Lumino: Tangible Building Blocks Based on Glass Fiber Bundles

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Abstract

We present *luminos*, tangible building blocks that allow users to assemble physical 3D structures on a tabletop computer. All luminos are tracked using the table's built-in camera, including those luminos located on top of other luminos. To enable this, each lumino contains not only a fiducial marker, but also a glass fiber bundle that allows the camera to "see through it". Applications include a tangible image editing application, a board game, and a tangible 3D construction kit.

1 Introduction

Physical building blocks allow quick construction and manipulation of structures through two-handed tactile interaction [ISHII & ULLMER,1992]. However, traditional tracking mechanisms, such as magnetic tracking make it hard to manage large numbers of objects—a prerequisite for complex tangible applications.

Tabletop computers based on diffuse illumination, in contrast, make it easy to track visual barcodes, aka *fiducial markers*, placed on their surface. Unfortunately, they do not allow tracking building block constructions, because (1) blocks located directly on the table surface prevent its camera from seeing blocks stacked on top and (2) the table's built-in diffuser makes objects unrecognizably blurry, unless they are in direct contact with the table surface. So far, researchers have therefore only been able to track stacks of foil-like objects [BARTINDALE, T. & HARRISON, 2009].

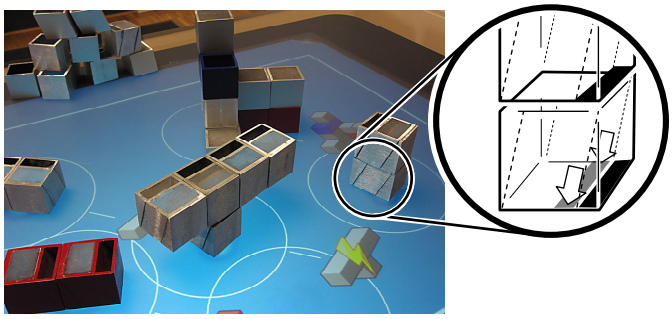

Figure 1: *Luminos* are tangible building blocks that allow the underlying diffuse illumination table to track their 3D arrangement. The shown lumino construction kit supports users with suggestions, such as the lightning-shaped "overhang" warning icon. Callout: The shown type of lumino contains a marker strip and a *slanted* glass fiber bundle.

2 Luminos

Luminos (Figure 1) overcome these limitations [BAUDISCH, BECKER, & RUDECK, 2010]. Each block contains a glass fiber bundle, i.e., a large number of parallel, vertical glass fibers. As illustrated by Figure 2, this allows the table (here Microsoft Surface) to "see" through luminos. On its way back down to the diffuser, light reflected off the marker is confined within the fibers; this prevents the marker image from blurring, so that the camera in the table sees a crisp image.

To prevent a vertical arrangement of markers from occluding each other, the glass fiber bundles inside of luminos are never fully vertical. In the design shown in Figure 1, for example, glass fiber bundles are *slanted*. This causes each marker image to be "projected" onto the space *next* to the marker below it, rather than directly onto it. The *round* luminos in Figure 2 demagnify marker images; this causes the markers of stacked blocks to appear as concentric rings.

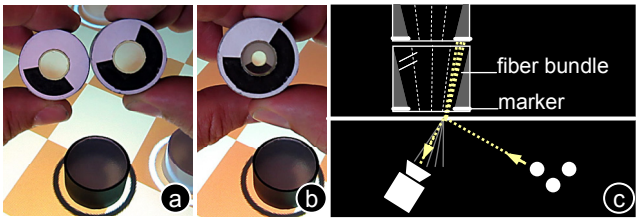

Figure 2: (a) These *round* luminos use a ring-shaped marker and contain a *tapered* glass fiber bundle. (b) When stacked, the marker on top shows up in the center. (c) How it works: the glass fiber bundle prevents the light reflected off a marker from spreading on its way to the diffuser.

While luminos extend the concept of fiducial markers to 3D, they preserve many of the benefits of regular tabletop markers: luminos are unpowered, self-contained objects that require no calibration, making it easy to maintain a large number of them.

3 Applications

We have created three demo applications. In *lumino checkers,* luminos allow the table to tell men from kings (Figure 2a, b). *Image Touch-Up* (Figure 3) allows users to improve digital photos by manipulating stacks of dials placed on top of a photo. A single dial allows removing color casts. An additional dial on top allows adjusting contrast, and so on. "Stamping" other images with a stack of dials applies the correction to other images.

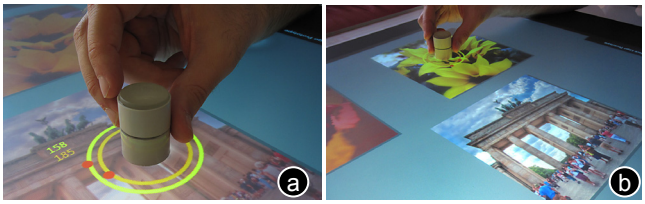

Figure 3: (a) The bottom dial removes a color cast; the top dial adjusts contrast. (b) Applying the same effect to other images by "stamping".

The *lumino construction kit* (Figure 1), finally, allows users to put together building block constructions. The kit is a simple envisionment of how a future tangible application might support architects. Luminos allow the table to keep track of the prototypes and design explorations on the table as the user is creating them. This allows the table to take on the role of an assistant, here a civil engineer. The system logs construction activities, checks the soundness of the hypothetical building, displays piece lists and running totals of construction cost, and informs the user about potential flaws and construction alternatives.

References

BARTINDALE, T. AND HARRISON, C. Stacks on the Surface: Resolving Physical Order Using Fiducial Markers With Structured Transparency. In *Proc. Tabletop '09,* 4 pages.

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