Look Mother, Virtual Puzzling without Buttons!

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ABSTRACT

Not many virtual 3D puzzle applications have been researched. We present a solution using tangible objects and a reach-in set-up. The user can solve a puzzle using natural and tangible interaction. To provide realistic interaction, the usage of buttons was avoided by design. In a user experiment the solution proved to be natural and intuitive.

1 INTRODUCTION

Solving a puzzle is a tangible activity performed by using your hands. In many situations during the puzzling activity both hands will be used in combination to place a puzzle block or to check in what direction or area a puzzle block could be placed. The solution we provide for the 3DUI Grand Prize 2011 takes this into account. Moreover, we opted for a solution in which no buttons are employed just as in a real life situation. Therefore we aim to make the experience as natural and familiar as possible.

First we will discuss our solution and afterwards we will present the results from our user study.

2 OUR SOLUTION

As explained earlier we have chosen for a tangible solution [4]. Instead of using a Head Mounted Display solution in combination with Augmented Reality for our tangible solution we decided for a more economical option: a LCD screen in combination with a semi-transparent mirror. This set-up is similar to the PDrive from De Haan et al. [3] which works with projectors. The co-location of the virtual environment rendered upon the mirror and the hands below the mirror provides a high sense of realistic interacting with the virtual world. In order to provide the possibility to interact with the virtual world, two different tangible props are provided to the user. These are tracked using two Microsoft LifeCam HD webcams running at 25 fps. The prop detection is done by markers using the library ALVAR [1]. An overview of the set-up can be seen in Figure 1.

The most important tangible prop is the one which serves as a replacement for the puzzle blocks and is used by the dominant hand. If no puzzle block is selected the tangible prop represents a selector to select puzzle blocks (red box). When a puzzle block is selected it represents the puzzle block itself.

The other tangible prop, used by the non dominant hand, represents the puzzling area. Puzzle blocks can only be placed on this area. This prop can be easily moved around and rotated to obtain a good overview of the current puzzle solution as well as expose areas more easily to place a puzzle block.

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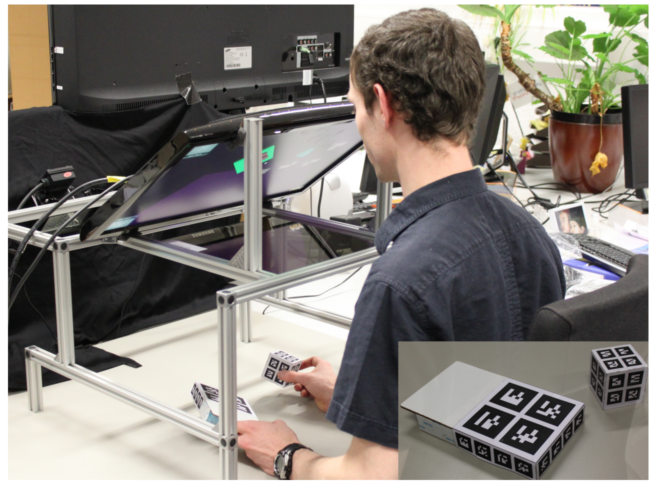


Figure 1: Overview of the set-up

2.1 Avoiding Buttons

In order to be able to solve a puzzle inside a virtual environment several typical interaction techniques have to be provided namely selection and manipulation [2]. Due to the fact that the puzzling area is represented through a tangible prop, which can freely be translated and rotated, the user does not need to navigate to view the current solution of the puzzle from another side. Therefore, navigation is not provided.

Our solution integrates the selection and manipulation technique into one fluent behavior. First of all the user needs to be able to pick up and place a puzzle block. In order to pick up (select) a puzzle block the tangible prop for the dominant hand has to be moved near one of the puzzle blocks in the virtual world. As we don't want to use a button to confirm the selection, the closest puzzle block is highlighted when within a certain distance (similar to the bubble cursor based on the voronoi regions [6]). If this distance becomes small – clearly indicating that the user wants to pick up this particular puzzle block – the confirmation is performed automatically.

When a puzzle block is selected the user can place it on the puzzle area in a chosen rotation. In order to place a puzzle block on the puzzle area a ghost puzzle block is used. This ghost puzzle block represents the nearest placement position (if possible) inside the puzzle area. To make sure that blocks can easily be placed next to or on top of each other, snap locations the size of one puzzle unit are used to determine the desired position. The ghost becomes visible when the distance between the hand of the user, holding the actual puzzle block, and the snapped position is smaller than a predefined distance. Similar to confirming selection, when the hand of the user moves near to the ghost puzzle block, the placement of the puzzle block will automatically be confirmed.

To perform other actions with the props, we provide a context-aware area in the back of the working space such that an action can easily be performed using proprioception [5]. If the selection prop is placed in this action area, the currently selected block (if any)

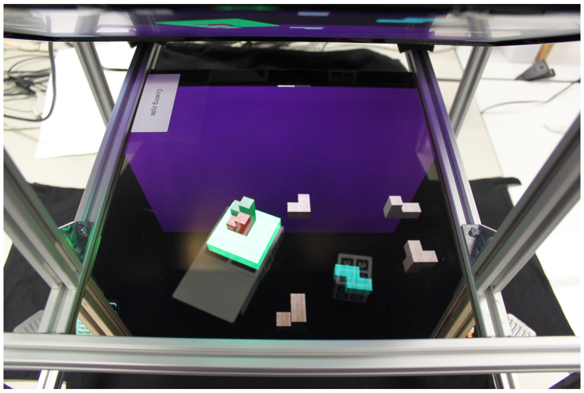
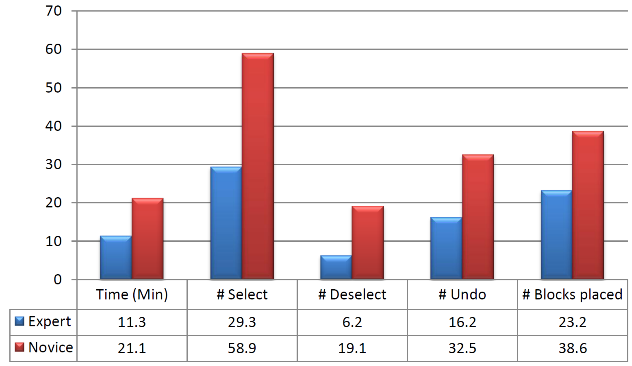


Figure 2: The viewpoint of the user, demonstrating the overlay



	Time (Min)	# Select	# Deselect	# Undo	# Blocks placed
Expert	11.3	29.3	6.2	16.2	23.2
Novice	21.1	58.9	19.1	32.5	38.6

Figure 3: An overview of the averages for the objective measures, split for novices and experts.

is deselected. Similarly, when the puzzle area prop is inside the action area, an undo operation is performed. Both operations return the applicable blocks to their initial positions using animations to keep track of the blocks.

3 User Experiment

To evaluate our solution we performed an informal user experiment. We used the set-up discussed in the previous section.

3.1 Participants

Seventeen participants (four females and thirteen males) served as participants in this experiment. Participants were selected among co-workers and had an age between 24 and 55 with an average of 30. All participants used their dominant/non-dominant hand for the respective dominant/non-dominant tangible props. Six participants were expert virtual reality users, the eleven remaining were novice users.

3.2 Procedure

The imposed virtual puzzle from the assignment for the 3DUI Grand Prize 2011 was used for this experiment. Users were first explained how they could solve the virtual puzzle using the presented system. Afterwards they could learn to use the system using a simple virtual puzzle consisting of only three big puzzle blocks. This virtual puzzle was so simple that they easily finished it within one minute. When the simple virtual puzzle was solved participants were asked to try and solve the imposed virtual puzzle. Participants were instructed that they could give up if they were not able to finish the virtual puzzle. Finally, the experiment concluded with a questionnaire.

4 Results

As objective measures, we measured the time it took to solve the puzzle together with the amount of times a puzzle block was selected, deselected or placed and how often the undo action was invoked. From the seventeen participants 3 gave up and were not able to solve the puzzle, they all were novice participants. Therefore the rest of the objective measures will contain data from those that successfully solved the virtual puzzle.

In Figure 3 an overview can be seen in which the data is split up between novice and expert users. The overall average completion time to solve the virtual puzzle was 16.9 minutes, the novice participants on average took 21.1 minutes while the experts were almost twice as fast with an average of 11.3 minutes. This trend maintains itself for the other measures as well. From the measures we can also deduct that experts users were more convinced that they had selected the correct object which they wanted to use next during their puzzling activity. This is further supported by the fact that experts less often placed a block or performed an undo.

In the post-experiment questionnaire the participant was asked to score several statements using a Likert scale from 1 to 5 (1=Strongly Disagree and 5 = Strongly Agree). The results in general were very positive with average scores almost always above 4. For example users indicated that the selection (M=4.8), deselection (M=4.5) and placement (M=4.1) of objects was easy and intuitive. Moreover the purpose (M=4.5) of the puzzle area as well as being able to manipulate it (M=4.7) was judged positively. The ability to remove a puzzle block from the area using the undo action was found to be clear (M=4.7), but users commented that the sequential undo action was at times frustrating and not useful. Typically users solved the puzzle by placing block after block, possibly undoing one block and trying another possible combination. Unfortunatly when they noticed that their initial placed blocks were wrong several sequential undo actions were required and no fast solution was provided.

Users were also asked to judge how easy the virtual puzzle experience was. This question scored worst with M=3.2. This can be contributed to two factors. Firstly, users commented that the virtual puzzle very difficult and complicated to finish. Secondly the placement of the puzzle blocks would sometimes change from the final goal position right before the block would be placed resulting in a misplaced puzzle block leading to frustration. This is probably due to a wrong perspective when placing the block downwards. The usage of tangible props felt natural (M=4.2) and overall users found the system intuitive (M=4.2) and enjoyed performing the puzzle (M=4.3).

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