The Virtual Room Inhabitant

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ABSTRACT

In this paper we describe a new way to improve the usability of complex hardware setups in Instrumented Environments (IEs). By introducing a virtual character, we facilitate intuitive interaction with our IE. The character is capable of freely moving along the walls of the room. In this way, it may offer situated assistance to users within the environment. We make use of a steerable projector and a spatial audio system, in order to position the character within the environment. Our concept of a virtual character "living" within the IE, and thus playing the role of an assistant, allows both novice and advanced users to efficiently interact with the different devices integrated within the IE. The character is capable of welcoming a first time visitor and its main purpose is to explain the setup of the environment and to help users while interacting with it.

CONCEPT

Intelligent Environments physically combine several different devices. These devices are spread all over the environment, and some may even be hidden in the environment. As Towns et al. [4] have shown, virtual characters capable of performing judicious combinations of speech, locomotion and gesture are very effective in providing unambiguous, realtime advice in a virtual 3D environment. The goal of the project discussed in this paper, is to transfer the concept of *deictic believability* [4] of virtual characters in virtual 3D worlds to the physical world, by allowing a virtual character to "freely" move within physical space. The idea of a Virtual Room Inhabitant is to allow the character to appear as an expert within the environment which is always available and aware of the state of each device. In this way, the character can facilitate the user's work in the Instrumented Environment.

REALIZATION

In order to realize our vision of a lifelike character "living" in our IE, several software/hardware components were combined (see figure 1). Each device has to be registered on our device manager as a service. The device manager, in combination with a presentation manager, grants access to all registered devices. In this way, we are able to share our devices between several applications running simultaneously.

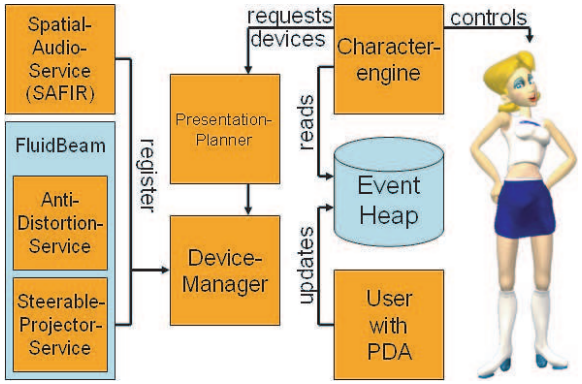

Figure 1. The system components of the VRI

To detect user positions we use two kinds of senders: Infrared beacons (IR beacons, allowing us to detect both position and orientation of the user due to the fact, that they demand a direct line of sight between sender and receiver) and active Radio Frequency Identification tags (RFID tags, as a backup mechanism, when the IR beacons are obstructed), both detected by the user's PDA. The calculated position is then forwarded by the PDA via wireless LAN to an Event Heap [1], where we collect all kinds of information retrieved within the environment (i.e. user positions, interactions with the system). Our central component, the character engine, monitors the Event Heap and automatically reacts according to changing user positions.

The Virtual Room Inhabitant (VRI) implementation is a combination of three components that will be explained in the following subsections: A character engine, a spatial audio system and a steerable projector, which allow the character to freely move within the room (i.e. move along the walls of the room).

Character Engine

The character engine consists of two parts, namely the character engine server (CE-server) written in Java and the character animation, which was realized with Macromedia

Flash MX[1]. These two components are connected via an XML-Socket-Connection. The CE-server controls the Flash animation by sending XML commands/scripts. The Flash animation also uses the XML-Socket-Connection to send updates on the current state of the animation to the CE-server (i.e. whenever a part of an animation is started/finished).
The character animation itself consists of ∼9000 rendered still images which were transformed into Flash animations. Whenever we have a demand for a certain gesture (or a sequence of gestures), the CE-server sends the corresponding XML script to the toplevel Flash movie which then sequentially loads the corresponding gesture movies. In addition to its animation control function, the CE-server also requests appropriate devices from the presentation manager. Once access to these devices has been granted, the CE-server controls the spatial audio device, the steerable projector and the anti distortion software.

Steerable Projector and Camera Unit (Fluid Beam)

A device consisting of an LCD projector and a digital camera placed in a movable unit is used to visualize the virtual character. It is mounted on the ceiling of the IE and can be rotated horizontally and vertically. In this way it is possible to project at any walls and desk surfaces in the room. The digital camera can provide high resolution images or a low resolution video stream which are used to recognize optical markers or simple gestures.
In order to avoid distortion due to oblique projection we apply a method described in [3]. It is based on the fact that projection is a geometrical inversion of the process of taking a picture given that the camera and the projector have the same optical parameters and the same position and orientation. The implementation of this approach requires an exact 3D model of the environment, in which the projector is replaced by a virtual camera.
In this way we create a sort of virtual layer covering the surfaces of the IE on which virtual displays can be placed. The VRI is implemented as a live video stream texture on a virtual display. Thus it can be animated in real time by the character engine. By moving the virtual display in the 3D model and an appropriate movement of the steerable projector the character appears to float along the walls of the room.

Spatial Audio Framework for Instrumented Rooms (SAFIR)

SAFIR runs as a service in our environment and allows applications to concurrently spatialize arbitrary sounds in our lab. The CE-server now sends the generated MP3 files and the coordinates of the current location of the character to the spatial audio system, which positions the sounds accordingly. The anthropomorphic interface obviously appears more natural with the speech being perceived from the same direction as the projection is seen. This is particularly helpful in situations when other applications clutter up the acoustic space with additional audio sources at the same time: The spatial attributes of the audio output of the virtual character allow the user to associate the speech with the projection of the avatar more easily. Furthermore it naturally directs the user's attention to the position of the character when it appears outside the user's field of vision.

CONCLUSIONS AND FUTURE WORK

While in the first phase of the project, we concentrated on the technical realization of the VRI, in the second phase we will focus on the behavior and interactivity of the character. To adapt the character's behavior to the user, we will integrate a combination of interaction history and external user model. While the interaction history will allow the character engine to adapt the presentations by relating to previously presented information, the external user model (which is available on the internet[2]) will allow the system to adapt to general preferences of the user (for example, a user might prefer to always use the headphones attached to his PDA, instead of a public audio system). To improve the flexibility of the approach, we will also allow the character to migrate from the environment to the PDA (this technology/concept is discussed in detail in [2]). In this way, the character will be capable of presenting personalized information to the user, while other users are in the same room.
In addition to adapting the application to multiple users we can create a personal virtual assistant for each of the potential users. Of course this only makes sense in a scenario with a limited number of users like for example a small office. Each character would have its particular appearance and voice, so that it can be easily recognized by the corresponding user.
In larger environments with plenty of users (like a shopping mall) it does not make sense to create a new character for each new user, but in this case the virtual assistant can call the attention of a particular user by addressing her or him by her or his name, which can be stored on the Event Heap together with other personal information.
The VRI has been successfully tested during many different presentations at our lab and we believe it is a promising first step towards an intuitive interaction method for Intelligent Environments.

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[1] http://www.macromedia.com/software/flash/

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