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Part 10: Carriage of timed metadata metrics of media in ISO base media file format

Technologies de l'information — Technologies des systèmes MPEG —

Partie 10: Transport de métriques de métadonnées de temporisation de supports au format de fichier de support en base ISO

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Foreword

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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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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

ISO/IEC 23001 consists of the following parts, under the general title *Information technology — MPEG systems technologies*:

— *Part 1: Binary MPEG format for XML*

— *Part 2: Fragment request UNITS*

— *Part 3: XML IPMP messages*

— *Part 4: Codec configuration representation*

— *Part 5: Bitstream Syntax Description Language (BSDL)*

— *Part 7: Common encryption in ISO base media file format files*

— *Part 8: Coding-independent code-points*

— *Part 9: Common encryption for MPEG-2 Transport Streams*

— *Part 10: Carriage of timed metadata metrics of media in ISO base media file format*

— *Part 11: Energy-efficient media consumption (green metadata)*

Introduction

This part of ISO/IEC 23001 specifies the carriage of timed metadata related to two fields, in files belonging to the family based on ISO/IEC 14496-12 the ISO base media file format. The two families of metadata are "green" metadata (related to energy conservation) and quality measurements of the associated media data (related to video quality metrics).

Information technology — MPEG systems technologies —

Part 10:
Carriage of timed metadata metrics of media in ISO base media file format

1 Scope

This part of ISO/IEC 23001 defines a storage format for timed metadata metrics. The timed metadata metrics can be associated with other tracks in the ISO Base Media File Format. Typical timed metadata, quality and power consumption information and their metrics, are defined in the specification for carriage in files based on the ISO Base Media File Format (ISO/IEC 14496-12 and ISO/IEC 15444-12). The timed metadata can be used for multiple purposes including supporting dynamic adaptive streaming.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 14496-10, *Information technology — Coding of audio-visual objects — Part 10: Advanced Video Coding*

ISO/IEC 23001-11, *Information technology — MPEG systems technologies — Part 11: Energy-efficient media consumption (green metadata)*

ISO/IEC 23008-2, *Information technology — High efficiency coding and media delivery in heterogeneous environments — Part 2: High efficiency video coding*

ITU-T Recommendation J.144, *Objective perceptual video quality measurement techniques for digital cable television in the presence of a full reference*

ITU-T Recommendation J.247, *Objective perceptual multimedia video quality measurement in the presence of a full reference*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 14496-10, and ISO/IEC 23008-2 apply.

3.2 Abbreviated terms

FSIG	Frame SIGnificance
MOS	Mean Opinion Score
MSE	Mean Signal Error
MS-SSIM	Multi-Scale Structural SIMilarity index
PEVQ	Perceptual Evaluation of Video Quality
PSNR	Peak Signal to Noise Ratio
SSIM	Structural SIMilarity Index
VQM	Video Quality Metric

4 Carriage of Quality Metadata

4.1 Introduction

If quality metrics are carried in an ISO Base Media File Format, they shall be carried in the metadata tracks within the ISO Base Media File Format. Different metric types and corresponding storage formats are identified by their unique code names. This section defines those quality metrics.

The metadata track is linked to the track it describes by means of a 'cdsc' (content describes) track reference.

Codes not defined in this specification are reserved and files must use only codes defined here.

4.2 Quality Metadata

4.2.1 Definition

Sample Entry Type: `'vqme'`

Container: Sample Description Box ('stsd')

Mandatory: No

Quantity: 0 or 1

The sample entry for video quality metrics is defined by the `QualityMetricsSampleEntry`.

The quality metrics sample entry shall contain a QualityMetricsConfigurationBox, describing metrics that are present in each sample, and the constant field size that is used for the values. The quality metrics are defined in 4.3.

Each sample is an array of quality values, corresponding one for one to the declared metrics. Each value is padded by preceding zero bytes, as needed, to the number of bytes indicated by field_size_bytes.

The codecs parameter value for this track as defined in RFC 6381 shall be set to 'vqme'.The sub-parameter for the 'vqme' codec is a list of the metrics present in the track as indicated by the metrics code names, joined by "+", e.g. 'vqme.psnr+mssm'.

4.2.2 Syntax

```
aligned(8) class QualityMetricsSampleEntry()
   extends MetadataSampleEntry ('vqme') {
```



```
   QualityMetricsConfigurationBox();
}
aligned(8) class QualityMetricsConfigurationBox
   extends FullBox('vqmC', version=0, 0){
   unsigned int(8) field_size_bytes;
   unsigned int(8) metric_count;
   for (i = 1 ; i <= metric_count ; i++){
      unsigned int(32) metric_code;
   }
}
```

4.2.3 Semantics

field_size_bytes indicates the constant size in byte of the value for a metric in each sample

metric_count the number of metrics for quality values in each sample

metric_code is the code name of the metrics in the sample

4.3 Quality Metrics

4.3.1 Peak Signal to Noise Ratio (PSNR)

4.3.1.1 Definition

PSNR for encoded video sequence is defined based on per-picture mean square error (MSE) differences:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left[I(i,j)-K(i,j)\right]^2$$

where I denotes luma plane of the reference $m \times n$ picture, K denotes luma plane of the reconstructed picture, and i,j denote indices enumerating all pixel locations.

The picture-level PSNR is defined as:

$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$

$$= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$

where $MAX_I = 2^B-1$ where B is the number of bits per sample in pictures.

PSNR for a given video sequence is computed as an average of all picture-level PSNR values obtained for all pictures in the sequence, i.e., for a sequence with N pictures we have

$$PSNR_{sequence} = \frac{1}{N}\sum_{n=0}^{N-1} PSNR_{picture(n)}$$

Only luma component of the video signal is used for PSNR computation.

Note 1 This is the traditional metric referred to as PSNR in the academic literature and in the context of video compression research.

Note 2 In cases when the spatial resolution of the reference pictures and the reconstructed ones do not match, reconstructed pictures must be up-sampled to match the spatial resolution of the reference

Note 3 In cases when the pictures of reconstructed video represent only a subset of pictures in the reference video sequence, reconstructed pictures must be replicated to produce time-aligned reconstructed pictures for all pictures in the reference sequence.

4.3.1.2 Metric code name

PSNR quality metric values shall be provided as ones under the 'psnr' metric code name.

4.3.1.3 Sample storage format

Each PSNR metric value shall be stored as an unsigned 16-bit integer value.

4.3.1.4 Decoding operation

Given stored 16-bit integer value x, the corresponding PSNR value (in dB) is derived as follows (expressed in floating point):

PSNR = (real) x / 100; with the exception of PSNR = infinity for x=0

4.3.2 SSIM

4.3.2.1 Definition

SSIM for encoded video sequence is defined based on SSIM index map obtained for each picture. Per-picture SSIM index map is computed as follows:

$$SSIM(x,y) = \frac{\left(2\mu_x\mu_y + c_1\right)\left(2\sigma_{xy} + c_2\right)}{\left(\mu_x^2 + \mu_y^2 + c_1\right)\left(\sigma_x^2 + \sigma_y^2 + c_2\right)}$$

where

x denotes the 8x8 window in the reference picture;

y denotes the 8x8 window in the reconstructed picture;

μ_x denotes the average sample value for pixels in x;

μ_y denotes the average sample value for pixels in y;

σ_x^2 denotes the average sample value for pixels in x;

σ_y^2 denotes the average sample value for pixels in y

σ_{xy} denotes the covariance computed for pixel values in x and y.

and where

$$c_1 = \left(k_1 L\right)^2, c_2 = \left(k_2 L\right)^2$$

are constants computed using

$$k_1 = 0{,}01, k_2 = 0{,}03, \text{and } L = 2^B - 1$$

where B is the number of bits per sample in reference video.

This formula is applied using an 8x8 sliding window, and producing a map of SSIM index values for all pixel positions within a picture. The overall SSIM index is then computed as the average of index values in the SSIM map.

This formula is applied only on luma components in each picture.

SSIM for video sequence is computed as an average of all picture-level SSIM values obtained for all pictures in the sequence, i.e., for a sequence with N pictures we have

$$SSIM_{sequence} = \frac{1}{N}\sum_{n=0}^{N-1} SSIM_{picture(n)}$$

Note 1 This is the traditional metric referred to as SSIM in the academic literature and in the context of video compression research.[1]

Note 2 The nominal range of SSIM index values is [-1..1].

Note 3 In cases when the resolution of the reference pictures and the reconstructed ones do not match, reconstructed pictures must be up-sampled to match the resolution of the reference

Note 4 In cases when the pictures of reconstructed video represent only a subset of pictures in the reference video sequence, reconstructed pictures must be replicated to produce time-aligned reconstructed pictures for all pictures in the reference sequence.

4.3.2.2 Metric code name

SSIM quality metric values shall be provided under the 'ssim' metric code name.

4.3.2.3 Sample storage format

Each SSIM metric value shall be stored as an unsigned 8-bit integer value.

4.3.2.4 Decoding operation

Given stored 8-bit integer value x, the corresponding SSIM value is derived as follows (expressed in floating point):

$$\mathrm{SSIM} = (\mathrm{real})(x - 127)/128.$$

4.3.3 MS-SSIM

4.3.3.1 Definition

MS-SSIM calculation procedure is described in Figure 1. Taking the reference and distorted image signals as the input, the system iteratively applies a low-pass filter and downsamples the filtered image by a factor of 2. The original scale is indexed by j=1 and the highest scale is indexed by j=M, for M-1 levels of iteration. Further details can be found in Reference [2].

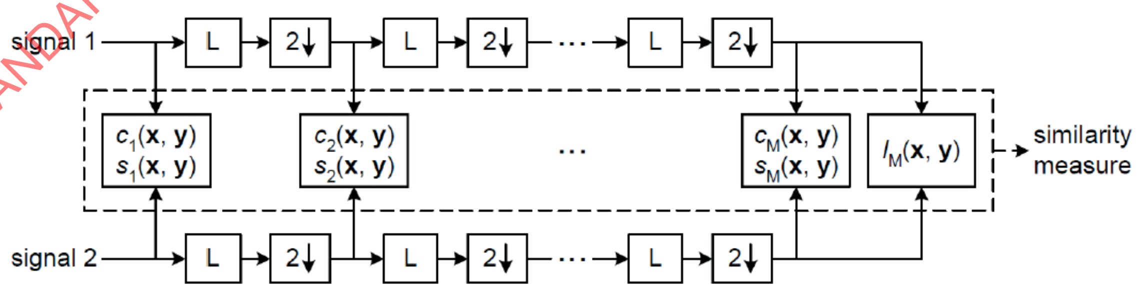

Figure 1 — MS-SSIM calculation procedure

Based on such M scales of processing, MS-SSIM for encoded video sequence is defined as follows:

$$MSSSIM(x,y) = \left[l_M(x,y)\right]^{\alpha_M} \prod_{j=1}^{M} \left[c_j(x,y)\right]^{\beta_j} \left[s_j(x,y)\right]^{\gamma_j} ,$$

where:

$c_j(x,y)$ is the contrast comparison at scale j (j=1,...M) given by $c_j(x,y) = \frac{2\sigma_x\sigma_y + C_2}{\sigma_x^2 + \sigma_y^2 + C_2}$

$s_j(x,y)$ is the structure comparison at scale j (j=1,...,M) given by $s_j(x,y) = \frac{\sigma_{xy} + C_3}{\sigma_x\sigma_y + C_3}$

$l_M(x,y)$ is the luma comparison (only computed at scale M) given by $l_M(x,y) = \frac{2\mu_x\mu_y + C_1}{\mu_x^2 + \mu_y^2 + C_1}$

where

x denotes the 8x8 window in the reference picture;

y denotes the 8x8 window in the reconstructed picture;

μ_x denotes the average sample value for pixels in x;

μ_y denotes the average sample value for pixels in y;

σ_x^2 denotes the average sample value for pixels in x;

σ_y^2 denotes the average sample value for pixels in y

σ_{xy} denotes the covariance computed for pixel values in x and y.

and where

$$C_1 = (K_1 L)^2, \quad C_2 = (K_2 L)^2, \quad C_3 = (C_2/2), \quad \alpha_j = \beta_j = \gamma_j \quad \text{and} \quad \sum_{j=1}^{M} \gamma_j = 1$$

are constants computed using

$$K_1 = 0{,}01, \quad K_2 = 0{,}03, \quad \text{and} \quad \mathrm{L} = 2^B - 1$$

where B is the number of bits per sample in reference video.

This formula is applied only on luma components in each picture.

MS-SSIM for video sequence is computed as an average of all picture-level MS-SSIM values obtained for all pictures in the sequence, i.e., for a sequence with N pictures we have

$$MSSSIM_{sequence} = \frac{1}{N} \sum_{n=0}^{N-1} MSSSIM_{picture(n)}$$

4.3.3.2 Metric code name

MS-SSIM quality metric values shall be provided under the 'msim' metric code name.

4.3.3.3 Sample storage format

Each MS-SSIM metric value shall be stored as an unsigned 8-bit integer value.

4.3.3.4 Decoding operation

Given stored 8-bit integer value x, the corresponding MS-SSIM value shall be derived as follows (expressed in floating point):

$$\mathrm{MS-SSIM} = (\mathrm{real})(x-127)/128;$$

4.3.4 VQM

4.3.4.1 Definition

VQM for encoded video sequence is defined as described in ITU-T Recommendation J.144.

4.3.4.2 Metric code name

VQM quality metric values shall be provided under the ‘j144’ metric code name.

4.3.4.3 Sample storage format

Each VQM metric value shall be stored as an unsigned 8-bit integer value.

4.3.4.4 Decoding operation

Given stored 8-bit integer value x, the corresponding VQM score is derived as follows (expressed in floating point):

$$\mathrm{VQM} = (\mathrm{real}) \times /50;$$

4.3.5 PEVQ

4.3.5.1 Definition

PEVQ for encoded video sequence is defined as described in ITU-T Recommendation J.247.

4.3.5.2 Metric code name

PEVQ quality metric values shall be provided as ones carrying ‘j247’ metric code name.

4.3.5.3 Sample storage format

Each PEVQ metric value shall be stored as an unsigned 8-bit integer value.

4.3.5.4 Decoding operation

Given stored 8-bit integer value x, the corresponding PEVQ score is derived as follows (expressed in floating point):

$$\mathrm{PEVQ} = (\mathrm{real}) \times /50;$$

4.3.6 MOS

4.3.6.1 Definition

MOS for encoded video sequence is defined as the arithmetic average of result of a set of standard, subjective tests[1] where a number of viewers rate the video sequence.

The MOS provides a numerical indication of the perceived quality from the users' perspective of received media after compression. The MOS is expressed as a single number in the range 1 to 5, where 1 is the lowest perceived quality, and 5 is the highest perceived quality. It can be obtained with reference to ITU recommendation ITU-R BT.500-12.

4.3.6.2 Metric code name

MOS quality metric values shall be provided as ones under the 'mops' metric code name.

4.3.6.3 Sample storage format

Each MOS metric value shall be stored as an unsigned 8-bit integer value.

4.3.6.4 Decoding operation

Given stored 8-bit integer value x ranging from 0 to 250 (251~255 are reserved), the corresponding MOS value is derived as follows (expressed in floating point):

$$\mathrm{MOS} = \mathrm{ceil}\left(\left(\mathrm{real}\right)\times/50\right);$$

ceil(x) is a function which gives the smallest integer not less than x.

4.3.7 Frame significance (FSIG)

4.3.7.1 Definition

FSIG, or frame significance, characterizes the relative importance of frames in a video sequence, and the sequence level visual impact from various combinations of frame losses, e.g, from dropping a temporal layer, can be estimated from this frame significance representation.

For a sequence with frames $\{f_1, f_2, ..., f_n\}$, The Frame Significance (FSIG) for frame f_k is defined as,

$$v_k = d\left(f_k, f_{k-1}\right)$$

where $d()$ is the frame difference function of two successive frames in the sequence. It is a differential function that captures the rate of change in the sequence,[5] and is computed from the Eigen appearance metric of the scaled thumbnails[4][5] of the frames,

$$d\left(f_j, f_k\right) = \left(S * f_j - S * f_k\right)^T A^T A\left(S * f_j - S * fk\right)$$

where S is the bi-cubicle smoothing and down-scaling function that brings the frames to the size of $h \times w$ pixels, and the matrix A is a metric of size d x (h x w), where d is the desired dimension of the metric. The metric A is computed from Eigen appearance modelling of thumbnail frames at size h=12, w=16, and d=12, its values are provided in the Appendix.

To characterize the QoE impact of different temporal layers in a video sequence, the visual impact of frame losses are computed from the FSIG in the following fashion. Let the frame loss index be,

$L=\{l_1, l_2, .., l_n\}$, where l_k =1 if there is a frame loss at time stamp k, and l_k=0, if no frame loss, then the frame losses induced distortion is computed as,

$$D(L)=\frac{1}{n}\sum_{k=1}^{n} l_k \sum_{j=k}^{p(k)+1} e^{-a(k-j)} v_j$$

where $p(k)$ is the last frame played in the sequence before the loss at frame time k. An exponentially decaying weight function with kernel size a=1 is introduced to model the temporal masking effects for consecutive frame losses.

4.3.7.2 Metric code name

FSIG quality metric values shall be provided as ones carrying ‘fsig‘ metric code name.

4.3.7.3 Sample storage format

Each FSIG metric value is limited to the max value of 255 and shall be stored as an unsigned 8-bit integer value.

4.3.7.4 Decoding operation

Given stored 8-bit unsigned integer value x, the corresponding FSIG value is directly decoded.

5 Carriage of Green Metadata

5.1 Introduction

If Green Metadata is carried in an ISO Base Media File Format, it shall be carried in the metadata tracks within the ISO Base Media File Format. Different Green Metadata types and corresponding storage formats are identified by their unique sample entry codes.

A metadata track carrying Green metadata is linked to the track it describes by means of a ‘cdsc’ (content describes) track reference.

5.2 Decoder Power Indication Metadata

5.2.1 Definition

Sample Entry Type: `‘depi’`

Container: Sample Description Box (‘stsd’)

Mandatory: No

Quantity: 0 or 1

The Decoder-Power Indication Metadata is defined in ISO/IEC 23001-11:2015 Energy-Efficient Media Consumption (Green Metadata). It provides decoder complexity reduction ratios for the media track to which the metadata track refers by means of ‘cdsc’ reference.

5.2.2 Syntax

The decoder power indication metadata sample entry shall be as follows.

```
class DecoderPowerIndicationMetaDataSampleEntry()
   extends MetaDataSampleEntry (‘depi‘) {

}
```

The Decoder-Power Indication sample shall conform to the following syntax:

```
aligned(8) class DecoderPowerIndicationMetaDataSample(){
   unsigned int(8) Dec_ops_reduction_ratio_from_max;
   signed int(16) Dec_ops_reduction_ratio_from_prev;
}
```

5.2.3 Semantics

Semantics are defined in ISO/IEC 23001-11.

5.3 Display Power Reduction Metadata

The Display-Power Reduction Metadata is defined in ISO/IEC 23001-11:2015 Energy-Efficient Media Consumption (Green Metadata). The Display Power Reduction Metadata provides frame statistics and quality indicators for the media track that the metadata track refers to by means of 'cdsc' reference. This Metadata allows the client to attain a specified quality level by scaling frame-buffer pixels and to reduce power correspondingly by decreasing the display backlight or OLED voltage.

Display-Power Reduction Metadata is of two types:

a) metadata that indicates power saving at different quality levels over the sample duration. This metadata shall use the 'dipi' (display power indication) sample entry type.

b) metadata that allows fine control of the display to achieve power reduction at a specified quality level. This metadata shall use the 'dfce' (display fine control) sample entry type.

Static metadata for the display fine control is stored in the sample entry. Dynamic metadata is stored in the samples.

5.3.1 Display Power Indication Metadata

5.3.1.1 Definition

Sample Entry Type: `'dipi'`

Container: Sample Description Box ('stsd')

Mandatory: No

Quantity: 0 or 1

This metadata indicates potential power saving at different quality levels over the sample duration.

5.3.1.2 Syntax

Display Power Indication Metadata shall use the following sample entry:

```
aligned(8) class DisplayPowerIndicationMetaDataSampleEntry() extends MetaDataSampleEntry
('dipi') {
}
```

The Display Power Indication sample shall use the following syntax :

```
class QualityLevels (num_quality_levels) {
   unsigned int(8) rgb_component_for_infinite_psnr;
   for (i = 1; i <= num_quality_levels; i++) {
      unsigned int(8) max_rgb_component;
      unsigned int(8) scaled_psnr_rgb;
   }
}
aligned class DisplayPowerIndicationMetaDataSample () {
   unsigned int(4) num_quality_levels;
   unsigned int(4) reserved=0;}
   QualityLevels(num_quality_levels)
}
```

Please note that the PSNR variables appearing in the syntax presented above are as defined in ISO/IEC 23001-11 and should not be confused with the PSNR metric defined in 4.2 of this specification.

5.3.1.3 Semantics

Semantics are defined in ISO/IEC 23001-11.

5.3.2 Display Fine Control Metadata

5.3.2.1 Definition

Sample Entry Type: `'dfce'`

Container: Sample Description Box ('stsd')

Mandatory: No

Quantity: 0 or 1

The Display Fine Control Dynamic Metadata is stored in the samples and is associated with one or more video frames.

The Decoding Time to Sample box provides the decoding time for the sample so that the metadata contained therein is made available to the display with sufficient lead time relative to the video composition time. Note that the video composition time and metadata composition time are identical. The lead time is required because display settings must be adjusted in advance of presentation time for correct operation. If `num_constant_backlight_voltage_time_intervals > 1`, then the lead time should be larger than the largest `constant_backlight_voltage_time_interval`.

5.3.2.2 Syntax

The Display Fine Control Metadata sample entry shall store static metadata as follows.

```
class DisplayFineControlMetaDataSampleEntry()
   extends MetaDataSampleEntry ('dfce') {
 DisplayFineControlConfigurationBox();
}

aligned(8) class DisplayFineControlConfigurationBox
   extends FullBox('dfcC', version = 0, flags = 0) {
   unsigned int(2) num_constant_backlight_voltage_time_intervals;
```

```
   unsigned int(6) reserved = 0;
   unsigned int(16)constant_backlight_voltage_time_interval[

   num_constant_backlight_voltage_time_intervals ];
   unsigned int(2) num_max_variations;
   unsigned int(6) reserved = 0;
   unsigned int(16) max_variation[ num_max_variations ];
}
```

The Display Fine Control Metadata sample shall use the following syntax:

```
class QualityLevels (num_quality_levels) {
   unsigned int(8) rgb_component_for_infinite_psnr;
   for (i = 1; i <= num_quality_levels; i++) {
      unsigned int(8) max_rgb_component;
      unsigned int(8) scaled_psnr_rgb;
   }
}
class MetadataSet (num_quality_levels) {
   unsigned int(8) lower_bound;
   if (lower_bound > 0)
      unsigned int(8) upper_bound;
   QualityLevels(num_quality_levels);
}
class DisplayPowerReductionMetaDataSample {
   unsigned int(4) num_quality_levels;
   unsigned int(4) reserved = 0;

   for (k=0; k<num_constant_backlight_voltage_time_intervals; k++)
      for (j = 0; j < num_max_variations; j++)
         MetadataSet(num_quality_levels);
}
```

5.3.2.3 Semantics

Semantics are defined in ISO/IEC 23001-11.

Annex A
(informative)

Eigen Appearance Metric Matrix Specificiation

The Eigen appearance of the frame thumbnails are represented by d=12 coefficients projected by A=[a_1^T, a_2^T,..., a_{12}^T] which are given below,

a1=[0.5637, 0.7948, 0.7851, 0.8250, 0.8072, 0.7905, 0.8612, 0.8782, 0.8421, 0.8776, 0.9065, 0.8902, 0.8844, 0.9003, 0.9013, 0.7772, 0.6060, 0.9059, 0.8250, 0.8210, 0.7832, 0.7921, 0.8573, 0.8400, 0.8286, 0.8665, 0.8988, 0.9216, 0.9188, 0.9442, 0.9504, 0.8561, 0.5635, 0.8915, 0.8870, 0.8120, 0.7668, 0.7445, 0.7463, 0.7154, 0.7147, 0.7776, 0.8056, 0.8347, 0.8719, 0.8924, 0.9227, 0.8306, 0.5855, 0.8835, 0.8648, 0.7803, 0.7410, 0.7072, 0.6743, 0.6260, 0.6196, 0.6963, 0.7460, 0.7772, 0.8069, 0.8672, 0.9117, 0.8450, 0.5869, 0.9038, 0.8820, 0.7710, 0.7229, 0.6707, 0.6302, 0.5741, 0.5419, 0.6277, 0.7011, 0.7171, 0.7424, 0.8312, 0.8934, 0.8359, 0.5652, 0.8669, 0.8668, 0.7933, 0.6967, 0.6532, 0.6198, 0.5512, 0.5139, 0.5881, 0.6448, 0.6966, 0.7656, 0.8375, 0.8937, 0.8190, 0.5560, 0.8586, 0.8606, 0.8189, 0.7268, 0.7117, 0.6671, 0.5707, 0.5779, 0.6299, 0.6975, 0.7464, 0.7726, 0.8260, 0.8890, 0.8162, 0.5704, 0.8732, 0.8580, 0.8378, 0.7418, 0.7039, 0.6949, 0.6145, 0.6218, 0.6881, 0.7322, 0.7619, 0.8090, 0.8624, 0.8842, 0.8085, 0.5777, 0.8767, 0.8470, 0.7863, 0.6685, 0.6828, 0.7224, 0.6064, 0.6112, 0.6958, 0.7424, 0.7355, 0.7861, 0.8603, 0.8939, 0.8116, 0.5465, 0.8291, 0.7953, 0.7397, 0.6258, 0.6443, 0.6623, 0.6213, 0.6356, 0.6695, 0.7067, 0.7229, 0.7111, 0.7437, 0.7721, 0.7057, 0.3266, 0.4746, 0.4481, 0.4492, 0.4418, 0.4172, 0.4059, 0.4002, 0.4049, 0.4134, 0.4216, 0.4405, 0.4335, 0.4101, 0.4274, 0.4258, 0.2554, 0.4131, 0.4401, 0.4505, 0.4508, 0.4424, 0.4269, 0.4086, 0.3949, 0.4015, 0.4035, 0.4151, 0.4314, 0.4408, 0.4476, 0.4346,]

a2=[-0.5756, -1.0646, -0.9233, -0.8619, -0.9356, -1.0360, -0.9027, -0.9101, -0.9893, -0.9654, -0.9877, -1.0265, -1.0232, -1.0157, -1.0630, -1.0707, -0.6478, -1.0293, -0.7629, -0.7996, -0.8736, -0.7677, -0.6384, -0.6009, -0.5471, -0.6105, -0.8498, -0.8735, -0.8259, -1.0498, -1.1239, -0.9199, -0.6718, -0.9221, -0.9231, -0.8848, -0.8378, -0.8236, -0.5308, -0.3908, -0.3809, -0.4991, -0.6460, -0.7472, -0.8497, -0.9599, -1.0608, -1.0007, -0.3817, -0.5613, -0.6587, -0.6254, -0.5516, -0.4667, -0.2410, 0.0523, 0.1388, -0.1232, -0.3148, -0.3745, -0.5009, -0.6176, -0.7143, -0.7899, -0.2491, -0.3857, -0.2864, -0.2468, -0.2694, -0.1260, 0.1639, 0.4451, 0.3777, 0.2464, 0.0579, -0.0288, -0.1865, -0.4067, -0.4514, -0.4410, -0.1546, -0.1912, -0.0185, 0.0243, -0.0005, 0.2102, 0.5496, 0.7468, 0.7138, 0.5656, 0.3856, 0.2989, 0.1429, -0.1112, -0.1879, -0.2278, -0.0253, 0.0340, 0.0832, 0.1855, 0.2470, 0.4501, 0.7395, 0.9126, 0.9984, 0.8508, 0.6905, 0.6608, 0.5784, 0.2831, 0.0342, -0.0803, 0.0451, 0.1190, 0.2331, 0.4031, 0.5569, 0.8529, 0.9957, 1.0738, 1.1815, 1.0830, 1.1711, 1.0447, 0.7653, 0.4478, 0.1839, -0.0015, 0.1547, 0.3178, 0.4590, 0.7580, 0.8777, 1.1366, 1.1179, 1.3218, 1.4127, 1.2906, 1.4067, 1.3865, 1.1298, 0.6237, 0.3385, 0.1060, 0.2214, 0.4425, 0.5939, 0.8598, 0.8869, 1.1357, 1.1749, 1.2390, 1.2628, 1.3530, 1.3616, 1.3106, 1.0130, 0.5601, 0.3505, 0.0774, 0.3577, 0.5456, 0.5571, 0.5963, 0.6186, 0.6724, 0.7344, 0.7861, 0.8133, 0.8001, 0.8130, 0.7817, 0.6309, 0.4718, 0.4378, 0.2889, 0.2815, 0.5002, 0.5685, 0.5778, 0.5900, 0.6558, 0.6966, 0.6907, 0.7061, 0.7245, 0.7147, 0.6840, 0.6840, 0.6203, 0.5461, 0.4408,]

a3=[0.5648, 0.7600, 0.8563, 0.9031, 0.8191, 0.7165, 0.6719, 0.6450, 0.5955, 0.6126, 0.6071, 0.6309, 0.6775, 0.7781, 0.8141, 0.6759, 0.3599, 0.4982, 0.4552, 0.4951, 0.3171, 0.2674, 0.1063, 0.0186, 0.0923, 0.1300, 0.1035, 0.1323, 0.1899, 0.2728, 0.3836, 0.3980, 0.1301, 0.1975, 0.1097, -0.0181, -0.1734, -0.3060, -0.4360, -0.4738, -0.3966, -0.3954, -0.4249, -0.4023, -0.2870, -0.1666, 0.0133, 0.1076, 0.1266, 0.0807, -0.1447, -0.3595, -0.5090, -0.6381, -0.7470, -0.7926, -0.7205, -0.7828, -0.7628, -0.6909, -0.5583, -0.3542, -0.1663, -0.0373, 0.0896, -0.0474, -0.2496, -0.5138, -0.6984, -0.8690, -0.9373, -0.9443, -0.9432, -0.9447, -0.8760, -0.7818, -0.6323, -0.4924, -0.2839, -0.0675, 0.0293, -0.1111, -0.3108, -0.5481, -0.7948, -0.8955, -0.9183, -0.8945, -0.9086, -0.8833, -0.9025, -0.7312, -0.4903, -0.4341, -0.2425, -0.0969, 0.0284, -0.1241, -0.3046, -0.5414, -0.7573, -0.8292, -0.8327, -0.8282, -0.8154, -0.7873, -0.7427, -0.6170, -0.4281, -0.3577, -0.2039, -0.0944, 0.0467, -0.1194, -0.2596, -0.4854, -0.6902, -0.7419, -0.7536, -0.6805, -0.6901, -0.6112, -0.5578, -0.4921, -0.3053, -0.2552, -0.1521, -0.0758, 0.0993, 0.0416, -0.0962, -0.1834, -0.4520, -0.4455, -0.4053, -0.4207, -0.3980, -0.2696, -0.1907, -0.1820, -0.0736, -0.0213, 0.1255, 0.1128, 0.2596, 0.3366, 0.2719, 0.2262, -0.0219, -0.0073, 0.0071, -0.0083, 0.0513, 0.1561, 0.1810, 0.2073, 0.0495, 0.0610, 0.2283, -0.0693, 0.9505, 1.4210, 1.2049, 1.3180, 1.1651, 1.1159, 1.2055, 1.3815, 1.4471, 1.3611, 1.3823, 1.3148,

