Hierarchic Argument Strength Semantics

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Although formal argumentation is primarily considered a qualitative method of reasoning aimed at conflict resolution, the need to judge and compare arguments and argument sets, as well as their practical role, also suggest more fine-grained considerations involving numerical assessments. In fact, ideas of strength are relevant for high-level concepts like acceptance and attack as well as for more specific notions linked to the structure of individual arguments interpreted as inferential constructions justifying claims. It is thus not surprising that in recent years there has been a growing interest in various facets of argument strength.

On the side of abstract argumentation, we have a blossoming field of quantitative approaches which tag abstract arguments and relations between them with numbers, typically linked to strength, and aim at global acceptance gradings of arguments. A number of prescriptive and descriptive principles are used to restrict, structure, and understand the space of possibilities [BRT 19]. What is less clear is where these numbers may or should come from, and to what extent the chosen evaluation methods are coherent and in line with the intended meaning and origin. This calls for a closer look at strength concepts arising when we instantiate them by structured arguments [BHPS 18]. However, even for structured argumentation grounded in probabilistic reasoning, where one can rely on a particularly well-developed formal and conceptual machinery, this turns out to be a non-trivial task [Pra 18].

Our goal here is to introduce and investigate different notions of strength in the context of hierarchic structured arguments, that is fine-grained inference trees with object-level conditionals as premises and interpretable by suitable plausibility semantics inspired from default reasoning. The higher expressivity and semantic background of this framework should support the modelling of arguments and their transparent evaluation. It also offers a further tool for critically analyzing more traditional, syntax-oriented accounts of argumentative reasoning. This work generalizes earlier ideas presented for instance in [Wey 13]. Let us recall the three major categories of strength:

Intrinsic strength: How strongly does an argument by itself support its claims, including premises and intermediate conclusions? What is its generic epistemic impact?

Interactive strength: What is the attack and defence capacity of arguments relative to other arguments? To what extent do attack/support links weaken or strengthen arguments?

Posterior strength: What is the ultimate acceptance strength of arguments and their claims in the context of an argument domain? What is their overall inferential impact?

We analyze the first two strength concepts in the context of a more expressive, semantic-oriented argument model, namely general defeasible inference trees. These are finite trees where each node is tagged, first by a formula from some base language L representing a claim, which could also be a conditional, and secondly by a local strict/defeasible inferential relationship $\mid\!\sim_{loc}$ over L, resp. an input predicate Inp for leaf nodes. The only condition is local correctness: the formulas of the children must $\mid\!\sim_{loc}$-infer the parent formula.

We focus on a simple variant where $L = L_0 \cup \{\varphi \Rightarrow \psi, \varphi \twoheadrightarrow \psi \mid \varphi, \psi \in L_0\}$, L_0 is a standard propositional language, $\twoheadrightarrow$ represents strict (not material) implication, and $\Rightarrow$ defeasible implication (or a graded family thereof). We consider two robust local inference notions for inferring L_0-claims: strict and defeasible preferential entailment, $\vdash_p, \mid\!\sim_p$. For $\Phi \cup \{\psi\} \subseteq L_0$ and $\Delta \subseteq L_0(\twoheadrightarrow, \Rightarrow)$,

$$\Phi \cup \Delta \mid\!\sim_p \psi \ \text{ iff } \ \Delta \vdash_p \wedge\Phi \Rightarrow \psi \ \text{ and } \ \Phi \cup \Delta \vdash_p \psi \ \text{ iff } \ \Delta \vdash_p \wedge\Phi \twoheadrightarrow \psi.$$

In addition we use two unary input predicates, KB_s for standard and KB_n for necessary premises. The resulting tree structures are called *simple hierarchic conditional arguments* over L_0. They generalize ASPIC+ arguments insofar as they use arbitrary propositional formulas, encode contingent conditional information in the object language (not by meta-level rules), and allow local inference steps beyond Modus Ponens.

Like defeasible arguments, standard defaults are qualitative entities which can be exploited without relying on numerical parameters. Nevertheless, major default inference notions still proceed by using the default knowledge base to specify in some justifiable way distinguished numerical plausibility models, which can then be used to identify reasonable defeasible conclusions. These semi-qualitative techniques can also be exploited in the context of argumentation. One of the first steps into this direction was the ranking-measure-based plausibility semantics for abstract arguments interpreted by elementary structured instantiations [Wey 13]. The advantage of ranking measures, which we can assume rational/real-valued, is that they allow a proper handling of independence without imposing overprecise value attributions and restrictive arithmetic conditions.

For each hierarchic conditional argument a we can define a set of conditionals Γ_a consisting of a's premise conditionals together with conditionals encoding the simple and necessary premises, i.e. $\mathbf{T} \Rightarrow \varphi$ for $KB_s(\varphi)$ and $\mathbf{T} \twoheadrightarrow \varphi$ for $KB_n(\varphi)$. The argument structure is partly reflected by also considering the main claim ψ_a of a and the collection Ψ_a^0 of all the L_0-claims/premises. $(\Gamma_a, \Psi_a^0, \psi_a)$ is called the logical profile of a. It can be used to estimate the intrinsic strength of an individual argument and the degrees of support for all its claims.

The idea is to use techniques from ranking-measure-based default reasoning to specify for each consistent argument a ($\Gamma_a \nvdash \mathbf{F}$) a canonical ranking measure R_a which can be interpreted as the generic epistemic state induced by a. The strength of a claim φ is interpreted as its degree of belief w.r.t. R_a, namely $R_a(\neg\varphi)$. The strength of the full argument can be identified with the degree of belief of its main claim, or more informatively, with the degree of belief of the conjunction of all its claims. Of particular interest are those R_a derived from well-behaved ranking-measure-based default inference concepts, from naive plausibility maximization encoded by System Z to well-behaved ranking-construction accounts like System JZ [Wey 98]. The resulting notions of strength may however be non-Markovian in the sense that the strength of an argument does not have to be a function of the strength of its direct subarguments.

This semantic perspective offers various ways, not only to specify attacks between arguments, but also to measure their strength. We introduce two types of attack semantics, both with as many instances as there are reasonable ranking measure choice strategies.

Individualized attack semantics adopts the perspective of the attacker. Here the existence and strength of an attack is determined by the relation between the ranking states generically interpreting the involved arguments.

Integrated attack semantics seeks a joint perspective and evaluates all the available conditional information to establish the nature of the attack relation.

It can be shown that the properties of these attack concepts may diverge from what holds for classical structured approaches. For instance, an attack on a subargument does no longer imply an attack on the full argument. In fact, because of possible semantic interactions, subarguments play a lesser role. Higher strength alone also does not guarantee success. A weaker argument may well defeat a stronger one. It is an open question whether there are semantic assumptions bringing back common features of classical argumentation. This could be relevant less for conceptual than for computational reasons. For collections of conflicting hierarchic conditional arguments, interacting according to the above attack semantics, one can apply extension- and grading-based approaches to specify synthetic plausibility valuations over L_0. It remains to be seen which ones are normatively privileged, and what this means for default reasoning.

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