Abstract

As the amount of cultural data available on the Semantic Web is expanding, the demand of accessing this data in multiple languages is increasing. Previous work on multilingual access to cultural heritage information has shown that mapping from ontologies to natural language requires at least two different steps: (1) mapping multilingual metadata to interoperable knowledge sources; (2) assigning multilingual knowledge to cultural data. This paper presents our work on making cultural heritage content available on the Semantic Web and accessible in 15 languages. The objective of our work is both to form queries and to retrieve semantic content in multiple languages. We describe our experiences with processing museum data extracted from two different sources, harmonizing this data and making its content accessible in natural language.

1 Introduction

As the amount of cultural data available on the Semantic Web is expanding (Dekkers et al., 2009; Brugman et al., 2008), the demand of accessing this data in multiple languages is increasing (Stiller and Olensky, 2012).

There have been several applications that applied Natural Language Generation (NLG) technologies to allow multilingual access to Semantic Web ontologies (Androutsopoulos et al., 2001; O’Donnell et al., 2001; Androutsopoulos and Karkaletsis, 2005; Androutsopoulos and Karkaletsis, 2007; Davies, 2009; Bouayad-Agha et al., 2012). The above authors have shown that making cultural data available across languages requires an extensive lexical and syntactic knowledge to generate from Semantic Web ontologies. However, while these applications mainly are concerned with two or three languages, it is still not clear how to minimize the efforts in assigning lexical and syntactic knowledge to generate adequate multilingual descriptions from ontologies.

This paper presents our work on making cultural heritage content available on the Semantic Web and accessible in 15 languages. The objective of our work is both to form queries and to retrieve semantic content in multiple languages. We describe our experiences with processing museum data extracted from two different sources, harmonizing this data and making its content accessible in natural language. Our experiences reveal some of the challenges we must face before multilingual Semantic Web can be reached.

The remainder of this paper is structured as followed. We present the related work in Section 2. We describe the underlying technology in Section 3. We provide a detailed description of the data and present the approach taken to make this data accessible in the Linked Open Data (LOD) in Section 4. We outline the multilingual approach and discuss the challenges we faced in Section 5. We discuss the results in Section 6 and end with some conclusions and pointers to future work in Section 7.

2 Related work

Lately there has been a lot of interest in enabling multilingual access to Cultural Heritage content that is available on the Se-
mantic Web. (Androutsopoulos et al., 2001; O’Donnell et al., 2001) have shown that accessing ontology content in multiple languages requires extensive linguistic data associated with the ontology classes and properties. However, they did not attempt to generate descriptions in real time from a large set of ontologies.

Similar to (Bouayad-Agha et al., 2012), our system relies on multi-layered ontology approach for generating multilingual descriptions.

In contrast to (Dekkers et al., 2009; Brugman et al., 2008) whose systems make use of Google translation services, which is data driven, our system is grammar driven.

In the context of cultural heritage there have also been some attempts to generate natural language from ontologies using controlled natural language mechanism (Damljanovic and Bontcheva, 2008). Our approach differs from the above approach as it maps from semantic representations to SPARQL (SPARQL Protocol and RDF Query Language) (Garlik and Andy, 2013) by enabling cross-language interaction using GF. In addition, it constructs answers in the form of coherent texts.

3 The technological infrastructure

Although the architecture of the Semantic Web and Linked Open Data provides access to distributed data sets,1 many of the resources available in these sets are not accessible because of cross-language meta-data. To overcome this limitation, the knowledge representation infrastructure adopted in our approach is designed as a Reason-able View of the Web of Data. The Reason-able View is a compound dataset composed of several RDFs. To query such a compound dataset, the user has to be intimately familiar with the schemata of each single composing dataset. That is why the Reason-able View approach is extended with the so called ontological reference layer, which introduces a unification ontology, mapped to the schemata of all single datasets from a given Reason-able View and thus provides a mechanism for efficient access and navigation of the data.

We developed a method to access this data using the Grammatical Framework, GF.

3.1 Museum Reason-able View (MRV)

The Museum Reason-able View is an assembly of RDF datasets. It is loaded into OWLIM-SE (Bishop et al., 2011) with inference preformed on the data with respect to OWL Horst (ter Horst, 2005).

3.2 The ontological reference layer

The Museum Reason-able View gathers: (a) datasets from LOD, including DBpedia;2 (b) the unification ontology PROTON;3 an upper-level ontology, consisting of 542 classes and 183 properties; (c) two cultural heritage specific ontologies: (i) CIDOC-CRM (Crofts et al., 2008),4 consisting of 90 classes and 148 properties; (ii) Museum Artifacts Ontology (MAO),5 developed for mapping between museum data and the K-samsök schema.6 It has 10 classes and 20 properties; (d) the Painting ontology,7 developed to cover detailed information about painting objects in the framework of the Semantic Web. It contains 197 classes and 107 properties of which 24 classes are equivalent to classes from the CIDOC-CRM and 17 properties are sub-properties of the CIDOC-CRM properties. It has been used as a reference unification ontology to support natural language to ontology interoperability and to allow a unified access to the different cultural heritage datasets.

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1http://linkeddata.org

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2DBPedia, structured information from Wikipedia: http://dbpedia.org.

3http://www.ontotext.com/proton-ontology

4http://www.cidoc-crm.org/

5It is just a coincidence that this ontology has the same name as the Finnish MAO (Hyvynen et al., 2008), which also describes museum artifacts for the Finnish museums.

6K-samsök http://www.ksamsok.se/in-english/, the Swedish Open Cultural Heritage (SOCH), is a Web service for applications to retrieve data from cultural heritage institutions or associations with cultural heritage information.

7http://sprakkdata.gu.se/svedd/painting-ontology/painting.owl
3.3 Grammatical Framework (GF)

The Grammatical Framework (GF) (Ranta, 2004) is a grammar formalism that is targeted towards parsing and generation. The key feature of GF is the distinction between an abstract syntax, which acts as a semantic inter-lingua, and concrete syntaxes, representing linearizations in various target languages, natural or formal.

GF comes with a resource grammar library (RGL) which aids the development of new grammars for specific domains by providing syntactic operations for basic grammatical constructions (Ranta, 2009). Out of the languages that are available in GF, our application supports the following languages: Bulgarian, Catalan, Danish, Dutch, English, Finnish, French, Hebrew, Italian, German, Norwegian, Romanian, Russian, Spanish, and Swedish.

4 Cultural heritage data

The data we have been experimenting with to enable multilingual descriptions of museum objects and answering to queries over them is a subset of the Gothenburg City Museum (GCM) database, and a subset of the DBpedia dataset. These two datasets are very different in size and nature. In the following we describe each of the sets in more details.

4.1 Gothenburg City Museum (GCM)

The set from the GCM contains 48 painting records. Its content, both the metadata and data that are originally were in Swedish, were translated to English. Example of a record from GCM is shown in Table 4.1.

4.2 DBpedia

The set from DBpedia contains 15,302 painting records, the data covers 97 languages, the metadata is in English. Example of a record from DBpedia is shown in Table 4.2.

4.3 Transition of data to the MRV

The transition of each data set to the Museum Reason-able View was different for each set.

Making the museum data available through the knowledge infrastructure required translation of the record fields and values, and mapping to a unified ontology. This process also required pre-processing of the free text fields such as Description and History to enrich the data content.

To make the DBpedia data accessible through the knowledge infrastructure, it required some pre-processing, cleaning, and mapping to the Painting ontology for data consistency. This unification was needed to use a consistent SPARQL queries from where NL descriptions could be generated.

Firstly, we attempted to clean data noise and results that would make a single painting reappear in the query results. Then, we transformed year and size strings into only numbers. This was necessary because some year strings contained a mixture of literal and numerical data, for example, words such as around the year and approximately.

For each painter, museum and painting instance we had a single representation in the data. We used a unified function that truncated Uniform Resource Identifiers (URIs)
Table 2: A painting object representation from DBpedia to unique identifiers (IDs). For example, <http://dbpedia.org/resource/A_Burial_At_Ornans> was truncated to A_Burial_At_Ornans, Salvador Dalí became Salvador_Dalí. This ID was searched in the rest of the data, to find unique paintings and unify them under the Painting ontology. For different URIs pointing to the same painting, we used the OWL (W3C, 2012) construct owl:sameAs. With this construct we were able to keep the data linked in the other graphs in the LOD cloud.

5 Multilingual linked data

Our application is targeted towards users who wishes to integrate with the cultural data in any language. Such users do not have any knowledge about ontologies or semantic data processing. For us it was therefore necessary to enable interactions in a simple use.

The work towards making Semantic Web data accessible to different users required lexicalizations of ontology classes, properties and instances.

Following the GF mechanism, lexicalizations is accomplished through linearizations of functions, which can differ for each language.

5.1 Lexicalizations of classes and properties

Most of the ontology classes that are defined in our grammar are linearized with noun phrases in the concrete syntaxes using the RGL. These were translated manually by a native speaker of the language. Examples from four languages are shown below. In the examples we find the following GF constructions: mkCN (Common noun) and mkN (Noun).

Class: Painting
Swe.
mkCN (mkN "målning");
Fre.
mkCN (mkN "tableau");
Fin,
mkCN (mkN "maalaus");
Ger
mkCN painting_N;

Class: Portrait =
Swe.
mkCN (regGenN "porträtt" neutrum);
Fre.
mkCN (mkN "portrait");
Fin
mkCN (mkN "muoto" (mkN "kuva");
Ger.
mkCN (mkN "Porträt"
"Porträts" neuter);

Two of the ontology classes that are not linearized with a noun phrase are: Year and Size. These are linearized with prepositional phrases in which the preposition is language dependent. Below are some examples that show how the Year function, i.e. YInt is lexicalized in six languages. In the examples we find the following GF constructions: mkAdv (Verb Phrase modifying adverb), Prep (Preposition) and symb (Symbolic).
The ontology properties are defined with operations in the concrete syntaxes. Because an ontology property is linearized differently depending on how it is realized in the target language, these operations are of type: verbs (e.g. `paint_V2`), adverbs (e.g. `painted_A`) and prepositions (e.g. `Prep`). Examples from three languages are shown below.

Swe.

```plaintext
paint_V2 : V2 = mkV2 "måla" ;
painted_A : A = mkA "målad" ;
at_Prep = mkPrep "på" ;
```

Fin.

```plaintext
paint_V2 = mkV2 "maalata" ;
painted_A = mkA "maalattu" ;
```

Ger.

```plaintext
paint_V2 : V2 = mkV "malen")
painted_A : A = mkA "gemalt" ;
at_Prepp = in_Prep ;
```

The above functions correspond to three ontological properties, namely `painted_by`, `painted` and `created_in`. This approach to ontology lexicalization permits variations regarding the lexical units the ontology properties should be mapped to. It allows to make principled choices about the different realization of an ontology property.

### 5.2 Lexicalizations of instances

The part of the MRV to which we provide translations for consists of 906 instances, their distribution across four classes is provided in Table 3. The lexical units assigned to paining titles, painters and museum instances are by default the original strings as they appear in the data. The majority of strings is given in English. However, because without translations of the name entities the results can become artificial and for some languages ungrammatical, we run a script that translates museum instances from Wikipedia automatically.

Automatic translation was done by: (1) curling for Web pages for a museum string; (2) extracting the retrieved translated entry for each string; (3) reducing the retrieved list by removing duplicated and ambiguous entries. The process was repeated for each language.

As a result of this process, a list of lexical pairs were created for each language. Museum instances were then linearized automatically by consulting the created list for each language. In the cases where no translation was found, the original string, as it appears in the dataset was used.

Unfortunately, the amount of the translated entities was not equal for all languages. The distribution of the amount of translated museum instances is given in Table 4.

Examples of how they are presented in the grammar are:

Swe.

```plaintext
MGothenburg_City_Museum = mkMuseum "Göteborgs stadsmuseum";
MMus_e_du_Louvre = mkMuseum "Louvre" ;
```

Ita.

```plaintext
MGothenburg_City_Museum = mkMuseum "museo municipale di Goteburgo";
MMus_e_du_Louvre = mkMuseum "Museo del Louvre";
```

Fre.
Table 4: The number of automatically translated museum instances from Wikipedia

| Language    | Translated instances |
|-------------|----------------------|
| Bulgarian   | 26                   |
| Catalan     | 63                   |
| Danish      | 33                   |
| Dutch       | 81                   |
| Finnish     | 40                   |
| French      | 94                   |
| Hebrew      | 46                   |
| Italian     | 94                   |
| German      | 99                   |
| Norwegian   | 50                   |
| Romanian    | 27                   |
| Russian     | 87                   |
| Spanish     | 89                   |
| Swedish     | 58                   |

Where the construct \(\text{mkMuseum}\) has been defined to build a noun phrase from a given string. A special case of \(\text{mkMuseum}\) appears in four languages: Italian, Catalan, Spanish and French, where a masculine gender is assigned to the museum string to get the correct inflection form of the noun.

5.3 Realization of sentences

To generate sentences from a set of classes we had to make different judgements about how to order the different classes. Below we provide an example of a sentence linearization from four languages. The sentence comprises four semantic classes: Painting, Material, Painter and Year. In the examples we find following GF constructors: \(\text{mkText} (\text{Text})\), \(\text{mkS} (\text{Sentence})\), \(\text{mkCl} (\text{Clause})\), \(\text{mkNP} (\text{Noun Phrase})\), and \(\text{mkVP} (\text{Verb Phrase})\).

**Ita. s1**: Text = \(\text{mkText} (\text{mkS} (\text{mkCl painting (\text{mkVP (\text{mkVP dipinto_A) material.s}) (\text{SyntaxIta.mkAdv by8agent_Prep (title painter.long))) year.s}))})\);

**Fre. s1**: Text = \(\text{mkText} (\text{mkS anteriorAnt (\text{mkCl painting (\text{mkVP (\text{passiveVP paint_V2) material.s}) (\text{SyntaxFre.mkAdv by8agent_Prep (title painter.long))) year.s})}))\);

**Ger. s1**: Text = \(\text{mkText} (\text{mkS pastTense (\text{mkCl painting (\text{mkVP (\text{passiveVP paint_V2) year.s}) (\text{SyntaxGer.mkAdv von_Prep (title painter.long))) material.s})}))\);

**Rus. s1**: Text = \(\text{mkText} (\text{mkS pastTense (\text{mkCl painting (\text{mkVP (\text{passiveVP paint_V2) year.s}) (\text{SyntaxRus.mkAdv part_Prep (title painter.long masculine animate))) material.s) year.s})}))\);

Some of the distinguishing differences between the languages are: in Finnish the use of an active voice, in Italian, present tense, in French, past participle. The order of the categories is also different. In German the material string appears at the end of the sentence as opposed to the other languages where year is often the last string.

5.4 Multilingual querying

Semantic Web technologies offer the technological backbone to meet the requirement of integrating heterogeneous data easily, but they are still more adapted to be consumed by computers than by humans, especially non-engineers or developers. The main obstacle for this is: 1. the need to master SPARQL, a query language for RDF (Resource Description Framework) (Garlik and Andy, 2013) in order to retrieve semantic content from the knowledge base; 2. holding knowledge about each integrated dataset in the knowledge base.
Our grammar provides solution to this. We have implemented an extra SPARQL layer that maps from NL to SPARQL and from SPARQL to NL. Some examples of the queries that can be formulated with the multilingual grammar and transformed to SPARQL are:

1. All About X
2. Show everything about X
3. How many X
4. Who is X
5. What is X
6. Some X
7. All X painted by Y
8. Some X painted on Y
9. What is the material of X
10. Show everything about all X that are painted on Y
11. X is by Y
12. X is made of Y

5.5 Multilingual text generation

Our approach allows different texts to be generated, depending on the information that is available in the ontology. A minimal description consists of three classes: a title, a painter and a painting type. A complete description consists of nine classes, as illustrated in Figure 2. With only one function DPainting our system is able to generate 16 different text variants. Figure 2, exemplifies two of the text variants.

6 Discussion

The majority of the challenges in the production of the CH data pool stemmed from the very nature of the Linked Open Data. The data in the LOD cloud are notoriously noisy and inconsistent. The multilingual labels from the FactForge datasets and more precisely from DBpedia, are not always available in all the supported languages.

Another problem was that not all art objects are uniformly described with the same set of characteristics. For instance, some paintings were missing a title or a painter name. Because we constructed the grammar in such a way that disallows absence of this information, we had to replace titles with id numbers and empty painter names with the string unknown. Moreover, the data contained many duplications. This occurred because some of the property assertions were presented with different strings and triggered two RDF triples.

To summarize, even though DBpedia in its large pool of data provides access to multilingual content, it is inconsistent. Many of the entries it contains are missing translations. There is a mixture of numeric and string literals. There are many duplications, most of them occur because the same ID appears in different languages. The content of the data is verbose, for example place-names and museum-names are represented with one string, for example: “Rijksmuseum, Amsterdam”, instead of two different strings linked by two separate concepts, i.e. Museum and Place. This kind of inconsistent data representation made the translation of museum entries harder because there was no match of those strings in the Wikipedia pages.
Figure 2: Multilingual generation results

7 Conclusions

We presented an ontology-based multilingual application grammar developed in the Grammatical Framework and a cross-language retrieval system that uses this grammar for generating museum object descriptions in the Semantic Web.

The presented application covers semantic data from the Gothenburg City Museum database and DBpedia. The grammar enables descriptions of paintings and answering to queries over them, covering 15 languages for baseline functionality.

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