Manipulate the Unreachable: *Through-The-Lens* Remote Object Manipulation in Virtual Environments

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Introduction

In this work, we introduce a concept for remote object manipulation. We have found that even though is does not have a counterpart in real life, remote object manipulation is both useful and intuitive. Our approach provides a solution to the problem of changing and examining the scene from the current viewpoint, while manipulating objects in distant locations of the virtual world. We achieve this with the aid of though-the-lens tools.

Through-the-Lens Concept

Through-the-Lens-tools (*TTL*-tools) provide an additional viewpoint and display the scene as seen from this viewpoint in a dedicated viewing window. In this way, a kind of preview window to a remote location is provided, similar to a wormhole known from science fiction. In our semi-immersive setup, this window can be mapped onto a hand-held pad tracked with 6DOF for convenient placement [7]. The pad becomes a magic lens [1, 10] into a remote location.

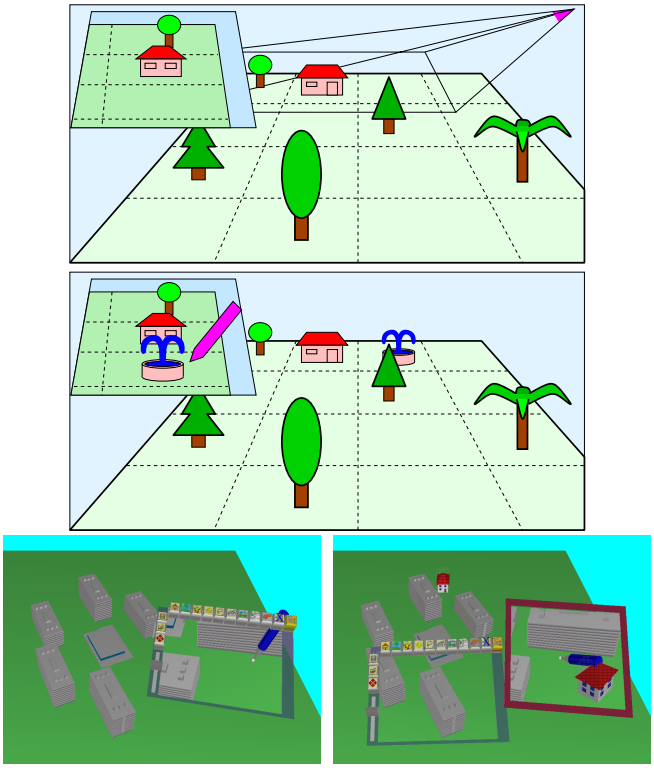
Previous remote object manipulation technologies such as Voodoo Dolls [5], scaled-world grab [2], or go-go [6] allow viewing and manipulation either in the remote or in the local environment, but not spontaneous combination of both. TTL remote object manipulation improves upon that by allowing both modes to be arbitrarily combined.

We have discussed elsewhere how the lens can be adjusted to show the desired remote location [9]. Once this is done, the user can manipulate remote objects shown through the lens, usually with the lens frozen in space rather than coupled to the hand-held pad. A tracked stylus is used for interaction with the remote objects.

Similar to image plane interaction methods [4], the user can manipulate remote objects by reaching with the stylus into the frustum volume defined by the lens and the current viewpoint (see figure below). If the stylus is outside this volume, it acts on the local environment in the normal way. Moving the stylus from the remote volume to the local volume and vice versa instantly changes the context of interaction, similar to the point-to-focus policy popular in some 2D windowing systems.

Moreover, this change of context can be exploited to teleport object between locations by drag and drop operations between volumes. In a slightly more complex scenario, it objects can be transferred between *multiple* remote locations with drag and drop operations. This application resembles some aspects of ToolSpaces [3]

We have found TTL manipulations to be intuitive and efficient. The user is not required to navigate to the remote location in order to manipulate objects, but can stay at the current location and examine the result of the remotely performed actions. The proposed scenario is useful even if the "remote" location is in the reach of the user, since scale and the position of the remote view can be arbitrarily chosen. For example, a magnifying lens allows precise manipulation of details, while a minifying lens allows manipulation similar to using a world-in-miniature approach [8].



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