A Hole-Filling Approach Based on Morphological Operation for Stereoscopic Image Generation

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Abstract - Apply the stereoscopic image generation from 2D to 3D conversion depth image based rendering (DIBR) technique it is 2D view to multi-angle virtual view by the single depth image. We develop a stereoscopic image generation method from one-view color image and its corresponding depth information. The DIBR firstly does the preprocessing of the depth image by using the smooth filter, which sharpens the discontinuous depth changes as well as to smooth the neighboring depth of similar color and also detain noises from appearing on the warped images. The occlusion regions are applied the morphological operations on the depth image with the background depth levels to keep the depth structure. With depth-guided exemplar-based image inpainting combines the color gradient to preserve the image structure in the restored regions.

Keywords: Depth image based rendering, Hole filling approach, Color gradient, Morphological operations

1 Introduction

3D Television has become an important entertainment medium, but in recent 3D contents of a large number of acceptable not to be one of the reasons is the lack of, and often is not currently suitable for initial purchase 3D TV causes. A quick fix the lack of 3D contents programs, namely 3D broadcast on television by the 2D transform 3D programs or movies. Today a number of 3D TVs already have this automatic conversion. However, the 2D-3D conversion, can only offer simple simulation 3D rather than genuine 3D. Actually it is not really 2D transformed into actual 3D, or just adding an actual depth textures within the image. In recent years, people will want to experience the more 2D images more realistic 3D Visual effects, 3D related technologies were becoming increasingly concerned by people, and stereoscopic display technology has greatly improved. Generation of stereo images can be divided into two broad categories: (1) by the dual-lens stereoscopic images; (2) single-camera images converted to multiple perspectives of the virtual image.

Currently twin-lens 3D camera is expensive and a twin-lens camera calibration and synchronization issues, internal parameter adjustment is also very complex. Mostly owned by the photographer is still dominated by single lens camera or camera. So many experts and scholars in relevant fields are studying or applying 2D images into 3D images, so we may avoid buying the expensive 3D Cameras and accompanied by undesired operation problem, also we can make 3D images rich and popular.

Internationally well-known seminar (Such as SIGGRAPH, and CVPR) stereoscopic images made by the relevant technical and learned that in computer graphics and computer vision technology has begun to integrate, wants to provide a more realistic and more in stereoscopic images. With the future of stereoscopic display technologies in recent years has become more mature, interactive full view 3D TV (interactive free-viewpoint 3D TV) household TV will be the next generation of new specifications, the showing of the film will not just be mere stereo image, will be further high quality 3D Stereo images of the model. This program is a three-dimensional image synthesis techniques will be explored, can be divided into two broad classes, image drawing method (Image based rendering, IBR), as well as the depth of image drawing method (Depth image based rendering, DIBR), which don't use depth information-image drawing method, but because of the restrictions on use, it is less frequently used. Current depth image drawing method for 2D conversion to 3D image synthesis technology in their evolution that adds up the stereo to stereo system for object image synthesis, mainly includes three parts: (1) pretreatment (pre-processing), (2) 3D Image deformation (image warping) (3) Hole filling (hole filling). Stereo image synthesizing method of this study was to explore effective and new technology made a hole to fill. Balcerek et al. [1] presents a red component of depth map generation and hole filling method in monitoring system of 3D effects. Its binary depth map is based on target recognition and tracking, and use the red component is mirrored and filter (blocking) hole filling method. Camplani and Salgado [2] the proposed method is based on a joint bi-directional filtering framework, including space and time information, with their repeated use of adjacent pixels depth of joint bilateral filter to recover their lost values. Chen et al. [3] within a depth of to the edge of the filter and put effective depth image of the drawing. It can effectively solve DIBR hole in the system fill problem. Cheng et al. [4] present three view image generation technologies to improve results. First is to use bilateral filters in depth on the image, it may help the continuous change of the depth and smoothness similar adjacent color depth, so noise can inhibit the image distortion. Secondly, in variants a new observation point on the image, depth to depth strata in order to fill the background of the shadowed area on the image in order to maintain depth structure. For color images, image drawing based on the depth-oriented examples, combines the structural strength of gradient colors, image to maintain schema in the reply area. Last triangular filter combined with the spatial position, color, intensity and depth of information to determine weight, enhances image synthesis of results. Choi et al. [5] they recommended depth estimation and image restoration of high quality 3D video hole filling.
method. First of all, they draw images and the depth maps. Then, there was a hole estimated in the depth map. Auxiliary images based on sparseness and depth of holes to fill to fix these holes. Cigla and Alatan [6] using reliable horizontal and vertical orientation of the texture transform from visible pixel to fill holes. They use similar to that of neighboring pixels and depth of color continuous weighted sum (SWS), the adaptive weighting and connection aggregation. Dong et al. [7] analyze on DIBR virtual view of the drawing process, two views presented to modify the parallax method for generating new views and combines the image patch to improve. Parallax is determined by the depth of the above information to infer, based on disparity gradient correction, thus reducing previous 3-D image deformation produced a new hole in the view area. Doria and Radke [8] combined the images from the supplement the basic concept of patch and the gradient field image editing, both in texture and structure of two species of fill light (LiDAR) to scan images. Once the depth gradient, they use image reconstruction techniques, to obtain the final 3D scene structure. Mokhtar and Pramod [9] used two new 3 by 3 structural elements can speed up the modified hole-filling algorithm. Hsiao et al. in [10] a new algorithm is presented, along with variants and holes to fill, making calculated overall significant reduction in the delay. Two ways to upgrade around the edges of parallax a horizontally mirrored is used to reduce the synthesis of virtual images generated by the visual flaws. Hung and Siu [11] propose a depth aided nonlocal-means algorithm, using information from the current frame and another frame figure to fill the hole in the synthesis of video. Hwang et al. [12] they recommended image based image segmentation method of patching holes to fill. Their holes filled can not only show the high quality of the results, can also be applied on the commonly used methods for real-time applications. Jung and Ho [13] make a hole filling algorithm using spatial domain of adjacent frames with 3D video synthesis of color and depth of deformation and eye hole in the depth of the linear interpolation. As the interpolated depth value, search in the time domain corresponds to the colors and the textures used to fill in the hole in the color image. Mao et al. [14] provide the first observation hole and fill the hole of expansion problems. First, proposed a depth to convert pixel histogram to identify missing or incorrect expansion arising out of holes. Then, put forward two different computational complexity of technology to fill the expanding holes (1) linear interpolation, and (2) based on graphical interpolation with sparseness of priority. An adaptive method of image distortion to improve the general method of deformation was presented by Plath et al. [15]. The algorithm is used to smooth a typical depth map, in order to reduce the potential for optimization problems. To prevent deformation of the hole must be found. This depth map divided into blocks of uniform depth, use the four-element tree and perform adaptive grid to achieve optimal results. Solh and AlRegib [16] proposed removing shaded areas DIBR with two new methods. Respectively, these two approaches are hierarchical holes filled (HHF) and the holes filled with Adaptive depth hierarchy to eliminate the depth map by any smoothing or filtering needs repair. Both technologies use a pyramid method to estimate, from 3D deformation of hole in the estimation of low resolution pixels in the image. The estimated the low resolution images to virtual zeros deleted, together with deformation of the Gaussian filter. With adaptive depth of HHF using the depth information result in a higher resolution to previously shaded areas of the drawing. Wang et al. [17] provide an asymmetric edge adaptive filter (AEAF) partially addressed two 3DTV Challenges, namely depth to generate and fill the hole. Unlike other similar treatment is, AEAF operation can be achieved when edge effects of pretreatment of correction and depth charts. Wang et al. [18] put forward based on projection onto convex sets a new hole to fill. They will observe the way pixels projected into the hole in the frame of reference of the frame formed by the convex set to fill the position of holes by it. Xu et al. [19] show the filtering shaded areas of the holes by Kinect photography method of the depth map. This method is used by traditional Kinect camera and depth maps provided by the original RGB image. They used the original image capturing moving objects and background differences, and then filled the main application area for 4-neighborhood pixels interpolated to holes area. Xu et al. [20] proposed a deep secondary image restoration method based on the model to restore a large shaded area. It includes two processing, deformation depth maps to fill and color image to fill. Because depth map can be considered without texture, grayscale images, it is easy to fill. Shaded areas of the color images are based on the associated filling depth map information to predict. Background area with the texture has a high priority in filling and shaded areas by model-based image restoration with its background texture fill. First of all, Yang et al. [21] the proposed method to 8 connecting depth as a benchmark the hole number. For each hole in the depth of a number, use deep holes neighborhood pixel depth distributions for filling deep holes. Then, use the improved cross-bidirectional filter to fill the holes. Simply use the depth distribution of neighboring pixels, this method to improve the depth map, and reduced depth due to incorrect color filled.

In this paper, we give the general procedure of stereoscopic image generation and a hole filling technique. Next section we show some basic previous works that we are going to apply. The third section we demonstrate the computer experiment results. The conclusions and comments are given in the final section.

2 Proposed method

Currently it often used in 2D to 3D converted image synthesis techniques for depth imaging of mapmaking. Depth image drawing method is based on stereo system for objects derived from stereo image synthesizing method that adds up, the main process consisted of three parts: (1) pre-processing, (2) 3D image warping (3) hole filling. Pre-processing uses mainly the depth map by smooth filter after processing, noise reduction, and decides to zero plane (left and right eye images of parallax for the 0 position) location. General views of zero plane Multi-DVD set for the depth value is 128 or 255
points. Fig. 1, as a parallel set of diagrams of the photo camera and stereo image synthesis, Cl, and Cr severally for the optical center of the camera in the right eye and left eye (optical Center), Cc the optical center of the camera shot for us.

![Fig. 1 a parallel set of diagrams of the photo camera and stereo image synthesis](image1.png)

Regardless of the advantages, it has a serious problem. When we synthesize a virtual view with single color and depth image, occlusion regions appear. The occlusion is a visible region created due to different view point position as shown in Fig. 2. Since the occlusion regions have no information in input data, they are shown like holes on the synthesized images.

![Fig. 2 the hole appearance in image synthesis](image2.png)

**2.1 Review of mathematical morphology**

1. The erosion of the binary image $A$ by the structuring element $B$ is defined by:

$$A \ominus B = \{ z \in E | B_z \subseteq A \},$$

where $B_z$ is the translation of $B$ by the vector $z$, i.e., $B_z = \{ b + z | b \in B \}, \forall z \in E$.

2. The dilation of $A$ by the structuring element $B$ is defined by:

$$A \oplus B = \bigcup_{b \in B} A_b$$

The dilation is commutative, also given by:

$$A \oplus B = B \oplus A = \bigcup_{a \in A} B_a$$

3. The opening of $A$ by $B$ is obtained by the erosion of $A$ by $B$, followed by dilation of the resulting image by $B$:

$$A \circ B = (A \ominus B) \oplus B.$$  

4. The closing of $A$ by $B$ is obtained by the dilation of $A$ by $B$, followed by erosion of the resulting structure by $B$:

$$A \bullet B = (A \oplus B) \ominus B.$$  

**2.2 Review of bilateral filter:**

The bilateral filter is defined as

$$I_{filtered}(x) = \frac{1}{W_p} \sum_{x_i \in \Omega} I(x_i) f_r(|| I(x_i) - I(x) ||) g_s(|| x_i - x ||)$$

where the normalization term

$$W_p = \sum_{x_i \in \Omega} f_r(|| I(x_i) - I(x) ||) g_s(|| x_i - x ||)$$

ensures that the filter preserves image energy and

- $I_{filtered}$ is the filtered image;
- $I$ is the original input image to be filtered;
- $x$ are the coordinates of the current pixel to be filtered;
- $\Omega$ is the window centered in $x$;
- $f_r$ is the range kernel for smoothing differences in intensities. This function can be a Gaussian function;
- $g_s$ is the spatial kernel for smoothing differences in coordinates. This function can be a Gaussian function;

**2.3 Proposed method**

In this method there are two of the most important parts is the acquisition of depth information, another is the hole
filling after image warping. For acquisition of depth information, edge information can be used to convert color images to grayscale depth map. Another problem for the depth maps for filling of holes you can do preprocessing. Preprocessing for depth map is doing image smoothing. It can reduce the number and scope of holes. The flow chart of our proposed as following:

**Step 1:** Depth image drawing method: 2D images into 3D images using depth image drawing method, as shown in Figure 3.

**Step 2:** Use depth information classification, the distinction between foreground and background: Mark the foreground area is to search for matching blocks can be judged, and morphological characteristics with a depth map of the closed holes filled up, so the blocks will be marked future errors can be avoided by taking to fill.

**Step 3:** Detecting Hole type: it makes different situation for different processing; by single image synthesis produces more virtual images, this process caused many images of broken situation, roughly divided into single points of broken hole, small range cracks, and big regional broken hole, its causes for rounded of calculation errors value, as referred to around eye calculation out of formula, and depth changes not obviously regional and prospects and background junction, depth dramatic changes.

**Step 4:** For a small break area get holes and cracks in the small, mean approach, breaking scenario for minor uses a simple way to do it, can effectively reduce the operation time, while maintaining the image quality.

**Step 5:** Large broken area filled: For a hole in the image to fill the order, select a gradient higher the value, the higher the priority, the aim is to give priority to the image partially filled with texture information to complete, avoiding vertical or horizontal lines break, imaging of the unnatural. Observation on imaging characteristics of holes, found forming holes due to image after Warping caused by horizontal displacement to the left or to the right, so the best way to fill is the holes around the blocks to find the closest replication similar to determine whether the sum of squared differences (SSD) as a judge and representatives of the smaller the number, the more similar. We use morphological holes filled at this time.

The procedure of our proposed method is shown in Figure 3.

### 3 Experiments Results

The experiment of the proposed algorithm, we apply it to one-view and one-depth video of the benchmark image “Ballet” shown in Fig. 4.

Fig. 5 shows the labeled of foreground of depth map after lateral filtering. We synthesize the single color image using 3D warping with the camera parameters. Fig. 6(a) is the left view of ballet and Fig. 6(b) is the right view of ballet after warping. Fig. 7 and Fig. 8 show the final results.

![Fig. 3 the flow chart of proposed method](image)

![Fig. 4 single color image Ballet](image)

![Fig. 5 (a) depth map after lateral filtering (b) labeled of foreground](image)
Fig. 6(a) left view image after warping (b) right view image after warping

Fig. 7(a) left view image after hole filling (b) right view image after warping

Fig. 8(a) left view depth after hole filling (b) right view depth after warping

4 Conclusions

Proposed method in this paper, we select the right way according to various characteristics of holes to fill, and use the morphology, texture information area for the highest priority, and also refer to the depth of information, avoid to use the foreground information to fill the hole in the background error conditions occur. Through experimental results demonstrate that this method effective in the benchmark scenes and complete hole repair images, which allows us to enjoy a more natural and proper 3D images of the future 2D convert to 3D technologies become more widespread.

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5 References


