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Pop-up digital tabletop: seamless integration of 2D and 3D visualizations in a tabletop environment

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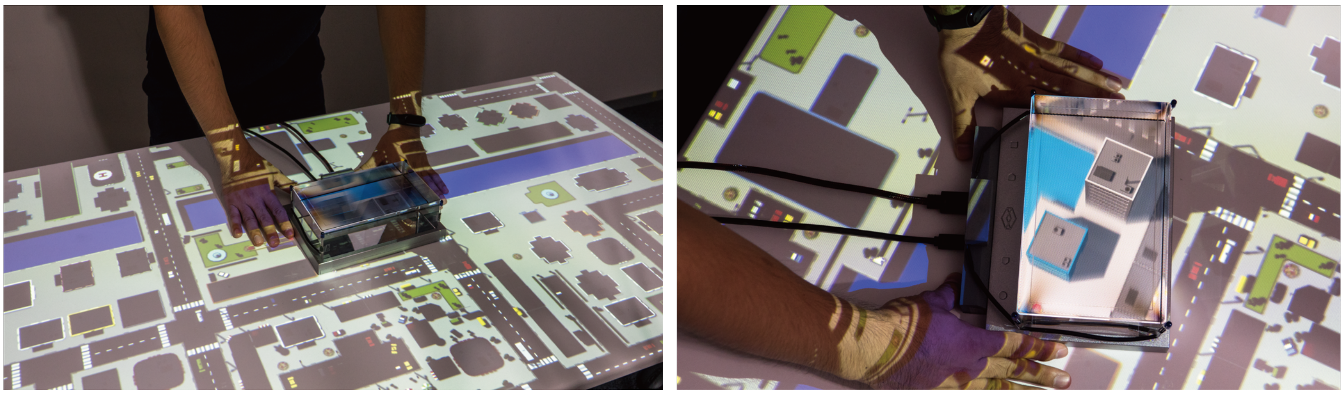

Figure 1: Pop-up digital tabletop system. Our system provides the 2D contents on a digital tabletop (left) and visualizes a part of the contents in 3D using a light-field display (right).

ABSTRACT

We propose a pop-up digital tabletop system that seamlessly integrates two-dimensional (2D) and three-dimensional (3D) representations of contents in a digital tabletop environment. By combining a digital tabletop display of 2D contents with a light-field display, we can visualize a part of the 2D contents in 3D. Users of our system can overview the contents in their 2D representation, then observe a detail of the contents in the 3D visualization. The feasibility of our system is demonstrated on two applications, one for browsing cityscapes, the other for viewing insect specimens.

CCS CONCEPTS

• **Human-centered computing** → *Systems and tools for interaction design.*

KEYWORDS

Digital tabletop, light-field display, contents visualization.

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1 INTRODUCTION

When contents with three-dimensional (3D) information are displayed on a monitor or paper, they must be converted into two-dimensional (2D) representations. For instance, buildings and products are represented by architectural and engineering drawings respectively, cities and terrains are represented on maps, and scientific specimens are represented by photographs. In general, such 2D conversions are performed by orthogonal or perspective projections and content-specific stylization. When converted into 2D representations, the original 3D contents lose their height (or depth) information.

A digital tabletop provides information on a table display. As multiple users can share information, digital tabletops are used in various collaboration tasks [Tang et al. 2006]. In addition, direct interaction techniques allow users to touch the display in the digital tabletop environment. However, standard digital tabletops are limited to 2D displays. To display 3D contents on such a device, the contents must be converted to 2D representations. To seamlessly bridge this gap, we combine a digital tabletop with a light-field display; the digital tabletop provides the 2D representation of a content, while the light-field display visualizes a part of the content in 3D (Figure 1).

Some projects have extended tabletop systems to support 3D interactions. For instance, Spindler et al. [2012] developed the Tangible Windows system, which presents a global window on the digital tabletop and a local window by projecting images on a board held by the user. Users can explore the 3D space above the tabletop by moving the board. Dalsgaard and Halskov [2012] presented the Tangible 3D Tabletop system that projects images onto physical 3D objects placed on a digital tabletop. However, previous systems using 2D projectors provide only the 2D projections of 3D contents.

2 POP-UP DIGITAL TABLETOP

We present Pop-up Digital Tabletop system that visualizes both the 2D and 3D representations of contents in a tabletop environment. The main idea is to combine a light-field display with a digital tabletop. As shown in Figure 1, the 2D representations of the contents are displayed on a large digital tabletop. The light-field display is placed on the table and can be freely moved by the user. Where the light-field display overlaps the digital tabletop, the user can observe the original 3D contents.

Our system is overviewed in Figure 2. The digital tabletop is constructed from a short focus projector (A) and a white table (B). As the light-field display, we use an 8.9-inch Looking Glass [2019], which provides 45 unique images over a horizontal range of 50°. The Looking Glass is placed face up on the table (C), and each corner of the upward face is attached with an infrared LED (Figure 2b). The positions of the four LEDs are tracked by a camera placed above the table (D).

To illustrate the feasibility of our system, we developed two applications, a city map viewer and a digital insect specimen viewer (see Figures 1 and 3, and the supporting video).

City map viewer. The city map viewer presents the 2D map of a city on the digital tabletop. In this representation, all buildings are orthogonally projected onto the ground in the height direction (Figure 3a). When the pop-up display is placed on the table, the buildings under the display are observed in 3D (Figure 3b). This application allows users to explore a 2D city map and observe a 3D city at a time. The 3D view also shows the shadow generated by the buildings, which is useful for understanding the sunshine conditions of individual rooms. Such visualization is obscured on the 2D map.

Insect specimen viewer. The insect specimen viewer presents 2D images of multiple insects on the digital tabletop (Figure 3c). When the user places the pop-up display on an insect image, the system visualizes the target insect in 3D (Figure 3d). The target insect displayed by the pop-up display is supplemented with text information displayed on the digital tabletop. This application allows users to overview all insect specimens in 2D, and observe the 3D shape of a selected specimen in detail. Note that currently available light-field displays have limited resolution and are not suitable for displaying small texts. In our application, this limitation is removed by combining the light-field display with a digital tabletop.

Limitations and future work. Users of our system cannot view contents from the side of our pop-up display, because the light-field display used in this study generates parallax images only in the horizontal direction. In future work, we should apply our system to various targets, such as industrial products and scientific specimens other than insects. We also would like to extend our system to multiple users and develop various interactions for collaborations.

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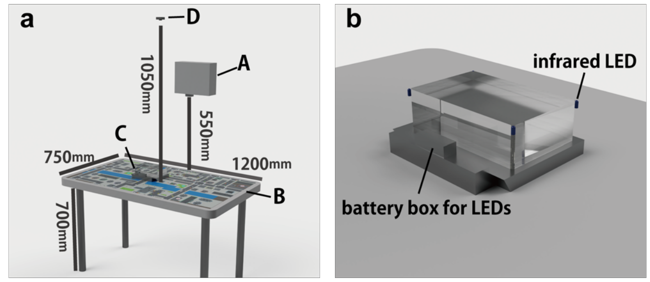

Figure 2: Overview of our system.

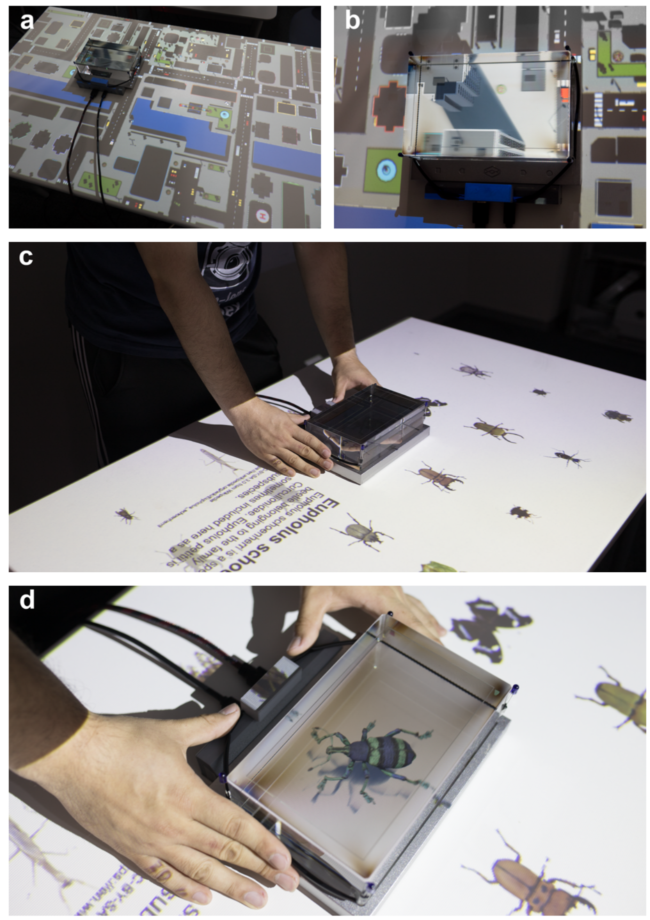

Figure 3: City map viewer (a,b) and insect viewer (c,d).

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