SMPTE STANDARD

for Television — A Data Reduction Method for the MPEG-2 Video Recoding Data Set

1 Scope

This standard specifies a data reduction method for the MPEG-2 video recoding data set for SDTV as defined in SMPTE 327M. The coding information is as derived from an ISO/IEC 13818 compliant MPEG bit stream during the picture decoding process, as described in ISO/IEC 13818-2.

This data-reduced MPEG-2 recoding data set may be transported by various means defined in other SMPTE standards (see annex for further details).

2 Normative references

SMPTE 319M-2000, Television — Transporting MPEG-2 Recoding Information through 4:2:2 Component Digital Interfaces

SMPTE 327M-2000, Television — MPEG-2 Video Recoding Data Set

3 Definitions

3.1 cascading: The process where video that has once been coded (compressed) is subsequently decoded and coded once more. This cascaded step could carry on for any number of generations.

3.2 coding: The process by which an uncompressed video sequence is compressed to a bit stream that conforms to the ISO/IEC 13818-2 standard.

3.3 decoder: A compressed bit stream decoder that complies with the ISO/IEC13818-2 standard.

3.4 macroblock: The four 8 by 8 blocks of luminance data and the corresponding blocks of chrominance data depending on the MPEG-2 profile coming from a 16 by 16 section of the luminance component of the picture as defined in ISO-IEC 13818-2.

3.5 macroblock rate information: The coding information from the ISO/IEC 13818-2 bit stream that relates to the individual macroblocks as defined in this standard

3.6 MPEG-2: The standard for the generic coding of moving pictures as defined in ISO/IEC 13818-2.

3.7 MPEG-2 video recoding data set: The data set for the representation of certain ISO/IEC 13818-2 MPEG coding information for the purpose of optimally cascading decoders and re-encoders as defined in SMPTE 327M

3.8 picture: Source, coded, or reconstructed image data as defined in ISO/13818-2

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3.9 picture rate information: Coding information from the ISO/IEC 13818-2 bit stream that relates to the whole picture, with some additional information derived from sequence & GoP (Group of Pictures) headers.

4 Introduction

The principal application of this standard is to preserve the quality of the decoded MPEG-2 long GoP signals when subsequently passed through compression schemes, such as DV-based at 50 Mb/s or MPEG compression at 50 Mb/s by feeding forward previous coding decisions.

In this standard, the video recoding data set defined in SMPTE 327M is data-reduced by applying compression techniques to allow this data-reduced recoding data set to pass through systems with a limited data capacity. In contrast, the SMPTE 327M standard defines subsets of this data (reduced bandwidth indicator) to reduce the bandwidth required.

The data reduction mechanism described has the advantage of being less damaging to the resultant picture quality than the simple removal of data.

The main features of this data reduction method are as follows:

- macroblock information is transmitted in the form of an MPEG-2 video elementary stream;
- coded_block_pattern and coefficient information are removed from the bit stream;
- motion vectors are transmitted to one-quarter of their usual precision;
- the remaining bits of the motion vectors are transmitted at the end of the bit stream.

The information required in the MPEG-2 video recoding data set can be broken down into two parts. These two parts consist of the picture rate information, described in clause 5, and the macroblock rate information, described in clause 6.

SMPTE 327M defines a method for signaling reduced bandwidth operation in any particular transport mechanism using the MPEG-2 video recoding data set. This standard uses that method. In the case of the present specification, for data sets that have been recoded with data-reduction, the decoder shall assume that red_bw_flag is set to 1 and that red_bw_indicator is set to “Indicator 1”. This value of red_bw_indicator indicates that coded_block_pattern, slice_start, mb_quant and skipped_mb are not transmitted. It will be noted that mb_quant and skipped macroblock information are in fact transmitted in the data-reduced bit stream, but this information is transmitted as part of the data reduction mechanism and does not automatically indicate the values of those parameters in the original MPEG-2 bit stream.

5 Picture rate information

The picture rate information consists of 4,320 bits, exactly as given in table 4 of SMPTE 319M.

If the MPEG-2 **picture_structure** is “Field picture”, then the picture rate information for the two field-pictures in the frame is transmitted in succession, a total of 8,640 bits.

6 Macroblock rate information

The macroblock rate information is transmitted immediately following the picture-rate information. It consists of two parts. The first part is essentially the picture data in an MPEG-2 video elementary stream without coefficients and containing reduced-precision motion vectors. The second part

consists of additional information which restores the precision of the motion vectors. The macro-block rate information is described in detail in the following tables.

6.1 Syntax of macroblock rate information

6.1.1 Picture data

This table is the same as 6.2.3.7 of ISO/IEC 13818-2, with the addition of motion_vector_precision_bits and its start-code. Note that if **picture_structure** is "Field picture", then the slice() information is transmitted for the two field-pictures in succession, followed by the motion_vector_precision_bits() for the two field-pictures in succession.

picture_data() {	No. of bits	Mnemonic
do {		
slice()		
} while (nextbits() = = slice_start_code)		
next_start_code()		
motion_vector_precision_bits()		
}		

6.1.2 Slice

This table is the same as 6.2.4 of ISO/IEC 13818-2, except that **slice_vertical_position_extension**, scalable modes and **extra_information_slice** are not supported. In the data-reduced video recoding data set bit stream, each slice corresponds exactly to a row of macroblocks, regardless of the slice structure of the original MPEG-2 bit stream. Any whole bytes of slice stuffing present in the original MPEG-2 bit stream are removed.

slice() {	No. of bits	Mnemonic
slice_start_code	32	bslbf
quantiser_scale_code	5	uimsbf
if(nextbits() = = '1') {		
intra_slice_flag	1	bslbf
intra_slice	1	uimsbf
reserved_bits	7	uimsbf
}		
extra_bit_slice /* with the value '0' */	1	uimsbf
do {		
macroblock()		
} while (nextbits() != '000 0000 0000 0000 0000 0000')		
next_start_code()		
}		

6.1.3 Macroblock

This table is the same as 6.2.5 of ISO/IEC 13818-2 except that coded_block_pattern() is not transmitted.

macroblock() {	No. of bits	Mnemonic
while (nextbits() = = '0000 0001 000')		
macroblock_escape	11	bslbf
macroblock_address_increment	1-11	vlclbf
macroblock_modes()		
if(macroblock_quant)		

quantiser_scale_code	5	uimsbf
if(macroblock_motion_forward ||		
(macroblock_intra && concealment_motion_vectors))		
motion_vectors(0)		
if(macroblock_motion_backward)		
motion_vectors(1)		
if(macroblock_intra && concealment_motion_vectors)		
marker_bit	1	bslbf
}		

6.1.3.1 Macroblock modes

This table is the same as 6.2.5.1 of ISO/IEC 13818-2 except that spatial_temporal_weight_code flag is never set.

macroblock_modes() {	**No. of bits**	**Mnemonic**
macroblock_type	1-9	vlclbf
if(macroblock_motion_forward || macroblock_motion_backward) {		
if(picture_structure = = 'frame') {		
if(frame_pred_frame_dct = = 0)		
frame_motion_type	2	uimsbf
} else {		
field_motion_type	2	uimsbf
}		
}		
if((picture_structure = = "Frame picture") && (frame_pred_frame_dct = = 0) && (macroblock_intra || macroblock_pattern)) {		
dct_type	1	uimsbf
}		
}		

6.1.3.2 Motion vectors

This section is the same as 6.2.5.2 of ISO/IEC 13818-2.

motion_vectors(s) {	**No. of bits**	**Mnemonic**
if(motion_vector_count = = 1) {		
if((mv_format = = field) && (dmv != 1))		
motion_vertical_field_select[0][s]	1	uimsbf
motion_vector(0, s)		
} else {		
motion_vertical_field_select[0][s]	1	uimsbf
motion_vector(0, s)		
motion_vertical_field_select[1][s]	1	uimsbf
motion_vector(1, s)		
}		
}		

6.1.3.2.1 Motion vector

This section is the same as 6.2.5.2.1 of ISO/IEC 13818-2 except that motion_residual is only transmitted for f_code values greater than 3. Pseudo-code is also provided to record for which

macroblocks, motion vectors and components the least-significant bits of the vectors will be expected in the motion_vector_precision_bits section. This information is carried in an array lsb_expected[2][MACROBLOCKS][2][2][2], all of whose elements are initialized to FALSE at the beginning of each frame.

Dual-prime additional arithmetic involving dmvector[] is performed as described in section 7.6.3.6 of ISO/IEC 13818-2 on the motion vectors resulting from the decoding process described in section 6.2 of the present document.

motion_vector(r, s) {	No. of bits	Mnemonic
motion_code[r][s][0]	1-11	vlclbf
if((f_code[s][0] != 1) && (motion_code[r][s][0] != 0)) {		
if (f_code[s][0] > 3) {		
motion_residual[r][s][0]	1-8	uimsbf
}		
if(f_code[s][0] > 2) {		
lsb_expected[0][mb][r][s][0] = TRUE;		
}		
if(f_code[s][0] > 1) {		
lsb_expected[1][mb][r][s][1] = TRUE;		
}		
}		
if(dmv == 1)		
dmvector[0]		
motion_code[r][s][0]	1-11	vlclbf
if(f_code[s][1] > 1) && (motion_code[r][s][1] != 0)) {		
if(f_code[s][1] > 3) {		
motion_residual[r][s][1]	1-8	uimsbf
}		
if(f_code[s][1] > 2) {		
lsb_expected[0][mb][r][s][1] = TRUE;		
}		
if(f_code[s][1] > 1) {		
lsb_expected[1][mb][r][s][0] = TRUE;		
}		
}		
if(dmv == 1)		
dmvector[1]		
}		

6.1.4 Motion vector precision bits

This table is specific to the data-reduced video recoding data set bitstream. It provides for the transmission of the second-least and least significant bits of the motion vectors where those bits are recorded as being expected in the lsb_expected[ ][ ][ ][ ][ ] array. Note that there is no protection against start code emulation within the data, because no further start codes can occur within the current picture.

motion_vector_precision_bits {	No. of bits	Mnemonic
motion_vector_precision_bits_start_code /* takes the value 1011 0000 */	8	uimsbf
for(mb=0; mb<MACROBLOCKS; mb++) { /* note MACROBLOCKS here is the number of macroblocks in the frame, which is either one frame-picture or two field-pictures */		

if(lsb_expected[1][mb][r][s][t]) {		
lsb[1][mb][r][s][t]	1	uimsbf
for(mb=0; mb<MACROBLOCKS; mb++) {		
if(lsb_expected[0][mb][r][s][t]) {		
lsb[0][mb][r][s][t]	1	uimsbf

6.2 Decoding the motion vectors

Each motion vector component, *vector'[r][s][t]*, shall be calculated by any process equivalent to the following one. Note that the motion vector predictors shall also be updated by this process. This section is the same as 7.6.3.1 of MPEG-2 with the following exceptions:

– The *r_size, f, delta, high, low, range, prediction* and *PMV*[*r*][*s*][*t*] variables are ¼ of their corresponding values in MPEG-2.

– The final value of *vector'[r][s][t]* is formed from the results of the motion vector calculation together with the lsb[k][mb][r][s][t] values transmitted in the bit stream.

Pseudo-code for calculating motion vectors:

```
r_size = f_code[s][t] – 3;
f = 1<<r_size
high = ( 16*f ) – 1;
low = ( ( -16)*f );
range = (32*f);

if (f = = 1) || (motion_code[r][s][t]= =0))
  delta = motion_code[r][s][t];
else {
  delta = ( ( Abs(motion_code[r][s][t])-1)*f) + motion_residual[r][s][t] + 1;
if (motion_code[r][s][t]<0)
  delta = -delta;
}

prediction = PMV[r][s][t];
if( ( mv_format = =”field” ) && ( t= =1 )&&( picture_structure = =
”Frame picture” ))
 prediction = PMV[r][s][t] DIV 2;

vector'[r][s][t] = prediction + delta;
if( vector'[r][s][t] < low)
        vector'[r][s][t] = vector'[r][s][t] + range;
if( vector'[r][s][t] > high)
        vector'[r][s][t] = vector'[r][s][t] - range;

if( ( mv_format = =”field” ) && ( t= =1 )&&( picture_structure = =
”Frame picture” ))
        PMV [r][s][t] = vector'[r][s][t]

vector'[r][s][t] = (vector'[r][s][t]<<2)-2 + ((1-lsb[1][mb][r][s][t])<<1) +  lsb[0][mb][r][s][t];
```

Note that lsb[ ][ ][ ][ ][ ] takes the value zero unless a value has been transmitted.

Annex A (informative)
Purpose of this standard

The aim of this data reduction method is to reduce the MPEG-2 video recoding data set data rate to below 1.5 Mb/s for standard definition systems so that the video recoding data set may be carried in an auxiliary transport path.

If the data-reduced video recoding data set bit stream should exceed the available capacity of the transport mechanism for a given video frame, this bit stream is truncated.

It is the responsibility of the re-encoder using this stream to take appropriate action in this eventuality.

Examples of this path include an AES-3 audio channel and the auxiliary data packets of the 50-Mb/s structure for DV-based DIF streams.

This standard exists because the data rate of SMPTE 327M (MPEG-2 video recoding data set) data exceeds the bandwidth of certain links on which it is desired to transport this information. The intention is to reduce the data rate of the SMPTE 327M data in such a way that the maximum quality benefit can be achieved from the data when transmitted on a restricted bandwidth channel such as the auxiliary data packets of the 50-Mb/s structure for DV-based DIF streams.

Verification of the validity of the data carried by this data reduction standard is beyond the scope of this standard. There are operational situations where picture information may change, but the related video recoding data carried by this standard remains unchanged. A simple example of this is where a particular picture transport system truncates the number of active lines without updating the recoding information. Implementations which may encounter this situation should ensure steps are taken to check the integrity of the data where possible.

Annex B (informative)
Bibliography

ISO/IEC 13818-2:2000, Information Technology — Generic Coding of Moving Pictures and Associated Audio Information: Video