Quadric Transfer for Immersive Curved Screen Displays

Ramesh Raskar, Jeroen van Baar, Thomas Willwacher, Srinivas Rao
Mitsubishi Electric Research Labs (MERL), Cambridge MA, USA

Abstract
Curved screens are increasingly being used for high-resolution immersive visualization environments. We describe a new technique to display seamless images using overlapping projectors on curved quadric surfaces such as spherical or cylindrical shape. We exploit a quadric image transfer function and show how it can be used to achieve sub-pixel registration while interactively displaying two or three-dimensional datasets for a head-tracked user. Current techniques for automatically registered seamless displays have focused mainly on planar displays. On the other hand, techniques for curved screens currently involve cumbersome manual alignment to make the installation conform to the intended design. We show a seamless real-time display system and discuss our methods for smooth intensity blending and efficient rendering.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism- Virtual reality

1. Introduction
Large seamless displays using overlapping projectors is an emerging technology for constructing high-resolution immersive visualization environments capable of presenting high-resolution images from scientific simulation, large format images for entertainment and surround environment for instruction. Such overlapped projector systems complement non-overlapping multi-projector technologies such as the CAVE [CNSD93], Blue-C [SGKM00] and well-defined tiled planar [Jup02] or curved displays [Tri02]. In the last few years, we have seen a number of ideas for creating seamless displays on planar screens using electro-optic approaches such as vignetting [LC99] or using camera in the loop [RvBC02, Sur99, YGHT01, BS02, Fut02] to determine the registration and blending parameters. In this paper, we extend the camera-based techniques to deal with curved screens.

1.1 Overview
Accurate estimation of geometric relationship between overlapping projectors is the key for achieving seamless displays (Figure 1). They influence the rendering and intensity blending algorithms. General techniques to support casually installed projectors and exploit geometric relationship between projectors and display surface eliminate cumbersome manual alignment and reduce maintenance costs. While camera-based parametric approaches for planar screens have exploited the homography, a 3 by 3 matrix, induced due to the plane of the screen [YGHT01, CSWL02, BS02], to our knowledge, there has been no similar work to exploit a parametric relationship for curved surfaces for immersive environments.

The relationship for surfaces that adhere to quadric equations, such as spheres, cylinders, cones, paraboloids and ellipsoids, can be defined using a quadric image transfer [ST97].

Contributions In this paper, we present a complete set of techniques to generate seamless displays on curved quadric surface. Our technical contributions are as follows.

- Adaptation of quadric transfer, in a semi-permanent setup using a stereo camera pair
- Calibration methods, to estimate quadric transfer using partial Euclidean reconstruction
- Head tracking support for immersive display
- Intensity blending scheme using parametric approach
- Single pass rendering, that can exploit rendering hardware while maintaining high image quality

Conventional non-parametric approaches for displaying multiprojector images on curved screens sample discrete image features to build a look-up table for bilinear interpolation for pixel locations [Jar97, RWF98] and hence errors in feature localization are immediately visible. We propose a completely parametric approach that fits a quadric model to the discrete features reducing them to a few parameters. Similar to the advantages of using a homography for planar screens,