Reasoning in Structured Argumentation: Assumption-based Argumentation and ASPIC$^+$

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Abstract

Research in computational argumentation, as a branch in Artificial Intelligence (AI), is dedicated to study representations of arguments and to develop automated argumentative reasoning. The subfield of structured argumentation comprises of several approaches, which describe how to perform rational and automated argumentative reasoning, usually based on rule-based knowledge bases. From such bases arguments, and relations among arguments, are instantiated. Subsequently, reasoning can be carried out on the constructed arguments, oftentimes without the need to consider the internal structure of these arguments. In this way, argumentation semantics drive the reasoning process on such abstracted arguments. In recent years, research on computational aspects, i.e., developing theoretical foundations, algorithmic approaches, and systems, for structured argumentation has gained significant traction in the research community. We give an overview of recent strands of research on two prominent structured argumentation formalisms: assumption-based argumentation (ABA) and ASPIC$^+$. We look at issues and benefits arising from instantiation or explication of arguments, discuss complexity results and algorithms for reasoning in ABA and ASPIC$^+$, and consider how incorporation of preferences changes the picture. We close with open issues and possible directions for future research.

Keywords

Computational argumentation, computational complexity, algorithms

The field of computational argumentation within Artificial Intelligence (AI) provides formalized approaches to argumentative reasoning [1, 2], with applications in the areas of legal and medical reasoning [3].

Central to several approaches, what is collectively referred to as structured argumentation [4, 5, 6, 7, 8, 9], is oftentimes a prescribed “argumentation workflow” [10], see Figure 1. From a (formalized) knowledge base, argument structures are instantiated, as well as their relationships, on which argumentative reasoning is carried out. Most prominently, arguments are then seen as abstract entities, and as the main relation between arguments only attacks are considered, e.g., in the form of argumentation frameworks (AFs) [11]. Reasoning is then driven by so-called argumentation semantics [11, 12], selecting sets of arguments that can “stand together” and can be accepted together.

As witnessed by foundational complexity results [13] and the biannual International Competition on Computational Models of Argumentation (ICCMA) [14, 15, 16, 17], argumentative reasoning is involved: almost all forms of such reasoning are NP (coNP) hard and algorithm design is non-trivial and involved.

SAFA’24: Fifth International Workshop on Systems and Algorithms for Formal Argumentation, September 17, 2024, Hagen, Germany

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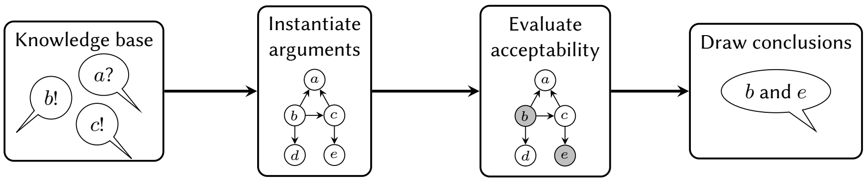

Figure 1: The argumentation workflow

We focus in this talk on recent advances in algorithmic approaches to two prominent forms of structured argumentation: assumption-based argumentation (ABA) [4, 18] and ASPIC$^+$ [5]. In brief, algorithms operate either by explication (instantiation) of arguments and relations between arguments [19, 20] or by computation directly on the given knowledge base (rule base) [21, 22]. The latter approach does not construct any arguments and works by selection of "defeasible elements" in the given knowledge base (such as assumptions or defeasible rules) and checking whether these provide a "compact" representation of a set of acceptable arguments.

Explication of arguments has the advantage that reasoning can be carried out on (relatively) simple structures (abstract arguments and attacks in many cases) and such arguments can also be utilized for argumentative explanations of results. On the other hand, the number of arguments to be generated can be high, e.g., exponential in the general case [23, 19, 20]. Computationally speaking, reasoning after explication of arguments is usually NP (coNP) hard, i.e., still complex after a possibly expensive argument generation. Operating without arguments thus has the advantage to potentially avoid costly intermediate structures not strictly required for solving reasoning.

Current experimental results favour the non-explication route of algorithms [21, 22], yet not in all cases [19, 20], e.g., when the complexity of solving a task on the knowledge base is higher than solving the task on a generated AF, as then the (costly) argument generation may pay off, which is the case, e.g., when considering non-flat ABA.

In this talk, we give an overview of such recent algorithmic and computational advances in the field of structured argumentation, and also discuss impacts of preferential reasoning that oftentimes increases complexity of reasoning.

Acknowledgments

This research was supported by the Austrian Science Fund (FWF) by grant P35632.

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