3D Interaction for Puzzle Solving with the Cubtile, 3D Multitouch Device

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ABSTRACT

This experimentation proposes a new interaction technique for 3D puzzle solving using a cubic device with five multitouch surfaces. The interaction is based on three levels. First, the device is used to move a 3D pointer (a selection box) into the virtual environment using. Such translations are performed relying on all the device faces. Once the selection icon is close to a piece of the puzzle, the user can grab it into this selection box, where he can orientate it freely using the four vertical faces of the device. The position of the 3D object is therefore global using the selection box, but its orientation is local regarding to the interaction on the device. Thanks to this combination the user can take, move, orientate and put in place the puzzle pieces to solve the problem.

KEYWORDS: 3D manipulation, multitouch, cubtile.

1 INTRODUCTION

To resolve the 3DUI contest puzzle, we chose to experiment with the cubtile, a 3D multitouch device we built as an attempt to bring the strengths of multitouch interaction into the 3D worlds. While the device has been studied in the scope of basic 3D manipulation, specific interaction techniques had to be built to support the complex selection and manipulation tasks that are proposed in the contest context.

The resulting application will be described through the following aspects: the hardware device by itself, the application environment and associated user feedback, and finally the actual interaction technique that makes use of the of the hardware and software interface combination.

2 HARDWARE CAPABILITIES: CUBTILE

The cubtile is a hardware device which early functionalities have been described in [1]. It basically is the freestanding cubic tactile device shown in figure 1, where each of the five upper part surfaces is equipped with the typical rotate / orientate and put in place the puzzle pieces. Later on, extra degrees of freedom necessary to achieve advanced 3D interaction tasks, such as in this puzzle issue.

3 DESCRIPTION OF THE APPLICATION

3.1 Virtual World Components

The virtual world is obviously centered on the various puzzle pieces, which we chose to represent in perspective 3D. The experience environment is composed of different parts.

A floor (figure 2: A) is displayed, where and above which all the puzzle pieces are randomly dispatched (figure 2: B). It is used as a referential to project shadows of the 3D objects on.

A semi-transparent cube is displayed in front of the screen (figure 2: C). This cube is always displayed at the same place / orientation / size, in front of the camera, and us used not only as a pointer, but also as a selection box inside which the objects (i.e. the pieces! of puzzle) can be manipulated (figure 2: D).

A platform with a 2D grid texture and fixed point creating a 3D grid on its top (figure 2: E) is displayed somewhere in the environment. It consists in the container of the 3D puzzle, within which the correct pieces have to be placed to resolve the puzzle. The pieces will snap to the grid to facilitate the manipulation (figure 2: F).

An original version of the puzzle used as a guide is presented to the user, so that he knows what the result must look like (figure 2: G).

3.2 General description

Our main objective and issue with such a 3D representation lies in how difficult it is to combine 3D navigation, selection and manipulation using a single device onto which we did not want to stick state modifiers buttons. The main interaction concept therefore is to allow the user to navigate in the 3D world by moving a selection box, then selecting a specific piece of puzzle. Once associated to the selection box, this selected 3D object can
be orientated independently from the selection box (or other any elements of the world), as well as translated along with the box.

In order to give access to two different levels of interaction, while maintaining a consistency in the cubic device manipulation, we chose to interpret the actions depending on the faces used on the device. The translations of the box, including the piece of puzzle in it, are possible on every surface of the device, whereas the rotations of the objects (the selection box and piece of puzzle) are not dependent one to the other. After first experimentations, we chose to use the top face only to orientate the selection box, and every other faces to orientate the 3D object selected. All the actions therefore can be performed simultaneously, using the same device in a single state.

3.3 Detailed Navigation & Selection

As explained previously, the navigation is obtained by moving the selection box within the 3D environment. The camera is attached to this pointer (the selection box), which makes it always stand at the same position on the screen. Moreover, it appears as a visual 3D representation of the actual physical device, which also always is in front of the screen. Translations on the cubite, performed by sliding the fingers on the surfaces of the device, will be equally applied on the virtual world to the selection box. Rotations of the point of view are also applied the same way, but only occur when the top face is used.

When the selection box is empty, the puzzle piece the closest to the pointer will be highlighted to notice to the user that this 3D object can be selected. To catch then release an object, we chose to implement two different types of gestures:

- Pinch-In / Pinch-Out: place two or more fingers on a surface of the cubite and pinch the fingers together to catch the object, then spread your fingers to release the object in the box. It acts as a metaphor for grabbing and unloosing a physical object.
- Double-tap: a double tap action on one surface of the cube with one finger to catch the object, and the same gesture to release the object already include inside the selection box.

3.4 Orientation & Positioning

Once selected, the piece of puzzle is attached to the selection box, consequently, when the user moves the box around the environment, the translation is also applied to the object. In the other hand, the selected object orientation is independent from the box orientation and can be performed using the four vertical faces of the cubite. The rotation around the Y axis is performed with a two hands motion on two opposite faces with two opposite sliding movements. The orientation and position of the object is therefore a combination of local orientation of the object within its local reference frame (the selection box, which is a virtual representation of the physical device) and global translations throughout the environment thanks to the selection box movement.

To help the correct positioning, we applied a semi-automatic snapping when the user releases the object, so the object will be aligned on the axes of the world, as well as aligned on the platform that will receive the pieces of puzzle. This kind of help is possible because of the specific shape, square based, of the 3D objects. When the user feels it is the right place for this piece of puzzle, he just has to release the object that will snap to the puzzle grid to correct the position, even if it is the correct puzzle solution.

3.5 Visual Feedback

Given the complex 3D interaction task, as well as the not so common input device and interaction technique we are relying on, we implemented custom visual feedback that should help to easily apprehend the 3D environment. That is why we added dynamic shadows displayed beneath the 3D objects to help understand their orientation in the 3D space and highlighted the objects to indicate the possibility to catch an object.

In the meantime the 3D stereoscopic view provides better space perception, in order to understand and comprehend the environment.

4 EXPERIMENTATIONS

We relied on an iterative design process, which greatly helped us to constantly enhance our interaction technique thanks to important user feedback. The first experimentations show in some ways a good handling of the application and the device after few minutes of experimentations in order to get used to the interface.

The first results of puzzle solving are, in our point of view, not fully exploitable.

<table>
<thead>
<tr>
<th>6 Experts in 3DUI (time to solve the problem in minute)</th>
<th>12 Non-experts (time to solve the problem in minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:37, 4:12, 8:53, 15:34, 3:29</td>
<td>15:34, 10:37, 8:53, 15:34, 3:29</td>
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</tbody>
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The fact is that some people get used pretty fast to the system but take many times to solve the problem, and other can solve the problem easily but are not fully comfortable with the interaction at the beginning. We thought it does not return usable results, in order to validate all the aspects of the interaction. However we can see that there is no real difference of results between experts in 3DUI and non-experts.

We noticed some recurrent comments about the interaction that must lead us to improvements:
- The camera orientation around the selection cube can be disturbing at the beginning. Some users feel that the rotations are opposite to the actual movement on the top face of the cubite.
- Some users want to tilt the camera to get a better point of view, in some particular cases
- The grabbing and releasing metaphor using the pinch-in / pinch-out gesture seems to be well understood during the explanation and the first movement. But during the exercise only the movement pinch-in is used, and the users are not at ease with the pinch-out gesture, it does not seem natural in practice.

5 CONCLUSION

This experimentation of a new interaction technique, which combines navigation, selection and manipulation with the cubite, and the first associated feedbacks, gave us very interesting results. It leads us to confirm some important points related to the device, such as disjoining the interaction depending on the face used on the device, but also to improve the application regarding to the user feedback in order to enhance quality of the user interaction in the next iteration. To achieve such a result, we also had to consider and propose solutions to the user feedback issue. The informal tests we conducted seemed to validate the potential of the techniques we built, and will definitely be pursued in the future.

REFERENCES