Chapter 20
A Real Time Topological Map Matching Methodology for GPS/GIS–Based Travel Behavior Studies

Carola A. Blazquez
Universidad Andres Bello, Chile

Pablo A. Miranda
Pontificia Universidad Catolica de Valparaiso, Chile

ABSTRACT

The map matching problem arises when GPS measurements are incorrectly assigned to the roadway network in a GIS environment. This chapter presents a real-time topological decision rule-based methodology that detects and solves spatial mismatches as GPS measurements are collected. A real-time map matching methodology is required in several applications, such as fleet management, transit control and management, and travel behavior studies, in which decision-making must be performed simultaneously with the movement of vehicles, individuals, or objects. A computational implementation in a real case scenario in Chile indicates that the algorithm successfully resolves over 96% of the spatial mismatches encountered in real time. Various algorithmic parameter values were employed to test the performance of the algorithm for data collected every 5 and 10 seconds. Overall, the algorithm requires larger buffer sizes and speed ranges to obtain better results with lower spatial data qualities.

INTRODUCTION

Intelligent Transportation Systems (ITS) are characterized by technological solutions that integrate information processing, communications, control, and electronic devices with transportation management systems and decision support tools (Sophabmixay et al., 2006). ITS aids in achieving goals such as optimizing existing transportation modes, facilitating public service utilization, and improving user quality and service. Rather than physically increasing capacities of transportation infrastructure, ITS intends to use existing capacity more effectively by collecting and pro-

cessing detailed spatial and temporal data about transportation systems (Miller & Shawn, 2001). Global Positioning Systems (GPS) integrated with Geographic Information Systems (GIS) are part of the innovative advanced technology applied by ITS to make transportation systems more efficient, less congested, safer, and less polluting (Drane & Rizos, 1998; Taylor & Blewitt, 2006). Other examples of ITS components being implemented are Advanced Traveler Information System (ATIS), Advance Traffic Management Systems (ATMS), Incident and Emergency Management, Commercial Vehicle Information Systems and Operations, Automatic Vehicle Identification Systems, etc. (Sussman, 2005). The majority of these applications provide vehicle tracking and routing services, in order to perform rapid response decisions.

Automatic Vehicle Location (AVL) integrated with GPS meet the special need of the logistic industry, and thus, is of great significance in the visualization of logistics, dynamic management, and decision analysis (Qingling et al., 2003). For example, the application of AVL/GPS technology in a fleet management system is utilized for accurate positioning and monitoring of moving vehicles and cargo to efficiently dispatch vehicles to meet customer demands resulting in shorter waiting time and lower costs, provide customer information about the cargo, and route guidance when performing pickup or delivery services in an unfamiliar area (Drane & Rizos, 1998; McLellan et al., 1993). In these control and transportation systems, decision makers are in need of performance measures to evaluate achievement of goals and objectives, and to improve logistic operations. Additionally, decision makers must utilize these performance measures, calculated by logistic operations in real time or post-processing, to analyze and evaluate system performance, including fuel consumption, vehicle cost, total travel distance, average vehicle speed, etc.

In the context of the ITS existence, a wide spectrum of geospatial technologies may be em-

ployed as a support tool for decision making at the strategic, tactical, and operational level (e.g., infrastructure design, system management and control) in different areas such as public transportation, freight transportation and industrial logistic systems, fleet management, urban and regional transportation planning, travel behavior studies, among others. Reliable predictions of travel behavior, traffic performance, and traffic safety are required to support long-term decisions. If travel behavior and traffic performance are well envisioned, then forecasts and policy measures will rely on more accurate data (Ramaekers et al., 2013). For example, according to Goulias (2000), ITS and other geospatial technologies play an essential role in the interacting behavior of all participants of the supply chain, e.g., freight shippers and carriers, producers, receivers, goods retailers, and customers. The behavioral aspects of freight transportation should be addressed for proper judgment and decision making of shippers, carriers, customers, and freight forwarders. Moreover, real time information of product status is essential for deciding about freight shipper, carrier mode, route, etc. for the selected type of commodity, and type of business.

Transportation practitioners' global efforts in understanding travel behavior through the collection of GPS data are essential to the planning, design, and operational analysis of transportation systems. Moreover, an adequate understanding and modeling of travel decision variability may improve transportation management and information systems. Travel behavior research may address trip purpose, route and parking choices, travel mode selection, travel modeling, congestion management, transportation system performance, and forecast demand models, which require the identification of accurate track movements of vehicles, individuals and objects along trip segments and routes on a digital roadway map (Dalumpines & Scott, 2011), usually embedded in GIS or AVL systems. Other common applications in this field are studies of behavioral responses to advanced

16 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/chapter/a-real-time-topological-map-matching-methodology-for-gpsgis-based-travel-behavior-studies/128677

Related Content

The Impact of Risks and Uncertainty in the Life Cycle Cost Analysis of Construction Projects: The Case of Energy Analysis on Construction Projects
Konstantinos Kirytopoulos, Vasileios Sarlis, Dimitris Marinakisand Theodoros Kalogeropoulos (2024).
Financial Evaluation and Risk Management of Infrastructure Projects (pp. 32-57).
www.irma-international.org/chapter/the-impact-of-risks-and-uncertainty-in-the-life-cycle-cost-analysis-of-construction-projects/333676

Structure Impact Localization Using Emerging Artificial Intelligence Algorithms
Qingsong Xu (2015). *Emerging Design Solutions in Structural Health Monitoring Systems (pp. 103-123).*
www.irma-international.org/chapter/structure-impact-localization-using-emerging-artificial-intelligence-algorithms/139287

Risk Requirement for Multi-Hybrid Renewable Energy for Marine System
Oladokun Sulaiman Olanrewaju (2015). *Transportation Systems and Engineering: Concepts, Methodologies, Tools, and Applications (pp. 160-173).*
www.irma-international.org/chapter/risk-requirement-for-multi-hybrid-renewable-energy-for-marine-system/128664

Prognostics Design for Structural Health Management
J. Chiachío, M. Chiachío, S. Sankararaman, A. Saxenaand K. Goebel (2015). *Emerging Design Solutions in Structural Health Monitoring Systems (pp. 234-273).*
www.irma-international.org/chapter/prognostics-design-for-structural-health-management/139292

DHS Minority Serving Institution (MSI) Programs: Research Linked to DHS Centers of Excellence (COE)
Kevin A. Petersand Nira C. Taru (2016). *Civil and Environmental Engineering: Concepts, Methodologies, Tools, and Applications (pp. 881-901).*
www.irma-international.org/chapter/dhs-minority-serving-institution-msi-programs/144529