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A Method of Pseudo 3D Video Reconstruction Based on 2D Video Sequences

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Abstract

A method of pseudo 3D video reconstruction based on 2D video sequences is proposed, which transforms the conventional 2D video into their stereo version using original image and depth-map image. The red-component map is shifted left to obtain the left-view according to the parallax information. Because the left image has holes, the depth-map preprocessing and novel hole-filling simplified algorithm are used to fill the holes effectively. The experimental results show that the proposed algorithm generates 3D visual view with the same image quality as well as faster rendering speed compared with the reference hole-filling algorithm. The method adapts to the stereo pair synthesis for 3D.

Keywords: *DIBR, the parallax information, hole-filling, 2D to 3D*

1. Introduction

Technology of synthesized view by Depth-Image-Based Rendering is the key to 3D synthesis technology. Depth-Image-Based Rendering (DIBR) is a 2D-to-3D conversion technique that can generate the left-view and right-view virtual images by a 2D image and a depth-map image. The DIBR system consists of three parts: preprocessing of depth image, 3D image warping and hole filling [1-3]. However, because of the visibility changes and other reasons, there are often holes in the synthesis views [4]. The effect of eliminating holes determines whether the view synthesis technology based on DIBR will be further generalized. Xiaoyan Xu *et. al.*, proposed a view synthesis method based on DIBR, which can accurately draw the image of corresponding information about the reference view with high computational complexity [5]. To propose a more effective method for 3D reconstruction, this paper presents a disparity-map hole filling algorithm, which can effectively reduce the computation time with the high 3D visual quality.

2. Method to Reconstruct Three-Dimensional Images Based on DIBR

In this paper, a method to reconstruct three-dimensional images based on DBIR is proposed as shown in Figure 1.

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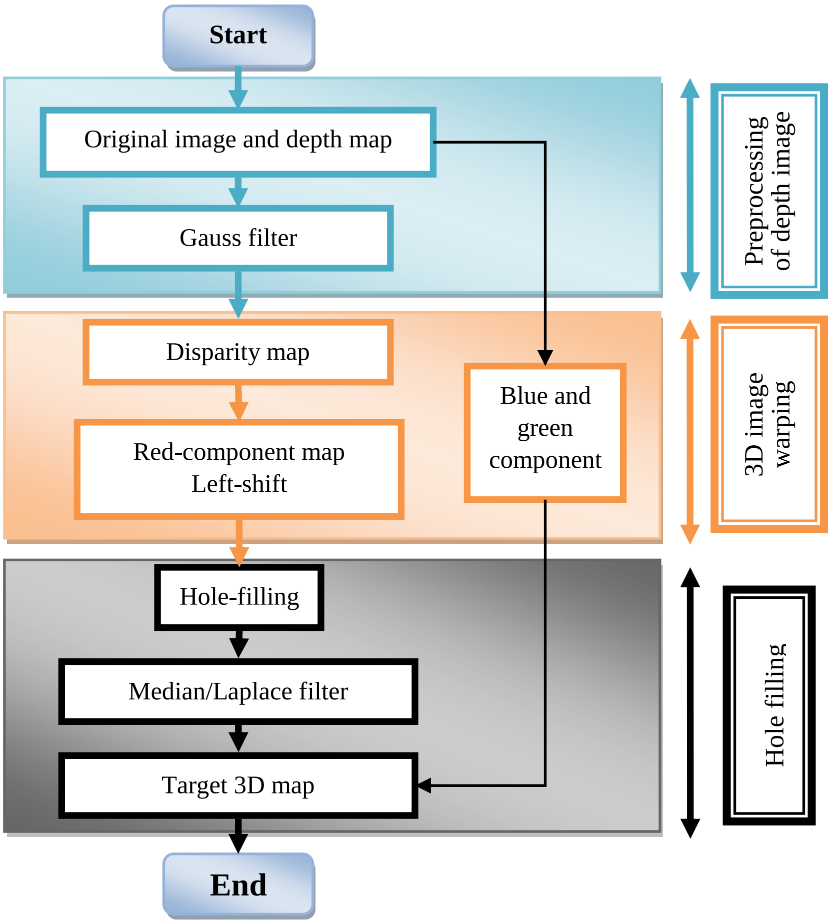

Figure 1. Method of Reconstructing 3D Images Based on DIBR

Firstly, the standard depth map is preprocessed by Gauss filter, the disparity map is created according to the disparity estimation algorithm. Then, the left view is created by offsetting the red-component map of the original image according to the parallax information. An improved method of hole-filling is used to fill the newly exposed areas (termed 'holes') having no corresponding information about the reference view. Finally, 3D images are created by using the green and blue components of the original image and left-view through the view synthesis technology.

2.1. Preprocessing of Depth Image

Depth map is a function, taking the corresponding depth values in the three-dimensional pixels for the dependent variable, which views the image coordinates of reference-image as the independent variable. There are gray level jumping in the interchange between background and foreground, making the big differences of the parallax information to produce the large hole in virtual 3D views. The emergence of false edges after filling seriously affect the quality of the reconstruction. To reduce the influence of discontinuous depth values affecting the virtual quality, Gaussian filter [6] is used to fill the hole-regions. Gaussian filter function is as shown in equation (1).

$$G(x,y)=\left[\frac{1}{\sqrt{2}\sigma_H}e^{-\frac{x^2}{\sqrt{2}\sigma_H}}\right]\left[\frac{1}{\sqrt{2}\sigma_V}e^{-\frac{y^2}{\sqrt{2}\sigma_V}}\right] \quad (1)$$

2.2. 3D Image Warping

2.2.1. Disparity Estimation: To make use of the depth map for synthesizing the left-view and right-view disparity maps, we calculate each pixel disparity and change the coordinates of each pixel value according to the parallax information. Each disparity of pixel point (x, y) is given in Equation (2).

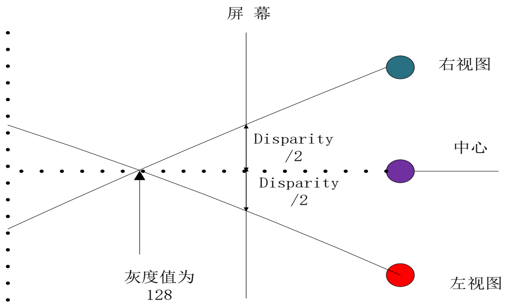

Figure 2. Disparity Estimation

$$Disparity(x,y)=M\times\left[1-\frac{depth(x,y)}{128}\right] \quad (2)$$

Where M represents the maximum disparity value, $depth(x,y)$ is the depth value of point (x,y). Therefore, the value of zero disparity is set to 128, values more than 128 having negative disparity information, less than 128 with positive disparity information, as shown in Figure 2. Under the circumstances, if the foreground has the negative disparity value, it will be in front of the screen [5] when watching the stereoscopic images.

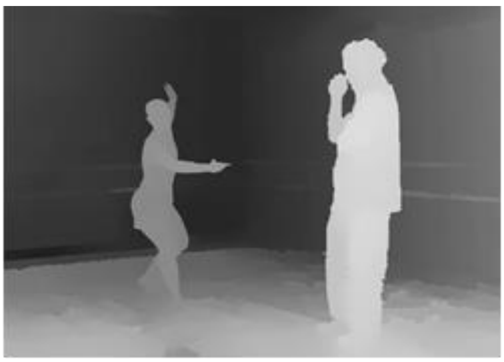

Figure 3. Standard Depth Map of Ballet”

Figure 4. Disparity Map of Ballet”

2.2.2. Creation of the Left-View: Extract the red-component map in the reference image in accordance with 3D stereo display technology based on color difference formula. As a result of the foreground image display is negative and the background display is in contrast, we shift the red primary component to the left according to the disparity to create the left-view, the rest of the green and blue is the right-view in the original position.

2.3. Hole Filling

The hole-filling algorithm based on disparity map is proposed by Xiaoyan Xu. The algorithm guarantees that the holes which satisfy the following condition will be filled first: the number of non-holes in 4-neighborhood-pixels set is larger than or equal to the threshold of the current iteration. After each iteration, the algorithm will re-search the holes whose 4-neighborhood-pixels are all non-holes for the next iteration. Experiment results show that the algorithm can be employed efficiently for the small holes, especially for the holes at lowly-textured area [5-7]. However, the algorithm is so complex that it needs large computational cost, more much calculation time. Therefore, real-time and practicality are poor.

In this paper, a novel hole-filling algorithm based on the original image and the disparity-map image is proposed. The algorithm process is shown in Figure 5.

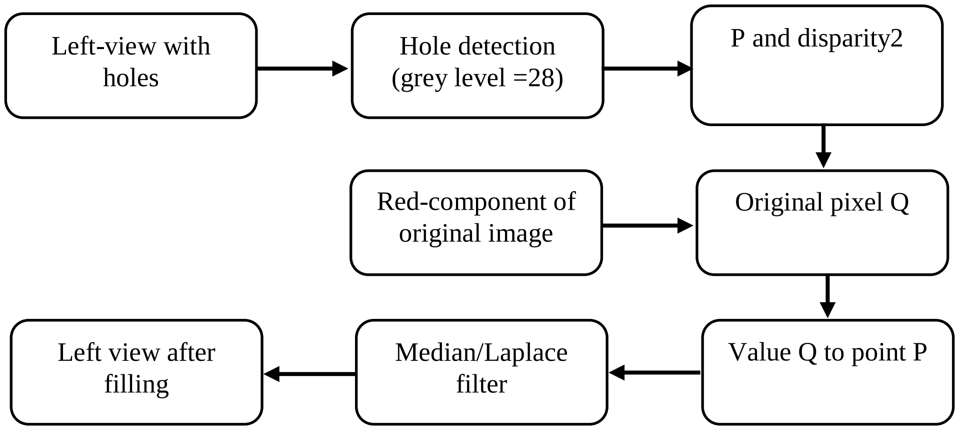

Figure 5. Flow Chart of Hole-Filling Algorithm

① **Detect the holes in the left-view**. See pixels' level (range of 0-255) less than 28 as holes by detecting from left to right in turn from top to bottom.

② **Fill the holes**. Move the hole-pixel P to the right with the distance of parallax disparity2 for finding the target-pixel Q coordinate value in the original red-component map, give the value of pixel Q to pixel P (namely holes).

③ **Filtering operation**. Median filter is used in the red-component map to reduce noise, Laplace sharpening is to make the edge clearer.

3. Experimental Results and Analysis

3.1. Preprocessing of Depth Image

This experiment adopts the "ballet" sequence image and its standard depth-map image. Gaussian parameters is set as follow: the standard deviation is set to 15, the size is 15×15. In this paper, the effect of the graph is shown in Figure 6, and Figure 7.

Figure 6. Standard Depth Image

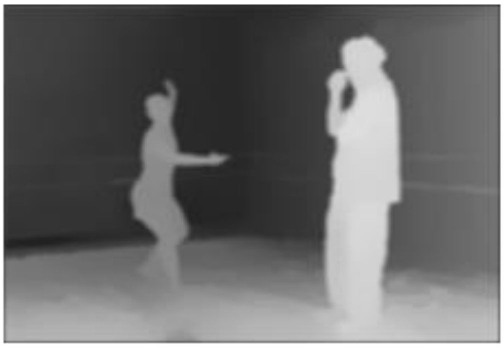

Figure 7. Depth Image after Gauss Filter

The original depth-map and the Gauss smoothing depth-map are used to view synthesis respectively. The results are as follows:

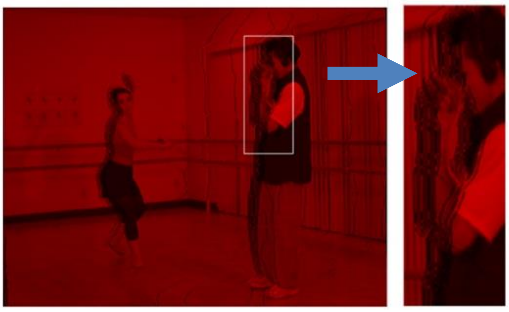

Figure 8. Original Left-View

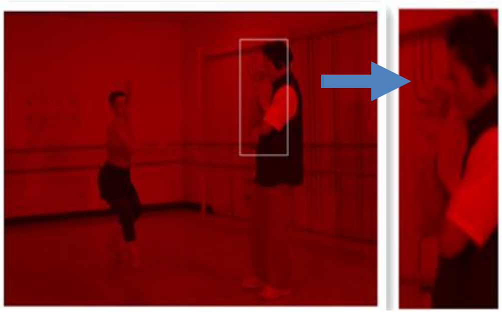

Figure 9. Gaussian Filtered Left-View

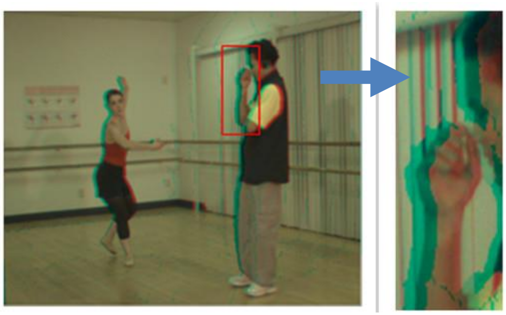

Figure 10. Original Visual 3D View

Figure 11. Gaussian Filtered Visual 3D View

The holes of target left-view are reduced through the Gauss filter, as shown in Figure 8, and 9. Holes in the visual 3D images also significantly reduced, compare the enlarged region of Figure 10, and 11, the holes got partly filled in the Figure 10, and the hole is become smaller and sparse in the Figure 11, which reached a preliminary to shrink holes. However, there are still a little holes in the visual 3D image obtained in this way, now we will adopt some methods to fill the holes in the left-view.

3.2. Hole Filling

For the pixels excessed the original image size, set the disparity value is invariable: disparity2=0, for the pixels not exceeding the size of the original image, give the parallax a value: disparity2=disparity. It produced the black areas on the vision because of the holes and the missing part of the color information in the left-view.

Use the same reference image, two algorithms results are shown below:

Figure 12. Hole-Map of Algorithm [5]

Figure13. 3D Visual View of Algorithm [5]

Figure 14. Hole-Map in this Paper

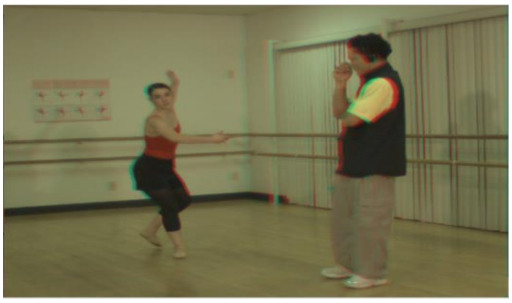

Figure 15. 3D Visual View in this Paper

The effect of hole-filling algorithm [5] is obviously good, as shown in Figure 13, image brightness loss is not obvious. The processing time of a frame image is approximately 44.4 seconds in the MATLAB software, so it costs large amount of computation. According to the data, if we play a video for a period of 10 seconds with the speed of 20 frames per second, we need 2.47 hours. So the algorithm is not conducive to video reconstruction.

In this paper, the color separation method is used in visual 3D display technology, the result is shown in Figure 15. From the view of computation, three colors are all in the experimental operation while migrating overall the part region in the algorithm [5], however, the red-component map is only involved in operation in this article, thus the operation in this paper is much simpler. This method can avoid degrading the image quality in non-hole area when filling the holes, thus the authenticity of the image is guaranteed. The comparison of runtimes required of two hole-filling algorithms are as follows:

Table 1. Runtimes Required of Two Hole-Filling Algorithms

Algorithm	Time
Reference hole-filling algorithm[5]	44.405503s
Hole filling algorithm in this paper	14.095473s

Due to the use of color separation, the proposed algorithm can generate 3D visual view with same image quality as well as faster rendering speed compared with the reference hole-filling algorithm. It makes consideration simpler and greatly improves the conversion rate, experiment results suggest that the method adapts to the stereo pair synthesis for 3D.

4. Conclusion

This paper is aim to generate the parallax left-view using the red-component shifting, making use of the existing RGB image and disparity information extracted in the depth-map. While the left-view thus obtained has the obvious fold and holes, numbers and sizes are significantly reduced by smoothing the depth-map through the Gauss filter. Although Gauss smoothing filter can reduce part of holes, the newly exposed areas in the left-view cannot be ignored, which greatly affect the 3D visual view quality. Therefore, hole-filling process is essential to the reconstruction. In this paper, a method of depth-image based rendering for 3D reconstruction is proposed, which greatly improves the rending speed with the same quality of 3D visual view, thus forming a kind of effective method to reconstruct 3D visual view based on DIBR.

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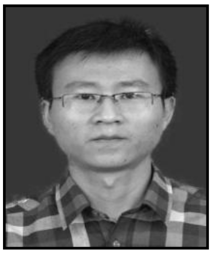

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