# Chloe@University: an indoor, mobile mixed reality guidance system

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**CR Categories:** I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—;

**Keywords:** Real-time systems, Mixed Reality, Virtual Human, Localization, Sensor Networks

## 1 Introduction

With the advent of ubiquitous and pervasive computing environments, one of promising applications is a guidance system. In this paper, we propose a mobile mixed reality guide system for indoor environments, Chloe@University. A mobile computing device (Sony's Ultra Mobile PC) is hidden inside a jacket and a user selects a destination inside a building through voice commands. A 3D virtual assistant then appears in the see-through HMD and guides him/her to destination. Thus, the user simply follows the virtual guide. Chloe@University also suggests the most suitable virtual character (e.g. human guide, dog, cat, etc.) based on user preferences and profiles. Depending on user profiles, different security levels and authorizations for content are previewed. Concerning indoor location tracking, WiFi, RFID, and sensor-based methods are integrated in this system to have maximum flexibility. Moreover smart and transparent wireless connectivity provides the user terminal with fast and seamless transition among Access Points (APs). Different AR navigation approaches have been studied: [Olwal 2006], [Elmqvist et al. ] and [Newman et al. ] work indoors while [Bell et al. 2002] and [Reitmayr and Drummond 2006] are employed outdoors. Accurate tracking and registration is still an open issue and recently it has mostly been tackled by no single method, but mostly through aggregation of tracking and localization methods, mostly based on handheld AR. A truly wearable, HMD based mobile AR navigation aid for both indoors and outdoors with rich 3D content remains an open issue and a very active field of multi-discipline research.

## 2 Our Approach

In this section we describe the different modules that we integrate in our solution.

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### 2.1 Virtual Guide Simulation and 3D display

Augmented Reality based virtual guides require robust, cumbersome and complex platforms to be adopted, mainly because of the fine accuracy required to blend virtuality with reality. We decided to adopt a mixed reality approach, less constraining. By using several tracking technologies (see 2.3) we can determine the approximate position of the user, with a precision ranging from ten to one meter. This information is used to determine an area of interest surrounding the user. This way, we show a world-aligned fly-by 3D reconstruction of this area (rooms, walls, hallways, etc.) on the HMD. By attaching an orientation sensor to the HMD, this 3D view always follows the same orientation as the real building. Thus, users can immediately match the abstract information displayed on the HMD with the surroundings.

### 2.2 Path planning and user interaction

To efficiently guide the user, the system needs first to determine the path to follow from the source to the destination. Furthermore, if the user deviates from his/her original way, this path has to be updated accordingly. To compute the path in an efficient manner, a dedicated version of the A* algorithm [Hart et al. 1968] was implemented. The path represented on the map uses a graph to store the position and links between the waypoints. For this purpose a tool was developed within the authoring application 3D Studio MAX to edit the map. Speech recognition will be used to obtain the user's destination.

### 2.3 Fusion of tracking methodologies

The purpose of localization is to provide some kind of location information for nodes in a sensor network. It can be used to identify an unknown mobile node for application requirements and/or to support routing algorithms. To do this, we use three different techniques that we enable, disable or combine according to the context and location of the user in order to improve localization in areas where one of them would lack of accuracy.

As has been noted, any non invasive indoor localization is not precise enough to be able to display convincing AR. For this reason, we chose to render a 3D map displayed on see-through glasses in third-person view. The idea is to point the user to his destination in the same way it would have been done with a traditional GPS navigator. Therefore, the map is always following the same orientation as the user thanks to an orientation tracker attached to the HMD.

A major advantage in using sensor networks for localization purposes is that, they often employ localization on their own for their own purposes (for instance to relate the context information to the actual position) and they will be probably already available in intelligent environments to acquire context information. The localization algorithm first approximates the distance between the mobile sensors and the anchors based on the lognormal propagation model applied to the received RSSIs. Then it uses this information to approximate the location of the mobile sensor in the environment using a standard multilateration technique. To this purpose the algorithm also uses pre-loaded information about the environment (position of the wall, room size, etc) and the position of the anchors.

Wifi Localization localization system presents a major advantage: it runs on any WiFi-enabled device and makes use of pre-existing WiFi access points. For the Chloe@University project, we need a localization system which provides a room-sized precision and a high accuracy. Our system works in two phases: the off-line phase which consists in collecting signal strength data in order to build a signal map, and the real-time phase, corresponding to the localization phase and based on the previously acquired signal map. During the off-line phase, the user creates a navigation graph: each room (or part of corridor) is represented as a vertex of the graph, then the user has to link neighbor vertices between them and records signal data (access point identifiers and signal strengths) for each vertex. After this quick training phase (30 seconds per vertex to capture signal data), the localization system is ready to use: the application takes WiFi samples every 250ms, locates the user (by a simple distance calculation) according to the signal map acquired during the off-line phase. The system uses the navigation graph to ensure that the new position is realistic (close to the previous one), and then avoid the biggest mistakes due to signal noise.

We also used active radio frequency identification (RFID) tags as a second positioning method. It may work as an alternative to the other positioning systems or in collaboration with them in order to provide improved coverage and accuracy especially in confined spaces where the signal strength of the WiFi access points (APs) or sensors network is diminishing. The position is realized using a computing device equipped with a single RFID reader and multiple active tags placed in fixed locations, which act as beacons to obtain the position of the computing device. For accuracy concerns, we are using a triangulation algorithm to estimate the position of the device instead of simply using the location of the tag with the strongest signal the reader receives.

### 2.4 Smart and transparent connectivity

Smart and transparent wireless connectivity aims at providing the user with fast and seamless transition among APs, by using already deployed infrastructures. The proposed approach provides for open APs at the campus entrances, which continuously transmit information about the location and available services. Once the user has supplied the required credentials and authentication has completed successfully, his device receives a set of connection parameters, including an IP address, a Mobility Management Server (MMS) reference, a shared secret, etc. From now on, security should rely on the 802.11i mechanisms, holding the MMS also the functionalities of the Authentication Server. This approach is basically zero-configuration and it assures the independence and privacy of guest and local traffic. In a campus-wide scenario like that one proposed, the whole network infrastructure (and therefore the APs) is very likely to be partitioned into small subsets, matching different organizational units; we envisage the creation of a specific IP subnet for guest users and the usage of a dedicated Virtual LAN (VLAN) between the whole AP set and the MMS: this is essential to avoid any IP-based roaming mechanisms (as Mobile IP) that would inject intolerable delays into the handover procedure. Moreover, the same approach is useful to keep the guest traffic behind a firewall, so to maintain a very fine control on connections from mobile users towards the local network and the Internet and vice versa.

## 3 Implementation

Implementation is planned in two steps. A first prototype is carried out supporting basic functionalities and meant as a basis for the whole project. The system relies on mobile and compact devices. For our tests, we targeted two different hardware and software architecture: the first one running on an ultra-mobile PC Sony Vaio UX70 (Windows XP/Vista), the second one running on a Dell Axim x50v PDA (Windows Mobile 5). We used a Liteye-500 monocular see-through head-mounted display in both setups. The main core is written in C++ using a dll-based pluging system and the MVisio graphics engine [Peternier et al. 2006]. Each localization technology features a shared interface accessed through dynamic librairies: switching from one technique to another is just a matter of loading another DLL and rebind the methods. So far, the whole platform is running onboard of the UMPC or PDA (in step two the data manager will be moved to a remote server). Orientation tracking has been achieved using the MTx inertial sensor from XSens, over USB or Bluetooth for wireless transmission. This sensor is attached on the HMD as we need to map the pitch and yaw information to the orientation of the map displayed in mixed reality.

First indoor localization experiments using the WiFi network have been conducted inside our laboratory. The results showed that the precision was limited to minimum 5 meters. However, it proved a remarkable consistency for locating the user in the radius of a room. A second series of tests performed in real contexts showed that the necessary parameterization task can easily be performed in less than 5 minutes for an optimum localization performance. The hardware (UMPC, see-through HMD, inertial tracker, batteries) we used for this experiment fits in a large pocket and is relatively unobtrusive during normal day-to-day activities.

## Acknowledgements

The work presented is being supported by the EU project INTERMEDIA, in the frame of the EU IST FP6 Program.

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