Revisiting Partially Preordered Possibilistic DL-Lite
An Extended Abstract

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A formal ontology is a description logic knowledge base composed of two components, namely a TBox and an ABox (Baader et al. 2007). The former is usually designed by experts in some application domain and contains terminological knowledge represented as axioms. The latter is a dataset containing ground facts about particular entities, also called assertions, which are usually obtained from various information sources. Reasoning with a formal ontology amounts to answering queries from semantically-enriched data pieces, which allows to derive new facts. While it is reasonable to assume the TBox axioms to be correct and unquestionable, the ABox assertions may be error-prone, incomplete and contradictory, potentially making the ABox to be inconsistent with the TBox. However, posing queries over an inconsistent knowledge base rules out the use of classical description logic semantics since any conclusion can be derived from contradictory information.

A significant body of work has addressed the problem of inconsistency management in formal ontologies, especially those that are specified in the DL-Lite family of lightweight Description Logics (Calvanese et al. 2007). The popularity of DL-lite is evidenced by its reasonable expressiveness coupled with good computational properties of the query answering task. Several inconsistency-tolerant semantics have been proposed to facilitate meaningful query answering. They basically consist in repairing the ABox in order to restore its consistency with respect to the TBox, where a repair is defined as a maximal subset of the ABox (in terms of set inclusion) that is consistent with the TBox, and such that an ABox may admit several repairs.

Several inconsistency-tolerant semantics have been proposed to allow for reasoning with an inconsistent ABox by choosing its most relevant repairs. One of the most well-known strategies is the Intersection of ABox Repair (IAR) semantics (Lembo et al. 2010). A query answer is an IAR-consequence (i.e., a valid conclusion) of the knowledge base if it can be derived from the intersection of all the repairs of the ABox. The set of IAR-consequences of a knowledge base is equivalent to the set of all the assertions that are not involved in any assertional conflict which is defined as a minimal subset of the ABox (in terms of set inclusion) that is inconsistent with the TBox.

In many applications, uncertainty or unreliability of the data is also a concern alongside inconsistency. Using possibility theory as the underlying framework, standard possibilistic DL-Lite has been proposed (Benferhat and Bouraoui 2017) to encode uncertainty in lightweight ontologies. Basically, the ABox assertions are assigned weights in the unit interval to express the fact that some data pieces are more reliable or more certain than others. The highest weight where inconsistency is met in the ABox is called the inconsistency degree. Hence, the possibilistic repair amounts to a consistent subset of the ABox containing all the assertions that are strictly more reliable than the inconsistency degree. Intuitively, the weights attached to the assertions induce a total preorder over the ABox assertions. It turns out that when the data pieces are obtained from various sources, the reliability levels may not be comparable on the same scale.

Recently, standard possibilistic DL-Lite has been extended to partial preorders (Belabbes and Benferhat 2021) in order to capture the cases of incomparability. The TBox axioms are assumed to be fully certain while the assertions may be uncertain and may be ignored or weakened if they are inconsistent with the TBox axioms. Uncertainty is represented by partially ordered symbolic weights that are attached to the assertions. A tractable method for resolving inconsistency in the ABox has been proposed. The idea consists in computing a single repair for the ABox, in the spirit of the IAR semantics. This is achieved by considering all the extensions of the partial preorder defined over the assertions, which yields as many compatible ABoxes for the initial ABox. Then, the possibilistic repair associated with each one of the compatible ABoxes is computed. Finally, the intersection of all the possibilistic repairs produces a single repair for the initial ABox.

The tractability of this method is established in DL-Lite through an equivalent characterization based on the notion of π-accepted assertions. Basically, these are assertions that are more certain than at least one assertion of each assertional conflict in the partially preordered ABox. The set of all π-accepted assertions thus constitutes the possibilistic repair. In DL-Lite, each assertional conflict involves (at most) two assertions, and the set of assertional conflicts of a knowledge base can be computed in polynomial time in the size of the ABox (Calvanese et al. 2010). As a consequence, computing the possibilistic repair can also be achieved in polynomial time in the size of the ABox, since it requires parsing the set of assertional conflicts.

Nevertheless, the favourable computational properties of this method might no longer hold when scaling to more expressive description logic languages. The reason is that the number of assertions involved in each assertional conflict might be larger than two and the number of all the assertional conflicts might be exponential.

In this work, we introduce a new characterization of π-accepted assertions that does not require exhibiting the set of all the assertional conflicts. It is rather based on a consistency check such that an assertion is π-accepted if it is consistent with all the assertions that are at least as certain or that are incomparable to it. This ensures the scalability of the method beyond DL-Lite.

References

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