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Bachelor Thesis

Knowledge Refinement in Expressive Description Logics

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Description Logics

- Family of logics used to represent knowledge
  → aiming for favorable trade-offs between complexity and expressivity

- Individuals, e.g., *roland* *oliver* *nicolas* *unibz* *blue*
  Concepts, e.g., *Student* *Professor* *Person* *University* *Color*
  Roles, e.g., *studiesAt* *supervisedBy* *hasColor*

- Complex concepts, e.g., $\neg Person$ $Person \sqcap Student$ $\exists studiesAt.University$

- Axioms, e.g., $Student \sqsubseteq Person$ $Student(roland)$ $studiesAt(roland, unibz)$

Knowledge Refinement in Description Logics

- Process of iteratively modifying and improving the ontology

- Using two refinement operators
  - → specialization operator, e.g., $Student$ is a specialization of $Person$
  - → generalization operator, e.g., $Person$ is a generalization of $Student$

- Using an axiom weakening operator
  - → converts axioms such that they are less restrictive
  - → using the refinement operators

Applications of Knowledge Refinement

- Repairing ontologies, e.g.,
  - → making inconsistent ontologies consistent
  - → removing unintended consequences
- Combination of conflicting knowledge
  - → also for computational concept combination
- Machine learning
  - → learning axioms from data

Weakening in Expressive Description Logics

Extend axiom weakening to the description logic $\mathcal{SROIQ}$

Simple roles can not be used in every context
→ using a non-simple role in some places is forbidden

The graph formed by the role inclusions must match constraints
→ adding new role inclusions can violate them

These problems have been prevented by ensuring that
→ all simple roles remain simple after refinement
→ only simple roles are used during the refinement

Implementation of Axiom Weakening

Implemented in Java using the OWL API

→ a library providing a uniform way of interfacing with reasoners

Using of-the-shelf reasoners for the Web Ontology Language

→ requires mapping between Web Ontology Language and $\mathcal{SROIQ}$

Tests to ensure correct behavior of the implementation

→ manual tests of expected operator results

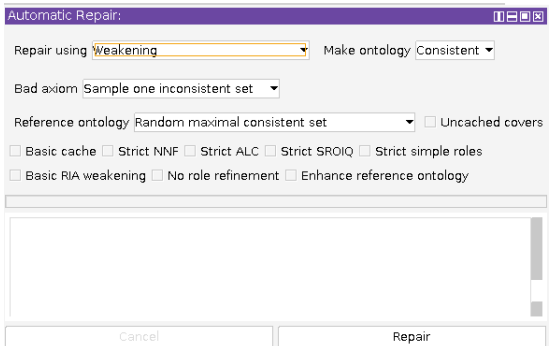
→ automatically generated tests asserting general properties and invariants

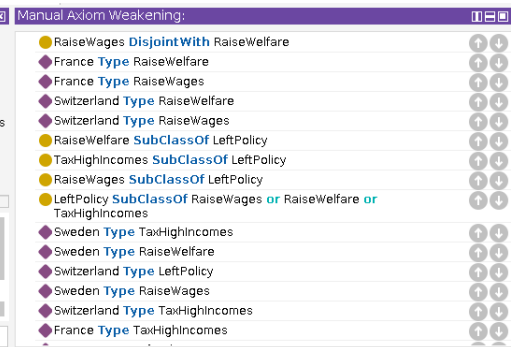
A Protégé Plugin supporting these Techniques

Protégé plugin for axiom weakening

→ allow computing weakening for specific axioms

→ enable automatic ontology repair





Evaluating Axiom Weakening for Ontology Repair

Repaired once using axiom weakening and once using removal
→ the quality of the resulting repairs is compared

Deciding which repair is “better” is not well-defined
→ we want to retain as many consequences as possible
→ we focus only on subsumption between simple concepts

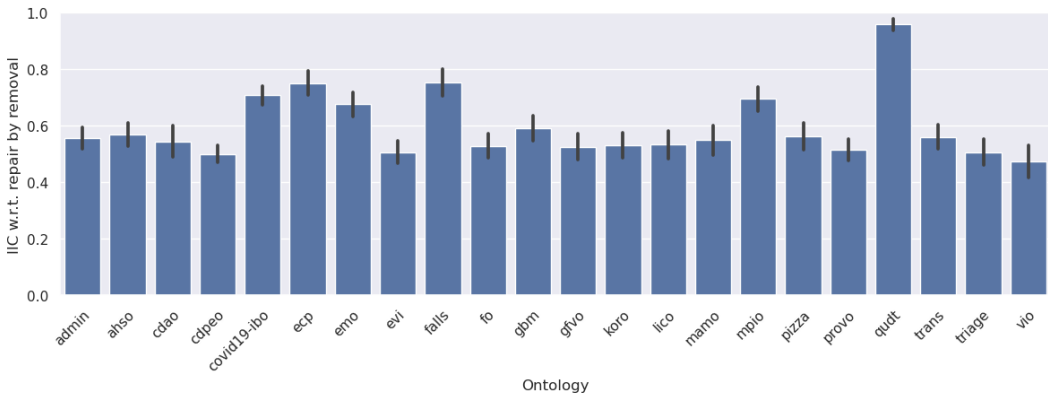
For comparing two repairs we define the IIC of $\mathcal{O}_1$ w.r.t $\mathcal{O}_2$
→ value close to 1 for when $\mathcal{O}_1$ is better
→ 0.5 if both repairs are equally “good”
→ value close to 0 for when $\mathcal{O}_2$ is better

Evaluation Results

Comparison between using axiom weakening and using removal

→ significantly better for some ontologies

→ in many cases only minor or no improvement



Outcomes of the Thesis

- Extended the axiom weakening operator to $\mathcal{SROIQ}$
  → and showed that the proposed approach maintains the necessary constraints
- Developed a Protégé plugin for applying these techniques
  → allowing users to easily repair ontologies and weaken axioms
- Evaluated the proposed approach on real-world ontologies
  → showing that axiom weakening can outperform removal

Future Outlook

- Study the possibility of loosening the restriction
  - → refine with non-simple roles in some cases
  - → more permissive weakening of role inclusions
- Study better ways of guiding the repair process
  - → using better heuristics, maybe domain specific
  - → using user input to guide the repairs
- Find better measures for comparing the quality of repairs
- Study other possible applications of axiom weakening