Intuitive and Natural Interfaces for Geospatial Data Classification

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Abstract. Increasing availability of GPS-enabled devices technically enables a broad variety of people to participate in the volunteered geographic information (VGI) movement and to collect and share information about places and spatial entities. But in order to be useful, geo-data has to be correctly classified, and inexperienced users need assistance to be able to provide correctly classified information, because the classification system is complex and not always intuitive. In this paper, we propose a natural classification approach for spatial entities based on speech recognition and ontological reasoning to allow users to contribute geo-data with as little barriers as possible.

1 Data for Everyone

In the last decade, volunteered and participatory initiatives to create repositories of geospatial information gained overwhelming success. The most prominent and successful example of *volunteered geographic information* (VGI) is OpenStreetMap[1] (OSM). OSM offers the opportunity to collect data where no commercial data sets are available for lack of (commercial) interest, such as for example rural areas of developing countries.

The great advantage of OSM data is the collection and provision by interested users. This method supports the collection not only of rather traditional data such as streets, buildings, or natural features. OSM contains a large variety of particular data like, e.g., barriers or surface properties, thus providing information essential for creating assistance for, e.g., disabled persons or athletes. This is a great advantage compared to official data sets: OSM contributors collect and share the information relevant to them and other users with similar interests. Such possibilities add enormous value to the freely available data, as it does not only map the street network, but potentially every spatial asset and facet of a place which is of interest to someone.

2 Interfaces for Everyone

To enable systems to make correct use of the collected data, it has to be classified correctly. For example, cartographic renderers can only draw and label objects with

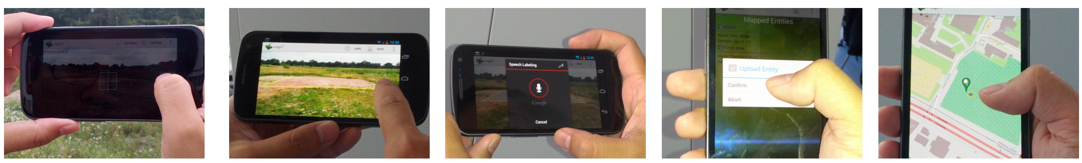
[1] www.openstreetmap.org

correct style if the entities follow a certain specification. The classification of geo-data is complex and often ambiguous. For example, the type of a street or the function of some grass covered ground may remain unclear to the contributor. Trained contributors know how to apply a classification system correctly; for non-experts or casual contributors, the lack of this knowledge marks a barrier: most of the tools to collect, contribute, and classify geo-spatial data are complex systems requiring high technical affinity and skills. Moreover, even for experts, repeated classification of objects can become tiresome, leading to the danger of incompletely specified data.

Places have different facets for different people. Namely, the same place can have very different functional roles depending on who is looking at it [8]. For example, the entrance area of our Bremen office building is frequently used by skateboarders in the late afternoons. So what is an entrance for the people working there is an urban sports facility for others. Thus, the place can be classified differently depending on the reporter. But, at a certain level of abstraction, all views on the place will be the same; in the end, the entrance area is a paved spot. Another example is a fish pond: for some, it is just a recreational decoration, for others a food supply; but in any case it is a (artificial) water body and in OSM terms "water". In this paper, we focus on the latter: a natural classification system for VGI applications that allows the collection of geo-data for untrained contributors.

3 MapIt: Intuitive and Natural Interfaces for VGIying

Research on VGI and Human-Computer Interaction (HCI) is increasingly addressing the technological gap between potential contributors and the existing data collection applications. The MapIt system [7] offers an intuitive interface for collecting spatial entities and is targeted at casual contributors with low technical affinity. It only requires basic smartphone usage knowledge: the user just has to make a photo, outline the entity on a map, classify it using natural language, and finally upload it to a server (see Fig. 1).



(a) (b) (c) (d) (e)

Fig. 1: The mapping process: Taking a photo (a), outlining the entity (b), annotating via speech (c), uploading to a geo-server (d), checking the entity on map (e).

3.1 Ontological reasoning for spatial classification

When we allow users to annotate spatial entities by means of natural language rather than by using a predefined catalogue, we have to expect a significant mismatch between what users think the entity is and what the classification system allows to describe. In [8], the authors demonstrated that natural descriptions of the same places are highly heterogeneous between individual users. To solve the mismatch between natural expressions and a catalogue based classification, we propose an ontological reasoning system to identify the best matching classifier for an entity.

Consider the following situation: some member of a development project wants to contribute data about the distribution of small backyard fish ponds which have been installed to minimize the lack of protein supply in poor areas of developing countries. This user is not educated to use a geographic classification system and is not aware of the proper term within a system like CityGML[2], OSM, ATKIS[3], or the OS MasterMap[4].

If the user now labels the backyard fish ponds with the term "fish pond", none of the above mentioned systems will recognize it as a valid entity. Without a proper classification, however, the data remains useless as it cannot be rendered or addressed by other algorithms.

To be able to match natural concepts of spatial entities with spatial classification systems, we propose a reasoning system as illustrated in Figure 2. The goal of the proposed reasoner is to identify the closest conceptual match in the classification system with the naturally spoken term. The term should not just be replaced, but the link between the spoken term and the linked term in the classification system is kept for further refinement of both the classification system and the reasoner's capabilities. A main ingredient to make this re-classification possible is an abstraction layer on top of existing GIS classifications, namely the meta-ontology GeoMO sketched in the next section.

3.2 The meta-ontology GeoMO and the OntoHub repository

OntoHub. Existing ontology repositories such as BioPortal[5] lack the ability to host heterogeneous ontologies in the sense of being formulated in ontology languages other than $\mathcal{OWL}$. As not all relevant ontologies will be $\mathcal{OWL}$ ontologies (Dolce, e.g., is formulated in first-order logic) we host our ontologies at OntoHub[6]. Users of OntoHub can upload, browse, search and annotate basic ontologies written in various standard ontology languages via a web frontend (see [6] for more information on OntoHub). Beyond basic ontologies, OntoHub supports linking ontologies across ontology languages, and creating distributed ontologies as sets of basic ontologies and links among them. An important difference to the mapping facilities of, e.g., BioPortal is that links in OntoHub

[2] http://www.citygml.org/
[3] http://www.adv-online.de
[4] http://www.ordnancesurvey.co.uk/oswebsite/products/os-mastermap/index.html
[5] See http://bioportal.bioontology.org/
[6] See http://ontohub.org/

have formal semantics, and therefore enable new reasoning and interoperability scenarios between ontologies, features that are essential for the automated classification scenario described in this paper.

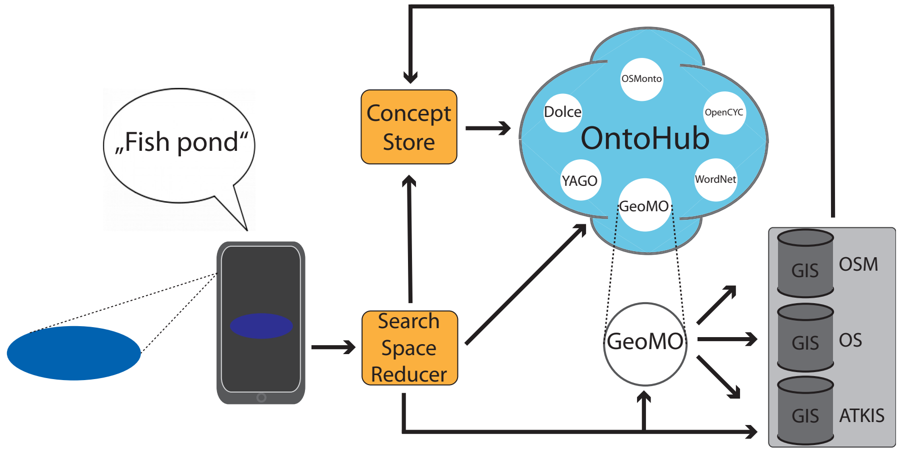


Fig. 2: Conceptual overview of the reasoning architecture of MapIt.

GeoMO. The role of the meta-ontology GeoMO is twofold: first, the *mediation* between human everyday concepts of space and spatial entities that should be matched against existing geo-spatial classifications, and secondly, to *translate* between different classification systems such as OSM, ATKIS, OS MasterMap, CityGML, etc. For OSM, we have already designed OSMOnto, an automatically generated ontology of OSM tags [2, 1].[7] In contrast to GeoMO, OntoHub is a collection of different ontologies with GeoMO being a part of it. The role of OntoHub is the provision of different sources of concepts of different domains and relations between them. We propose to use DBPedia[8], OpenCYC[9], YAGO [10], Dolce [3] and WordNet[10] as ontologies to mediate between everyday concepts and classification systems. DBPedia is an ontology extracted from Wikipedia entries, OpenCYC a collection of commonsense knowledge, whilst WordNet provides, e.g., *synsets*, i.e. sets of terms that are considered synonymous in natural language.

The GeoMO ontology, on a technical level, results from a colimit operation on the ontologies reflecting the classification systems of the participating GISs (we mentioned the OSMOnto ontology above, being one component), together with knowledge (i.e. term mapping, subsumptions between terms, etc.) about their relationship. Such mappings are part of the OntoHub infrastructure.

Here is a simple example illustrating the functionality of GeoMO. The OS MasterMap might contain the category s (i.e. 'water structure — manmade'), whilst OSM

[7] See also http://wiki.openstreetmap.org/wiki/OSMonto
[8] www.dbpedia.org
[9] www.opencyc.org
[10] www.wordnet.princeton.edu

might use the term t (i.e. 'water body'). GeoMO establishes the subsumption $s \sqsubseteq t$, i.e. the term t is *more general* than s. If the user now expresses the term 'Fish pond' with spoken, natural language, the term is translated by available speech recognition into a proccessable term. The Concept Store uses this term for a lookup in WordNet and identifies the synonym w. Moreover, OpenCYC will tell us that this synonym w is in fact a special case of s, an official category in the OS MasterMap classification scheme. Finally, GeoMO can infer that t can be used as a more general category for labeling 'Fish pond', without any user interaction.

3.3 A sketch of the Architecture of MapIt

The reasoner depicted in Figure 2 will work as follows: the smartphone translates the spoken term "fish pond" via a standard speech recognition module into parsable text. The detected term "fish pond" is then send to the Search Space Reducer (SSR). The function of the SSR is to cut down the search space in a context-sensitive way: as we are in a geographic domain, we only want to query ontologies or parts of ontologies dealing with spatial objects and activities related to them. This situation allows the SSR to ignore a significant amount of entries, like facts about artists, movies, books, vehicles, etc.

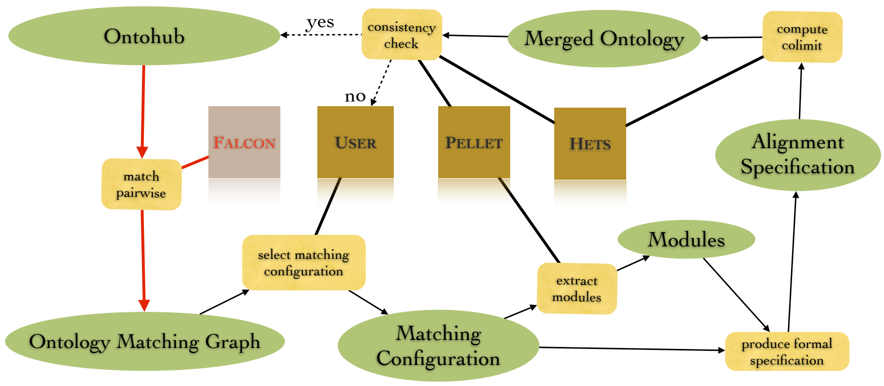


Fig. 3: A basic workflow of the concept store.

After checking for the existence of the term in the target classification (in this case OSM) and GeoMO. If both do not contain a direct correspondence, the reasoner looks up the *Concept Store*. A core component of the *Concept Store* is illustrated in Fig. 3. It illustrates the implementation of a workflow, previously developed in [5], for aligning sets of ontologies and checking for consistency of their combination. This workflow is in particular essential for the construction of GeoMO, as the compatibility of mappings between the terms used in the various GIS ontologies has to be verified. We here briefly introduce these tools.

The ontologies to be matched and aligned are taken from OntoHub. As matching system we use Falcon [4] which matches $\mathcal{OWL}$ ontologies by means of linguistic and structural analysis. For module extraction as well as consistency checks we use Pellet [9] which in particular makes use of the $\mathcal{OWL}$-API [11]. Finally, we use Hets[12] for the computation of colimits (i.e. 'realized' alignments).

4 Conclusion and Outlook

The MapIt architecture carefully integrates existing ontologies and reasoning systems and aims at an enhanced classification technology for geo-data. We expect that MapIt, once realized as a system, has the potential to lower the barrier of contribution of VGI tag data to OpenStreetMap or any other geographic classification catalogues. Currently, tagging in OpenStreetMap mostly happens at geographical level, and much less at a higher ontological level, e.g., concerning activities or individual perception, or place usage of users. This situation could greatly improve using MapIt.

Acknowledgements

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[11] See http://owlapi.sourceforge.net

[12] See www.informatik.uni-bremen.de/cofi/hets