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Title: **Global Disparity Compensation for Multi-view Video Coding**

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1. Introduction

This document describes the global disparity compensation for multi-view video coding (MVC). After we explain the global disparity and its compensation in Section 2, we present our experimental results and show the effectiveness of the proposed method in Section 3.

2. Global Disparity Compensation

Due to the global disparity, current MVC schemes employ a large search range for view prediction and this makes it difficult to expand the GOP structure for view prediction [1]. The proposed algorithm compensates for the global disparity by shifting the reference frame as much as the global disparity [2].

Fig. 1. Global Disparity between Exit_0 and Exit_1

2.1 Global Disparity

Multi-view video coding uses the multi-view video sequences taken by several cameras. So, there exists a disparity called global disparity between adjacent views.

Figure 1 shows the global disparity between Exit_0 and Exit_1. Exit_1 looks like the shifted version of Exit_0 by the shaded area.

Following simulation results show the needs of global disparity consideration. We simulate the coding efficiency for various search range. We use the IPPP GOP structure, QP=31, and view-interlaced structure as shown in Fig. 2.

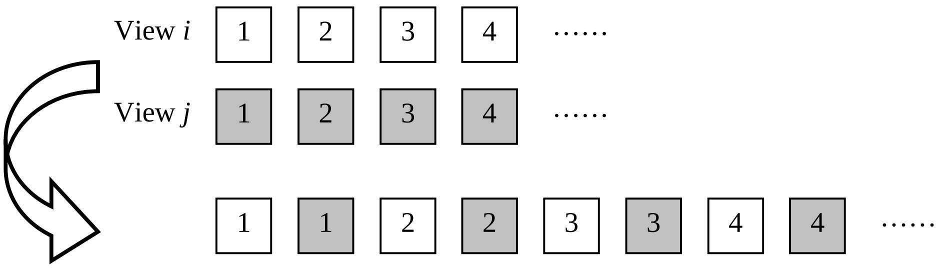

Fig. 2. View-interlaced Sequence

Table 1 shows the simulation results. As you can see, coding efficiency increases up to a certain size of search range, however it is saturated over a certain point. It means that the boundary search range is proper for that structure**.**

Table 1. Simulation Results of “Exit_3 and Exit_5”

Search range	16	32	64	96	128	160
PSNR	38.054	37.928	37.889	37.885	37.875	37.881
Bitrate (kbps)	1340.98	1171.45	1114.11	1111.56	1105.74	1108.33

2.2 Global Disparity Calculation

To obtain an accurate global disparity, we use the binary image instead of original image. The binary image is less sensitive to the illumination change and other color changes. And then, we apply a disparity measure like Eq. (1). img0 and img1 in Fig. 3 are two pictures for global disparity calculation and R is the number of pixels in the overlapped area.

$$(g_x, g_y) = \min_{x,y} \left[\frac{\sum_{i,j \in R} \left| img0(i,j) - img1(i-x, j-y) \right|}{R} \right] \qquad (1)$$

Fig. 3. Global Disparity Calculation using Binary Images

2.3 Global Disparity Compensation

By using the calculated global disparity, we can compensate the global disparity. Before motion estimation, we shift the reference frame as much as the global disparity. And then, we pad outside of the boundary by copying the boundary pixel values. From the Fig. 4, 5, 6, and 7, you can easily understand the procedure of global disparity compensation. The picture in Fig. 4 is the frame to be encoded as B frame, and two pictures in Fig. 5 are reference frames for that. As you can see, there exist the global disparities between pictures in Fig. 4 and Fig. 5. So, we need large search range in the motion estimation process to search the proper region.

Fig. 4. Frame to be Encoded as B frame

Fig. 5. Two Reference Frames for Fig. 4 (Top: List0, Bottom: List 1)

However, if we shift the reference frame as much as the global disparity, we do not need the large such range anymore. Figure 6 shows the global disparity compensated pictures. As you see, all objects in the picture are located at similar positions compared with the Fig. 4. Some outer pixels do not have pixel values, because we move the reference frames. So, we copy the values of the boundary as shown in Fig. 7.

Fig. 6. Global Disparity Compensated Pictures (Top: List0, Bottom: List 1)

Fig. 7. After Padding of the Outer Pixels (Top: List0, Bottom: List 1)

To demonstrate the efficiency of the global disparity compensation, we introduce one simple experiment and show its results. We use the full search mode in motion estimation instead of the fast search mode and encode just three frames using I-B-I structure for “Exit” sequence. A quantization parameter (QP) is 31. Table 2 shows the coding results of B picture when search range varies from 32 to 128. In this case, global disparities are (-75, 0) and (126, 0). As you can see, the proposed algorithm shows better results and it is less sensitive to change of the search range. Therefore, we can know that global disparity compensation improves the coding efficiency of MVC and it also leads to shorter encoding time.

Table 2. Coding Results for Global Disparity Compensation

Search Range	Bit Rate (bits)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
32	56272	45096	38.1103	38.0668
64	49096	44224	37.9909	38.0532
96	45480	44360	37.9919	38.0622
128	44136	44352	38.0649	38.0589

3. Experimental Results and Analysis

In order to evaluate the proposed method, we have experimented with “Exit”, “Ballroom”, “Race1”, and “Uli” sequences. For each sequence, three search ranges (8, 16, and 32) and three bit rate are used. The following tables and figures show the coding results of the proposed method compare to the results of the reference software. For more details see the attached excel file. As you can see, most results of the proposed scheme are better than the ones of the reference software. Especially, smaller search range shows better results. The more global disparity values are large, the more coding gains are obtained.

Table 3. Coding Results for “Exit” Sequence (Search Range = 8)

Basis QP	Bit Rate (kbps)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
31	225.3965	207.5966	36.7711	36.8364
29	281.8687	261.6957	37.5198	37.5773
26	422.223	397.0089	38.5535	38.5935

Table 4. Coding Results for “Exit” Sequence (Search Range = 16)

Basis QP	Bit Rate (kbps)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
31	215.2517	201.1167	36.8097	36.8607
29	270.1393	254.1260	37.5571	37.5992
26	409.4742	388.4348	38.5786	38.6056

Table 5. Coding Results for “Exit” Sequence (Search Range = 32)

Basis QP	Bit Rate (kbps)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
31	200.7635	196.0792	36.8467	36.8731
29	254.0064	248.3927	37.5877	37.6114
26	389.2278	381.4437	38.5988	38.6186

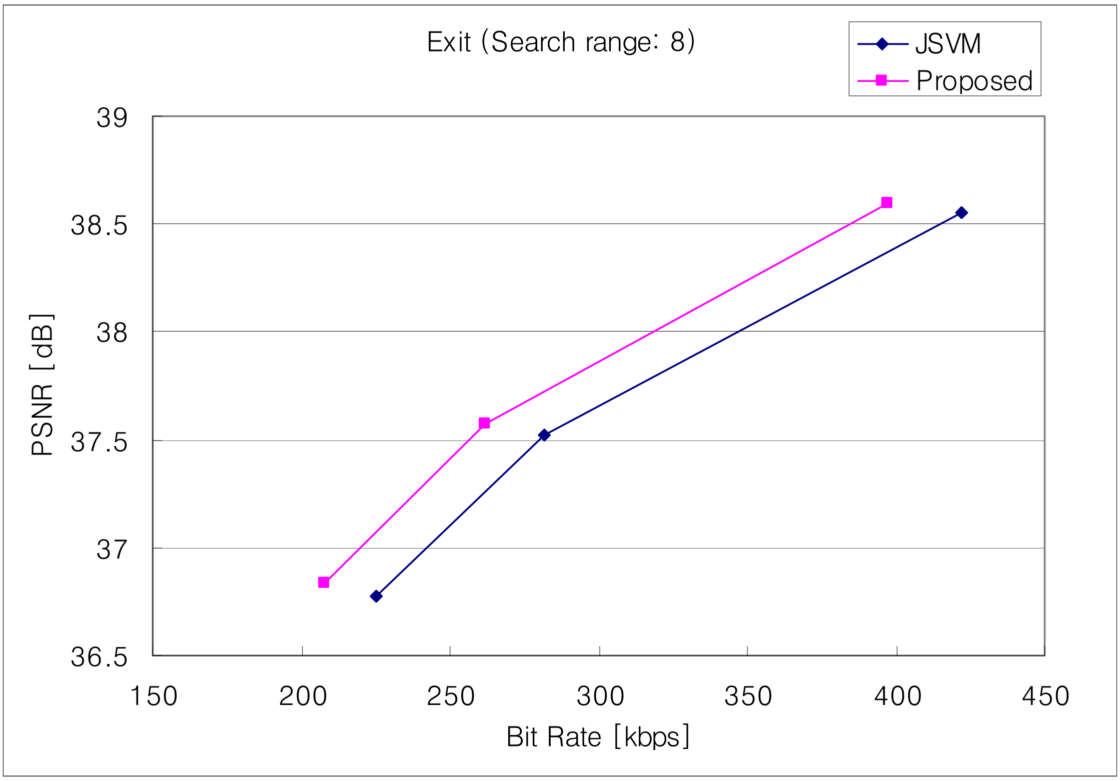

Fig. 10. Rate-Distortion Curve for “Exit” (Search Range = 8)

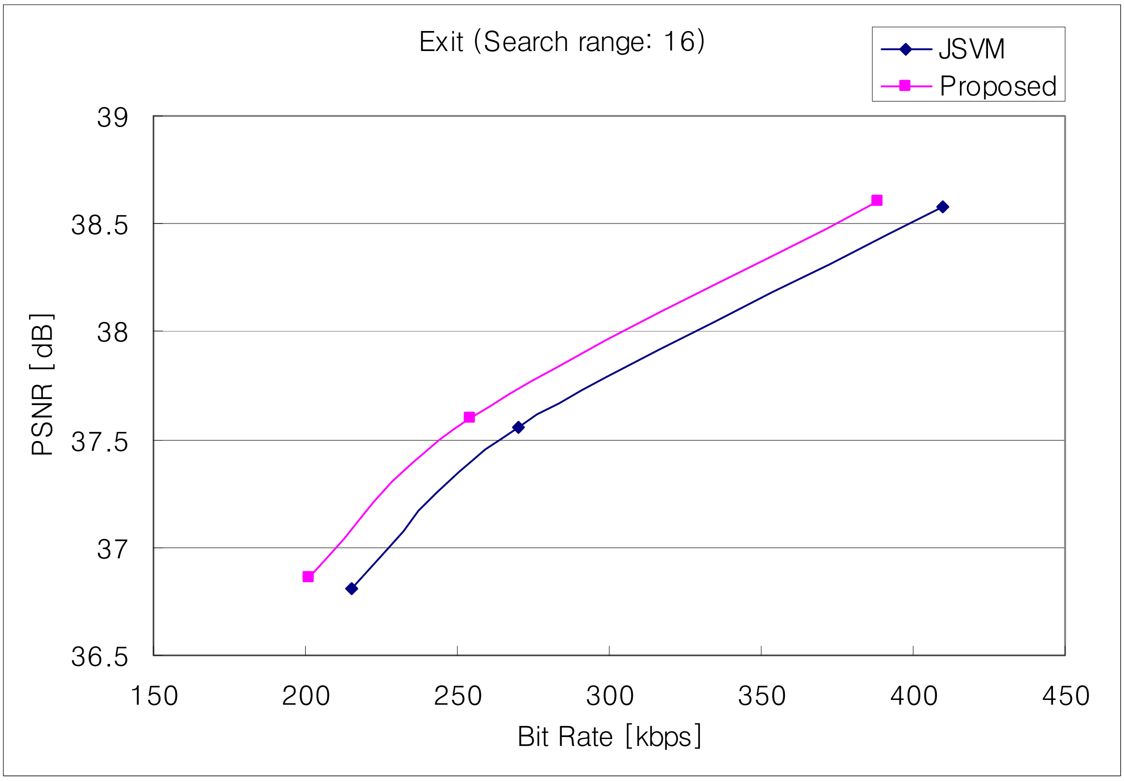

Fig. 11. Rate-Distortion Curve for “Exit” (Search Range = 16)

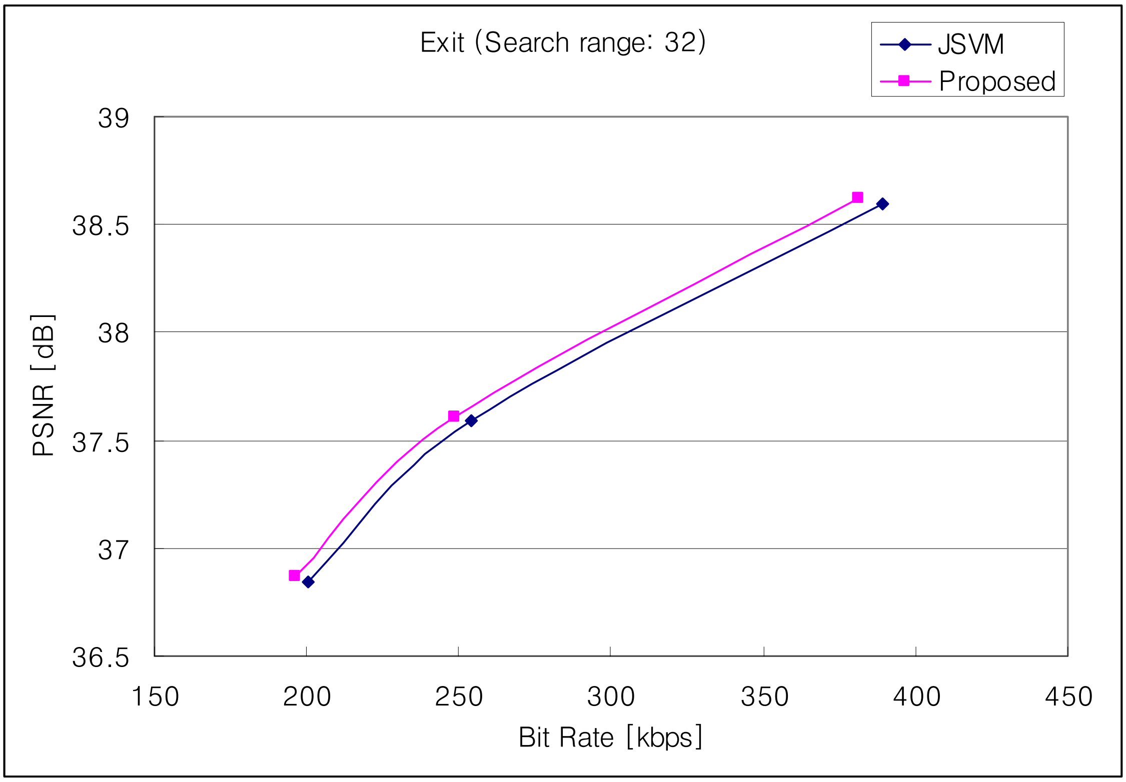

Fig. 12. Rate-Distortion Curve for “Exit” (Search Range = 32)

Table 6. Coding Results for “Ballroom” Sequence (Search Range = 8)

Basis QP	Bit Rate (kbps)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
34	296.8733	290.9902	33.1184	33.1392
31	424.7817	418.7413	34.7413	34.7570
29	539.4065	532.0914	35.7373	35.7499

Table 7. Coding Results for “Ballroom” Sequence (Search Range = 16)

Basis QP	Bit Rate (kbps)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
34	284.1172	281.4938	33.1438	33.1504
31	409.3903	406.8826	34.7613	34.7704
29	522.0857	519.2054	35.7527	35.7609

Table 8. Coding Results for “Ballroom” Sequence (Search Range = 32)

Basis QP	Bit Rate (kbps)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
34	274.4390	274.1711	33.1608	33.1682
31	398.1177	398.0155	34.7754	34.7820
29	509.2276	509.8091	35.7649	35.7711

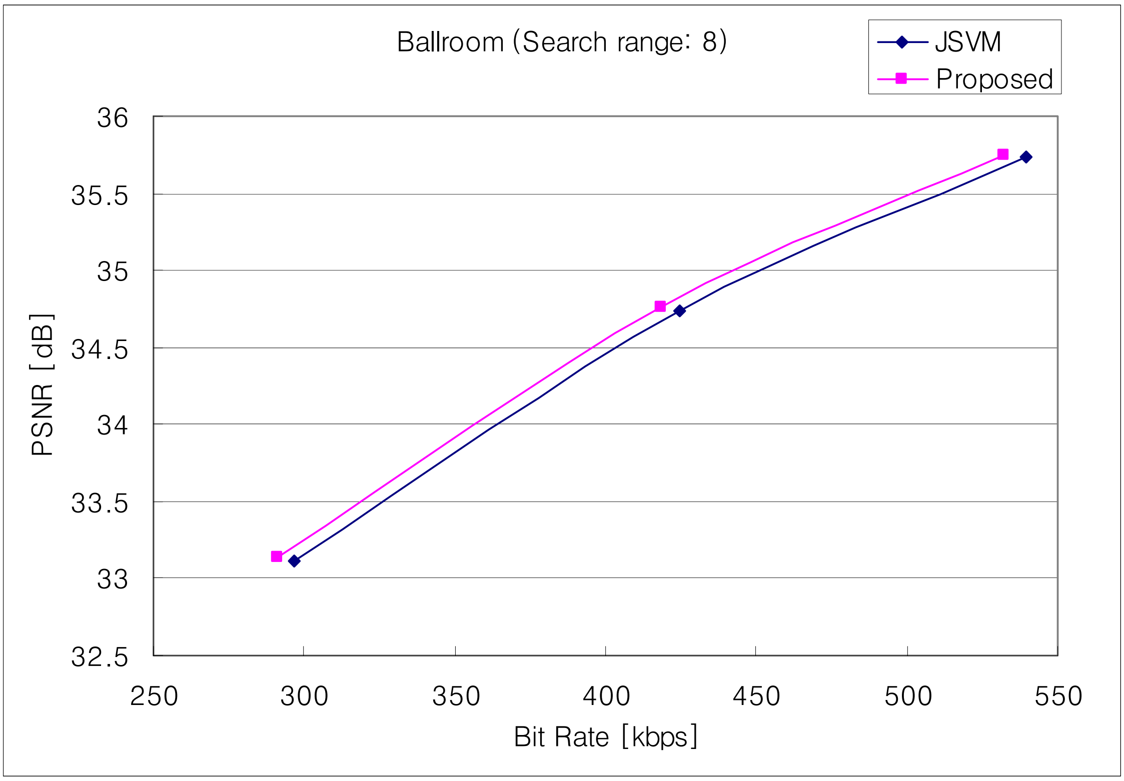

Fig. 13. Rate-Distortion Curve for “Ballroom” (Search Range = 8)

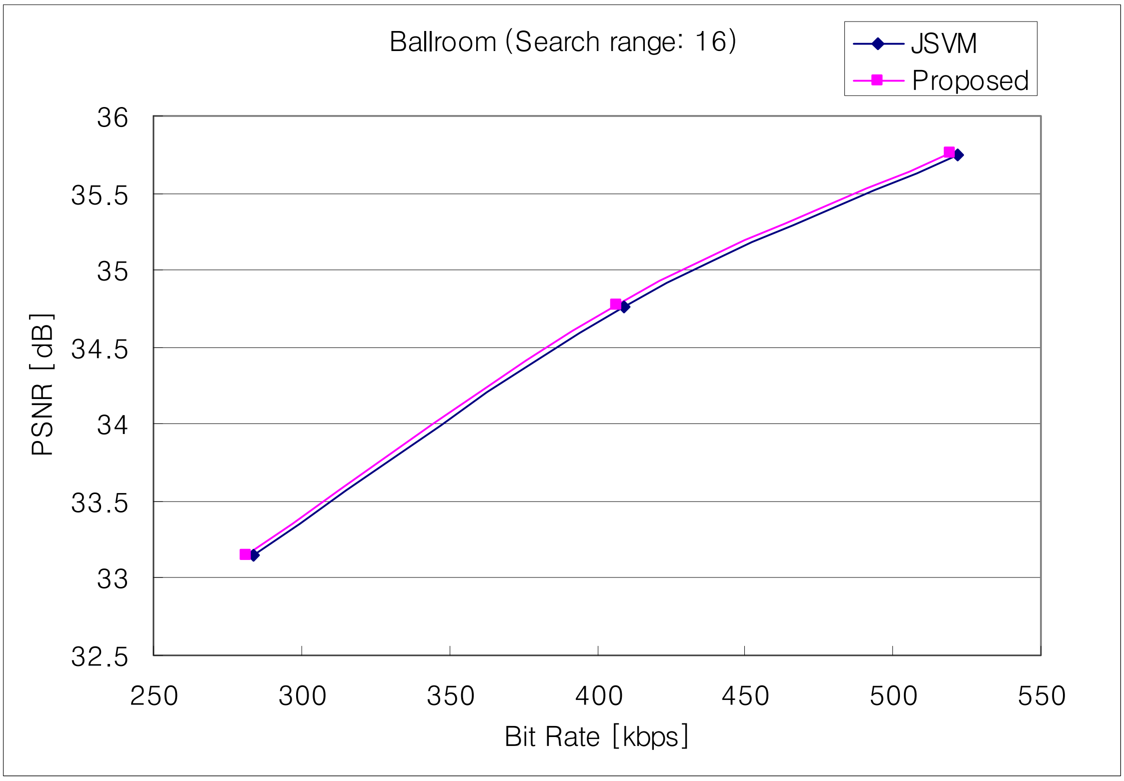

Fig. 14. Rate-Distortion Curve for “Ballroom” (Search Range = 16)

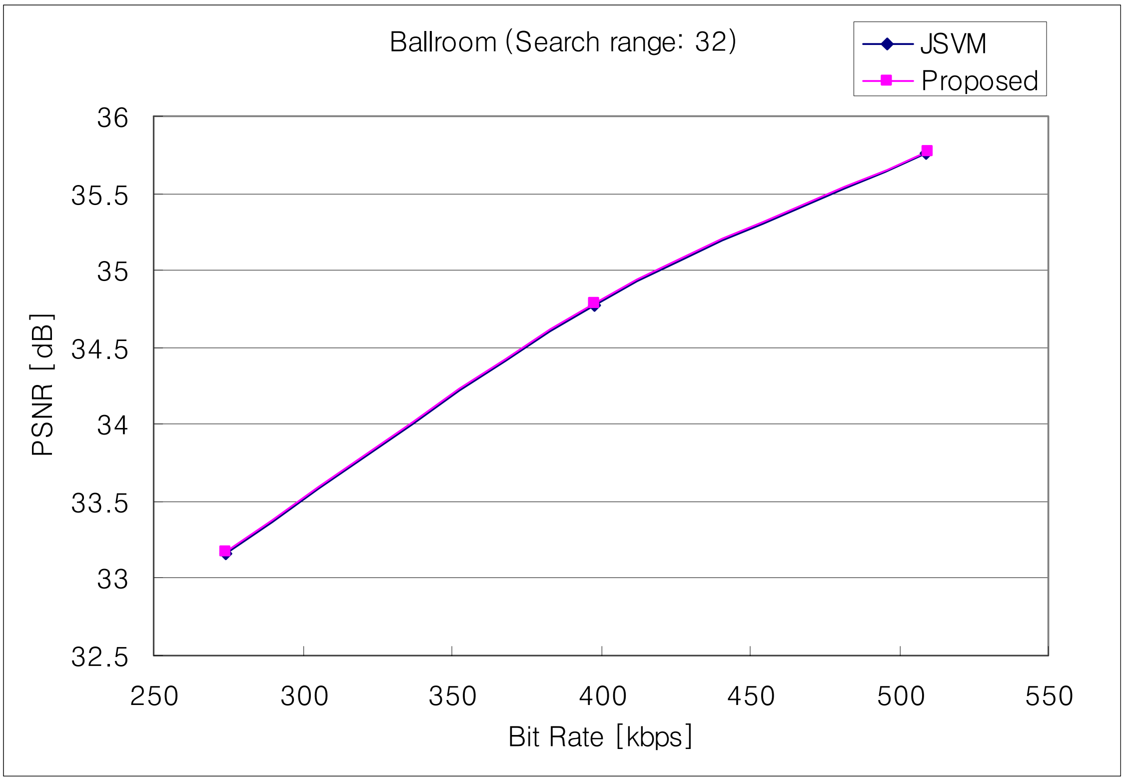

Fig. 15. Rate-Distortion Curve for "Ballroom" (Search Range = 32)

Table 9. Coding Results for "Race1" Sequence (Search Range = 8)

Basis QP	Bit Rate (kbps)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
28	570.2616	553.1940	37.2086	37.2461
26	736.3945	720.0177	38.2589	38.2901
24	970.8349	955.8798	39.3494	39.3785

Table 10. Coding Results for "Race1" Sequence (Search Range = 16)

Basis QP	Bit Rate (kbps)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
28	520.9102	523.9526	37.2861	37.3083
26	681.7470	686.9382	38.3175	38.3328
24	908.2832	918.2905	39.4015	39.4120

Table 11. Coding Results for "Race1" Sequence (Search Range = 32)

Basis QP	Bit Rate (kbps)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
28	483.1812	491.4911	37.3635	37.3681
26	637.1638	647.9756	38.3823	38.3859
24	857.1673	968.8114	39.4529	39.4581

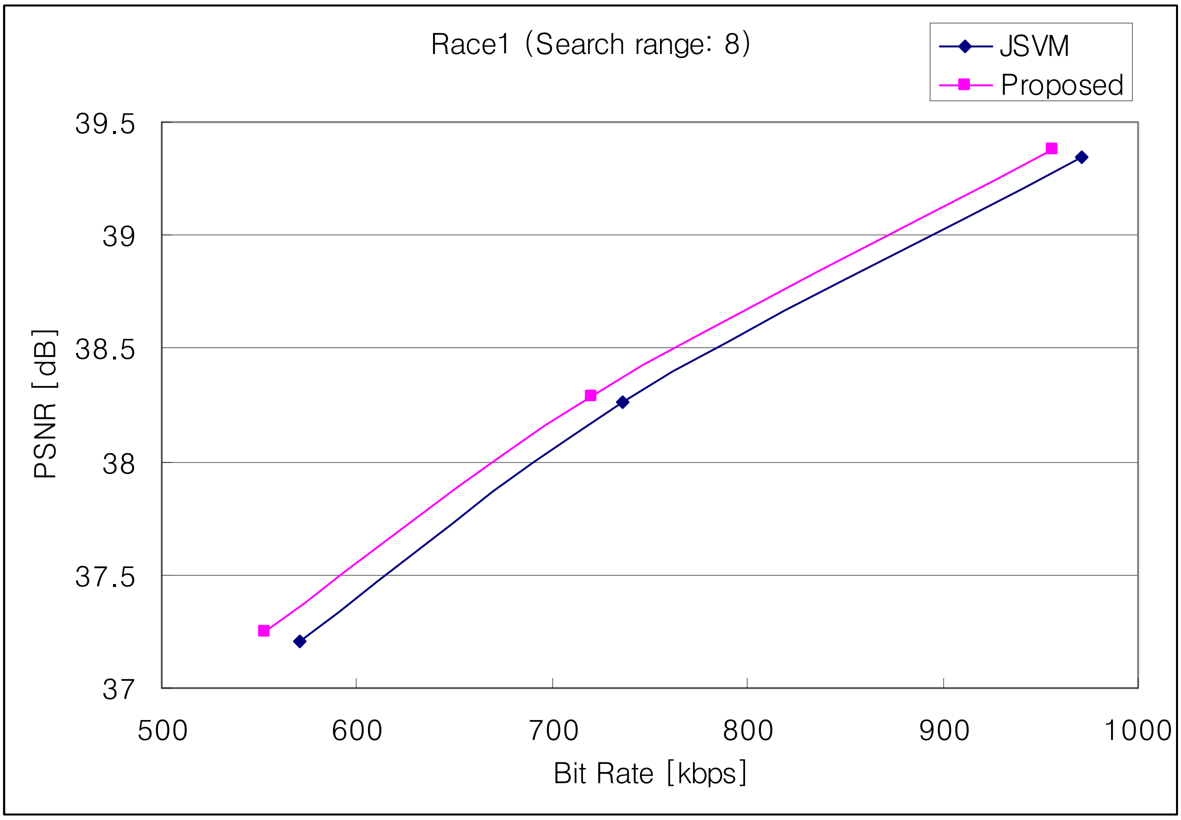

Fig. 16. Rate-Distortion Curve for “Race1” (Search Range = 8)

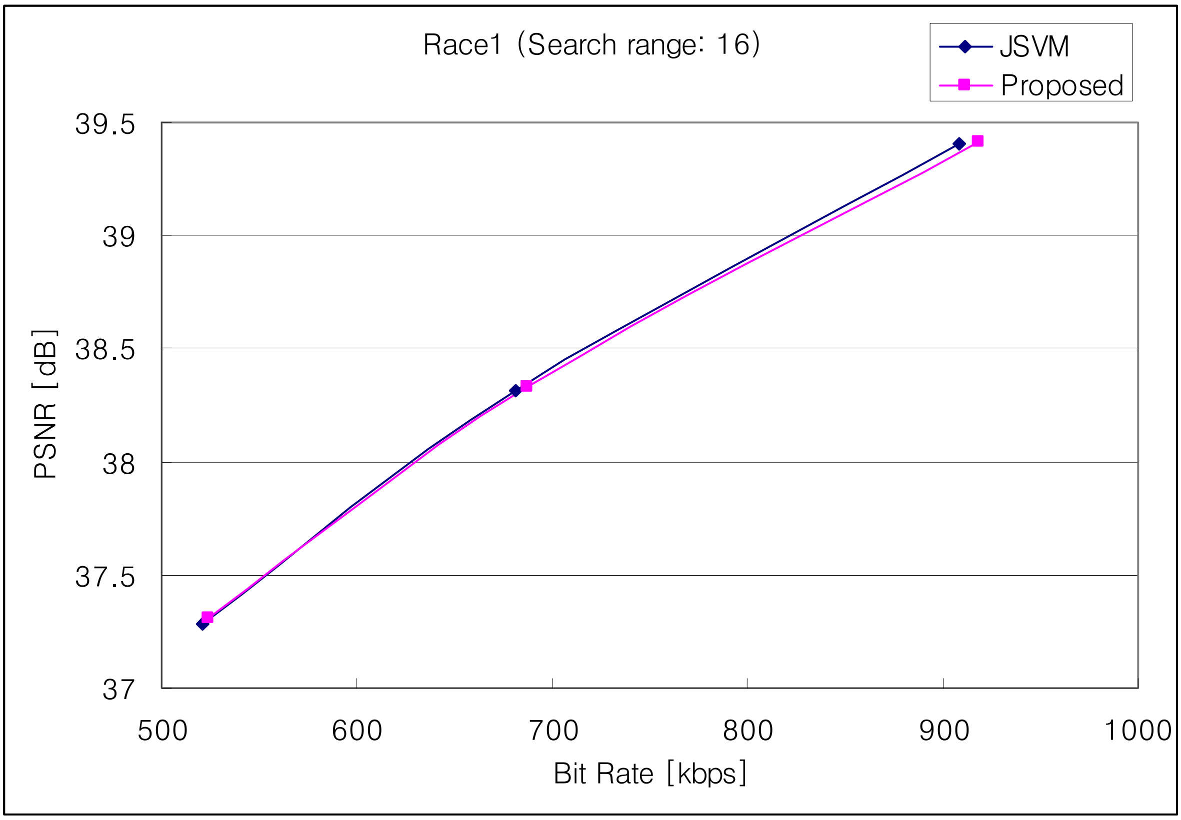

Fig. 17. Rate-Distortion Curve for “Race1” (Search Range = 16)

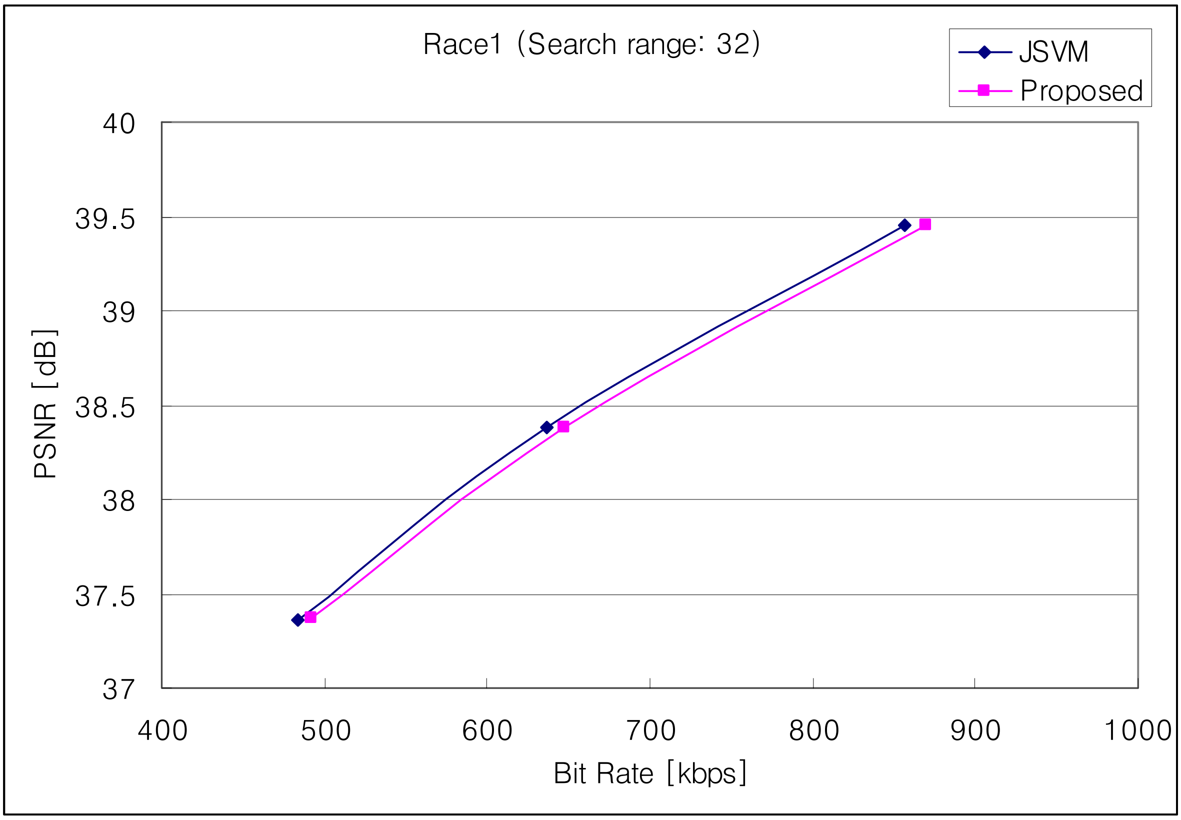

Fig. 18. Rate-Distortion Curve for "Race1" (Search Range = 32)

Table 12. Coding Results for "Uli" Sequence (Search Range = 8)

Basis QP	Bit Rate (kbps)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
36	783.2786	784.7239	32.1611	32.1643
30	1596.9376	1599.0301	35.4598	35.4626
28	2017.2141	2019.7763	36.4678	36.4684

Table 13. Coding Results for "Uli" Sequence (Search Range = 16)

Basis QP	Bit Rate (kbps)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
36	778.7904	780.2266	32.1560	32.1609
30	1589.6962	1591.6644	35.4591	35.4606
28	2008.8201	2011.4774	36.4655	36.4670

Table 14. Coding Results for "Uli" Sequence (Search Range = 32)

Basis QP	Bit Rate (kbps)		PSNR (dB)	
	JSVM	Proposed	JSVM	Proposed
36	774.4344	773.1992	32.1543	32.1544
30	1582.7317	1581.3115	35.4582	35.4612
28	2001.1838	2000.038	36.4685	36.4696

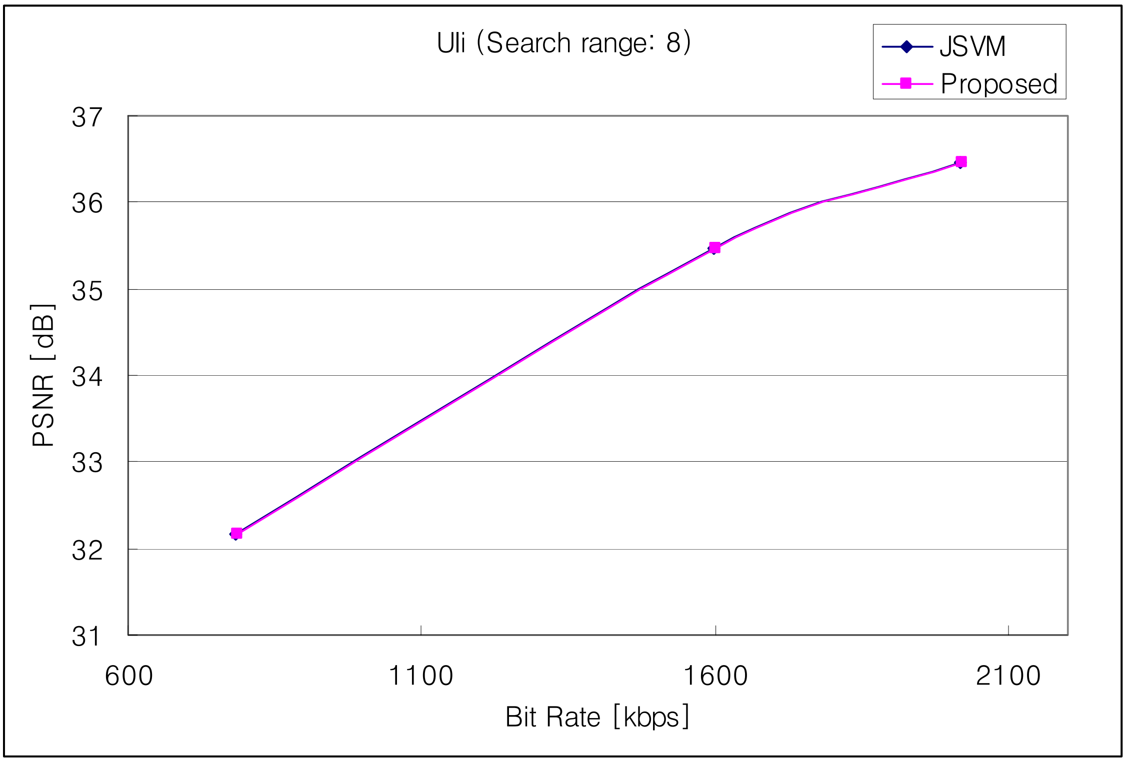

Fig. 19. Rate-Distortion Curve for “Uli” (Search Range = 8)

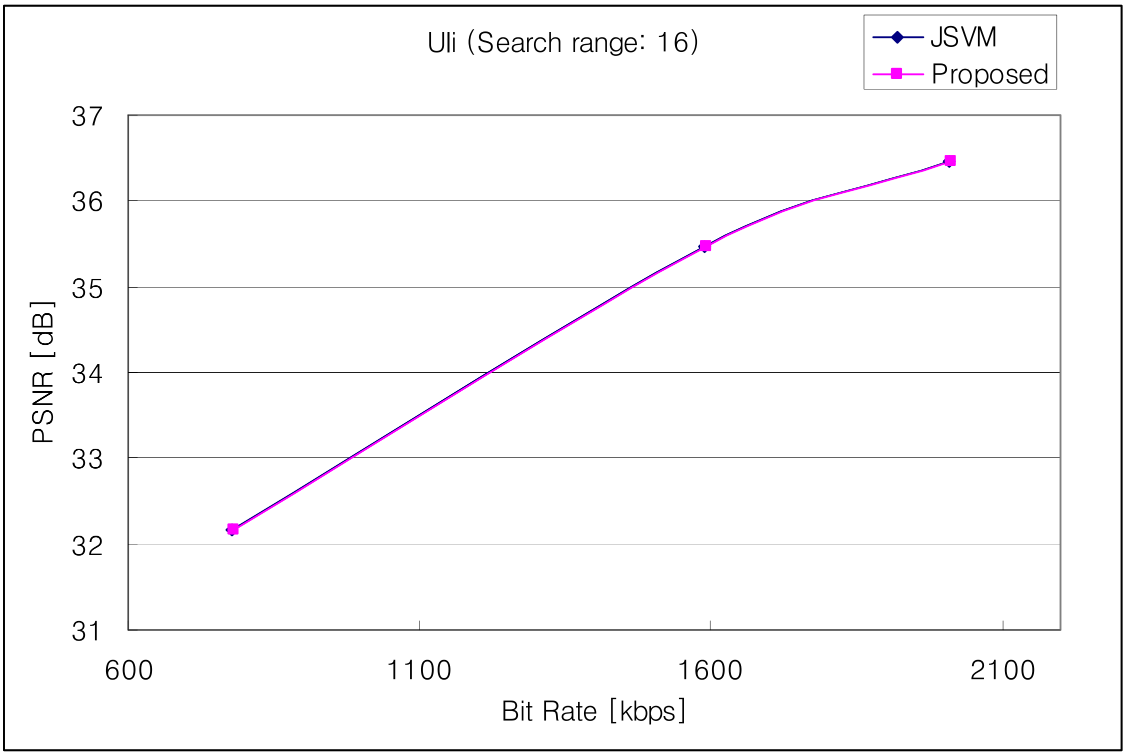

Fig. 20. Rate-Distortion Curve for “Uli” (Search Range = 16)

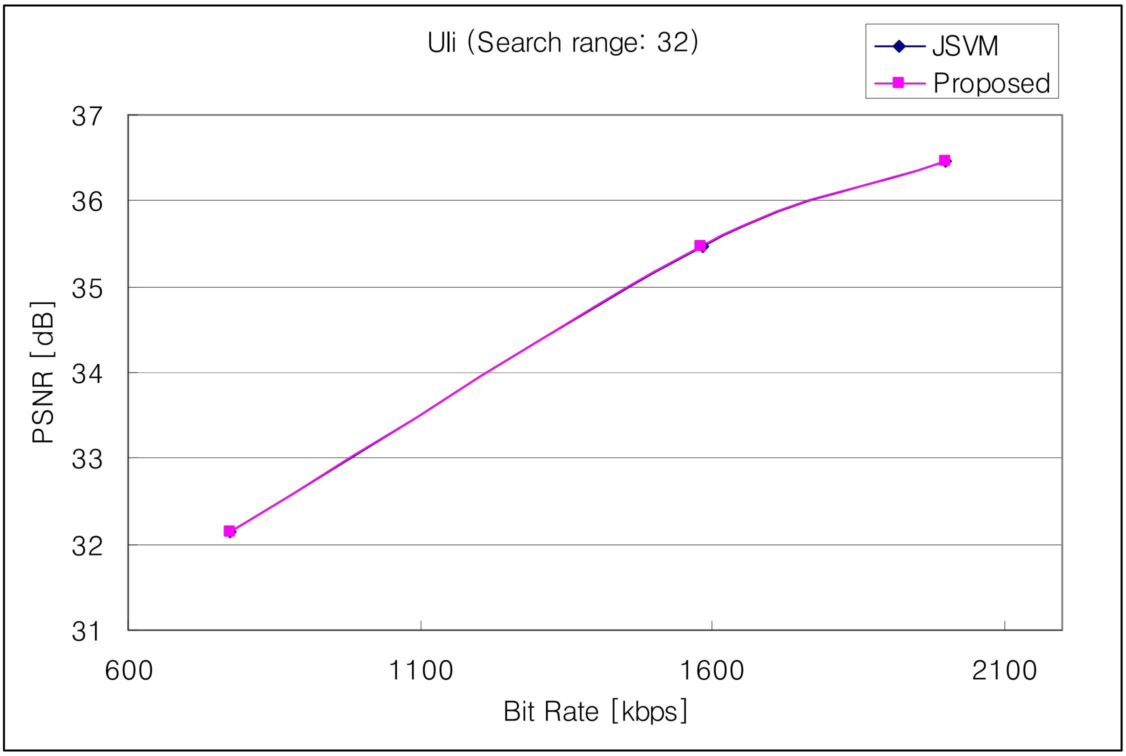

Fig. 21. Rate-Distortion Curve for “Uli” (Search Range = 32)

4. Conclusion

In this document, we have proposed the multi-view video coding using global disparity compensation. With some test sequences, we have verified quality improvement over the coding scheme of the reference software.

5. Acknowledgements

This work was supported in part by the Information Technology Research Center (ITRC) through the Realistic Broadcasting Research Center (RBRC) at Gwangju Institute of Science and Technology (GIST), and in part by the Ministry of Education (MOE) through the Brain Korea 21 (BK21) project.

6. References

[1] ISO/IEC JTC1/SC29/WG11 W8019, “Description of Core Experiments in MVC,” April 2006.
[2] ISO/IEC JTC1/SC29/WG11 M13581, “Global Disparity Compensation for Multi-view Video Coding,” July 2006.

(Append for Proposal Documents)

JVT Patent Disclosure Form

International Telecommunication Union Telecommunication Standardization Sector	International Organization for Standardization	International Electrotechnical Commission

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