The CAT – When mice are not enough

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Abstract

Depending on their nature, some interaction tasks are better performed from 3D interaction techniques whereas others are better performed from 2D interaction techniques. The CAT allows 3D as well as 2D interaction. In this paper we focus mainly on the 2D interaction techniques we have developed to be used with the CAT. These techniques are based on two different metaphors: the virtual tabletop metaphor and the virtual screen metaphor. We present an experiment showing that it does not exist any significant differences between the performances of the users for a 2D pointing task with these two metaphors.

1. Introduction

2D input devices, among which the mouse, are standard devices to deal with applications displayed on classical monitor desktop. They permit to easily move a cursor on a screen, making them very efficient for 2D interaction tasks, such as pointing 2D widgets.

The limited degrees of freedom (DOF) of the 2D input devices make them not well adapted for interaction with VE where 3D interaction tasks have to be performed (eg. manipulation of 3D objects and control of the camera viewpoint).

Consequently, a variety of 6 DOF input devices have been developed to adapt the structure of the device to the structure of the task, as recommended by Jacob and Sibert [1]. Among these devices, we state the flying mice, which are generally instrumented with 6 DOF electromagnetic trackers and the 6 DOF isometric joysticks (eg. Spacemouse, Spaceball). One of the main limitations of these devices is that they generally suffer from a lack of physical constraints for 2D interaction, whereas 2D interaction is sometimes more efficient than 3D interaction in VE.

We have developed a new input device for interaction with VE: the CAT [2]. This device allows to perform 3D as well as 2D interaction techniques. In this paper, we focus mainly on the 2D interaction techniques we have developed.

2. 2D vs. 3D interaction

2D interaction refers to interaction in a 2D space (x, y position on a plane) whereas 3D interaction refers to interaction in the 3D space (x, y, z positions and yaw, pitch, roll orientations). Even if there is no more doubt about the interest of 3D interaction for interaction with VE, 2D interaction can often efficiently supply 3D interaction.

2D interaction has the advantages to be quick and accurate, and the interaction techniques have generally been learned within previous standard 2D applications. With VE, 2D interaction can be efficient for different interactive tasks. First 2D interaction techniques can be used to make some 3D tasks that are difficult to perform directly in 3D easier to perform. Then, as some interactive tasks are mainly 2D tasks (eg. picking an object) 2D interaction techniques are sometimes much more adapted than 3D interaction techniques.

3. Related works

Interfaces have been proposed to mix 3D and 2D interaction. For example the screen of Ergodesk [3] is used as a support for 2D interaction. Then 3D trackers can be used to perform 3D interaction techniques.

Several tracked tools known as “tablets-and-pen” have been proposed to allow 2D interaction within immersive VE. These devices consist in physical surfaces on which the position of stylus can be recovered. Some of them are dedicated to Head-Mounted-Displays (eg. [4]). Others use transparency to be adapted to Immersive-Projection-Technologies (eg. [5][6]). Finally, the PIP has been developed for an augmented reality use [7].

Even if the “tablets-and-pen” solve many problems in VE, in particular for the control of the system, they have limitations too as the users have to carry the devices almost all the time. Permanently carrying a tablet and a pen induces fatigue and avoids to uses one's hands for other tasks. The accuracy of the performed interaction tasks can be affected by human shaking. Finally, all the "tablet-and-pen" like devices are dedicated to one head tracking user.

4. The CAT

The CAT (Control Action Table) is a 6 DOF device we have developed to allow several co-located users to interact with VE displayed on large screens. The freestanding characteristic of the CAT allows a limited fatigue, and allows the users not to be constrained by the device. Compared to other devices, the CAT has the originality to mix isotonic and isometric resistance modes. The rotations in the VE, which are cyclic, can directly be controlled by freely orientating the tabletop of the CAT in space (isotonic mode). The translations, which are infinite, can be controlled by applying pressure on the tabletop, without displacing it (isometric mode). Figure 1 illustrates the CAT.

Figure 1. The CAT

The 6 DOF of the CAT allows to perform 3D tasks. By associating the rotations of the tabletop to the rotations of an object (or the whole scene), users can easily orientate the object in any direction. The similar orientations of both the object and the tabletop provides the users a passive haptic feedback. To translate the object in a given direction, as far as they want, the users just have to push the tabletop in the corresponding direction. The 6 DOF of the CAT can be used to travel in VE too. In this case, the movements applied to the tabletop are mapped to the movement of the camera viewpoint and the CAT is used as a 3D steering wheel. A more in depth description of the CAT and its associated 3D interaction techniques can be found in [2].

5. 2D interaction with the CAT

In order to benefit from 2D interaction, the tabletop of the CAT is equipped with a standard tablet on which the position of a stylus can be recovered, as shown in figure 2. The 2D interaction techniques we have developed for the CAT are organized around two metaphors: the virtual tabletop metaphor and the virtual screen metaphor.

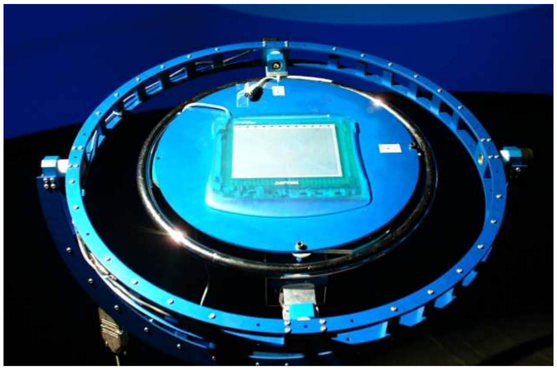


Figure 2. The tabletop of the CAT is equipped with a standard 2D tablet.

8.1. The virtual tabletop metaphor

The virtual tabletop metaphor consists in moving a 2D cursor on a plane which is oriented in space. This plane, called the virtual tabletop, corresponds to a semitransparent representation of the physical tabletop of the CAT. Thanks to the 6 DOF of the CAT, the users can quickly move the virtual tabletop in space. Then, by sliding the pen on the tablet, they can easily control the position of the cursor in the VE. The aim of the virtual tabletop metaphor is to add constraints in the VE, as recommended by Bowman and Hodges [8]. For example, rather than trying to directly translate an object in space, it can sometimes be more efficient to first choose the translation plane and then to apply a translation on the selected 2D plane with speed and accuracy. Figure 4 illustrates an example where the virtual tabletop metaphor is used to build a virtual city. The viewpoint on the city can easily be changed by modifying the orientation of the tabletop. The locations of the building are accurate as the users operate on a 2D plane.

Figure 3. The virtual tabletop metaphor

8.1. The virtual screen metaphor

The virtual screen metaphor consists in moving a cursor on a virtual screen, which always faces the camera viewpoint. The virtual screen can be moved in space thanks to the isometric DOF of the CAT. This metaphor has been developed to benefit from the well known 2D techniques used with classical monitor desktop. For example, 2D widgets can be easily pointed to control the system as illustrated in figure 5. Another example is to select the objects by picking their projection on the virtual screen, as we would do with a classical screen.

The interest of the virtual screen is to be totally independent from the real screen. Consequently, stereoscopic visualization can be used and the immersion feeling is not affected by the displacement of a cursor on the physical screen. Moreover, in case of huge screens, the accuracy of the cursor movements does not depend on the size of the display.

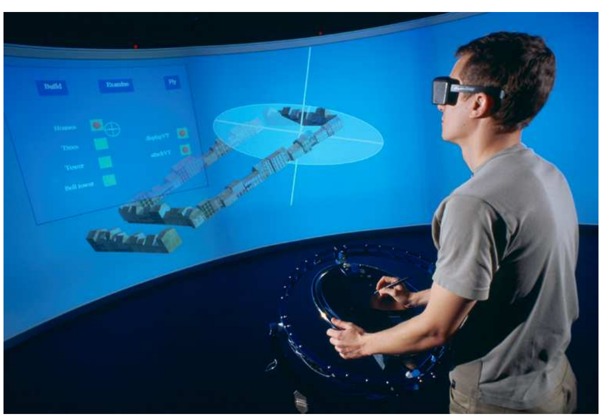


Figure 4. The virtual screen metaphor

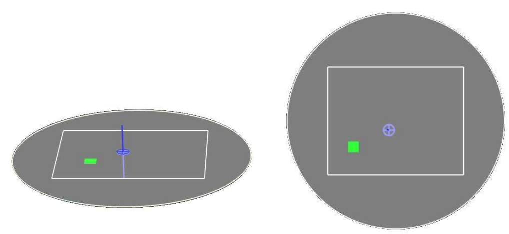
6. Experiment

We wanted to have an idea of the differences of performances of the users when dealing with the two described metaphors. Thus, we have led an experiment where the users had to point to 2D targets on the depth-oriented virtual tabletop and on the camera-faced virtual screen. Our hypothesis was that the performances with the virtual tabletop metaphor were as good as the performances with the virtual screen metaphor, even if the users had to deal with the notion of depth in addition.

6.1. Task and procedure

The task consisted in pointing a square on the display zone (virtual tabletop or virtual screen). Before each trial, the square was positioned at the center. When the subject clicked on it, the square appeared at a random position on the display zone. The subject had then to point to the square, as quick as possible. The color of the target was modified when the cursor was on it. If the cursor stayed more than 0.5 second on the square, the trial was deemed as completed.

The experiment took place in front of a 10x3 meters curved screen. For the two metaphors, the CAT was located at the center of the screen and the tabletop was oriented with 45 degrees facing the subject. For the virtual tabletop metaphor, the graphical representation was oriented in space with the same orientation (figure 6(a)). For the virtual screen metaphor, the graphical representation was facing the subject (figure 6(b)).



(a) (b)

Figure 5. 2D pointing task with the virtual tabletop metaphor (a) and the virtual screen metaphor (b)

16 subjects performed the experiment with the two metaphors (students, 10 males, 6 females). None of them had previous experience with immersive interfaces. 8 subjects began with the virtual tabletop and the 8 others began with the virtual screen. For each metaphor, the subjects performed 5 training trials and 20 measured trials.

We measured the completion time, the number of completed trials and the coordination with the measure of inefficiency proposed by Zhai [9]. The inefficiency corresponds to the ratio between the length of the user trajectory and the length of the optimal trajectory.

6.1. Results

We used the paired t-test for the statistical analysis of the obtained means. We found no significant differences between the users performances for the two metaphors, as shown in table 1 (VT = Virtual Tabletop, VS = Virtual Screen).

Table 1. Results

Completion time (s)		
VT = .43	VS = .44	t(15)=0.557; p=0.586 *NS*
Inefficiency		
VT = 1.08	VS = 1.06	t(15)=-1.364; p=0.193 *NS*
Number of completed trials		
VT = 18.19	VS = 17.69	t(15)=-0.953; p=0.335 *NS*

6.1. Discussion

The virtual screen metaphor is easily understood by the subjects because this metaphor benefits from the human skills that have been learned with the classical monitor desktop and the standard 2D input devices. The virtual tabletop metaphor deals with the depth. Even if the subjects do not know this new technique for interaction, they don't have any difficulties to point the target because the cursor movements in the VE correspond to the stylus movements on the tabletop. Consequently, the semantic link between the users' actions and the resulting actions operates well.

7. Conclusion

Many input devices have been proposed for 3D interaction with VE. Even if 3D interaction is necessary, we think that 2D interaction is very helpful for many interaction tasks in VE. The CAT is an innovating device that allows mixing 3D and 2D interaction without constraining the users. In this paper, we focused in 2D interaction techniques. We proposed two metaphors that can be used for different tasks. The virtual screen metaphor benefits from the well-known 2D techniques. The virtual tabletop metaphor allows interacting in the 3D space. We showed that, even if the users had to deal with the depth, the performances with the depth-oriented virtual tabletop were statically not different from the performances with the camera-faced virtual screen. Consequently, the CAT opens new possibilities for efficient constrained interaction with VE. We think theses possibilities can contribute to the development of new real applications as CAD applications.

10. References

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