
Augmented Reality, Surface Style

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Abstract

Most displays can show information only on a planar surface. In some cases it is advantageous to extend the display into the third dimension or inside objects on the surface. For instance, a person on one side of an interactive table might want to read a message displayed privately to themselves. This paper describes a novel use of fiber optics to take the light from a planar surface and extend it to display into the third dimension, both vertically and in any direction that the fiber optic is bent.

Keywords

Augmented reality, display, 3d display, fiber optics, Design.

ACM Classification Keywords

Software General, Hardware input/output and data communications, computer applications general.

General Terms

Design, experimentation

Introduction

A few years ago, I saw a demo of physical objects being tracked on an interactive display. I became fascinated by the magic of blending the virtual and physical worlds together.

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When I joined the Microsoft Surface design team, I realized that one of the most novel and unique aspects of Microsoft Surface is the ability to “tag” physical objects with clear, infrared patterns. These tags are clear to visible light, but they have unique visual patterns when they are illuminated with infrared light (for example, through a camera with an infrared filter).

With these tags, my team created clear, physical objects that could be tracked on a Surface interactive display. We started prototyping clear objects by using clear plastic, and I then extended the display into the physical objects by using refraction.

Another characteristic of surface that enabled the practical creation of this type of augmented reality is the horizontal orientation of the screen – objects don’t fall off the screen when placed down.

The following sections describe three prototypes and how they extend the blend the line between the virtual world and the physical world.

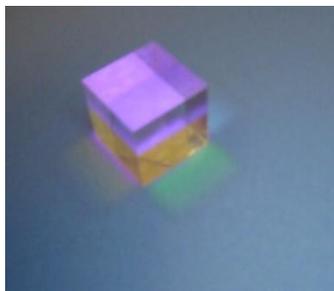


Figure 1. A clear, acrylic cube that is tagged with six clear infrared tags

Clear cube (Single-pixel 3-D display)

The first prototype is a simple, clear cube. Each side of the cube includes a unique, clear infrared tag and displays a unique color when each side is placed on Surface. Colored light is also cast around each side to indicate the color of the adjacent sides. This prototype provides a single-pixel display that is raised into 3-D space.

Fiber optic array (Multi-pixel 3-D display)

The second prototype focuses on extending the light from the display above the surface. The prototype consists of thick pieces of plastic fiber optic (or *light pipe*), combined into two arrays by using tape and glue and shaped into a cone and a dome. The prototype objects are also tagged with clear, infrared tags.



Figure 2. A cone-shaped object that consists of multiple fiber optic pieces

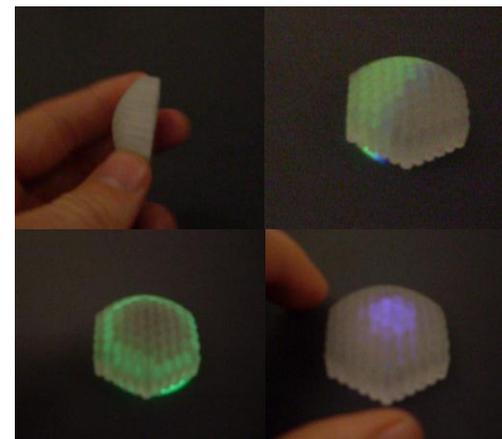


Figure 3. A dome-shaped object that consists of multiple fiber optic pieces

In figure 2 and 3, visualizations appear inside the objects by using the TagVisualizer control from the Microsoft Surface Software Development Kit (SDK). Because the visualization is projected inside the physical object, no screen real estate is wasted for displaying information about the object around the object. So if this knob were an opaque volume knob you might show the volume as a percentage outside the volume knob. Using a clear fiber optic object allows you to use the screen more efficiently and visualize the volume level inside the knob. If you wanted to show a volume level of 25%, you could illuminate a quarter pie inside the object. And if you wanted to show 50% volume, you could illuminate a half pie inside the object.

Bent fiber optic grid (Multi-pixel 3-D display at arbitrary angle)

The third prototype includes fiber optics that are not straight, but are bent to other configurations or planes.

To demonstrate this physical property of light, the prototype consists of a toy monster with a face that can dynamically change into any image. The fiber optic pieces (which come from a child's fiber optic lamp) are pushed through a cylindrical hole in the toy that extends from its feet to its face. The toy monster also includes clear, infrared tag to track its location, creating a unique physical object interaction.



Figure 4. A toy that includes multiple fiber optics routed through it

When the toy is placed on the interactive display, the monster looks around by using its one eye until a cup is placed on the display. When a cup is placed down, if the cup is empty, the monster asks you to fill its cup. If you fill the cup, the monster thanks you and its eye follows its cup no matter where you move the monster or the cup.

To view more of this interaction, see "Microsoft Surface Monster Mashup" on YouTube[1].

Opportunity for future work

A few challenges we encountered and areas for future work are...

- 1) Maintaining a clear and non-distorted image. It is imperative that the fibers stay parallel to each other. Otherwise the image becomes distorted. The larger the fibers, the easier it is to maintain a clear image. But the downside is lower resolution. A good description of how to create high quality fiber optic grids can be found in the Lumino [3] paper.
- 2) Triangular or square fibers could be used to minimize the dead unused space between “pixels”.
- 3) Clear tags for Surface are hard to come by. There is an opportunity for a company to manufacture and sell them.
- 4) It is possible to use a fiber optic grid like the one in the Surface Monster to input into the system as well as output from the display. Dustin Freeman from the University of Toronto [2] successfully produced touch input on the eye of the monster that is reliably recognized by Microsoft Surface. In his application, placing the monster on top of virtual bubbles sucked the bubbles into the eye of the monster. Touching the monster’s eye caused the bubbles to spill back out on the table. Lumino [3] is another instance where a fiber optic grid was used to recognize input from above the Surface.

Conclusions

- 1) Clear, infrared tags allow you to create completely clear objects and project images into the entire object.
- 2) Fiber optics allow you to extend displays into objects blurring the lines between the physical and virtual world in new and unique ways. This also allows for endless customization of objects at relatively low manufacturing cost.
- 3) Bending the array of fiber optics allows you to project images on any surface of objects.
- 4) Projecting inside objects rather than around them optimizes screen real estate by not wasting touchable screen real estate for visualizations for an object.

Example citations

[1] Microsoft Surface Monster Mashup
<http://www.youtube.com/watch?v=pi8cUoGNvaU>

[2] Surface Monster Nom Nom Nom
<http://www.youtube.com/watch?v=8-om4oiVNLc>.
Dustin Freeman, University of Toronto.

[3] Lumino: Tangible Blocks for Tabletop Computers Based on Glass Fiber Bundles. Patrick Baudisch, Torsten Becker, and Frederik Rudeck. 2010.