On a Query Language for Weighted Geometries

(Extended Abstract)

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Computational design relies on effective models of geometry, for the creation of (geometries of) design artifacts and the querying of the characteristics of these (geometries). In the search for appropriate solid models, there is a consensus - namely, a solid model has to be complete - that is, the corresponding representations are ``adequate for answering arbitrary geometric questions algorithmically''. However, this statement becomes more difficult to qualify as users and, in particular, designers pose new questions that go beyond geometry and require other information to be included.

Current CAD systems tend to focus on the representation of design artifacts, and on the tools and operations for the creation and manipulation of these representations. Techniques for querying are mostly added as afterthoughts, constrained by the data representation system and methods. Yet, querying a design is as much an intricate aspect of the design process as is the creation or manipulation thereof. In this paper, we explore the foundation of a query language that allows for a rich body of queries, using both geometric and non-geometric data, and incorporating spatial rules as a syntactical expression for pattern matching on geometries.

Independent of whether the questions or queries posed are purely geometric or require other types of data, it is important that the data be accessible in a uniform and straightforward way, such that new queries can be constructed and posed without having to alter the representational model or the access mechanisms in any way. Such a query language can only be developed if based on a uniform model for representing different types of information, as well as a model that adheres to a consistent logic using simple and straightforward operations. We present an algebraic model that is based on a part relationship for weighted geometries, i.e., geometries with non-geometric attributes. The algebraic model applies to spatial as well as non-spatial elements and to geometries of different dimensionality. It defines arithmetic operations of sum, difference and product on weighted geometries and supports the geometric relations of containment, overlap, sharing boundary and disjointedness. Furthermore, the algebraic model is highly appropriate for the representation and application of spatial rules.

The arithmetic operations and geometric relations form the basic components of the query language. We augment this set with operations derived from the conceptual techniques of counting, pattern matching and rules. Counting provides a straightforward method for answering basic geometric queries. Pattern matching and spatial rules allow for more complex and versatile geometric and non-geometric queries to be composed.

In conventional CAD systems, the objects of manipulation are a priori defined in the data-structures, that is, the only objects that can be queried correspond to those prescribed minimal entities that have been predefined in the data-structures. As such, the querying of an object can be achieved by a straightforward search in the database, instantiated using either a spatial lead or attribute constraints. In the latter case, the mechanism for answering such queries is a non-geometric pattern matching. In contrast, the algebraic model allows for a more powerful geometric pattern matching based on the concept of emergent geometries, i.e., geometries that are not a priori defined, but emerge under the part relation. Under the algebraic model, a geometry defines an infinite set of (sub)geometries that are a part of the original geometry. The specification of such an emergent geometry is an expression of pattern matching. Emergent geometries also play an important role in spatial rule application. A spatial rule may be considered the specification of a transformation on emergent geometries.

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