A Projected Hemispherical Display with a Gestural Interface

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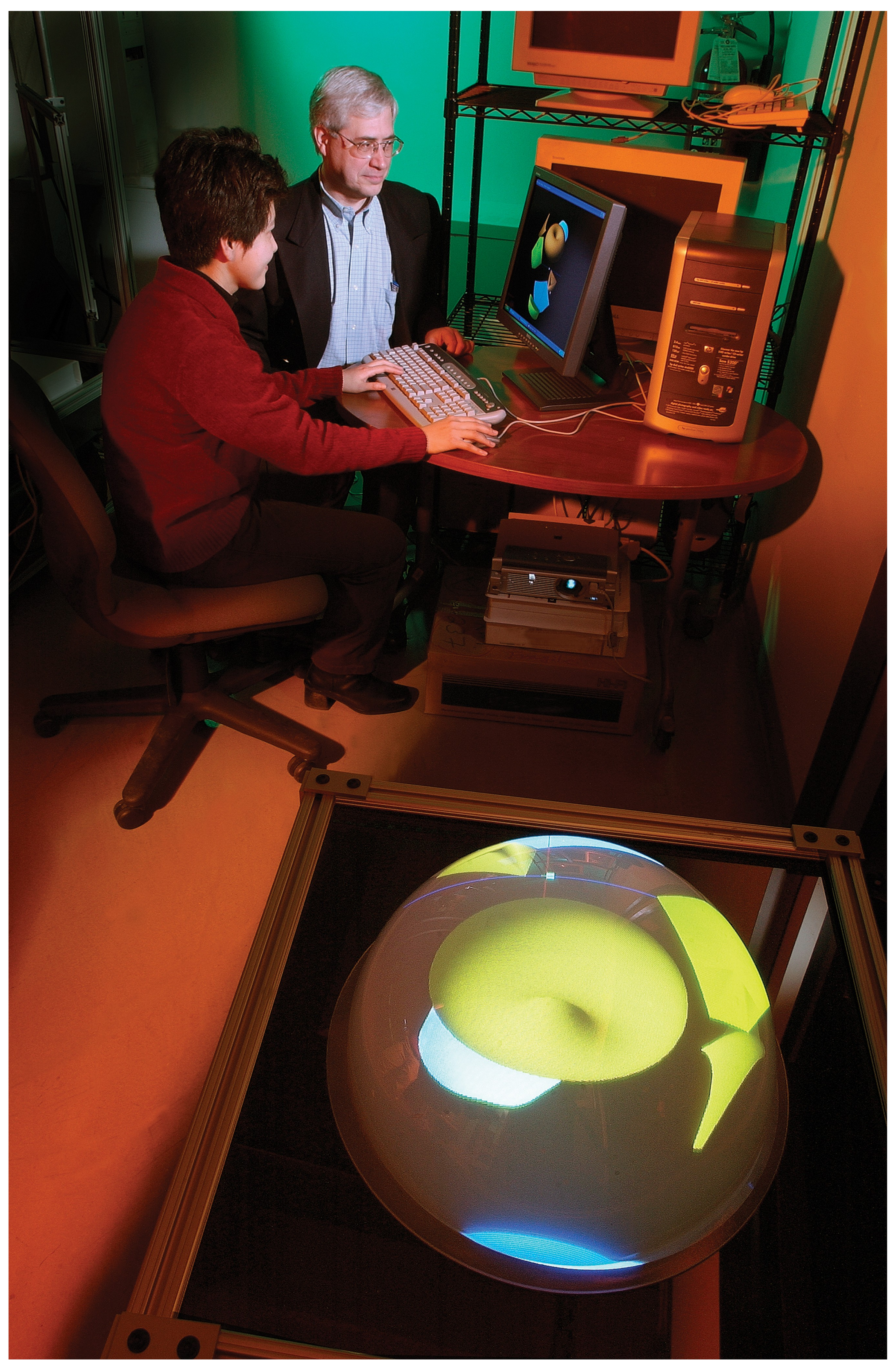
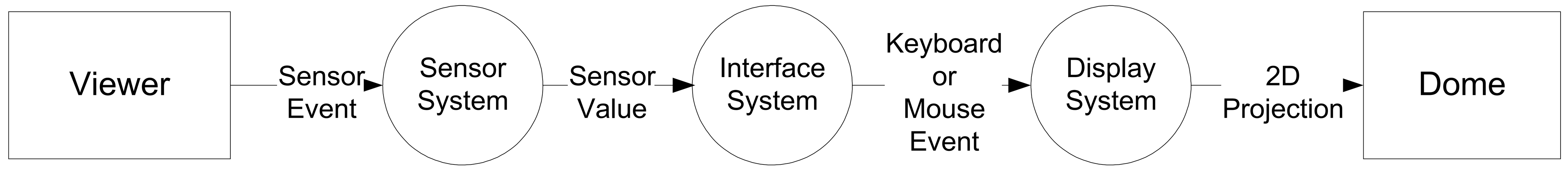
Introduction

We have recently built an inexpensive alternative to a volumetric display [Favalora 2005] based on video projector technology that supports omni-directional viewing (figure below). It can show mapped spherical surfaces, such as globes, and scenes composed of three-dimensional objects. In the latter case, an algorithm was developed to perform hidden surface elimination in the hemisphere's reference frame.

Participants can sit around the hemisphere, which is built into a low table. Sensors capture hand movements near the hemisphere. This allows for relaxed adjustment of the position, orientation, and size of the objects that are projected from underneath onto the inside of the display. It is not necessary to touch the surface as in Grossman et al. [2004] or to use an intermediate device [Yasuhara et al. 2005].





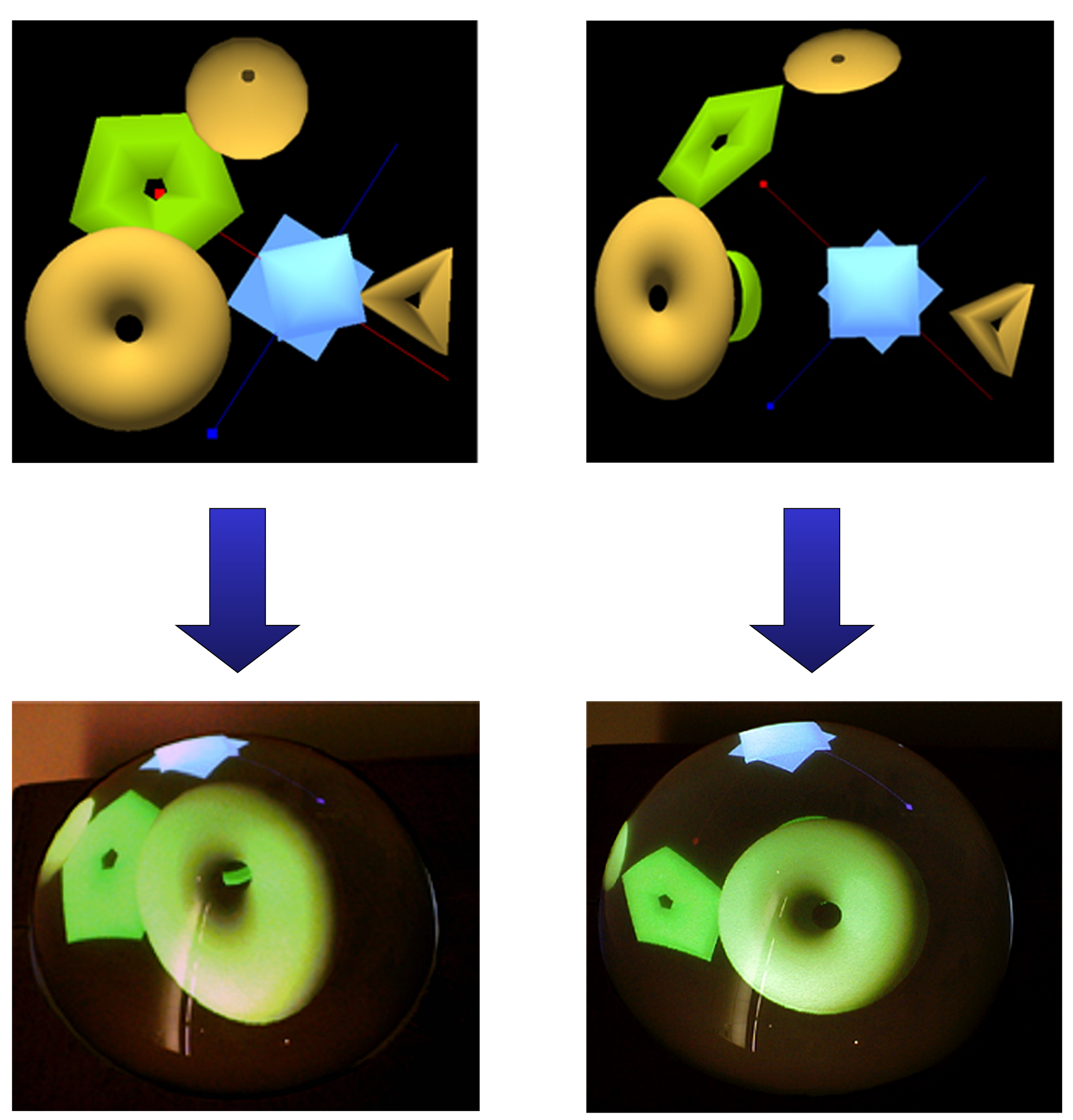
Display System

The display system takes a flat image and projects it onto a hemisphere. A two-dimensional spherical map projection of the Earth that appears distended at the poles and compressed at the equator will correctly map to the hemisphere with no intermediate processing. But a single point projection of a three-dimensional scene will not.

A variation on ray casting was employed that considers every point on the dome's surface a viewpoint. Objects are warped along a radial path from the sphere's center to its surface. Then hidden surface methods are applied. The figure below shows the projection before and after warping. The application is written in OpenGL.

Image as seen on traditional display

Standard projection | Warped for hemisphere



Unwarped image | Warped to hemisphere

Image projected onto hemisphere

Sensor System

- Three sonar sensors (Range - 2cm to 3m (~.75" to 10'))
- Basic Stamp 2 microcontroller by Parallax, Inc.

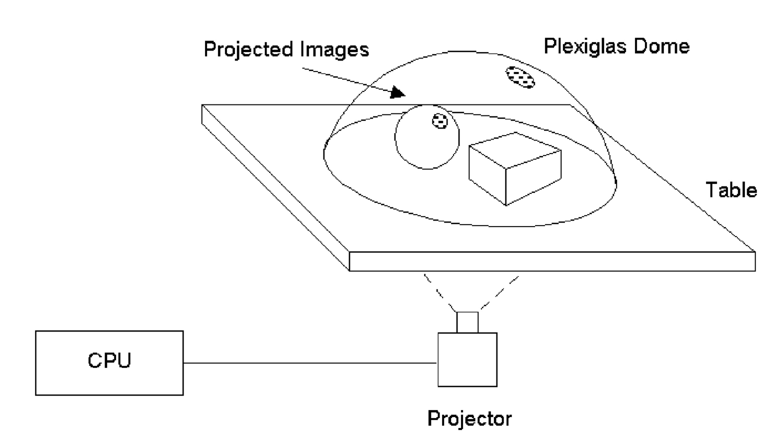
Each sensor is associated with a specific input control: x-axis, y-axis, and zoom. The microcontroller was programmed in Basic to send sensor id and data to the serial port. The intuitive motion of a user's hand toward or away from a sensor causes the images on the hemisphere to move predictably.

Interface System

An interface controller was written in Processing.org, a programming environment based on Java. It keeps track of the current system state, reads the sensor data from the serial port, interprets it, and issues commands that are recognized by the application programs.

The interface controller can issue either keyboard or mouse commands. As such, it can be used as an interface between sensors and any program.

The two applications that were adapted to the sensors via the interface system were Google Earth which accepts mouse input and the 3D OpenGL program that accepts keyboard commands.



A commodity video projector with XGA resolution (1024 x 768) is attached to a standard video card. The computer generated image is projected onto the inside of a Plexiglas hemisphere that has been sprayed with a light-diffusing coating.

Conclusions and Future Work

- The hemispherical display works well for geographical charts because they map as flat surfaces.
- The projection algorithm for three-dimensional objects gives a sense of depth within the display.
- The system is less successful at producing a sense of transparency and depth, characteristics intrinsic to true volumetric displays, but objects rendered in the hemisphere maintain a better sense of solidity and light and shadow.
- The number of sensors and their placement around the display remain to be optimized so that multiple users can control the display.

These are areas for continued research.

Literature cited

Favalora, G.E. 2005. Volumetric 3D displays and application infrastructure, *IEEE Computer 38*, 8, 37-44.

Grossman, T., Wigdor, D., and Balakrishnan, R. 2004. Multi-finger gestural interaction with 3D volumetric displays. In *Proceedings of UIST '04*, October 24–27, Santa Fe, New Mexico, 61-70.

Yasuhara, Y., Sakamoto, N., Kukimoto, N., Ebara, Y., Koyamada, K. 2005. Interactive controller for 3D contents with omni-directional display, In *Proceedings of ICPADS*, 167-171.

For further information

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