BUILD-IT:

a video-based interaction technique of a planning tool for construction and design

M. Rauterberg[1], M. Fjeld[1], H. Krueger[1], M. Bichsel[2], U. Leonhardt[2] & M. Meier[2]

[1]Institute for Hygiene and Applied Physiology (IHA)
[2]Institute of Construction and Design Methods (IKB)
Swiss Federal Institute of Technology (ETH)
Clausiusstrasse, CH-8092 Zurich, SWITZERLAND
http://www.ifap.bepr.ethz.ch/~rauter/science.html

1. Introduction

The embodiment of computers in the work place has had a tremendous impact on the field of human-computer interaction. Mouse and graphic displays are everywhere, the desktop workstations define the frontier between the computer world and the real world. We spend a lot of time and energy to transfer information between those two worlds. This could be reduced by better integrating the virtual world of the computer with the real world of the user.

The most promising approach--to overcome the obstacles of immersive VR--is *Augmented Reality* (AR) [6]. The expected success of this approach lies in its ability to build on fundamental human skills: namely, to interact with real world subjects and objects! In this paper we present a new interaction technique, called Natural User Interface (NUI) [5]. A prototypical application was implemented to demonstrate its technical feasibility.

2. The prototype "Build-it"

In a first step we designed a system that is based primarily on the concept of NUIs without supporting the communication aspects of a computer supported cooperative work environment. We choose the task context of planning activities for plant design. A prototype system, called "BUILD-IT", has been realized and an application, supporting engineers in designing assembly lines and building plants, was implemented. The realized design room (see Fig. 1) enables the users to sit around a table and to act in the interaction space with a mixture of virtual and real world objects. The vertical area for communication and work (in the background of Fig. 1) is used for a perspective view into the plant.

The hardware has seven components:
- A table with a white surface is used as a horizontal projection and interaction area (the top view).
- A white projection screen provides a vertical projection area (the side view).
- An ASK 960 high resolution LCD projector projects the top view of a computer graphics scene vertically down to the table.
- An ASK 860 high resolution LCD projector projects a perspective view into a computer graphics scene horizontally onto the projection screen.
- A CCD camera with a resolution of 752(H) by 582(V) pixels looks vertically down to the table.
- A wooden brick, sized 3cm*2cm*2cm, is the physical interaction 'device' (the universal interaction handler).
- A low-cost Silicon Graphics Indy (IP22 133 MHz processor, R4600 processor, and the standard Audio-Video Board) provides the computing power for digitising the video signal coming from the camera, analysing the users' interactions on the table, and rendering the interaction result in the two views.
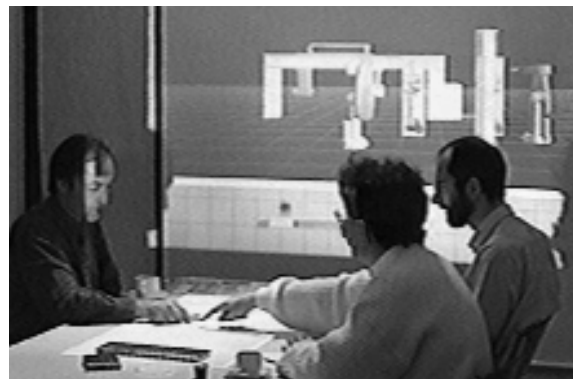

Fig. 1: The design room of BUILD-IT

The software consists of two independent processes communicating with each other through socket connection.
- The real time analysis process of the video reads images from the camera, extracts contours of moving objects, analyses these contours [2] [3], and determines the position and orientation of the universal interaction handler (the wooden brick).
- An application is built on top of the multi-media framework MET++ [1]. This application interprets the user action based on the position and orientation of the interaction handler, modifies a virtual scene according to the user action, and renders the top view of the new scene (for the vertical projector) and the side view into the scene (for the horizontal projector) (see Fig. 1).

The application is designed for supporting providers of assembly lines and plants in the early design processes. It can read and render arbitrary CAD models of machines in VRML format. The input of a 3D model of the virtual objects is realized by connecting BUILD-IT with the CAD-System CATIA. So it was possible to import the original CAD-models into BUILD-IT.

Today one important aspect is to interact in more than geometrical aspects with product data (cost, configuration possibilities, variants, etc.). For the near future it is planned to transfer additionally metadata from and to BUILD-IT.
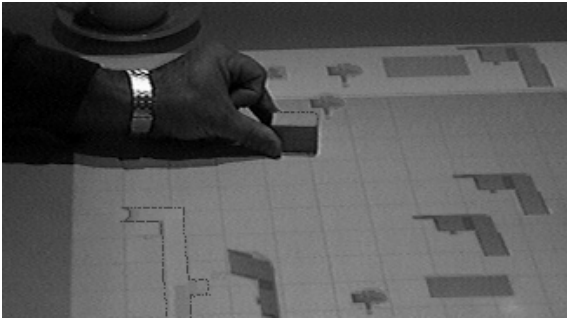
Fig. 2: The top view with the planning area below (grey), the menu area above (white), and a human hand moving the interaction handler (the wooden brick).

BUILD-IT currently supports the following user (inter-)actions (see Fig. 2):
- Selection of a virtual object (e.g., a specific machine) in a 'virtual machine store' by placing the interaction handler onto the projected image of the machine in the menu area on the table (see Fig. 2).
- Positioning a machine in the virtual plant by moving the interaction handler to the corresponding position in the projected plant layout on the table. Positioning includes machine orientation that is coupled to the orientation of the interaction handler.
- Fixing the machine by covering the surface of the interaction handler with the hand and removing it.
- Re-selection of a machine by placing the interaction handler onto the specific machine.
- Deleting the machine by moving it back into menu area (the virtual machine store).
- Moving a virtual camera through the plant, rendering the perspective view of this camera, and displaying it on the vertical projection screen (the side view).

To change the side view the virtual camera can be moved on a level with the eyes of a virtual person of 1.7 m body height. The virtual camera is selected and moved exactly the same way as all other virtual objects. The current view position and viewing direction corresponds to the current position and orientation of the virtual camera icon in the plant layout.

3. Conclusion

One of the most interesting advantages of a NUI-like interface is the possibility to mix real world objects with virtual objects in the same interaction space (see also [4]). One of our next steps is the implementation of two or three interaction handlers to allow simultaneous interactions among several users sitting around the design table.

By using this new interaction technique it will be possible to discuss and manage difficult 3D objects with any customer who might not be expert in CAD-systems. Technical descriptions and products can be presented in an easy way, and changes--affected by changing requirements--can be realized and presented in a very short time. The virtual camera allows a walk-through through the designed plant. Such kind of walk-through gives a very good feed-back of all parts in the complex system.

As a vision, one could imagine a direct information flow between customers and large product databases by using this type of a natural user interface. Imaginable is that if a user wants to change one detail in a machine he or she pushes a button and gets several possible variants of this configuration directly displayed on the table. For example, if he or she chooses one configuration, the exact costs are calculated and directly shown.

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