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| *Title:* | **AHG7: Shutter interval information SEI message** | | |
| *Status:* | Input document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes an SEI message for HEVC and AVC to indicate the shutter interval associated with video content prior to encoding, decoding, and display. The proposed SEI message is shutter interval information SEI message.

To enable shutter interval information to be signaled, we propose two variations of new syntax and semantics to:

1. indicate that shutter interval values are the same or different for different temporal sub-layers; and,
2. signal one shutter interval value if all sub-layers have the same shutter angle, or signal one shutter interval value for each temporal sub-layer.
3. **Introduction**

This contribution relates to the shutter angle information SEI message [1] we proposed at the 15th meeting of JVET in Gothenburg, SE, in July, 2019. Shutter angle information can be used to improve the look of video on a display. However, the previously proposed shutter angle information SEI message did not provide timing information that would be useful to receivers of coded video. This current contribution provides such timing information while retaining the original proposed functionality, as suggested by the group during the discussion at the JVET meeting.

* 1. ***Shutter angle***

Shutter angle is a term and parameter of cinematic art that indicates shutter interval relative to frame interval. The concept and use of shutter angle was developed in the cinema industry where content has historically been created at fixed 24 fps. In cinema, shutter angle is an indicator of motion smoothness and picture sharpness. Small values of shutter angle (short shutter interval) are associated with more stutter and non-smooth motion but sharp pictures. Large values of shutter angle (long shutter interval) are associated with smooth but blurrier pictures as a result of temporal summation (motion blur).

In the fixed frame rate cinematic use case, shutter angle and shutter interval are equivalent and the interpretation of shutter angle values is well understood. However, for frame rates different than 24 fps, the interpretation of shutter angle values is not as well established. In such cases, shutter interval provides a more direct indicator of motion blur, whilst the shutter interval relative to displayed frame rate provides an indicator of motion smoothness.

* 1. ***Shutter interval and shutter angle***

Shutter interval typically indicates the amount of time that an image sensor was exposed to produce a picture; but it may also be applied to non-camera-captured content such as screen capture content and computer-generated content.

Shutter interval affects the amount motion blur (temporal summation) in video. Short shutter interval results in less motion blur and thus sharper images. Long shutter interval results in more motion blur and thus blurrier images in the direction of motion.

Shutter interval relative to frame interval (the inverse of frame rate) affects the smoothness of perceived motion [2], and is analogous to shutter angle:

shutter\_angle = 360 \* frame\_rate \* shutter interval

Short shutter interval relative to frame interval (small value of shutter angle) results in more stutter and non-smooth perceived motion compared to long shutter interval relative to frame interval (large value for shutter angle), particularly for low frame rates.

Shutter interval, as and independent parameter, and shutter interval relative to frame interval (shutter angle) are parameters that are used purposefully to adjust the look of video, particularly for professionally created content.

When original content is encoded, the coded picture rate may be different than the original frame rate. Consequently, the shutter interval relative to the coded picture interval (inverse of coded picture rate) would be different than the shutter interval relative to the original frame interval. As a result, the look of the coded video may be different than was originally intended by the content creator.

The effective shutter interval may be artificially modified by a display or other post-decode process to affect the look of displayed video. For example, synthetic motion blur may be increased or decreased to achieve a desired look.

The current versions of HEVC and AVC do not provide means of signalling shutter interval information to displays or other post-decode processes designed to achieve a desired look of displayed video. It is thus proposed to provide an SEI message to signal shutter interval information associated with content prior to encoding to enable receivers of coded video adjust the look of displayed video.

* 1. ***Temporal sub-layers***

HEVC and AVC support temporal sub-layers that enable bitstreams to be extracted at multiple picture rates. For example, as illustrated in Figure 1, a 60 Hz video sequence can be derived from a 120 Hz progressive video sequence by dropping every other picture. Similarly, a 30 Hz video sequence can be derived by dropping 3 out of every 4 pictures, and a 24 Hz video sequence can be derived by dropping 4 out of every 5 pictures.

In the example illustrated in Figure 1, the shutter interval is independent of the picture rate of the extracted bitstream. However, the shutter interval relative to the picture interval (the shutter angle) of each of the resulting videos (24, 30, 60, and 120 Hz) would be different and may thus result in a different look. For example, motion in the 24 fps video would have more stutter and be more non-smooth than the 120 Hz video.

By providing shutter interval information, a display or other post decoding process that also had access to frame rate information (or equivalent) could simulate a longer or shorter shutter interval using synthetic motion blur or other method. For example, a display might add motion blur in the 24 Hz example to reduce stutter and non-smooth motion.

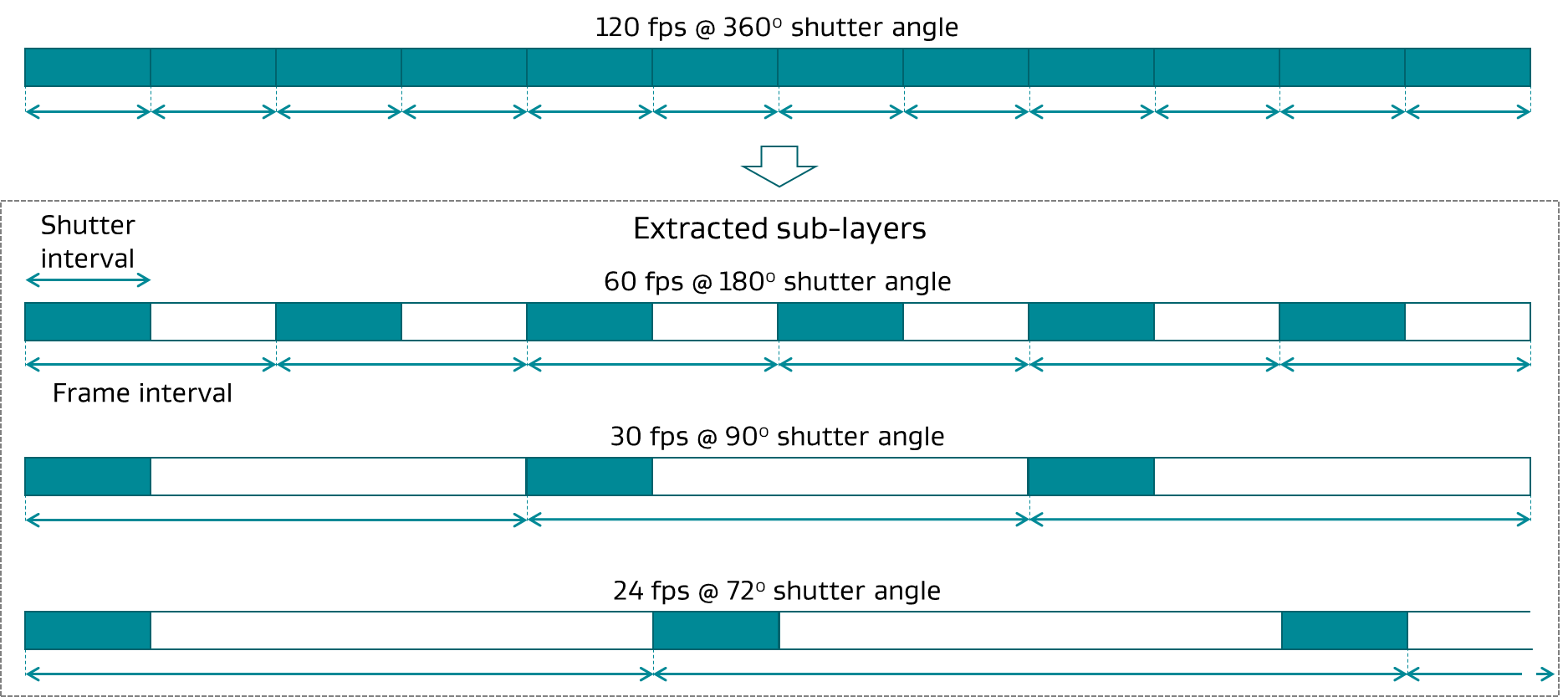


Figure illustration of using temporal sub-layers to extract bitstreams at various picture rates

* 1. ***ATSC 3.0***

As noted in JVET-M0579 [3], the fidelity of extracted temporal sub-layers to the visual look of the original video sequence, including the smoothness of motion and amount of motion blur, is an important component of meeting quality expectations in broadcast use cases, including those that use temporal sub-layering as specified in ATSC 3.0 [4].

JVET-M0579 also discusses the ATSC 3.0 Multiple Frame Rate Temporal Filtering Tool to support both high and low frame rates in a backward-compatible manner whilst avoiding stutter and non-smooth motion. The key concepts of the ATSC tool are illustrated in Figure andFigure , which are based on the ATSC 3.0 specification [4]. As an example, to create an ATSC 3.0 Multiple Frame Rate Temporal Filtering stream, temporal sub-layer 0 may be composed of pictures having a long shutter interval and temporal sub-layer 1 may be composed of pictures having a short shutter interval. Temporal sub-layers 0 and 1 may be sourced from different camera feeds (Figure 2, panel *A*) or sub-layer 0 may be synthesized from the high frame rate camera feed (panel *B*).

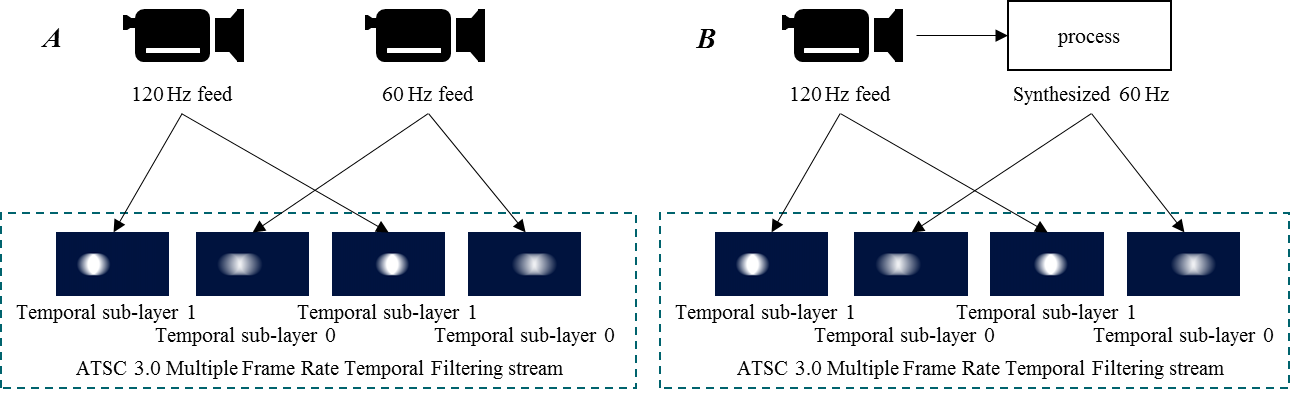


Figure Two examples of creating an ATSC 3.0 Multiple Frame Rate Temporal Filtering stream

As illustrated in Figure , the backwards-compatible low frame rate video is obtained from an ATSC 3.0 Multiple Frame Rate Temporal Filtering by extracting temporal sub-layer 0, which has the longer shutter interval and thus smoother motion for low frame rates. Also illustrated in Figure is the process of generating high frame rate video by extracting sub-layer 1 and synthesizing other short shutter interval pictures from sub-layers 0 and 1 pictures.

The ATSC 3.0 Multiple Frame Rate Temporal Filtering system would be facilitated by signalling shutter interval.

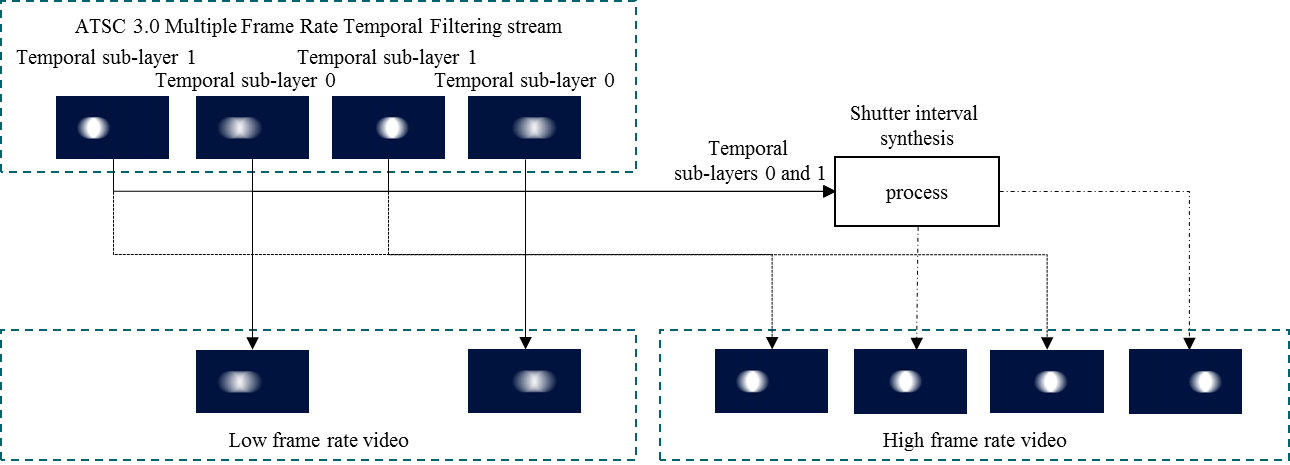


Figure recovery of low and high frame rate video from an ATSC 3.0 Multiple Frame Rate Temporal Filtering stream

The current versions of HEVC and AVC do not provide shutter interval information to displays or other post-decode processes to facilitate achieving a consistent or other desired look for different extracted temporal sub-layers.

1. **Proposal**

In this contribution, we propose a shutter interval information SEI message to HEVC and AVC.

Two variations of the syntax and semantics for shutter interval information SEI message are presented below. The variations differ with respect to signalling shutter interval for sub layers. The first variation signals a pair of values to form a ratio. The second variation signals a single value. Both variations support signalling the following:

1. fixed shutter interval for all temporal sub-layers and different shutter interval for different temporal sub-layers;
2. shutter interval equal to zero, which may be used to indicate the associated video sequence contains screen captures, computer generated content, or other non-camera-captured content;
3. shutter interval greater than coded picture interval, which may be used to indicate that the video content is coded and displayed at a frame rate greater than the frame rate at which it was created – e.g. high-speed video playback; and,
4. shutter interval is unknown or unspecified (Variant 1 enables indicating shutter interval is unknown or unspecified for each sub layer. Variant 2 enables indicating shutter interval is unknown or unspecified for all layers.)

## Variant 1

**7.3.x Shutter interval information SEI messsage syntax (variant 1)**

**Table 1.** **Shutter interval information SEI message syntax (variant 1)**

|  |  |
| --- | --- |
| shutter\_interval\_information ( payloadSize ) { | **Descriptor** |
| **sii\_num\_units\_in\_shutter\_interval** | u(32) |
| **sii\_time\_scale** | u(32) |
| **sii\_max\_sub\_layers\_minus1** | u(3) |
| **fixed\_shutter\_interval\_within\_cvs\_flag** | u(1) |
| if ( !fixed\_shutter\_interval\_within\_cvs\_flag ) |  |
| for( i = 0; i <= sps\_max\_sub\_layers\_minus1; i++ ) { |  |
| **sub\_layer\_shutter\_interval\_numer[ i ]** | u(16) |
| **sub\_layer\_shutter\_interval\_denom[ i ]** | u(16) |
| } |  |
| } |  |

**7.3.x Shutter interval information SEI message semantics (variant 1)**

The shutter interval information SEI message indicates the shutter interval for the associated video content prior to encoding and display – e.g., for camera-captured content, the amount of time that an image sensor was exposed to produce a picture.

**sii\_num\_units\_in\_shutter\_interval** specifies the number of time units of a clock operating at the frequency sii\_time\_scale Hz that corresponds to one increment of an shutter clock tick counter. Shutter interval, defined by variable ShutterInterval, in units of seconds, is equal to the quotient of sii\_num\_units\_in\_shutter\_interval divided by sii\_time\_scale. For example, when ShutterInterval is equal to 0.04 seconds, sii\_time\_scale may be equal to 27 000 000 and sii\_num\_units\_in\_shutter\_interval may be equal to 1 080 000.

**sii\_time\_scale** specifies the number of time units that pass in one second. For example, a time coordinate system that measures time using a 27 MHz clock has a sii\_time\_scale of 27 000 000.

When the value of sii\_time\_scale is greater than 0, the value of ShutterInterval is specified by:

ShutterInterval = sii\_num\_units\_in\_shutter\_interval ÷ sii\_time\_scale

Otherwise (the value of sii\_time\_scale is equal to 0), ShutterInterval should be interpreted as unknown or unspecified.

NOTE – A value of ShutterInterval equal to 0 may indicate that the associated video content contain screen capture content, computer generated content, or other non-camera-capture content.

**sii\_max\_sub\_layers\_minus1** plus 1 specifies the maximum number of temporal sub-layers that may be present in each CVS referring to the SPS. The value of sii\_max\_sub\_layers\_minus1 shall be in the range of 0 to 6, inclusive.

It is a requirement of bitstream conformance that the value of sii\_max\_sub\_layers\_minus1 in the shutter interval SEI message shall be equal to the value of sps\_max\_sub\_layers\_minus1 in the SPS.

**fixed\_shutter\_interval\_within\_cvs\_flag** equal to 1 specifies that the value of ShutterInterval is the same for all temporal sub-layers in the CVS. fixed\_shutter\_interval\_within\_cvs\_flagequal to 0 specifies that value of ShutterInterval may not be the same for all temporal sub-layers in the CVS.

**sub\_layer\_shutter\_interval\_numer**[ i ]specifies the numerator used to derive sub layer shutter interval, defined by variable subLayerShutterInterval[ i ], in units of seconds, when HighestTid is equal to i.

**sub\_layer\_shutter\_interval\_denom**[ i ]specifies the denominator used to derive sub layer shutter interval, defined by variable subLayerShutterInterval[ i ], in units of seconds, when HighestTid is equal to i.

The value of subLayerShutterInterval[ i ] for HighestTid equal to i is derived as follows. When the value of fixed\_shutter\_interval\_within\_cvs\_flag is equal to 0 and the value of sub\_layer\_shutter\_interval\_denom[ i ] is greater than 0:

subLayerShutterInterval[ i ] = ShutterInterval \* sub\_layer\_shutter\_interval\_numer[ i ] ÷  sub\_layer\_shutter\_interval\_denom[ i ]

Otherwise (the value of sub\_layer\_shutter\_interval\_denom[ i ] is equal to 0), subLayerShutterInterval[ i ] should be interpreted as unkown or unspecified. When the value of fixed\_shutter\_interval\_within\_cvs\_flag is not equal to 0,

subLayerShutterInterval[ i ] = ShutterInterval

## Variant 2

**7.3.x Shutter interval information SEI message syntax (variant 2)**

**Table 2. Shutter interval information SEI message syntax (variant 2)**

|  |  |
| --- | --- |
| shutter\_interval\_information ( payloadSize ) { | **Descriptor** |
| **sii\_num\_units\_in\_shutter\_interval** | u(32) |
| **sii\_time\_scale** | u(32) |
| **sii\_max\_sub\_layers\_minus1** | u(3) |
| **fixed\_shutter\_interval\_within\_cvs\_flag** | u(1) |
| if ( !fixed\_shutter\_interval\_within\_cvs\_flag ) |  |
| for( i = 0; i <= sps\_max\_sub\_layers\_minus1; i++ ) { |  |
| **sub\_layer\_num\_units\_in\_shutter\_interval[ i ]** | u(32) |
| } |  |
| } |  |

**7.3.x Shutter interval information SEI messsage semantics (variant 2)**

The shutter interval information SEI message indicates the shutter interval for the associated video content prior to encoding and display – e.g., for camera-captured content, the amount of time that an image sensor was exposed to produce a picture.

**sii\_num\_units\_in\_shutter** specifies the number of time units of a clock operating at the frequency sii\_time\_scale Hz that corresponds to one increment of an shutter clock tick counter. Shutter interval, defined by variable ShutterInterval, in units of seconds, is equal to the quotient of sii\_num\_units\_in\_shutter\_interval divided by sii\_time\_scale. For example, when ShutterInterval is equal to 0.04 seconds, sii\_time\_scale may be equal to 27 000 000 and sii\_num\_units\_in\_shutter\_interval may be equal to 1 080 000.

**sii\_time\_scale** specifies the number of time units that pass in one second. For example, a time coordinate system that measures time using a 27 MHz clock has a sii\_time\_scale of 27 000 000.

When the value of sii\_time\_scale is greater than 0, the value of ShutterInterval is specified by:

ShutterInterval = sii\_num\_units\_in\_shutter\_interval ÷ sii\_time\_scale

Otherwise (the value of sii\_time\_scale is equal to 0), ShutterInterval should be interpreted as unknown or unspecified.

NOTE – A value of ShutterInterval equal to 0 may indicate that the associated video content contain screen capture content, computer generated content, or other non-camera-capture content.

**sii\_max\_sub\_layers\_minus1** plus 1 specifies the maximum number of temporal sub-layers that may be present in each CVS referring to the SPS. The value of sii\_max\_sub\_layers\_minus1 shall be in the range of 0 to 6, inclusive.

It is a requirement of bitstream conformance that the value of sii\_max\_sub\_layers\_minus1 in the shutter interval SEI message shall be equal to the value of sps\_max\_sub\_layers\_minus1 in the SPS.

**fixed\_shutter\_interval\_within\_cvs\_flag** equal to 1 specifies that the value of ShutterInterval is the same for all temporal sub-layers in the CVS. fixed\_shutter\_interval\_within\_cvs\_flagequal to 0 specifies that value of ShutterInterval may not be the same for all temporal sub-layers in the CVS.

**sub\_layer\_num\_units\_in\_shutter\_interval[ i ]** specifies the number of time units of a clock operating at the frequency sii\_time\_scale Hz that corresponds to one increment of an shutter clock tick counter. Sub layer shutter interval, defined by variable subLayerShutterInterval[ i ], in units of seconds, when HighestTid is equal to i, is equal to the quotient of sub\_layer\_num\_units\_in\_shutter\_interval[ i ] divided by sii\_time\_scale.

When the value of fixed\_shutter\_interval\_within\_cvs\_flag is equal to 0 and the value of sii\_time\_scale is greater than 0, the value of subLayerShutterInterval[ i ] is specified by:

subLayerShutterInterval[ i ] = sub\_layer\_num\_units\_in\_shutter\_interval[ i ] ÷ sii\_time\_scale

Otherwise (the value of sii\_time\_scale is equal to 0), subLayerShutterInterval[ i ] should be interpreted as unknown or unspecified. When the value of fixed\_shutter\_interval\_within\_cvs\_flag is not equal to 0,

subLayerShutterInterval[ i ] = ShutterInterval

1. **Conclusion**

This contribution proposes a shutter interval information SEI message for HEVC and AVC.

Shutter interval information can be particularly useful when coded video or temporal sub-layers have picture rates different than the frame rate of associated original video content. In such situations, the look of coded video when displayed may be different than what was intended by the creator of the associated original video. For example, the displayed coded video may be perceived to have stutter and non-smooth motion or excessive motion blur compared to the associated original content.

Signalling shutter interval information associated with original content may facilitate display processing, or other post-decode processing, to improve the look, quality, and creative fidelity of coded video.

1. **References**
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3. C. Carbonara, J. DeFilippis, M. Korpi, “High Frame Rate Capture and Production”, SMPTE 2015 Annual Technical Conference and Exhibition, Oct. 2015
4. A. Segall, S. Deshpande, M. Hannuksela, “On Frame Rate Support and Extraction in VVC”, JVET-M0579, Marrakech, Morocco, Jan., 2019
5. “ATSC Standard: Video – HEVC”, Advanced Television Systems Committee, A/341:2019, 14 Feb. 2019
6. **Patent rights declaration(s)**

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