Interframe Hole Filling for DIBR in 3D Videos

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***Abstract* — Depth-image-based rendering (DIBR) produces multiple views efficiently. However, its process lacks some viewpoint information. There will be holes, which influences the 3D video quality. Previous DIBR techniques were mainly applied to 3D images, so it only relied on the single view and the depth map to fill the holes, but insufficient repair information resulted in incorrect repair. In this paper, we aim to repair 3D videos by the hole filling for DIBR, which introduces the relation between frames to increase the repair information. We apply the moving behavior and the texture similarity within interframes to assure the accuracy of the repair information. The experiment results demonstrate that compared to previous methods, the proposed method obtain better 3D video quality. The average peak signal-to-noise ratio (PSNR) increases by 1.014 dB, and the structural similarity (SSIM) index increases by 0.012, which shows that the proposed method obtains better quality than the methods that only apply the single view image information.**

I. INTRODUCTION

The 3D technology progresses significantly in recent years. Consumers can experience realistic 3D effects in real time through the stereoscopic display and 3D videos at home. The stereoscopic display applies the binocular parallax principle [1] to combine images of different viewpoints into 3D scenes in the brain. However, the 3D video contents are not widespread, and expensive stereo cameras are needed for filming. To produce 3D videos more efficiently, the DIBR is applied to synthesize multiple views, and the 3D scenes can be obtained. However, the synthesized virtual view is the new viewpoint. It makes the original viewpoint lack the image information of the new viewpoint. The disocclusion will occur, which leads to the missing pixels on the virtual views, known as the holes. To maintain the effects of 3D scenes, the image inpainting is required.

Previous methods were mainly applied to still 3D images, which often used the single view or combined the depth map to fill the holes. [2] and [3] distinguished the foreground and the background by the depth value. [2] compared the depth value in the background for selecting the repair information, while [3] applied the textural intensity and the textural directionality to fill the holes. These algorithms were easy and efficient. The repair information completely relied on the single view of the original viewpoint to fill the holes. However, for 3D video applications, they did not exhaust the repair information between frames.

In this paper, we develop a hole filling algorithm for 3D videos. We not only apply the information between frames in videos to increase the repair information, but also introduce the moving behavior and the intraframe texture similarity to assure the accuracy of the repair information. We analyze the moving behavior of the objects between frames in the video to predict the compensated position of the repair information. On the other hand, we introduce the texture features around the holes to obtain the repair information, which achieves efficient and better repair quality. The final result is shown in Section III, which applies the PSNR and the SSIM to analyze the quality objectively. For example, in test sequence Dancer, the average PSNR increases by 1.07 dB, and the average SSIM index improves by 0.0127, which shows that the proposed method enhances the quality of 3D videos.

II. PROPOSED HOLE FILLING METHOD

The DIBR is a multi-view synthesis technology, which redefines the original 2D color images in the 3D space through depth maps. The color image will warp on the new viewpoint by 3D warping, and the virtual view is generated. However, during the process of warping, the disocclusion leads to the holes on virtual views. To maintain the quality of 3D videos, we have to repair the holes.

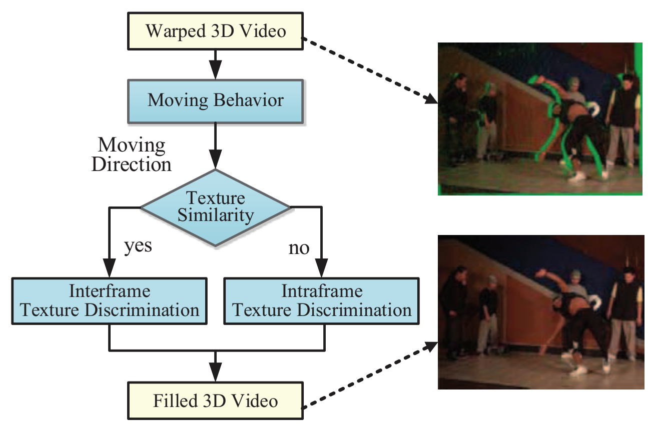

Fig.1 The proposed hole filling algorithm

Fig.1 is the proposed hole filling algorithm. The upper-right image in Fig.1 is the warped virtual view, and the green parts are the holes. We repair the holes with the proposed method, and the filled virtual view is shown in the bottom-right image. We first use moving behavior to analyze the moving direction of the foreground and the background. The moving behavior applies the moving direction and the clustering algorithms to group the motion information with close values as the same cluster, and we apply the cluster as unit to determine the correct moving of interframe images. It splits the foreground and the background, and we estimate the moving directions of the foreground and the background. The foreground moving directions use the foreground information between interframe images after clustering. Then, we conjecture the foreground moving directions around the holes by the position of the foreground cluster. The background moving directions are applied to search for the region that is not in the foreground, and the behavior of this region can be used as the comparative information, which is used to compare with the background

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part in interframe images. Thus, the background moving directions are obtained. Finally, we estimate the moving repair information with the foreground and the background moving direction. Meanwhile, the background is still, i.e. the current viewpoint lacks the correct information. We acquire the original positions of the holes in the current viewpoint directly. Then, we receive the repair information according to the relative position in the interframe images. It causes the creation of the repair information that the current view lacks. If the background state is not still, after the calculation of the foreground and the background moving directions, we estimate the compensated positions of the moving repair information in interframe images, as shown in Fig.2, wherein the green parts indicate the holes, and the orange parts represent the moving repair information.

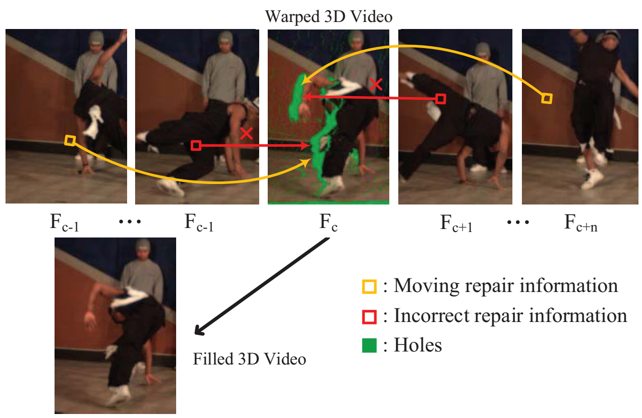


Fig.2 Estimated moving repair information

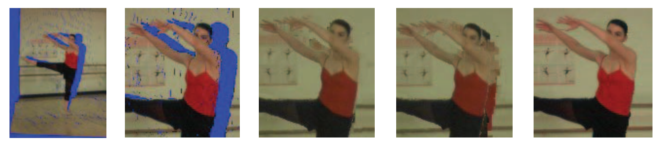
To assure the accuracy of the repair information, we estimate that the moving repair information is a similar region to the neighbor of the holes, and we analyze the texture similarity of the two regions. If they are similar regions, we use the interframe texture discrimination to repair, which is the moving repair information. If they are not similar regions, it indicates that the composed textures around the holes are complex. Therefore, for the repair, we apply the intraframe texture discrimination to estimate the texture features around the holes. Then, we further compare the consistency of the texture according to the texture direction, which solves incorrect repair of complex texture images and obtains more accurate repair information.

III. EXPERIMENTAL RESULTS

We applied 3 multi-view video-plus-depth (MVD) datasets to synthesize the virtual views, and we used the PSNR and the SSIM to compare the proposed method with previous methods [3], [4], [5]. The PSNR and the SSIM are objective image quality metrics. The higher value of PSNR represents higher quality, and the quality is better when the SSIM index approaches 1. Table I shows the comparison of the average PSNR and SSIM between the proposed method and previous methods. We apply the average frame rate (frame per second, FPS) to complete the complexity analysis on sequence Dancer. The image size is 1920 × 1088 pixels, and higher frame rate represents more efficient algorithms. Finally, Fig.3 is the comparison of the repair results, which shows that the proposed method enhances the quality of 3D videos better than previous methods.

Table I. Comparison of different methods

Method	Dancer		PoznanHall2		PoznanStreet		Average FPS
	PSNR(dB)	SSIM	PSNR(dB)	SSIM	PSNR(dB)	SSIM	
Daribo's [3]	28.59	0.9228	32.51	0.843	25.17	0.7648	
Wexler's [4]	28.39	0.9230	32.51	0.8434	25.37	0.7660	0.00363
VSRS [5]	29.07	0.9241	31.28	0.8440	25.40	0.7678	0.5038
Proposed method	29.755	0.936	33.04	0.8634	26.344	0.7696	2.994
[3] Diff.	1.165	0.0132	0.53	0.0204	1.174	0.0048	
[4] Diff.	1.365	0.013	0.53	0.02	0.974	0.0036	2.99037
[5] Diff.	0.685	0.0119	1.76	0.0194	0.944	0.0018	2.4902
Average Diff.	1.07167	0.0127	0.94	0.01993	1.03067	0.0034	2.74
Average PSNR Diff.	1.014113		Average SSIM Diff.	0.01201			



(a) (b) (c) (d) (e)

Fig.3 Results of the proposed and previous methods in sequence Ballet at frame 10. (a) and (b) are warped images. (c) is Daribo's method [3]. (d) is Wexler's method [4]. (e) is the proposed method.

IV. CONCLUSION

In this paper, we propose a 3D DIBR algorithm for 3D videos. It solves the problem that previous repair methods only applied the single view information and often resulted in incorrect repair. The proposed method uses the interframe images in the video to increase the repair information. We introduce the moving behavior and the texture similarity to assure the accuracy of the repair information. The proposed method achieves higher performance than previous methods listed in Table I. The average PSNR increases by 1.014 dB and the average SSIM index increases by 0.012, which shows that the proposed method supports the better quality for 3D video applications.

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