Matching Geospatial Ontologies

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In recent years, multiple geospatial ontologies have been developed for a wide range of different spatial databases. In addition, the development of volunteered geographic information both challenges and provides opportunities to the traditional authenticated geospatial information. Though volunteered geographic information is typically not as reliable and structured as the authenticated geospatial information, it often reflects changes in the real world more quickly and contains richer information related to human activity [1]. It is therefore desirable to link the corresponding information from disparate geospatial information sources, allowing users to use them synergistically. Aligning disparate geospatial ontologies is an essential element to realizing this.

We propose a new semi-automatic method to align geospatial ontologies, based on coherence and consistency checking in description logic, as well as domain experts' knowledge. We evaluate it on real world data and compare it to two state of the art ontology mapping systems, CODI [2] and LogMap [3]. By a geospatial ontology we mean an ontology which contains both definitions of geospatial concepts in its TBox and facts about geospatial individuals in its ABox. When designing our approach, we assume that the TBox is not very large, but contains concepts which are more ambiguous, compared to for example biomedical ontologies. We also assume that geospatial individuals have geometry and location information. In common with other approaches, we use additional disjointness axioms to improve the quality of mapping. Since they are not part of the original ontology and may be wrong, we treat generated disjointness axioms as assumptions retractable by users. We treat original ontology axioms as correct and not retractable. Given two geospatial ontologies, our method has two main steps: generating assumptions and calculating a consistent and coherent assumption set (CAS) which contains the mapping.

Step 1: Retractable assumptions include disjointness axioms and mapping axioms. For TBoxes, disjointness axioms are generated for sibling classes. Initial mapping axioms between TBoxes are generated by stating equivalence of atomic concepts with identical names. Initial mapping axioms between ABoxes are generated based on three criteria: location, lexical labelling, and cardinality of mapping (one-to-one or one-to-many). We ensure that the geospatial instances from different sources are first represented at the same scale and using the same coordinate reference system scaling and transforming the input data as necessary. Given two instances, if their geometries are not spatially disjoint, we first generate a candidate 'sameAs' axiom for them. (When dealing with polygon geometries, the geometry checking is based on spatial disjointness, rather than shapes or sizes of geometries or their percentages of overlapping, because two corresponding geospatial individuals may be represented differently in different datasets, and the representations may be of different geometry accuracy levels.) Then, each correspondence will be checked lexically. If the labels of the instances cannot be matched, we remove the correspondence. After that, the mapping will go through cardinality checking. In the case that several instances are mapped to the same instance, we change 'sameAs' relation to 'partOf' relation in the corresponding axioms. The geometry, lexical and cardinality checking are all necessary, since different geospatial individuals may share the same label or the same location in an ontology, and a same geospatial individual may be represented as a whole in one ontology, whilst as several parts of it in the other.

Step 2: Two ontologies are aligned by calculating a CAS with respect to them. We use Pellet [4] to check consistency and coherence of overall information. While inconsistency or incoherence exists, minimal inconsistent or incoherent assumption sets (MIAs) will be calculated and visualized clearly, allowing domain experts to correct them, until a CAS is obtained. We decide against automatic fixing of MIAs since none of the methods give entirely reliable results.

The method is implemented as a system called GeoMap. We evaluate it using the Ordnance Survey of Great Britain (OSGB) Buildings and Places ontology [5] and the OpenStreetMap (OSM) controlled vocabularies [6], which are representatives of formal and informal geospatial ontologies respectively. The data used in evaluation is available at `http://www.cs.nott.ac.uk/~hxd/GeoMap.html`. GeoMap, CODI [2] and LogMap [3] are employed to align the OSGB Buildings and Places ontology and the OSM ontology, extended with additional disjointness of siblings axioms. Based on manual evaluation, the precision rates of GeoMap, CODI and LogMap terminology mappings are 89%, 76% and 70% respectively. CODI generates 5 more correct mapping axioms than GeoMap, whilst LogMap generates 11 less. In the GeoMap instance mapping, more than 95% correspondences are reasonable. The experimental result shows that, when aligning geospatial ontologies, using geometry or location information helps, and domain experts are indispensable.

References

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