A survey paper based on effective inpainting technique using DIBR

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Abstract— Image inpainting is the process of restoring lost parts of an image and reconstructing them based on information gathered from surrounding areas. This paper we have analysis review of a image inpainting method for Depth-Image-Based Rendering (DIBR) synthesized images technique to solve disocclusion holes problems in texture images and their respective depth maps. Quality of synthesized view by Depth-Image-Based Rendering (DIBR) highly depends on hole filling, especially for synthesized view where large disocclusion exists. Thus, many hole filling methods are proposed to improve the synthesized view quality. Inpainting is the most popular approach to recover the disocclusion regions.

Keywords— Image Inpainting, DIBR, Disocclusion region, Autostereoscopic image.

I. INTRODUCTION

Image inpainting is a technique of modifying an image in an undetectable way to the user. The purpose of inpainting is to fill the missing regions with information from known region in whole image. Image inpainting methods can be classified broadly into: Texture synthesis algorithm and Structure synthesis algorithm. Here we combination of this two algorithm for capable of inpainting large regions. Large image may take a lot of time to be inpainted. The most important applications of the image inpaiting are object removal, scratch removal, restoring missing areas, image repairing etc [5].

Figure 1: Idea of image inpainting

The fast development in 3D technology in recent years, has made the 3D displays an effective way to enjoy 3D content and so popular around the world. Today, there are TV sets, mobile devices and displays with 3D display function available in the market; hence, there are more technical demands in the 3D field. 3D image usually contains information of two or more viewing angles from left and right eyes that create a stereo feeling to both eyes while people are viewing the screen [3]. Autostereoscopic displays with 2D+Depth format has increased the number of available free viewing positions and one of the reasons is

the optimal quality of the synthesized views generated by the specific hardware used for this purpose. Taking this fact as a priority, effective, fast and low computational cost algorithms are necessary [1]. Through two images of different viewing angles and different shifts among objects in the images, we can estimate the disparity, then the disparity value can be normalized into gray value of 0~255, then through gray value distribution, we can obtain a depth map with distance information of the image. Such a process is called Depth Estimation [1-5], and such method can be used to obtain a set of original images and a depth map with distance information of different objects in the images. The original image and estimated depth map can be used together with Depth-image-based rendering [3] to calculate images of other different viewing angles.

DIBR can be used to generate virtual views by warping from the reference views based on depth information. However, DIBR has intrinsic limitation with disocclusion arising in rendering process. It is due to the fact that areas covered by objects in the reference views may appear in the synthesized views. Newly exposed areas (termed 'disocclusions' or 'holes') do not have corresponding information about the reference view, their texture and depth attributes are uncertain [2].

This paper is organized as follows: an overview of Depth-image-based rendering (DIBR) in Section 2 and depth-aided exemplar-based disocclusion filling is introduced in Section 4. The details of warped depth map filling and warped color image filling are described in section 3 and finally a conclusion is drawn in section 5.

II. DEPTH IMAGE BASED RENDERING (DIBR)

Depth-image-based rendering (DIBR) is an algorithm most commonly used in 2D to 3D conversion technique. In the researches of Fang- Hsuan Cheng and Moo-di Loo Tam [3], the flow of DIBR contains mainly pre-processing, image warping and hole filling as depicted in Figure 2.
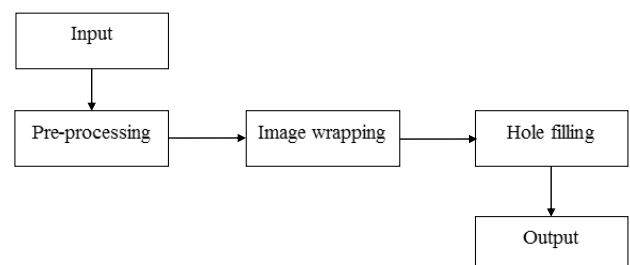

Figure 2: The Process flow chart of DIBR

In pre-processing, filter is used to reduce noise in original image and depth map, in the meantime, the reference point of viewing is also decided [3]. Reference point is the location where disparity between left and right

eye is 0. The plane reference point located is called zero-plane. When we own a set of original images and their depth map, we can then use the depth information to make image warping action. Classifying holes and adopting corresponding hole-filling methods not only can improve hole filling effect but also can reduce the excessive computation effort. Quality of synthesized view by DIBR highly depends on hole filling, especially for synthesized view where large disocclusion exists [1].

III. OVERVIEW

Disoccluded regions are usually the background regions and need to be filled properly to avoid the annoying artifacts. To recover the structures and texture information using background information are the two purposes of the disocclusion filling. Depth-aided exemplar-based disocclusion filling contains two procedures [2]:

(1) Warped depth map filling, and
(2) Warped color image filling.

Before disocclusion filling, color and depth images are warped together. Then disoccluded regions in the warped depth map are filled first using background information. Since depth map is gray-scale non-texture plane, it is much easier to fill the disoccluded regions. After the warped depth map is filled, color image is filled by depth-aided exemplar-based inpainting. After the warping process, new background areas appear without corresponding information about the reference view [1]. For this reason, many inpainting methods based on exemplar-based techniques has been applied to solve this problem, each one focused on optimization and giving a realistic synthesized view with minimal presence of artifacts [2].The problem with the DIBR is the appearance of dissoclusions in the virtual views that reduce the visual quality. These disocclusions look like holes in the synthesized images and could degrade the visual quality of the synthesized images greatly. In this context, it is defined the difference between background and foreground of the scene. The foreground is the area or object closest to the camera in the scene and the background being otherwise [1].

1. WARPED DEPTH MAP FILLING

In the warping process, positions of holes appear between the foreground and background objects. One example is shown in Fig. 3. Depth based extrapolation is used to fill the disoccluded regions. The disoccluded regions are created by relative disparity between foreground and background objects, like pixels A and B in Fig. 3(a). Pixel A is the neighbouring pixel to Pixel B before warping process. So the disoccluded regions between A and B have higher probability to be filled using the background information that is the minimum value of A and B [2].

The depth based extrapolations are respectively described by Equation (1) and (2):

$$D[n] = \min(D[m_l], D[m_r]), \qquad (1)$$
$$d(W^{-1}(m_l), W^{-1}(m_r)) = 1, \qquad (2)$$

Fig. 3: (a) Warped depth map; (b) Filled depth map using depth based extrapolation [2]

Where D is the warped depth image and W^{-1} describes the inverse 3D warping function; m_l and m_r are the positions of foreground and background pixels lying in the contour of hole; d(a, b) denotes the Euclidean distance, and n is the pixel location from m_l to m_r. Fig. 3(b) shows the filled depth map using the depth based extrapolation [2].

2. WARPED COLOR IMAGE FILLING

The color image filling has two procedures: filling order estimation and searching best matched patch. Filling order estimation is used to decide the order of patches to be filled. The best matched patch searching is to find the most similar patch to describe the patch to be filled. Filling order is updated after each patch is filled. The highest priority patch is selected and is filled by the best matched patch. This process repeats until the complete hole regions are filled [2].

A. Filling order estimation

Filling order is crucial to non-parametric texture synthesis, especially in view synthesis process. The background texture in disoccluded regions cannot be recovered if the filling order is not well organized. It fills the disoccluded region using sequential order, from left to right, top to bottom, and proposed similarity function in section B [2].
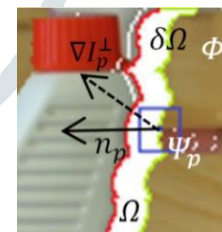

Fig. 4: Notation: Center of patch Ψ_p lies in the contour $\delta\Omega$. n_p is the normal to $\delta\Omega$ and $\nabla I1/p$ is the isophote at center of Ψ_p. Φ and Ω denotes the non-hole regions and the hole regions, respectively. The green line and red line of $\delta\Omega$ are the background and foreground pixels, respectively [2].

The notation diagram of filling order is shown in Fig. 4. It is judged by four factors: 1) whether patch lies in the background region. 2) Continuation of strong edge inside the patch, 3) confidence of patch which is described by the percentage of non-hole pixels inside the patch and 4) Consistent depth information of hole and non-hole of the patch [2].

B. Searching best matched patch

To search the best matched patch for the color image hole filling, a depth-aided similarity function C_d is used to

measure the similarity. The similarity term (C_d) includes two parts, cost of non-hole region (M_{nh}) and hole region (M_n). The non-hole region is measured by both color and depth information while the hole region is only measured by the depth information due to the lack of color information. By considering the depth information, the best matched patch has a very similar property as the patch to be filled, both in the hole region and non-hole region with texture and depth information [2].

IV. DEPTH AIDED EXEMPLAR BASED INPAINTING

The exemplar based consists of two basic steps 1. Priority assignment is done and the 2. The selection of the best matching patch. The exemplar based approach samples the best matching patches from the known region, whose similarity is measured by certain metrics, and pastes into the target patches in the missing region. Exemplar- based Inpainting iteratively synthesizes the unknown region i.e. target region, by the most similar patch in the source region [5]. The method fills structures in the missing regions using spatial information of neighboring regions. Normally, an exemplar-based Inpainting algorithm includes the following main steps:

I. Initializing the Target Region: in which the initial missing areas are extracted and represented with appropriate data structures.

II. Computing Filling Priorities: in this a predefined priority function is used to compute the filling order for all unfilled pixels p∈δΩ in the beginning of each filling iteration.

III. Searching Example and Compositing: in which the most similar example is searched from the source region Φ to compose the given patch, Ψ (of size N × N pixels) that centered on the given pixel p.

IV. Updating Image Information: in which the boundary δΩ of the target region Ω and the required information for computing filling priorities are updated.
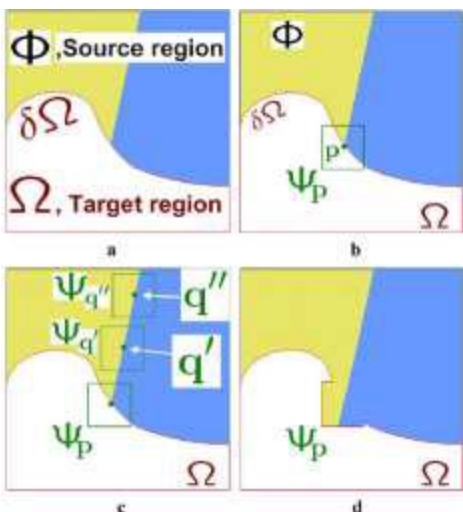

Fig. 5: Structure propagation by exemplar-based texture synthesis, (a) Original image, with the target region Ω, its contour δΩ and the source region Φ clearly marked. (b) We want to synthesize the area delimited by the patch ψp centred on the point p ∈δΩ. (c) The most likely candidate matches for ψp lie along the boundary between the two textures in the source region, e.g., ψq' and ψq''. (d) The best matching patch in the candidates set has been copied into the position occupied by ψp therefore achieving partial filling [5].

Exemplar based approaches work as follows:
Computing Filling Priorities, in which a predefined priority function is used to compute the filling order for all unfilled pixels p∈ δΩ in the beginning of each filling iteration.
Searching Example and Compositing, in which the most similar example is searched from the source region Φ to compose the given patch Ψ (of size N × N pixels) that centred on the given pixel p.
Updating Image Information, in which the boundary δΩ of the target region Ω and the required information for computing filling priorities are updated.

Algorithm:
Input: Original Image and Marked target region
Output: Inpainted Image

Step 1: Initialize confidence values; this confidence value does not change once the pixel has been filled, and initialize the confidence value for all the pixels in the source region (Φ) to be 1 and the confidence values for the pixels in target region (Ω) to be 0.
Step 2: Find boundary of region to be inpaint, if boundary is "empty set" than exit.
Step 3: Find priority for all patches on the boundary.

$$P(p)= \alpha \times Rc(p)+ \beta \times D(p)$$

$$C(p) = \frac{\sum_{q \in \psi_p \cap \phi} C(q)}{|\psi_p|},$$

$$D(p) = \frac{|\nabla I_p^{\perp}.n_p|}{\alpha'} \text{ and}$$

$$R_c(p) = (1 - \omega) \times C(p) + \omega.$$

Where, $|\Psi p|$ is the area of the patch, Ψp and α'' is the normalization factor, n_p is unit vector orthogonal to the front ($\delta\Omega$) at the point p and $\nabla I1/p$ is represents the perpendicular isophote at point p and also α, β and ω are constants.
Step 4: Select the patch which has highest priority, call that patch, Ψ_p.
Step 5: Find the n non-local exemplar patches from search window which is best match to patch Ψ_p, call that patch, Ψqi, where i=1, 2…, n.
Step 6: Calculate the weight of n best non-local exemplar patches w (Ψqi). Using weight of all exemplar patches find normalized linear combination coefficient αi.
Step 7: Calculate average for Ψ_p (avg Ψ_p), and also find average for all sample patch.
Step 8: Find Pearson's correlation for the all sample patch with Ψ_p.
Step 9: Suppose k is missing pixel in Ψ_p, for all sample patch calculate sum of difference of k_{th} pixel of Ψqi with avg Ψqi. Divide that sum with avg of Pearson's correlation.
Step 10: Find Sum of step9 result with avg Ψ_p. Replace K_{th} pixel with that value. And repeat step9 until all the value fill in Ψ_p patch.

Comparison of Inpainting Techniques:

Table 1 Comparative study of various image inpainting techniques shown in below table [5]**.**

Image Inpainting Methods	Advantages	Disadvantages
PDE based image inpainting	It is perform well for smaller inpaint region and noise removal application.	It cannot fill the large missing region. This method is that due to blurring effect of diffusion process replication of large texture is not perform well. Pixel on edges are not handle properly.
Texture Synthesis based image inpainting	The structure reconstruction good for selected set of image.	This method not perform well for natural image. It is not handle edges and boundaries well.
Exemplar based image inpainting	This method will prouce good result for inpainting the large missing region also these algo can inpaint both structure and textured image as well.	This algorithm generate staircase effect in image inpainting. Curved structure are not handle properly and biasing in due to incorrect selection of patches.
Hybrid based image inpainting	In this technique the tensor voting method is good for maintaining curvature.	Tensor voting method is not perform well on complex structures and Image segmentation of natural image.

V. CONCLUSIONS

According to Literature Review number of technique and Algorithm available for hole filling in image inpainting but still inpainting algorithm cannot fill the image missing region and it cannot restore the texture pattern. So in This paper we have analysis review of a image inpainting method for Depth-Image-Based Rendering (DIBR) use to reduce this problem issue using matlab. Also improve and work on different parameters.

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