A Road-Based 3D Navigation System in GIS: A Case Study of an Institute Campus

Vijay Kumar Bansal, National Institute of Technology Hamirpur H.P., India*

ABSTRACT

A user-controlled navigation system is one of the important aspects of human-computer interaction. Finding best path from one location to another and navigating through that path has been a great concern in the geo-virtual navigation. Earlier studies on the geo-virtual navigation systems mainly focus on navigation and visualization, but lack in geo-spatial analysis. Geo-spatial analysis is the domain of geographic information systems (GIS) in which 3D geo-spatial information is used for navigation, geo-visualization, and geo-spatial analysis. The present study deals with wayfinding in the road network of the campus of National Institute of Technology (NIT) Hamirpur, India, in a hilly terrain. It facilitates perform various types of geo-spatial analyses on the road network and virtual travelling in a 3D space.

KEYWORDS

navigation, optimal path, travelling, Virtual reality, wayfinding

INTRODUCTION

Navigation is the process of monitoring and controlling the movement of a person or a vehicle from one location to another. It requires *navigational awareness* which includes complete spatial knowledge of an area. People generally acquire spatial knowledge of an area through direct personal experience or by viewing maps. *Navigational awareness* includes two types of knowledge (Satalich, 1995). First, called *route knowledge*, is gained by the personal exploration of an area. A navigator goes from one location to another through the known route but does not recognize alternate routes or shortcuts. A navigator having *route knowledge* may know the approximate distance between the locations frequently traveled (Allen and Kirasic, 1985). Second, called *survey knowledge*, is attained by multiple explorations of an area through multiple routes. It generates a bird's eye view of the physical map of an area in the mind of a navigator (Goldin and Thorndyke, 1982). The *survey knowledge* gained through the personal physical exploration of an area is called *primary survey knowledge*. The *survey knowledge* gained through maps or pictures is called *secondary survey knowledge* (Presson & Hazelrigg, 1984). Complete *navigational awareness* means that a navigator has both *route* and *primary survey knowledge* (Thorndyke and Hayes-Roth, 1982).

DOI: 10.4018/IJAGR.316887

*Corresponding Author

This article published as an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/) which permits unrestricted use, distribution, and production in any medium, provided the author of the original work and original publication source are properly credited.

Gaining *route knowledge* does not guarantee of having *survey knowledge*, although this frequently happens. To achieve complete *navigational awareness*, a navigator has to go through the *sequential and hierarchical* model which includes: landmark recognition, routes or links identification, and *primary survey knowledge* achieved after significant physical traveling (Satalich, 1995). Landmark knowledge is the memory of salient objects, about their shapes and locations. *Route knowledge* is formed by the integration of landmarks with a path/route. Studying a map before entering in an area is helpful for developing *secondary survey knowledge*; however, signs or narrative directions help a navigator in finding the target location more than using hardcopy maps (Satalich, 1995).

People generally acquire *navigational awareness* through direct experience or by viewing maps. Advancements in information technology (IT) like: simulation of an environment, video, or most recently virtual environment have contributed in various ways to acquire *navigational awareness* (Wu et al., 2009). Fan et al. (2017) provided an overview of past and present road navigation technologies and discussed recent advancements in crowd intelligence and identified unique challenges and opportunities therein. The *navigational awareness* obtained through the use of IT or from virtual environments (VE) is almost similar to learning from real-world physical exploration. IT or VE sometime does not produce the same level of awareness as learning from a real-world physical exploration (Satalich, 1995). However, IT or VE helps in developing a good virtual navigation system. Bowman et al. (1997) divided virtual navigation into two parts: *wayfinding* and *traveling*. *Wayfinding* is finding a path from one location to another. *Traveling* is a virtual movement from one location to another in VE.

Wayfinding involves determining the present location with respect to nearby landmarks/locations and finding a route from a present location to a target location. Spatial processing abilities, familiarity with the existing environment, presence of landmarks, direction pointing, distance milestones, and complexity in the environment's layout are the factors that influence *wayfinding* performance (Farr et al., 2012). *Wayfinding* is the interplay between an individual's characteristics such as age, gender, cognitive development, perceptual capability, spatial ability, mental and physical conditions, and the characteristics of an environment such as size, luminosity, signage, and structure (Allen, 1999). Studies show that the help of a map before entering in an area is beneficial but alone it does not give complete *navigational awareness* in *wayfinding*. Virtual navigational aids have a positive effect on *navigational awareness* (Ropinski et al., 2005). Several virtual navigation techniques have been developed to aid both experts as well as novice users in *wayfinding* (Jwa 2016, Prandi et al. 2021). Despite this, *wayfinding* principles and factors affecting are a set of variables making it a complex process.

Traveling denotes a virtual action performed to get from one location to another. In the real life, a navigator travels straight or can turn his eyes around to explore his surroundings. However, in most of IT or VE, it is not possible to perform such kind of virtual *traveling* because of lack of one-to-one mapping between the locations of a navigator (target) and a camera. In virtual *traveling,* a navigator needs to be aware of his current position, destination, the best path to reach the destination, and the knowledge of his surroundings (Satalich, 1995). The global positioning system (GPS) provides coordinates of a location of interest. GPS has enabled the development of outdoor navigation systems based on the knowledge of a map and the location of a user (Clementini & Pagliaro 2020).

Literature suggests the use of IT to develop the VE to facilitate virtual *traveling*. Yang (2019) developed a mobile mapping system that semi-automatically produces good quality texture information of 3D building models to create 3D urban models by using a hybrid approach. With the availability of building footprints and light detection and ranging (LiDAR) technology, machine learning has provided opportunities to generate large-scale 3D city models at a low cost (Park and Guldmann 2019). Allam et al. (2022) used the metaverse as a virtual form of smart cities to explore opportunities and challenges for environmental, economic, and social sustainability. Quan et al. (2019) explored artificial intelligence-aided design for sustainable city development. Halik and Kent (2021) investigated user preference and behavior associated with 2D and 3D models of urban representation within a novel topographic immersive virtual environment. Ceccarini et al. (2021) developed an integrated

18 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage: www.igi-global.com/article/a-road-based-3d-navigation-system-in-gis-a-case-study-of-an-institute-campus/316887

Related Content

Location-Based Services: A Taxonomy on Theory and Practice
Henrik Hankeand Alf Neumann (2013). *Geographic Information Systems: Concepts, Methodologies, Tools, and Applications (pp. 17-23).*
www.irma-international.org/chapter/location-based-services/70430

An Experimental Study Using SDS Tools for a Participatory Approach to Local Land Use Planning
Piotr Jankowskiand Milosz Stasik (2006). *Collaborative Geographic Information Systems (pp. 150-166).*
www.irma-international.org/chapter/experimental-study-using-sds-tools/6657

State of the Art of HBIM to Develop the HBIM of the HeritageCare Project
Aurélie Talon, Clémence Cauvinand Alaa Chateauneuf (2017). *International Journal of 3-D Information Modeling (pp. 33-43).*
www.irma-international.org/article/state-of-the-art-of-hbim-to-develop-the-hbim-of-the-heritagecare-project/208158

BIM Enabled Approach for Performance-Based Design: Process, Renewable Technology, Design Rules and Assessment
Renas K.M. Sherko, Yusuf Arayiciand Mike Kagioglou (2018). *International Journal of 3-D Information Modeling (pp. 1-27).*
www.irma-international.org/article/bim-enabled-approach-for-performance-based-design/238825

Irregular Light Scattering Properties of Fenestration for Comfortable and Energy-Efficient Buildings
Lars Oliver Grobe (2021). *International Journal of Digital Innovation in the Built Environment (pp. 1-16).*
www.irma-international.org/article/irregular-light-scattering-properties-of-fenestration-for-comfortable-and-energy-efficient-buildings/283113