A Low Cost Multi-Camera Array for Panoramic Light Field Video Capture

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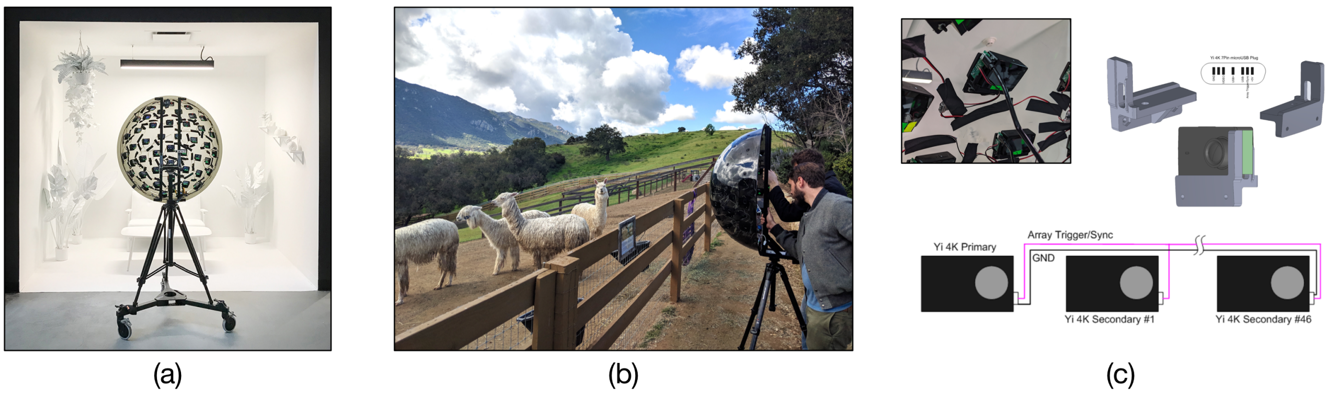

Figure 1: (a) Our light field video camera array with 47 Yi 4k unit cameras on a hemisphere. (b) The array is portable and easily transported for location shooting. (c) Cameras are time synchronized and mounted using custom 3D printed brackets.

ABSTRACT

We present a portable multi-camera system for recording panoramic light field video content. The proposed system is capable of capturing wide baseline (0.8 meters), high resolution (>15 pixels per degree), large field of view (>220°) light fields at 30 frames per second. The array contains 47 time-synchronized cameras distributed on the surface of a hemispherical, 0.92 meter diameter plastic dome. We use commercially available action sports cameras (Yi 4k) mounted inside the dome using 3D printed brackets. The dome, mounts, triggering hardware and cameras are inexpensive and the array itself is easy to fabricate. Using modern view interpolation algorithms we can render objects as close as 33-cm to the surface of the array.

CCS CONCEPTS

• **Computing methodologies → Image and video acquisition**; **Rendering**;

KEYWORDS

light field, camera array, image-based rendering, view synthesis

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1 INTRODUCTION

The recent rise of consumer 6 degree-of-freedom (6-DOF) VR headsets and cell-phone based AR has increased the need for rich 3D content. However, most current 6-DOF content uses synthetic 3D models and textures that are far from photorealistic, especially on low powered mobile devices. In contrast, light field video can capture real-life photorealism while maintaining full freedom of movement. However, existing light field video cameras are expensive and unwieldy [Milliron et al. 2017; Wilburn et al. 2001], while portable solutions have been applied only to static scene capture as in [Overbeck et al. 2018] or have a small viewing baseline [Smith et al. 2009; Wang et al. 2017].

This poster presents a novel camera array for panoramic light field video capture that is portable, relatively inexpensive (roughly $5k for parts), straightforward to build, and easy to use (tens of shots can be taken over a variety of locations in a single day). This is achieved without sacrificing quality: our light field content is high resolution (>15 pixels per degree) with a wide field of view (>220°), and it records a large viewing volume (0.8 meters) at 30 frames per second.

In the following, we describe the key contributions of this light field rig. We detail the benefits of choosing the Yi 4k action cameras, including automatic temporal synchronization along with efficient charging and data offload. We demonstrate how our novel use of a thermo-formed acrylic dome provides an inexpensive and convenient solution for positioning the cameras onto the surface of a sphere. Finally, we describe our camera layout design and how it affects the quality of the recorded light field.

2 HARDWARE DESIGN AND FABRICATION

Our camera array, shown in Figure 1(a), consists of 47 Yi 4K action cameras. A single master camera controls the others via a 2-wire trigger/synchronization cable as shown in Figure 1(c). Each camera uses its own built-in battery that offers roughly one hour of recording time. A 7-pin USB connection on each camera charges the array and transfers USB 2.0 data. This eliminates the need to physically remove batteries or micro SD cards.

The Yi 4K software supports an array mode that enables master camera control of the following features: (1) sync master camera settings to the entire array, (2) start/stop recording, and (3) powering down the array. Once it receives the "start recording" signal, each camera relies on internal timing for image capture. Our array synchronization tests indicate that the cameras begin recording within 4ms of each other and the intra-array temporal drift is less than 1/2 of a video frame time @ 15 minutes.

We placed cameras at the vertices of a v3 icosohedral tiling of a 92-cm diameter sphere. The sphere itself is fabricated from a 6-mm thick sheet of acrylic shaped into a hemisphere using a draped plastic thermo-forming process (theplasticsguy.com). To position the cameras on the hemisphere we projected a perspective image of the camera layout into the dome using a standard video projector. Cameras were mounted into custom 3D printed brackets fitting the inner curve of the dome structure as shown in Figure 1(c).

3 CAMERA LAYOUT

Our array was designed to capture immersive 6-dof light field content. Figure 2 illustrates (in a simplified 2D view) how camera spacing and rig diameter impacts the size of the viewing baseline and the distance to the closest object that can be recorded by the spherical array. The dome surface (black circle) is shown along with the positions of 9 cameras. The diameter of the array and the nominal $120° \times 90°$ field of view of each Yi 4k camera influences the size of the ray intersection volume (red circle); i.e. the area of overlap in the angular sampling recorded by each camera in the array. This is the "sweet spot" where wide FOV views can be synthesized without missing rays or viewpoint interpolation artifacts. Modern viewpoint interpolation techniques [Flynn et al. 2019; Mildenhall et al. 2019; Penner and Zhang 2017; Zhou et al. 2018] permit some degree of viewpoint extrapolation outside of the ray intersection volume, but we found the geometric construction in Figure 2 to provide a useful estimate of real-world viewing baseline.

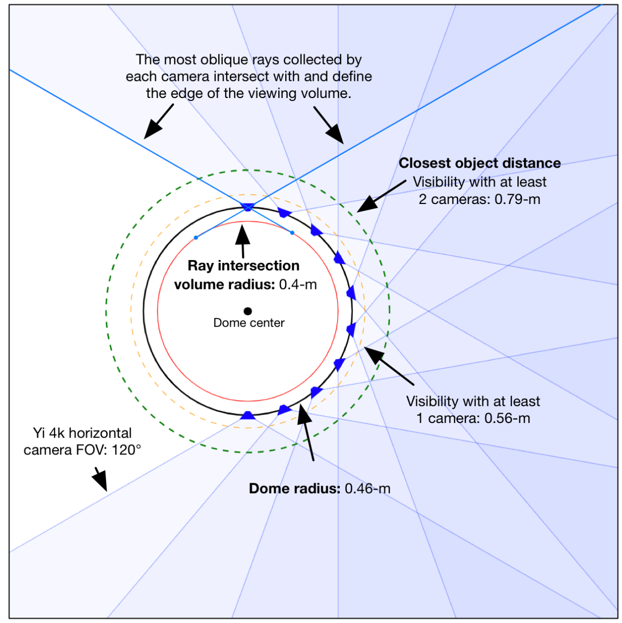

Figure 2: The radius of the array and the inter-camera spacing determine the viewing baseline and closest object that can be captured as a light field by the array.

We also considered the visibility of a scene point from multiple cameras. Light field reconstruction is only possible for objects that are visible from at least two cameras (green dotted circle). This suggests a trade-off between the "closest object distance" and the inter-camera spacing distance, for a given array radius. For our array, an inter-camera spacing that ranges from 16-cm to 19-cm results in an approximate closest object distance of 79-cm.

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