Querying Multigranular Spatio-temporal Objects

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Abstract. The integrated management of both spatial and temporal components of information is crucial in order to extract significant knowledge from datasets concerning phenomena of interest to a large variety of applications. Moreover, multigranularity, i.e., the capability of representing information at different levels of detail, enhances the data modelling flexibility and improves the analysis of information, enabling to zoom-in and zoom-out spatio-temporal datasets. Relying on an existing multigranular spatio-temporal extension of the ODMG data model, in this paper we describe the design of a multigranular spatio-temporal query language. We extend OQL value comparison and object navigation in order to access spatio-temporal objects with attribute values defined at different levels of detail.

Keywords: Spatio-temporal query language, Spatial and temporal granularities.

1 Introduction

As the available datasets are becoming increasingly large and often unnecessarily detailed due to the development of sophisticated collection technologies, effective methods for presenting information to users are required. In such respect approaches able to present the data at different levels of detail (i.e., granularities) represent an effective solution to facilitate the analysis when additional details are only required for specific subsets of the data. For example, zoom-out operations can improve the efficiency of spatio-temporal data mining algorithms, which are time consuming [1]. On the other hand, zoom-in operations can help in refining the mining of specific data subsets. Multigranularity, multiresolution and multiple representation have been investigated first for temporal data [5,6], and more recently for both spatial [2,22] and spatio-temporal data [7,12,19,20].

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In particular, the $\text{ST}_\text{ODMG}$ data model \cite{9} has been defined as an extension of ODMG \cite{10}, the reference model for object-oriented databases. $\text{ST}_\text{ODMG}$ models multigranular spatio-temporal values, relying on the definition of temporal granularity proposed by Bettini et al. \cite{6}, which is commonly adopted by the temporal databases and reasoning community. The model also relies on a notion of spatial granularity compliant with the formalization of stratified map spaces proposed by Stell and Worboys \cite{26}. Moreover, unlike other multigranular models, it incorporates a framework for the conversion of spatio-temporal values at different spatial and temporal granularities.

Since the effectiveness of a model greatly depends on the associated query language, several spatio-temporal query languages have been developed \cite{13,15,17,19}. Among these approaches, in \cite{13,15} SQL:99 has been extended to spatio-temporal support. The extension of SQL proposed by Chen and Zaniolo \cite{13} is based on user-defined spatio-temporal aggregates and functions in order to minimize changes to SQL. Erwig et al. \cite{15} propose an extension of SQL to include spatio-temporal objects defined in terms of abstract data types relying on the abstract framework defined in \cite{18} for moving objects.

By contrast, the approaches by Huang and Claramunt \cite{19} and by Griffiths et al. \cite{17} define how to query spatio-temporal values in an object-oriented paradigm. Huang and Claramunt propose an OQL spatio-temporal extension that includes spatio-temporal operators for evaluating spatial queries and topological relationships; Griffiths et al. propose supporting queries against spatio-temporal objects at application level.

This paper focuses on the access of multigranular spatio-temporal data, which has not been discussed in the previous proposals. Specifically, we investigate the impact of multigranularity on the specification and execution of spatio-temporal queries. Spatio-temporal multigranularity may not be simply supported relying only on data types and operators already available in object-oriented and relational query languages: a specific query language must be designed in order to support accesses to subsets of data that refer to spatio-temporal granules and sets of granules, both explicitly and implicitly represented through constraints against database values. Thus, simple expressions for representing temporal and spatial granules at different granularities must be provided. Furthermore, expressions in a multigranular query language must support multigranular spatio-temporal comparison of attribute values. Moreover, since an attribute can be accessed with granules at a different granularity levels, a suitable set of value conversions to convert spatio-temporal data at different granularities has to be integrated in the query language. Such conversions should support attribute values conversions according to the semantics of the attribute involved in the query. Therefore the types of conversion should vary according to the data types and the semantics of the represented information.

In this paper we propose a multigranular spatio-temporal query language which provides specific solutions to these requirements; its design relies on the multigranular model defined in \cite{9}. The overall conceptual design of a multigranular spatio-temporal model and query language addresses some important issues.