Stereoscopic 3D Mobile Maps for Indoor Navigation in Multi-Level Buildings

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Abstract
Autostereoscopic 3D (S3D) displays, enabling the perception of depth without requiring the viewer to wear special glasses, are now commercially available in a variety of sizes, from phones to large displays. In this paper, we present our research demonstrator where S3D display equipped mobile devices are used to provide a user interface (UI) for indoor navigation. The design approach suits especially for aiding navigation within multi-level buildings, such as shopping malls, airports and museums. Compared to the current 2D design approach of displaying building floor levels side-by-side, the use of stereoscopic 3D offers potential to improve understanding of the space, glanceability of map based UIs, and the ability to navigate between locations on different floor levels.

Author Keywords
Stereoscopic 3D User Interfaces; Indoor Navigation; Maps.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

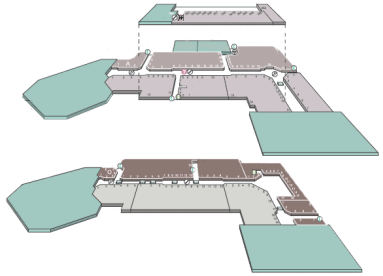

Figure 1: A typical current way of representing a 3 level shopping mall on in store signage.

Introduction

Mobile devices employing a stereoscopic 3D (S3D) display have gained increasing attention during past few years. In the context of large screen static public displays, Alt et al. [1] report on the increasing penetration of stereoscopic displays in to the arena of public displays, whilst focusing in particular on eye-tracking based interaction. Research on mobile S3D has proposed designs that use stereoscopy e.g. with mixed reality [4]. Recently, the area of S3D UI design has gained more attention, and e.g. new design techniques for developing S3D UIs, such as low-fi prototyping [2], have been proposed. Yet, the UI design solutions for S3D UIs have not reached their full potential, and especially there are further possibilities to exploit the illusion of the depth dimension in a more utilitarian manner.

Previous research on user perceptions of mobile stereoscopic 3D UI design has identified that the S3D effect could be used to present topographic information [9]. We see this as especially interesting for cases where the user is navigating through a multi-level space, such as large indoor spaces. Puikkonen et al. have proposed design recommendations for indoor navigation mobile UIs, and point out, e.g., that more attention should be paid to vertical navigation cases, i.e. between floors [7].

Currently the majority of research and commercial solutions related to navigation have focused on map based 2D user interfaces designed for outdoor navigation, whereas indoor navigation and unconventional graphical UI (GUI) design solutions, such as the use of 3D, have gained less attention.

One alternative solution has been presented by Schöning et al. in their mobile mapping solution based on 'you are here' maps [8]. Prior art has investigated the use of 3D virtual world representations for navigation [5, 6], although these have not considered the stereoscopic case. When comparing different mobile UI designs in a user study, Kray et al. have reported that people used the (virtual world type) 3D representation to help in orienting themselves with the physical world in the urban context [5].

To the best of our knowledge, our work is the first one investigating the case of indoor navigation from the stereoscopic 3D UI design point of view.

Prototype Stereoscopic 3D Mobile Map

Visual Design

In our demonstration, we present a prototype stereoscopic indoor map for a multi-level shopping center complex. For comparison, Figure 1 presents a conventional way of visualizing a multi-level map, with different floors shown as visually separate areas. In the following, we describe the visual design for our S3D mobile map UI, where the representation is condensed by layering the floors on top of each other.

In our S3D multi-level map design, the idea is to utilize the perception of depth in communicating the different floors of the indoor space, the principle illustrated in Figure 2. The core challenge in creating a usable multilayer stereoscopic map is that of visual design. Simply overlaying existing 2D maps of each floor and applying stereoscopic depth separation will not create a usable solution. Rather, the map visualization must be designed from scratch based on the requirements of

the stereoscopic visualization. In general our design approach follows the design guidelines for S3D UIs summarized by Broy et al. [2]. However, we make some additions and deviations to suit our particular application case.

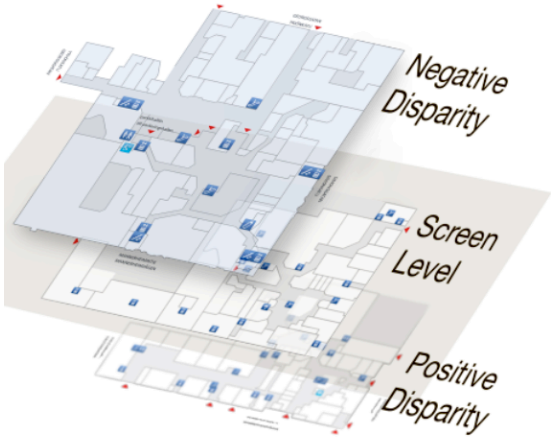

Figure 2: Stereoscopic depth is applied to floor levels, e.g. upper floors are shown with negative disparity, i.e. appearing above the screen level.

In order to enable the see-through effect, the upper floors will need to be rendered with some degree of opacity to enable lower floors to be visible. Here, applying different opacity levels to object strokes vs. fills seems to be beneficial. Although we experimented with very low levels of opacity for fills (0-10%), relying on strokes to provide visual definition, we found that at such levels the stereoscopic effect becomes compromised.

As in typical buildings walls on one level align with walls on other levels, we found that some amount of planar offset between the floor layers was needed to enable visual separation of the floors. Similarly the relative scale of each floor level should be considered, i.e. upper floor levels that appear closer to the user maybe be rendered at a larger size than lower levels. These visual parameters related to viewpoint and perspective, need to be aligned with the stereoscopic disparity to correctly reinforce the 3D perception [2]. Additionally the stereoscopic depth should be reinforced with visual depth cues, such as blurring, shadows, lighting effects and intensity of color.

The demo

The map is displayed on a Gadmei E8-3D tablet, which incorporates an autostereoscopic display (see Figure 3). The device has an 8.1” display and utilizes a parallax barrier to create the stereoscopic effect.

Figure 3: Simulated image of our prototype S3D indoor map and its use context (Note: image is simulated for printing)

In the demonstration, we show the audience the tablet with the S3D map visualization of a multi-level space.

Figure 4: Participant in preliminary user study (Note different device hardware was used in this study).

The users are able to interact with the demo and browse through the different floors and see how the stereoscopic effect is used to visualize the points of interests, location and navigation in a simulated multi-level environment (shopping center). Additionally different techniques for visualizing the 3D indoor space are explored.

Discussion

Our demonstration offers, to our knowledge, a new perspective for designing map based UIs, and tackles design challenges especially relevant for complex indoor spaces. So far, we have conducted a preliminary user study with an earlier version of the demo, (Figure 4), and observations from that have been incorporated to the current demo design. As a next step, we aim to conduct a user study comparing user perception and performance in an indoor wayfinding task, using conventional 2D and our prototype S3D map presentation. Here, one interesting aspect is to compare the glancability of the two presentations.

For buildings with a large number of floors, some level of interaction to select floors of interest should be considered e.g. for handheld navigation based on the location of the device and the target destination. When considering the possibility of touch screen interaction with the S3D map particular consideration should be given to the size of the touchable targets [3]. Similarly, it may not be necessary to visualize all levels with the same visual granularity and there may be benefit in conveying only general depth context information, rather than a detailed map for all floors.

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