From Logic Programming and Non-monotonic Reasoning to Computational Argumentation and Beyond

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Abstract. Argumentation has gained popularity in AI in recent years to support several activities and forms of reasoning. This talk will trace back the logic programming and non-monotonic reasoning origins of two well-known argumentation formalisms in AI (namely abstract argumentation and assumption-based argumentation). Finally, the talk will discuss recent developments in AI making use of computational argumentation, in particular to support collaborative decision making.

1 Introduction

Computational Argumentation (CA, aka 'Argumentation in AI') amounts to the definition of formalisms, semantics, algorithms and systems to support reasoning with conflicting and incomplete information, as well as, in many instances, explaining the outcomes of this reasoning. Abstract argumentation (AA) [Dun95] and Assumption-based Argumentation (ABA) [BTK93, BDKT97, DKT09, Ton14] are two well-known CA formalisms, equipped with a variety of semantics, algorithms and systems, and deployed to support a number of applications. AA frameworks can be simply thought of as directed graphs whose nodes are arguments and whose edges represent conflicts (where an edge from A to B represents an *attack* from A to B). Whereas in AA frameworks arguments and attacks are primitive notions, in ABA they are defined in terms of other, primitive notions, and have, as a result, an internal structure. Thus, ABA is a form *structured CA* [BH14]. In the case of ABA the primitive notions based on which arguments and attacks are obtained are those of *rules* in an underlying *deductive system*, *assumptions* and their *contraries*: arguments are supported by rules and assumptions and attacks are directed against (assumptions deducible from) assumptions supporting arguments, by building arguments for the contrary of these assumptions. Semantics of AA are characterised in terms of sets of arguments (or *extensions*) [Dun95, DMT07] and semantics of ABA frameworks in terms of sets of assumptions or arguments (or *extensions*, again) [BTK93, BDKT97, DMT07] meeting desirable requirements, including, but not limited to, the core requirement of *conflict-freeness* (where an extension is *conflict-free* iff none of its elements attack any of its elements).

M. Balduccini and T. Janhunen (Eds.): LPNMR 2017, LNAI 10377, pp. 36–39, 2017.
DOI: 10.1007/978-3-319-61660-5_4

2 From Logic Programming and Non-monotonic Reasoning to AA/ABA

The AA/ABA semantics of admissible, preferred, complete, grounded, stable and ideal extensions [Dun95,BDKT97,DMT07] differ in which additional desirable requirements they impose upon extensions, but can all be seen as providing argumentative counterparts of semantics that had previously been defined for logic programming and, in the case of stable extensions, other non-monotonic reasoning frameworks, by appropriately instantiating AA/ABA frameworks [BTK93,Dun95,BDKT97] to "match" the original logic programming and non-monotonic reasoning frameworks.

AA/ABA are equipped with a range of computational tools, in the form of algorithms and/or systems. Some of these are top-down, query-oriented, based on *dispute trees*, as defined in [DKT06,DMT07], and amount to *dispute derivations* of various kinds for different semantics [DKT06,DMT07,TDH09,Ton13]. These dispute derivations generalise in turn existing SLD-based procedures for logic programming [Ton13]. Other computational tools are bottom-up, based on the computation of extensions, and are based on mappings of CA frameworks onto Answer Set Programming (ASP) and the use of ASP solvers [EGW10] or onto constraint problems and the use of constraint solvers [BS11].

3 Applications of CA

Computational tools for AA/ABA based on dispute trees have been used to support explanations of reasoning outputs, in various settings and senses, e.g. to explain (non-)membership in answer sets of logic programs [ST16], to explain "goodness" of decisions [FT14,FCS+13,ZFTL14] and, more generically, to explain admissibility of sentences in ABA [FT15], and to explain predictions of recommendations in case-based reasoning [CST16]. Moreover, they can be used to support collaborative decision-making in multi-agent systems, e.g. to speed up the agents' individual learning, as in [GT14], or to allow agents to converge to socially optimal but privacy preserving solutions, as in [GTWX16].

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