Spheree: A 3D Perspective-Corrected Interactive Spherical Scalable Display

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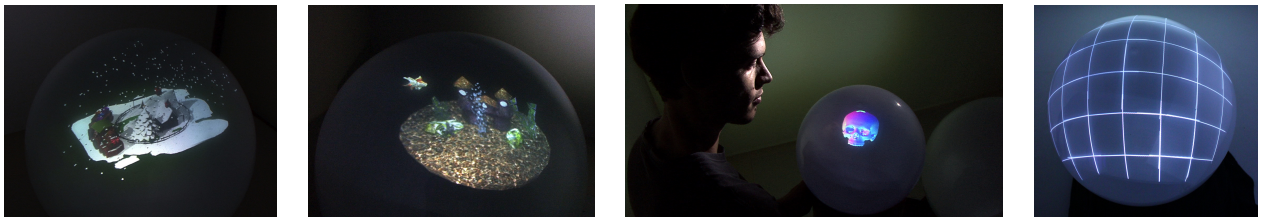

(a) **(b)** **(c)** **(d)**

Figure 1: *(a) A snowglobe; (b) a fish-tank animation; (c) a 3D skull in a portable sphere; (d) geometric aligning of eight projectors.*

1 Introduction

We constructed a personal, spherical, multi-projector perspective-corrected display called *Spheree*. Spheree uses multiple calibrated pico-projectors illuminating a spherical screen with perspective-corrected 3D content. The pico-projectors are mounted *inside* the spherical display surface, creating a seamless backprojected display. Spheree uses optical tracking to support head-coupled rendering to provide motion parallax-based 3D depth cues. Spheree is relatively compact and supports direct interaction techniques. For example, existing models can be modified via a 3D interaction interface on the sphere, providing a 3D sculpture experience, and the final models can be exported or printed on a 3D printer.

Other related 3D displays include: 1. pCubee [Stavness et al.], a cubic fish-tank VR device with interaction based on physical motion; it does not use touch, is not scalable, and has bezels cause disruptive scene occlusion; 2. SnowGlobe [Bolton et al. 2011], a spherical display with a single stereo 3D projector and a hemispherical mirror; it has non-uniform resolution and a blind spot from the mirror; 3. Other projection spheres[1] that use a single projector with a fish-eye lens, but do not scale to high-resolution.

2 Our Approach

We developed a novel multiple pico-projector system that automatically calibrates and blends using a camera+projector approach. This creates a uniform pixel space on the surface of the sphere. Our auto-calibration algorithm uses a spherical modification of [Teubl et al. 2012], which uses a simple webcam. This same webcam is used to calculate the parametrization of the spherical screen for the correct view-point rendering of a scene from the head-coupled viewer. Spheree is highly scalable allowing as many projectors as needed for virtually any sphere size. Our spherical display design has no corners, hence no singularities in blending, and provides uniform pixel density across the whole sphere. Additionally, no mirrors are used so there are no blind spots. We only use lenses that come with the pico-projectors, rather than special ones such as fish-eye lenses, simplifying rendering. Spheree supports bi-manual gesture, hands-free and moving-the-display interactions. We coupled Spheree to a 3D modelling package, Blender, to illustrate its use in a 3D modelling workflow. People can use a 3D modelling environment or capture real objects, such as designs moulded with clay, and easily put them inside Spheree. We have tested a 20" diameter, eight pico-projector and a 7", four pico-projector Sphere. The 20" Spheree allows participants to experience and interact with 1:1 models of human sized objects. The small spheree can be held in your hands; thus, users are able to pick it up and interact with the models inside.

3 Conclusion

Spheree uses an acrylic spherical, translucent display with multiple off-the-shelf LED pico-projectors that needs less energy and produces less heat than conventional projectors. By combining position tracking of the user, an auto-calibrated blended array of pico-projectors and perspectively rendered animations, Spheree provides the experience of a compelling 3D scene suspended in space, like a hologram, such that users hardly realize that there is an actual physical sphere in front of them. By using a spherical screen we avoid the singularity of corners that often causes visual artifacts in multi-faced screens such as in CAVE environments. Thus, the use of a spherical screen with correct perspective and view-point correction offers a highly compelling visual experience. We are continuing to improve the Spheree experience by adding stereoscopic projectors, support multi-person viewing, dynamic, physics-based simulation, and richer interaction abilities. *A demonstration of this system has been presented at Emerging Technologies 2014.*

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