Tethering and Reattachment in Collaborative Virtual Environments

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Abstract

We explore a family of specific dynamical methods that support the contrasting goals of presence and independence in collaborative virtual environments. We pose for ourselves the basic tasks of "tethering" — keeping a collaborator close to a group or leader, and of "reattachment" — returning to a collaborative virtual activity after a period of independent exploration. We first present a taxonomy of methods and parameters associated with tethering and reattachment, and then describe a formative evaluation study.

1. Introduction

Navigation through virtual worlds is challenging, especially in collaborative environments where users must deal with higher cognitive loads and increased temporal pressures. In addition, there is frequently a conflict between the need to work or navigate in a group and the need to explore independently. Natural and effective tethering and reattachment techniques can alleviate some of these challenges for collaborative virtual environments.

2. Taxonomy of Methods

We make the simplifying assumption that there is a central focal point or leader for the collaborative group. With this assumption, we can then outline a taxonomy of methods and parameters.

Models of Tethering. The basic features of tethering are the relative position and viewing posture of the collaborator relative to the leader. *Tether position parameters* include: the distance and direction from the leader, and the range and elasticity of the attachment. *View gaze methods* include: gazing at the leader, co-gazing with the leader, gazing in the direction of motion, or a weighted combination of these. The *heads-up direction* of the viewer may be based on world gravity, pathway normals, or object-of-interest directions.

Models of Reattachment. Reattachment is achieved by interpolating a collaborator's position and orientation from their initial values to their corresponding destination values. *Interpolation styles* include: linear (spherical) interpolation in cartesian and quaternion coordinates, a standard ease-in/ease-out velocity interpolation, and a more natural "joining-up" ease-in/ease-out method. *Speed control methods* include: traveling at a constant speed, ramping the speed up and down (slow-in/slow-out), traveling in a constant amount of time (regardless of distance), and permitting the user to control or modify the speed.

Constraint Manifolds. A final option for both tethering and reattachment is to travel straight as the crow flies, through buildings and walls if needed, or to follow a designer-supplied constraint manifold that is sensitive to the surrounding context, avoids collisions, and keeps interesting things in view. It is also possible to select among several different manifolds or to interpolate between them.

3. User Studies

We gathered data from eight subjects embodying a range of experience with VR environments. The subjects experienced combinations of tethering and reattachment methods with a simulated leader in a CAVE. The CAVE was also used to simulate a workbench, head mounted display, and a desktop "fishtank" display. Subject feedback was assembled into a set of overall formative evaluations; a few of the highlights are presented here.

Tethering Results. Subjects evaluated tethering methods on the basis of naturalness and the ability to freely explore the scene while maintaining a sense of presence with the leader. The preferred distance was highly dependent on the size of the leader's avatar relative to the viewable display, while the preferred position and view orientation were dependent on the degree of immersion. Parameter elasticity was generally disliked, and constraint manifolds were preferred only when they introduced limited vertical motion.

Reattaching Results. Subjects were asked to evaluate reattachment methods based on comfort and ability to maintain context within the environment. Subjects found the "joining-up" interpolation the most natural as it best allowed them to see where they were going. Collisions with objects in the environment were universally disconcerting, so subjects preferred the use of the constraint manifold over straight paths. The preferred speed method was user modification of the slow-in/slow-out reattachment speed.

Further studies are underway to obtain quantitative values to support these qualitative results.