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A Review of Image- based Rendering Techniques

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Abstract— *In this paper, we survey the techniques for image-based rendering and fundamental principles behind each technique. Image-based rendering is used to create a geometric model in 3D and then projecting it onto a 2D image. Image-based rendering is divided into three categories on the basis of how much geometric information is used. First is rendering without geometry, second is rendering with implicit geometry, and third is rendering with explicit geometry. Image-based modelling and rendering allows the use of multiple two-dimensional images in order to generate directly original two-dimensional images without using the manual modelling stage. Image-based rendering has gained attention in graphics to create realistic image.*

I. INTRODUCTION

In recent years image-based rendering get a place in graphics community for creating realistic images. It's one of the important benefit is ability to create real world effects and details of the real world by using collection of images. According to previous work on image based rendering it reveals that it based on the tradeoffs that how many images are needed and how much is known about the scene geometry.

Image based rendering techniques are classified into three categories rendering without geometry, rendering with implicit geometry and rendering with explicit geometry. It is shown in diagram.

Rendering with no geometry

Light field Lumigraph Mosaicking
Concentric mosaics

Rendering with implicit geometry

Transfer methods View morphing View
interpolation More Geometry

Rendering with explicit geometry

LDIs Texture-mapped models 3D warping View-dependent geometry View-dependent texture

Figure 1 Categories of rendering techniques

There are three main categories of image based rendering: rendering with no geometry, rendering with implicit geometry and rendering with explicit geometry. Each category is further divided; rendering with no geometry has three categories light field, mosaicking and concentric mosaics. Other categories are also further subdivided which is already shown in above diagram.

The remainder of this paper is organized as follows. Three categories of image-based rendering systems, with no geometry, implicit geometry, and explicit geometric information respectively, are presented in Sections 2, 3, and 4 and concluding remarks are discussed in Section 5.

II. RENDERING WITH NO GEOMETRY

In this section, we are going to discuss about rendering with no geometry. This technique is dependent on plenoptic function.

2.1 Plenoptic modelling

Image based rendering is a powerful new approach of generating photorealistic computer graphics. They can provide animations without any external geometric representations. Plenoptic function is given by Adelson and Bergen, is a parametric function which describe anything that is visible from a given point in space.

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Plenoptic function is a 7D function to describe light intensity passing through every viewpoint, for every direction, for every wavelength, and for every time instant. The original 7D plenoptic function is defined as the intensity of light rays passing through the camera center at every location (Vx, Vy, Vz) at every possible angle (θ, φ), for every wavelength λ, at every time t, i.e.,

$$\mathbf{P7 = P(Vx, Vy, Vz, \theta, \varphi, \lambda, t).} \quad (1)$$

Adelson and Bergen extracted a compact and useful description of the plenoptic function's local properties (e.g., low order derivatives). It was proofed that light source directions can be incorporated into the plenoptic function for illumination control. McMillan and Bishop introduced 5D plenoptic function for plenoptic modelling, by eliminating two variables, time t (static environment) and light wavelength λ (fixed lighting condition).

$$\mathbf{P5 = P(Vx, Vy, Vz, \theta, \varphi).} \quad (2)$$

The simplest plenoptic function is a 2D panorama (cylindrical or spherical) when the viewpoint is fixed.

$$\mathbf{P2 = P(\theta, \varphi).} \quad (3)$$

Image-based rendering becomes one of constructing a continuous representation of the plenoptic function from observed discrete samples.

2.2 Lumigraph and Light field

It was seen that if we lie outside the convex hull of an object then we can convert a 5D plenoptic function into 4D plenoptic function for both lumigraph and light field,

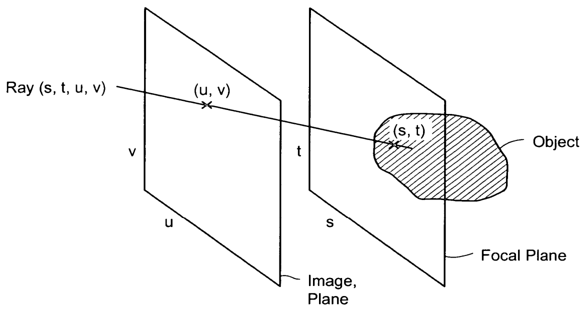

Figure 2 Light Field Representations [1]

i.e.

$$\mathbf{P4 = P(u,v,s,t)} \quad (4)$$

where (u, v) and (s, t) parameterize two parallel planes of the bounding box.

Aliasing effect can be reducing in light field by applying pre-filtering before rendering. Vector quantization approach is used to reduce amount of data in light field and on the other hand lumigraph can be constructed from a set of images taken from any viewpoint and after this a re-binning process is required.

2.3 Concentric mosaics

Constrain camera motion to planar concentric circle; create concentric mosaics by composing slit images taken at different locations along each circle. It is a 3D parameterization of plenoptic function: radius, rotation angle, vertical elevation. If we want to capture all view point then we need 5D plenoptic functions. If we stay inside the convex hull we have 4D lightfield and if we don't move at all for that we have 2D panorama. And concentric mosaic is a 3D plenoptic function.

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Figure 3: Rendering a lobby: rebinned concentric mosaic (a) at the rotation center (b) at the outermost circle (c) at the outermost circle but looking at the opposite direction of (b) [1]

(d) a child is occluded in one view but not in the other; [1]

(e) parallax change between the plant and the poster [1]

Concentric mosaic represents 3D plenoptic function: radius, rotation angle and vertical elevation. Vertical distortion exists in the rendering image, depth correction alleviate vertical distortion. In depth correction rays in the capture plane have no problem, for rays off the plane: Only a small subset of the rays off the plane is stored so have to approximate all rays off the plane from only the slit images. This may cause vertical distortion in the rendered images. Concentric mosaic has good space and high efficiency. In comparison off light field or lumigraph, concentric mosaic has smaller file size. Concentric mosaics are easy to capture except that it require more number of images. It is useful for capturing many virtual reality applications.

Rendering a lobby scene is shown in figure 3. A rebinned concentric mosaic at the rotation center is shown in 3 (a), at the outermost circle is shown in 3(b) and at the outermost circle but looking at the opposite direction of (b) is shown in 3(c). In 3(d), a child is occluded in one view but not in the other is shown. In Figure 3(e), strong parallax can be seen between the plant and the poster in the rendered images.

2.4 Image mosaicing

Incomplete sample of images are used to create a complete plenoptic function at fixed point. A panoramic mosaic is constructed by many regular images. For arbitrarily camera motion, first register the images by recovering the camera movement before converting into the cylindrical/spherical map. Now a day's many systems has been built to construct cylindrical panorama by overlapping multiple images. Multiple slits of images are used to construct large panoramic mosaic. By using omnidirectional camera it is easier to capture large panorama. Many transformation operations are applied on set of images to construct a panorama. Transformation matrix is associated with each input image. A rotation mosaic representation associates a rotation matrix with each input image.

Figure 4: Tessellated spherical panorama covering the North Pole (constructed from 54 images). [1]

III. RENDERING WITH IMPLICIT GEOMETRY

Rendering with implicit geometry is a technique that depends on positional correspondence across a small number of images to render new views. In this technique implicit geometry is not directly available but 3D information is computed only using the usual projection calculations.

3.1 View interpolation

View interpolation is one of the algorithms for image based rendering. This method was given by Chen and Williams. In this method we need sample number of depth images, by this sample make adjacent graph in which images are nodes and edges are mapping between them and after that interpolate pixels to construct in between images. This method works well when all the input images have same gaze direction and all the output images have restriction to gaze angle less than 90 degree. [1]

3.2 View morphing

By using this technique we can reconstruct any viewpoint on the line linking two optical centres of the original image from two input images. If the camera motions of the intermediate views are perpendicular to the camera viewing direction then intermediate views are exactly linear combinations of two views. A pre-warp stage can be employed to rectify two input images so that corresponding scan lines are parallel only if the two input images are not parallel [1]. Accordingly, a post-warp stage can be used to un-rectify the intermediate images.

3.3 Transfer methods

Transfer methods use small number of images with the application of geometry constraints to reproject image pixels at a given virtual camera viewpoint. Geometric constraints can be of the forms of known depth value at image pixels. View interpolation and view morphing methods are specific instances of transfer method. For generating novel view from two or three reference images, first the reference trilinear tensor (that link correspondences between triplets of images) is calculated from the point correspondences between reference images. In the case of two images, one of the images is replicated as third image.

IV. Rendering with explicit geometry

This technique has 3D information encoded in it in the form of depth along known line-of-sight or in 3D coordinates.

4.1 3D warping

3D image warping is a process of generating a novel view on the scene based on depth information from one or more images. An image can be rendered by any near view point information by projecting the pixels of original image into 3D location and then re-projecting them into new image. Many holes are generated in wrap an image that is the main problem and this is happened because of sampling resolution difference in input and output image. For filling the holes, the method used is to splat a pixel in the input image to several pixels size in the output image.

To improve the rendering speed of 3D warping, there are two steps firstly pre-warping step and then **texture mapping** step. **Texture mapping** step can be performed by graphics hardware. 3D warping technique can also be applied on multi-perspective images.

4.2 Layered depth images

By storing not only what is visible in image but also what is behind the visible surface we can deal with disocclusion artifacts in 3D warping in LDI. In LDI, each pixel in input image store level of depth and colour information where ray from pixel intersect the environment. LDI is the simplest method of warping a single image.

4.3 View-dependent texture maps

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In computer graphics texture mapping are used to generate photo realistic environment. Texture mapping models for real environments can be generated using 3D scanner. Vision techniques are not enough robust to recover accurate 3D models. It is difficult to capture visual effects such as highlights, reflections, and transparency using a single texture-mapped model.

V. CONCLUDING REMARKS

We have surveyed recent development in image based rendering techniques and, categorize them on the basis of how much geometry information is needed. Geometry information is used as compressing representation for rendering. Image based rendering representation have advantage of photorealistic rendering but have high cost for storing information.

IBR and 3D model based rendering techniques have many commendatory characteristics that can be exploit that is clear by our survey. In future rendering hardware customization should be done to handle both 3D model-based rendering and IBR.

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