

Making Axiom Weakening Work in \mathcal{SROIQ}

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Introduction

Background

- Many methods for repairing inconsistent ontologies involve identifying and removing problematic axioms.
- This approach can lead to unnecessary information loss.
- Axiom weakening is able to preserve more information and has previously been explored for \mathcal{ALC} .

In this paper

- We extend axiom weakening principles to \mathcal{SROIQ} , including weakening of RIAs.
- We discuss a number of scenarios where weakening can impact regularity of \mathcal{SROIQ} RBoxes, and provide a framework where this is avoided.
- We perform experimental evaluation of repairing \mathcal{SROIQ} ontologies with axiom weakening.

Axiom Weakening for Ontology Repair

To achieve axiom weakening, two types of concept refinement operators are used, a specialization operator and a generalization operator. These are used to define the axiom weakening operator. These operators need a consistent reference ontology to yield useful results. The process of repairing an inconsistent ontology using axiom weakening proceeds as follows:

Repairing ontologies

- Choose a consistent subset as the reference ontology.
- Select a problematic axiom.
- Weaken the selected axiom using the axiom weakening operator based on the reference ontology.
- Replace the selected axiom with the weaker axiom.
- Repeat steps 2-4 until the ontology is consistent.

Extending Axiom Weakening to \mathcal{SROIQ}

Difficulties

- \mathcal{SROIQ} imposes global restrictions on the ontology that cannot be checked by looking at an axiom individually.
- Non-simple roles may not be used in cardinality constraints, *Self* constraints, or disjoint role axioms.
- RBoxes must be regular.

⇒ Adding valid axioms generated by weakening to a valid \mathcal{SROIQ} ontology can make the ontology invalid.

Avoiding these problems

- The allowed weakenings must be restricted to ensure the result is a valid \mathcal{SROIQ} ontology.
 - We only use simple roles whenever we have to replace roles using the refinement operators.
 - For RIAs we only ever refine the super role if the RIA is simple and the sub role is simple.
- ⇒ These two rules ensure that all simple roles remain simple even after applying the weakening.
- ⇒ They further guarantee that the RBox remains regular.

Example: Weakening that breaks regularity

Take the ontology

$$\mathcal{O} = \{r \circ s \circ r \sqsubseteq t, \top \sqsubseteq \forall t. \{a\}, \top \sqsubseteq \exists s. \{a\}\}.$$

Since the range of t is restricted to the single individual a , and s contains all connections to a , $t \sqsubseteq_{\mathcal{O}} s$. The axiom $r \circ s \circ r \sqsubseteq t$ could therefore be weakened to $r \circ s \circ r \sqsubseteq s$. Yet, this would result in a non-regular RBox.

Theorem

Given that the original ontology to be repaired and the reference ontology are valid \mathcal{SROIQ} ontologies, then, for every axiom ϕ of the original ontology: if ϕ' is a weakening of ϕ generated using the weakening operator, then the result of replacing ϕ with ϕ' in the original ontology yields a valid \mathcal{SROIQ} ontology.

Experimental Evaluation

Performed experiment

- Selected different ontologies from BioPortal.
- Generated inconsistent ontologies by adding axioms.
- Repaired the inconsistent ontologies using both removal and axiom weakening.
- Compared the quality of the resulting repairs using a measure IIC for 'inferred information content'.

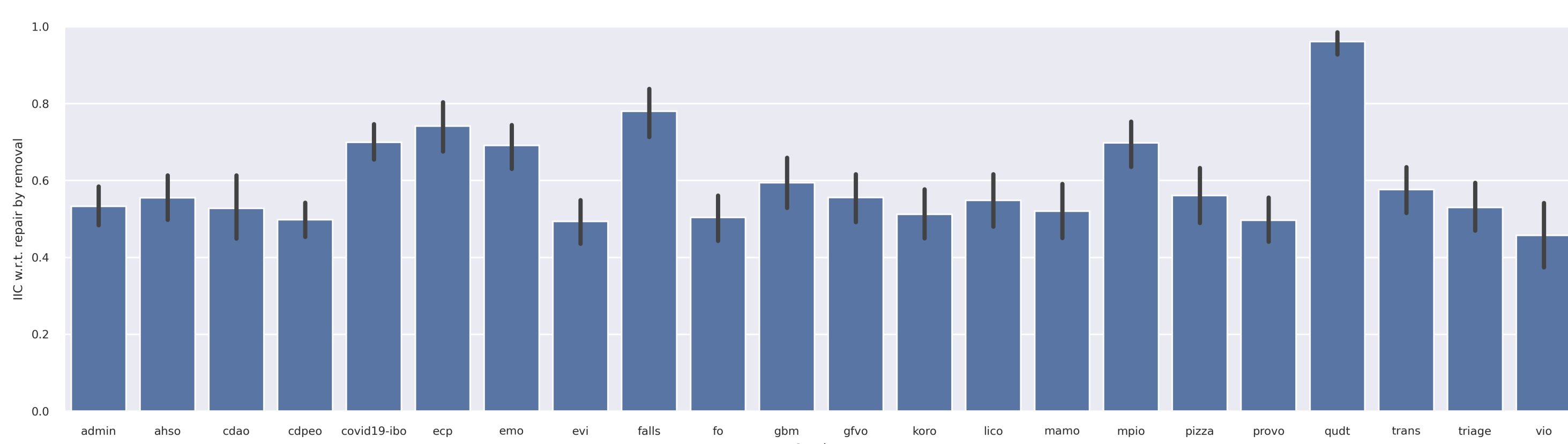


Figure 1. Mean IIC per ontology of repairs using axiom weakening with respect to repairs via removal.

Conclusions and Outlook

Conclusions

- We have proposed refinement operators and an axiom weakening operator for all aspects of \mathcal{SROIQ} .
- Axiom weakening has been shown to be able to retain more information than removal.
- Weakening's advantage over removal is less pronounced in our experiments than previously reported.

Outlook

- Further additions to the refinement operators may be studied, e.g., using non-simple roles in certain contexts.
- Allowing more weakening for RIAs may also be considered, also to cover extended regularity conditions.
- The repair algorithm likely needs better heuristics to steer the repair process in order to achieve better repairs.
- Future work could further focus on finding more robust measures for comparing the quality of repairs.