Modeling Coverage Between Geospatial Resources

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ABSTRACT

Ontologies evolve when the underlying domain world changes at different points of time. In historical geospatial domain, for example, the result then is chains of changes like merges and splits between ontology resources. Our focus is on modeling and determining partial overlap, i.e. the coverage between the ontology resources. The idea is to provide the ontology developer with an intuitive change ontology for expressing local ontological changes in a declarative and easy way. We have created a method that can determine and visualize a global coverage between two geospatial resources based on the declared local changes. The method can be applied, e.g., in concept-based information retrieval for ranking search results according to their relevance.

1. INTRODUCTION

Ontologies are a key technology underlying the Semantic Web. They are used for defining vocabularies by which the metadata describing web contents is represented in a machine-interpretable way. Based on ontologies, intelligent content-based web services can be created and semantic interoperability of web systems enhanced.

An important area of semantic web applications is information retrieval. In ontology-based search, content annotations and queries are based on concepts rather than on keywords. This leads not only to better precision and recall, but ontologies can be used as a navigational aid to help the end-user in formulating the queries and results. For example, in the semantic portal MuseumFinland [1] a location partonomy[1] is used for annotating museum artifacts with metadata about the place of manufacture and usage.

A problem in applications like this is that the content in the underlying history-related databases is annotated using historical location concepts that have evolved as time has gone by. For example, an artifact may have been manufactured in East Germany—a country that does not exist any more in the location ontology used today.

If the today's ontology is used for formulating a query concerning modern Germany, which may be natural from the end-user's viewpoint, then finding artifacts made or used in East Germany becomes problematic. To solve the mapping problem between query and annotation concepts, a spatio-temporal model of the ontological change from East Germany to current united Germany is needed.

[1]This partonomy is a part-of hierarchy of individuals of the classes Continent, Country, County, City, Village, Farm etc.

2. REASONING ABOUT EVOLVED CONCEPTS

In this paper we focus on one aspect in the field of spatial reasoning [9, 7]: spatial overlap of regions. We are interested in how much a geospatial region A covers other resource B. The other dimensions of spatial relevance, such as topology (of neighboring regions), directions (of related regions), and distances (between regions) are not considered here but could in principle be combined with partonomical relevance, as discussed in [7], chapter 8.

When dealing with historical data, the ontological vocabulary has to cover relevant location categories through different times of interest. There is a time series of location ontologies each of which is valid during a limited period of time. The next ontology in the series is needed whenever a set of simultaneous changes in the modeled domain occurs. This kind of evolution of ontology time series is due to changes in the underlying domain and should not be confused with ontology versioning [4], database schema evolution, or ontology evolution [5] that deal with ontology refinements or other changes in the conceptualization [3, 6]. Each member ontology in an ontology time series may be used quite rightly for both annotations and for querying.

3. CHAINS OF CHANGES

Local change bridges like *merges* and *splits* between resources of a geospatial ontology form chains that span over wider time intervals. Each local bridge can be defined relatively easily but the global areal relations are not necessarily so obvious. For example, if a museum artifact x has been manufactured in the region of Viipuri (-1906)[2], and the end-user is looking for material that has been manufactured within the area of modern Lappeenranta (1989-), how likely is it that the artifact x indeed is what the end-user is looking for?

We have developed a method [2] for determining and visualizing global coverings between two geospatial concepts. The method has the following phases:

1. Local Bridges. Changes are modeled as instances of basic change classes like *merged*, *split*[3].

2. Local Coverings. The bridges represented in RDF are transformed into a form where the local coverings are

[2]Viipuri (-1906) is here an identifier for a Finnish county called Viipuri before it split at the beginning of year 1906.
[3]The change operations listed in [5] have been used as a basis.

made explicit using the sizes of geospatial resources.

3. Global Coverings. Global overlaps are calculated by chaining local coverings and by considering different change paths between concepts.

4. Visualization of global coverings between resources.

4. RESULTS AND DISCUSSION

We are applying our method to build a Finnish Temporal Region Ontology (Suomen Ajallinen PaikkaOntologia, SAPO) based on a real dataset from [8].

Currently SAPO consists of 667 different regions in time, that is, Finnish counties that have existed during a period from the beginning of the 20th century until today. We have bridged a small subset to test our method in determining global coverings of regions. An initial analysis of the dataset suggests that there will be in total 887 different basic change bridges like *merges*, splits and *label changes* between the regions.

The method of determining global coverings using the RDF(S) ontology has been implemented in Java with the help of the Jena library[4]. The complete global overlap table of the concepts is visualized in Figure 1. Here the black color indicates a full 100% coverage between the temporal regions and the white color a 0% coverage, accordingly. Different shades of grey indicate the level of coverage: the darker the box, the higher is the coverage. From this illustration it is easy to see the mutual asymmetric coverages between the regions, and that the overlapping relation in this case is fairly complicated.

For example, the current city of Lappeenranta (1989-) covers the area of historical Viipuri (-1906) by 0.12, i.e. 12%, and Lappeenranta (1989-) is covered by Viipuri (-1906) by 19%. When querying a database with Lappeenranta (1989-), an object annotated with Viipuri (-1906) would match with this value with relevance value 12%—a result that many users could find a bit surprising due to the turbulent changes on the Finnish eastern border. A more obvious result in the table is that Lappeenranta (1989-) does not overlap with Viipuri (1921-1944) at all (0%).

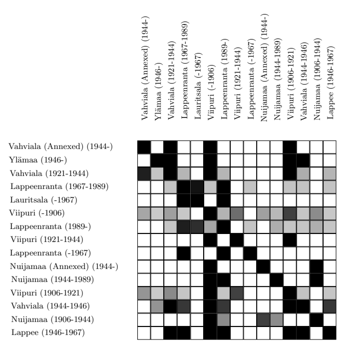

Figure 1: Coverages visualized using colored boxes.

The problem of modeling change in partonomy time series has not been discussed much in the literature, although there is lots of research going on related to ontology versioning [3, 6]. In GIS systems, overlap of physical areas is usually determined by representing the real world in terms of intersecting polygons [9, 7]. However, in application cases like ours, such geometrical modeling may not be feasible because precise geometrical information is not available or it could be difficult to create and computationally difficult to use. Local change bridges could be expressed more easily, be used for deriving the global covering information needed in the application, and for presenting the ontologies at different times. An additional benefit of dealing with change mappings is that this notion is more general than that of areal two-dimensional overlap. This suggests that the same approach could perhaps also be used in other more complex application domains dealing with other forms of conceptual overlap, e.g., by using more than two dimensions.

[4]http://www.hpl.hp.com/news/2004/jan-mar/jena2.1.html

5. CONCLUSIONS

This paper presented a method for determining and visualizing global coverages between geospatial resources that have evolved over time. The idea was to provide an ontology developer with an intuitive set of local change bridges like *merges* and *splits* and calculating and visualizing relevance measures automatically based on this knowledge.

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