A Study of Robustness in Abstract Argumentation Frameworks

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Abstract. In this paper we describe a work-in-progress on the study of *robustness* (intended as how many changes can an Argumentation Framework sustain before its semantics turns into another): in particular we present a tool able to visualize Argumentation Frameworks as nodes in a graph and highlight those with certain properties, like a specific semantics or attacks' type. This tool will be used to find relations between an Argumentation Framework and the sets of extensions accepted by each semantics and eventually, to extract new theorems in order to cope with some of the open problem related to abstract argumentation.

Key words: Argumentation Frameworks, Robustness, Semantics, Visualization tools

1 Motivations

The relation between belief revision and argumentation is the subject of several studies aiming to find a connection between the consistency of beliefs and the preservation of a certain semantic when the knowledge base changes. However, in the literature, such a relation is often found for the grounded semantics by way of comparison, assuming that considerations concerning this semantics have the same implications of belief revision.

In this work we would like to extend this relationship, disengaging from the use of (only) the grounded semantics and trying to generalize the already established concepts; the goal is to focus on the modifications in the semantics of an Abstract Argumentation Framework (AAF), also called Argumentation Framework (AF) *à la Dung*, due to changes in terms of arguments and attacks between arguments. We will, in this way, investigate the notion of "robustness" to cope with changes in AFs.

Another goal is to obtain a method to find, given a specific semantics, all the graphs representing an AF with that semantics. We will extract theorems and proofs on the possibility or not that semantics with certain properties exist partitioning the AFs set according to attacks type between arguments. For example, one can focus on the properties of the AFs in which the only attacks are all self attacks or bidirectional attacks, to find relations between AFs containing the same extensions for a certain semantics. In this way, we could be able to solve some of the open problem related to abstract argumentation, like those proposed by Baumann and Strass in [1]. Some example problems could be: given an AF, can all implicit conflicts be made explicit (by adding one or two attacks between them)? Or even what is the maximal number of extensions for each semantics in an AF with n arguments?

In order to better understand problems related to argumentation, we developed a graphical tool capable of representing different aspects of an AF. This tool has three panels: in the first one, we find the complete set of the graphs obtained from a predetermined number of arguments. In the second panel, the tool displays in detail a particular graph selected from the complete set of them. The last panel shows a lattice of semantics ordered by inclusion, in which those corresponding to the selected graphic will be highlighted.

2 Background

In this section we give the basic definitions of AF and extension-based semantics.

Definition 1. *An AF [8] is defined as a pair* $F = \langle A, R \rangle$ *where* A *is a set of arguments and* R *is a binary relation on* A *called attack relation. An argument* $a \in A$ *is acceptable with respect to* $S \subseteq A$ *if and only if* S *defends* a*, that is* $\forall b \in A$ *such that* $(b, a) \in R$, $\exists c \in S$ *such that* $(c, b) \in R$.

The "acceptability" of an argument, defined under different semantics, depends on its membership to some sets, called extensions whose definition is given in Def. 2.

Definition 2. *Let* $F = \langle A, R \rangle$ *be an AF, a set* $S \subseteq A$ *is i) conflict-free if there are no attacks between arguments in* S*, ii) admissible iff it is conflict-free and all its arguments are acceptable w.r.t.* S*, iii) complete if it is admissible and every acceptable argument w.r.t.* S *belongs to* S*, iv) grounded only if it is the minimal element w.r.t. set inclusion among the complete extensions of* S.

3 A Visual Tool

Robustness [2] in AF is considered as the property of an argumentation graph to withstand changes in terms of classical extension-based semantics and is measured by computing the number of changes needed to change the corresponding extension. We give two definitions, useful to understand the aim of the tool.

arguments: 3 self: ☐ bidirectional: ☑ other: ☑

Fig. 1. A screenshot of the tool menu.

Definition 3. *Let $G = \langle A, R\rangle$ be a graph representing an AF. G is said i)* robust *w.r.t. a given semantics if changes in A or R don't change the semantics, ii)* partially robust *w.r.t. a given semantics and an extension if changes in A or R change the semantics, but preserve the given extension in the new semantics.*

Starting from an alpha version (presented in [3]) we have developed *Rob*[1], a tool that allows displaying all the AFs obtainable by any combinations of attacks between a fixed number of arguments. Each of these AFs is represented as a node in an oriented graph and each node in this graph is connected by an edge to all other nodes whose corresponding AF only differs by one attack. Moreover, when a certain AF is selected by clicking on it, the tool displays the graph relative to that AF and the sets of extensions obtainable for each semantics. So, the notion of robustness exploited by Rob is the partial robustness.

The tool's menu allows selecting the number of arguments that the AFs will contain and one can choose whether to take in account or not AFs in which arguments attack themselves (self attacks), defend themselves from every other attack (symmetric AFs) or attack without direct counterattacks. In Fig. 1, for example, we chose to consider only all the AFs with 3 arguments and no self attacks. Whenever the "draw" button is clicked the lattice of all AFs is drawn. Clicking on a node allows displaying a lattice of extensions for the corresponding AF. These extensions are computed by ConArg[2], a tool able to solve problems related to the AFs. Each set is colored according to the less inclusive semantics to which it belongs. For instance, a set marked as admissible will imply its belonging to conflict free semantics too. At last, selecting a set of extensions will show all the AFs on the first panel for which there exists a semantics containing those extensions and each AF will be colored according to that semantics. The notion of partial robustness is well represented in Fig. 2: on the left, we can see the graph in which colored nodes are those representing the AFs allowing the selected extension $\{2\}$ and in the right panel we can see that even if the semantics changes together with the AF, it always contains the extension $\{2\}$.

4 Insights

The features introduced in this version of the tool allowed us to get some significant results. At first, we focused on the set of *symmetric* AFs, in which every attack is bidirectional, i.e. if a and b are two arguments of an AF and a attacks b, then b attacks a and we found out some interesting properties, also suggested by Coste-Marquis et al. in [6].

For instance, we observed that all the *conflict-free* extensions are also *admissible.* Indeed it holds that an extension in a symmetric AF is admissible if and only if it's conflict-free. Another property we observed concerns the grounded extensions: in a symmetric AF the grounded extension is given by the set of arguments which are not attacked. If every argument is attacked, then the empty

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[1] `www.dmi.unipg.it/rob`

[2] `www.dmi.unipg.it/conarg`

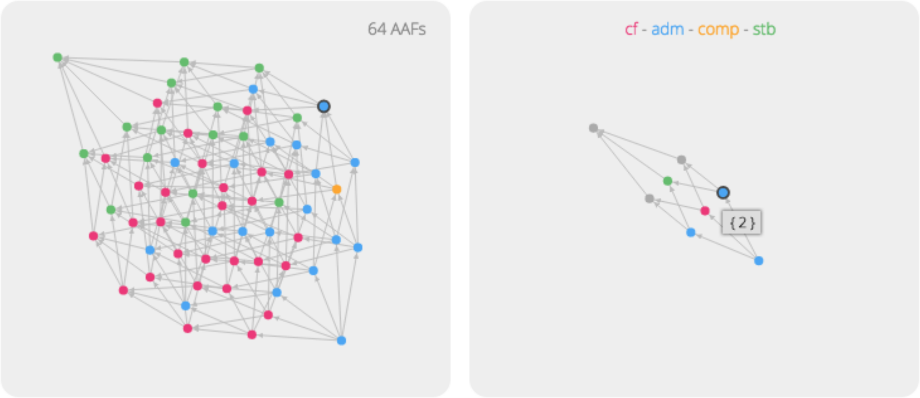

Fig. 2. On the right, the graph of extensions in which the set {2} is selected. On the left, the lattice of AF showing in which semantics the set {2} appears.

set is the grounded extension. In Fig. 3 we can see that the argument with label 3 (on the left graph) is the only one which is not attacked. Hence the extension set containing the only argument 3 (the yellow node in the right graph) is the grounded extension (and in this example, it is also the only complete extension). Changing the parameters used for the representation (number of arguments and attacks type) it is possible to exploit the functionality of the tool in order to study semantics properties, with respect to the inclusion between AFs, linked to the notion of robustness.

5 Related Work

Abstract Argumentation has been proved as a simple yet powerful approach to manage conflicts in reasoning with the purpose to find subsets of "surviving" arguments. In the following, we condensate some of the work related to what we intend to do in the future.

Cayrol et al. [5] proposed an Abstract Argumentation system that allows the addition of a new argument that may interact with previous arguments. The revision of an AF produces a new framework and a new set of extensions. We could exploit this system to introduces changes in the set of arguments.

In [11] Stefan Woltran briefly point out two directions for the development of next-generation argumentation systems: the first one is a review of the *Explicit Conflict Conjecture* while the second one discusses how semantics can be exploited in practice. We could use our tool to cope with the problems here introduced.

Doyle [7] presents the truth maintenance system, which is a knowledge representation method for representing both beliefs and their justifications. The aim of such systems is to restore consistency when a new justification is added.

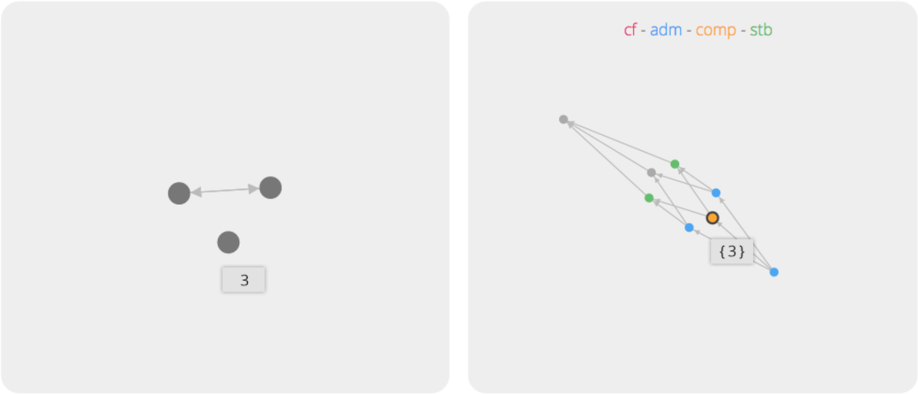

Fig. 3. A representation of 3 arguments AFs lattice with a selected AF drawn on the right side.

Boella et al. [4] try to show a direct relation between argumentation and belief revision establishing a link between *reinstatement* (an argument that is not acceptable become acceptable again) and *recovery* (AGM postulates). Furthermore in [9] the authors consider some semantics and show how that their expressive power relies on rejected arguments and implicit conflicts.

In [10] Rotstein et al. introduce an abstract theory that captures the dynamics of an argumentation framework through the application of belief revision concepts. The presented argument revision techniques allow introducing new arguments ensuring they will be believed afterwards.

6 Conclusion and Future Work

The work presented in this paper is a first step towards the study of the concept of robustness in AFs. Several works in the literature concern the connection between consistency of beliefs and the preservation of semantics in knowledge base when changes are introduced; however, none of them focuses on studying the implications of the changes in terms of variations of attacks between arguments. Due to the inherent complexity in generating the AFs, the current version of the tool is able to generate all the AFs with a maximum of 3 arguments. By setting 3 as the number of arguments, 3^2 different attacks can be presented, for a total of 2^9 different AFs. In the future, we intend to bring this threshold to 6, by only considering non-isomorphic AFs in order to reduce the generated nodes. Also, we would like to study inclusion between extensions of a single AF and between sets of AF in the graph. At this point, a more detailed study concerning subclasses of directed graphs (such as symmetric and simple) could be carried out. Finally, we would like to extend the concept of robustness to coalitions of arguments, by studying how much a group of arguments derived from partitioning the original set is more robust than another.

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