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Email of convenor:	**leonardo@chiariglione.org**
Committee URL:	**http://mpeg.chiariglione.org**

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CODING OF MOVING PICTURES AND AUDIO

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Editor:	Adrian Dziembowski

1 Introduction

IV-PSNR [1] is a PSNR-based objective quality metric adapted for Immersive Video applications. Compared to PSNR, two major modifications were added: Corresponding Pixel Shift and Global Color Difference. Corresponding Pixel Shift eliminates the influence of a slight shift of objects' edges caused by reprojection errors. Global Color Difference reduces the influence of different color characteristics of different input views.

IV-PSNR for YUV file is calculated as:

$$\mathrm{IVPSNR}_{\mathrm{YUV}} = \frac{\sum_{c=0}^{2} \mathrm{IVPSNR}(c) \cdot \mathrm{CCW}(c)}{\sum_{c=0}^{2} \mathrm{CCW}(c)},$$

where $\mathrm{CCW}(c)$ is the Color Component Weight for each color component c and $\mathrm{IVPSNR}(c)$ is the IV-PSNR for that component:

$$\mathrm{IVPSNR}(c) = 10 \cdot \log\left(\frac{\mathrm{MAX}^2}{\mathrm{IVMSE}(c)}\right),$$

where MAX is the maximum value of the color component (e.g. 1023 for 10-bit video) and:

$$\mathrm{IVMSE}(c) = \frac{1}{W \cdot H} \sum_{y=0}^{H-1} \sum_{x=0}^{W-1} \min_{\substack{x_R \in [x-\mathrm{CPS}, x+\mathrm{CPS}] \\ y_R \in [y-\mathrm{CPS}, y+\mathrm{CPS}]}} (c_T(x,y,c) - c_R(x_R, y_R, c) + \mathrm{GCD(c)})^2 \ ,$$

where W and H are width and height of the image, $c_T(x,y,c)$ and $c_R(x,y,c)$ are values of color component c in the position (x,y) in the test image and the reference image, respectively, CPS is the maximum Corresponding Pixel Shift between reference and test image, and GCD is the Global Color Difference for component c:

$$\mathrm{GCD}(c) = \max\left(\frac{1}{W \cdot H}\sum_{y=0}^{H-1}\sum_{x=0}^{W-1}\left(c_R(x,y,c) - c_T(x,y,c)\right), \mathrm{MUD}(c)\right),$$

where $\mathrm{MUD}(c)$ is the Maximum Unnoticeable Difference for color component c.

In order to provide better quality assessment for omnidirectional video, WS-PSNR technique [2] was applied (however, in the current version of the IV-PSNR software only the equirectangular projection is supported):

$$\mathrm{WS\text{-}IVMSE}(c) = \frac{\sum_{y=0}^{H-1}\sum_{x=0}^{W-1}\min_{\substack{x_R\in[x-\mathrm{CPS},x+\mathrm{CPS}]\\ y_R\in[y-\mathrm{CPS},y+\mathrm{CPS}]}}(c_T(x,y,c) - c_R(x_R,y_R,c) + \mathrm{GCD}(c))^2 \cdot w_{x,y}}{\sum_{y=0}^{H-1}\sum_{x=0}^{W-1} w_{x,y}},$$

where weight $w_{x,y}$ is calculated as:

$$w_{x,y} = \cos\frac{\left(y + 0.5 - \frac{H}{2}\right)\cdot\pi}{H},$$

where x, y is a position of the pixel in ERP image and H is the height of this image.

$\mathrm{CCW}(c)$, $\mathrm{MUD}(c)$ and CPS values are predefined:

- $\mathrm{CCW}(c)$:
  - $\mathrm{CCW}(0) = 1$ (luma component),
  - $\mathrm{CCW}(1) = 0.25$ (1st chroma component),
  - $\mathrm{CCW}(2) = 0.25$ (2nd chroma component),
- $\mathrm{MUD}(c) = 1\%$ for all the color components,
- $\mathrm{CPS} = 2$.

IV-PSNR is calculated separately for each frame of the sequence. In the end, the mean IV-PSNR value is returned.

The IV-PSNR quality metric is based on PSNR, therefore, the higher the number, the better is the quality.

2 Software manual

IV-PSNR executable requires 9 parameters:

```
IV-PSNR   ref.yuv   test.yuv   W   H   NOF   BPS   CS   ERP?   out.txt
```

ref.yuv:	path to reference .yuv file
test.yuv:	path to test .yuv file
W:	video width
H:	video height
NOF:	number of frames
BPS:	bits per sample
CS:	chroma subsampling format (420 and 444 formats are supported)
ERP?:	0 if perspective, 1if ERP
out.txt:	path to output .txt file

When no parameters are used, syntax help is outputted.

3 Examples

1. IV-PSNR of SA_v04_ref.yuv and SA_v04_test.yuv. Sequence resolution is 4096x2048, YUV420, 10 bits per sample. Sequence format is ERP. Mean IV-PSNR calculated for the first 20 frames will be written into IV-PSNR.txt:

```
IV-PSNR SA_v04_ref.yuv SA_v04_test.yuv 4096 2048 20 10 420 1 IV-PSNR.txt
```

2. IV-PSNR of SD_v08_ref.yuv and SD_v08_test.yuv. Sequence resolution is 2048x1088, YUV420, 8 bits per sample. Sequence format is perspective. Mean IV-PSNR calculated for first 100 frames will be written into IV-PSNR.txt:

```
IV-PSNR SD_v08_ref.yuv SD_v08_test.yuv 2048 1088 100 8 420 0 IV-PSNR.txt
```

4 Software

MPEG Git Repository:	http://mpegx.int-evry.fr/software/MPEG/MIV/RS/IVPSNR
Public read-only access:	https://gitlab.com/mpeg-i-visual/ivpsnr
Software coordinator:	Adrian Dziembowski, adrian.dziembowski@put.poznan.pl

5 References

[1] A. Dziembowski, M. Domański, "[MPEG-I Visual] Objective quality metric for immersive video", ISO/IEC JTC1/SC29/WG11 MPEG/M48093, Jul. 2019, Göteborg, Sweden.
[2] Y. Sun, A. Lu, L. Yu, "Weighted-to-Spherically-Uniform Quality Evaluation for Omnidirectional Video", IEEE Signal Processing Letters 24.9(2017):1408-1412.