A Flexible Tracking Concept Applied to Medical Scenarios Using an AR Window

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Abstract

This paper presents an approach to use a semitransparent display as a kind of window into a patient in the context of medical Augmented Reality (AR) applications. Besides the presentation of the non-off-the-shelf display, the tracking aspects of such an application are in focus of the work presented. In order to allow augmentations of real objects by virtual ones on the display, the user (i.e. physician), the display, the object (i.e. patient) and optional instruments have to be tracked. If required, a tracking system consisting of more than one subsystem, e.g. optical tracking combined with electromagnetic tracking, is used to satisfy all the needs of such a medical application.

1 Introduction

One of the basic questions for the implementation of an Augmented Reality (AR) application is: What kind of device should be used to display the augmentations? In lack of other possibilities, in many cases video see-through Head Mounted Displays (HMD) or the harder to handle optical see-through HMDs are applied.

Alternative display devices for AR are very rare, above all under the condition not to use them in video see-through mode. In the context of the project Medarpa (Medical Augmented Reality for Patients), funded by German Federal Ministry of Education and research (BMBF) a semitransparent display as an AR Window was developed and will be improved based on the gained experience.

While the tracking concept is not limited to a certain application with a fixed choice of tracking systems, a special combination of tracking systems, needed to use the AR Window for a typical medical application, is presented. A flexible controlling unit and a standardized interface for tracking systems allow easily realizing special applications, system extensions and the exchange of tracking systems.

2 Related Work

Similar examinations as presented in this paper concerning the AR Window are made by using a beam splitter (a half-silvered mirror) which is both transparent and reflective [1, 10]. Positioned above the beam-splitter is a display device (flat panel display [7] or video projector). A pair of liquid crystal shutter glasses allows the user to view stereo images.

An alternative technique for the generation of stereoscopic displays was proposed in [9] but this auto stereoscopic technique is not applicable for transparent displays.

Other approaches [4] use a surgical microscope for augmentation or make investigations to integrate an holographic screen [2, 5].

3 Application and Components

The current realization of the AR Window is a pivoted transparent display mounted on a swivel arm (see Figure 1) and based on a 17” active-matrix LCD (TFT) screen allowing a resolution of 1024×768 at 75 Hz. Due to the available display technology the transparency is restricted, but if sufficient light can be supplied to the observed scene the display meets the transparency requirements. Since the display will be close to the area of intervention, sterility has to be achieved by covering the display with panes of glass, whose surfaces can easily be sterilized.

The construction of the display and its swivel arm has been planned and implemented by GfM (Gesellschaft für Medizintechnik, Weiterstadt, Germany) within the Medarpa project. The current version of the display can easily be moved inside a working volume of at least 2 m^3.

A medical scenario for navigation of instruments inside a patient’s body by using the augmented view through the AR Window, includes the tracking of the physician, whose eye positions are needed, the display as device for displaying the augmentations, the patient, equipped with landmarks,

Proceedings of the International Symposium on Mixed and Augmented Reality (ISMAR’02)
0-7695-1781-1/02 $17.00 © 2002 **IEEE**

placed on his body before image acquisition (CT, MRT, ...) and a medical instrument.

In doing so, virtual objects, used to augment the scene to provide navigation information, i.e. a model of the inside of patient's body, can be aligned with the patient by relating to the real landmarks on the patient.

The video-based infrared tracking system EOS, developed at ZGDV in Darmstadt, has been chosen to follow the motion of the display and user's head. Similar video-based tracking systems have been introduced in [6], [3] and [8]. Infrared-LEDs are used as active markers for the objects to be tracked. These objects are the head of the physician and the display.

EOS allows that the physician has not to be connected by cable to the system, but has the problem with partial or full occlusion of the tracked objects. This is the reason, why an electromagnetic tracking system is designated to keep track of the physician's instruments.

Figure 1. AR Window in a first demonstration.

If two or more different tracking systems are used, their coordinate systems have to be aligned. To solve this problem, a set of points with their representations in the coordinate systems of both trackers has to be recorded. This leads to an over-determined linear equation system, which is solved in a least-squares sense. The result is taken as an initial guess for a non-linear optimization using the Levenberg-Marquardt method. For the registration of the virtual model onto the patient, the same method as for the alignment of the tracking systems is applied.

A controlling unit connects different tracking systems with a rendering unit and applies the appropriate alignment transformations to incoming poses. It also provides the alignment procedure itself and other registrations. Thus, the rendering unit is supplied with poses in one shared coordinate system, even if different tracking systems are used.

4 Conclusion and Future Work

The main results of this paper are the proof of concept of the controlling unit within a first demonstrator and the successful integration of the AR Window. The demonstrator allows the user to navigate with an instrument in a flexible mass, where a sensor as navigation target is hidden for tests.

Concerning the tracking of instruments and registration devices, both approaches, electromagnetic and optical, are aimed at. Upcoming electromagnetic tracking systems with sensors with less than 1 mm diameter, would allow real tracking within the body of a patient. Since the modular concept allows integration new tracking systems easily, such a tracker can be used as an extension of the system on demand.

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Proceedings of the International Symposium on Mixed and Augmented Reality (ISMAR'02)
0-7695-1781-1/02 $17.00 © 2002 **IEEE**