Classifying Inconsistencies in DBpedia Language Specific Chapters

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Abstract
This paper proposes a methodology to identify and classify the semantic relations holding among the possible different answers obtained for a certain query on DBpedia language specific chapters. The goal is to reconcile information provided by language specific DBpedia chapters to obtain a consistent results set. Starting from the identified semantic relations between two pieces of information, we further classify them as positive or negative, and we exploit bipolar abstract argumentation to represent the result set as a unique graph, where using argumentation semantics we are able to detect the (possible multiple) consistent sets of elements of the query result. We experimented with the proposed methodology over a sample of triples extracted from 10 DBpedia ontology properties. We define the LingRel ontology to represent how the extracted information from different chapters is related to each other, and we map the properties of the LingRel ontology to the properties of the SIOC-Argumentation ontology to build argumentation graphs. The result is a pilot resource that can be profitably used both to train and to evaluate NLP applications querying linked data in detecting the semantic relations among the extracted values, in order to output consistent information sets.

Keywords: DBpedia language specific chapters, inconsistencies detection, bipolar argumentation

1. Introduction
The Web is an information space which is evolving from sharing textual documents to publishing structured data. In particular, the Linked Data initiative aims at fostering the publication and interlinking of data on the Web, giving birth to the so called Web of Data, a dataspace where structured data are interlinked with each other. The best known example of Linked Data is DBpedia (Bizer et al., 2009), a structured information dataset extracted from Wikipedia. The advantage brought by the availability of such information in a structured format (usually expressed in RDF\(^1\)) is that in this way sophisticated queries can be raised against Wikipedia data to extract further information (e.g., using the SPARQL query language\(^2\)), and new links to different datasets on the Web may be exploited. DBpedia presents several language specific chapters\(^3\) extracted from the language specific Wikipedia chapters, where information is presented in a structured format. DBpedia chapters, well connected through Wikipedia instance interlinking, can contain different information from one language to another. In particular, language specific chapters can provide i) more details about certain topics, ii) fill information gaps (provide information missed in the other DBpedia chapters), or iii) conceptualize certain relations according to a specific cultural viewpoint (Rinser et al., 2012). If on the one side relying on information contained in language specific DBpedia chapters in Natural Language Processing (NLP) interfaces and applications (e.g., NL question answering systems over Linked Data) would bring promising improvements on systems coverage, on the other side they face the following problems: i) different results can be obtained for the same query (e.g., English and French DBpedia chapters provide a different date of birth of Louis IX of France), and ii) the combination of these query results may lead to inconsistent information sets about the same topic.

To better understand the problem, let us consider for instance a question answering system that takes as input NL questions and queries two (or more) language specific chapters of DBpedia for answer retrieval (e.g. QAKiS\(^4\) (Cabrio et al., 2013)). Ideally, we would expect that each DBpedia endpoint returns its own answer and all these answers are identical. However, this is not always the case, and three possible situations arise, illustrated in Figure 1 (Cojan et al., 2013): i) the same result is provided from both chapters (i.e., both datasets contain the same value for the same relation), ii) two different results are provided (i.e., the datasets contain different values for the same relation), iii) the result is provided from one chapter only (only one dataset provides the value for the queried relation). Considering the two DBpedia biggest chapters, i.e. English and French ones, on the total of all the properties used in the two chapters, 11.4% of the properties have the same value in the two chapters (~343,000), 5.8% have different values in the two chapters (~175,000), 67.3% have a value only in the English chapter (~2,022,500), and 15.5% has a value only in the French chapter (~460,500). If the results are the same, the answer to the user is precisely this result set, but if the results are different then a specific management of the query result has to be done before returning the answer to the user.

While several initiatives are proposed to push DBpedia contributors into extending the property mapping to DBpedia common ontology, in this paper we focus on case (ii), and we address the following research question:

- How to detect the inconsistencies arising from merging information from DBpedia language specific chapters?

In particular, the research question breaks down into the

\(^1\)http://www.w3.org/RDF/
\(^2\)http://www.w3.org/TR/rdf-sparql-query/
\(^3\)http://wiki.dbpedia.org/
\(^4\)http://qakis.org/qakis2/
following sub-questions:

1. Which kind of semantic relations can be established to reconcile information provided by language specific DBpedia chapters to obtain a consistent results set?

2. How to compute in an automated way consistent results sets starting from the identified relations?

To answer the research questions, we propose a data-driven approach to identify and classify the semantic relations holding among the possible different answers obtained for a certain query on DBpedia language specific chapters. We consider 17 DBpedia ontology properties, and we collect the data from the different multilingual chapters of DBpedia concerning such properties. We further identify which kind of relations hold between the query results items. In order to provide a machine-readable version of our dataset, we introduce the LingRel ontology, a lightweight vocabulary composed of properties only, where the relations we identified are formally represented.

Starting from the identified semantic relations between two pieces of information, we further classify them as positive or negative, and we exploit bipolar abstract argumentation (Dung, 1995; Cayrol and Lagasquie-Schiex, 2011) to represent the result set as a unique graph, such that argumentation semantics can be adopted to detect the (possible multiple) consistent sets of elements of the query result. Only this consistent set of information items has to be returned to the user. Again, in order to provide such argumentation graphs in a machine-readable format, we adopt the extended SIOC Argumentation vocabulary5 proposed by Cabrio et al. (2013c) where two kinds of relations among the nodes of the graph hold, i.e., a support relation and an attack relation.

The remainder of the paper is as follows. We first present our classification of the relations holding between the values we retrieved from the results set over different language specific DBpedia chapters (Section 2.), and second we adopt argumentation theory to detect the inconsistencies arising in the results set of the query (Section 3.). The feasibility study of our data-driven approach is detailed in Section 4. Section 5. compares the proposed approach with other approaches adopting argumentation theory for ontologies alignment and communities management. Finally, some conclusions are drawn.

5http://bit.ly/SIOC-Argumentation

2. Inconsistencies classification

The first step of our approach consists in identifying which kind of semantic relation holds among the different values obtained by querying a set of language specific DBpedia chapters with a certain query. More precisely, we want to detect the linguistic phenomena holding among the inconsistent values obtained querying two DBpedia language specific chapters at a time, given a certain subject and a certain ontological property.

In the following, we propose our classification of the linguistic phenomena we detected, defined referring to widely accepted linguistic categories in the literature. We identify the following positive relations between values (mainly discourse and lexical semantics relations):

- **a) identity, i.e. same value but in different languages** (missing SameAs link in DBpedia)
  E.g., Dairy product vs Produits laitiers (property: product); Yevgeny Kaspersky vs Eugene Kaspersky (property: owner)

- **b) acronym, i.e. initial components in a phrase or a word**
  E.g., PSDB vs Partito della Social Democrazia Brasileira (property: leaderParty); RFID vs Radio-frequency identification (property: product)

- **c) disambiguated entity, i.e. one value contains in the name the class to which the entity belongs**
  E.g., Michael Lewis (Author) vs Michael Lewis (property: author); David Williams (oil baron) vs David Williams (property: fundedBy)

- **d) identity:stage name, i.e. pen/stage names pointing to the same entity**
  E.g., Lemony Snicket vs Daniel Handler (property: author); The Wachowskis vs Andy et Larry Wachowski (property: director)

- **e) coreference, i.e. an expression referring to another expression describing the same thing (in particular, non normalized expressions)**
  E.g., William Burroughs vs William S. Burroughs (property: author); Arup vs Arup Associates (property: architect)

- **f) renaming, i.e. reformulation of the same entity name in time**
  E.g., Charleville (Ardennes), old name of
An AF encodes, through the conflict (i.e., attack) relation, the existing conflicts within a set of arguments. It is then interesting to identify the conflict outcomes, which, roughly speaking, means determining which arguments should be accepted (“they survive the conflict”) and which arguments should be rejected, according to some reasonable criterion. (Dung, 1995) presents several acceptability semantics that produce zero, one, or several consistent sets of accepted arguments. The set of accepted arguments of an argumentation framework consists of a set of arguments that does not contain an argument conflicting with another argument in the set. This set is called a conflict free set of arguments. Following from this notion, an admissible set of arguments is required to be both internally coherent (conflict-free) and able to defend its elements. In our framework, we adopt admissibility based semantics. Roughly, an argument is accepted if all the arguments attacking it are rejected, and it is rejected if there is at least an argument attacking it which is accepted. The (possibly multiple) sets of accepted arguments computed using one of the acceptability semantics are called extensions, and the addition of another argument from outside the set will make the set inconsistent. For more details about acceptability semantics, see (Dung, 1995). An example of abstract argumentation framework is visualized in Figure 2.a.

Since we represent in the argumentation graph also positive relations among the arguments, we adopt bipolar argumentation theory (Cayrol and Lagasquie-Schiex, 2011) where in addition to the conflict relation, we have a binary support relation among arguments.

Definition 2 A bipolar argumentation framework is a tuple \( \langle A, \rightarrow, \leftarrow \rangle \) where \( A \) is a finite set of arguments, \( -> \subseteq A \times A \), and \( \leftarrow \) is a binary relation called support defined on \( A \times A \).

An example of bipolar argumentation framework is visualized in Figure 2.b where the dotted edge represents the support relation.

Bipolar argumentation has been exploited by (Cabrio et al., 2013b) to detect inconsistencies among the answers provided by a QA system over linked data. However, in this work only the subsumption and the identity relations were considered as positive relations among the arguments, and no distinction was provided w.r.t. the different kinds of conflicts.

Among the positive relations, some of them (e.g., identity, coreference) are bidirectional which means that they are translated in the AAF as a bidirectional support relation. Some others are directional (e.g., meronymy, hyponymy).
Table 1: Results of the pilot annotation phase

| ontology properties | # annotated triples | # annotated positive relations | # annotated negative rel. |
|---------------------|---------------------|--------------------------------|--------------------------|
| architect           | 21                  | a b c d e f g h i j k l m      |                          |
| author              | 25                  | 8 5 3 2 1 4 7 6 8 9 2 1 3     |                          |
| birthDate           | 25                  | - - - - - - - - - 25 - -       |
| BirthPlace          | 25                  | 6 - - - - - - - - - - - -       |
| capital             | 25                  | 1 2 - - - - - - - - - - - -     |
| deathDate           | 25                  | - - - - - - - - - - - - - -     |
| director            | 25                  | 7 1 4 - - - - - 1 - 2 - -      |
| foundedBy           | 25                  | 4 6 - - - - - - - - - 8 -      |
| height              | 25                  | - - - - - - - - - - - - - -     |
| leaderParty         | 25                  | 5 8 2 - - - - - - - - - 22     |
| nationality         | 16                  | 1 - - - - - - - - - - - - -    |
| numberOfStudents    | 25                  | - - - - - - - - - - - - - -     |
| owner               | 25                  | 6 5 2 - - - - - - - - - - - -  |
| product             | 25                  | 1 - - - - - - - - - - - - -    |
| recordLabel         | 25                  | - - - - - - - - - - - - - -     |
| sourceCountry       | 25                  | 4 - - - - - - - - - - - - -    |
| spokenIn            | 13                  | 2 - - - - - - - - - - - - -    |
| total               | 40                  | 51 11 28 8 28 8 11 63 28 16 39 50 47 |

and we map them as a directional support relation in the argumentation graph. On the contrary, all mismatches are always bidirectional conflicts among the arguments. Figure 3 shows how the examples of date mismatch and meronymy are represented as bipolar argumentation graphs. In the first case, given that the two arguments attack each other, they are evaluated as undecided (e.g., using preferred semantics). The idea is that either we accept one of them rejecting the other, or we evaluate them both as undecided as they contradict each other. In the second case, the directional support relation from the meronymy relation is from the more precise argument Justicialist Party to the more general one Front for Victory. Both the arguments are accepted, as there are no conflicts between them.

Figure 3: Example of (a) date mismatch, and (b) meronymy. The reader may argue that argumentation theory is too much powerful (i.e., too complicated) for the task of detecting an inconsistency, as in the case of date mismatch. For instance, just looking at the kind of properties involved, i.e., functional properties like birthDate, would lead to the identification of an inconsistency. However, it must be noticed that when the query is raised against 10 or more DBpedia chapters, then the result is a bipolar argumentation graph where there is a node for each result item provided by each chapter. The idea of using argumentation is that in this way we are able to solve the inconsistency and know what is the right result. Consider for instance, a case where we query 5 different DBpedia multilingual chapters: two of them return the values for birthDate in Figure 3, and the remaining three return the value 1215-04-25. These values will support each others, leading to the final choice of the result 1215-04-25, as the only consistent result to be proposed to the user.

4. Feasibility study
In the following, we describe the ongoing work of creation of a dataset of values extracted from DBpedia language specific chapters, that we annotate with the semantic relations holding among pairs of values, so that to highlight possible inconsistencies. More specifically, in Section 4.1. we detail how we extracted the DBpedia triples to be annotated with the linguistic categories listed in Section 2. In Section 4.2., we present the data translation and the LingRel vocabulary we designed to describe the data. In Section 4.3. we build the argumentation graphs by adopting the SIOC-Argumentation extended ontology.

4.1. Dataset annotation
To assess the feasibility of the proposed approach to build a dataset of possibly inconsistent information, we randomly selected a sample of 17 DBpedia ontology properties (Table 2., column ontology properties). We then query English, French and Italian DBpedia chapters in such a way to extract a set of RDF triples (subject, property, object) where the subject and the property are the same, but with a different object or datatype value. More specifically, for each property of the DBpedia ontology we extract 25 triples providing possibly inconsistent values (13 for the property spokenIn, 16 for property nationality, and 21 for the property architect) in at least two DBpedia chapters (e.g. English vs French chapter, or English vs Italian chapter). We narrow the scope of our search to the instances (subjects) that have only one value for the property under observation.6 An annotator with skills in linguistics annotated these instances handling the data format of the pairs in the dataset. The information conveyed by Example 1 is that there exists a relation of metonymy between the entities Joseph Barbera and Hanna-Barbera, indicated as authors of the show The Ruff & Reddy Show, respectively from the English and the Italian DBpedia chapters. The information conveyed by Example 2 is that there exists

6The underlying reason is that in this work we focus on possibly inconsistent information, and not on incomplete lists of values.
a relation of geo-specification between the entities Londra
(i.e. London) and Camden Town, indicated as birthPlace
of the English actor Anthony Head, respectively from the
English and the Italian DBpedia chapters.
For each pair in the dataset (each containing therefore a
triple with a certain subject and a certain property, and for
which the object assumes different values in the language
specific DBpedia chapters), the subject of the triple is ex-
pressed as the value of the attribute dbpedia:subj, the prop-
erty as the value of the attribute dbpedia:ontology:property.
The different values of the object are contained into the el-
ments value1 and value2, respectively. For each value, the
DBpedia chapter of provenance is reported (attribute dbpe-
dia:chapter). The relation holding between the two values
is reported as attribute of the element pair (i.e. relation).

Example 1

Example 2

To assess the validity of the annotation task, we calcu-
late the inter-annotator agreement. Another annotator with
skills in linguistics has therefore independently annotated
a sample of 30 pairs of the data set. While the percentage
of agreement between the two annotators is 72%. Fixed-
marginal kappa is 0.69. Overall, we consider this value
high enough to demonstrate the stability of the categories of
the proposed set of semantic relations, thus validating their
classification model. Most of the disagreements between
annotators were due to misunderstandings in the definition
of the categories identity and coreference, whose distinction
can be not very straightforward at first sight.
Table 2. reports on the results of this pilot annotation, as
obtained after the reconciliation phase. The resource is cur-
rently composed of 400 annotated pairs of values, where the
actual distribution of linguistic phenomena holding among
possibly inconsistent values in DBpedia chapters emerges.
A number of remarks can be made on the data presented in
Table 2. First of all, a distinction exists between datatytpe
properties (properties for which the value is a data literal)
and object properties (properties for which the value is an
individual). For the former properties (e.g. birthDate, numberOfStudents), a different value in the range iden-
tifies always an inconsistent result sets. Possible rules could
then be chosen to reconcile such information when possi-
ble, for instance defining a tolerance value (applicable to
properties such as numberOfStudents, but not applicable to
functional properties like birthDate).
For object properties, we can notice recurrent types of re-
lations occurring between possibly inconsistent values, de-
pending on the class of the range of the property. For in-
stance, for properties as birthDate and sourceCountry,
whose range is of class place (or of semantically similar
classes as country or PopulatedPlace), the most recurrent
cause of values mismatch is the fact that one DBpedia chap-
ters contains a more fine-grained location with respect to the
other chapter (that we call geo-specification), as showed
for instance in Example 2. The classes of such possibly
inconsistent values should therefore be taken into consid-
eration when possible, so that to find an adequate knowl-
dge base supporting a system in reconciling such informa-
tion (e.g. GeoNames7 for geographical entities). For
more “standard” lexical semantics relations (as hyponymy,
or meronymy) lexical databases such as WordNet (and its
multilingual variants EuroWordNet or MultiWordNet) can
contribute to the fulfillment of this purpose. The number
of pairs labeled with the relation identity highlights the fact
that the SameAs links between the same instance in differ-
ent DBpedia chapters are often missing, and that an effort is
required by the DBpedia community to fill this gap. Finally,
as expected, relations as renaming and identity:stage
name are less frequent than the others in the data, but we
consider it important to include them in our classification,
since they capture two relations among possibly inconsis-
tent values that were not captured by the other relations.
Note that the list of semantic relations we propose in this
work is not exhaustive, and reflects the types of relations
we detected in the sample of DBpedia triples we analyzed.

4.2. LingRel vocabulary
In order to describe the data using the semantic prop-
erties we highlighted in Section 2., we designed a new
lightweight vocabulary called LingRel8. In particular,
LingRel models the ten positive semantic relations we identi-
fied on the data. We need to design our own ontology since
we could not find another ontology actually modeling the
properties we required. However, in the light of the Web
of Data philosophy, the properties of LingRel have been
aligned with other vocabularies like SKOS, Ontology Pat-
terns, when possible. The properties and their alignment
are presented below (XML/RDF format).

7http://www.geonames.org/
8http://ns.inria.fr/lingRel/v1
Negative relations, i.e., text mismatch, date mismatch, and numerical mismatch, are more subtle and cannot be represented in the same way in the vocabulary. These relations have been detected in the data, and they characterize the possible kinds of inconsistencies. These inconsistencies arise due to functional properties that present more than one value, i.e., for birth dates, height, etc. In order to include also such data in the machine-readable dataset we create using LingRel, we introduce in the vocabulary also a “negative” relation called mismatch, that we use to annotated the data when one of the possible mismatches we identified arises.

We create a machine-readable dataset using the LingRel vocabulary. The dataset is available at http://www-sop.inria.fr/members/Elena.Cabrio/resources.html. An example of stage name relation annotated using the LingRel vocabulary is visualized below.

4.3. SIOC-Argumentation extended vocabulary

We then build the argumentation graphs by adopting the SIOC-Argumentation extended ontology9 provided in (Cabrio et al., 2013d). The main classes of the vocabulary are highlighted below

We generated a dataset10 in the RDF format using such extension of the SIOC Argumentation vocabulary such that

9Available in both XML and RDF formats at http://www-sop.inria.fr/members/Elena.Cabrio/resources.html
10http://bit.ly/SIOC-Argumentation
the information items we retrieved from the different chapters are linked by a support or a conflict relation (expressed through the two properties defined in the ontology). The ten positive relations of LingRel are mapped with the support relation in SIOC-Argumentation, and the mismatch relation with the challenges (i.e., attack) relation in SIOC-Argumentation. The final aim of such pilot study is that such dataset can be queried using SPARQL to discover further insightful information. An example of data extracted from the RDF dataset annotated with the extended SIOC Argumentation vocabulary is provided below, where the semantic relation stage name is translated into a support relation in the argumentation perspective.

<http://dbpedia.org/resource/madeleine_wickham> a sioc_arg:Argument ;
<http://it.dbpedia.org/resource/sophie_kinsella> a sioc_arg:Argument ;
<http://dbpedia.org/resource/madeleine_wickham> sioc_arg:supportsArg
<http://it.dbpedia.org/resource/sophie_kinsella> .

5. Related Work

Several works address alignment agreement based on argumentation theory. More precisely, Laera et al. (Laera et al., 2007) address alignment agreement relying on argumentation to deal with the arguments which attack or support the candidate correspondences among ontologies. Doran et al. (Doran et al., 2009) propose a methodology to identify subparts of ontologies which are evaluated as sufficient for reaching an agreement, before the argumentation step takes place, and dos Santos and Euzenat (dos Santos and Euzenat, 2010) present a model for detecting inconsistencies in the selected sets of correspondences relating ontologies. In particular, the model detects logical and argumentation inconsistency to avoid inconsistencies in the agreed alignment. The framework we propose has common points with this line of works, i.e., the use of argumentation theory to select a consistent set of information items, but the scenario in which the two approaches are exploited is different and this leads to a different addressed issues and proposed solutions. Another framework combining argumentation theory and NLP in the Semantic Web has been proposed by Cabrio et al. (Cabrio et al., 2013c). The authors propose an automatic framework to support the management of argumentative discussions in wiki-like platforms. In particular, a natural language module is proposed to detect the arguments in natural language returning the relations among them, and argumentation theory provides the overall view of the argumentative discussion highlighting the accepted arguments. The arguments and their relations are then translated in RDF using the SIOC Argumentation vocabulary to be queried using SPARQL in order to retrieve additional information. In this paper, the arguments are represented by the results of a query over the multilingual chapters of DBpedia, and we use the semantic relations among the information items to provide the relations among the arguments, and then compute the accepted ones.

6. Conclusions and perspectives

The pilot study we have described is a first step toward the creation of a large-scale annotated dataset of DBpedia language specific chapters inconsistencies. We have extracted 400 pairs of values for the 17 DBpedia ontology relations we selected, and we identified ten positive relations holding between such values extracted from the multilingual chapters. Finally, we mapped the relations with the support and attack relations in argumentation, such that argumentation graphs are built to further support inconsistencies detection and discovering information thanks to the machine-readable argumentation graphs. Such resource can be exploited both to train and to evaluate NLP applications querying linked data in detecting the semantic relations among the extracted values, to output consistent information sets (lexical semantics resources can for instance be integrated into such systems to turn the inconsistencies belonging to categories a to j into support relations). Moreover, pointing out mismatches (categories k to m) in the queried data improves the systems reliability. As for future work, we plan to exploit the outcomes of the study presented here to improve our automatic framework to detect the inconsistencies which may arise into a set of answers provided by a QA system over linked data. In our first attempt (Cabrio et al., 2013b), only the subsumption and the identity relations were considered as positive relations among the arguments, and no distinction was provided w.r.t. the different kinds of conflicts. We plan therefore to investigate how to deal with more fine-grained relations among possibly inconsistent answers, and to propose ad-hoc strategies to reconcile such information.

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