Semantic Representation of Liver Patients Radiological Reports

STSM Scientific Report

Carry out by María del Mar Roldán Garcia from February, 15th to February 22sd 2015

1 Introduction and Background

Semantic annotation of unstructured content in the form of ontologies with data as instances is a task of paramount importance for a wide range of Semantic Web and Knowledge Management applications. The majority of current ontologies are expressed in the well-known Web Ontology Language (OWL) [1] which is based on a family of logical formalisms called Description Logic (DL). Managing large amounts of OWL data, including query answering and reasoning, is a challenging technical prospect, but one which is increasingly needed in numerous real-world application domains from Health Care and Life Sciences to Financials and Government.

Using ontologies for information retrieval has certain advantages over simple keyword based access methods: An ontology provides a shared vocabulary for expressing information about the contents of documents. In addition, it includes axioms for specifying relationships between concepts. Such an ontology may then in turn be used to formulate more complex queries and to deliver exactly the information we are interested in. Furthermore, the axioms provide a means for deriving information which has been specified only implicitly. Therefore, ontologies are very suitable as the basis of a Semantic Classification System.

In the clinical world, the indexing of clinical documents and patient records is called "coding". One of the most widely used "code sets" in this context is the International Classification of Diseases (ICD), which has been used for more than a century for coding morbidity, mortality, billing and reimbursement. Another standard that is getting widely adopted, at least within the European Union, is SNOMED-CT (Systematized Nomenclature of Medicine-Clinical Terms [2]). Providing a wide and comprehensive coverage for diseases, findings, procedures, pharmaceuticals etc., SNOMED-CT provides a consistent way to index, store, retrieve, and aggregate clinical data across specialties and sites of care. Similarly, the UMLS Metathesaurus has also been used in some cases for coding clinical documents [3].

The last decade has seen a marked increase in representation of "biomedical entities" in the form of ontologies. Arguably, this has led to their adoption in various aspects of biomedical informatics ranging from clinical decision support to scientific knowledge management and semantic data integration and exchange. Biomedical ontologies provide essential domain knowledge to drive data integration, information retrieval, data annotation, natural-language processing and decision support. Developing an ontology for a particular domain requires training and a background in ontology development best practices.

The proliferation of ontologies in the biomedical sciences brings about a new problem for knowledge sharing namely that concepts of the same meaning in different ontologies are not explicitly cross-linked. Many of these ontologies contain overlapping information. To be able to use multiple ontologies they have to be aligned or merged. Ontology alignment is the task of identifying such equivalence relations between concepts across ontologies.

1.1 ONLIRA

Radiologists inspect CT scans and record their observations in reports to be shared with physicians. These reports may suffer from ambiguous language and inconsistencies resulting from subjective reporting styles, which present challenges in interpretation. Standardization efforts, such as the lexicon RadLex for radiology terms, aim to address this issue by developing standard vocabularies. While such vocabularies handle consistent annotation, they fall short in sufficiently processing reports for intelligent applications. To support such applications, the semantics of the concepts as well as their relationships must be modeled, for which, ontologies are effective. They enable software to make inferences beyond what is present in the reports. The researchers of VAVLab have developed the open source ontology ONLIRA [4] (Ontology of the Liver for Radiology), the aim of which is to support such intelligent applications, such as identifying and ranking similar liver patient cases. The development of ONLIRA was partially supported by the ICT COST Action IC1302 KEYSTONE[1].

1.2 CaReRa PROJECT

Based on the fact that clinical experience plays a key role in the performance of medical professionals, it is conjectured that a Clinical Experience Sharing (CES) platform, i.e. a searchable collective clinical experience knowledge-base, accessible by a large community of medical professionals, would be of great practical value in clinical practice as well as in medical education. Such a CES would be composed of a multi-modal medical case database, would incorporate a Content Based Case Retrieval (CBCR) engine and would be specialized for different domains.

Project CaReRa[2] aims to develop such a CES for the domain of liver cases. During the course of the project, multi-modal case data is being collected, anonymized and stored in a structural database, CBCR technologies will be developed, experiments for the assessment of its impact on the clinical workflow as well as medical education will be designed and conducted.

1.3 DBOWL

The Khaos Research group have developed DBOWL [5], a scalable reasoner for classifying instances of OWL ontologies with very large Aboxes (billions of instances). DBOWL is based on mature relational database technology. It stores the ontologies in a relational database, using a tableau-based OWL reasoner for obtaining the reasoned Tbox information, which is also stored in the database. Relational algebra expressions and fixed-point iterations are combined in order to create the knowledge base. DBOWL includes a SPARQL engine which allows the evaluation of SPARQL queries on DBOWL.

2 Purpose of the STSM

The purpose of the STSM was to visit the Bogazici University in Istambul for 5 working days to:

1. Develop a new ontology, based on ONLIRA, to include information about Liver Patients, such as laboratory results, previous diagnosis, physical examination, etc (LiCO).
2. Align LiCO with RADLEX, LOINC, SNOMED CT and ICD10 terminologies in order to develop an extended OWL ontology.
3. Use DBOWL and LiCO to classify a selected dataset consisting of annotated liver radiologist reports and prepare at least one scientific publication.
4. Study next extension of LiCO which includes information about Gallbladder

3 Main results

During the STSM several results were obtained:

1. LiCO ontology first version was developed. The ontology was classified using the Pellet [6] reasoner.
2. Data needed to populate the ontology which cannot be obtained directly from the CaReRa project were identified. An algorithm to automatically generate these data was defined.

[1] http://www.cost.eu/domains_actions/ict/Actions/IC1302
[2] http://www.vavlab.ee.boun.edu.tr/pages.php?p=research/CARERA/carera.html

3. LiCO ontology was populated by using RDF data about Liver Patient from CaReRa Project and the consistency of data with respect to the ontology was checked. Detected inconsistences were solved.
4. Radlex terminology was studied and mappings between Radlex and LiCO were identified. These mapping were included in LiCO.
5. LiCO physical examination data were mapped into SNOMED terms. LiCO laboratory results data were mapped into LOINC terms. These mappings were also included in LiCO.
6. Information about Gallbladder structure was extracted from RadLex as well as from a radiologist in order to prepare a first version of an OWL ontology modelling Gallbladder.
7. Structure and content of a scientific paper on LiCO was agreed.

4 Future collaboration

Close collaboration with the hosts Dr. Burak Acar and Dr. Suzan Uskudarli will continue and several joint publications are planned.

This collaboration has the following objectives:

1. Organize the image CLEF2015 workshop liver annotation task.
2. Complete the LiCO ontology.
3. Complete liver case representation using LiCO.
4. Improve the similarity analysis method for liver lesions developed by VAVLAb by exploiting the new medical knowledge included in the LiCO ontology.
5. Implement the liver patient search engine using DBOWL. In order to do this, some improvements and extensions of DBOWL must be developed.
6. Improve semantic query results by using the LiCO together with the developed Semantic Classification System.

References

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