Interaction Techniques in Virtual Environments

Elena-Gina CRACIUN, Stefan-Gheorghe PENTIUC

Abstract—**Interaction techniques represent the methods which offer the user the opportunity to accomplish a specific task inside a virtual environment. Interacting with this informational environment supposes the identification of new modalities which simulate familiar actions from the real world. Throughout this paper article project we are presenting an overview to the current interaction techniques: navigation, selection, manipulation and system control [1]. The goal of this paper is to provide the reader a more appropriate understanding of these techniques.**

Index Terms— **interaction technique, interface, manipulation, selection, system control, virtual environment.**

I. Introduction

INTERACTION techniques are usually defined as the methods which offer to the user an opportunity to accomplish a specific task using an appropriate interface. According to [1] the interaction techniques can be divided into three main categories: Selection and Manipulation, System Control and Navigation. These are the responsible components for translating information provided by an input device into a specific action system. In order to project an appropriate interaction techniques, an important part is given also to the input device, and more precisely for its degree of freedom (DOF) [10],[11]. Working with a large number of DOF, in an intuitive mode, is in generally most desirable. This supposes the use of input devices with large DOF, such as data gloves, or to achieve a larger number of DOF by adding new components to the input device with small DOF (mouse – 2DOF in combination with keyboard). Starting with input device like speech input, data gloves, mouse buttons and keyboards, the recent technology lead us to new trend in interaction - multi-touch surface.

In the contents of this paper we try to provide the user a better understanding and to illustrate the new perspectives on the available interaction techniques for virtual environments.

The paper is organized as follows: the next section presents an overview on interaction techniques, presenting for each one the related concepts and their components classification. Section 3 provides examples for the interaction techniques, which are based on multi-touch technology; in the same time the latest trends in designing interaction techniques are also highlighted. The last section offers to the reader the conclusions and it also defines the future work directions.

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II. Techniques Taxonomy

A. Selection and manipulation

The fundamental tasks, both in a physical but also in a virtual environment, involve efficient techniques for objects selection and manipulation. This can be seen like an imperative condition so as to offer complete possibilities for the other interaction techniques like system control or navigation.

The success of selection and manipulation techniques depends on the task to which they are applied. It is important to determine the area of use for this interaction technique [13],[15].

This method used in 3D manipulation usually tries to simulate the techniques that can be found in the real world. Assuming that we want to manipulate a rigid object in a physical environment, these can be seen like a sequence of tasks as grabbing an object, moving it to the desired position and manipulating its orientation. These tasks projected in the virtual environment have to assure that the designed interaction techniques for 3D manipulation provide means to accomplish as:

Selection - select an object or a set of objects from a predefined collection (also called target acquisition task). It corresponds to the action of grabbing an object or a set of objects in the real world, using one or both hands.

Positioning - move the object to a desired position. The real world equivalent is moving the object from the start position to its target position.

Rotation - change the orientation of an object. This task relates in the real world to the rotation of an object from a starting orientation to a target orientation.

The selection and manipulation techniques are known as being interrelated. While selection specifies an object or a set of objects for different purposes, the manipulation is trying to deal more with the object properties (position, orientation, attributes). Selection and manipulation are usually used together even thought they could accomplish their task separately.

The common basic components of a selection and manipulation task are illustrated in **Fig. 1** and **Fig. 2**.

The goals of these techniques are the indication of an action to one object, making an object active and traveling to object location. It should also provide to the user an indication about the selection of an object followed by the confirmation for the selection.

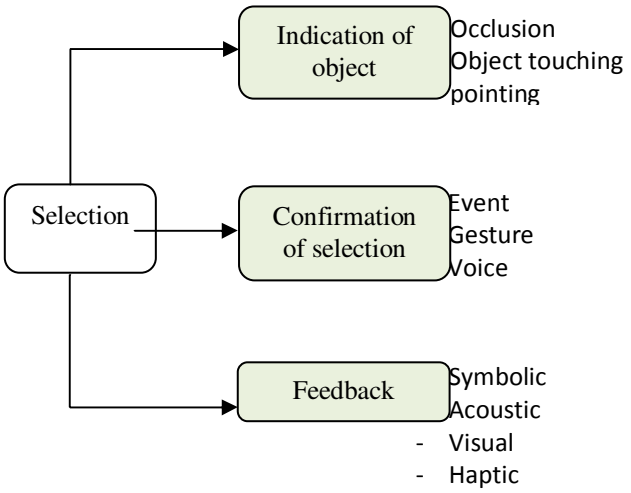

Fig. 1. Classification of selection technique task decomposition [1].

The task performance depends on the variables that are affecting the user's performance, such as object distance from the user, object's size, density of objects in the area, occluders. Each subtask can be described through canonical parameters such as:

a) Selection - distance and direction to target, target size, density of objects around the target, number of targets to be selected, target occlusion.

b) Positioning - distance/direction to initial position, distance/direction to target position, translation distance, required precision of positioning.

c) Rotation - distance to the target, initial orientation, final orientation, amount of rotation.

B. System control

The system control task describes the possibility that through commands, a user can change the interaction mode or the state of that system. A command always includes the selection of an element from a set. In this way, between object selection and system control techniques can be observed some similarities. In desktop based environments a lot of work has been done for developing system control techniques (pull-down menus, toolboxes, radio buttons, buttons, etc). The most common technique used in desktop systems is the Windows-Icons-Menus-Pointers (WIMP) metaphor. There were applications for which WIMP was not well suited; this includes any application requiring devices that provides continuous input signals, showing 3D models, or simply portraying an interaction for which there is no defined standard widget. To overcome these problems [2] proposed new types of interfaces and called them post-WIMP GUIs.

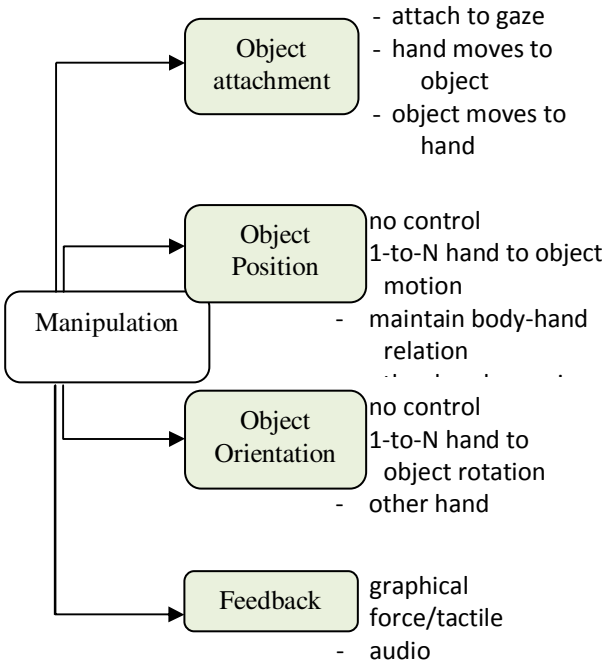

Fig. 2. Classification of manipulation techniques task decomposition [1].

The system control task can be viewed as a joint between the task of selection, manipulation and input handling and it allows to the user to control the interaction flow of an application.

In general, a system control task concerns commands that permit the execution of a specific system function (like removing a virtual object from the scene), changing the interaction mode (switching from a drag tool to a rotation tool), changing the state of the system (e.g. activating a specific workspace). The three most common metaphors are graphical menus, voice commands and gesture commands.

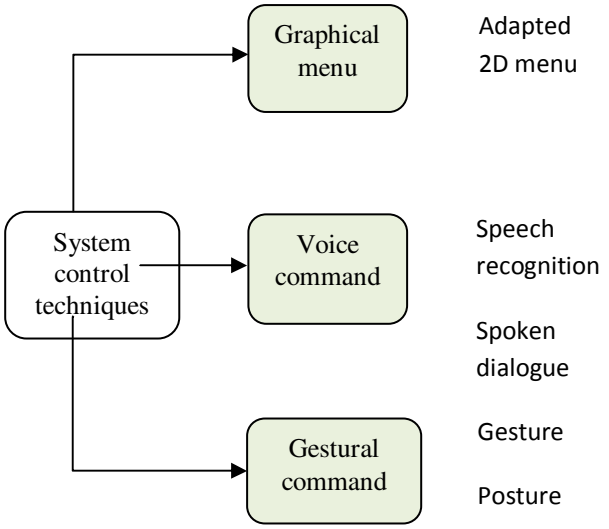

Fig. 3. Classification of system control techniques [1].

C. Navigation

The user's movement in a virtual environment describes the navigation task. It has two components: traveling, which involves moving from the current location to the desired point and one way-finding which refers to finding and setting routes to get to a travel goal within the virtual environment. An extensive and in depth description of various navigation techniques can be found in [1] [3].

[1] classifies the navigation in three categories: exploration, search and maneuvering.

Exploration – a user moves without an explicit goal. The exploration of an environment is made in order to find interesting objects or location, to build up knowledge about the environment. In exploration task the path followed by a user is not predefined.

Search - a user travels to a specific location within the environment. If a user has no knowledge about the position and the path to get there, the task is called a naive search task. In case a user has visited the target location before or has some sort of knowledge about its position, it is denoted as a primed search task.

Maneuvering - tasks of this kind are taking place in a local area and these involve short and very precise movements in order to perform a specific task. It can be seen as sort of primed search task, because the target is known. However, navigation techniques suited for a general search task are often too coarse for maneuvering tasks.

III. PROBLEMS AND NOVEL TECHNIQUES SOLUTIONS

The questions which are raised when analyzing different interaction techniques, through the developing system, those are which problems are confronted by the user when he wants to access the system information? And what does a user want to do with the information inside a virtual environment? Analyzing some reference systems, we can mention the following basic actions: translation, rotation, zooming, scaling, selecting object /group of objects, change display mode / system state. Taking this action separately or by combining them we achieve an intuitive interaction technique. But we realize that all the above actions meet some constraints which the user should resolve. The raised problems for the current system and also for the user's actions are further presented, and they are grouped by the developing interaction technique.

Selecting large objects by finger pointing is an easy operation, but it can become a difficult one when the user has to select very small objects or he should specify pixel-accurate locations.

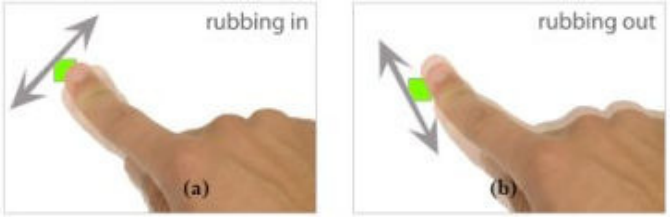

Fig. 4. Rub-Pointing technique [4].

In order to perform a *precise selection*, [4] have investigated the use of rubbing and tapping techniques. The rubbing and tapping gestures are *combining pointing and zooming to make precision selection*. The two developed techniques are Rub-Pointing (use a diagonal single-hand gesture in order to integrate the pointing and the zooming) and Zoom-pointing (a two handed operation, in which the dominant hand point while the non-dominant taps the zoom). During the evaluation process, the user's study showed that the techniques which zoom in by tapping are very fast and precise in selection.

Manipulation of 3D data still attracts the interests of researchers, since it has to control the performance of 6DOF (translation and rotation around the three axis x, y, z). Based on the modality of *controlling the degree of freedom – integration or separation* – different solutions have been lately proposed. The Sticky-Tools technique, developed by [5], allows the full control of DOF by using three fingers. Each finger controls in a separate mode the degree of freedom, which are afterwards integrated. The benefit of this method is that it was the first one designed to provide full 6DOF manipulation control. Screen-Space technique [6] introduced a method to handle 3D manipulation in a direct way (the virtual object is touched by the finger), more precisely it allows direct control in 2D, or in 3D for multi-touch surfaces. Even thought there are many ways which allow the user to manipulate 3D data, none of them allows direct control of the objects.

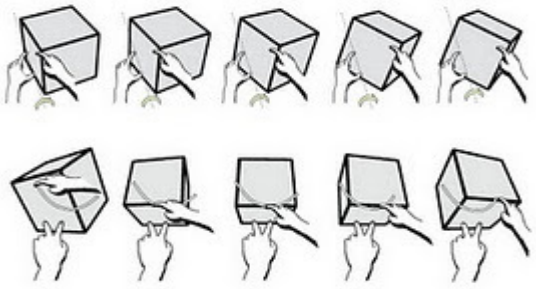

Fig. 5. Two-three fingers manipulations [6].

Contrary to the first two techniques, which use the integration for some degree of freedom, [7] propose taxonomy for a new 3D manipulation technique, DS3, based on the separation of translation and rotation. The evaluation of this technique shows an improvement of performance for 3D manipulation for more than 22%.

Control of system state is not an easy task to achieve only by using single gesture. The complex operations which characterize the virtual environment, had lead today to an increasing use of *context menu*. The menus are called by a gesture, or by tapping with the finger on the screen; it can appear around the tapping finger and using the other hand, it can select a mode or option [8].

The development in the last decade, of these applications on touch-sensitive surfaces has provided new ideas to be followed. [9] have introduced two navigation techniques which are trying to deal with the problem of *navigation* on *small or large size surfaces*, where appears the scale problem or difficulty or even impossibility to reach the hard buttons located around, while touching the surface at the desired location.

The gesture solution has inquired been study [12],[14],[16]-[18],[20], so, their approach is based on *controlling continuous variables using oscillatory movements.* The two techniques, *CycloPan* and *CycloZoom+,* exploit the degree of freedom for an elliptical movement, and each of them makes possible to pan in 2D or to zoom and pan in the same time, while dynamically controlling the scale.

Fig. 6. The Cyclo* technique [9].

Since elliptical movement can control up to seven variables (orientation, amplitude, eccentricity, x and y location, frequency, direction), this technique represents the favorite source for implementing new interaction techniques.

IV. Conclusions

This paper gives an overview to the interaction techniques and describes the use of existing systems in order to attain interactivity. Each technique has been presented and exemplified through the information from the innovative systems which implemented them. Multi-touch surfaces have opened new approaches to be followed. Designing interaction techniques for 3D context with 2D resources still attracts researchers' attention. We will like to further developing a study, on a precise domain context and observe if the current implementation can provide enough information in order to full interact with that system. So the problem we want to further address is in which manner all the interaction techniques that have been developed can attain the functionality for a specific domain?

References

[1] Bowman, D. A., Kruijff, E., Laviola, J., & Pou, I. (2005). 3D User Interfaces: Theory and Practice. Boston, MA, USA: Addison-Wesley.

[2] Andries, van D., (1997). Post-WIMP user interfaces, Communications of the ACM, v.40 n.2.

[3] Burdea, G. C., Coiffet, P. (2003). Virtual Reality Technology. Second Edition.

[4] Olwal, A., Feiner, S., Heyman, S., (2008). Rubbing and Tapping for Precise and Rapid Selection on Touch-Screen Displays, CHI, Florence, Italy.

[5] Hancock, M.C., Cate, T.T., Carpendale, S.(2009). Sticky tools : Full 6dof force-based interaction for multi-touch tables. In Proceedings of Interactive Tabletops and Surfaces 2009.

[6] Reisman, J.L., Davidson, P.L., Han, J.Y. (2009). A screen-space formulation of 2D and 3D direct manipulation. In Proceedings of the 22nd annual ACM symposium on User interface software and technology.

[7] Martinet, A., Casiez, G., Grisoni, L. (2010). The design and evaluation of 3d positioning techniques for multi-touch displays. IEEE Symposium on 3D User Interfaces.

[8] Tse, E., Shen, C., Greenberg, S., Forlines, C. (2007). How pairs interact over a multimodal digital table. In CHI'07: Proceedings of the working conference on Advanced visual interfaces, New York, USA.

[9] Malacria, S., Lencroit, E., & Guiard, Y. (2010). Clutch-Free Panning and Integrated Pan-Zoom Control on Touch-Sensitive Surfaces : The CycloStar Approach. *CHI.* Atlanta: ACM.

[10] Craciun, E., & Pentiuc, S. (2009). Hand Detection using a Set Of Classifiers Based on Haar-Like features. *Sisteme Distribuite.* Suceava.

[11] Craciun, E., Rusu, I., Pentiuc, S., & Vatavu, R. (2010). System for Real Time Detection of Hands and Pedestrians Movements. *DAS Conference.* Suceava.

[12] Ong, C. R., & Venkatesh, Y. (2006). Understanding gestures with systematic variations in movement dynamics. *39*.

[13] Poupyrev, I., Billinghurst, M., Weghorst, S., & Ichikawa, T. (1996). The go-go interaction technique: non-linear mapping for direct manipulation in virtual reality .

[14] Bragdon A., Zeleznik R., Williamson B., Miller T., LaViola Jr. J.J. (2009). GestureBar: Improving the Approachability of Gesture-based Interfaces. CHI 2009 - Gesture UIs April 9th, Boston, MA, USA.

[15] Poupyrev, I., Ichikawa, T., Weghorst, S., & Billinghu, M. (1998). Egocentric object manipulation in virtual environments: Empirical evaluation of interaction techniques.

[16] Wobbrock, J., Wilson, A., & Li, Y. (2007). Gestures without libraries, toolkits or training: A $1 recognizer for user interface prototypes. *Proceedings of the ACM Symposium on User Interface Software and Technology (UIST '07).* Newport, Rhode Island: New York: ACM Press.

[17] Appert C. , Bau O. (2010). Scale Detection for a priori Gesture Recognition, CHI 2010: Gesturing and Drawing, Atlanta, GA, USA.

[18] Bau O., Mackay W. E. (2008). OctoPocus: A Dynamic Guide for Learning Gesture-Based Command Sets, UIST'08, Monterey, California, USA.

[19] Jayaram S., Jayaram U., Wang Y., Tirumali H., Lyons K., Hart P. (1999). VADE: a virtual assembly design environment, IEEE Computer Graph Application.

[20] Signer, Kurmann U., Norrie M. C.,(2007). iGesture: A General Gesture Recognition Framework, Proceedings of ICDAR 2007, 9th International Conference on Document Analysis and Recognition, Curitiba, Brazil.

[21] Williamson J., (2006). Continuous Uncertain Interaction, Department of Computer Science, Faculty of Information and Mathematical Sciences, University of Glasgow.