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MPEG VIDEO CODING

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Title **[MIV] Joint bit allocation for MIV with rate-distortion optimization**
Author **Soonbin Lee, Jong-Beom Jeong, Eun-Seok Ryu**

1 Introduction

The main purpose of this document is to provide the rate-distortion optimization (RDO)-based joint bit allocation results for MIV. Optimizing the bitrate allocation for texture and geometry is very important to maximize the quality of the synthesized view in the MIV. The RDO-based model is already proposed in the V-PCC, but the current MIV standard does not consider the effective bit allocation [1] yet. Thus, this contribution reports the study on the proposed method of RDO-based joint bit allocation for MIV.

2 Proposal

The total constraint bitrate R_c is the sum of the geometry bitrate and texture bitrate, where R_g is the geometry bitrate and R_t is the texture bitrate. Different bit allocation between texture video and geometry influences the quality of synthesized image. The coding distortion of both geometry and texture information determines the distortion of immersive video coding, where D_r is the distortion of the synthesized views:

$$R_c = R_t + R_g \qquad (1)$$

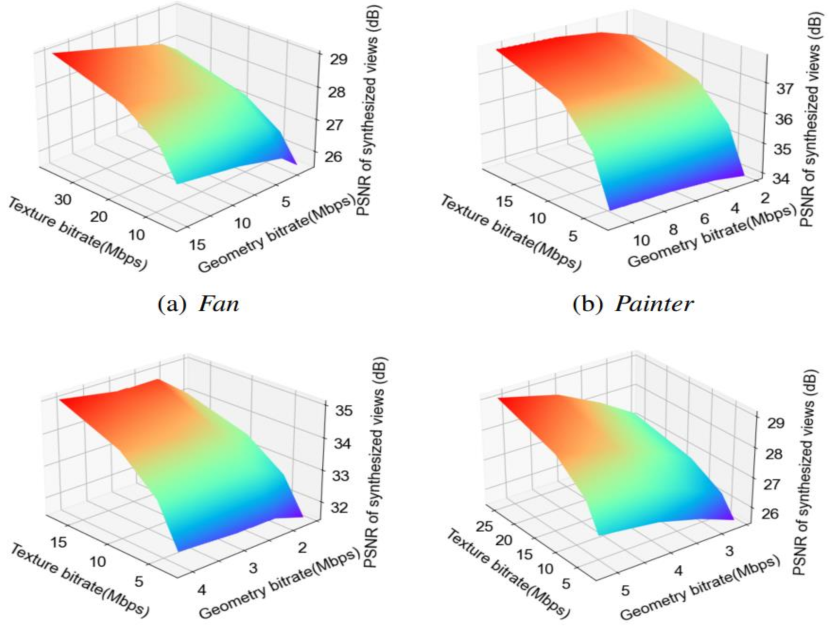
$$\arg \min_{(R_t, R_g) \in \Omega} D_r \quad \text{s.t. } R_t + R_g \leq R_c \qquad (2)$$

The proposed method solves the bit allocation problem by formulating its constrained optimization problem through deriving rate and distortion models. As the coding distortion of geometry D_g and texture D_t information determines the distortion of MVD, the bit allocation problem in immersive video coding can be expressed as [2,3]:

$$D_r \approx D_t + D_g \qquad (3)$$

where D_t is the view synthesis distortion induced by texture video compression, and D_g is the view synthesis distortion induced by geometry compression. Fig. 1 illustrates the RD surface of the quality of the synthesized views and the bitrates of immersive video test sequences. The bit allocation algorithm establishes the relationship between bitrate and view synthesis distortion to determine the best bit budget between the texture and geometry from equation:

$$
\begin{aligned}
D_t(R_t) &\cong \gamma_t R_t^{-\beta_t} \\
D_g(R_g) &\cong \gamma_g R_g^{-\beta_g}
\end{aligned}
\qquad (4)
$$



(a) *Fan* (b) *Painter*

(c) *Kitchen* (d) *Group*

Figure 1. Rate distortion surface of immersive video sequence.
(a) *Fan*, (b)*Painter*, (c) *Kitchen*, (d) *Group*

Therefore, the optimum bit allocation problem in equation (4) is for effective distribution of the bit budget between texture and geometry to achieve the minimum view synthesis distortion. The algorithm formulates the following optimum bit allocation based on the proposed RD model:

$$
\begin{aligned}
&\left(R_t^{\mathrm{opt}}, R_d^{\mathrm{opt}}\right) = \underset{(R_t, R_d)\in\Omega}{\arg min}\left(\gamma_t R_t^{-\beta_t} + \gamma_g R_g^{-\beta_g}\right) \\
&\text{s.t. } R_t + R_g \le R_c
\end{aligned}
\qquad (5)
$$

Based on pre-encoded MIV atlases with five different QP pairs, the distortion of synthesized views is calculated from these candidate QPs. Accordingly, optimized Q_t and Q_g are calculated. Fig. 3 shows the flow chart of proposed RDO-based MIV coding.

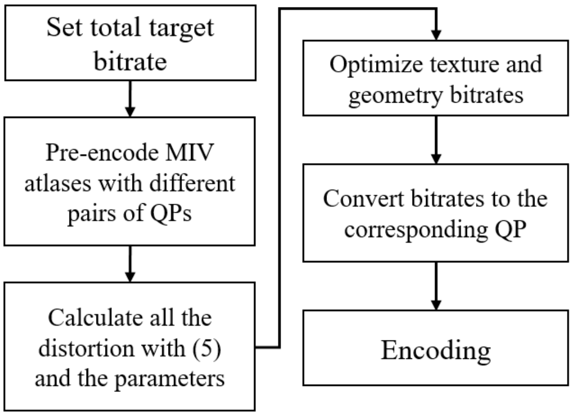


Figure 3. Flow chart of the RDO-based MIV coding

3 Experimental Results

Table 1 demonstrates the BDBR and the BDPSNR performances with the CTC QPs and the proposed joint bit allocation method. 17 pre-encoded frames determine the optimal QPs of texture and geometry for all bit allocation methods. TMIV software version 8.0 and the HEVC test model (HM) reference software version 16.16 were used to encode texture video [4]. QP points of each video sequence are matched to the target bitrates {5, 9, 16, 28} Mbps.

	CTC QPs v.s. RDO-based			
	BDBR(%)	BDPSNR(dB)	IV-BDBR(%)	IV-BDPSNR(dB)
Painter	-47.96%	1.61	-49.44%	1.68
Frog	-30.19%	1.02	-34.22%	1.23
Carpark	-31.91%	1.15	-36.99%	1.42
Fan	-41.12%	1.52	-40.88%	1.69
Kitchen	-1.47%	0.03	-0.65%	0.01
Group	-9.96%	0.22	-2.23%	0.05

Table 1. Performance comparison with CTC QPs

4 Conclusion

This document represents a new joint bit allocation method for MIV. Its experimental results conducted with TMIV 8.0 and HM 16.16 clearly show that the RDO-based model improves the coding performance significantly. Thus, this document recommends:

- Adoption of the new joint bit allocation method into the MIV test model.
- Further study on this method with the newest and updated CTC.

5 References

[1] "RDO-based joint bit allocation for V-PCC", Li Cui, XiangYu Ye and E. S. Jang, ISO/IEC JTC1/SC29/WG7 input document m55393, October 2020, online meeting.

[2] H. Yuan, Y. Chang, J. Huo, F. Yang, and Z. Lu, "Model-based joint bit allocation between texture videos and depth maps for 3-d video coding," IEEE Transactions on Circuits and Systems for Video Technology, vol. 21, no. 4, pp. 485–497, 2011.

[3] F. Shao, G. Jiang, M. Yu, K. Chen, and Y.-S. Ho, "Asymmetric coding of multi-view video plus depth based 3-d video for view rendering," IEEE Transactions on Multimedia, vol. 14, no. 1, pp. 157–167, 2012.

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