Capturing Spherical Light Fields of a Real Scene

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Abstract

We have developed a spherical light-field capturing system that can generate arbitrary views from a real scene, not a synthetic one. It allows us to render high-quality (XGA) novel views for inside-looking-out observation of a surrounding environment with six degrees of freedom.

1. Introduction

Image-based rendering such as *light fields rendering* is a promising method for creating photo-realistic views of a scene without 3D models. Most techniques, however, fall short when an omnidirectional viewing range is desired. Unlike conventional capturing systems, our system can generate translational views in addition to rotations. Previous methods such as *Circular projection* [Peleg and Ben-Eza 1999] and *concentric mosaics* [Shum and He 1999] support 360˚ horizontal range, but lack vertical field of view and restrict vertical translation. Although several reports [Ihm et al. 1997; Shen et al. 2001] extend the range, yet none is able to use real data. We introduce the first system that can automatically acquire *spherical light fields* of a real scene to generate a virtual tour in six degrees of freedom.

2. Spherical Light Fields

We employ a variation of sphere-plane parameterization of a light field which consists of a spherical surface S and an orthogonal plane I associated with a surface point of S parameterized by (θ, φ). Points on I are parameterized by (u, v) across the plane. Thus, each quad (u, v, θ, φ) defines an oriented ray assumed having constant intensity within S.

3. Acquisition

Acquisition is automated utilizing a digital still camera mounted on a computer-driven pan-tilt unit (PTU). To generate translational views, we use the PTU customized by Directed Perception Inc. and our specially designed jig. [Fig. 1]. This system can be configured such that the camera's projection center has an offset to rotational centers. Two kinds of rotations, panning and tilting, share the same center. For capturing images at uniformly spaced positions Pi around S is important, we use a geodesic sphere subdivided from an icosahedron. The PTU rotates the camera to the positions of vertices of the sphere. As a result, each captured image corresponds to a plane Ii orthogonal to the vector pointing from the rotation center to Pi. A virtual image plane can be placed anywhere within S .

4. Rendering and Ray Correction

We use the ray-tracing technique to render novel views. For each pixel of a virtual image, a ray is cast from the viewpoint to intersect S to find the nearest sample image. The sample point is determined by re-casting the same ray to intersect the sample image plane. However, this procedure can lead to severe errors due to the problem of sampling rate. The chosen sample point is likely to be on a differently oriented ray when the sampling rate is lower than the resolution of the virtual image. We minimize this error by using a ray that is parallel to the cast ray and passes through the sample image's projection center. The new sample point determined by the alternative ray is used.

5. Experimental Results

Fig. 2 and 3 show generated high-quality views. The capturing time for a total number of 12,007 XGA-size images was 19 hours to cover one vertical hemisphere of a room. The rendering time for each image was 9.6 seconds on a Pentium 4 (2.26MHz). To reduce it, a quad-tree structure was used. A generated walkthrough video shows the effectiveness of this system for realizing photorealistic and immersive VR simulations.

6. Discussion

Since the angular resolution of the PTU (0.01 degrees) was reliable, no camera calibration was necessary. No 3D information was used to render even for close objects. We can shorten the capturing time by adding cameras. We have also rendered views for stereoscopic images.

Our future topics include an analysis of sampling-rate in image acquisition against rendered image quality. We might be able to avoid the traditional problem of 3D depth recovery if we capture a sufficient number of images.

References

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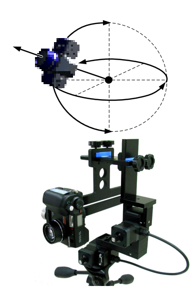

Fig. 1: Capturing apparatus

Fig. 2: Rendered novel image

Fig. 3: Rendered images in different viewing directions

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