HARPER++: USING GROUNDED SEMANTICS FOR APPROXIMATE REASONING IN ABSTRACT ARGUMENTATION

Matthias Thimm
Institute for Web Science and Technologies
University of Koblenz-Landau
Germany
thimm@uni-koblenz.de

ABSTRACT

We present HARPER++, a solver for approximate reasoning for various tasks in abstract argumentation. The solver operates by determining the grounded extension of an input argumentation framework and answering queries solely based on information extracted from that extension.

1 Introduction

An *abstract argumentation framework* AF is a tuple $\mathsf{AF} = (\mathsf{A}, \mathsf{R})$ where A is a (finite) set of arguments and R is a relation $\mathsf{R} \subseteq \mathsf{A} \times \mathsf{A}$ [1]. For two arguments $a, b \in \mathsf{A}$ the relation $a\mathsf{R}b$ means that argument a attacks argument b. For a set $S \subseteq \mathsf{A}$ we define

$$S^+ = \{a \in \mathsf{A} \mid \exists b \in S, b\mathsf{R}a\}$$
$$S^- = \{a \in \mathsf{A} \mid \exists b \in S, a\mathsf{R}b\}$$

We say that a set $S \subseteq \mathsf{A}$ is *conflict-free* if for all $a, b \in S$ it is not the case that $a\mathsf{R}b$. A set S *defends* an argument $b \in \mathsf{A}$ if for all a with $a\mathsf{R}b$ there is $c \in S$ with $c\mathsf{R}a$. A conflict-free set S is called *admissible* if S defends all $a \in S$.

Different semantics [2] can be phrased by imposing constraints on admissible sets. In particular, a set E

- is a *complete* (co) extension iff it is admissible and for all $a \in \mathsf{A}$, if E defends a then $a \in E$,
- is a *grounded* (gr) extension iff it is complete and minimal,
- is a *stable* (st) extension iff it is conflict-free and $E \cup E^+ = \mathsf{A}$,
- is a *preferred* (pr) extension iff it is admissible and maximal.
- is a *semi-stable* (sst) extension iff it is complete and $E \cup E^+$ is maximal.
- is a *stage* (stg) extension iff it is conflict-free and $E \cup E^+$ is maximal.
- is an *ideal* (id) extension iff $E \subseteq E'$ for each preferred extension E' and E is maximal.

All statements on minimality/maximality are meant to be with respect to set inclusion.

Given an abstract argumentation framework $\mathsf{AF} = (\mathsf{A}, \mathsf{R})$ and a semantics $\sigma \in \{\mathsf{co}, \mathsf{gr}, \mathsf{st}, \mathsf{pr}, \mathsf{sst}, \mathsf{stg}, \mathsf{id}\}$ we are interested in the following computational problems [3, 4]:

DC-σ: For a given argument a, decide whether a is in at least one σ-extension of AF.

DS-σ: For a given argument a, decide whether a is in all σ-extensions of AF.

Note that DC-σ and DS-σ are equivalent for $\sigma \in \{\mathsf{gr}, \mathsf{id}\}$ as those extensions are uniquely defined [2]. For these, we will only consider DS-σ.

The HARPER++ solver supports solving the above-mentioned computational problems wrt. to all $\sigma \in \{\mathsf{co}, \mathsf{gr}, \mathsf{st}, \mathsf{pr}, \mathsf{sst}, \mathsf{stg}, \mathsf{id}\}$. In the remainder of this system description, we give a brief overview on the architecture of HARPER++ (Section 2) and conclude in Section 3.

2 Architecture

The HARPER++ solver is based on the insight that grounded semantics almost perfectly approximates other semantics in many practical instances of argumentation frameworks [5]. In particular, arguments contained in the grounded extension are always contained in every σ-extension as long as σ is based on complete semantics (which is true for all semantics considered except stage semantics). So a positive answer to DS-gr implies a positive answer to DS-σ and DC-σ for these other semantics σ. On the other hand, if an argument is attacked by an argument contained in the grounded extension then the answer to DS-σ and DC-σ is negative for these semantics due to these semantics being based on conflict-freeness and the aforementioned observation. In [5] it has been observed that on many practical instances of argumentation frameworks—i. e., those used as benchmarks in previous competitions—skeptical reasoning with any semantics often coincides with reasoning with grounded semantics in general. For example, the Jaccard distance[1] between the grounded extension and the set of arguments contained in each (some) preferred extensions averaged over a set of 426 argumentation frameworks compiled from assumption-based argumentation frameworks submitted to ICCMA 2017[2], has been observed to be 0.03 (0.06) [5]. The advantage of only relying on grounded semantics to approximate reasoning with other semantics, is of course tractability: computing the grounded extension can be done in polynomial time [4].

For any $\sigma \in \{\mathsf{co}, \mathsf{st}, \mathsf{pr}, \mathsf{sst}, \mathsf{stg}, \mathsf{id}\}$, the computational problem DS-σ is solved by the HARPER++ solver via

1. If the query argument is in the grounded extension, the answer is YES,
2. otherwise the answer is NO.

The problem DC-σ is addressed slightly different: arguments neither in the grounded extension nor attacked by it are accepted, as it is likely that those arguments appear in at least one σ-extension. So, for any $\sigma \in \{\mathsf{co}, \mathsf{st}, \mathsf{pr}, \mathsf{sst}, \mathsf{stg}, \mathsf{id}\}$, the computational problem DC-σ is solved by the HARPER++ solver via

1. If the query argument is attacked by an argument in the grounded extension, the answer is NO,
2. otherwise the answer is YES.

Preliminary tests on several random instances of argumentation frameworks show that these algorithms can reach accuracy levels of over 90% across all considered semantics.

3 Summary

We presented HARPER++, an approximate solver for various problems in abstract argumentation. HARPER++ only makes use of the information provided by the grounded extension to answer queries with respect to other semantics. The source code of HARPER++ is available at `http://taas.tweetyproject.org`.

References

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[5] Federico Cerutti, Matthias Thimm, and Mauro Vallati. An experimental analysis on the similarity of argumentation semantics. *Argument & Computation*, 11(3):269–304, October 2020.

[1] The Jaccard distance J between two sets X_1, X_2 is defined via $J(X_1, X_2) = 1 - \frac{|X_1 \cap X_2|}{|X_1 \cup X_2|}$ and it is zero iff the two sets are the same.

[2] `http://argumentationcompetition.org/2017/ABA2AF.pdf`