ARIPOTER-hcat: ARgumentatIon apPrOximaTE Reasoning using the h-Categorizer semantics

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***Abstract*—This document describes our approach for approximating the acceptability of arguments under various extension-based semantics using the classical h-Categorizer gradual semantics, and the tool we have implemented in Java. It solves all the problems in the approximate track of ICCMA 2023, namely** DC-{CO|ST|SST|STG|ID} **and** DS-{PR|ST|SST|STG}**.**

***Index Terms*—Abstract argumentation, approximate reasoning, Java tool**

I. Background: Semantics and Problems

An abstract argumentation framework (AF) [2] is a directed graph $\mathcal{F} = \langle \mathcal{A}, \mathcal{R} \rangle$ s.t. $\mathcal{A}$ is the set of *arguments* and $\mathcal{R} \subseteq \mathcal{A} \times \mathcal{A}$ is the *attack relation* over the arguments. For two arguments $a, b \in \mathcal{A}$, the notation $(a, b) \in \mathcal{R}$ means that a attacks b. For a set of arguments $S \subseteq \mathcal{A}$, we note $S^+ = \{a \in \mathcal{A} \mid \exists b \in S, (b, a) \in \mathcal{R}\}$.

A. Extension-based semantics

In this work, we focus on extension-based semantics whose aim is to return sets of arguments that are compatible with each other according to different criteria. Mathematically, these semantics are functions σ s.t. $\sigma(\mathcal{F}) \subseteq 2^{\mathcal{A}}$. The extension-based semantics that we consider are based on conflict-freeness and admissibility: $S \subseteq \mathcal{A}$ is *conflict-free* iff $\forall a, b \in S$, $(a, b) \notin \mathcal{R}$, and *admissible* iff it is conflict-free and it defends all its elements, meaning that $\forall a \in S$, $\forall b \in \mathcal{A}$ s.t. $(b, a) \in \mathcal{R}$, $\exists c \in S$ s.t. $(c, b) \in \mathcal{R}$).
The extension-based semantics we consider in this work are:

- Complete (CO): S is an extension iff it is an admissible set which does not defend any argument outside of S,
- Preferred (PR): S is an extension iff it is a $\subseteq$-maximal complete extension,
- Stable (ST): S is an extension iff it is a conflict-free s.t. $\forall b \in \mathcal{A} \setminus S$, $\exists a \in S$ s.t. $(a, b) \in \mathcal{R}$,
- Grounded (GR): S is an extension iff it is the unique $\subseteq$-minimal complete extension.
- Ideal (ID): S is the unique ideal extension iff it is the $\subseteq$-maximal admissible set included in all preferred extensions
- Semi-Stable (SST): S is an extension iff S is a complete extension s.t. S^+ is $\subseteq$-maximal.
- Stage (STG): S is an extension iff S is a conflict-free set s.t. S^+ is $\subseteq$-maximal.

We consider both decision problems from the Approximate Track of ICCMA 2023:[1]

- DC-σ: Given an AF $\mathcal{F} = \langle \mathcal{A}, \mathcal{R} \rangle$ and $a \in \mathcal{A}$, is a a member of some σ-extension of $\mathcal{F}$?
- DS-σ: Given an AF $\mathcal{F} = \langle \mathcal{A}, \mathcal{R} \rangle$ and $a \in \mathcal{A}$, is a a member of each σ-extension of $\mathcal{F}$?

B. h-Categorizer semantics

A gradual semantics assigns to each argument in an argumentation framework a score depending on different criteria (e.g. number of attackers or defenders, quality of these arguments). Among the existing gradual semantics, the h-categorizer semantics [1] uses a categorizer function to assign a value to each argument by taking into account the strength of its attackers, which itself takes into account the strength of its attackers, and so on. Formally, given $\mathcal{F} = \langle \mathcal{A}, \mathcal{R} \rangle$ and $a \in \mathcal{A}$,

$$\mathrm{hcat}(a, \mathcal{F}) = \frac{1}{1 - \sum_{(b,a) \in \mathcal{R}} \mathrm{hcat}(b, \mathcal{F})}$$

Thus, this function assigns to each argument a score between 0 (excluded) and 1 (included).

II. Approximation Approach

A. Related Work: Harper++

For all considered semantics σ (except STG), if an argument a belongs to the GR extension then it belongs to every σ-extension. If on the contrary a is attacked by an argument in the GR extension, then a does not belong to any σ-extension. Moreover, computing the GR extension can be done in polynomial time. So it has been proposed to use the GR extension as an approximation of other forms of reasoning in abstract argumentation. More precisely, the solver Harper++ [3] has proposed to solve all the decision problems from ICCMA 2021 as follows. For any semantics σ under consideration,

- Harper++ answers YES to DS-σ queries iff the given argument is in the grounded extension,

You are a solver, ARI.

[1] https://iccma2023.github.io

- Harper++ answers NO to DC-σ queries iff the given argument is attacked by an argument in the grounded extension.

Said otherwise, it always says YES (resp. NO) if the argument belongs to (resp. is attacked by) the grounded extension. The status of arguments which are not in the grounded extension nor attacked by it is assigned to "accepted" for DC-σ queries, and to "rejected" for DS-σ queries. Our goal is to propose new approaches to deal with these arguments.

B. ARIPOTER-hcat

For arguments whose status cannot be determined directly thanks to the GR extension, we consider that they are accepted if their hcat value is higher than a given threshold. Formally, given $\tau \in [0,1]$, our approach answers YES if $a \in \mathrm{GR}(\mathcal{F})$ or $\mathrm{hcat}(a,\mathcal{F}) \geq \tau$. Otherwise, the answer is NO.

Our approach does not distinguish by nature between DC-σ and DS-σ queries, but suitable values of τ can be chosen experimentarilly for all the tasks.

III. System

A. Tool Description

We have implemented our approximation approach for DC-σ and DS-σ queries in a Java tool which is available online.[2]

Argumentation frameworks are represented as double adjacency lists. Although we only need the attackers of an argument to obtain its h-Categorizer score, we use the list of arguments attacked by a given argument in the algorithm that computes the grounded extension.

The core components of the tool are the interface `ArgumentationFramework`, which provides methods to manipulate the sets of arguments and attacks, and the abstract class `Solver`, which provides the method `solve` where concrete algorithms for various reasoning tasks must be implemented. Adding a new reasoning task can thus be made by implementing a new concrete class which inheritates from `Solver`, with the dedicated algorithm.

Our tool follows the specifications of ICCMA'23, regarding the command line interface, the input file format, and the standard output.

B. Choice of parameters

Table I describes our choice of the threshold τ for solving the various problems of ICCMA 2023.

TABLE I
CHOICE OF AND PARAMETERS

Semantics σ	DC-σ	DS-σ
CO	0.5	n/a
PR	n/a	1
ST	0.5	0
ID	1	n/a
SST	0.5	1
STG	0	1

[2]https://github.com/jeris90/approximate_hcat

DC-PR is ommitted since it corresponds to DC-CO. DS-CO is ommitted since it corresponds to the (polynomially solvable) DS-GR, which is not included in the competition. Finally DS-ID corresponds to DC-ID.

IV. Conclusion

Future development of our application include the implementation of other gradual semantics in order to diversify the approach currently based on h-categorizer.

References

[1] P. Besnard and A. Hunter. A logic-based theory of deductive arguments. *Artif. Intell.*, 128(1-2):203–235, 2001.

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