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| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  32nd Meeting: Ljubljana, SI, 12–18 July 2018 | Document: JCTVC-AF0023-v1 |

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| *Title:* | **On fisheye video information SEI message** | | |
| *Status:* | Input document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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| *Source:* | LG Electronics Inc. | | |

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# Abstract

In the fisheye video information SEI message in JCTVC-AE1005, two approaches of lens projection are defined: the polynomial coefficients based projection and the equidistant model based projection. In addition to them, other lens projection models, such as perspective projection, stereographic projection, sine-law projection, and equi-solid angle projection, could be considered for different lenses. To support variety of lenses of different applications and use cases, a new syntax element which indicates the type of the lens projection model is proposed.

# Background

In the fisheye video information SEI message in JCTVC-AE1005 [1], two approaches for lens projection are defined: the polynomial coefficients based projection and the equidistant model based projection. The former provides more accurate method for sample to unit sphere conversion by using numbers of parameters adjusted for a specific lens. Comparing to this, the latter uses simple indication to derive the recommended mapping: in the current working draft, the equidistant projection is indicated when the number of the polynomial coefficients equal to 0 and it is also allowed to assume that the equidistant projection is used when the number of the polynomial coefficients does not equal to 0.

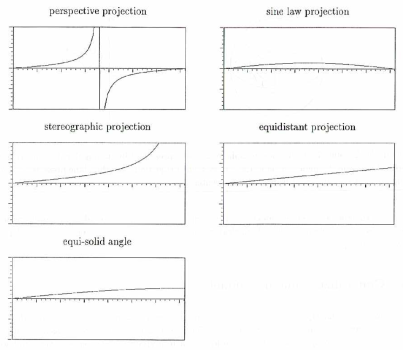


Figure 1. The radial projection functions, mapping the angles [0, 180] degrees   
onto distances from the image center [2]

While equidistant projection is widely used for fisheye lens projection, other projection models could be considered for different lens characteristics. In Figure 1, five lens projection models are described, which are perspective projection, sine-law projection, stereographic projection, equidistant projection, and equi-solid angle projection models [2]. In the theoretical lens design, perspective projection could be used to emulate wide angle lenses, which cover between 64 degrees and 84 degrees of angle of view. In case of extremely wide angle lenses, which cover over 140 degrees of angle of view, equidistant, sine law, or equi-solid projection could be used. In the other applications, such as mathematics and graphics, stereographic projection is widely used. Based on the studies of different projection geometry of lenses [2], consideration of those lens projection models is needed to use the fisheye video information SEI message in different applications and use cases.

# Proposal

In this proposal, a new syntax element which indicates the type of the lens projection models, such as equidistant, perspective, stereographic, sine-law, and equi-solid angle projections, is proposed to be defined in fisheye video information SEI message. In addition, the converting equations of a sample location of an active area to sphere coordinates are proposed corresponding to the lens projection types. In the followings, the proposed changes on the syntax elements and corresponding semantics are highlighted in yellow.

**D.2.41.3 Fisheye video information SEI message syntax**

|  |  |
| --- | --- |
| fisheye\_video\_info( payloadSize ) { | **Descriptor** |
| **fisheye\_cancel\_flag** | u(1) |
| if( !fisheye\_cancel\_flag ) { |  |
| **fisheye\_persistence\_flag** | u(1) |
| **fisheye\_view\_dimension\_idc** | u(3) |
| **fisheye\_reserved\_zero\_3bits** | u(3) |
| **fisheye\_num\_active\_areas\_minus1** | u(8) |
| for( i = 0; i  <=  fisheye\_num\_active\_areas\_minus1; i++ ) { |  |
| **fisheye\_lens\_projection\_type**[ i ] | u(4) |
| **fisheye\_reserved\_zero\_4bits** | u(4) |
| **fisheye\_circular\_region\_centre\_x**[ i ] | u(32) |
| **fisheye\_circular\_region\_centre\_y**[ i ] | u(32) |
| **fisheye\_rect\_region\_top**[ i ] | u(32) |
| **fisheye\_rect\_region\_left**[ i ] | u(32) |
| **fisheye\_rect\_region\_width**[ i ] | u(32) |
| **fisheye\_rect\_region\_height**[ i ] | u(32) |
| **fisheye\_circular\_region\_radius**[ i ] | u(32) |
| **fisheye\_scene\_radius**[ i ] | u(32) |
| **fisheye\_camera\_centre\_azimuth**[ i ] | i(32) |
| **fisheye\_camera\_centre\_elevation**[ i ] | i(32) |
| **fisheye\_camera\_centre\_tilt**[ i ] | i(32) |
| **fisheye\_camera\_centre\_offset\_x**[ i ] | u(32) |
| **fisheye\_camera\_centre\_offset\_y**[ i ] | u(32) |
| **fisheye\_camera\_centre\_offset\_z**[ i ] | u(32) |
| **fisheye\_field\_of\_view**[ i ] | u(32) |
| **fisheye\_num\_polynomial\_coeffs**[ i ] | u(16) |
| for( j = 0; j < fisheye\_num\_polynomial\_coeffs[ i ]; j++ ) |  |
| **fisheye\_polynomial\_coeff**[ i ][ j ] | i(32) |
| } |  |
| } |  |
| } |  |

***D.3.41.1.7 Conversion from a sample location of an active area to sphere coordinates relative to the global coordinate axes***

Inputs to this process are:

– the sample location (x, y) in units of luma samples,

– the centre location (xc, yc) and the radius (rc) of the circular region that contains the i-th active area, given by fisheye\_circular\_region\_centre\_x[ i ], fisheye\_circular\_region\_centre\_y[ i ], and fisheye\_circular\_region\_radius[ i ], respectively, all in units of 2−16 luma samples,

– the field of view (θv) of the lens corresponding to the i-th active area, given by fisheye\_field\_of\_view[ i ], in units of 2−16 degrees,

– the rotation parameters (αc, βc, γc), given by fisheye\_camera\_centre\_azimuth[ i ], fisheye\_camera\_centre\_elevation[ i ], and fisheye\_camera\_centre\_tilt[ i ], respectively, all in units of 2−16 degrees,

– the lens projection type of the lens corresponding to the i-th active area given by fisheye\_lens\_projection\_type[ i ], and

– the number of polynomial coefficients numCoeffs and the polynomial coefficients coeffVal[ j ] (for j ranging from 0 to numCoeffs − 1, inclusive) of the i-th active area, given by fisheye\_num\_polynomial\_coeffs[ i ] and fisheye\_polynomial\_coeff[ i ][ j ] (for j ranging from 0 to fisheye\_num\_polynomial\_coeffs[ i ] − 1, inclusive), respectively.

Outputs of this process are:

– sphere coordinates (ϕ, θ) relative to the global coordinate axes.

The method of converting a sample location of an active area to sphere coordinates is determined as follows:

– If numCoeffs is equal to 0, there is only one method of converting a sample location of an active area to sphere coordinates that is specified, which is to not use polynomial coefficients.

– Otherwise (numCoeffs is not equal to 0), there are two methods of converting a sample location of an active area to sphere coordinates that are specified, which are to not use polynomial coefficients or to use polynomial coefficients. The method using polynomial coefficients is preferred, as this method is intended to provide a more precise model of the fisheye characteristics. However, the other method may also be appropriate for some uses, as it provides a single conversion process that can be used regardless of whether numCoeffs is equal to 0 or not. This Specification does not prescribe which of the two methods is to be used in this case.

The outputs are derived as follows:

– If polynomial coefficients are not used

and if lens projection type equal to 0 (the equidistant projection model), the angle ϕ′ is derived by

ϕ′ = ( Sqrt( ( x − xc ÷ 216 )2 + ( y − yc ÷ 216 )2 ) ÷ ( rc ÷ 216 ) ) \* ( θv ÷ 216 \* π ÷ 180 ) ÷ 2 (D‑XX)

and if lens projection type equal to 1 (the perspective projection model), the angle ϕ′ is derived by

ϕ′ = Atan( Sqrt( ( x − xc ÷ 216 )2 + ( y − yc ÷ 216 )2 ) ÷ ( rc ÷ 216 ) ) \* ( θv ÷ 216 \* π ÷ 180 ) ÷ 2 (D‑XX)

and if lens projection type equal to 2 (the stereographic projection model), the angle ϕ′ is derived by

ϕ′ = Atan( Sqrt( ( x − xc ÷ 216 )2 + ( y − yc ÷ 216 )2 ) ÷ ( rc ÷ 216 ) ) \* ( θv ÷ 216 \* π ÷ 180 ) (D‑XX)

and if lens projection type equal to 3 (the sine-law projection model), the angle ϕ′ is derived by

ϕ′ = Asin( Sqrt( ( x − xc ÷ 216 )2 + ( y − yc ÷ 216 )2 ) ÷ ( rc ÷ 216 ) ) \* ( θv ÷ 216 \* π ÷ 180 ) ÷ 2 (D‑XX)

and if lens projection type equal to 4 (the equi-solid angle projection model), the angle ϕ′ is derived by

ϕ′ = Asin( Sqrt( ( x − xc ÷ 216 )2 + ( y − yc ÷ 216 )2 ) ÷ ( rc ÷ 216 ) ) \* ( θv ÷ 216 \* π ÷ 180 ) (D‑XX)

– Otherwise (polynomial coefficients are used), the angle ϕ′ is derived by

ϕ′ = ( ( coeffVal[ j ] \* 2−24 ) \* ( Sqrt( ( x – xc \* 2−16 )2 + ( y – yc \* 2−16 )2 ) ÷ ( rc \* 2−16 ) )j )  
 (D‑XX)

The outputs are then derived as follows:

θ′ = Atan2( y − yc ÷ 216, x − xc ÷ 216 )  
x1 = Cos( ϕ′ )  
y1 = Sin( ϕ′ ) \* Cos( θ′ )  
z1 = Sin( ϕ′ ) \* Sin( θ′ )  
α = ( αc ÷ 216 ) \* π ÷ 180  
β = ( βc ÷ 216 ) \* π ÷ 180  
γ = ( γc ÷ 216 ) \* π ÷ 180  
x2 = Cos( β ) \* Cos ( γ ) \* x1 − Cos( β ) \* Sin( γ ) \* y1 + Sin( β ) \* z1 (D‑XX)y2 = ( Cos( α ) \* Sin( γ ) + Sin( α ) \* Sin( β ) \* Cos( γ ) ) \* x1 +  
 ( Cos( α ) \* Cos( γ ) − Sin( α ) \* Sin( β ) \* Sin( γ ) ) \* y1 −  
 Sin( α ) \* Cos( β ) \* z1z2 = ( Sin( α ) \* Sin( γ ) − Cos( α ) \* Sin( β ) \* Cos( γ ) ) \* x1 +  
 ( Sin( α ) \* Cos( γ ) + Cos( α ) \* Sin( β ) \* Sin( γ ) ) \* y1 +  
 Cos( α ) \* Cos( β ) \* z1ϕ = Atan2( y2, x2 ) \* 180 ÷ π  
θ = Asin( z2 ) \* 180 ÷ π

**D.3.41.4 Fisheye video information SEI message semantics**

**fisheye\_lens\_projection\_type**[ i ] indicate the type of lens projection model correspond to the i-th active area. fisheye\_lens\_projection\_type[ i ] equal to 0 specifies the equidistant projection model. fisheye\_lens\_projection\_type[ i ] equal to 1 specifies the perspective projection model. fisheye\_lens\_projection\_type[ i ] equal to 2 specifies the stereographic projection model. fisheye\_lens\_projection\_type[ i ] equal to 3 specifies the sine-law projection model. fisheye\_lens\_projection\_type[ i ] equal to 4 specifies the equi-solid angle projection model. fisheye\_lens\_projection\_type[ i ] equal to 5 to 15, inclusive, are reserved for future use.

**fisheye\_reserved\_zero\_4bits** shall be equal to 0 in bitstreams conforming to this version of this Specification. Other values for fisheye\_reserved\_zero\_4bits are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore the value of fisheye\_reserved\_zero\_4bits.

# References

[1] JCTVC-AE1005, “Additional Supplemental Enhancement Information for HEVC (Draft 2)”, J. Boyce, H.-M. Oh, G. J. Sullivan, A. Tourapis, Y.-K. Wang, April, 2018, San Diego, US.

[2] Technical report 95-01, “Perspective projection: The wrong imaging model”, M. M. Fleck.

# Patent rights declaration(s)

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