lambda,b,g]$	bitplane count of precinct p , line λ , band b and code group g
$M_{top}[p,\lambda,b,g]$	vertical predictor of the bitplane count of precinct p , line λ , band b and code group g
N_c	number of components in an image
$N_{cg}[p,b]$	number of code groups in precinct p and band b
N_β	number of bands per component
N_g	number of coefficients in a code group
$N_s[p,b]$	number of significance groups per line band b of precinct p
$N_p[t]$	number of precincts in slice t
N_L	number of bands in the wavelet decomposition of the image (wavelet filter types times components)
$N_{L,x}$	number of horizontal decomposition levels
$N_{L,y}$	number of vertical decomposition levels
$N_{p,x}$	number of precincts per sampling grid line
$N_{p,y}$	number of precincts per sampling grid column
$N_{pc}[p]$	number of packets in precinct p
$O[c,x,y]$	unscaled output of the inverse wavelet transformation at coordinates x and y of the component c
$\Omega[c,x,y]$	output of the inverse multiple component transformation at position x,y for component c
$P[b]$	priority of band b
P_{lev}	level a particular codestream complies to
P_{pih}	profile a particular codestream complies to
P_{poc}	progression order in which bands are transmitted in the codestream
$Q[p]$	quantization parameter of precinct p
Q_{pih}	quantization type of the picture
R_m	run mode used for significance coding
$R[p]$	refinement of precinct p
$R[c,x,y]$	reconstructed sample value at position x,y for component c
S_s	size of a significance group in code groups
$s_x[i]$	sampling factor of component i in horizontal direction
$s_y[i]$	sampling factor of component i in vertical direction
$s[p,\lambda,b,x]$	sign of the wavelet coefficient in precinct p , line λ , band b and position x
$T[p,b]$	truncation position of precinct p and band b

$T_{top}[p,b]$	vertical truncation position predictor of precinct p and band b
$T[\beta,x,y]$	temporary wavelet coefficient of filter type β at location x,y
$v[x,y]$	sample value at the sample grid position x,y
$v[p,\lambda,b,x]$	quantization index magnitude of the wavelet coefficient in precinct p, line λ , band b and position x
$W_b[b]$	width of band b in wavelet coefficients
$W_c[i]$	width of component i in samples
W_f	width of the image in sampling grid points
$W_p[p]$	width of the precinct p in sampling grid points
$W_{pb}[p,b]$	width of subband b of precinct p in coefficients
Wt_x	wavelet filter type for horizontal filtering
Wt_y	wavelet filter type for vertical filtering
$X[y]$	one-dimensional temporal array of wavelet coefficients
$Yslh$	vertical slice order within the picture
$Z[p,\lambda,b,j]$	significance flag of precinct p, line λ , band b and significance group j

4 Conventions

4.1 Conformance language

The keyword "reserved" indicates a provision that is not specified at this time, shall not be used, and may be specified in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be specified in the future.

4.2 Operators

NOTE Many of the operators used in document are similar to those used in the C programming language.

4.2.1 Arithmetic operators

+	addition
−	subtraction (as a binary operator) or negation (as a unary prefix operator)
×	multiplication
/	division without truncation or rounding
<<	left shift: $x \ll s$ is defined as $x \times 2^s$
>>	right shift: $x \gg s$ is defined as $\left\lfloor x/2^s \right\rfloor$
Umod	$x \text{ umod } a$ is the unique value y between 0 and a−1 for which $y + Na = x$ with a suitable integer N