Using proprioception as a cue towards effective spatial input in VR : a framework for an experimental study

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Abstract

We developed a free form deformation application for an immersive environment in which users can interact freely by using datagloves. In this paper, we present an experimental protocol designed to investigate the contribution of proprioception and bimanual interaction on spatial input tasks in the context of our modeling application.

Categories and Subject Descriptors (according to ACM CCS): H.5.1 [INFORMATION INTERFACES AND PRE-SENTATION]: Artificial, augmented, and virtual realities H.5.2 [INFORMATION INTERFACES AND PRESEN-TATION]: User Interfaces

1. Introduction

Virtual Reality and 3D interaction are often presented as a major step towards real, direct and intuitive manipulation. Indeed, Immersive Virtual Environments (IVE) allow users to interact with virtual objects using everyday actions and commands. For example, users can manipulate (i.e. grab, move, rotate, etc...) an object using their bare hands.

However, major manipulation and perception problems, first identified in early studies on virtual reality, still remains and have to be resolved before drawing a real profit from IVE potentialities. Bimanual interaction and proprioception have been suggested and are promising solutions to some of the known fundamental issues [HPGK94].

Our aim is to investigate whether bimanual interaction and proprioception can be used as a significant improvement towards effective and convenient spatial input in IVE, and how they influence the users' performance and satisfaction.

2. Bimanual interaction

Bimanual interaction has been explored as an obvious and easy way to make interaction in IVE as natural as possible in its two modalities : symmetrical or differentiated [Gui87].

Symmetrical gestures involve both dominant and non-dominant hand for the achievement of the same task simultaneously or alternatively. This modality has usually been explored to improve scene navigation and object positioning operations (scaling, rotation, translation, etc...). For these tasks, both hands seem to have almost an identical proficiency, when given the appropriate tools [BWRC06]. It has also been noticed that the combination of both hands action can enrich the set of operations performable [ZFS97].

Bimanual interaction can also be differentiated : each hand is then used to perform a different task. In that case the motion of the right hand finds its spatial references in the results of the motion of the left hand. Handwriting, for exemple, usually involves the non-dominant hand in maintaining a sheet of paper while the other hand writes.

Considering that this modality represents most daily activities, it seems obvious to expect it to improve the user's sense of ease and comfort in IVE [BCW*04] . However, we found no studies assessing if there is an actual gain in precision and speed and how it depend on the kind of task at hand.

3. Proprioception in IVE

Proprioception is the perception of absolute (the body within its environment) and relative (each part of the body relatively to the other) movement and spatial orientations.

This simple specific perception of the position of the body

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can be used in IVE through a direct manipulation, physical mnemonics or gestural actions [MBS97].

Most studies seem to consider proprioception as a convenient way of positioning menus and widgets relatively to body parts, thus rendering research and selection tasks easier [HPGK94, GH98]. Our objective is rather to investigate whether if, through proprioception, the motor activity of the non-dominant hand could delineate frames in which the right hand could find its spatial reference, thus facilitating spatial input tasks [CFH97], and, most of all, to what extent.

4. OMM : A free form 3d modeling application for bimanual interaction

We have developed a free form deformation application called *OMM* (Odd Mesh Maker) for a Workbench, based on the *Twister* deformation model [LKG*03], where user's can freely perform deformations on 3D objects by using datagloves. Users can indifferently use both hands, simultaneously or alternatively, to realize the basic tasks allowed by the application : translate, rotate or warp the object.

In this experiment, the unimanual input modality will be considered as the reference modality, since it is the mostly used in IVE.

We defined a set of 5 tasks increasing in difficulty, from basic selection tasks, to complex deformation tasks. These tasks will be performed on common 3d shapes. In the unimanual situation, subjects will use only their dominant hand. In the biminual situation, they will be authorized to grasp the object of interest with the non dominant hand, introducing a physical reference in the object manipulated, while the other hand performs the task. Each task, in each situation, will be performed by a group of 15 subjects .

For each task performed, the results will include error rates (failure to grasp the target), completion time and precision. For selection tasks, precision will be given by the distance between the selected point and the center of the target. For the deformation tasks, subjects will be asked to reproduce several times identical deformations. In that case, precision will be given by the differences between the deformations.

We will also present to the subjects a satisfaction questionnaire to determine if this modality actually increases users feeling of comfort.

5. Conclusion and future work

We have defined an experimental protocol to investigate whether the non-dominant hand, assuming it ensures the introduction of proprioceptive information, can be used in IVE to ensure optimal control over spatial input tasks. Our preliminary investigations tend to show that in bimanual condition, users' sense of comfort is improved.

We are now gathering experimental results to assess the actual gain of precision and speed. We hope to obtain statistical evidence of our results and, afterwards, to be able to express recommendations to the development of bimanual user interfaces in IVE.

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