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JPEG XE — Event coding system —

Part 1: Core coding system

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Foreword

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This document was prepared by ITU-T (as ITU Common text T.JPEG-XE) 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 26112 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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Introduction

Purpose

Recommendation ITU-T T.JPEG-XE | International Standard ISO/IEC 26112-1 specifies the core coding system of an event coding system designed to efficiently represent sequences of events, typically generated by event vision sensors, allowing interoperability between event sensing, storage, and processing applications. In addition to providing high compression efficiency, this Specification also facilitates ultra-low latency and allows for low complexity implementations with low-power consumption. The scope of JPEG XE is the creation and development of a standard to represent *Events* in an efficient way allowing interoperability between sensing, storage, and processing, targeting machine vision and other relevant applications.

The Core coding system describes the JPEG XE codestream syntax for the reconstruction task and thus specifies parsing of the coded stream and the event sequence reconstruction process.

Profiles and levels

This Specification is designed to be flexible and cover a wide range of applications, bit rates, event rates, qualities, and services. Applications include, but are not limited to, coding of event sequences for digital storage, transport of events over sensor and chip physical interfaces or networks. While creating this Specification, several use cases and their associated requirements for typical applications have been considered, necessary algorithmic elements have been developed, and these have been integrated into a single syntax. Hence, this Specification is designed to facilitate event sequence data interchange among different target applications.

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

A profile represents a subset of the entire codestream syntax that is specified in this Specification. Thus, profiles allow implementation of decoders that rely on just a subset of the complete syntax of this Specification while maintaining compliance and interoperability. By allowing only a subset of the syntax it is possible to make the trade-off between required coding performance, time- and memory complexity, coding latency, and available functionalities. Note that the encoder can always rely on a partial implementation of the syntax under the condition that it delivers a compliant codestream.

A level is a specified set of constraints imposed on values of the syntax elements in the codestream. 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 event content conforming to this Specification uses a common syntax. To achieve a subset of the complete syntax, flags, parameters, and other syntax elements are included in the codestream that signal the presence or absence of syntactic elements that occur later in the codestream.

Encoding process, decoding process, and the suite of JPEG XE standards

Any encoding process that produces codestream data that conforms to the specified codestream syntax format requirements of this Specification is considered to be in conformance with the requirements of this Specification. The decoding process is specified such that decoders that conform to a specified combination of capabilities known as the profile and level will be capable of reconstructing events from a compliant codestream that falls within the specified combination of capabilities defined by the profile and level. Decoders that lack support for the profile and level used by the codestream will be limited in what can be reconstructed. The reference software implementation Rec. ITU-T T.JPEG-XE-RS | ISO/IEC 26112-3 provides a decoder that complies to all profiles and levels.

Rec. ITU-T T.JPEG-XE-P | ISO/IEC 26112-2 specifies profiles and levels. Rec. ITU-T T.JPEG-XE-RS | ISO/IEC 26112-3 specifies the reference software which is used by the conformance tests to produce the reference decoder output. Rec. ITU-T T.JPEG-XE-C | ISO/IEC 26112-4 specifies the process of conformance tests and allowed margins for each profile and level.

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Some design elements (such as event reordering and filtering) are optional and outside of the scope of this Specification.

Versions of this Specification

This is the first version of this Specification.

Summary

Recommendation ITU-T T.JPEG-XE | International Standard ISO/IEC 26112-1 specifies an event coding system designed to efficiently represent sequences of events, typically generated by event vision sensors, allowing interoperability between event sensing, storage, and processing applications. In addition to providing high compression efficiency, this Recommendation | International Standard also facilitates ultra-low latency and allows for low complexity implementations with low-power consumption.

Core coding system describes the JPEG XE standard for reconstruction of events from the coded representation and thus specifies the coded stream parsing and event reconstruction process.

This Recommendation was developed collaboratively with ISO/IEC JTC 1/SC 29 and corresponds with ISO/IEC 26112-1 as technically aligned twin text.

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JPEG XE — Event coding system —

Part 1:
Core coding system

1 Scope

This Specification specifies the syntax and an accompanying decoding process that is capable to efficiently represent event sequences in the context of event-based vision applications, relevant in the field of computer vision and image processing.

Visual event sequences are generated by event-based (EB) vision sensors. Unlike conventional image sensors, EB vision sensors do not use a common sampling rate — known as the frame rate — for all pixels, but instead each pixel continuously tracks the amount of incident light and asynchronously samples the signal upon change. This highly efficient way of acquiring sparse data, the high temporal resolution, and the robustness to uncontrolled lighting conditions — having high dynamic range — are characteristics of the EB sensing process that make EB imaging attractive for numerous applications, like in industrial automation, process monitoring, surveillance, IoT, AR/VR, automotive and mobile environments.

This Specification:

— specifies decoding processes for converting compressed event sequence data to reconstructed event streams;

— specifies the codestream syntax containing the information necessary for interpreting the compressed event sequence data;

— provides guidance on encoding processes for converting event streams to compressed event sequence data.

2 Normative references

The following Recommendations and International Standards contain provisions which, through reference in this text, constitute provisions of this Specification. 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 Specification 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.

— None

— Rec. ITU-T T.JPEG-XE-P | ISO/IEC 26112-2— *Event coding system — Profiles and levels*

— Rec. ITU-T T.JPEG-XE-RS | ISO/IEC 26112-3— *Event coding system — Reference software*

— Rec. ITU-T T.JPEG-XE-C | ISO/IEC 26112-4— *Event coding system — Conformance*

3 Terms and definitions

For the purposes of this Specification, the following definitions apply.

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3.1
bit
binary digit (0 or 1).

3.2
byte
sequence of 8 bits, with the bits ordered from most to least significant.

3.3
byte-aligned
at a bit position in the *codestream* that is an integer multiple of 8 bits counted from the position of the first bit in the *codestream*.

3.4
codestream
syntactically well-formed sequence of *bits* conforming to this Specification.

3.5
contrast detection
observation of a change of light intensity in an event pixel.

3.6
decoder
embodiment of a *decoding process*.

3.7
decoding process
process specified in this Specification that reads a *codestream* and derives *reconstructed events* from it.

3.8
embedded event packet
HBP message with embedded variable sized payload

3.9
encoder
embodiment of an *encoding process*.

3.10
encoding process
process not specified in this Specification that produces a *codestream*.

3.11
event
message that signals the result of an observation at a precise point in time.

3.12
event pixel
pixel that can detect a light intensity transition from dark-to-light or light-to-dark.

3.13
level
defined set of constraints on the values that may be taken by the *syntax elements* and variables of this Specification.

3.14
marker
two-byte code in which the 8 most significant bits (MSBs) are set to 0xff.

3.15
marker segment
part of the codestream started with marker.

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3.16
profile
specified subset of the syntax of this Specification.

3.17
reconstructed event stream
event stream produced by applying the *decoding process*.

4 Abbreviations

For the purposes of this Specification, the following abbreviations apply.

AER	Address Event Representation
CD	Contrast Detection
EB	Event-based
EEP	Embedded Event Packet
HBP	Huffman Based Prefix
IFS	Image Frame Synchronization
IMU	Inertial Measurement Unit
LSB	Least Significant Bit
MSB	Most Significant Bit

5 Conventions

5.1 General

The term "this Specification" is used to refer to this Recommendation | International Standard.

The word "shall" is used to express mandatory requirements for conformance to this Specification. When used to express a mandatory constraint on the values of syntax elements or the values of variables derived from these syntax elements, it is the responsibility of the encoder to ensure that the constraint is fulfilled.

The word "may" is used to refer to behaviour that is allowed, but not necessarily required.

The word "should" is used to refer to behaviour of an implementation that is encouraged to be followed under anticipated ordinary circumstances, but is not a mandatory requirement for conformance to this Specification.

The content of this Specification that is identified as "informative" does not establish any mandatory requirements for conformance to this Specification and is thus not considered an integral part of this Specification. Informative remarks in the text are, in some cases, set apart and prefixed with the word "note" or "NOTE".

The word "reserved" is used to specify that some values of a particular syntax element are for future use by ITU-T | ISO/IEC and shall not be used in syntax structures conforming to this version of this Specification, but could potentially be used in syntax structures conforming to future versions of this Specification by ITU-T | ISO/IEC. Reserved values shall be set to zero and can be ignored by the decoder.

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