

Applying rule-based evolution on spatiotemporal objects

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Abstract. *Modeling and representation of geographical objects has received an increasing attention in GIScience due to the challenge of handling spatiotemporal objects. In this paper, we deal with evolving objects, objects whose geometry, topology and properties change over time. We are specifically interested in cases where the evolution of objects is dependent of their types. To handle this kind of object we propose a rule-based approach for description of spatiotemporal object evolution. By developing semantics of type-based evolution, we can keep a detailed history of change. Preliminary results show that the model is able to represent type conversions, recover the evolution history of a set of objects, answer important questions about causes of change and thus deal with situations not supported by model with a single type of object.*

1. Introduction

An interesting research topic in GIScience is the modeling and representation of geographical objects whose properties change over time. Pelekis et al. (2004) and Roddick et al. (2004) review the different types of spatiotemporal data models proposed in the literature. They point out the differences between models that describe moving objects and those focused on object lifelines. Moving objects are the ones whose position and extent change continuously. Güting et al. (2003) and Güting and Schneider (2005) propose an algebra for moving objects, composed by a set of spatiotemporal data types, axioms and their operations.

A second area of research concerns object lifelines. These works focus on describing the history of incremental changes in the life of an object. These situations arise in applications such as urban cadastre, where parcels are created, merged, split and eliminated. To keep track of an object's history, all changes need to be modeled and recorded. Hornsby and Egenhofer (2000) point out the importance of maintaining an object's identity as it changes its geometry, topology, and attributes in time. This view is also supported by Grenon and Smith (2003). Medak (2001) developed an algebra of operations to model object lifelines. Medak's algebra provides a set of basic operations, which are a foundation for more specific applications.

Our work focuses on object lifelines. We consider that the current work on object lifelines focuses on objects of the same type. The usual examples involve parcels and counties. To advance the modeling of spatiotemporal objects, we need to consider cases of operations involving objects of different types. We are interested in cases where the simple rules of merging and splitting are not sufficient to describe their

evolution. These situations arise when objects are defined not only by their shape and properties, but also by their *type*.

This situation arises in applications such as rural cadastre and land cover modeling. Consider the case of riverbanks. The definition of what is ‘the river’ and what is ‘the land’ changes over the seasons. When a river expands during the wet season, the part of the land that is flooded will be split and merged with the river. The object that corresponds to the flooded area will change its type and properties. In the dry season, this object may become land once again. In this evolution, expansions and contractions produce junctions and splitting which are type-dependent. In this and similar cases, recording the history of changes requires keeping track of type-dependent situations. This requires a higher-level of semantics above that of the basic operations of creation, splitting and merging. We shall refer to those objects as *typed evolving objects*. This raises the question we investigate in this paper: “*How can we deal with spatiotemporal objects whose evolution is type-dependent?*”

2. Ruled-based Evolution

Our work proposes a rule-based approach for description of object evolution. The rules are derived from knowledge about the application domain. They provide a higher-level semantic layer that uses low-level operations and deals with type-dependent situations. By developing semantics of type-based evolution, we can keep a detailed history of change. Then, we can recover the evolution history of a set of objects and answer important questions about the causes of change.

Using the type and rules defined for each area of interest, we can develop operations express the object types and the evolution rules in a computer model. This section presents some operations for the evolution of typed spatiotemporal objects. These operations were used to model an example of typed cadastre land changes (Bittencourt et al., 2007) and we are currently developing a model to describe the evolution of patterns deforestation in Amazonia.

We defined the operations *create*, *split*, *merge*, *evolve*, *setType*, *getType*, *getInstance* and *remove* in our experiments. These operations allow us correctly handle and evolve typed spatiotemporal objects in our experiments. The operations continuous to be developed and their signatures and explanations can be found on Bittencourt et al. (2007).

We created the *evolve* function to give us the option of grouping evolutions according with similarity concepts or specific actions significant to user and that will be further recognized during the history recovery. Its signature is:

```
evolve identifier [ timestamp ] { operations }
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Furthermore, we defined polymorphic operations to recover the *history* of objects. There are options that allow using the object identifier, alias, complete or reverse history and some date options. This polymorphism allows defining richer and relevant forms of recovering information inside the history of objects. It is more than just recovering the static operations. Our distinct signatures give us kinds of looking the history by different points of view, recovering distinct information and combining it

with relevant information that is related to the evolution of the spatiotemporal object. The basic signature of *history* is:

history option1 option2 option3 →[(s_object, timestamp)]

3. Comments and future work

Our work proposes the concept of *typed spatiotemporal objects* and the use of rule-based evolution to capture the history of changes of spatiotemporal objects. We are interested in cases where the simple rules of merging and splitting are not sufficient to describe their evolution and the evolution of objects is dependent of their *types*.

Rule-based evolution works best when the domain knowledge is well-known, and we are able to assign a meaningful type system to the objects. In these situations, the model is able to represent type conversions, recover the evolution history of a set of objects, answer important questions about causes of change and thus deal with situations not supported by model with a single type of object.

Another work is being realized on other areas and we are interested in studying the evolution deforestation on Brazil. For these next steps, an algebra of evolving objects will be developed as well as new operations to advance our model and to characterize these another problems.

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