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Abstract

This document presents the method of view interpolation for multi-view video coding (MVC), and it shows experimental results. We have improved the quality of synthesized image using several steps. The first step is the initial disparity estimation using region dividing which does not need the maximum disparity. Upon initial disparities, we estimate fine disparities using that variable block-based estimation and pixel-level estimation having adaptive search range. In addition, the disparity error correction process has included reducing the disparity errors. The experimental results show the quality of synthesized image which has improved about 1~3dB.

1. Introduction

The view interpolation generates a new intermediate image using stereo images. The objective of the view interpolation for multi-view video coding (MVC) is to improve the coding efficiency by adding the synthesis image as a reference frame. If the quality of synthesized image is not enough good, it would be not selected in mode decision. In this view of point, the quality of synthesized image is very important. Since the view interpolated image is depends on the accuracy of disparities, we have to estimate disparities correctly. Almost of the view interpolation methods use a search range which is used for estimate disparities. The quality of synthesized image is depends on the maximum disparity search range as Fig 1. The maximum disparity is very hard to estimate without any information of a sequence. Therefore, the quality of synthesized image using previous method is not effective for MVC. In this document, we describe a view interpolation method to estimate disparities more correctly.

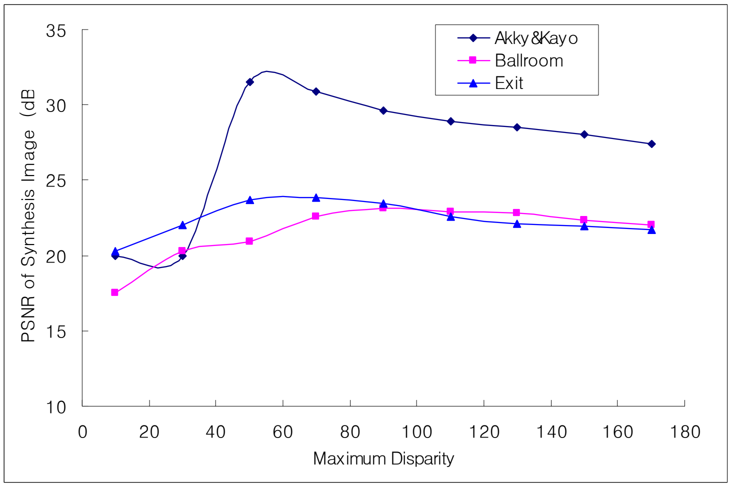

Fig. 1. Sensitivity of the maximum disparity range

2. View Interpolation Method for Multi-view Coding Having Adaptive Search Range

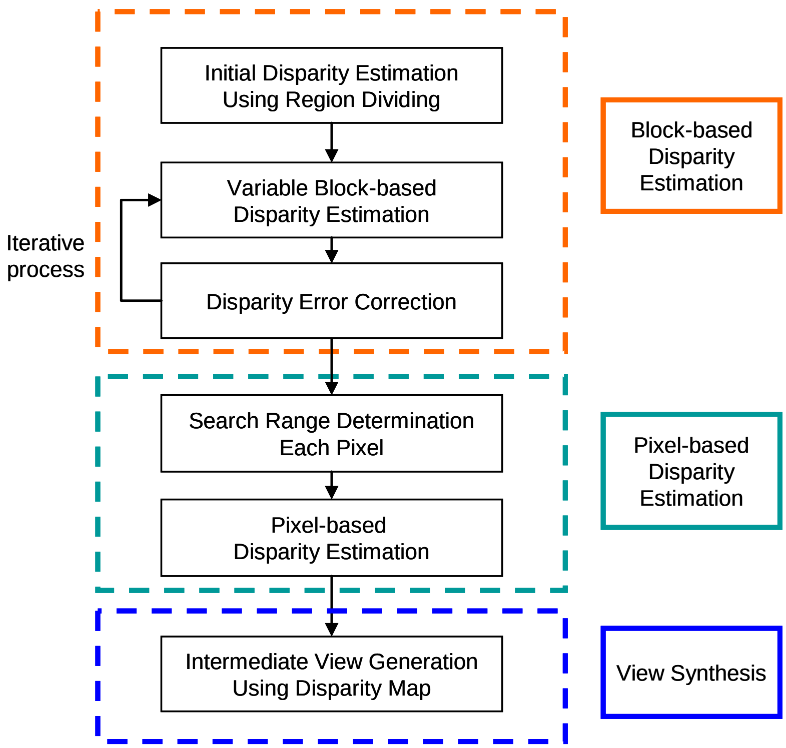

Fig. 2. Proposed View Interpolation Method

An algorithm to generate an intermediate image has been proposed in Nagoya University that uses pixel-level disparity estimation. It has several defects. The first is that have to set a maximum disparity search range. It is almost impossible to predict without disparity estimation. The second is that the accuracy of disparity around disparity discontinuity is very poor. So, we propose a developed view interpolation method like Fig. 2 that shows the whole process to obtain an intermediate view image. The first step is block-based disparity estimation which does not consider the maximum disparity search range because of using region dividing. Using disparity map in previous step, we can estimate fine disparities in pixel level using adjusted search ranges. In the last step, we can syntheses a new image considering the obtained disparity information.

2.1 Initial Disparity Estimation Using Region Dividing

Almost of the stereo matching algorithms use a maximum disparity search range. However, to predict the maximum disparity of each sequences is very difficult, because the general camera distance of multi-view video is quite far apart and the range of disparity can be vary with the motion of objects. Therefore, we propose an initial disparity estimation method using region dividing method which does not set a maximum disparity range. It is based on the ordering constraint of stereo images indicating the positions of objects. Fig. 3 describes the ordering constraint that B is located on the right side of A in the left image, so the B' is always located in the right side of A' in the right image.

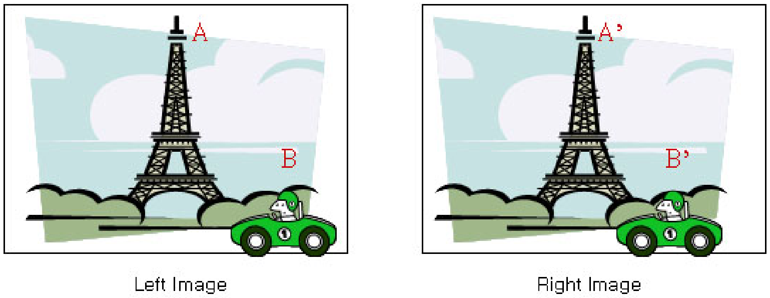

Fig. 3. Ordering Constraint

We used the gradient values of the stereo images to divide the region that is less affected by the illumination differences. Fig. 4 shows the matching process of disparity estimation method using region dividing. At first, make block-order of right image in order of gradient sum. Then estimate the disparity of the first block using the search range 0 to image width. If d1 is the disparity of the first block, the left image can be divided into two regions [0, x'_1] and [x'_1, width]. These two regions are the search ranges of the following two blocks. Similar to this, we can estimate every block by iterative estimation using reduced search range. Fig. 5 describes the search ranges of each block

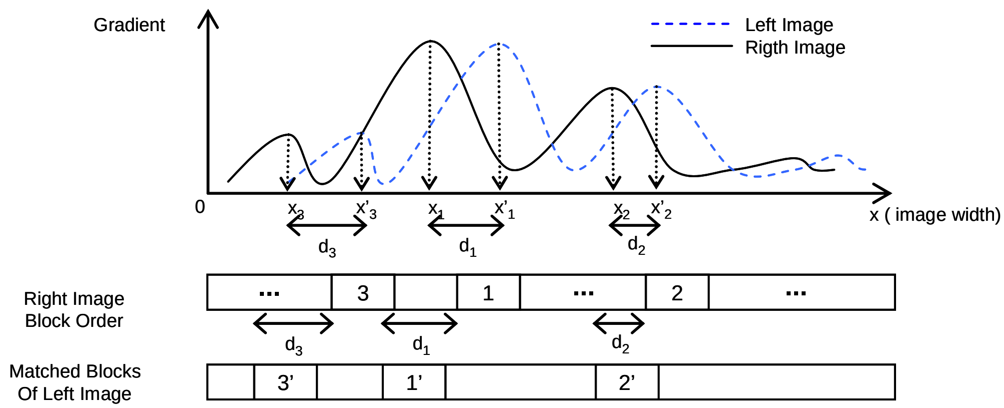

Fig. 4. Block Matching using Order Constraint

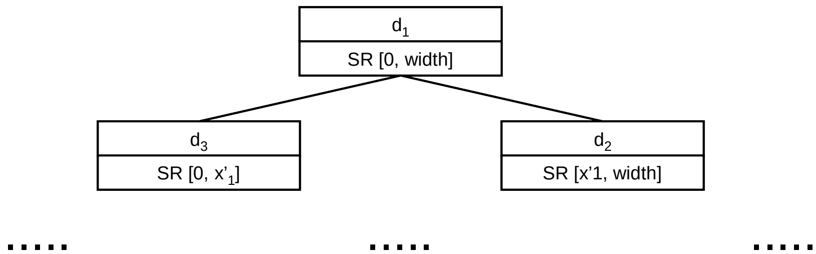

Fig 5. Disparity Search Ranges of Each Block

2.2 Variable Block-based Disparity Estimation

Since we use block-matching method, the accuracy of the disparity estimation in disparity discontinuous region is depended on the size of block. So we propose variable block-size disparity estimation method to improve the accuracy of estimation. Because we have assumed that the almost of the region have very similar disparities, we can use block-based disparity estimation. On the other hand, if a block is located on the region having large discontinuity, the disparity of the block has to be estimated in lower-size blocks. Using comparison of the costs between the upper-block and lower-blocks, we can find disparities of a certain block more precisely only in case of the difference were larger than a certain threshold. Fig. 6 shows the procedure of block-based disparity estimation using variable block-size.

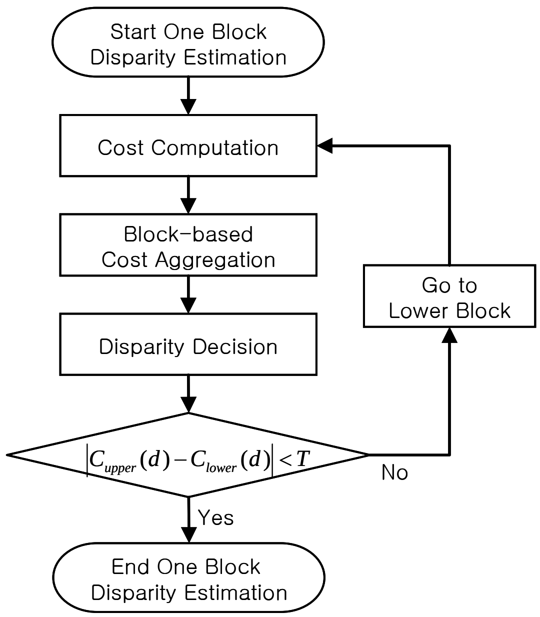

Fig. 6. Variable Block-based Disparity Estimation

Especially, in case of the block contains the edge of the objects, the block can be varied into lower block-size.

2.3 Pixel-level Disparity Estimation Using Adjusted Search Ranges

The final step to get a precise disparity map is pixel-level disparity estimation. Upon the block-based disparity map, a precise disparity of each pixel can be estimated in a small search ranges. In this process, we don't have to set search ranges widely. Eq (1) describes the determination of search ranges of each pixel. The search range does not to be wider than the block size. Actually, the search range was most efficient to set 5~10 by experiments.

$$\begin{cases} MinRange = D(x, y) - SearchRange / 2 \\ MaxRange = D(x, y) + SearchRange / 2 \end{cases} \quad (1)$$

After this setting, the pixel-level disparity can be estimated using eq. (2) and eq. (3). Those show the disparity decision strategy. It is very similar with previously proposed algorithm by Droese in Nagoya University. However, eq. (3) is a modified equation adding the second term. Eq. (3) shows the cost function considering three factors. $C_W^{\overline{err}}$ is Mean Absolute Difference (MAD) which is main factor of disparity estimation. C_W^{StDev} is standard deviation and the last C_W^{reg} is regularization factor which is the average disparity value neighboring pixels.

$$d(x,y) = \min_{d} C_W(x,y,d) \quad (2)$$

$$\begin{cases} C_W(x,y,d) = C_W^{\overline{err}}(x,y,d) + \alpha \cdot C_W^{StDev}(x,y,d) + \beta \cdot C_W^{reg}(x,y,d) \\ \alpha,\ \beta : \text{constant} \end{cases} \quad (3)$$

2.4 Disparity Error Correction

Our algorithm takes disparity error correction process to improve the accuracy of disparities. Since we do not use the maximum disparity range, there can be a lot of disparity errors. Therefore, the disparity error correction process is unavoidable. Disparity error correction process has two modes like block-level and pixel-level. Because the region dividing process and variable block-based disparity estimation are a block-based process, the disparity error can occur in the similar gradient region and disparity discontinues regions. Block-level disparity error correction process is added right after the region dividing process. A disparity of a block can be found again by setting a new search range using the minimum and maximum disparity values of the error correction window like Fig. 7. The pixel-level disparity error correction is the same as block-based one, but the disparity value to be corrected is just one pixel. This disparity error correction process significantly improves the disparity reliability.

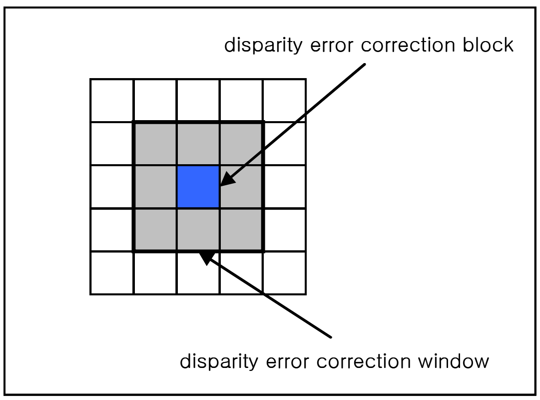

Fig. 7. Disparity Error Correction

3. Experimental Results and Analysis

We have used “EXIT”, “BALLROOM” and “Akko&Kayo” to experiment the proposed view interpolation. As Table 1 and Fig. 8 show the results, we simulated our method with 30 frames each sequences. The overall PSNR of each sequences are improved comparing with previous method. The main block-size is 16x16. This is used in the block-based and pixel-level disparity estimation. The threshold to divide a block is 10 which is found in data-driven process. Fig. 8 describes the results of PSNR of synthesized image. The previous method takes a maximum disparity value with 30~50, and the proposed method takes a search range with 5~15. If the search range is larger than the block-size, the results is getting poor.

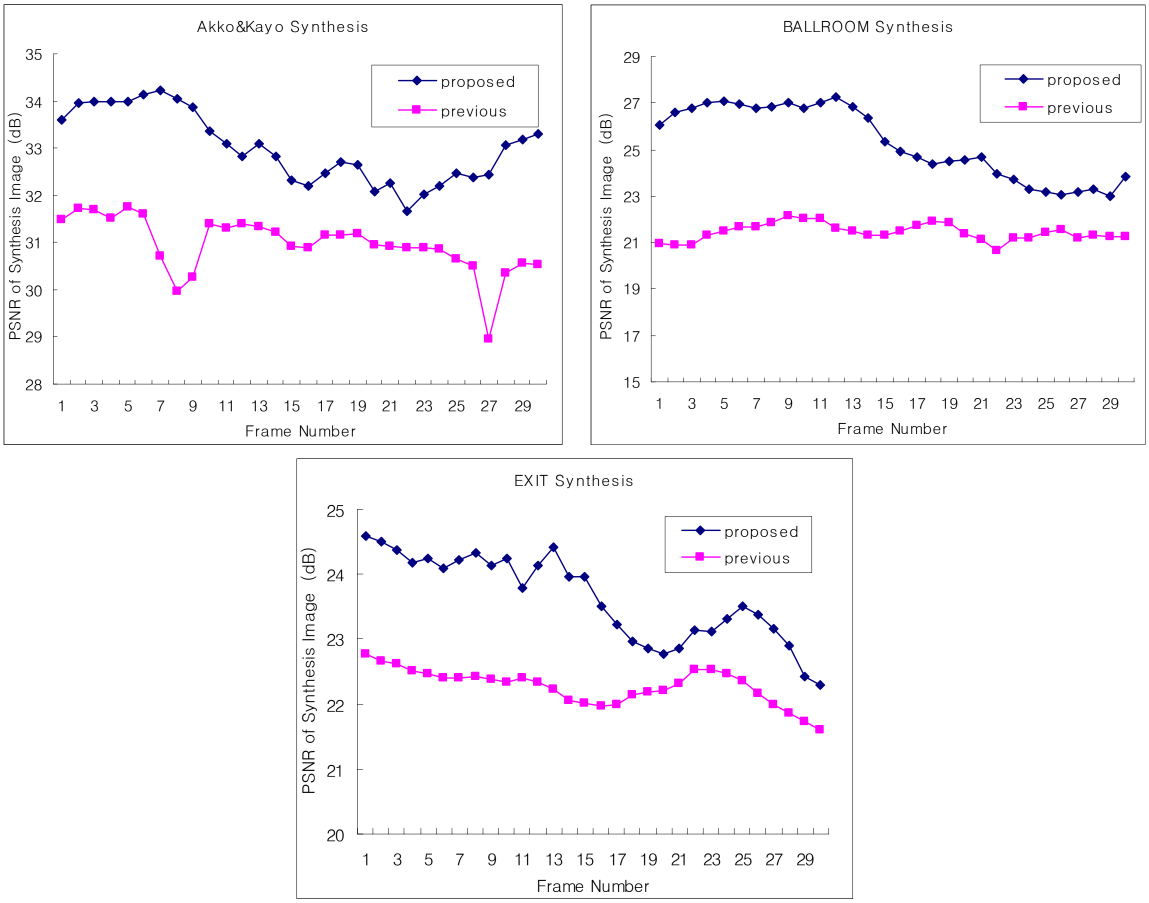

Fig. 8. The PSNR of View Interpolated Images

Table 1. View Interpolation Results of 30 frames

Sequences	Previous Method			Proposed Method		
	Maximum Disparity			Pixel-level Search Range		
	30	40	50	5	10	15
Akko&Kayo	27.778	31.453	30.959	33.013	32.659	32.273
Ballroom	20.699	21.043	21.435	25.287	25.297	25.265
Exit	21.350	22.270	23.205	24.525	23.675	23.672

Unit: (dB)

As you see in the table 1, the overall quality of synthesized image has increased comparing with previous method and less sensitive to the search ranges.

4. Conclusion

We have proposed an improved view interpolation method for the use of MVC. Since the maximum disparity range is very hard to predict in advance, we proposed an initial disparity estimation algorithm using region dividing. Additionally, we used variable block-size method to estimate precise disparity at the disparity discontinuous region, and then we finally estimate disparities in pixel-level using previously estimated disparity map. During the whole process, the disparity error correction process has included to improve the accuracy of disparities. The experimental results show that the overall quality has been improved. Therefore we propose this view interpolation method for the use of synthesized image in the MVC.

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] M. Droese, T. Fujii and M. Tanimoto, "Ray-Space Interpolation based on Filtering in Disparity Domain," Proc. 3D Conference, pp. 213-216, June, 2004.

(Append for Proposal Documents)

JVT Patent Disclosure Form

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Joint Video Coding Experts Group - *Patent Disclosure Form*

(Typically one per contribution and one per Standard | Recommendation)

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