Tangible Interfaces in Virtual Environments

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Abstract: Integrating Tangible User Interfaces (TUIs) in Virtual Environments is a promising approach to overcome the rigidity of Tangible User Interfaces (TUI) and to ease Virtual Reality (VR) interaction techniques. Advantages and problems of the integration are being described, especially occlusion, focal displacement and shifting.

1 Introduction

An increasing number of applications in several areas show the potential of the Tangible Interaction approach in supporting user's creativity, deepening the interaction experience and giving full control over the interface to the user. But in contrast to WIMP applications, most current tangible artefacts have no means to change their shape by the system. This might obstruct system developers to accept the concept and thus hinder the spreading of tangible interaction in real production systems and end user's applications.

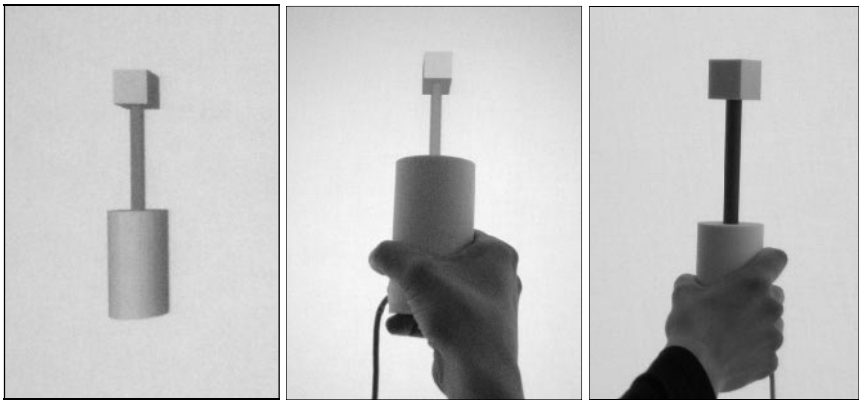

Figure 1: Virtual, hybrid and purely physical variants of the same model.

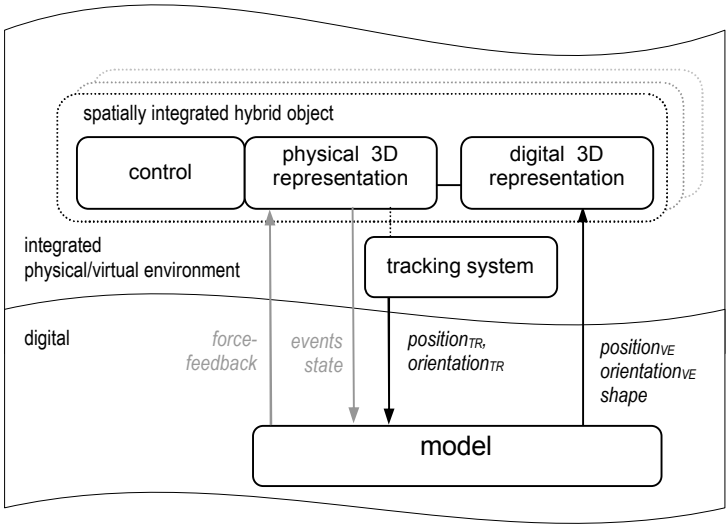

Figure 2: Extended MCRpd interaction model [UI01]
of TUI in Virtual Environments

2 Spatial integration of tangible interfaces into virtual environments

Our approach to integrating physical objects in Virtual Environments might be a way to overcome the rigidity of Tangible User Interfaces (TUI). It is similar to Mixed Reality (MR) and Augmented Reality (AR) technologies and focuses on:

- Integration of action and perception (input and output) space
- Interaction with spatially distributed objects instead of single input devices
- Fully functioning tangible artefacts
- Hybrid objects (spatially connected physical and virtual, graphical objects, see figure 1)
- Integration into working environment with distinct interaction spaces (preferably Holobench systems)
- Lightweight interaction (no head mounted displays)

Several hybrid tangible interfaces with flexible 2D graphical output have been described, e.g. bricks [FIB95] and metaDESK [UI97], and several Toolkits have been developed, e.g. iStuff [BRSB03], Phidgets [GF01], Papier-Mâché [KLLL04], which might facilitate the development of (graphically represented) tangible interfaces. For the integration of physical objects into 3D environment, accurate spatial tracking and graphical rendering are needed. Optionally, tangible interfaces might be equipped with interactive control elements such as buttons, sliders, LEDs etc. Furthermore it is possible to augment the objects kinesthetically [KINB05]. Figure 2 shows our approach as an extension of Ullmer and Ishii's *model-control-representation (physical and digital) MCRpd* [UI01].

3 Integration problems

Integration of tangible interfaces into virtual environments causes some problems, especially *occlusion*, *focal displacement* and *shifting*, which limit the illusion of an integrated virtual environment. Occlusion occurs if real objects block the view onto virtual objects. Focal displacement occurs due to different focal levels of the physical objects (focus on the object at hand) and the virtual environment (focus on the projection plane). Shifting is caused by inaccurate tracking of the tangible object's $position_{TR}$ and $orientation_{TR}$ which results in gaps between the observed physical objects position and its effects in the virtual environment.

4 Outlook

Linking Virtual Reality (VR) technology and Tangible User Interfaces is a promising approach to ease VR interaction techniques and increase flexibility and programmability of TUIs. Future VR interaction techniques will possibly involve distributed physical objects and not rely on single interaction devices. Future TUIs will benefit from the possibilities of virtual environments, their powerful graphical output and their "virtual" laws of nature.

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