

Enhancing Wayfinding Abilities in a Large-Scale Virtual City by Schematization

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Abstract. People have severe problems in orienting in large-scale virtual environments and in acquiring survey knowledge of these environments. In our research, we aim at enhancing wayfinding in virtual cities (VCs), which are 3D models of (usually existing) cities. Here, the navigation problems apply in particular. To support navigation, we propose to apply concepts and methods of schematization to focus on the relevant information in representing VCs. To this end, we need to investigate processes which play a role in forming mental representations of city environments, processes that are used in schematizing virtual cities, and the interplay of these processes. We further propose to use a cognitive agent for evaluating different schematization principles applied to a VC by simulating wayfinding tasks.

1 NAVIGATING IN VIRTUAL CITIES

Navigation in large scale virtual environments is a difficult task. People have severe problems in orienting in a virtual environment and in acquiring survey knowledge of that environment. Some of these problems can be attributed to the absence of vestibular and/or proprioceptive stimuli, but many wayfinding difficulties and spatial behavior issues within virtual environments are still poorly understood (Nash et al, 2000). A lot of research has been done on assisting people to improve their navigation performance (e.g., Darken & Siebert, 1993, 1996). Different kinds of assistance can be provided, for example maps to ease orientation. Also, the environmental structure itself can be enhanced. This requires knowledge about the structural features of an environment that enhance the navigation performance; which again is dependent on the navigation task, on the way the virtual reality is presented, and on the kind of environment.

We deal with virtual cities (VCs), which are 3D models of (usually existing) cities that try to represent them as they are. Virtual cities are large, complex virtual environments that inherit the structural features of the represented city. They aim at evoking the illusion of moving in the real city. Navigational problems as outlined above apply here in particular.

Depending on the field of application, different approaches try to construct a legible virtual city (e.g. Ingram & Benford, 1996; Conroy-Dalton, 2002; Omer et al., 2005). All approaches aim for a structure that enhances wayfinding in a VC. The foundation of legibility in real cities was laid by Kevin Lynch (1960) who analyzed which structural elements of a city allow for robust navigation performance. ‘Robust’ refers to a navigation that is based on a coherent mental representation of an environment and that can be performed (mostly) unaided and error-free. The idea of ‘legibility’, and the closely related ‘imageability’, can be understood as how easily someone can identify physical features in a city layout that are important to form an ‘image’, i.e. a mental representation of the layout. Lynch identified five key components: paths, edges, landmarks, nodes, and districts. Many researchers take these features into account when designing a virtual environment. Ingram and Benford (1996), for example, explore algorithms for constructing a structural design of virtual cities by automatically creating or enhancing legible features.

In the case of virtual models of real cities, the problem is different. Here, the real city may have a legible structure or it may not. Key features for easy navigation may be present or they may not. How can we support navigation in areas which do not have a clear structure? One way to deal with this problem is to emphasize certain structural elements and to reduce information for others so that there are highlighted spots at crucial areas. This approach of information emphasis and reduction is known as schematization (Klippel et al., 2005). The central question is to identify spatial information that is crucial for the navigation task, information that may not be necessary but helpful, and information that interferes with the navigation task. Our goal is to create a schematized representation of VCs which is cognitively adequate. We deal with Strube’s second definition of ‘cognitively adequate’: a representation that supports cognitive processes (Strube, 1992). We aim at constructing a representation of a virtual city that reduces cognitive effort and is easily navigable by people.

2 CONSTRUCTING A SCHEMATIZATION MODEL

In this section, we outline our approach to schematization in virtual cities and the goals of our project. To construct VCs that are easily navigable and allow acquiring survey knowledge, we need to understand what makes an environment legible. Consequently, we need to investigate processes involved in navigating such environments and their interplay. Those processes that play a role in forming mental spatial representations of city environments are investigated in empirical human subject studies. In these ex-

periments different hypotheses about mental schematization will be tested. Here, we need to take into account that schematization is not a universal process but is task-specific, environmentally situated, and conditioned by specific actions (Freksa, 1999).

We also need to investigate processes that are used in schematizing virtual cities. This will be done using a virtual cognitive agent. Based on our initial assumptions about schematization of real-world environments, the cognitive agent allows testing different schematization principles and methods applied to a VC by simulating wayfinding tasks. The agent will explore a VC and will build up an internal representation of it. This internal representation illustrates which objects or configurations the agent has memorized and how they have been schematized internally. By testing the navigation behavior of the agent we can draw conclusions about the navigation performance resulting from using the tested schematization principles.

Both research approaches in their interplay will advance each other. On the one hand the agent model will be adapted to the results of the empirical human subject studies. On the other hand experiments with the virtual agent will result in new questions that need to be answered in different studies. The combination and interaction of both approaches will provide information that is crucial in creating a schematization model for enhancing human navigation performance in a virtual city. A possible application is making the emerging internet VCs more legible. Currently, it is only possible to fly over a few 3D models of some cities; but in the near future it can be expected that it will be possible to virtually visit cities, walk through them, and acquire survey knowledge before getting to their real-world counterpart.

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