



# CREATING THE LIVING NETWORK™

JVET-G0088

AHG8: On the derivation of weighted to spherically uniform PSNR (WS-PSNR) for adjusted cubemap projection (ACP) format

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# Introduction

- Adjusted cubemap projection (ACP)
  - Improves the spherical sampling uniformity of the cubemap projection (CMP) by adjusting sample coordinates in one CMP face
  - 2D-to-3D conversion

$$u = f(u') = \text{sgn}(u') \cdot \frac{0.34 - \sqrt{0.34^2 - 0.09 \cdot |u'|}}{0.18}$$

$$v = f(v') = \text{sgn}(v') \cdot \frac{0.34 - \sqrt{0.34^2 - 0.09 \cdot |v'|}}{0.18}$$

- 3D-to-2D conversion

$$u' = g(u) = \text{sgn}(u) \cdot (-0.36 \cdot u^2 + 1.36 \cdot |u|)$$

$$v' = g(v) = \text{sgn}(v) \cdot (-0.36 \cdot v^2 + 1.36 \cdot |v|)$$

- The WS-PSNR for the ACP in 360Lib-3.0

$$w_{(x',y')}^{acp} = \frac{\left(t_{x'}^2 + t_{y'}^2 + 1\right)^{-3/2}}{\sqrt{(1.36^2 - 1.44 \cdot t_{x'}) \cdot (1.36^2 - 1.44 \cdot t_{y'})}}$$

$$\text{where } t_{x'} = \frac{0.34 - \sqrt{0.34^2 - 0.09 \cdot |2(x'+0.5)/W-1|}}{0.18}, \quad t_{y'} = \frac{0.34 - \sqrt{0.34^2 - 0.09 \cdot |2(y'+0.5)/H-1|}}{0.18}$$

- It is unclear how the equation of the ACP WS-PSNR is derived

# The proposal

- The proposed WS-PSNR weight derivation for the ACP
  - Firstly derive the weight value of the corresponding sample in the CMP face
  - Secondly adjust the weight value based on the transform functions between the coordinates in the CMP face and the ACP face

- The mathematical derivation of the proposed method

- The WS-PSNR weight for each sample is proportional to the area that the sample covers on the sphere

$$Area_{sphere} = w_{(x',y')}^{acp} \cdot |dx'| |dy'| = w_{(x,y)}^{cube} \cdot |dx| |dy|$$

- The derivation of the ACP weight from the CMP weight for calculating the WS-PSNR

$$w_{(x',y')}^{acp} = w_{(x,y)}^{cube} \cdot \left| \frac{dx}{dx'} \right| \cdot \left| \frac{dy}{dy'} \right|$$

- The proposed WS-PSNR weight for the ACP

$$w_{(x',y')}^{acp} = \frac{1}{\left\{ 1 + 4 \cdot \left[ \left( \left( x + \frac{1}{2} - \frac{W}{2} \right) / W \right)^2 + \left( \left( y + \frac{1}{2} - \frac{H}{2} \right) / H \right)^2 \right] \right\}^{\frac{3}{2}}} \cdot \frac{1}{16 \cdot \sqrt{0.34^2 - 0.09 \cdot |2(x' + 0.5)/W - 1|} \cdot \sqrt{0.34^2 - 0.09 \cdot |2(y' + 0.5)/H - 1|}}$$

# Simulation results

- Simulations are based on JEM-6.0-360Lib-3.0
- The codec-based WS-PSNR values are calculated in the ACP domain
- The S-PSNR-NN values, calculated using 655352 samples (CTC), 4 million and 8 million samples, are used as comparison

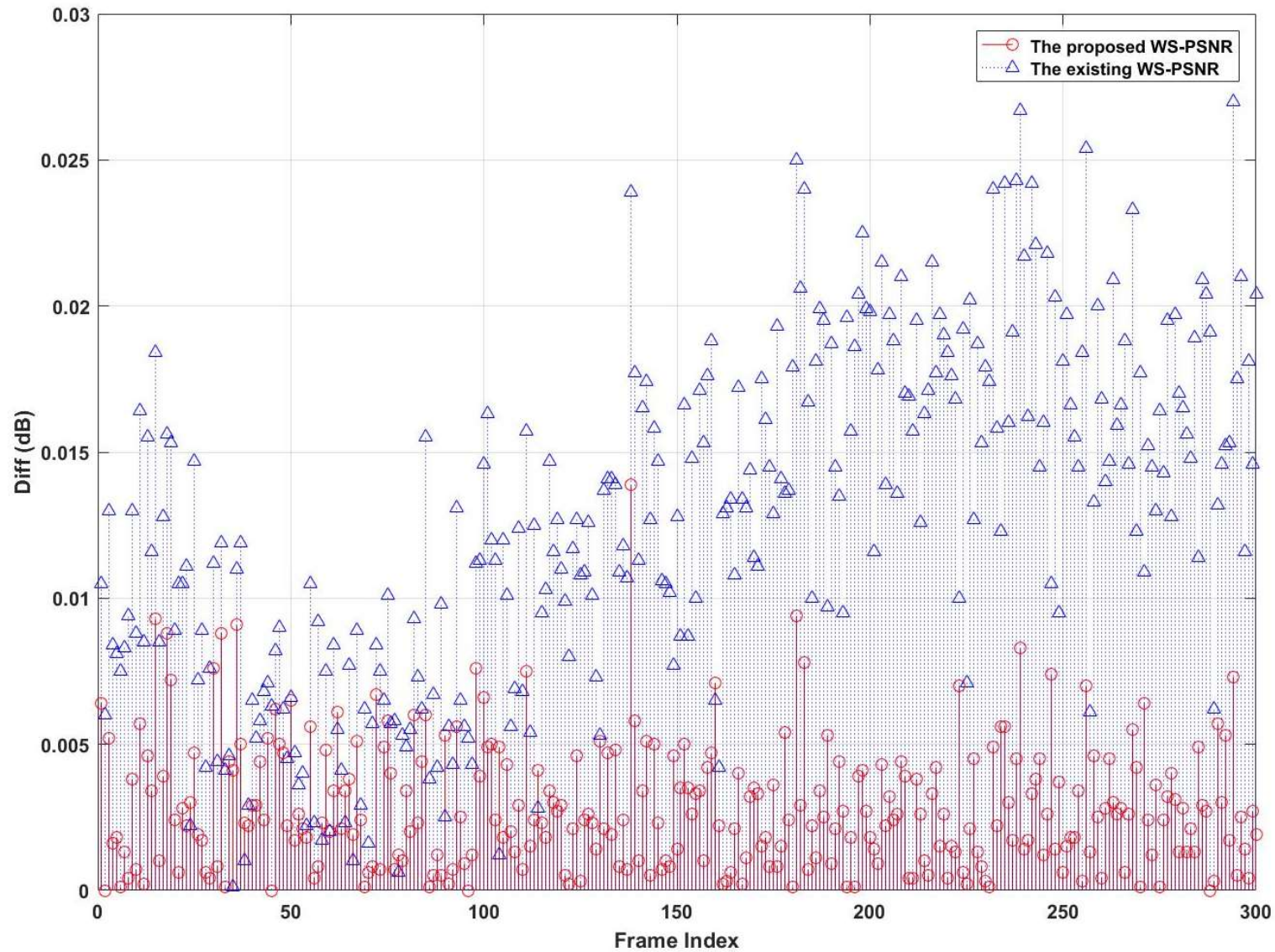
| Quality metric                                                 | Overall        |                |                |
|----------------------------------------------------------------|----------------|----------------|----------------|
|                                                                | Y              | U              | V              |
| WS-PSNR (existing)                                             | 39.3077        | 47.0260        | 47.3860        |
| WS-PSNR (proposed)                                             | 39.3240        | 47.0404        | 47.3986        |
| S-PSNR-NN (default)                                            | 39.3289        | 47.0397        | 47.3985        |
| S-PSNR-NN (4M)                                                 | 39.3249        | 47.0419        | 47.3994        |
| S-PSNR-NN (8M)                                                 | 39.3240        | 47.0406        | 47.3983        |
| <b>Delta between WS-PSNR (existing)<br/>and S-PSNR-NN (8M)</b> | <b>-0.0163</b> | <b>-0.0146</b> | <b>-0.0122</b> |
| <b>Delta between WS-PSNR (proposed)<br/>and S-PSNR-NN (8M)</b> | <b>0.0000</b>  | <b>-0.0001</b> | <b>0.0003</b>  |

## Observations

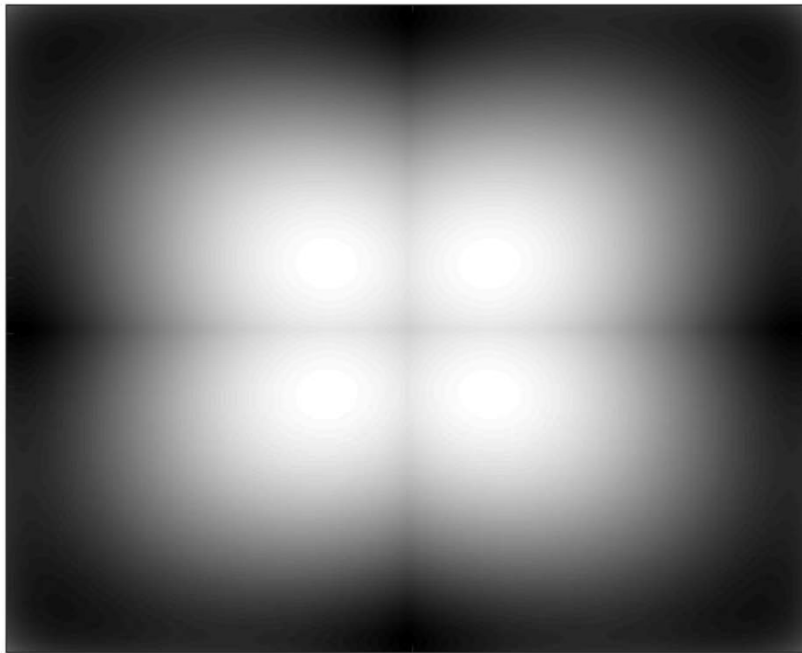
- The proposed WS-PSNR is more consistent with S-PSNR-NN
- The difference between WS-PSNR and S-PSNR-NN almost disappear when 8 million sample positions are used for S-PSNR-NN calculation



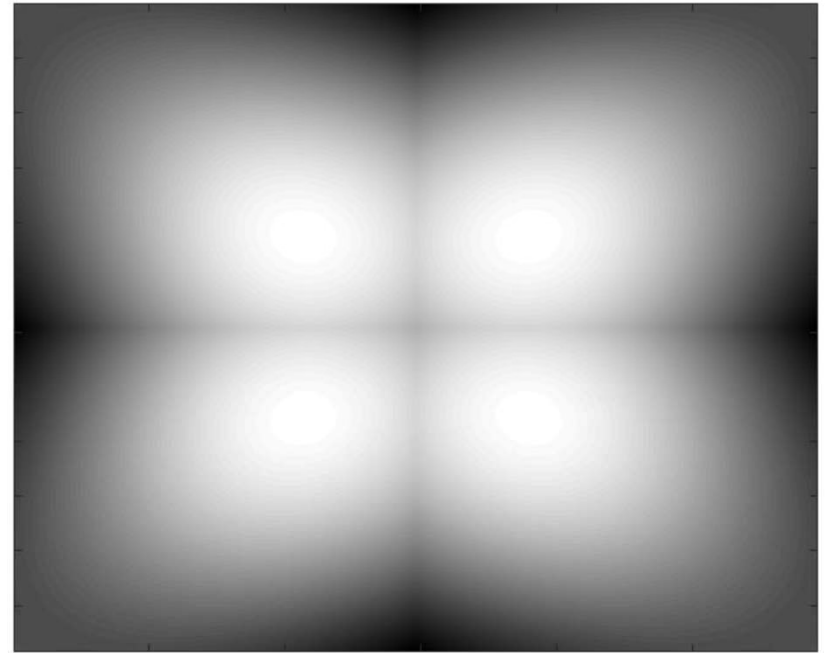
# Frame-by-frame diff btw WS-PSNR and S-PSNR-NN (8M)



# Visualized comparison of the weight values



**(a) the existing method**



**(b) the proposed method**

# Closing remarks

- A modified weight derivation method is proposed for the WS-PSNR calculation of the ACP
- Simulation results
  - The WS-PSNR value derived by the proposed method is more consistent with the S-PSNR-NN
  - The proposed method presents a more uniform distortion of the weight values in one ACP face
- It is recommended to adopt the proposed method for calculating the ACP WS-PSNR in the next release of 360Lib