Chapter 1
Visual Mobility Analysis Using T–Warehouse

A. Raffaetà
Università Ca’ Foscari Venezia, Italy

L. Leonardi
Università Ca’ Foscari Venezia, Italy

G. Marketos
University of Piraeus, Greece

G. Andrienko
Fraunhofer Institute for Intelligent Analysis and Information Systems, Germany

E. Frentzos
University of Piraeus, Greece

N. Giatrakos
University of Piraeus, Greece

S. Orlando
Università Ca’ Foscari Venezia, Italy

N. Pelekos
University of Piraeus, Greece

A. Roncato
Università Ca’ Foscari Venezia, Italy

C. Silvestri
Università Ca’ Foscari Venezia, Italy

ABSTRACT

Technological advances in sensing technologies and wireless telecommunication devices enable research fields related to the management of trajectory data. The challenge after storing the data is the implementation of appropriate analytics for extracting useful knowledge. However, traditional data warehousing systems and techniques were not designed for analyzing trajectory data. In this paper, the authors demonstrate a framework that transforms the traditional data cube model into a trajectory warehouse. As a proof-of-concept, the authors implement T-Warehouse, a system that incorporates all the required steps for Visual Trajectory Data Warehousing, from trajectory reconstruction and ETL processing to Visual OLAP analysis on mobility data.

DOI: 10.4018/978-1-4666-2148-0.ch001
INTRODUCTION

The usage of location aware devices, such as mobile phones and GPS-enabled devices, is widely spread nowadays, allowing access to vast volumes of trajectory datasets. Effective analysis of such trajectory data on the one hand imposes new challenges for their efficient management, while on the other hand it raises opportunities for discovering behavioral patterns that can be exploited in applications like traffic management and service accessibility.

Data Warehousing and Online Analytical Processing (OLAP) techniques can be employed in order to convert this vast amount of raw data into useful knowledge. Specifically, the variable number of moving objects in different urban areas, the average speed of vehicles, the ups and downs of vehicles’ speed can be analyzed in a Trajectory Data Warehouse (TDW) and provide us with useful insights, like discovering popular movements. DWs are optimized for OLAP operations that include the aggregation or de-aggregation of information (called roll-up and drill-down, respectively) along a dimension of analysis, the selection of specific parts of a cube (slicing and dicing) and the reorientation of the multidimensional view of the data on the screen (pivoting) (Kimball et al., 2008).

The motivation behind a TDW is to transform raw trajectories into valuable knowledge that can be used for decision making purposes in ubiquitous applications, such as Location-Based Services (LBS), traffic control management. Intuitively, the high volume of raw data produced by sensing and positioning technologies, the complex nature of data stored in trajectory databases and the specialized query processing demands make extracting valuable information from such spatio-temporal data a hard task. For this reason, the idea is to develop specific traditional aggregation techniques to produce summarized trajectory information and provide visual OLAP style analyses.

It is worth noticing that visual representations of data are essential for enabling a human analyst to understand the data, extract relevant information, and derive knowledge. One of the objectives of visualization is to aid abstraction and generalization (Thomas & Cook, 2005). With relatively small and simple data, this can be achieved by appropriate positioning and/or appearance of visual elements representing individual data items. When the data are large and complex, a common approach is to apply computational techniques for data abstraction and generalization, in particular, aggregation. The visualization is then applied to the resulting aggregates. Trajectory Data Warehouse offers a powerful technological support to visual analysis of movement data by efficiently aggregating the data in various ways and at different spatial and temporal scales.

One could mention an abundance of applications that would benefit from the aforementioned approach. As an example, let us consider an advertising company which is interested in analyzing mobility data in different areas of a city in order to decide upon road advertisements (placed on panels on the roads). More specifically, the analysis concerns the demographical profiles of the people visiting different urban areas of the city at different times of the day so as to decide about the proper sequence of advertisements that will be shown on the panels at different time periods. This knowledge will enable the company to execute more focused marketing campaigns and apply a more effective strategy.

The above analysis can be efficiently offered by a TDW. However, various issues and challenges have to be considered to develop such a system:

- The presence of a preprocessing phase dealing with the explicit construction of the trajectories, which are then stored into a Moving Object Database (MOD) that offers powerful and efficient operations for their manipulation.