Evaluating Navigation Methods for an AR System

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ABSTRACT
BUILD-IT is a planning tool based on computer vision technology, supporting complex planning and composition tasks. A group of people, seated around a table, interact with objects in a virtual scene using real bricks. A plan view of the scene is projected onto the table, where object manipulation takes place. A perspective view is projected on the wall. The views are set by virtual cameras, having spatial attributes like shift, rotation and zoom. However, planar interaction with bricks provides only position and rotation information. This paper explores two alternative methods to bridge the gap between planar interaction and three-dimensional navigation. An empirical evaluation of the two alternatives is in process.

Keywords
Augmented Reality, design,, ubiquitous, tangible, interaction, groupware, bricks, navigation, viewpoint control, evaluation

INTRODUCTION
We present two alternative navigation methods for a brick-based Augmented Reality (AR) system. The given examples have been implemented with the BUILD-IT system [3, 5]. BUILD-IT enables users, grouped around a table, to interact in a virtual scene, using real bricks to select and manipulate objects in the scene. Users have two up-to-date views of the scene: the plan view and the side view (Fig. 1). The plan view is the bird's eye view from above; the side view is the human eye's view from the side. The system consists of a rack with a mirror, a camera, a computer, two projectors and several bricks. A virtual storage space, or menu, allows users to create and delete objects. This menu also offers the navigation methods.

Figure 1. Plan and side view (left); object handling (right).

The innovative feature of BUILD-IT, beyond the brick-based interaction, is that the objects are part of a three-dimensional (3D) setting [3]. Two-dimensional, planar brick-based interaction has already been explored [2, 6]. Also, bimanual camera handling and object manipulation in 3D graphics interfaces has been investigated [1] using two mice, a keyboard and a screen. Here, we combine the strengths of these two approaches.

The exploration of an environment or a product is important in a range of composition and planning activities [3], for instance design of production lines and walkthroughs of architectural simulations. To explore a 3D virtual world, a set of operations are required. With BUILD-IT, the use of a multimedia framework allows for *full 3D* interaction, including *shift*, *rotation*, *zoom*, *tilt* and *roll*. However, planar interaction with bricks provides only position and rotation but not height information. Hence, there is a need to bridge the gap between planar interaction and 3D, spatial navigation [3]. In a first approach, a *full* 3D control of the side view was explored, using so-called *EyeCatchers*.

Searching for a general answer to this need, applicable to both views, we explored different ways of handling a virtual scene [3]. Based on the idea of grabbing and handling a virtual world directly, we implemented the *Continuous Update* method (window analogue: grabbing hand). Based on the idea of handling a virtual viewpoint and then updating the virtual scene, we implemented the *Select and Reframe* method (window analogue: scroll bar). Further details are given in a video production [4].

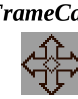
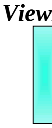
	Continuous Update	**Select and Reframe**
Plan view control 	***GroundCatcher*** 	***FrameCatcher*** 
Side view control 	***Camera*** 	***ViewFrame*** 

Table I. *Continuous Update*; *Select and Reframe*.

Each method consists of two tools, one for plan and one for side view control (Table I). The tools are offered in the menu (Fig. 1, right). Using one brick - unimanual handling - *shift* and *rotation* of the controlled view can be set. Using two bricks -bimanual handling - *shift*, *rotation* and *zoom* of the controlled view can be set (this case will be shown here). Only one tool per view can be activated and used at a time.

METHOD 1: CONTINUOUS UPDATE
As soon as the *GroundCatcher* (Fig. 2, top) is selected from the menu and placed, it locks to the scene. All subsequent handling affects the plan view. To quit the tool, the bricks are covered and removed.

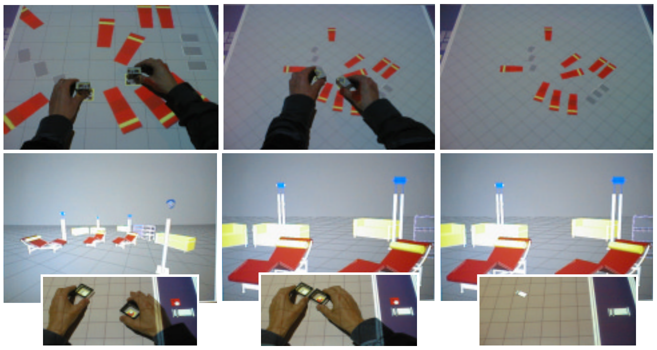


Figure 2. *GroundCatcher* (top):Placing bricks; view handling; removing bricks (l. to r.). *Camera* (bottom): Consecutive zoom handling steps; removing bricks (right).

By selecting the *Camera* (Fig. 2, bottom) from the menu, the part of the scene shown in the side view can be set. A zoom handle is selected with a second (here: right hand) brick. By moving the zoom handle and the camera further apart, the side view can be enlarged; by moving them closer, the side view can be focused. Covering and removing the second brick freezes the zoom.

METHOD 2: SELECT AND REFRAME

When the *FrameCatcher* (Fig. 3, top) is selected from the menu, the scene automatically is zoomed out to show a wider context. As soon as the *FrameCatcher* is placed within the frame, it locks to the frame. All subsequent handling affects the frame and the desired part of the scene can be selected. Covering and removing the brick triggers a reframe of the view, responding to user selection.

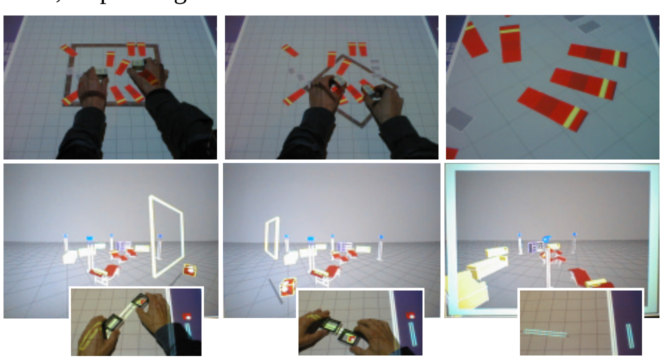


Figure 3. *FrameCatcher* (top): Placing bricks; selection; reframe (l. to r.).*ViewFrame* (bottom): Consecutive selection steps; reframe (right).

When the *ViewFrame* (Fig. 3, bottom) is selected from the menu, the side view automatically is zoomed out to show a wider context. The desired part of the scene can be selected. A zoom handle is selected with the second brick, thus resizing the window. Covering and removing the second (here: right hand) brick freezes the zoom. Covering and removing the first brick triggers a reframe of the side view, responding to user selection.

EMPIRICAL EVALUATION AND DISCUSSION

The two methods were designed and implemented in order to explore the navigation possibilities within a brick-based AR system. For empirical evaluation, typical task types [1] are positioning, searching, and tracking. To leverage the whole potential of the methods, tasks should call for *shift*, *rotation* and *zoom*. Therefore, they must have a certain complexity. However, complex graphics slow down the system. Probing for a trade-off between task complexity and system performance, we found that search tasks with the following characteristics would fulfill our requirements: A virtual landscape consisting of textured boxes arranged in a few clusters where each cluster has a distinct form. The clusters are so far from each other that *bimanual plan view navigation* is required. Within each cluster is a 3D model that must be found and moved to a target area. To find a 3D model, *bimanual side view navigation* is required.

To start with, we chose to use 2D textures combined with 3D models of molecules. The models have depth cues and contrast the textured landscape. A task is solved when all models are found and collected in the target area. Subjects will be offered one tool for each view, giving four possible pairs of tools: the first column, the second column, and the diagonals of Table 1. Tasks may be completed within a given time. Task completion and the time spent will indicate task-solving performance. Using log files, we will quantify the use of the different tools (e.g. number of times selected and average time of use). Objective versus subjective rating will be investigated by asking subjects for their preference.

For reasons of continuous feedback and a lower number of operations, we hypothesize *Continuous Update* to deliver higher task-solving performance than *Select and Reframe*. However, some users may prefer combinations of tools from both methods (diagonals, Table 1).

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