Beyond the Surface: 3D Interactions for Tabletop Systems

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Figure 1: *(a) iView enables users to explore 3D views from different perspectives above the 2D table surface. (b) iLamp highlights and enhances resolution of a particular region, (c) iFlashlight, a mobile version of iLamp, facilitates cooperative information exploration.*

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1 Introduction

Current tabletop systems are designed to sense 2D interactions taken place *on the tabletop surface*, such as finger touches and tangible objects. The ability to interact *above the tabletop surface* makes it possible to support 3D interactions. For example, an architect can examine a 2D blueprint of a building shown on the tabletop display while inspecting 3D views of the building by moving a mobile display above the tabletop. Recent approaches to localize objects in 3D requires visible markers or the use of embedded sensors [Song et al. 2009]. The use of visible markers often interferes with the content users are focusing on, limiting its usefulness and applicability.

In this work, we propose a new 3D tabletop system that overcomes this limitation by using invisible markers. We combine an infrared (IR) projector and a regular, color projector to simultaneously project visible content with invisible markers. Embedded IR cameras are used to localize objects above the table top surface. In addition, we use programmable marker patterns to refine object localization at both far distance and closeup.

2 Our Approach

We propose a 3D tabletop system that combines a programmable infrared (IR) projector, a color projector, and IR cameras. As shown in Fig. 2a, the color projector provides visible content to the viewers, while the IR projector delivers content that is invisible to human eyes but can be captured by IR cameras. Two IR cameras are installed under the table to detect finger touches directly on the tabletop surface. In addition, IR cameras are embedded in objects that need to be localized above the tabletop surface.

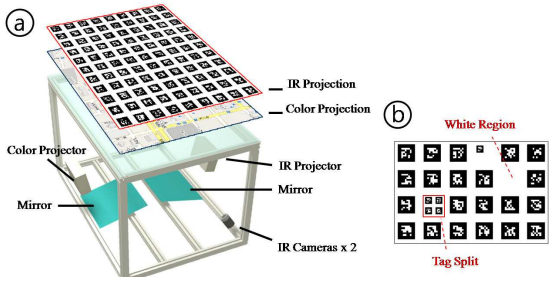

Figure 2: *The system architecture.*

The programmable IR projector is used for two purposes. First, it projects a uniform white screen for multi-touch detection and recognizing tangible objects placed on the surface, similar to other direct-illuminated (DI) tabletop systems. Second, it projects special marker patterns to enable IR cameras to estimate their 3D positions relative to the tabletop.

In order to simultaneously perform 2D detection and 3D localization, we propose an adaptive IR projection framework, based on input from the IR cameras under and above the table (Fig. 2b). By default, the IR projection only projects marker patterns, allowing for 3D localization. When the IR cameras under the table detect objects on the surface, the IR projector will project a white region enclosing the foregrounds. This enables IR cameras to accurately detect finger touches and tangible objects.

In addition, when the IR cameras above the table detects the marker patterns, they report the quality of the patterns perceived. The IR marker patterns adaptively change in size based on the reported quality and distance of the cameras.

3 Interaction Metaphors

We propose three interaction metaphors (Fig. 1). **iView** is composed of a tablet computer with an attached IR camera, which is an intuitive tool to see 3D content from different perspective. **iLamp** is composed of a projector with an IR camera that projects high-resolution content on the surface, mimicking the use of a desk lamp. Similarly, **iFlashlight** is a mobile version of iLamp, facilitating information explorations and cooperative tasks.

References

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