A Study on Multi-scale/Multi-theme Map Information Model and Nearest Neighbor Search Method

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With the tremendous growth of applications that rely heavily on geometric data, database researchers are currently devoting their considerable attentions to spatial data management issues. A country-wide Geographic Information System (GIS) is such an application which provides good access to essential geographic information, and makes sound decision in country's economic growths and its social activities. On the basis of GIS, map information management systems have been researched from both of the conceptual model and physical structure.

In this dissertation, we propose a Multi-scale/Multi-theme (M^2) map information model for country-wide integrated map information of different scales for different themes, and a Multi-levels of Object-Relation (MOR-tree) spatial data structure for efficient management of multi-scales of road networks under M^2 model. M^2 map information model can be regarded as a forest consisting of two kinds of trees: one is a directory tree, which is obtained by recursively decomposing the region of a country into a sequence of increasingly finer tessellations with regard to the granularities of administrative units; and another is a series of theme trees, which are obtained by uniquely dividing spatial objects into different themes and then by dividing every

theme into different scales in regard to the important degrees. Also, the theme trees are divided into different tessellations in regard to the directory tree. This information model is powerful to integrate various scales and themes of maps uniformly and possesses advanced extensibility. MOR-tree is an extension of R-tree. Being the most popular access method for spatial object, R-tree is a height-balanced tree with index records in its nodes and can be viewed as a multi-dimensional extension of B-tree. MOR-tree consists of a main hierarchy for indexing spatial objects of multiple levels and composition hierarchies for arranging relations among objects in different levels. The integration of the conceptual information model with the physical data structure has seldom been studied previously. Our work shows a good direction of this research.

In addition, to process searches on multi-themes of map datasets we propose Cyclic Optimal Multi-Step (COMS) method. Multi-themes of map information are different from the "pure" spatial data in that 1) the multi-themes of map datasets are usually indexed by spatial structures, respectively; 2)there are underlying geographical relations among the map datasets. Thus, the search on such kind of spatial datasets is specific. COMS based Nearest Neighbor search on road networks and other map themes is discussed. Experiments show that our method outperforms the state-of-the-art methods on doing such kind of searches. We also expand COMS method and present a set of heuristics for Continuous Nearest Neighbor search based on large scale of road network. The discussion shows that COMS method has potential to provide more efficient search solution to multiple spatial datasets with underlying relations.

The work in this dissertation is discussed based on map information. However, M^2 map information model, MOR spatial structure and COMS search method can be applied to information in other areas with large datasets.