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muenster semantic interoperabiltity lab

Strategies to enable Semantic Interoperability in Geospatial Applications

INTRODUCTION

The geographic information (GI) community needs strategies that enable the assessment of semantic interoperability within the information flow of geospatial applications. Our focus is on automated information processing: information has to be discovered, retrieved, evaluated and translated in distributed environments. We present different strategies for semantic interoperability assessment that are subject to research at the Muenster Semantic Interoperability Lab. The employed strategies include subsumption reasoning, instance checking, similarity based reasoning and alignment to foundational ontologies.

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SCENARIO

Alice and her family plan to spend a summer vacation in a cottage near the sea or a lake. She would also like to get information on the average water temperature of the waterbody the cottage is located at.

MISSION STATEMENT

To improve the usability of geospatial information by advancing semantic interoperability through research on semantic reference systems and ontologies.

RESEARCH QUESTIONS

- What is the ontological nature of geospatial entities and their qualities?
- How to generate semantic annotations of geospatial information sources?
- How to design and encode ontologies for varying application purposes?
- How to use similarity measures to assess the semantic interoperability of geospatial information sources?
- How to perform semantic translation between ontologies in order to improve schema mapping?
- How to model the role of space and time for trust inference?

RESULTS

- [x] Ontology-based annotation and discovery of geospatial features
- [x] Ontological modelling of geoprocessing service functionality
- [x] Hybrid similarity measure combining geometric and network models
- Automated annotation of geospatial features
- Semantic similarity theory for description logics
- Image-schematic upper level ontology
- DOLCE extension by reference spaces for measurements
- [ ] The role of accuracy propagation in semantic interoperability
- [ ] The role of trust and reputation in maintenance by mashup

STRATEGY I: SEMANTIC SIMILARITY MEASUREMENT

To find relevant information for the query "cottage at the edge of river", we compare Alice's requirements with conceptualisations in our knowledge base using similarity measures. Similarity delivers ranked results for uncertain and vague queries by determining the degree of conceptual overlap.

In MUSIL we investigate two measurement approaches: one for a logic-based knowledge representation and the other one for geometric representations.

STRATEGY II: SUBSUMPTION REASONING

Alice's queries for "cottage at the edge of a waterbody" or "average water temperature" may lead to various semantic heterogeneity problems. For example, ambiguities in keyword-based search lead to low precision and recall in the result set and unintuitive attribute names impede filter formulation for retrieval. By explicating the meaning of spatial information objects in a logicbased knowledge representation (i.e. semantic annotation), automatic matchmaking can be employed for GI service discovery. Once an adequate service has been found by subsumption reasoning, the system can automatically generate the request for information retrieval. Furthermore, we investigate methods for automating the semantic annotation of spatial information objects.

STRATEGY III: ALIGNMENT TO A FOUNDATIONAL ONTOLOGY

Conceptual models in geospatial applications specify information objects, e.g. feature types. The information objects (symbols) in a conceptual model become meaningful only if they are connected to the real world "in the right way". We develop a theory of semantic reference systems that allow to compare the underlying conceptualizations of data providers that commit to the same semantic reference system. Central to the approach is the alignment of application concepts to a foundational ontology.

Alice will be able to distinguish information sources providing surface water temperature in proximity to the lake shore from sources providing water temperature in 10 m depth. Thus, based on a precise conceptual description, Alice can select information sources accounting for water temperature that are relevant for judging whether swimming in the water will be fun or not.

STRATEGY IV: RULES FOR DATA TRANSLATION

After differences in underlying conceptual models of information providers and users are sorted out (strategy III) data transformation may be required. In this context, the semantics of data types used within varying information encoding models need to be mapped to each other. We consider such mappings schema morphisms. Since GI highly depends on measurements, methods for data transformation especially have to account for measurement errors serving the propagation of positional, temporal and thematic accuracy descriptions.

Alice gets support in using temperature measurements as input for calculating the average water temperature of the lake during the visit. Transformations, like unit conventions, are derived from heterogeneous information relating encoding models of available data to input models of processing components. Their execution includes propagation of associated accuracy descriptions.

CONCLUSION AND FUTURE WORK

In past and ongoing research projects the proposed strategies have been integrated into geospatial web environments and tested in prototypical applications. Currently, we see strategy III to eventually support strategies I, II and IV in reaching their full potential. However, the introduced strategies are based on different representation languages and thus support different reasoning capabilities. The challenge is to combine the benefits of all strategies in distributed information environments.

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