Remote Reality Demonstration

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Abstract

Remote Reality is an approach to providing an immersive environment via omni-directional imaging. The system can use a live video-feed from a remote location or can use recorded data and be remote in both space and time. While less interactive than traditional VR, remote reality has an important advantages: there is little to no need for model building. In addition, the objects, the textures and the motions are not just realistic, they are remote views of reality.

System Overview

The development of the RR system was made possible by recent research, [Nayar-1997], which revolutionized wide-field of view imaging by introducing an omnidirectional sensor – a system that images a full hemisphere while maintaining a single perspective viewpoint. Unlike fish-eye lenses, each image in the new system can be processed to generate *geometrically correct perspective images* in any direction within the viewing hemisphere. Unlike Quicktime VR, it images the full viewing hemisphere (or more) at once and can hence be used for full motion video. The current system provides a viewing volume of 360×210. Placing two systems back-to-back (and using 2 cameras) would allow a true viewing sphere, i.e. 360×360 viewing.

The main components of the system are the omnidirectional camera, video recording systems, car mounting bracket and a head-mounted-display (HMD). (See www.cyclovision.com for commercial Para-cameras with basic WindowsNT software.)

The current prototype system was designed for minimal cost while maintaining acceptably quality. In total, our current data collection system was approximately $5K and the computing/HMD play-back system was about $3K. The system uses a 233Mhx based computer (running Linux) & real-time frame capture card. The system computes monocular CIF-resolution full-rate "video" (30 fps) (25fps PAL). This is reasonably well matched to the resolution of the Virtual I-O glasses HMD. The HMD has a built in head tracker which provides yaw,pitch an roll, with updates to the viewing direction at 15-30fps. The system provides (digital) zoom and color/contract manipulation. A mouse or joystick can also be used for view slection. We are currently adding GPS localization to the collection system to better support augmented reality applications.

Because the camera is compressing a viewing hemisphere (or larger), maintaining resolution and captured image quality is quite important. While the process scales to any size imager, the current system uses NTSC (640x480) or PAL (756x568) video cameras. The spatial resolution along the horizon is $\frac{2 \cdot \pi \cdot 240 \text{ pixels}}{360 \text{ degree}}$ or 4.2 $\frac{\text{pixels}}{\text{degree}}$ (5.1 for PAL).

Omni-Directional Imaging

The Omni-directional imager is an catadioptric system (lens plus mirros) , which combines an orthographic lens and a parabolic mirror. The axis of the parabolic mirror is paralled to the camera's optic axis. To see how it works, let us trace rays backwards from the camera. Because the lens is orthographic, these rays are parallel. By definition, rays parallel to the axis reflect off a parabolic surface at an angle such that, if extended to lines, they would all meet at the focus of the parabolic surface. (This is why that point is called the focus). Thus we see that the focus of the parabolic surface provides a single "virtual" viewpoint which is enabling many novel applications, e.g. see http://www.eecs.lehigh.edu/research/omni

This single virtual viewpoint is important because it allows for consistent interpretation of the world in any viewing direction. To generate a proper perspective image from the paraimage we can place an "imaging plane" in a viewing direction and sample image the location where the rays through the focus would intersect that image. The result can be captured in an inverse warping table and computed very efficiently. As the HMD turns, the viewpoint is stationary and only the "imaging plane" is moved providing for a consistent and smooth view variation.

[Nayar, 1997] S. K. Nayar. Catadioptric Omnidirectional Video Camera. *Proc. of DARPA Image Understanding Workshop*, May 1997.

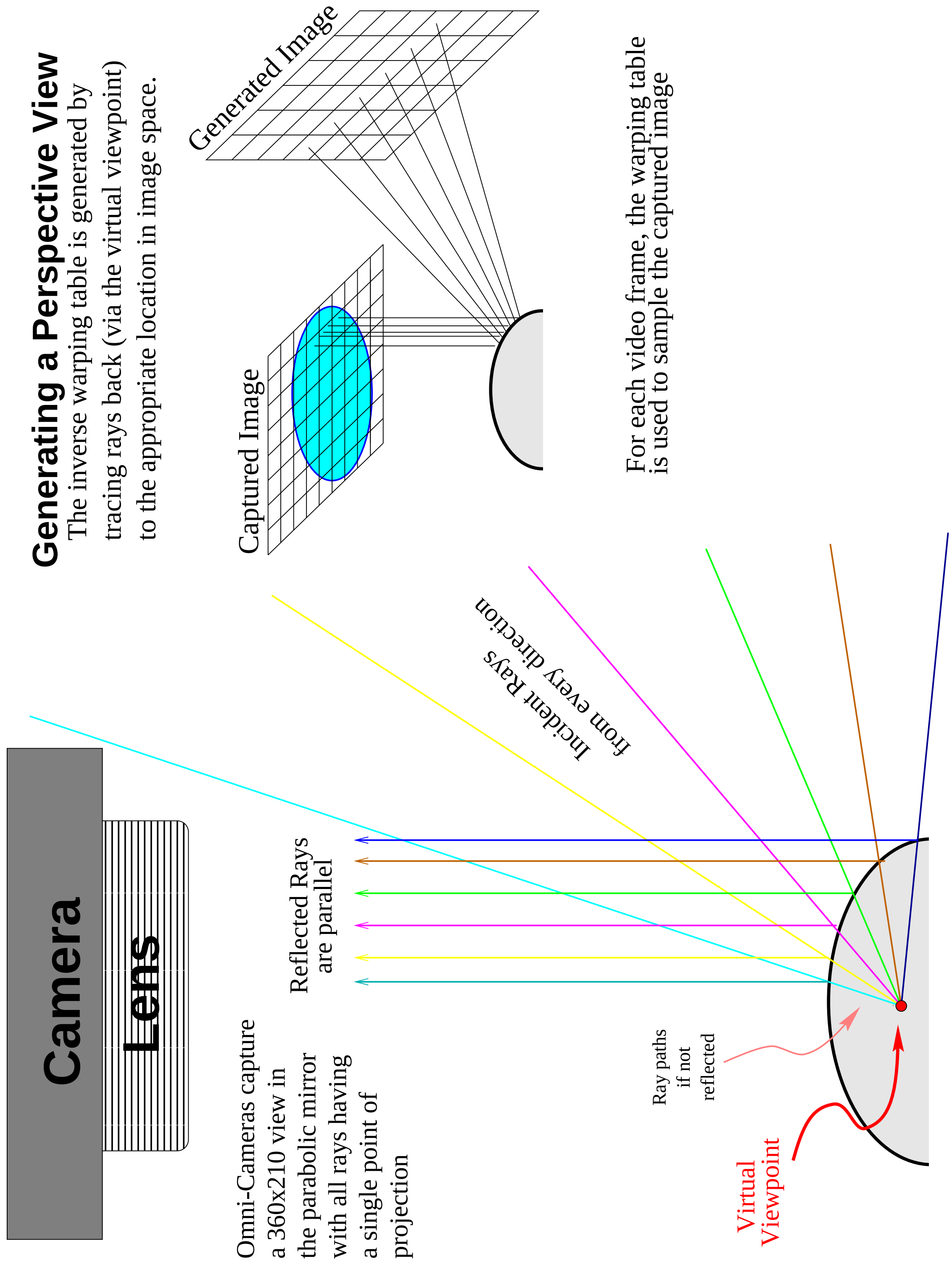

Figure 1: Omni-directional Imaging Geometry

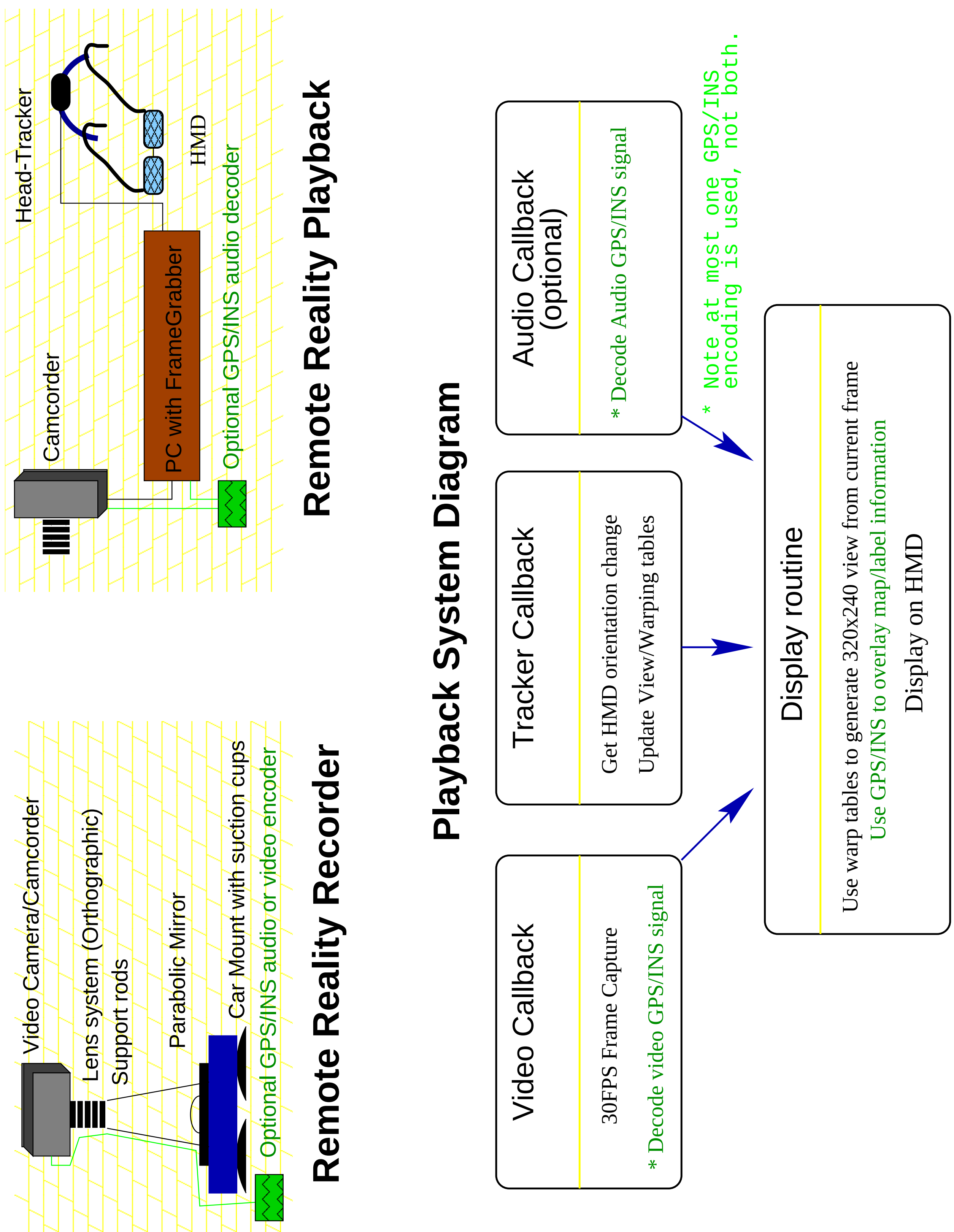

Figure 2: Remote Reality System Diagram

Hardware/Software needs:

The system needs PC's, at least K6233 in power, running Linux (though we might have finished the windows Port by July). We use Virtual I-O glasses with head trackers. If needed I will bring my own PC's and 3 sets of Head Mounted Display.

During the presentation I will need a VGA compatible projector, hopefully one that can sync at at resolution of both 640x480 and 320x240. (I can tune to particular frequencies if it supports anything close).

I would be very, very, interested in taking part in the Creative Applications Lab. The sketch will explain how it works, but the system needs the immersive nature of the HMD to appreciate what it can do. The participation would be a running Remote Reality system using either video-taped tours (I'll bring a few) or a live camera setup somewhere at SIGGRAPH. Again I can bring my own hardware (3 units) if necessary.

I would be interested in taking part in the SIGGRAPH TV Program. There are a number of things we could do with omni-directional imaging. The simplest is that we could set up a Omnicamera "web-tv" site where remote viewers could each control a "virtual pan-tilt" camera sitting somewhere at the SIGGRAPH conference. This uses a simple Java client and push technology so that end users don't need anything special.

A second potential SIGGRAPH TV contribution would be to multi-cast on MBONE (or at a lower bandwidth on the general Internet) an omnivideo and provide a streaming omni-movie-viewer that remote computers users could use to unwarp the image. (This streaming viewer does not yet exist but is under development and should be ready by May.)

A final component could be the development of a Remote Reality Video Tape capturing the the SIGGRAPH Experience. This would involve collecting and editing the video. Trying to capture a normal "eye-level" view is very challenging because of the nonstandard orientation of the camera and, more significantly, the super-hemispherical view which leaves the camera crew nowhere to hide.