Matching Ontologies using a Frame-driven Approach

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Abstract. The need of handling semantic heterogeneity of resources is a key problem of the Semantic Web. State of the art techniques for ontology matching are the key technology for addressing this issue. However, they only partially exploit the natural language descriptions of ontology entities and they are mostly unable to find correspondences between entities having different logical types (e.g. mapping properties to classes). We introduce a novel approach aimed at finding correspondences between ontology entities according to the intensional meaning of their models, hence abstracting from their logical types. Lexical linked open data and frame semantics play a crucial role in this proposal. We argue that this approach may lead to a step ahead in the state of the art of ontology matching, and positively affect related applications such as question answering and knowledge reconciliation.

1 Introduction

Ontologies are artifacts encoding a description of a domain of interest for some purpose. Due to the Web's open nature, ontologies can be defined by different people and can vary in quality, expressiveness, richness, and coverage, hence increasing semantic heterogeneity of the resources made available through the Web of Data. Among the various semantic technology proposed to handle heterogeneity Ontology Matching [9] has proved to be an effective solution to automate integration of distributed information sources. Ontology Matching (OM) finds correspondences between semantically related entities of ontologies. However, most of the current ontology matching solutions present two main limits: (i) they only partially exploit the natural language descriptions of ontology entities and lexical resources as background knowledge; (ii) they are mostly unable to find correspondences between entities specified through different logical types (e.g. mapping properties to classes).

Frame Semantics [2] is a formal theory of meaning based on the idea that human can better understand the meaning of a single word by knowing the relational knowledge associated to that word. For example, the meaning of the verb *buy* can be clarified by knowing that it is used in a situation of a commercial transfer which involves individuals playing specific roles, e.g. a buyer, a seller, goods, money and so on. In other words, the verb buy *evokes* a scene where there are some individuals are playing specific roles. Our hypothesis is that the frames evoked by words associated with an ontological entity can be used to derive the intended meaning of that entity thus facilitating the ontology matching task.

In this paper we introduce a novel approach aimed at finding correspondences between ontology entities according to the intensional meaning of their models, hence abstracting from their logical types. This strategy allows us to match ontological entities with respect to their intensional meaning (that we suppose is evoked by the textual annotations associated with them) instead of their axiomatization, hence to abstract from their logical type. In fact, the axiomatization could have been forced by the choice of certain language for specifying the ontology, by the personal modeling style of the designer, or, other requirements (e.g. the compatibility with an existing ontology) unrelated to the modeled domain.

2 Proposed approach

Following [4], we devised an approach for ontology matching that considers frames as "*unit of meaning*" for ontologies and exploits them as means for representing the intensional meaning of the entities. Our strategy consists of three steps, summarized as follows.

Selecting frames evoked by annotations. In order to associate ontological entities with frames we analyze the textual annotation associated with them. Annotations provide humans with insights of the intensional meaning the designer wants to represent with a certain entity. The main idea of this approach is that words used in annotations *evoke* frames that are representative of the intensional meaning of the entity. In associating entity with frames, the ambiguity of words has to be taken into account. For instance, the verb *bind* evokes either the FrameNet's frame *Imposing obligation* or *Becoming attached*. Therefore, to associate entities with the most appropriate frames, we have: (i) to associate words in the entities' annotation with the most appropriate sense (WSD by using UKB [1] and Babelfy [5]); (ii) and then, to select evoked frames by exploiting the Framester's mapping between WordNet's synsets and FrameNet's frames [3]. This approach is able to associate ontology entities to frames even if its annotations use specialized terminology. In this case it is exploited the Framester's mapping from Babelnet synsets and DBPedia resources[4] to frames. At the end of this step ontology entities are associated with a set of frames. For instance the object property `isParticipantIn` of the ODP Participation[5] is associated with the frames: *Participation*, *Collaboration*, *People* and *Evaluative comparison.*

Mapping frames and ontologies. This step creates an effective mapping between ontology entities and frames evoked by its textual annotations. An example of mapping is provided by FrameBase's integration rules [8]. In order to identify the effective mapping between ontologies and frames, for each entity we compute any possible mapping between the entity and the frames selected in the

[4] Both Babelfy and UKB are able to perform entity linking over text.

[5] `http://ontologydesignpatterns.org/wiki/Submissions:Participation`

previous step (i.e. those evoked by its annotations). In frame semantics, a frame is characterized by its roles (also called frame elements) and each element possibly define the semantic type of the individual that can play that role in the frame. Frames, frame elements and semantic types have a name and a description. For each ontology entity we compute the semantic text similarity (by means of ADW [6]) between the textual annotations of the ontology entity and those associated with the evoked frames, its elements, and its semantic types. We map the ontology entity to the top-scoring frame entity in semantic text similarity. For instance, it easy to see that the top-scoring alignment for `isParticipantIn` is that mapping it on the frame *Participation*[6], its domain/range (i.e. `Object` and `Event`) on the frame elements *Participant* and *Event*, respectively.

Frame-based ontology matching. Once input ontologies and frames are aligned, each ontology entity is associated with a formal specification of its intensional meaning (that we call *frame-based specification*). As pointed out in [7] the properties *subclass of* and *sub-property of* are not enough to explicit complex relation between entities. In light of this consideration we express the relation between frames and ontology entities by interpreting both as *predicates*. A formalization of frames as *multigrade predicates* is provided by [3]. A straightforward interpretation of ontology entities as predicates represents classes as n-ary predicates (the arguments of the n-ary predicate are the entities in its neighborhood) and properties as binary predicates. For instance, the class `TimeIndexedPartipation`[7] can be represented as a ternary predicate with arguments provided by `Event`, `TemporalEntity` and `Object`. Interpreting frames and ontology entities in predicates allows us to express complex relationship which cannot be formalized by only using OWL/RDFs vocabularies. Framester ontology [3] defines a set relationship holding between predicates. Using the Framester vocabulary the class `TimeIndexedPartipation` can be specified as `projectionOf` the frame *Participation*, with members `involveEvent`, `atTime` and `includesObject` (which can be interpreted as subroles of *Event*, *Time* and *Participant*). Also the property `isParticipantIn` of the ODP *Participation* can be specified as `projectionOf` the frame *Participation*, with members `Object` and `Event`. Therefore, the class `TimeIndexedParticipation` and the object property `isParticipantIn` are "aligned" to the same frame and a complex correspondence between `TimeIndexedParticipation` and `isParticipantIn` can be derived. In this case `isParticipantIn` is a `subframeOf` `TimeIndexedParticipation`. The subframe relation might be used for creating a `CONSTRUCT` SPARQL query or an inference rule[8] transforming instances of the class in instances of the property.

3 Conclusion and Future work

In this paper we introduced a novel approach for ontology matching. This method exploits the frame semantics as cognitive model for representing the intensional

[6] FrameNet Frame Participation `https://goo.gl/IMdAwA`
[7] Time Indexed Participation ODP `https://goo.gl/qX3DDr`
[8] Refer to [8] for examples of these kinds of rules.

meaning of ontology entities. The frame-based representation enabled finding correspondences between ontology entities abstracting from their logical type thus leading a step ahead the state of the art of ontology matching.

The proposed approach has been implemented in a software that is currently being evaluated. We are evaluating the resulting alignments in a both *direct* and *indirect* way. The benchmarks used for assessing ontology matching systems are not able to evaluate the capability of finding correspondences among ontology entities with different logical types. In order to accomplish this purpose we are extending the existing benchmarks for ontology matching. On the other hand, we are using the proposed approach in a question answering system for selecting relevant resources answering a given question. The frame occurrences in a question together with the frame-ontology alignment help in formulate the query over the linked data, hence identifying resources that answer the given question.

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