Towards More Personalized Navigation in Mobile Three-dimensional Virtual Environments

Teija Vainio
Hypermedia Laboratory, University of Tampere,
Kanslerinrinne 1, 33014 University of Tampere, Finland
teija.vainio@uta.fi

ABSTRACT
Adaptive information systems and adaptive user interfaces are important issues for design when human computer interaction is being studied in large information systems. Three-dimensional virtual environments can be defined as visually emphasized large information spaces. Designing a user interface that adapts automatically according to user's behavior or an interface that adopts according to user's own choices can be seen as an assistance tool for navigation in three-dimensional environments. This paper presents an approach in which adaptive support to three-dimensional virtual environments is provided. This approach is grounded on three basic concepts related to the locating of a user, to the adapting of three-dimensional environment automatically, and the adopting environment by user. In conclusion, some preliminary guidelines for designers to support a user's navigation in three-dimensional virtual environments are presented.

ACM Classification Keywords
H.5.2 User Interfaces: Graphical user interfaces (GUI), and H.5.1 Multimedia Information Systems: Artificial, augmented, and virtual realities

INTRODUCTION
Three-dimensional (3D) virtual environments have been used for several years to visualize information. On the other hand, the problems of using large information systems have been one major cause for the development of adaptive information systems and user interfaces. It is not possible to offer "all things to all" in large information systems, and a diversity of users should be taken into account In applications utilizing 3D virtual environments, navigation is one of the key usability challenges from the users' point of view. Navigation in 3D environments has been studied widely, e.g., [5], but as it is argued here, research of adaptive 3D environments that aim to support users to navigate better is not as abundant. Some projects, primarily related guides for tourists [3] already exist, but challenges of designing adaptive 3D environments for mobile users are not widely known. In addition, in mobile applications one focus is turning to more personalized and more context-aware applications than, for example, in adaptive information systems for wired applications.

Navigation is a process of moving through an environment There are different kinds of navigation; it can e.g., be goal-directive or explorative [5]. Way finding is an essential part of navigation. The tasks of way finding can be categorized as naïve search, primed search, and exploration. Purposeful movement during navigation improves with increased spatial knowledge of the environment. Spatial knowledge can be described as three-level information: landmark knowledge, procedural knowledge and survey knowledge. [5] It is stated that most of the users are not willing to spend too much effort in navigating in the environment [3]. An adaptive user interface can be defined as "a software artifact that improves its ability to interact with a user by constructing a user model based on partial experience with that user" [7]. Adaptive user interfaces can be focused, e.g., to a task of information or content-based filtering, a task of recommendation, a task of social or collaborative filtering, and a task of optimizing. [8] Designing adaptivity and adaptability is based on a theoretical model about the user's behavior. A user model describes what is known about the user and the user's interests. [7]. Furthermore, the user's interests can be classified, e.g., the users' short-term interests (such as current tasks), long-term interests that are stable (such as work or a learning path) and to hybrid interests, which include both of these. [8]

TOWARDS MORE PERSONALIZED NAVIGATION
One solution to develop adaptability and support navigation in 3D environments is to use personal agents, e.g., intelligent virtual agents.[6] In this paper the main focus is on finding navigation assistance from the 3D environment itself, not from additional tools. In previous studies it has been stated that with agents like numens, which are bound to a user, and *genius loci*, which are related to interaction areas or locus, a user's interaction can be observed and adapt the environment to his/her needs. [2] Approaches of this kind are directed mainly for wired users. In case when the 3D environment is displayed in a small screen for mobile users, first of all, finding a space enough to display a recognizable agent is not easy, and furthermore, the com-

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munication traffic needed between a user, a genius loci, and a numen [see 2] can overload the network connections and cause extra delays in using of the system. Recent studies have also suggested that it would be useful if 3D systems were able to adjust the elements of a user interface based on tracking of the position of users. In addition, target sizing, target positioning and movement angles are the key issues for navigation. [6]

This study aims to continue in this direction by defining additional factors that are properties of 3D environments themselves. In this paper, two basic assumptions are made. The first one is that the location of a user is known and log data of his/her movements is saved. The other assumption is that the task of navigation is way finding. It is also argued here that the distance of the actual user's location and the location of the objective is being searched for is the most essential factor when adaptability is to be implemented in 3D environments. Utilizing the location of a user implicates context-awareness mobile applications. The 3D environment should somehow visually change while the user is approaching the object he/she is searching for. This can be done in several ways, e.g. by creating symbols or changing the brightness of the objects in the 3D environment. It is argued here that the system should automatically adapt if the navigation and way finding are more goal-oriented, and therefore the user is able to concentrate on finding something rather than to navigate in the system. The user's speed, position, and orientation seem to be some key issues in mobile navigation systems [1]. Furthermore, the task (e.g. way finding), navigation style (goal-oriented or explorative navigation), manipulation of UI (scalability and zooming), the levels of detail of the 3D model, and user specific issues are seen as categories of the adaptive 3D environments. If way finding is goal-oriented, the relevance scale of objects searched for should be visualized to a user, for example, by changing the brightness of the objects in the 3D environment. Furthermore, if navigation is explorative, a user should be able to adopt a system himself/herself more actively, for example, by downloading his/her own preferences, such as his/her *personal navigation style* or his/her *personal landmark setting* in the system. A user should also be able to use an environment as a client side application, for example, by marking his/her own routes in an environment. It is assumed here that no other data except the user's actual location, orientation and navigation path is gathered actively by the system. The task of navigation in this case is way finding. The guidelines are presented according to two navigation styles: goal-oriented and explorative. The former is more specifically defined when way finding is more like a formal learning situation, and the latter is more an informal learning situation. Based on this distinction, in the goal-oriented way finding the system is more active by adapting the environment, and in the explorative way finding the user has a more active role.

Goal oriented navigation (the system is adapting)

- **Moving speed**: The speed of the user's movement slows down automatically as the user is approaching the target.
- **Manipulation of UI**: The 3D environment automatically changes visually, e.g., by changing the brightness as the user is approaching the target.

Explorative navigation (the user is adopting the system)

- **Moving speed**: The speed of the user's movement should be free.
- **Manipulation of UI**: The user is able to make his/her *personal preferences*, e.g., a navigation style or personal symbols for landmarks, directly to the 3D environment. The system visualizes the routes and places where the user has already been automatically or by the user's remarks.

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