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### NOVEL METHOD FOR DEPTH MAP PRE-PROCESSING IN DEPTH IMAGE BASED RENDERING

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#### ABSTRACT

3D technology increases the visual quality as compared to 2D technology. DIBR (Depth Image Based Rendering) technique is used to convert 2D to 3D using a single color image and its corresponding depth map. But the main problem with DIBR is that the generated 3D quality is of low quality due to the presence of disocclusions in the depth map. This work proposes an adaptive multimode filtering of depth map to improve the quality of 3D image generated by DIBR. The proposed method uses a Fast Parallax Lookup table to identify the hole locations. Then the depth map is divided into sub-blocks, which is further subjected to classification to categorize the holes into bigger and smaller holes. After that multi-mode filtering is applied according to the hole size to optimize the depth map. The experimental result shows that the proposed method results in high PSNR value as compared to existing methods.

**KEYWORDS:** 3D technology, Depth Image Based Rendering, disocclusions, depth map, holes

#### INTRODUCTION

In present era every multimedia devices needs 3D technology. 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. 3-D view generated using more than two images, requires more resources for compression and transmission. During this time DIBR (Depth image based rendering) has 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. Depth map contains depth information. There are several methods for obtaining depth map. They are a stereo metric camera, a depth camera and image structure analysis. A depth camera uses depth sensors to estimate depth map. A stereo metric camera estimates the corresponding depth map by using the parallax value and image structure analysis uses image characteristics.

DIBR generates virtual left or right view of an image and that requires a depth value to give a dimensional effect from a depth map. A major source of problem with depth image based rendering is that holes or disocclusions in the generated view. These are caused by various depth changes and incomplete depth information that may result in to degradation of 3-D image. These depth changes are mainly due to the variations occurred while capturing the depth map and also changes of external environment parameters. The quality of depth map determines the quality of DIBR synthetic view massively. However 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 Applications that aims good visual effects such as free view point video rendering, augmented reality etc. requires high quality depth map. With the existing depth sensing techniques a complete and precise depth map is hard to be met. Since many applications requires a complete depth map there is need of an efficient depth enhancement method. In the rest of the paper we will be discussing about a technique for pre-processing the depth map.

## RELATED WORKS

In [1] Tam *et al.* proposed a symmetric Gaussian filter. In this method the hole occurrences are reduced by smoothing the whole depth map. The advantages of this method are it is simple and easy to implement. But on the other side it causes geometric distortions on vertical regions and also computation time is high.

In order to overcome the disadvantages of [1] Zhang *et al.* proposed an asymmetric Gaussian smoothing filter in [2]. As the name asymmetric, it provides more smoothing effect on vertical direction rather than horizontal direction. Even though it is better than symmetric Gaussian filter in [1] its computation complexity is high. Another method is proposed by Chen *et al.* in [3]. This method uses an edge-dependent depth based symmetric smoothing filter. Edge filter is used to detect holes and smoothing is performed only in those areas thus preserving original information of depth map and computation time. But the main drawback is that it causes geometric distortions in vertical regions.

In [4] Lee *et al.* proposed a method that uses Adaptive edge oriented smoothing filter. Smoothing is performed based on the characteristics of holes, that is whether the hole region contains vertical lines or not. It consists of asymmetric smoothing filter and symmetric smoothing filter. The asymmetric smoothing filter is applied to regions with vertical lines in order to reduce distortions. Symmetric smoothing filter is applied otherwise. The drawback of this method is that the original information of the depth map is lost.

In another method [5] Chih-Hsien Hsia proposed an Adaptive compensation method. Here depth map is divided into sub blocks and then pre-processing is performed. Even though the computation time is low, this method fails when there are large number of holes.

## METHODOLOGY

In order to improve the performance of DIBR depth map pre-processing is used. This method uses a Fast parallax Lookup table to locate hole positions. After identifying holes the image is divided into blocks, and then the number and type of holes in each block is identified, blocks are then classified into three modes for further processing. Block diagram of the proposed method is given below in Figure 1.

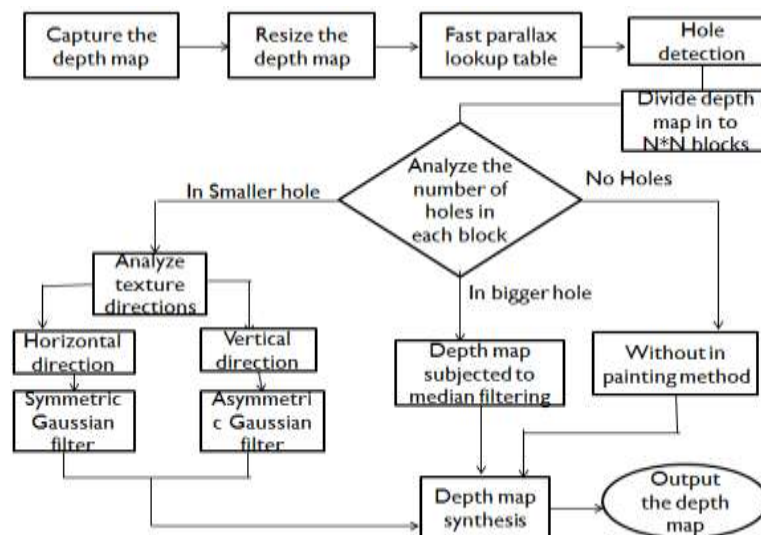


Figure1: Block diagram of proposed method

As the first step this method converts the depth value in the depth map to parallax value, using the fast parallax look-up table. After that the depth map is divided into blocks and then the number and type of holes in each block is identified. Blocks are classified into three modes: blocks with bigger holes, with smaller holes and with no holes. The bigger holes with greater depth values are subjected to median filtering. In the case of smaller holes, vertical line analysis is required, areas with stronger vertical lines are subjected to an asymmetric

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Gaussian filter, and areas with lesser vertical lines to a symmetric Gaussian filter. No action is taken in areas without holes. Finally, the results for the system after hole filling, are output.

#### Depth To Parallax Conversion Table

This table contains the parallax value for the corresponding depth value in the depth map. Conversion is performed to easily locate the hole positions using the below equation(1).

$$\text{Parallax} = M \times \{ 1 - \text{depth\_value} / 255 \} \quad (1)$$

where M is the parallax, generally 5% of the image width, *depth value* denotes the depth value in the depth map and Parallax denotes the parallax value computed.

#### Detection Of Holes

Holes can be identified at edges and regions with noises. This method uses the equation (2) to identify the hole locations. The criteria for hole detection works as if the difference between the parallax values of  $p(x,y)$  and its neighbor is greater than  $Th_0$ ,  $p(x,y)$  is determined as a hole and labeled by  $\text{Label } p(x,y) = 1$ ,

$$\text{Label}(x,y) = \begin{cases} 1, & \text{if } p(x+1,y) - p(x,y) > Th_0 \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

where the threshold value  $Th_0$  is set to 8 and  $p(x,y)$  denotes the value of parallax for a pixel.

#### Hole Block Mode Analysis And Classification

This method utilizes the results from the previous stage, to divide the depth image into  $N \times N$  blocks for analysis. Based on the experiments we choose  $N=16$ , since some holes are too bigger. The figure below shows block segmentation.

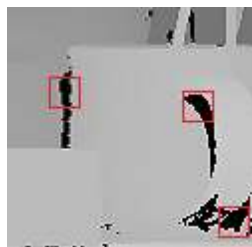


Figure2: Segmentation of Blocks

The procedure given below is used for classification of blocks into three modes, based on the number and type of holes. Mode 1 is the areas with bigger holes, Mode 2 is the areas with smaller holes, and Mode 3 is the areas with no holes, as seen in equation (3).

$$\text{Blocks} \begin{cases} \text{Mode1-no.of holes} > Th_1 \\ \text{Mode2-no.of holes} < Th_1 \\ \text{Mode3-no.of holes} = 0 \end{cases} \quad (3)$$

where  $Th_1$  is the threshold value.

#### Hole filling In Three Modes

If mode 1 is identified, that is areas with bigger holes they are subjected to median filtering. Median filtering is a nonlinear method used to remove noise from images. It is widely used since it is very effective at removing noise while preserving edges. The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighboring pixels. The pattern of neighbors is called the "window", which slides, pixel by pixel over the entire image. The median is calculated by first sorting all the pixel values from the window into numerical order, and then replacing the pixel being considered with the middle (median) pixel value. Before applying median filter `repmat` function is used to replicate the matrix. Then `cofilt` function is used to perform column wise neighborhood filtering on image. Performing sliding neighborhood operations columnwise when possible can reduce the execution time required to process an image.

In the case of mode 2 that is areas with smaller holes a Gaussian filter is used for smoothing, if the region does not contain vertical lines. If the hole region contains vertical lines we use an asymmetric Gaussian filter for blurring, or the symmetric Gaussian filter is chosen conversely. Texture directions are detected using sobel filter. The figure below shows Adaptive smoothing filter.

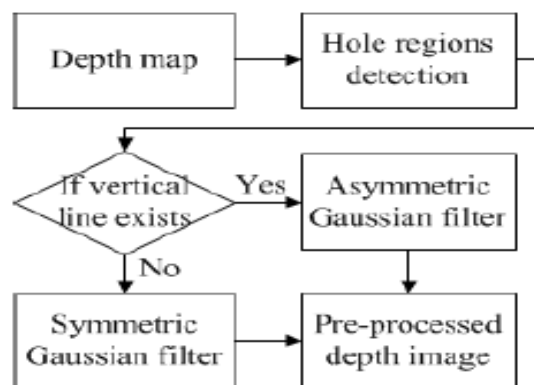


Figure3: Adaptive Smoothing Filter

When a region is determined as mode 3, no hole filling method is applied in order to preserve the depth map.

## RESULTS AND DISCUSSION

The test images for experiment are selected from Middlebury Stereo Vision database. According to the experiments conducted  $Th_0$  is selected as 8,  $Th_1$  as 25 and  $N$  as 16. Mode 1 is selected when the number of holes in a block is greater than 25. Mode 2 is selected when the number of holes in a block is less than 25. With symmetric Gaussian filter smoothing effect in horizontal direction is same as vertical direction. On the other side with Asymmetric Gaussian filter the vertical line smoothing strength is six times the horizontal direction. So for the symmetric Gaussian filter the window size is set to  $3 \times 3$  and for the asymmetric Gaussian filter it is set to  $18 \times 3$ .

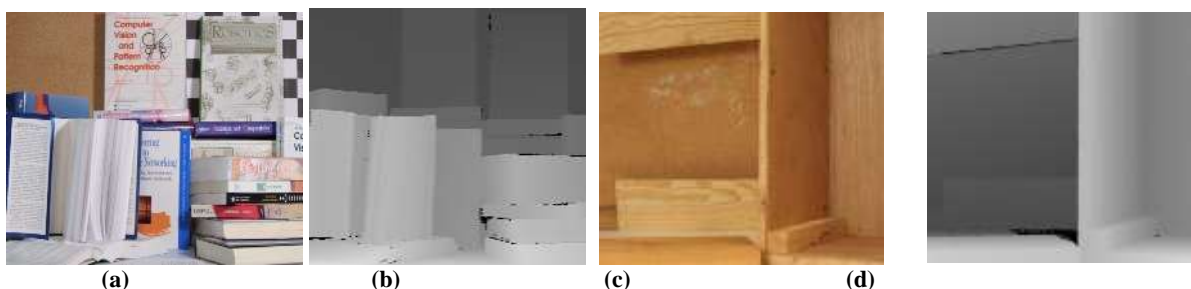
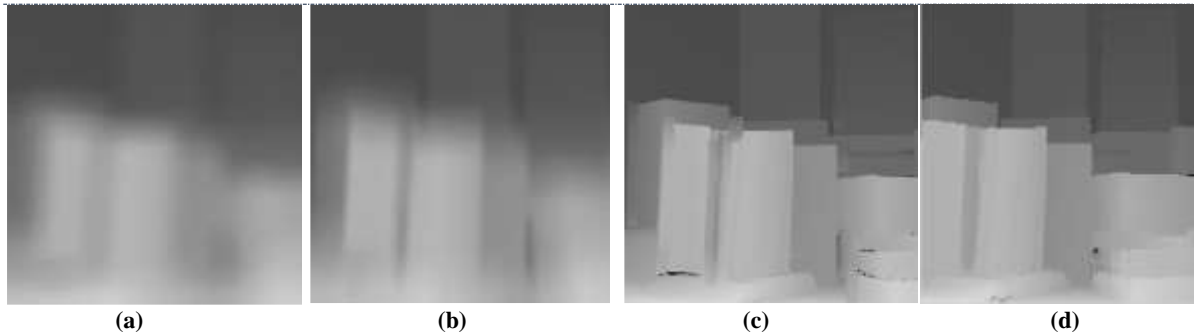
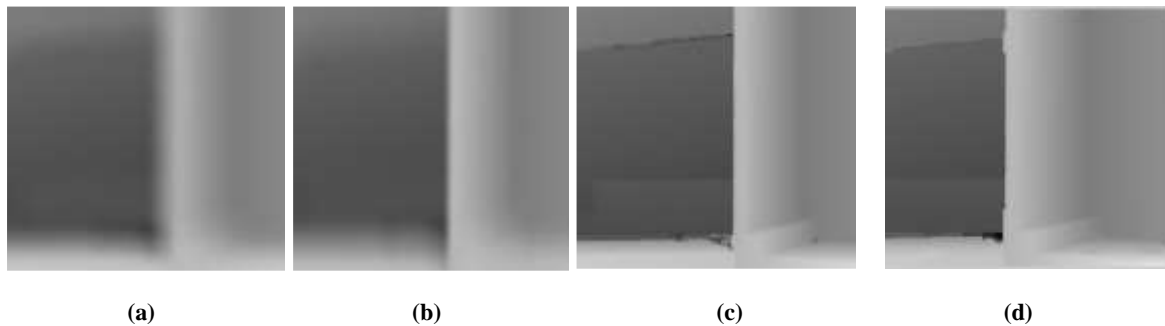


Figure4: Test Images (a) and (c) Books and Wood (b) and (d) Corresponding depth map



**Figure5: The result of Books (a) With symmetric smoothing filter (b) With asymmetric smoothing filter (c) With adaptive smoothing filter (d) This work.**



**Figure6: The result of Wood (a) With symmetric smoothing filter (b) With asymmetric smoothing filter (c) With adaptive smoothing filter (d) This work**

Figure 4 shows the Test images like Books and Wood. Fig 5 and Fig 6 shows the results using various methods and the proposed work. From the resultant image itself we can identify that the proposed work shows better result. Using the symmetric Gaussian filter the computation time is too long and the image is blurred. Although the geometric distortion of vertical lines was addressed by asymmetric Gaussian filter ,it causes blurring in non hole regions. From the comparison of the proposed method and previous works, it is worth noting that the proposed algorithm renders images with adaptive multi-mode filters, which are chosen according to different sizes of holes generated and maintains the vertical and horizontal lines well, non-hole regions in the original depth map information is also preserved, the results are shown in Figs. 5(d), 6(d).Table below shows the comparison of PSNR and Computation time of various methods.

Table1. Comparison of PSNR, Computation time for various methods

Test Images	Methods	PSNR	Computation Time(s)
Books	Symmetric Smoothing	26.408	5.2333
	Asymmetric Smoothing	27.075	4.573
	Adaptive Compensation method	35.852	.3
	Proposed method	92.4	.13
Wood	Symmetric Smoothing	25.243	9.9
	Asymmetric Smoothing	26.959	4.509
	Adaptive Compensation method	33.287	.298
	Proposed method	96.63	0.096

## CONCLUSION

In this work, an adaptive multi-mode filtering is proposed. The proposed method locates the hole positions using a fast parallax look-up table. It then divides the depth map into blocks to determine the number and types of holes. After this division the results are used for further classification. Blocks are classified into three modes based on the number and type of holes. Based on the modes multi mode filtering is applied. The proposed methodology needs to be tested for huge database. The experimental results show that the proposed method reduces the number of holes, computation time, and maintains the original information in the depth map. It also improves the quality of DIBR Technique.

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