INTERNATIONAL STANDARD

ISO/IEC 21122-1

First edition
2019-05

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

Part 1:
Core coding system

Reference number
ISO/IEC 21122-1:2019(E)

Contents

Page

Foreword ... **iv**

Introduction ... **v**

1 Scope ... **1**

2 Normative references ... **1**

3 Terms and definitions, abbreviated terms and symbols ... **1**
- 3.1 Terms and definitions ... 1
- 3.2 Abbreviated terms ... 5
- 3.3 Symbols ... 6

4 Conventions ... **8**
- 4.1 Conformance language ... 8
- 4.2 Operators ... 8
  - 4.2.1 Arithmetic operators ... 8
  - 4.2.2 Logical operators ... 9
  - 4.2.3 Relational operators ... 9
  - 4.2.4 Precedence order of operators ... 9
  - 4.2.5 Mathematical functions ... 9

5 Functional concepts ... **10**
- 5.1 Sample grid, sampling and components ... 10
- 5.2 Wavelet decomposition ... 10
- 5.3 Codestream ... 10

6 Encoder requirements ... **11**

7 Decoder ... **11**
- 7.1 Decoding process general provisions ... 11
- 7.2 Decoder requirements ... 13

Annex A (normative) **Codestream syntax** ... **14**

Annex B (normative) **Image data structures** ... **23**

Annex C (normative) **Entropy decoding** ... **32**

Annex D (normative) **Quantization** ... **48**

Annex E (normative) **Discrete wavelet transformation** ... **52**

Annex F (normative) **Multiple component transformations** ... **61**

Annex G (normative) **DC level shifting and output clipping** ... **63**

Annex H (informative) **Examples and guidelines** ... **65**

Bibliography ... **70**

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).

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 http://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.

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 21122 series can be found on the ISO website.

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.

Introduction

The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this document may involve the use of a patent.

ISO and IEC take no position concerning the evidence, validity and scope of this patent right. The holder of this patent right has assured ISO and IEC that he/she is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO and IEC. Information may be obtained from:

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

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
Bw	nominal overall bit precision of the wavelet data
B_r	number of bits required to encode a bitplane count in raw
Cpih	colour transformation type
c[p,λ,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
Cw	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
Fs	sign packing flag
Fslc	slice coding mode
Fq	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,λ,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
Lcod	codestream length in bytes
Ldat[p,s]	size of the data subpacket of precinct p and packet s in bytes
Lcnt[p,s]	size of the bitplane count subpacket of precinct p and packet s in bytes
Lsgn[p,s]	size of the sign subpacket of precinct p and packet s in bytes
Lprc[p]	length of the entropy coded data in precinct p
Lslc	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
Plev	level a particular codestream complies to
Ppih	profile a particular codestream complies to
Ppoc	progression order in which bands are transmitted in the codestream
Q[p]	quantization parameter of precinct p
Qpih	quantization type of the picture
Rm	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[β,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,λ,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,λ,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<<s is defined as $x \times 2^s$
>>	right shift: x>>s is defined as $\lfloor x/2^s \rfloor$
Umod	x umod a is the unique value y between 0 and a–1 for which y+Na = x with a suitable integer N

4.2.2 Logical operators

||	logical OR
&&	logical AND
!	logical NOT

4.2.3 Relational operators

>	greater than
≥	greater than or equal to
<	less than
≤	less than or equal to
==	equal to
!=	not equal to

4.2.4 Precedence order of operators

NOTE Operators are listed below in descending order of precedence. If several operators appear in the same line, they have equal precedence. When several operators of equal precedence appear at the same level in an expression, evaluation proceeds according to the associativity of the operator either from right to left or from left to right.

Operators	Type of operation	Associativity
()	expression	left to right
[]	indexing of arrays	left to right
–	unary negation	
×, /	multiplication, division	left to right
Umod	modulo (remainder)	left to right
+, –	addition and subtraction	left to right
<<, >>	left shift and right shift	left to right
< , >, ≤, ≥	relational	left to right
&	bitwise AND	left to right

4.2.5 Mathematical functions

$\lceil x \rceil$	ceil of x: returns the smallest integer that is greater than or equal to x
$\lfloor x \rfloor$	floor of x: returns the largest integer that is less than or equal to x
$\lvert x \rvert$	absolute value of x, $\lvert x \rvert$ equals –x for x < 0, otherwise x