INTERNATIONAL STANDARD

ISO/IEC 10918-7

Information technology — Digital compression and coding of continuous-tone still images —

Part 7:
Reference software

Technologies de l'information — Compression numérique et codage des images fixes à modelé continu —
Partie 7: Logiciel de référence

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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).

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This document was prepared by ITU-T as ITU-T T.873 (05/2019) and drafted in accordance with its editorial rules. It was assigned to 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 10918 series can be found on the ISO website.

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Table of Contents

Electronic attachment with two reference implementations of Rec. ITU-T T.81 | ISO/IEC 10918-1.

Introduction

The ITU-T T.80-series | ISO/IEC 10918-series establishes guidelines and specifies requirements for coding of continuous-tone still images known under the name JPEG. Rec. ITU-T T.81 | ISO/IEC 10918-1 specifies the codestream format and the decoding process. Rec. ITU-T T.81 | ISO/IEC 10918-1 is designed primarily for compression of continuous-tone photographic content.

This Recommendation | International Standard provides reference software for Rec. ITU-T T.81 | ISO/IEC 10918-1. The software has been successfully compiled and tested on Linux and Windows operating systems and conforms to the decoder requirements set forth in Rec. ITU-T T.83 | ISO/IEC 10918-2. It has also been tested for conformance to Rec. ITU-T T.86 | ISO/IEC 10918-4 and ISO/IEC 18477-4.

Instructions for unpacking and building the software are found in Annexes A, and C. Instructions for its use are listed in Annexes B and D.

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INTERNATIONAL STANDARD
ITU-T RECOMMENDATION

Information technology – Digital compression and coding of continuous-tone still images: Reference software

1 Scope

This Specification provides reference software for the coding technology specified in Recommendation ITU-T T.81 | ISO/IEC 10918-1. While the reference implementations also provide an encoder, conformance testing of their encoding process is beyond the scope of this Specification.

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.

  – Recommendation ITU-T T.81 (latest) | ISO/IEC 10918-1 (latest), *Information technology – Digital compression and coding of continuous-tone still images: Requirements and guidelines*.

3 Definitions

For the purposes of this Specification, the terms and definitions specified in Rec. ITU-T T.81 | ISO/IEC 10918-1 and the following apply.

3.1   codestream; JPEG file: Sequence of bytes.

3.2   pgx format; portable graphics format: Image format describing integer-based continuous-tone images.

  NOTE – For the purposes of this Specification, the image format is as specified in Rec. ITU-T T.803 | ISO/IEC 15444-4.

3.3   pnm format; portable any map format: Image format describing integer-based continuous-tone images of either one or three components consisting of a header determining image dimensions and sample precision and component-interleaved image samples encoded as 8-bit or 16-bit big-endian integers.

  NOTE – For a specification of the pnm format, see Bourke (1997).

3.4   R′G′B′: Colour space that describes a colour by three gamma-corrected coordinates relative to three colour primaries.

3.5   upsampling: Procedure that increases the spatial or temporal sampling rate of a time-discretely sampled signal.

3.6   Y′C_BC_R: Colour space that describes a colour by 1 luma coordinate and 2 chroma coordinates derived from a gamma-corrected R′G′B′ colour space by a linear transformation.

4 Abbreviations

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

DCT   Discrete Cosine Transform

DNL   Define Number of Lines

IDCT   Inverse Discrete Cosine Transform

MCU   Minimum Coded Unit

POSIX   Portable Operating System Interface

5 Conventions

Text in Times New Roman provides instructions, comments or details for the reader.

Text in Courier New indicates program input or output as necessary to either run the software or as generated by the software on the console.

6 Reference software

6.1 Purpose

For the purposes of this Recommendation | International Standard, the codestream shall conform to Rec. ITU-T T.81 | ISO/IEC 10918-1.

The purpose of this Specification is to provide:

– reference decoder software capable of decoding codestreams that conform to Rec. ITU-T T.81 | ISO/IEC 10918-1;

– sample encoder software capable of producing codestreams that conform to Rec. ITU-T T.81 | ISO/IEC 10918-1.

The use of the reference software is not required to implement an encoder or decoder in conformance to Rec. ITU-T T.81 | ISO/IEC 10918-1. Requirements established in Rec. ITU-T T.81 | ISO/IEC 10918-1 take precedence over the behaviour of the reference software.

6.2 Examples of use

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

– as an illustration of how to perform the decoding processes specified in Rec. ITU-T T.81 | ISO/IEC 10918-1;

– as the starting basis for the implementation of a decoder that conforms to Rec. ITU-T T.81 | ISO/IEC 10918-1;

– for (non-exhaustive) testing of the conformance of a codestream (or file) to the constraints specified in Rec. ITU-T T.81 | ISO/IEC 10918-1.

NOTE 1 – The lack of detection of any conformance violation by any reference software implementation cannot be considered as a definitive proof that the codestream under test conforms to Rec. ITU-T T.81 | ISO/IEC 10918-1.

Some examples of use for reference encoder software are as:

– an illustration of how to implement an encoding process that produces codestreams that conform to Rec. ITU-T T.81 | ISO/IEC 10918-1;

– a starting point for an implementation of an encoder that conforms to Rec. ITU-T T.81 | ISO/IEC 10918-1;

– a means of generating codestreams conforming to Rec. ITU-T T.81 | ISO/IEC 10918-1 for testing purposes;

– a means of demonstrating and evaluating examples of the quality that can be achieved by an encoding process that conforms to Rec. ITU-T T.81 | ISO/IEC 10918-1.

NOTE 2 – No guarantee of the quality that will be achieved by an encoder is provided by its conformance to Rec. ITU-T T.81 | ISO/IEC 10918-1, as the conformance is only defined in terms of specific constraints imposed on the syntax of the generated codestream and maximum tolerable errors of the discrete cosine transform (DCT) coefficients after reconstruction. In particular, while sample encoder software implementations could suffice to provide some illustrative examples of which quality can be achieved within Rec. ITU-T T.81 | ISO/IEC 10918-1, they provide neither an assurance of minimum guaranteed image encoding quality nor maximum achievable image encoding quality.

NOTE 3 – The computation resource characteristics in terms of program or data memory usage, execution speed, etc. of sample software encoder or decoder implementations cannot be construed as representative of the typical, minimal or maximal computational resource characteristics to be exhibited by implementations of some parts of Rec. ITU-T T.81 | ISO/IEC 10918-1.

6.3 General

The reference software implementations for Rec. ITU-T T.81 | ISO/IEC 10918-1 are available from ISO at https://standards.iso.org/iso-iec/10918/-7/ed-1/en and also from ITU at https://www.itu.int/rec/T-REC-T.873/en. Each of the two zip archives contains one reference software implementation.

– The file "reference1.zip" contains a reference implementation for all processes of Rec. ITU-T T.81 | ISO/IEC 10918-1. 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 "reference2.zip" contains a reference implementation for the baseline and extended Huffman and arithmetic coding DCT processes of Rec. ITU-T T.81 | ISO/IEC 10918-1. This software does not implement the lossless and hierarchical processes of Rec. ITU-T T.81 | ISO/IEC 10918-1. Unpacking and compilation of this software is explained in Annex C. Guidance on how to use this software is given in Annex D.

Annex A

Unpacking and compiling reference software A

(This annex does not form an integral part of this Recommendation | International Standard.)

Source code of the reference software implementation is provided in a zip archive available at https://standards.iso.org/iso-iec/10918/-7/ed-1/en, and https://www.itu.int/rec/T-REC-T.873/en. Unpacking a zip file is operating system specific. Under portable operating system interface (POSIX) compliant operating systems, open a command line window and enter

```
unzip reference1.zip
```

This will unpack all components of the software into the current directory.

To compile the software, follow these steps:

– for POSIX compliant operating systems, go to the directory into which the electronic attachment was unpacked, then enter on the command line

```
./configure
make
```

This assumes that a POSIX compliant shell is available, and the GNU compiler (make, gcc compiler and linker) are installed on the system. The reference software will then be built in the current directory, and a binary named `"jpeg"` will be created.

– For Microsoft Windows, the Visual Studio VS2010 or VS2013 compiler suite provides another option for building the software. A VS2010 solution file allowing loading and compiling the project can be found in the directory "vs10.0/jpeg". A solution file for VS2013 can be found in the directory "vs12.0/jpeg".

The compiler will generate a command line tool without any graphical interface that compresses images represented in the pnm format into JPEG and expands JPEG images into pnm or pgx files. pnm-files represent one component integer grey-scale or three-component integer colour data, whereas pgx files describe non-upsampled N-component raw sample data bare any colour interpretation.

For the purpose of testing for conformance to Rec. ITU-T T.81 | ISO/IEC 10918-1, the pgx output is preferable as it includes neither a transformation from $Y'C_BC_R$ to $R'G'B'$ and nor an upsampling process. These processes are not formally part of Rec. ITU-T T.81 | ISO/IEC 10918-1, but have been included in later standards. such as Rec. ITU-T T.871 | ISO/IEC 10918-5, also known as JFIF, or ISO/IEC 18477-1.

Annex B

Using reference software A

(This annex does not form an integral part of this Recommendation | International Standard.)

B.1 General

This annex describes the usage of the software prepared and compiled with the instructions given in Annex A.

The software can both compress images to JPEG files and expand such files back to pnm or pgx. The encoder and decoder are both contained in the same executable, named "jpeg". If a quality parameter (see clause B.2) is included on the command line, or the command line parameters request lossless coding, the executable encodes images. If only an input and an output file are provided, the software attempts to expand the input file to the output file.

The encoder requires one input image encoded in the pnm format that is to be compressed. For lossy compression, the -q parameter defines a quality parameter between 0 and 100. The −p parameter will enable lossless compression.

The command line parameters for the encoders are as follows:

```
jpeg [options] source target
```

where options is a set of command line options, all starting with a hyphen, source is the source image to be compressed, and the target is the output file to which the encoder writes the output codestream. Command line switches control the operations of the software. They are listed in clauses B.2 to B.8.

Decoding from a JPEG file to a ppm or pfm file requires only the input and output file name:

```
jpeg [options] source target
```

The only command line options recognized for decoding are −c and −U, which are described in subclause B.3.

B.2 Encoder options defining the quality of the image

The following options control the quality of the encoded images.

 -q quality   selects the encoding mode and defines the quality of the base image

B.3 Options controlling the colour space

The following options control how out of gamut colours and gamut extension is handled:

 -c   inserts a marker into the codestream that signals that the transformation from Y′C_BC_R to R′G′B′ is disabled by the decoder

> NOTE − Colour space interpretation and specifically the usage of this marker is beyond the scope of Rec. ITU-T T.81 | ISO/IEC 10918-1 and is further specified in Rec. ITU-T T.871 | ISO/IEC 10918-5 and ISO/IEC 18447-1.

B.4 Options controlling the scan generation and entropy coding

The following parameters control the entropy coding and generation of scan patterns for JPEG scans. Especially the −h parameter (optimize Huffman tables) is recommended, and for most configurations even necessary as Rec. ITU-T T.81 | ISO/IEC 10918-1 does not provide for all modes examples for tables the encoder could choose.

 -h   optimize the Huffman tables

 -v   use progressive instead of sequential encoding

 -p   use the lossless (predictive) mode of Rec. ITU-T T.81 | ISO/IEC 10918-1

 -y N   use hierarchical coding with N hierarchical layers. If N is 0, a two-scan hierarchical process is initiated of which the first scan is a DCT process and the second hierarchical scan is a lossless coding process