

Interaction in a Collaborative Augmented Reality Environment

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ABSTRACT

In this paper we describe an Augmented Reality (AR) system which allows multiple participants to interact with two- and three-dimensional data using tangible user interfaces. Interactively controllable 2D and 3D information is seamlessly integrated into the system.

Keywords

Augmented Reality, Collaboration, CSCW, Tangible User Interfaces, 3DUI

INTRODUCTION

Augmented Reality (AR) attempts to enrich a user's real environment by adding spatially aligned virtual objects (3D models, 2D textures, textual annotations, etc) to it (see [1,2] for definitions). The goal is to create the impression that the virtual objects are part of the real environment. The users of the AR system experience the augmented environment through special display devices, which are either worn on the body or are placed in the working environment. From a technical point of view, AR faces three major challenges: (1) to generate a high quality rendering, (2) to precisely register (in position and orientation) the virtual objects with the real environment, and (3) to do so in interactive real-time.

In collaborative AR systems multiple users share at least one common place within the environment. The users can collaborate in two ways: either face-to-face or remote or in a combination of both ways. Each user has his or her own view on the private and shared objects of the augmented space (e.g. [3,4]).

The system presented here ("MagicMeeting") combines collaborative AR technology with (a) new interaction techniques utilizing ordinary desktop items (Tangible User Interfaces, see [5]), (b) interactive 2D desktop screens integrated into the 3D environment [6], and (c) linking mechanisms between 2D MS Windows applications and the augmented 3D space.

SYSTEM SETUP

In our setup, four users (more are possible) in a face-to-face collaborative setting wear head-mounted displays (HMD) with built-in cameras. The HMD-camera combinations are connected to networked PCs (Pentium III/933, Windows 2000, bt878 card, GeForce2 graphics board, or alternatively high-end notebook computers). The tracking of the cameras (heads) and objects is based on the popular ARToolKit marker tracking library [7].

The users sit around a meeting table with a 2D presentation screen and a so-called "cake platter" in the middle of the table (see figure 1). The cake platter is the main device for shared 3D display (figure 2). An extra monitor-screen can be used for additional 2D content display.



Figure 1: Environment



Figure 2: Four users looking at one common model

INTERACTION TECHNIQUES

The main goal of the system presented here is an almost seamless integration of 2D and 3D data into one shared environment. The interfaces should provide an intuitive and efficient access to the information displayed. We achieve this by relying on tangible interaction techniques based on props.

Besides more "traditional" AR interaction techniques, like mouse raycast, MagicBook, and models-on-marker (e.g. [6]) some new techniques are introduced here.

"Cake platter"

This turnable, plate-shaped device functions as the central location for shared 3D objects (figure 3). The objects or models can be placed on the platter using different interaction techniques, e.g. by triggering the transfer from a 2D application or by using transfer devices brought close to the cake platter



Figure 3: 3D model area on "cake platter"

Personal Digital Assistant

We use PDAs (in our case a PalmPilot IIIc) as catalogues of virtual models; the main form of interaction within our system being model selection and transfer to and from the cake platter (see Figure 4).



Figure 4: Using a PDA for object transfer to/from cake platter

Clipping plane and Lighting

To see what is "inside" of a virtual object a clipping plane technique is very useful. In the MagicMeeting setup the user holds a (transparent or opaque) real plane in his or her hand to clip through the model on the cake platter (figure 5).



Figure 5: Clipping plane

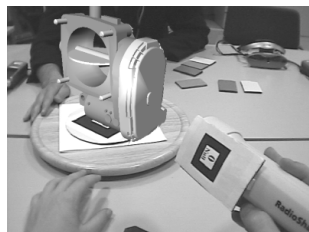


Figure 6: Real lamp controlling virtual light source

To evaluate the surface properties of a 3D model, the simulation of a light source is implemented in our system. Instead of using a virtual light only, the direction and distance of the light is controlled by moving a real office lamp or flashlight (figure 6).

Annotations

Each user can use tools with markers on it to color parts of the model for discussion purposes. Especially in design review scenarios this procedure is very common. After annotating a model part (on the cake platter) with a color (red, yellow, green) an update is sent to a database containing data about the person annotating, the part's design status ("needs to be redesigned"), and the part itself as 3D information.

2D - 3D linkage

To integrate 2D and 3D information into one shared environment we have implemented several mechanisms.

First, interactive Windows desktops can be placed within the 3D environment. Second, 2D applications, like Netscape (via Java) or Microsoft Office (via Visual Basic) can control the models displayed in the environment. Third, data out of the 3D space (like the image of a clipped plane) can be put into a 2D application, like Microsoft Access (figure 7).



Figure 7: Transfer and transformation of clipped image to data base

FUTURE WORK

In the future we are going to (a) add new interaction forms according to user needs, (b) combine different tracking technologies for more accuracy, (c) investigate alternative display and communication technologies, (d) consider more comprehensive inclusion of IT processes and programs, and (e) add one or more remote participants to the meeting setup via networking technologies.

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