

# Location-aware visualization of a 3D world to select tourist information on a mobile device

Luca Chittaro  
HCI Lab  
Dept. of Math and Computer Science  
University of Udine  
via delle Scienze 206, 33100 Udine, Italy  
+39 0432 558450  
chittaro@dimi.uniud.it

Stefano Burigat  
HCI Lab  
Dept. of Math and Computer Science  
University of Udine  
via delle Scienze 206, 33100 Udine, Italy  
+39 0432 558457  
burigat@dimi.uniud.it

## ABSTRACT

In this paper, we present an approach to the selection of tourist information on a mobile device which could be usefully applied in the context of location-aware mobile guides and which is based on two specific aspects: supporting users' navigation by providing them with a 3D representation of the area they are exploring and allowing users to easily obtain information on the objects they are interested in by directly selecting them on the 3D representation. We will describe the functionalities of the prototype system we implemented to test this approach and provide some observations obtained from the informal user testing we carried out.

## Categories and Subject Descriptors

H.5.1 [Information interfaces and presentation]: Multimedia Information Systems – *Artificial, augmented, and virtual realities*.  
H.5.2 [Information interfaces and presentation]: User Interfaces – *Interaction styles, evaluation*. I.3.6 [Computer graphics]: Methodology and techniques – *Interaction techniques*.

## General Terms

Algorithms, Experimentation, Human Factors.

## Keywords

Mobile guides, 3D virtual worlds, mobile devices, interaction style.

## 1. INTRODUCTION

In recent years, mobile guides have been object of a widespread interest. The main advantage of these systems over more traditional Touristic Information Systems is the possibility to access many different services from portable lightweight devices, such as PDAs or high-end mobile phones. Tourists, businessmen and occasional users may thus benefit from up-to-date contextual information while traveling.

Two important services that are usually provided by most mobile

guides are *navigation support*, that allows users to obtain directions to navigate an environment, and *information delivery*, that allows users to obtain information on the points of interest located in the visited area. The usually adopted solution to provide the two above mentioned services is to employ graphical representations such as 2D maps. Some researchers (e.g. [1,2,8]) are also investigating 3D graphics as a more intuitive and user-friendly way to provide information on the explored area. However, limitations of current mobile devices make it difficult to obtain a smooth navigation of 3D representations, especially when complex environments (e.g., full cities) are taken into consideration.

In this paper, we will describe our experience in the design and implementation of a prototype location-aware mobile guide which uses 3D graphics to visualize the area the user is currently exploring and allows the user to request information on the objects of interests by directly pointing to their representation in the 3D world.

## 2. LOCATION-AWARE MOBILE GUIDES

Many location-aware mobile guides have been developed in recent years, following the pioneering work of the Cyberguide [3] and GUIDE [4] projects. Location-awareness is a basic feature of all these applications and allows for services such as navigation support to be easily provided to users. The current position of the user may be obtained using different techniques. For outdoor applications, satellite-based approaches, such as GPS, are the most used. Their main problem is the need to maintain contact between the receiver and at least four satellites to obtain a sufficient accuracy and this may represent a critical issue in urban areas. To obtain better results, it is possible to employ correction methodologies such as DGPS (Differential GPS) and AGPS (Assisted GPS) or to use MPS (Mobile Phone Positioning) techniques which exploit the cellular phone infrastructure to locate the user. For indoor applications, it is necessary to use specific approaches such as ultrasounds, radio frequency or infrared.

Most of the implemented location-aware mobile guides use 2D maps to show the area where the user is located, pinpointing her position and, usually, providing visual information on the route she has to follow to reach specific destinations (e.g., [7]). Information on the currently explored area can be provided by means of two methods: using a *pull* technique, where users have to select their objects of interest clicking on sensible spots on the map or through lists, sometimes filtered according to the context

(e.g., in the CRUMPET project [9]), or using a *push* technique, where information is automatically provided to users when they approach the objects of interest (e.g., in the GUIDE project [5]). Mixed approaches are also being used such as in the REAL project [6], where data is gradually provided to users as they remain in a certain area, but detailed information on the points of interest must be manually requested by interacting with the map.

Recently, some attempts have been made at using 3D graphics on mobile devices for navigation assistance and information delivery. Rakkolainen et al. [2] have developed a system that combines a 2D map of an area with a 3D representation of what users are currently seeing in the physical world, studying the effects of 3D graphics on navigation and wayfinding in a urban environment. They found that 3D models help users to recognize landmarks (i.e., distinctive features of an environment that can be used as reference points during navigation) and find routes in cities easier than using traditional 2D maps. 3D city models for route guidance have been tested also by Kulju et al. [1] who obtained similar results and highlighted the need for detailed modeling of buildings and additional route information such as street names. Both projects focused only on navigation support and no information delivery service about points of interest was provided. Unlike the previous experiments, TellMaris [8] supports different mobile platforms, providing a *full-featured* mobile guide which is able to visualize 3D maps along with more classical 2D maps. The 3D maps support navigation in a city and route finding to points of interest such as city attractions or restaurants. There is, however, no feature allowing users to directly obtain more detailed information about the area they are visiting by interacting with the 3D maps. In the BPN project [11] 3D maps of the environment (consisting of 2D maps on top of which abstract 3D models of the landmarks and additional meta-graphical elements are placed) are used to support pedestrian navigation. Using the PDA's stylus users can interact with a map to select its elements and can then verbally query the system about the selected objects.

### 3. THE PROPOSED APPROACH

#### 3.1 Overview

When tourists are visiting a city they can be interested in several different kinds of information (e.g., history, culture, art, entertainment, dining, sports, shopping, ...). Therefore, they often take with them paper guides to be consulted when needed. However, this is not always a quick and efficient way to obtain the needed information. Mobile guides may represent a better alternative. They can be used on lightweight mobile devices, providing an easy (partially automated) access to the various classes of information, they can manage multimedia information, enriching the visiting experience, and they usually provide many other useful services for the tourist, such as tour planning, weather forecast, opening times for city attractions and shops, online bookings and so on.

As we have seen in the previous section, information may be provided by means of a pull approach, a push approach or a combination of the two. With a pull approach users are more in control of the system and can request information when they need it. A limitation of this approach in current mobile guides is that finding information is not always quick and efficient as it should be because it often involves scrolling lists of available items or

querying the system or trying to figure out where the relevant point of interest is located on a 2D map of the visited area.

We try to overcome this limitation by combining a 3D representation of the currently visited area (see, e.g., Figure 1) with the possibility to directly select the objects of interest in the 3D representation. This solution aims at making it easier for the user to obtain the desired information about an object. The easiest way for the user to ask information about a building or some other point of interest in a city is to point at it with a finger. Our system supports this by allowing the user to touch her objects of interest in the 3D representation of the city using a finger or a pointing device such as a stylus.

A tourist is usually interested in the buildings or objects she is looking at, while information on other objects becomes more relevant later. By making the 3D representation location-aware, our system makes the information about the closest points of interest easily accessible to the user: in this way, we propose a natural filtering criteria based on proximity. However, it should be possible for the tourist to request information also through more traditional techniques which take into consideration all the available objects in the area.



Figure 1 – 3D representation of a city square

The available information about a selected object is provided in a separate window (see, e.g., Figure 2). Only textual information, organized in separate pages for better readability, was used for the purpose of testing our prototype, but adding richer media such as HTML pages with 2D pictures is straightforward.

Three navigation modes are available to the user in our system. In *manual navigation*, the user changes her point of view by manually moving it in the 3D world using specific buttons available in the user interface. The second mode is *automatic navigation* based on the actual position and orientation of the user: the system is responsible for gathering the necessary information from a GPS device and for changing the viewpoint so that the visualized 3D representation corresponds to the actual viewpoint of the user in the physical world. The third mode is

*replayed navigation*: the system uses position and orientation information previously recorded by a human guide or by users themselves to propose a virtual tour in the city.

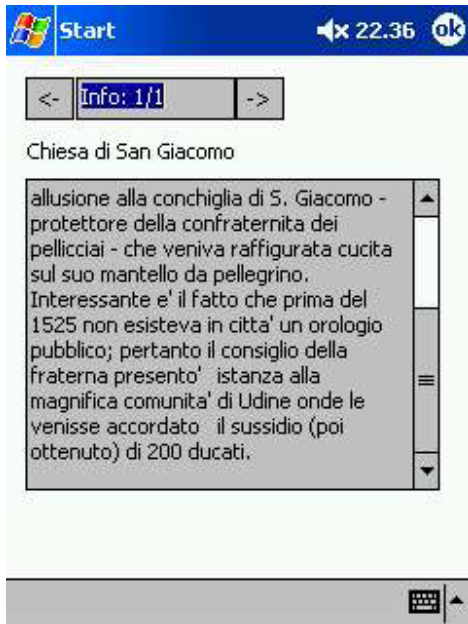


Figure 2 – When tapping on the church in Figure 1 a related information window appears

### 3.2 User Interface

Figure 3 depicts the interface of the first prototype system we have developed. Two main parts may be identified: an upper area where the actual 3D representation is visualized and a lower area providing status information to the user and allowing access to the tools for setting the system and moving in the environment. The lower area may be further subdivided into a *Menu area* containing all the commands for managing files, changing system options and activating the GPS, a *Control area* where the buttons for manually navigating in the 3D representation are located, a *GPS area* providing visual feedback to the user on the status of the GPS, an *Information area* showing position and orientation of the user, currently selected object and availability of additional information (which can be retrieved by clicking the Info button), a *Status area* providing feedback on what the system is currently doing.

In the Control area, four buttons allow the user to manually navigate the 3D world while the top button opens a special window where the user can manually specify coordinates in the world or can choose a predefined viewpoint among the available ones.

By using the options in the Menu area, the user can change some of the parameters of the system. In particular, it is possible to vary the speed and the viewpoint angle for manual navigation and set some GPS options such as communication port, operation mode (with real data or replayed data) or data logging activation (for recording data to be used in replayed navigation).

In the GPS area, starting from the top, there is a letter indicating the navigation mode (M for manual navigation, R for replayed navigation and G for automatic navigation using GPS), a virtual

led indicating if the GPS is activated (green color), deactivated (gray color) or idle (yellow color), a color rectangle providing feedback on the received data (green color for valid data, red color for invalid data, gray color for no data availability) and an area showing the number of available satellites.

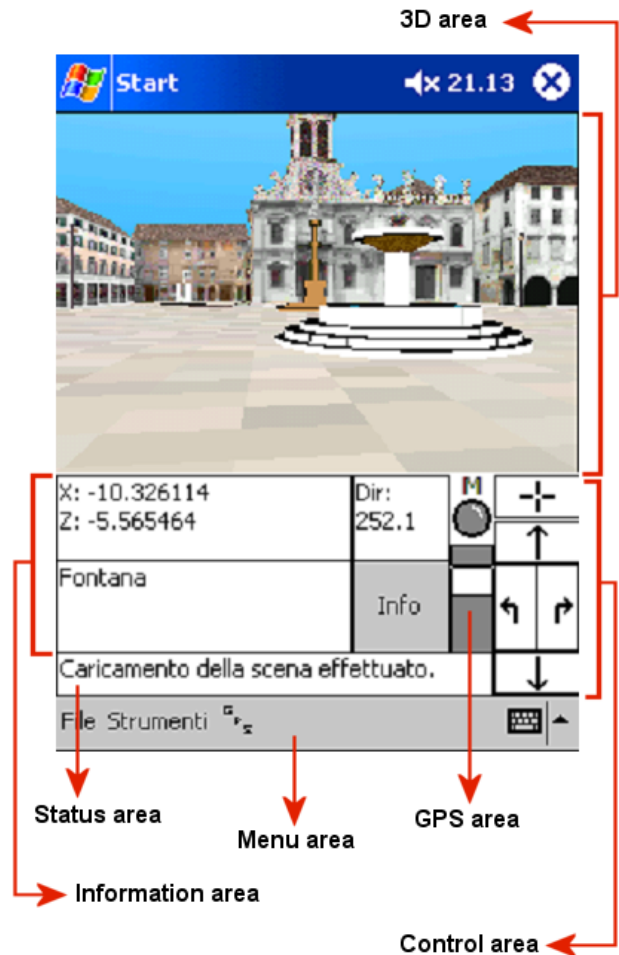


Figure 3 – The user interface of the system

### 3.3 System architecture

In the current version of the system, all data (geometric data on the environment and information on the objects) as well as all computing modules are stored locally in the memory of the mobile device. Although this could be a limitation for a full-featured mobile guide, which might benefit from the possibility of downloading information wirelessly by exploiting a client-server architecture, it allows for a faster data retrieval and was sufficient for our main goal which was to evaluate the effectiveness of using a 3D representation as a way to access information.

The architecture of the system is depicted in Figure 4. The *User Interface* allows the user to manually navigate the system, access system options, look at status information and request additional information on the objects of interest. The *GPS Component* is the module which is responsible of providing the other modules with the actual position and orientation of the user, obtaining them from the GPS unit. Internally, it parses the flow of GPS data,

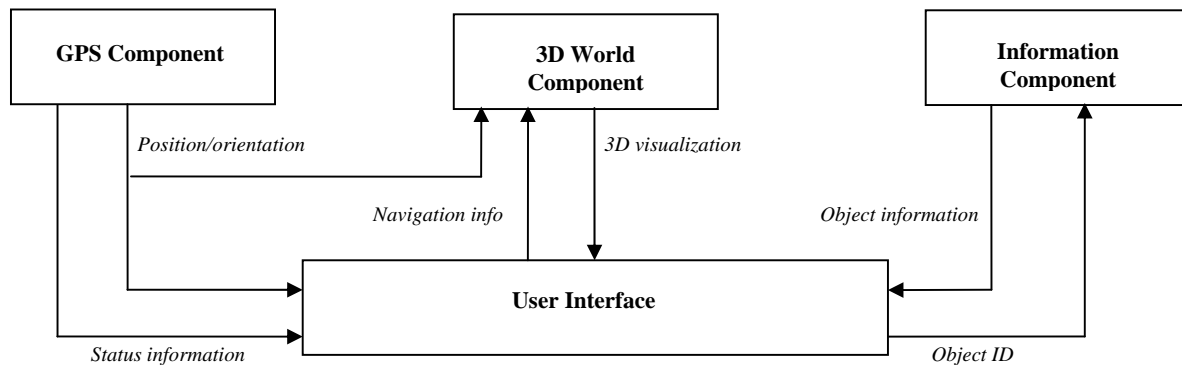


Figure 4 – System architecture

acquiring the necessary information, and stores this information in a special data structure for further use by the system. It also manages the status of the GPS unit, providing this information to the user through the User Interface. The *Information Component* is devoted to manage the information on the objects of interest in the city. When the user selects an object on the 3D world, this module provides the corresponding available data in a separate window. All the information about the objects is stored locally on the device in XML files. It would be however possible, in a future version of the system, to retrieve this data from a remote database and automatically format it according to the DTD (Document Type Definition) accepted by the system. The *3D World Component* is responsible for the management of the 3D representation. It exploits the Pocket Cortona browser from Parallelgraphics for visualizing the geometric data on the environments and, among other functionalities, it has to be able to manage large-scale environments efficiently and to update the viewpoint according to the navigation mode.

#### 4. PROTOTYPE EVALUATION

The system has been tested on the field (Figure 5) in a square of the city of Udine, for which we have produced a detailed 3D model available at [10]. The Web version of the model did not produce an acceptable frame rate on the PDA so we had to apply some simplifications to improve the performance. In particular, we simplified some complex objects, removing unneeded geometries, optimized the textures by reducing their resolution, and eliminated unessential elements of the representation.

We carried out only an informal evaluation with four users to obtain qualitative observations on the system and point out problems. We activated data logging (allowing us to use replayed navigation) and video recorded users to better study the behavior of the system.

After the 3D representation of the environment was loaded users had to activate the GPS using the special icon on the Menu area. When a sufficient number of satellites was acquired (all icons in the GPS area were to be green) users could freely move in the square and use the PDA's stylus to tap their objects of interest in the 3D representation (which was synchronized with the users' view in the physical world) and obtain information on them.

Users found the system easy to use because of the minimal effort needed to interact with it (which consisted only in tapping the

objects of interest and the Info button to get information). Moreover, users had no difficulty matching objects in the physical world with the 3D representation.



Figure 5 – Testing the prototype on the field

While the comments of the users about this way of getting information were positive, some negative issues emerged during the use of the system. The most critical problem was the accuracy of the positioning which was not always sufficient because of poor GPS precision. In some occasions, especially with cloudy weather, errors were up to 10 meters and, consequently, the visualized 3D representation did not adequately correspond to the actual viewpoint of the user in the physical world. To reduce errors, we employed an averaging technique which is used only when the user is not moving and allows to improve the positioning accuracy. It is also highly likely that, while walking on the streets of a city, there would be situations when satellite visibility will not be sufficient to allow for accurate GPS tracking. In those situations, the system informs the user by showing the number of available satellites and a qualitative estimate of the data accuracy. However, when no useful data is available, the user has to navigate in the 3D representation by using the manual controls. Another related problem concerns the viewpoint: when the user is moving, her current orientation can be automatically obtained from the GPS data but when the user stops deriving this data can be more

difficult. An alternative and more interesting solution would be to integrate an electronic compass to obtain accurate orientation information.

With respect to the 3D representation, users found the graphic quality sufficient but they pointed out some problems which occurred in particular situations. When the user is near a building, for example, the low resolution of the textures, which was necessary for improving the frame rate, becomes evident. Moreover, it is impossible to modify the inclination of the viewpoint while navigating and it is thus difficult to easily look at an object when the user is too close to it.

Finally, users complained that there is no visual indication of which objects have additional information associated: the information area gives feedback to the user (possibly with a "Object without info" message) only after selecting an object.

## 5. CONCLUSION AND FUTURE WORK

As pointed out by previous research in this area, using 3D representations in a mobile guide seems a promising direction. From the experience with the prototype described in this paper, having the possibility to actually see in a mobile device what one is looking at in the physical world and to easily request information on the objects of interest by pointing at them are features which users find very useful and natural to use. Computational limitations of current mobile devices do not allow for a sophisticated use of 3D graphics in mobile guides but the situation is gradually improving and more powerful devices, equipped with dedicated 3D hardware, will be available in the near future.

As we have seen, the informal user testing we carried out on the system highlighted some problems and we are currently working at solving them before a more formal experimental evaluation can be carried out.

## 6. ACKNOWLEDGMENTS

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