3DVN: A Mixed Reality Platform for Mobile Navigation Assistance

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Abstract
We present 3DVN, a Mixed Reality platform for navigation assistance in indoor environments. Built on top of a PC-based wearable computer running the Windows operating system, the platform provides a multimodal user interface to navigate existing physical buildings, including wireless networking, data glove gestural input, voice communication, head-mounted display, and a 3DOF head tracker. Local positioning is performed using a software-only WLAN-based engine to accurately pinpoint the mobile device in three dimensions. We use this system as a platform for a simple theoretical framework for classifying interaction for mobile navigation assistance. Informal qualitative evaluation of our system seems to conform to predictions derived from our framework and shows the need for a rich set of interaction components for successful mobile navigation.

Keywords
Location-aware computing, mobile navigation, multimodality, wearable computers

ACM Classification Keywords
H.5.2 [Information Systems]: User Interfaces; I.3 [Computer Methodologies]: Computer Graphics.

Introduction

New mobile devices provide vast and largely untapped opportunities for aiding and assisting humans exploring unknown terrain or gaining new knowledge about already familiar environments. Thereby, visitors may become less reliant on paper maps and carefully written or spoken directions to their destination by being able to access dynamic and interactive maps showing their position on the site, as well as being in direct communication with human guides in a remote visitor's center. Furthermore, by providing meta-information connected to geographical entities in the environment, such as opening hours for a store, upcoming events for a concert hall, or,a customer's/spectator's annotations in the store/concert hall, these mobile devices will encourage exploration of a site even for people already familiar with it.

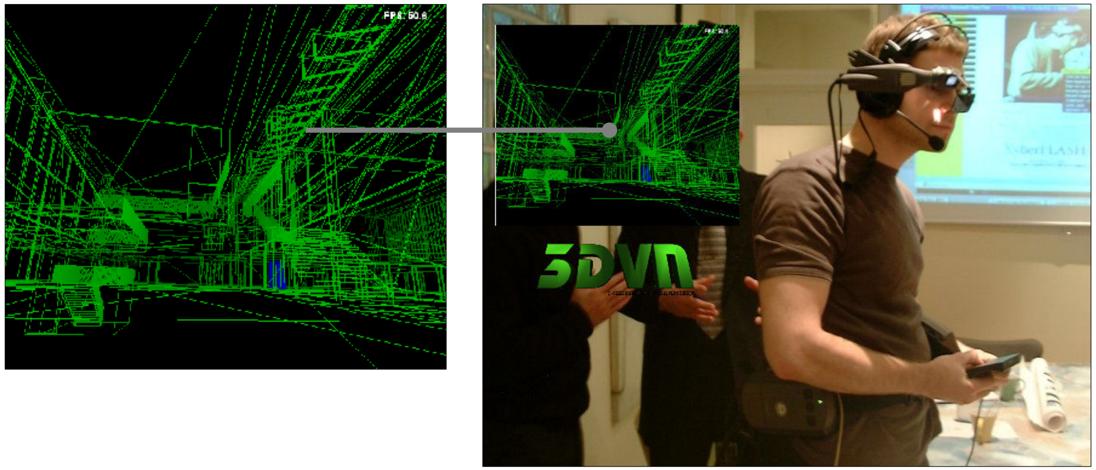

Figure 1. The 3DVN system running on a Xybernaut Mobile Assistant IV with inset screenshot from the display.

This paper presents the 3DVN system, short for three-dimensional virtual navigation, a Mixed Reality (MR) platform for this kind of exploration support in indoor environments using a wearable computer system. 3DVN not only shows wayfinding information to the user, but also gives an auditory and a visual connection to a base station or other roaming devices. We use 3DVN as a testbed for evaluating a simple theoretical framework for mobile navigation assistance and study the framework's correlation with reality.

Related Work

MR systems are ideal for building electronic guides and navigation assistants, examples of so-called location-aware computing [1]; one of the earliest of such systems is Cyberguide [5], a location-aware tourist information source. A seminal project is the GUIDE [2] electronic tourist guide for the city of Lancaster. By providing a mobile infrastructure for this purpose, many of the traditional shortcomings of tourist information can be addressed and a whole new range of possibilities are made available.

The purpose of the 3DVN system is to help users in getting an experience and understanding of their physical surrounding world, a practice sometimes referred to as situational visualization [4]. However, the hardware does not allow for overlaying computer-generated information and graphics on the real world, and is thus not a true Augmented Reality system. Most relevant of location-aware AR systems is the augurscope [6], a portable AR interface based on a wheeled tripod-mounted display that overlays a virtual environment on the physical background.

Another important AR guide system is MARS [3], a mobile visualization platform implemented on a wearable with a head-mounted display and a PDA.

The 3DVN Platform

The 3DVN system is built on a core module keeping track of the user's environment and acting as a hub for the information flowing through the system. Input is accepted from different device handlers and interpreted by the input event manager and then forwarded to the core for processing. Different handler implementations manage different kinds of input devices, ranging from head trackers and mouse input to gesture detection and webcam interfacing.

The positioning subsystem gathers user location data from sensors and keeps track of user location and orientation in the world. This is done through a software-only WLAN positioning system provided by Ekahau Inc that is able to triangulate the position of the wearable unit using only standard WiFi access points.

Display is driven by a 3D renderer module taking spatial information from the positioning system as input to update a set of 3D cameras in the virtual environment.

3DVN is a network-aware software platform and has a TCP/IP-based network module that communicates with other 3DVN instances on the network.

Interaction for Mobile Navigation

We view interaction for mobile navigation both in terms of it being either natural or artificial, as well utilizing input and output channels, yielding the 2x2 classification matrix seen in Figure 2.

	natural	artificial
input	Gestures Voice queries Position (physical)	Text queries Map queries
output	Virtual guide/agent Virtual signposts Voice guidance	Heads-up display Arrows and waypoints

Figure 2. Classification of mobile navigation assistance.

The 3DVN system features all of the above methods except for natural output methods such as virtual guides (the "helpful policeman") or signposts. A fully developed navigation assistance system should ideally support several methods from each class.

Due to the lack of a keyboard for the mobile user, the 3DVN system supports a number of different multimodal input techniques, gestures being the main component. Gesture recognition and detection is performed only when the user holds down a button on a trackball held by the user's non-dominant hand. The detection algorithm uses a system recognizing hand posture (or sequences thereof), allowing for simple yet powerful interactions. See Figure 3 for some of the postures recognized by the system.

Figure 3. Hand postures and gestures supported by 3DVN. Gestures are used for changing camera modes, cycling between waypoints, and selecting targets.

Field Study

We performed an informal qualitative evaluation of the 3DVN system in the student center building of our university. At the time of testing, the WLAN network in the student center was not fully completed, so the accuracy of the positioning subsystem was not optimal and considerable time was spent calibrating the system. The full 3D building model we used was acquired from an architect. Some basic location-specific information as well as wayfinding support was manually added to the spatial database; for future implementations, this should be done automatically, perhaps by retrieving information from sources on the Internet.

A number of passers-by were enlisted for qualitative testing of the system. They were asked to perform some simple navigation tasks in the environment. This was followed by open-ended structured interviews of the test participants. In general, the test persons were very impressed by the capabilities of the system and saw huge potential for its future. Informal observations showed that most subjects exercised at least one feature from each class in Figure 2.

It is clear that the physical factors must be improved; participants complained about the bulkiness of the device and the difficulty of putting it on. Furthermore, a much different physical setup may be necessary for the rescue worker scenario we envision for the future.

Summary

We have presented the 3DVN Mixed Reality platform for assisted navigation of real-world environments using a wearable computer. Results from an informal qualitative test session indicate the need for true multimodal interaction for maximum performance. In the future, we plan to continue our investigations into location-aware mobile computing, such as exploring the use of wearable navigation systems for rescue workers.

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