

Modeling Three Dimensional Interaction Tasks for Desktop VR

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A virtual environment is an interactive, head-referenced computer display that gives a user the illusion of presence in a virtual world. Two most significant differences between a virtual environment and a more traditional interactive 3D computer graphics system are the extent of the user's sense of presence and the level of user participation that can be obtained in the virtual environment. Over the years, advances in computer display hardware and software have substantially progressed the realism of computer-generated images, which dramatically enhanced user's sense of presence in virtual environments. Unfortunately, such progress into user's interaction with a virtual environment has not been observed.

In this research, we aimed to improve interaction aspects in virtual environments. The approach applied focused on the development of a methodology "modeling" that allows for a quantitative analysis of users' performance on carrying out the common 3D spatial interaction tasks, such as 3D pointing, steering and object pursuit tasks.

Pointing, also known as rapid aimed movement or target acquisition, requires users to rapidly move toward and acquire (or select) a target. In the study of pointing task, we used a two-component model to break a pointing task into an initial ballistic and a final corrective phase, and compared users' performance in virtual reality to that in the real world. The results indicated that significant temporal differences arose in both ballistic and corrective phases, but the difference was much larger in the corrective phase. This finding inspired us to design a methodology with two-component model and Fitts' law, which decreased the index of the difficulty of the pointing tasks during the correction phase in an attempt to improve the efficiency of the correction phase. The methodology enables us to develop and quantitatively evaluate interaction techniques for pointing tasks.

Steering task studies how quickly one may navigate through a path without going out of the boundary. In the study of steering task, we introduced the effect of path curvature and orientation to the steering law which was proposed for modeling 2D steering tasks, and empirically verified our new model for 3D manipulation tasks. In addition, we also introduced force feedback to the tasks and extended the application of our model to 3D haptic steering tasks. The effect of force feedback was successfully modeled as a predictor for the time of steering through a path.

Finally, we introduce object pursuit as a 3D interaction task that continuously tracks a 3D moving target in a virtual environment and investigated the interaction with moving objects. A spatio-temporal relationship that resembles Fitts' law and steering law is initially proposed and empirically verified for modeling object pursuit tasks.

The models proposed in our research provide a quantitative approach to develop, evaluate and compare between interaction techniques and input devices. Therefore, they can serve as a guideline for designing efficient 3D user interfaces, which can ultimately lead to more insight and improvement of 3D interaction.