Details-on-demand Mobile Visual Interface for Facilitating Indoor Wayfinding

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1. Introduction

Wayfinding in indoor spaces, as well as transition between outdoor and indoor spaces (O/I spaces), is a common but sometimes difficult and tedious process in everyday life. This is particularly evident for indoor travel through complex buildings where traditional external aids, such as signs or You-Are-Here maps, are often absent or inadequate (Moeser et al., 1988). In these instances, navigators can become frustrated, stressed, and get lost or disoriented. Therefore, an indoor wayfinding tool with an efficient, intuitive, and user-friendly visual interface could be very useful in people’s daily lives.

Traditional interfaces for indoor navigation employ 2D maps with a fixed top-down, north-up viewpoint and only visualize details about a single-level (e.g. floor) of the space. North-up displays maintain an external reference frame, thus emphasizing global awareness, whereas track-up displays employ an egocentric frame, thereby improving local guidance (Taylor et al., 2008). Solely emphasizing global awareness or local cues is not optimal for a spatial display, as both types of information are important for navigation (Taylor et al., 2008). Similarly, using visualization of only single-level building details may not be optimal, as users may need to access different details based on different wayfinding demands.

A better approach is to flexibly combine the advantages of multiple viewpoints and indoor visualization techniques based on these demands, which are categorized according to the user requirements encapsulated in the five navigation phases illustrated in Table 1.

Table 1. Five levels of wayfinding demands for transition between O/I spaces.

<table>
<thead>
<tr>
<th>Levels</th>
<th>Navigation phases</th>
<th>Spaces</th>
<th>Wayfinding demands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Plan to enter a building</td>
<td>O</td>
<td>Overview of building, such as functional areas, entrances, etc.</td>
</tr>
<tr>
<td>Level 2</td>
<td>Enter a building</td>
<td>O/I</td>
<td>Learn main floor layout, important features (elevators, staircases, etc.)</td>
</tr>
<tr>
<td>Level 3</td>
<td>Navigation on one floor</td>
<td>I</td>
<td>Learn current floor layout</td>
</tr>
<tr>
<td>Level 4</td>
<td>Navigation between floors</td>
<td>I</td>
<td>Integrating vertical information</td>
</tr>
<tr>
<td>Level 5</td>
<td>Plan to exit a building</td>
<td>I/O</td>
<td>Overview of the spatial reference of O/I</td>
</tr>
</tbody>
</table>

This research proposes a details-on-demand mobile visual interface for facilitating indoor wayfinding and transition between O/I spaces. Details-on-demand in our research means that the optimal visual interface is dynamically adaptive to users’ specific wayfinding demands (e.g., as listed in Table 1). Our hypothesis is that the details-on-demand visual interface is a more intuitive, user-friendly, and efficient visual interface for facilitating spatial learning and real-time indoor wayfinding and seamless transition between O/I spaces than the standard use of fixed-viewpoint, single-level visual interfaces.

Three empirical studies are designed (discussed in section 2) to evaluate the optimal visual interface variables, as listed in Table 2, on each level of wayfinding demands.
Although several studies have previously investigated these visualization variables for indoor wayfinding in isolation (Chittaro et al., 2006; Münzer et al., 2011), our research is the first known effort to combine these variables in a unified informatics framework.

Table 2. Visual interface variables affecting indoor wayfinding performance.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Option</th>
<th>Other Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map type</td>
<td>2D map</td>
<td>3D map</td>
</tr>
<tr>
<td>Viewpoint</td>
<td>First-person (egocentric)</td>
<td>Third-person (bird’s-eye view)</td>
</tr>
<tr>
<td>Map orientation</td>
<td>North-up</td>
<td>Track-up</td>
</tr>
<tr>
<td>Assistance Information</td>
<td>Static</td>
<td>Animation</td>
</tr>
<tr>
<td>Visualization object filtering</td>
<td>Wall</td>
<td>Window, door, etc. (based on O/I spaces ontology)</td>
</tr>
</tbody>
</table>

2. Experimental Design

Empirical experiments will be conducted using immersive Virtual Environments (VEs) coupled with a simulated PDA-sized screen as the visual interface to display information about navigation assistance. The advantage of using VEs is that we can leverage accurate real-time indoor positioning and tracking and easily manipulate the simulated building layouts and information content.

Figure 1. Experimental environment in VEs.

2.1 Experiment 1: Assessing the visual granularity of 3D indoor maps

One practical question for these 3D map based navigation systems is how the realism of the 3D maps affects human navigation performance? We experimentally evaluate four simulation fidelity conditions which manipulate the level of visual granularity provided to the user by a simulated mobile device during learning of two-story virtual buildings.
Results indicated that the sparse model led to significantly higher navigation accuracy (whether subjects successfully indicated the correct location and orientation of the target) than the low fidelity model and that navigation efficiency (shortest route length over travelled route length) with the sparse model was significantly higher than both the high fidelity and low fidelity models. Our results also showed that it is more difficult for people to maintain the spatial relation of objects between floors than within floors.

Experiment 1 provides empirical foundations for experiments 2 and 3, currently being designed, where we will use sparsely rendered 3D maps to explore the optimal viewpoint and the most relevant objects to render with different levels of wayfinding demands.

2.2 Experiment 2: Integrating vertical information

Indoor wayfinding performance involving floor level changes is greatly hindered by disorientation during vertical travel (Soeda et al., 1997; Montello et al., 1993; Holscher et al., 2006). In Experiment 2, we will empirically evaluate the optimal mobile interface for supporting users’ development of a multi-level 3D cognitive map to facilitate vertical travel in indoor spaces. This experiment corresponds to level 4 of the wayfinding demands, listed in Table 1.

There are three conditions in this experiment: 3D maps using an egocentric view (model 1), 3D maps using a north-up bird’s-eye view (model 2), and combined maps where the map dynamically switches based on the user’s position and movement behaviour in the building. For instance, model 1 is used when users navigate on a specific floor and model 2 is used when users transition between floors. Our hypothesis is that the combined map condition is the optimal visual interface for integrating vertical information.

2.3 Experiment 3: Supporting seamless transition between O/I spaces

As shown in Figure 4, many people have similar experiences in using the wrong exit to get to their car in the parking lot. Experiment 3 is designed to address such problems by evaluating the optimal visual interface for supporting seamless transition between O/I spaces. This experiment corresponds to level 1 and level 5 of the wayfinding demands listed in Table 1.
Figure 4. Scenarios for transition between Outdoor/Indoor spaces.

Experiment 3 comprises two conditions. In the control condition, the visual interface for transition between O/I spaces is the same as the interface before transition (i.e., they have the same viewpoint and environmental details). In the O/I reference information condition, the viewpoint and space details dynamically change to represent domain-specific information. For example, if users plan to exit the building, the indoor staircases will be removed from the display and the outdoor streets will be visualized. Meanwhile, the user’s perspective gradually changes from an egocentric viewpoint to a track-up bird’s eye viewpoint, to a north-up bird’s-eye viewpoint based on their location.

The hypothesis is that the O/I reference information condition is better than the control in supporting seamless transitions between O/I spaces, as it emphasizes the spatial relations between spatial domains based on visualizing the most important information supporting current wayfinding demands.

3. Conclusion

This research proposes a details-on-demand mobile interface for facilitating spatial learning and navigation of complex indoor spaces and transition to outdoor spaces using a visual interface which dynamically adapts the information content displayed as a function of wayfinding demands. Further empirical studies will be conducted to show the efficacy of this interface as being more intuitive, user-friendly, and efficient than traditional fixed-detail navigation displays.

Acknowledgements

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References


