A Platform for location based Augmented Reality Applications

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Abstract:

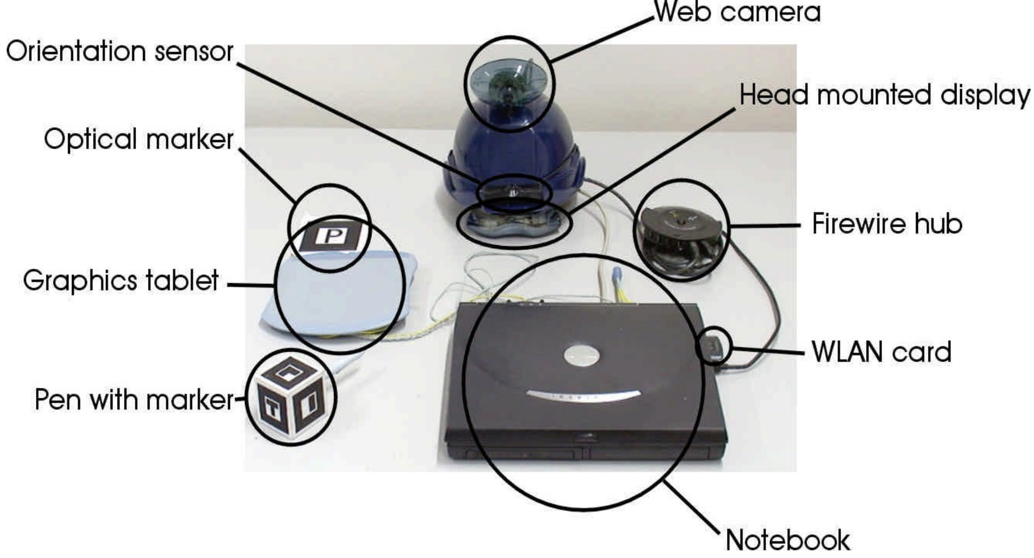
Augmented Reality (AR), enhancing a user's perception of the real world with computer generated entities, and mobile computing, allowing users to access and manipulate information anytime and independent of location, are two emerging user interface technologies that show great promise. The combination of both into a single system makes the power of computer enhanced interaction and communication in the real world accessible anytime and everywhere. This paper describes our work to build a mobile Augmented Reality system that supports true stereoscopic 3D graphics, a pen and pad interface and direct interaction with virtual objects. The system is assembled from off-the-shelf hardware components and serves as a basic test bed for user interface experiments related to computer supported collaborative work in Augmented Reality. It also describes some applications we are developing in the area of location based computing.

Introduction and related work :

Augmented Reality (AR), annotating the real world with computer generated entities, is a powerful user interface paradigm allowing users to interact with computers in a natural way. Mobilizing such an interface by deploying wearable computers is a logical extension as the body of related research shows.

Wearable computing allows the user to access resources at any location and at any time. AR is often used as an user interface technique in wearable computing because it provides an information space which is continuously and transparently accessible . Information can be accessed hands-free, and the user's view of the real-world is not interrupted, a requirement for continuous use.

If these technologies are combined with position tracking, location aware applications are possible. The computer transparently changes its behavior based



on the environment without the user's intervention. An impressive demonstrator for mobile location aware AR using both a head-mounted and a hand-held display is Columbia's Touring Machine [3] which was used to create a campus information system and situated documentaries [4].

The mobile AR setup :

While the computational power for stereoscopic rendering and computer vision is becoming available in mobile computer systems, the size and weight of such systems is still not optimal. Nevertheless, our setup is solely build from off-the-shelf hardware components to avoid the effort and time required for building our own. On one hand this allows us to quickly upgrade old devices or add new ones and to change the configuration easily. On the other hand we do not obtain the smallest and lightest system possible.

Hardware :

The most powerful portable graphics solution available currently is a PC notebook equipped with a NVidia GeForce2Go video chip. The device has a 1GHZ processor and runs under Windows 2000. We also added a wireless LAN network adapter to the note-book to enable communication with our stationary setup or a future second mobile unit. It is carried by the user in a backpack.

As an output device, we use an i-glasses see-through stereoscopic color HMD. The display is fixed to a helmet worn by the user. Moreover, an InterSense InterTrax2 orientation sensor and a web camera for fiducial tracking of interaction props are mounted on the helmet.

The main user interface is a pen and pad setup using a Wacom graphics tablet and its pen. Both devices are optically tracked by the camera using markers. The 2D position of the pen (provided by the Wacom tablet) is incorporated into the processing to provide more accurate tracking on the pad itself. Figure 1 gives an overview of the setup.

User interface management software :

As our software platform we use *Studierstube* 2.1 [5], a user interface management system for AR based on but not limited to stereoscopic 3D graphics. It provides a multi-user, multi-application environment, and supports a variety of display devices including stereoscopic HMDs. It also provides the means of 6DOF interaction, either with virtual objects or with user interface elements registered with and displayed on the pad.

Applications are implemented as runtime loadable objects executing in designated volumetric containers, a kind of 3D window equivalent. While the original stationary Studierstube environment allowed a user to arrange multiple application in a stationary work-space, our mobile setup with body-stabilized display allows to arrange 3D information in a wearable workspace that travels along with a user. Applications stay where they are put relative to the user, and can easily be accessed anytime, aided by proprioception and spatial memory. Figure 2 shows a simple painting application.

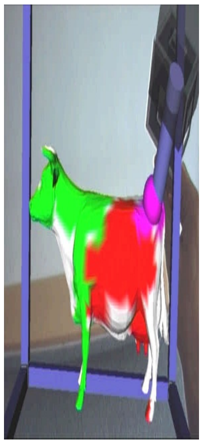


Figure 2. A user interacting with the paint application . The view of the user.

Our user interface management system is also capable of managing multiple locales, which can contain any number of graphical objects. Locales are important for multi-user or multi-display operation. For example, each mobile user will require a separate wear-able workspace that defines a distinct locale (coordinate system). As one user moves about, a second user's locale will be unaffected, but the second user will be able to see movement of the graphical objects contained in the first user's locale. For effective collaboration, it will in most cases be necessary to add a third stationary locale that contains graphical applications that both users should work with.

Tracking :

Mobile AR requires significantly more complex tracking than a traditional VR application. In a typical VR or AR application tracking data passes through a series of steps. It is generated by tracking hardware, read by device drivers, transformed to fit the requirements of the application and send over network connections to other hosts. These tasks are handled by a library called *OpenTracker* [6], an open software architecture for the different tasks involved in tracking input devices and processing multimodal input data.

The main concept behind OpenTracker is to break up the whole data manipulation into these individual steps and build a data flow network of the transformations. The framework's design is based on XML, taking full advantage of this new technology by allowing the use of standard XML tools for development, configuration and documentation.

OpenTracker uses a vision tracking library called ARToolkit [7] to implement the tracking of the fiducial markers on the interaction props. It analyses the video images delivered by the web camera mounted to the helmet and establishes the position of the pen and pad relative to the users head.

Location tracking :

A similar technique is used to track the user's position within the environment. Our laboratory and neighboring rooms are rigged with larger markers along the walls. The locations of these markers are measured and incorporated in a model of the building. Together with the tracking information delivered by the fiducial tracking the system computes the users position within these rooms from the detected markers.

Location based AR applications :

Building on the mobile platform described above we are currently developing a number of prototype location based Augmented Reality applications. These applications are based on the location tracking described in the last section.

A simple location based application is the AR library. It performs two basic tasks : Firstly, it shows a user the location of a requested book in the vast bookshelves of a library. And secondly, it recognizes books when the user looks at them and again displays the correct location of the book in the library shelves.

A bookshelf was fit out with fiducial markers used for tracking. Then the bookshelf's position can be computed by the tracking library. Dedicated books were rigged as well with these markers, so that the system recognizes such a book when the user is looking at it. In the prototype application, the markers are attached to the wall instead of a real shelf. Figure 3 shows both modes.

Figure 3. The correct location of a detected book is displayed. A selected book is

shown in the shelf.

Another typical scenario for mobile AR systems is a way finding application. The aim is to guide a user along a path to a selected destination. This is accomplished using two means: a world in miniature model of the environment with the users location and pathhighlighted and augmenting the user's view with navigation guides such as arrows, high-lighted doors and lines along the desired path.

Such an application requires a model of the environment as well as a means to track the user's location within the environment. As described above we prepared the environment to allow the system to compute this. For each room a set of markers was set up and their locations measured. The tracking can now establish the user's location and the direction she is looking in. Thus the system can continuously display navigation information registered to the real world.

In the application itself the user is presented with a miniature model of the environment on the tablet. The user's location and current room are highlighted. She can select a destination by clicking into the room she wants to go to. Then the system computes the shortest path to this room and highlights the rooms she needs to cross. Additionally the doors that she needs to take are augmented in the user's view to guide her along the path to the destination.

Future work :

The prototype applications are not finished yet. We plan to augment a real library and test the application within this real environment. The way finding application will be ex-tended to encompass a part of our building to allow the user to roam in a larger environment. The integration of both applications is straightforward because of the multi application features of the Studierstube system. This will allow the user to find her way to the library and then use the library application in place.

Conclusion:

This paper describes our work to develop a mobile AR platform that allows location-based computing. While most related work focuses on providing information as text or 2D overlays, we concentrate on 3D information that the user can interact with. First we describe the mobile setup itself consisting of the hardware used and the software system developed. Then we describe two prototype applications we are currently developing to demonstrate the abilities of the platform.

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