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A NEW APPROACH FOR GESTURE-BASED SKETCHING

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1. Introduction

As people want to use computers and mechanical systems with a minimal effort of learning new input devices become more important. A very ergonomic and intuitive user interface can be realized through gesture recognition. A gesture is a movement of the body that contains meaningful information. Humans can transmit gestures with a lot of parts of their body. For example the mimic of the face or the movement of the eyes can transmit meaningful information. Some gestures only have a meaning in combination with other gestures. To recognize gestures eye trackers, data gloves and cameras are used single or in combination.
Gestures can be classified into arbitrary, mimetic, iconic deictic and coverbal gestures. The meaning of arbitrary gestures is defined per convention. That's why the user has to learn them. Mimetic gestures imitate the natural handling of objects. Iconic gestures try to imitate the shape of objects. With deictic gestures the user points at things. Coverbal gestures are gestures that are used in combination with speaking. Beside this classification gestures can be differed into static and dynamic gestures.
Gesture recognition is used in many fields, for example for robot programming and controlling, for the handling of complex simulation and medical data or to help functionally handicapped people. In our approach we use static hand gestures in combination with dynamic movements of arm and hand for the generating and handling of sketches and simple geometries.
Our main goal is to develop an intuitive VR-based computer aided design system that allows a designer a intuitive modelling during all phases of construction. This means we look at the design process from the early phases of sketching up to the generation of a more exact CAD-model (Figure 1).

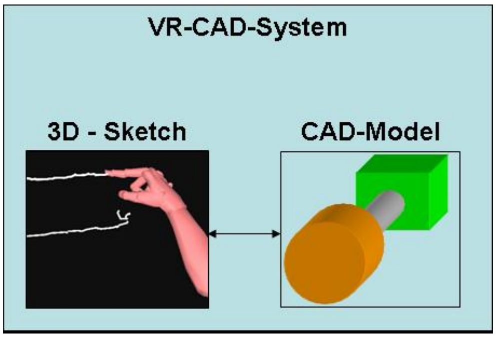

Figure 1. VR-CAD-System

To create new solutions, the designer has to be creative. Because the process of generating geometries in standard CAD-Systems is very complex and the user interface isn't designed very intuitive the creative process is being hindered. Only after a long time of learning one can create models with a CAD-System in a short time. That's why we have to think about alternative input devices, user-interfaces and user interaction in general. In this paper we want to present a first prototype-system for intuitive 3D-Sketching and creation of geometric primitives with a data glove as input device.
The information, which is present in the mental models of the early design phases, is often vague, incomplete, abstract and even irrational. Furthermore these models may be rapidly manipulated and thus a multiplicity of variants is produced and evaluated [HACKER 2002]. Normally designers help themselves with paper based sketches. Compared with CAD, sketches fit the designers mental model of the product much better, but the problem with paper based sketching is the break of media. Sketches have to be "translated" into a digital format. Also the 2D sketch has to be (re)transformed into a real 3D-Model. To solve this we have an approach for digital sketching in 3D space.
We try to support the designer in the early phases with a new tool. A tool that allows to generate digital 3D-Sketches and primitives easily and fast with a gesture based intuitive user interface. The user is wearing a data glove in combination with an electromagnetic tracking system to recognize static gestures. We developed a 3D User Interface with 3D-Buttons to call functions for the creation of primitives and their modification. The whole scene or single objects can be moved very intuitively by grasping objects and subsequently moving the hand. No further input devices are needed.

2. State of the Art of VR-Modelling-Programs

A lot of systems for the modelling of geometries that use VR-technology have been developed over the last few years. These systems differ in their focused modelling method and the area of application. Some of the modelling systems only use 2D-input-devices and 2D-output-devices others support more than one 3D-input-device in combination with speech recognition. There are systems that focus on rough and fast sketching, but some systems also allow the generation of exact geometries. Below we want to give an short overview about different modelling systems.
A system that supports the designer in the early stages of design with sketching-functions and the reconstruction of geometries out of sketches is GIDeS (Gesture based Intuitive Design System) [PEREIRA 2000]. The developers of the system wanted to support the designer in his natural working style. They developed a gesture recognition system that is able to recognize defined gestures and to retrieve the users intention. If the system recognizes a gesture, it displays a suggestion. The user is able to accept or withdraw this suggestion. In the case of ambiguity a list of suggestions is generated by the system. A pen without buttons in combination with a tablet is used as input device.
SKETCH [ZELEZNIK 1996] is a different 3D modelling system that also uses 2D-input devices and gesture recognition. There are two different types of gestures linked with the first and second button of the supported 3 button mouse. When the first button of the mouse is pressed, the system is able to differ 5 stroke-gestures. The functions that are linked with these gestures are used for geometry modelling. Interaction functions are being called with gestures that are linked with the second button. For manipulating the viewpoints position the third button is being used.
Another geometry modelling system is using a transparent tablet in combination with a transparent pen at a virtual table[ENCARNAÇÃO 1999]. Iconic gestures that are similar to the projection of the specific geometry are used to generate geometries.
Tapedrawing is a frequently used design-technique in the automotive industry. Grossman et al [GROSSMAN 2001] tried to realize this function with Virtual Reality. The developed program is using two tracking systems with buttons that are being held in the right and the left hand. Working at a silver screen on which the picture is projected realizes a big working space. For the creation of a wire frame model lines can be lengthened and modified like rolling of a tape. The flowing shift from 2D views to perspective viewpoints is being emphasized.
Wire frame models can also be created with 3-Draw [SACHS 1991]. A position tracked pen is being used in combination with a position tracked tablet as input device. The viewing perspective on the object can be changed through rotating the tablet. For painting and editing the pen is being used.

C. M. Schmandt [SCHMANDT 1993] uses an approach that is similar to a 3D-Sketching System [DIEHL et al. 2003] (that was developed at our department). A Monitor is being rotated about 45°, so that the picture is being projected on a semitransparent mirror. Under the mirror C. M. Schmandt uses a Pohelmus Tracking Sensor as input device. The system was used to create 3D-Sketches. In our system [DIEHL et al. 2003] we use a Phantom Desktop Device that is positioned underneath the mirror. Because the user looks from above on the mirror he can see his hand holding the phantom desktop as well as the 3D-picture of the projected object hence projection- and interaction room are merged (see Figure 2). The user is able to draw and feel lines in 3D-space. Via a force feedback menu options like line thickness or colour can be changed. Saving and loading of sketches as VRML-Objects is possible.

Figure 2. AR-3D-Sketching Tool

Surface Drawing by Schklone and Schröder [SCHKLONE 1999] makes it possible to paint surfaces intuitively on a workbench. The surface of hand is being rendered into space once per simulation loop. Through special algorithm it is possible to create triangulated meshes in real time.
Gadh et al developed the multimodal system COVIRDS [ARANGARSAN 2000] for the conceptual design. Two data gloves in combination with a tracking system for the recognition of gestures as well as a speech recognition system for the calling of functions are supported. A enhanced system called DVDS (Detailed Virtual Design System) has been developed for the detailed design. DVDS has an interface to a CAD-system.

3. A gesture based VR-Modelling-Program

Our first approach of drawing lines with a phantom desktop into 3D-Space (see above) has some problems. The sketching of simple lines in 3D is very easy and intuitive. But it is quite difficult to sketch objects with closed surfaces, like spheres or cones, just with lines. Based on the analysis of the phantom-based approach the VR-Modelling Program with gesture-based input commands was developed. This approach will be described in the following chapter.

3.1 Technical Description

In principle a 3D sketcher can be realised with every position-tracked input device. An intuitive user interface can be realised by the use of a data glove. This approach is promising because the use of gestures is a natural behaviour of people. In contrast to the Phantom no mechanic linkage limits the

available working space. So it is possible to work at large-area displays or with Head-Mounted-displays.
In the described application a data glove Cyber glove with 22 sensors is used. Tracking is realised with the system “Flock of birds”. It is possible to carry out the basic functions sketching, deleting of sketch elements and moving of the sketch with the aid of static gestures. Further functions can be called with three dimensional buttons and carried out.
The sketching-function is called with a showing-gesture. Thereby the forefinger is stretched and the remaining fingers are bent. Cylinder pieces are created at the fingertip.
For lack of edges some simple geometries like spheres, cones and cylinders can be modelled quite difficult as line based 3D sketch. This was the reason to expand the functionality with the possibility for the generation of easy geometries.

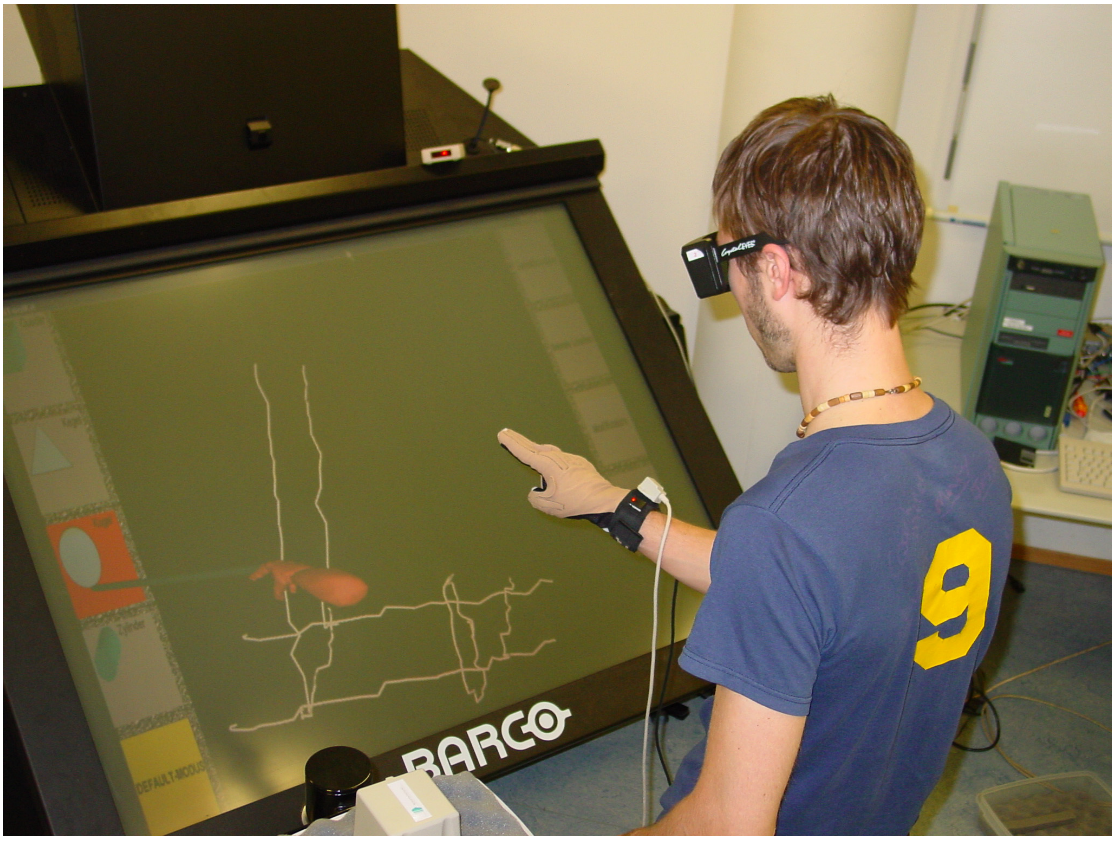

Figure 3. Generation of sketches and primitive geometries

3.2 User Interface

The basic geometries are raised from their centre while generated. For this purpose the centre is selected with the data glove. Then the relative distance of the fingertip of the graphical manual model serves to the centre serves to control the scaling of the geometrical object (see Figure 3). After each simulation cycle the size of the object is adapted so that the user receives a visual feedback. If the desired size of the geometry is adjusted, the size is confirmed with a gesture.
The subsequent modifying of selected geometries occurs analogue. The objects are selected with first activating the modification mode with a button and subsequent cutting the desired object with the forefinger. This is emphasized then in colour way. The selection is conformed with a flat hand.
A very intuitive service was implemented for the moving of the entire sketch and/or individual selected objects: If one carries out a griffin movement that ends in a clenched fist, the sketch and/or. coupled marked elements are coupled with the virtual manual model and can be turned free in the room until one opens the hand again.

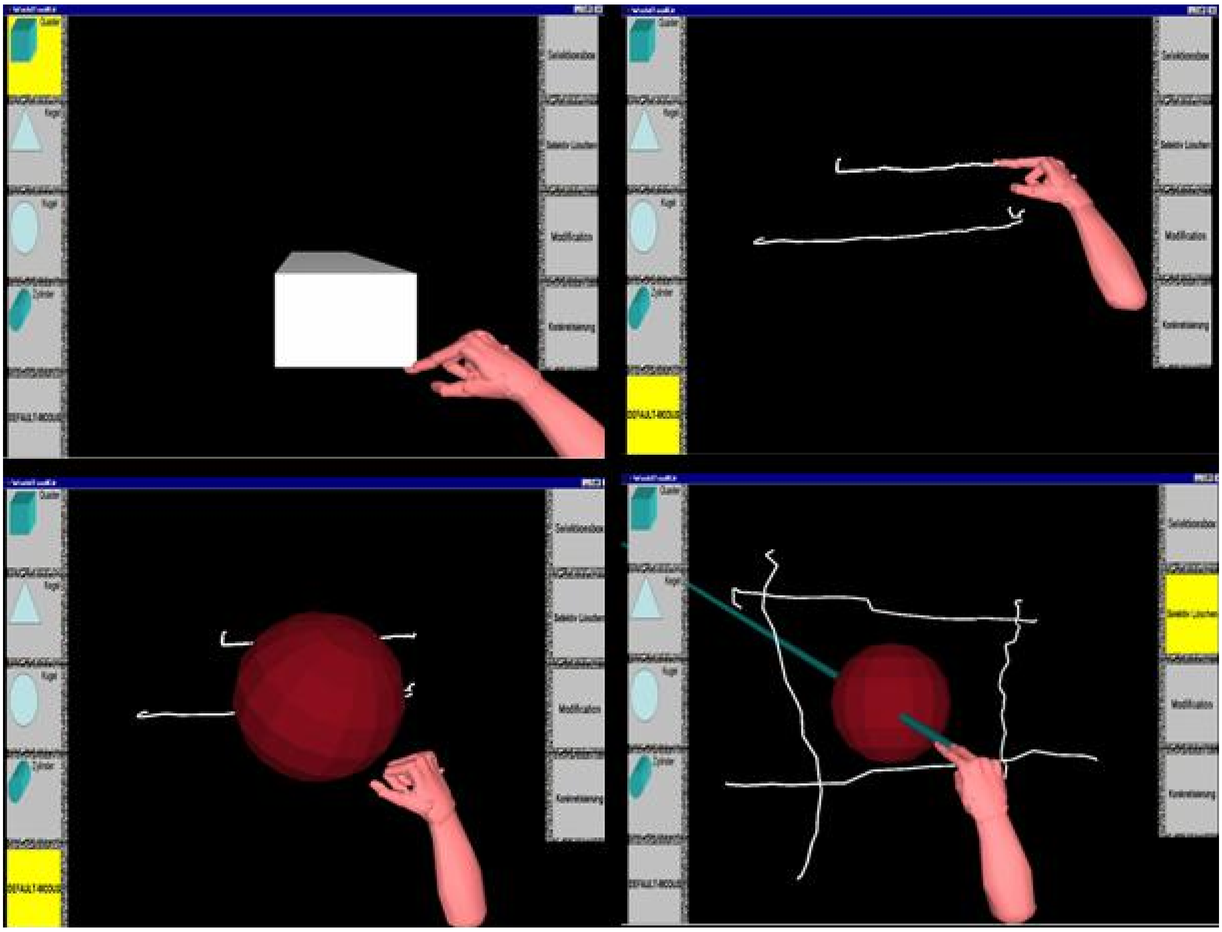

Figure 4. User Interface –Gestures for Sketching (Sketching, selecting, sphere, moving)

4. Results of first tests

For evaluating the approach and the user interface a questionnaire was developed. Ten students tested the program after a short time for familiarization. For the usability of the software criterias like time for learning, error rate, working speed, and subjective satisfaction were defined. The results of the usability tests were satisfying, nevertheless there are some points for enhancing the approach.
The usability of the user interface was good: after a short time of learning the users orientation in the user interface was very good. The symbols for the creation of geometry were comprehensible. Nevertheless further symbols for highlighting other functions would be good. The selection of the buttons was intuitive practicable. An improvement could be time limit of the selection by picking the element as this was noted as difficult to use. The functions for creating geometries were felt intuitive. The process for selecting and moving was easy to learn for the users. On the other hand the method for selecting volumes was evaluated not very intuitive.

5. Outlook

Based on a literature research of the state of the art of VR-Modelling programs an approach for a gesture-based sketching tool was developed. The prototype was tested by students. Based on the results of the test some improvements are suggested. A more extensive user interface would improve the functionality of the program. For enhancing the immersion of the system an integration on a Powerwall would be desirable. Further improvements are : fusion of action- and perception-room and enhancing of the tracking.

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