Design Challenges of Interactive Spherical User Interfaces

Hrvoje Benko
Microsoft Research
One Microsoft Way
Redmond, WA 98052
benko@microsoft.com

Andrew D. Wilson
Microsoft Research
One Microsoft Way
Redmond, WA 98052
awilson@microsoft.com

CHI 2009, April 4 – April 9, 2009, Boston, MA, USA
ACM 978-1-60558-247-4/08/04.

Abstract
We present our experience on designing interactive applications for *Sphere*, our multi-touch-sensitive spherical display prototype. We believe that the compelling application design for future non-flat user interfaces will greatly depend on exploiting some unique characteristics of the given form factor. While our observations primarily focus on spherical displays, we envision that the ideas presented here are applicable to a variety of non-flat or curved display form factors that will be available in the future.

Keywords
Interactive surfaces, spherical displays.

ACM Classification Keywords
H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces – Input devices and strategies: Graphical user interfaces.

Introduction
Most of the computing devices available today are equipped with a rectangular flat display. Therefore, it is hardly surprising that most of the current applications mimic the characteristics of the flat display with 2D (or 2.5D) rectilinear user interface elements and concepts, such as rectilinear buttons, windows, scrollbars, etc.

Recently, researchers have become intrigued with the possibilities of using non-flat surfaces as computer displays as well as enabling direct freehand interaction on such surfaces [1,2,3,4]. The promise of curved, deformable, or organic-looking displays opens up numerous novel uses and interaction possibilities; however, most of the current applications are ill-suited for such non-traditional surfaces. In this position paper, we argue that the design of compelling applications for non-flat user interfaces greatly depends on the designers' ability to overcome inherent interaction challenges and exploit some unique characteristics of such unusual display form factors. We motivate our position with observations and experience with designing interactions and applications for the multi-touch-sensitive spherical display prototype called *Sphere* [1].

Sphere Prototype

Our multi-touch-sensitive spherical display, *Sphere* (figure 1), is built on a podium version of the commercially available *Magic Planet* display[1]. The Sphere's surface is an empty plastic ball coated with a diffuse material that serves as a passive curved projector screen. Touch-sensing is performed with an infra-red camera built into the base of the device right next to the projector.

This novel hardware configuration permits the enclosure of both the projection and the sensing mechanism in the base of the device (sharing the same wide angle lens), and also easy 360-degree access for multiple users, with a high degree of interactivity and without any shadowing or occlusion problems. For more details on Sphere's implementation, please refer to [1].

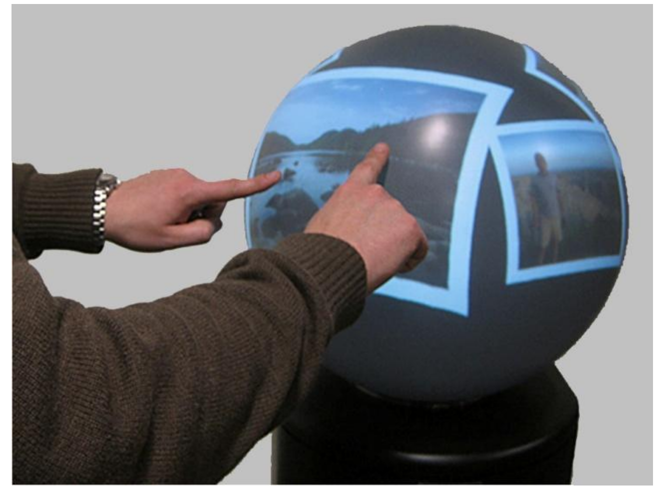

figure 1. Interacting on Sphere, our multi-touch spherical display prototype.

Challenges of Spherical Display Interactions

We have developed several prototype Sphere applications such as painting, photo viewer, globe and panoramic visualizations, interactive game concepts, as well as some new multi-touch interactions that facilitate data sharing around the display. We now discuss some unique characteristics of spherical displays and explain how those can be used to design more compelling applications on such unusual form factors.

Borderless, but Finite Display

Spherical displays present a difficult design challenge as they require a user interface to be thought of as a continuous surface without borders. Standard flat displays often require an opposite mental model, the

[1] Magic Planet device is made by Global Imagination, Inc. www.globalimagination.com

content can often stretch beyond the borders of the display, i.e., the display can be thought of as a window into the larger digital world. But for a spherical display, such "off-screen space" usually does not exist; rather, any data moved far enough in one direction will eventually make it full circle around the display. This characteristic can be exploited for interesting effects. For example, we implemented a "potter's wheel" metaphor in our painting application (figure 2a) where the entire canvas can rotate in place, thus allowing the user to continuously paint all around the display without changing his location.

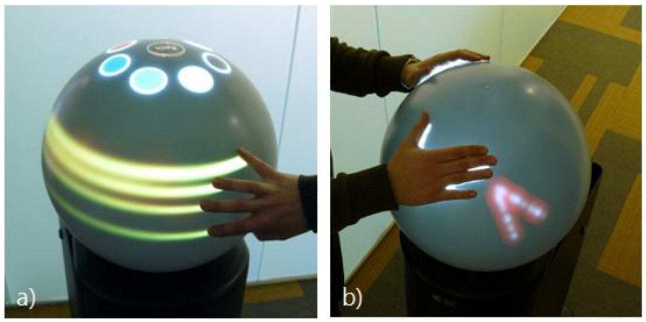

figure 2: Two interactive applications that exploit the spherical nature of the interface: (a) potter's wheel painting application and (b) spherical pong game where the entire "field" of the game is not visible to any single player.

This characteristic of a borderless, but finite display also create difficulties when application needs to facilitate zooming (e.g., zooming in a global mapping application, such as Virtual Earth). With flat displays, zooming mental model assumes that a lot of content transitions into the off-screen area. Given the lack of off-screen area in a borderless display, standard zooming techniques introduce zippering problems on the opposite side of a display. A better metaphor for zooming on a sphere would be to implement a "fish-eye" effect and provide simultaneous focus and context areas thus preserving the benefits of a continuous surface while providing more details in some areas.

Non-Visible Hemisphere

Unlike true 3D volumetric displays [3], the diffuse nature of the spherical surface makes it impossible for users to see inside the display and ensures that each user, at any given time, can see at most one half (one hemisphere) of the display. While not being able to see the entire display simultaneously may be a disadvantage for some applications, we believe that in many scenarios this presents a unique benefit. For example, not being able to see all your opponent's actions makes our Sphere pong game (figure 2b) simultaneously challenging and very engaging.

Visible Content Changes with Head Position

Around the spherical interface, even small changes in head position may reveal new content or hide previously visible content. In our pong game, this means that while the user can hope to gain some advantage by shifting their position and peeking at the opponent's actions, they are simultaneously leaving another part of their interface unattended, i.e. vulnerable. Such actions are also socially obvious and participants can rely on standard social cues to ensure "pseudo privacy" for their actions or content.

No Master User Position or Orientation

In contrast to horizontal tabletop displays for which orientation of displayed content is often a difficult problem, spherical displays do not have a "master user" position. In many ways, spherical displays offer an egalitarian user experience, with each viewer around the display possessing an equally compelling perspective.

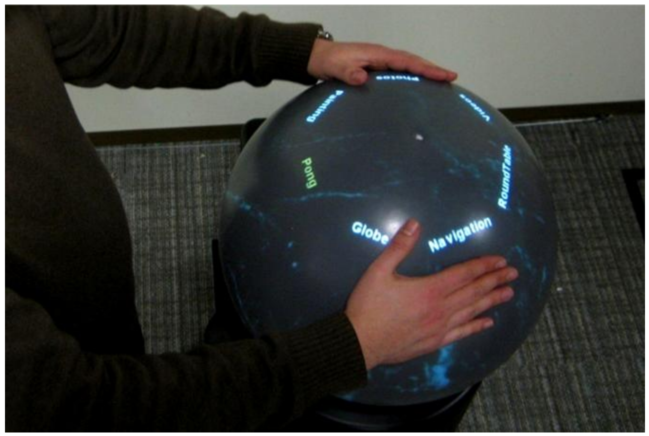

figure 3: Invoking a shared circular menu on top of Sphere using a bimanual orb-like invocation gesture.

Smooth Transitions between Vertical and Horizontal, Near and Far, Shared and Private

A spherical display can be thought of as a continuously varying surface that combines the properties of both vertical and horizontal surfaces. The top of the display can be considered a shared, almost horizontal, flat zone, while the sides of the sphere can be thought of as approximating multiple vertical displays. While this is also true of a cuboid or a cylindrical display, spherical displays offer continuously smooth transitions between all such areas. The top shared portion of the display can be used for content of interest to all participants, such as the circular menu we designed to switch between all our applications (figure 3). Furthermore, the menu is operated by rotating, rather than directly selecting, which further reinforces the rounded nature of the interface.

Conclusions

Commercial spherical displays are used today as output-only devices for visualization of geographical data or as high-visibility advertizing, but many more interactive applications will be possible with direct touch interactions enabled on their surface. We believe that the most compelling applications for spherical displays will embrace and exploit some of the unique properties outlined in this paper, rather than attempting to eliminate them. Similarly, most of the upcoming non-flat, 3D, or deformable displays will carry some similar set of unique properties, and targeting applications that build on top of such characteristics will be critical in the adoption of those interfaces.

Acknowledgements

We thank Mike Foody and Global Imagination for loaning us two units of their MagicPlanet display.

References

[1] Benko, H., Wilson, A.D., and Balakrishnan, R. Sphere: Multi-Touch Interactions on a Spherical Display. In *Proc. UIST 2008*, ACM Press (2008), 77-86.

[2] Kettner, S., Madden, C. and Ziegler, R. (2004). Direct Rotational Interaction with a Spherical Projection. In *Creativity & Cognition Symposium on Interaction: Systems, Practice and Theory.*

[3] Grossman, T., Wigdor, D. and Balakrishnan, R. (2004). Multi-Finger Gestural Interaction with 3D Volumetric Displays. In Proc. *UIST.* 61–70.

[4] Holman, D. and Vertegaal, R. (2008) Organic User Interfaces: Designing Computers in Any Way, Shape or Form. In *Comm. of the ACM*, Vol. 51, Num. 6.