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Information technology — JPEG AI learning-based image coding system —

Part 1: Core coding system

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This document was prepared by ITU-T (as ITU-T T.840.1) 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*.

A list of all parts in the ISO/IEC 6048 series can be found on the ISO and IEC websites.

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INTERNATIONAL STANDARD ISO/IEC 6048-1
RECOMMENDATION ITU-T T.840.1

Information technology – JPEG AI learning-based image coding system: Core coding system

Summary

Recommendation ITU-T T.840.1 | ISO/IEC 6048-1 specifies an image coding technology known as *JPEG AI learning-based image coding (JPEG AI)* and it has been designed with multi-task goal. It facilitates the compression and processing of images for both human and machine vision. This Recommendation | International Standard describes the JPEG AI learning-based standard for the creation of an image from the parsed single-stream, which contains the compact compressed domain representation, targeting both human visualization, with significant compression efficiency improvement over image coding standards in common use at equivalent subjective quality, and effective performance for image processing and computer vision tasks.

Core coding system describes the JPEG AI standard for the human vision reconstruction task and thus specifies the parsing of the coded stream and the image reconstruction process.

The trainable model parameters, which are an integral part of this Recommendation | International Standard, are not contained in the Specification due to their size. Instead, the trained model parameters are available at: https://standards.iso.org/iso-iec/6048/-1/ed-1/en/ and https://www.itu.int/myworkspace/#/t-signals/vectors?val=40 (see subclause 18.2).

This Recommendation | International Standard was developed collaboratively with ISO/IEC JTC 1/SC 29, and corresponds with ISO/IEC 6048-1 as common text.

History *

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Coding, compression, decoding, human vision, image, machine vision, neural network.

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FOREWORD

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Introduction

Purpose

This Recommendation | International Standard specifies an image coding technology known as *JPEG AI learning-based image coding (JPEG AI)*, and it has been designed with multi-task goal. It allows the compression and processing of images for both human and machine vision. The scope of JPEG AI is the creation of a learning-based image coding standard offering a single-stream, compact compressed domain representation, targeting both human visualization, with significant compression efficiency improvement over image coding standards in common use at equivalent subjective quality, and with effective performance for image processing and computer vision tasks.

Core coding system describes the JPEG AI standard for the human vision reconstruction task and thus specifies the parsing of the coded stream and the image reconstruction process.

Profiles and levels

This Recommendation | International Standard is designed to cover a wide range of applications, bit rates, resolutions, qualities and services. Applications include, but are not limited to, image coding for digital storage media, image sharing through messengers or social media, visual surveillance, screen sharing applications and real-time communication. In the course of creating this Recommendation | International Standard, several requirements from typical applications have been considered, necessary algorithmic elements have been developed, and these have been integrated into a single syntax. Hence, this Recommendation | International Standard is designed to facilitate image data interchange among different applications.

Considering the practicality of implementing the full syntax of this Recommendation | International Standard, however, a limited number of subsets of the syntax are also stipulated by means of "stream profiles", "decoder profiles" and "levels". These and other related terms are formally defined in clause 3.

A stream profile is a subset of the entire bitstream syntax that is specified in this Recommendation | International Standard while a decoder profile defines the capabilities of the decoder, i.e. a subset of tools that allow the obtention of the decoded image. Different decoded qualities can be achieved for different decoder profiles using the same stream compliant with a specific stream profile. This means that interoperability may not be broken between decoders that use the same stream profile but use different decoder profiles. Within the bounds imposed by the syntax of a given stream and decoder profile, it is still possible to obtain a very large variation in the performance of encoders and decoders depending on the values taken by syntax elements in the bitstream.

A level is a specified set of constraints imposed on values of the syntax elements in the bitstream. Some of these constraints are expressed as simple limits on values, while others take the form of constraints on arithmetic combinations of values. A lower level specified is more constrained than a higher level.

Coded picture content conforming to this Recommendation | International Standard uses a common syntax. In order to achieve a subset of the complete syntax, flags, parameters and other syntax elements are included in the bitstream that signal the presence or absence of syntactic elements that occur later in the bitstream.

Encoding process, decoding process and use of optional codestream segments

Any encoding process that produces bitstream data that conforms to the specified bitstream syntax format requirements of this Recommendation | International Standard is considered to be in conformance with the requirements of this Recommendation | International Standard. The decoding process is specified such that all decoders that conform to a specified combination of capabilities known as the profile and level will produce cropped decoded output pictures that are allowed to be different within a margin or closer to the source than is produced by the described decoding process. Any decoding process that produces cropped decoded output pictures within such a specified margin to those produced by the process described herein (with the correct output order or output timing, as specified) is considered to be in conformance with the requirements of this Recommendation | International Standard.

Some design elements (such as post-filters and rendering parameters) are optional. Information related to those design elements is signalled in optional code stream segments and does not affect conformance. These optional design elements and parameters may be used together with this Recommendation | International Standard.

Versions of this Recommendation | International Standard

This is the first version of this Recommendation | International Standard.

Overview of the design characteristics

The coded representation specified in the syntax is designed to enable high compression for a desired image quality. The algorithm is not mathematically lossless, as the exact source sample values are not preserved through the encoding and decoding processes. A learnable coding solution was trained to minimize distortion between source and reconstructed sample values. A reduced set of conventional techniques are specified to enable content adaptation. Encoding algorithms are not specified within the scope of this Recommendation | International Standard, but two informative encoder specifications producing code streams conformant with the standard are included. An encoder converts the image to the tensor representation (latent tensor) and hyper tensor. The latent tensor is differentially coded using a prediction, which is generated from hyper tensor and earlier reconstructed elements of the latent tensor. The residual is the difference between latent tensor and its precision and is entropy coded with probability distribution parameters derived from the hyper tensor. On the decoder side, the reconstructed latent tensor is processed by one of several synthesis transforms, producing a reconstructed image. The reconstructed image can be optionally processed by filters for further quality improvement.

This Recommendation | International Standard supports several functionalities such as region of interest decoding and progressive decoding, and operates with images in 4:4:4, 4:2:2 or 4:2:0 colour sampling representation. The bit-depth of the image can be 8, 10, 12, 14 or 16 bits.

INTERNATIONAL STANDARD
ITU-T RECOMMENDATION

Information technology – JPEG AI learning-based image coding system: Core coding system

1 Scope

This Recommendation | International Standard specifies an image coding technology known as *JPEG AI learning-based image coding (JPEG AI)* comprising an image coding technology that facilitates the compression and processing of images for both human and machine vision. The scope of the JPEG AI Recommendation | International Standard is the creation of a learning-based image coding standard offering a single-stream, compact compressed domain representation, targeting both human visualization, with significant compression efficiency improvement over image coding standards in common use at equivalent subjective quality, and effective performance for image processing and computer vision tasks.

The core coding system describes JPEG AI standard for the human vision reconstruction task and thus specifies the JPEG AI specifies the parsing coded stream and the image reconstruction process. Only the syntax format, semantics, and associated decoding process requirements are specified, while other matters such as pre-processing, the encoding process, system signalling and multiplexing, data loss recovery, post-processing, and video display are considered to be outside the scope of this Recommendation | International Standard.

This Recommendation | International Standard is designed to be generic in the sense that it serves a wide range of applications, bit rates, resolutions, qualities and services. In the course of creating this Recommendation | International Standard, several requirements from typical applications have been considered, necessary algorithmic elements have been developed, and these have been integrated into a single syntax. Hence, this Recommendation | International Standard is designed to facilitate image data interchange among different applications and services.

2 Normative references

The following Recommendations and International Standards contain provisions which, through reference in this text, constitute provisions of this Recommendation | International Standard. At the time of publication, the editions indicated 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

– None.

2.2 Paired Recommendations | International Standards equivalent in technical content

– None.

2.3 Additional references

– Rec. ITU-T H.265 | ISO/IEC 23008-2, *Information technology – High efficiency coding and media delivery in heterogeneous environments – High efficiency video coding.*

– Rec. ITU-T H.273 | ISO/IEC 23091-2, *Information technology – Coding-independent code points – Video.*