

Survey on Depth Map Pre-processing Techniques in Depth Image Based Rendering

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ABSTRACT: This paper presents a survey on different depth map pre-processing techniques used in DIBR (depth image based rendering). The recent years have witnessed 3-dimensional technology to become increasingly popular, as it can provide high quality and immersive experience to end users. DIBR is a 2-D to-3-D conversion technology that is used in many applications such as 3DTV and auto stereoscopic displays. One of the main problems in DIBR is how to reduce holes that occurred on the generated virtual view images due to the disoccluded areas in the depth map. For many applications the input depth map are demanded to be complete and precise which is hard to be met by existing depth sensing techniques. The problem can be solved by incorporating depth enhancement methods as a pre-processing step.

KEYWORDS: Depth image based rendering, auto stereoscopic, 3DTV, disoccluded, depth map

I. INTRODUCTION

As new technologies are arising day by day 3-D can be regarded as the next revolution for many applications such as television, movie and electronic games. Traditional methods synthesize a 3-D view by using more than two images, which costs high for processing resources for compression and transmission. During this time DIBR (Depth image based rendering) have been proposed by Advanced Three Dimensional Television System Technologies (ATTEST) of European information society technology that uses a 2-D image and a corresponding depth map. DIBR improves the saving and transmission defects in traditional 2-D to 3-D conversion techniques. In this image rendering technique, information contained in a gray-level depth map is used to shift pixels in the original image to generate a new image as if it were captured from a new viewpoint. Depth map contains information regarding the distance of scene objects from a view point or camera. Currently there are three methods for obtaining depth map. They are a depth camera, a stereo metric camera, and image structure analysis. A depth camera estimates a depth map by utilizing light source sensors such as infrared and laser. A stereometric camera estimates the corresponding depth map by using the calculated parallax between two images taken by two cameras and image structure analysis uses image characteristics.

DIBR generates a multi -virtual view of the left or right image and that requires a depth value to give a dimensional effect from a depth map. A major source of problem with image based rendering is that holes or disocclusions occur during 2-D to 3-D conversion technology. These are caused by various depth changes and incomplete depth information that may result in to degrade 3-D image and stereoscopic views. These depth changes are mainly due to the intrinsic features of kinect used to capture depth map and also changes of external environment parameters. The quality of depth map determines the quality of DIBR synthetic view massively. Errors in the occlusion areas in depth map will decrease the resultant 3-D image quality significantly. However such a poor quality depth map has a narrow scope of application, leading the produced 3-D image severe mistakes.

One of the solutions for this is pre-processing of the depth map. A high quality depth map that is consistent with the color image is important for many applications especially those aiming to achieve good visual effects such as free view point video rendering, augmented reality etc.. For many applications the input depth maps are demanded to be complete

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and precise which is hard to be met by existing depth sensing techniques. Obviously if an efficient depth enhancement method is available, the problem can be greatly relieved by using it as a pre-processing step. In the rest of the paper we will be discussing various techniques for pre-processing the depth map.

II. LITERATURE SURVEY

In the following section we will be discussing about various techniques used for pre-processing depth map.

1. *Symmetric Gaussian filter*

Tam *et al.* [1] proposed a symmetric Gaussian filter for smoothing the whole depth map to reduce the hole occurrences, especially in the depth regions with horizontal sharp discontinuities. Smoothing of depth map before image warping is one solution for reducing the number of holes

because it reduces the sharp discontinuities in the depth map. The advantage of this method is that it is simple and easy to implement. The main drawbacks are it causes geometric distortions on the regions with vertical lines and since it is applied to the whole depth map the computational time is increased.

2. *Reshaping the Dynamic Range of Depth Map*

Ravi Krishnamurthy *et al.* [2] proposed the concept of reshaping the dynamic range of depth map in order to improve coding efficiency and rendering quality. In this method the dynamic range of higher depth values are expanded and the dynamic ranges of lower depth values are compressed. In this method first the depth maps was scaled to a value [0, 1]. Then we passed the depth map through a quadratic function for expanding and compressing higher and lower depth values.

3. *Asymmetric Gaussian filter*

Zhang *et al.* [3] proposed an asymmetric Gaussian smoothing filter to pre-process the whole depth map. Gaussian smoothing filter deals with geometric distortions caused due to symmetric smoothing filtering [1]. It employs larger smoothing strength on the vertical direction than on the horizontal direction thus vertical geometrical distortions are reduced. The strength of the smoothing of depth maps in the horizontal direction should be less than that of the smoothing in the vertical direction and this is called asymmetric smoothing.

We can use an asymmetric filter to smoothen the sharp depth changes in a manner that will overcome the disocclusion problem and also will provide good, reasonable disparity cue. Smoothing has many advantages it reduces the contrast of depth maps and thus, narrows the range of disparities contained in the rendered images. And also it reduces the sharp transitions at the edges and borders of objects that are in front of a background and, therefore, smoothes out the depth at and near the outlines of objects. The main drawback with the asymmetric smoothing filter is since it is applied to the whole depth map, which causes depth degradation and also increases computational complexity.

4. *Edge Dependent Depth Filter*

Chen *et al.* [4] proposed an edge-dependent depth based symmetric smoothing filter. This method detects the hole location by special edge filter. And the pre-processing of depth map is operated on the detected edges. In this way the required computation time for the DIBR system is less than the time for smoothing the whole depth map. Moreover the depth quality of non-hole region is preserved. The main drawback of this paper is that it still produces vertical geometric distortion on the hole region of the virtual view.

4. Adaptive Edge Oriented Smoothing

Lee *et al.* [5] proposed a method that uses Adaptive edge oriented smoothing process depending on the characteristics of holes, that is whether the hole region contains vertical lines or not. Adaptive edge oriented smoothing filter contains two types of filters: the asymmetric smoothing filter and symmetric smoothing filter. The asymmetric smoothing filter is used to reduce geometric distortions by smoothing the vertical lines that occurs in the holes. The symmetric smoothing filter is used to reduce the number of holes and computation time by smoothing the hole regions without vertical lines. Smoothing filter selection is based on the edge information around the hole regions. Unnecessary smoothing of the non hole regions of depth image is also avoided.

This method is used to reduce the hole occurrences, geometric distortions and computation time. Smoothing process is performed only in depth map with sharp depth discontinuities, thus the computational time is reduced and depth quality of non-hole regions is also preserved. The major steps includes hole detection, vertical line detection using Sobel mask. After these steps, holes with vertical lines are smoothed using asymmetric smoothing filter and holes without vertical lines are smoothed using symmetric smoothing filter. The main drawback of this method is that the original information of the depth map is lost because of the various sizes and direction of holes that are created by different sizes and direction of rapid changes in the depth map which destroys the 3-D view.

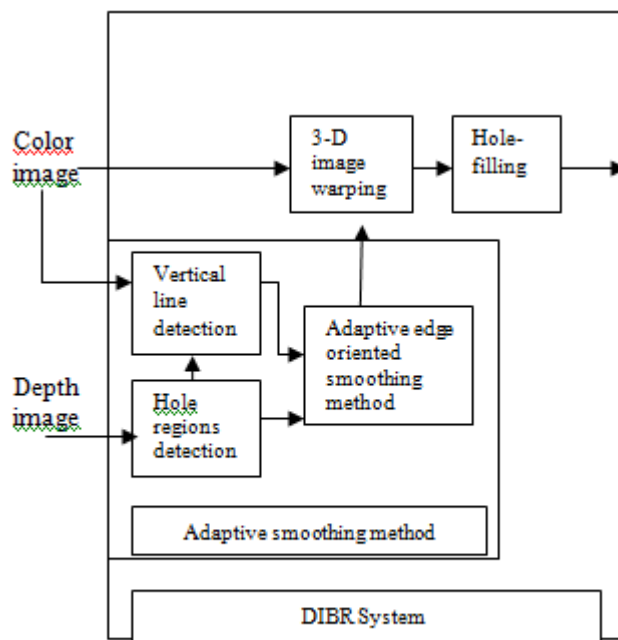


Fig1. Adaptive smoothing method

5. Distance Dependent Filtering

Daribo *et al.* [6] proposed a Distance dependent filtering for pre-processing the depth map. This paper proposes that the disocclusion occurs at nearby object boundaries. And the depth map is filtered only in those regions, which reduces the filtered region of the depth map. However the geometric distortion still exists, since it uses the symmetric smoothing filter. Instead of using a full smoothing on the whole depth map, we uses here an adaptive filter taking into account the distance to the edges. In order to obtain this information a preliminary pre-processing stage is applied to extract the regions around the Contours of Interest.

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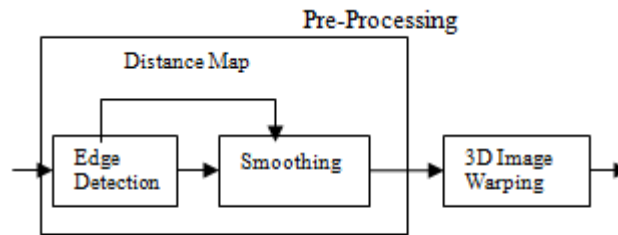


Fig 2 .Distance dependent filtering

The main drawbacks are it causes geometric distortions and it doesnot consider the strength of the depth map discontinuity, therefore the depth quality is not sufficient.

6. Discontinuity Adaptive Filter

Sang-Boem Lee *et al.* [7] proposed a discontinuity adaptive depth map filtering to reduce both holes and distortions. We apply an asymmetric smoothing filter to the depth map only nearby object boundaries. Before filtering the depth map, we determine the filtered region by the depth edge detection and the depth discontinuity analysis. Unlike [5] this method considers the strength of the depth map discontinuity.

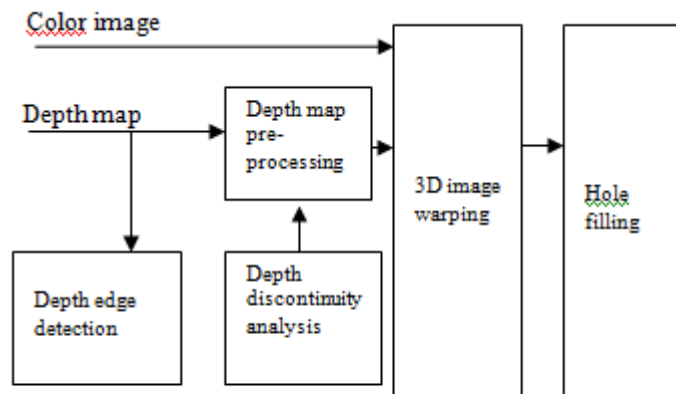


Fig 3. Discontinuity Adaptive Filter

- 1) Depth Edge Detection: Disocclusion areas are detected near object boundaries with sharp depth discontinuity. In this method object boundaries are extracted from the depth map first. Then the smoothing is performed nearby the boundaries thus reducing the filtered region.
- 2) Depth Discontinuity Analysis: Analyse the amount of depth discontinuity of object boundaries and then determine the filtered areas, we can minimize the depth map deformation.
- 3) Depth Map Pre-processing: In this method we use an asymmetric smoothing filter and the 4-neighbor distance from the point to the object boundary

7. Bilateral filter

Cheng *et al.* [8] proposed a non-linear Bilateral filtering technique .Compared to Gaussian filter ,the Bilateral filter preserves the sharp depth changes in conjunction with the intensity variation ,which results in consistent boundary of the distinct depth levels between the depth and color images. Moreover the smoothing of depths in the neighbourhood

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of similar color pixels deviates the sensitivity of depth noises .It is basically a non-linear, edge preserving and Gaussian noise reducing filter for color and grey images. The main drawback of this method is that it replaces each pixel with filtered value whether it is noisy or not

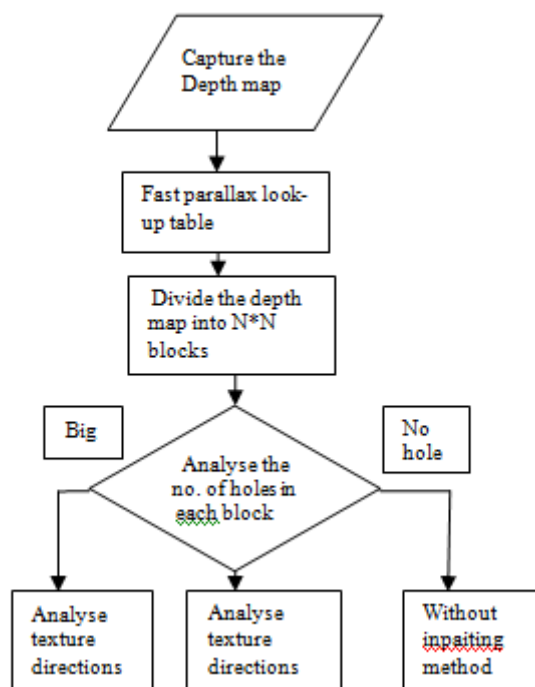
8. Color and Depth Consistency Based Method

Yanke Wang *et al.* [9] proposed a method that exploits the consistency between the depth map and the coupled color image .This method estimates confidence of each pixel in the depth map ,uses the multiple features extracted from the color image as guidance and perform an MRF(Markov Random Field) based optimization to correct errors in the depth map and fill the missing depth pixels.Raw depth map is smoothed under the guidance of the color image to reduce the effect of noise.Multiple cues are extracted from the color image.The multiple cues and the smoothed depth map are fused to produce the output depth map.

The main drawback of our method is that it performs depth optimization based only on the color image and smooth prior and the main objective is to improve the consistency between color image and the depth map but not to measure the true depth. Another drawback is that it does not consider temporal constraint, therefore when being used for video temporal coherence may not be maintained.

9. Adaptive Compensation Method

The previous studies proposed a smooth filter to construct images. But with a fixed size smooth filter it is less flexible, in terms of adaptation so there can be more false holes. Chih-HsienHsia [10] proposed an adaptive compensation method. Firstly the depth value is converted in to parallax value using a fast parallax look-up table. The depth image is then divided into N*N blocks and the number of holes in each block is determined .and classified into 3 modes according to the number of holes in each blocks that is Mode 1 Mode 2, Mode 3.Mode 1 which covers regions having large number of holes are in painted in accordance with the texture directions using Sobel mask. Mode 2 represents smaller holes, areas with stronger vertical lines are subjected to asymmetric Gaussian filter and areas with less vertical lines are subjected to symmetric Gaussian filter . Mode 3 represents areas with no holes.No action are taken in areas with no holes.



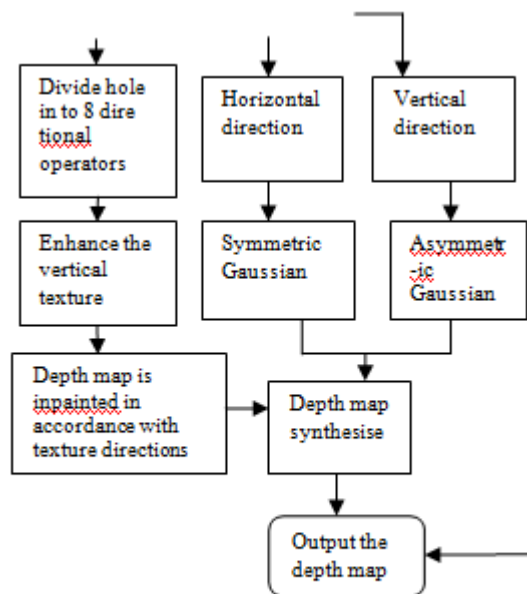


Fig4. Compensation method

III. CONCLUSION

The literature review presents the facts that there are large numbers of depth map pre-processing techniques are available. For many applications, the depth map are demanded to be complete and precise. We have discussed so far many techniques, their advantages and disadvantages. Further the review reveals the fact that even though abundant information on depth map pre-processing techniques are available, a performance evaluation of various schemes is absent. At present an adaptive compensation method shows better result than any other previous works. Previous works have proposed the concept of a smoothing filter to construct different images. However a fixed sized filter is less flexible in terms of adaptation to more false holes. The adaptive compensation method addresses all these issues.

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