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Chapter IX

Simple and Incremental Nearest-Neighbor Search in Spatio-Temporal Databases

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Abstract

The efficient processing of nearest-neighbor queries in databases of moving objects is considered very important for applications such as fleet management, traffic control, digital battlefields and more. Such applications have been rapidly spread due to the fact that mobile computing and wireless technologies nowadays are ubiquitous. This chapter presents important aspects towards simple and incremental nearest-neighbor search for spatio-temporal databases. More specifically, we describe the algorithms that

have already been proposed for simple and incremental nearest neighbor queries and present a new algorithm regarding that issue. Finally, we study the problem of keeping a query consistent in the presence of insertions, deletions and updates of moving objects.

Introduction

Spatio-temporal database systems aim at combining the spatial and temporal characteristics of data. There are many applications that benefit from efficient processing of spatio-temporal queries, such as: mobile communication systems, traffic control systems (for example, air-traffic monitoring), geographical information systems and multimedia applications (Wolfson, Xu, Chamberlain & Jiang, 1998; Theodoridis, Sellis, Papadopoulos & Manolopoulos, 1998). A dataset of moving objects is composed of objects whose positions change with respect to time (for example, moving vehicles). Examples of basic queries that could be posed to such a dataset include window queries, nearest-neighbor queries and join queries.

Queries that must be evaluated for a time interval $[t_s, t_e]$ are characterized as continuous (Tao, Papadias & Shen, 2002). The research conducted in access methods and query processing techniques for moving object databases are generally categorized in the following areas:

- Query processing techniques for past positions of objects (Nascimento & Silva, 1998; Pfoser, Jensen, & Theodoridis, 2000; Tao & Papadias, 2001, 2002).
- Query processing techniques for present and future positions of objects (Kollios, Gunopoulos & Tsotras, 1999; Agarwal, Arge & Erickson, 2000; Saltenis, Jensen, Leutenegger & Lopez, 2000; Procopiuc, Agarwal & Har-Peled, 2002; Lazaridis, Porkaew & Mehrotra, 2002).

We focus on the second category, where it is assumed that the dataset consists of moving point objects, which are organized by means of a Time-Parameterized R-tree (TPR-tree) (Saltenis et al., 2000). The TPR-tree is an extension of the well-known R-tree (Beckmann, Kriegel & Seeger, 1990), designed to handle object movement.

Among the different types of queries, we focus on the k nearest-neighbor query, which asks for the k closest neighbors to q during a specific time interval $[t_s, t_e]$. An interesting variation of the problem is to compute the $(k+1)$ nearest neighbor, given the result of the k-NN query. This approach requires high computation