Ranking-based Argumentation Semantics Applied to Logical Argumentation (Extended Abstract)

Jesse Heyninck[1,*], Badran Raddaoui[3,4] and Christian Straßer[4]

[1]Open Universiteit, the Netherlands
[3]SAMOVAR, Télécom SudParis, Institut Polytechnique de Paris, France
[4]Institute for Philosophy II, Ruhr-Universität Bochum, Germany

Abstract

In formal argumentation, a distinction can be made between extension-based semantics, where sets of arguments are either (jointly) accepted or not, and ranking-based semantics, where grades of acceptability are assigned to arguments. Another important distinction is that between abstract approaches, that abstract away from the content of arguments, and structured approaches, that specify a method of constructing argument graphs on the basis of a knowledge base. While ranking-based semantics have been extensively applied to abstract argumentation, few work has been done on ranking-based semantics for structured argumentation. In this recently published paper [1], we make a systematic investigation into the behaviour of ranking-based semantics applied to existing formalisms for structured argumentation. We show that a wide class of ranking-based semantics gives rise to so-called culpability measures, and are relatively robust to specific choices in argument construction methods.

Keywords

formal argumentation, logic-based argumentation, inconsistency measures, culpability measures, reasoning with inconsistent information

1. Introduction

A central concept in formal argumentation [2] is that of an *argumentation graph*, that consists of a set of nodes interpreted as arguments, and edges interpreted as argumentative attacks. Within the area of formal argumentation, one can distinguish between *abstract* and *structured* approaches. Abstract argumentation abstracts away from the content of arguments and thus can be seen as taking argumentation graphs as primitive objects of study. Structured approaches, on the other hand, specify construction methods defining how an argumentation framework is generated on the basis of a knowledge base consisting of formulas specified in a logical language. *Plausible reasoning* is a sub-class of structured argumentation formalising reasoning on the basis of defeasible premises and non-defeasible rules or logical systems such as classical logic. *Argumentation semantics* specify the acceptability of arguments given an argumentation graph. One can distinguish between so-called *extension-based* semantics, that specify which

KoDis'23: The 2nd International Workshop on Knowledge Diversity, September 3, 2023, Rhodes, Greece
*Corresponding author.
jesse.heyninck@ou.nl (J. Heyninck); badran.raddaoui@telecom-sudparis.eu (B. Raddaoui); christian.strasser@rub.de (C. Straßer)
0000-0002-9421-8566 (C. Straßer)

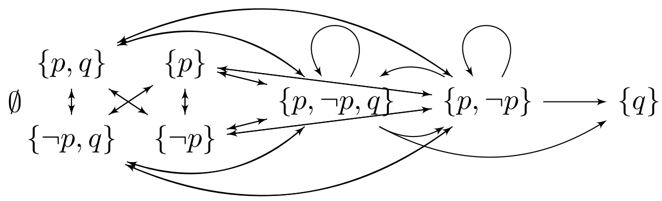
sets of arguments are jointly acceptable, and *gradual* or *ranking-based* semantics, that express acceptability in terms of a ranking over the arguments. Recent years have seen an intensive study of both kind of semantics in both breath and depth (see [3, 4] for some overviews) from the abstract perspective. For extension-based semantics, the structured perspective has played a major role. For ranking-based semantics, on the other hand, virtually no work has been carried out from the structured perspective (the only exception being [5]). Such a gap is rather surprising, as structured argumentation still provides one of the gold standards of the construction or generation of abstract argumentation graphs. Indeed, it is not clear whether and how the ranking-based semantics provide intuitive meaning from the logical perspective of structured argumentation.

In this recently published paper [1, 6], we make the first general study of ranking-based semantics applied to structured argumentation frameworks. We focus on logic-based argumentation, an important and well-studied sub-class of structured argumentation. In particular, we answer the following questions:

1. What is the logical meaning of ranking-based semantics applied to argumentation graphs generated on the basis of strict and defeasible information?
2. What is the influence of choices underlying the construction of the argument graph (e.g. the form of argumentative attacks) on the outcome of ranking-based semantics?

2. Preliminaries

Assumption-based argumentation [7, 8] is a form of structured argumentation where aguments are constructed on the basis of a set of strict premises Γ, plausible assumptions Ab and strict rules. Conflicts between arguments are determined on the basis of a contrariness relation $\sim$. We assume that the strict rules are generated on the basis of a *contrapositive logic* (e.g. classical logic CL). An example is the assumption-based framework making use of classical logic CL, using no strict premises (i.e. $\Gamma = \emptyset$), and plausible assumptions $Ab = \{p, \neg p, q\}$. The corresponding argumentation-graph looks as follows:



There has been a wide range of ranking-based semantics proposed in the literature to rank arguments from the most acceptable to the weakest arguments [3]. Following Baroni, Rago and Toni [4], we consider ranking-based semantics as mappings σ of arguments to a set $\mathbb{I}$ preordered by $\leq$ relative to an argumentation framework $\mathsf{AF} = (\mathcal{A}, \rightarrow)$. Given $a, b \in \mathcal{A}$, $\sigma(a) \geq \sigma(b)$ means that the argument a is at least as acceptable as the argument b according to σ. For simplicity, we assume the image of σ is always $\mathbb{R}_{\geq 0}$. In the remainder of the paper, we will denote σ_{AF} as the ranking-based semantics relative to AF. A high ranking $\sigma_{\mathsf{AF}}(a)$ represents a high quality of an argument a w.r.t. AF according to σ.

As an illustration of a ranking-based semantics, we look at the *categorizer semantics*, first presented in [9] for acyclic frameworks but generalized to any argumentation framework in [10]. This semantics formalizes the idea that the number of attackers decreases the quality of an argument. Formally, it works by taking the inverse of the sum of the score of the attacking arguments iteratively. In more detail, given an $\mathsf{AF} = (\mathcal{A}, \rightarrow)$ and $a \in \mathcal{A}$: $\mathtt{cat}_0(a) = 1$ and $\mathtt{cat}_{i+1}(a) = \frac{1}{1+\Sigma_{b \in a^-} \mathtt{cat}_i(b)}$, where a^- are the attackers of a. Consider the argumentation framework above. It can be verified that: $\sigma^{\mathsf{cat}}_{\mathsf{AF}}(\emptyset) = 1$, $\sigma^{\mathsf{cat}}_{\mathsf{AF}}(\{q\}) = 0.71$, $\sigma^{\mathsf{cat}}_{\mathsf{AF}}(\{p\}) = \sigma^{\mathsf{cat}}_{\mathsf{AF}}(\{\neg p\}) = 0.52$, and $\sigma^{\mathsf{cat}}_{\mathsf{AF}}(\{p, \neg p, q\}) = 0.41$.

In the full paper, several postulates are formulated and shown to be satisfied by a wide range of ranking-based semantics applied to simple-contrapositive assumption-based semantics.

3. Ranking-based Semantics as Culpability Measures

In this section, we look at the logical meaning of ranking-based semantics. More precisely, we ask the following question: when applying ranking-based semantics to an argumentation framework generated using a structured argumentation methodology, *what is the logical meaning of the ranking over arguments?* It turns out that a ranking-based semantics has a clear logical meaning: it induces an inversed culpability measure [11].

In more detail, in the full paper it is shown that under very minimal assumptions on the ranking-based semantics σ (satisfied by e.g. the categoriser semantics [9], any instantiation of the social model semantics [12], the burden-based semantics and the discussion-based semantics [13]), for any simple contrapositive assumption-based framework $\mathsf{ABF} = (\mathfrak{L}, \Gamma, Ab, \sim)$ the following postulates generalizing the definition of culpability measures [11] are satisfied:

Freeness. If $\Psi \subseteq \mathsf{Free}(\mathsf{ABF})$, then $\sigma_{\mathsf{ABF}}(\Psi) \geq \sigma_{\mathsf{ABF}}(\Delta)$ for any $\emptyset \neq \Delta \subseteq Ab$.

Dominance. If $\Gamma \cup \{\phi\} \vdash \psi$ and $\Gamma \cup \{\phi\} \not\vdash \mathsf{F}$, then $\sigma_{\mathsf{ABF}}(\{\psi\}) \geq \sigma_{\mathsf{ABF}}(\{\phi\})$.

Blame. If $\phi \in \bigcup \mathsf{MIC}(\mathsf{ABF})$, then $\sigma_{\mathsf{ABF}}(\{\phi\}) < \mathsf{BestScore}(\sigma)$.

Consistency. If $\Gamma \cup Ab \not\vdash \mathsf{F}$, then $\sigma_{\mathsf{ABF}}(\Phi) = \mathsf{BestScore}(\sigma)$ for every $\Phi \subseteq Ab$.

In these postulates, BestScore is the rank assigned to the maximally plausible formulas (we refer to the full paper for more details).

4. Conclusion

In the full paper, the results are generalized to other frameworks for logic-based structured argumentation [14, 15]. In this way, the paper presents a general picture on the logical behaviour of ranking-based semantics when applied to logic-based structured argumentation. To the best of our knowledge, ranking-based semantics have been applied to structured argumentation in only two other works, namely [5, 9]. Our results are broader in the number of ranking-based semantics and the formalisms for logic-based structured argumentation that are considered

This paper contains a principled investigation of ranking-based semantics applied to structured argumentation. Rather than having the last word on this topic, we hope to have established that ranking-based semantics for structured argumentation are meaningful and useful, and thus open new ground for research. We believe this work can be extended in various directions, e.g. to ranking-semantics over sets of attacking logical arguments or other frameworks for structured argumentation.

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