Two-Handed Direct Interaction with ARToolKit

Stephan Veigl, Andreas Kaltenbach, Florian Ledermann, Gerhard Reitmayr, Dieter Schmalstieg
Vienna University of Technology, Austria
{e9526342|e9526343}@student.tuwien.ac.at, {ledermann|reitmayr|schmalstieg}@ims.tuwien.ac.at

Abstract

A mobile augmented reality system for 3D interaction requires an easy to use, interactive input device. In our work on the Studierstube *project, we had long-term experience with two-handed direct manipulation interfaces based on tracked props. However, for a mobile setup, props are no longer appropriate as they permanently occupy the user's hands and prevent the user from performing everyday tasks such as opening doors. Instead, we resorted to the common tool which is very intuitive to use and can be applied for nearly all interactions: our hands. A big advantage of hand based interaction is the intuitive use of gestures such as pointing, grabbing or stretching.*

1. Introduction and Related Work

There is a certain tradition in virtual reality systems of using glove based input for direct manipulation in 3D. The most popular implementation is based on light-weight pinch gloves, that provide a 3D cursor moved relative to the hand, and allows to trigger actions by pinch gestures. The stream of input event can easily be interpreted for direct object manipulation, but the issue of accessing system control functions remains. Our previous user interface designs always incorporated an augmented panel offering system and application control functions, that could be accessed with a 3D or 2D manipulator (e. g., stylus). Inspired by the movie "Final Fantasy", we chose to implement a wrist-mounted augmented reality panel made from a simple 2D touch pad.

There are many different works related to two-handed direct interaction using gloves and/or additional input devices. The state of these works ranges from first prototypes to commercial products like the PINCH Gloves by Fakespace [2]. Our development is similar in spirit to the pinch gloves used in Tinmith-Metro [3], however these could only be tracked within a limited set of hand positions.

2. Interaction Setup

The interaction setup is composed of the following two main components:

1. A helmet with optical stereo see-through head mounted display (Glasstron), single Firewire camera (Firefly) for ARToolKit tracking, and inertial tracker (Intertrax2) for improved tracking accuracy (see Fig. 1). Note that the helmet camera will pick up any object fitted with markers – the gloves / wrist pad devices as well as any other markers used to implement for example a card-based tangible interface. This leaves a lot of freedom in the application design.

Figure 1. The helmet equipped with a miniature Firewire camera for optical tracking and an inertial sensor.

2. Gloves and wrist-worn touch panel, fitted with ARToolKit markers which will be described in detail in the following sub sections (see Fig. 2).

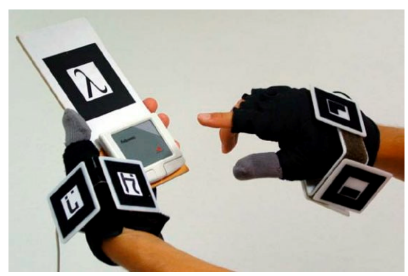

Figure 2. Gloves and touch pad used together. A naked finger is needed to operate the pad.

2.1. Gloves

We use robust finger-free bicycle gloves. Only the thumb is fully covered with two layers of cotton that have a pressure sensitive foil embedded at the inner side tip of the thumb. The pressure sensor acts as a button. Due to the relatively fixed offset from the back of the hand to the thumb tip when thumb and index finger are pressed together, the 3D cursor can easily be calculated. Four fingers are left free to manipulate physical objects and to operate the touch panel, that does not respond to skin covered in cloth.

The pressure sensors we use are environmentally sealed with an overall thickness of less than 1 millimeter. Due to there extreme flexibility and thinness, the thumb movement is not restricted in any way by the sensors. We

do not think that open contacts can be an alternative to a closed sensor. Even if it would be possible to construct an even thinner sensor, open contacts are much to sensitive to failures or false current. We cover the sensor with an additional layer of cotton for both, as an extra mechanical protection and for optical reasons.
A finger-free bicycle glove has been shown as the best compromise between user comfort and a robust and stable base structure. It is light weight and comfortable to wear, even for longer periods of time. Moreover it provides a stable frame to mount pressure sensors and tracking devices, or as we did, ARToolKit markers.
Three ARToolKit markers have been mounted in a rigid structure attached to the back of the glove, so that at least one marker can always be picked up by the camera independent of the hand rotation.
To make the handling and maintenance easier, the gloves are build modular (see Fig. 3). This means that we use detachable markers and cables. While we found that markers are rarely removed, it is convenient to put on the disconnected glove and plug in the cable later. For this reason a small light weight lockable plug system has been chosen for the glove. It is important that the plug can be fixed so that it won't disconnect by accident.

Figure 3. Individual parts of the Glove

2.2. Touch Panel

The touch panel is mounted to the wrist with an elastic band, and also has a marker attached. While the graphical overlay of the panel is only presented when it is in the user's field of view, the panel operation itself does not rely on the tracking of the panel marker, and can be done while looking at something else (see Fig. 4).

Figure 4. Touch panel with augmented user interface.

3. Experiences and Future Work

The setup is operated by embedding appropriate drivers and parameter information into OpenTracker [5], our device management framework that interfaces to the *Studierstube* [1] application platform.
Some experimental work went into making the whole setup durable, so it can sustain everyday work in the lab, and demonstrations to the public. This means in particular that the device can be put on and off many times. We found that particular care must be taken of durable cable mounting. We successfully verified our implementation in a "stress test" at a public science fair with 1500 participants, and found it durable and easy to use (see Fig. 5). During this test, we found that many users prefer to hold the touch pad in their hand. While the glove handling itself seems very intuitive to the users.

a) b)

Figure 5. a) Demonstration of the mobile augmented reality system at a local science fair. b) A Participant is introduced to the use of the mobile setup .

A possible future extension is creating a wireless radio-operated touch panel, that can be attached to one's belt when not in use.

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4. References

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