Towards Ranking Arguments in Incomplete Argumentation Frameworks

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1 Introduction

Argumentation frameworks (AF) are a model for rational decision-making. They focus on the representation and relationships of *arguments* and can be represented as a directed graph were the arguments are the vertices and an *attack* from one argument to another is represented as an edge. However these AFs are unable to handle any structural uncertainty or incomplete information about the existence of arguments or attacks. Hence the so called *incomplete argumentation frameworks* (IAF) were proposed to solve this problem, see [1] for a survey. In this framework the set of arguments and attacks are split into *uncertain* and *certain* elements. The existence of the uncertain elements is unknown. The classical approach to reason on IAF, similar to AF, are *extensions* i.e., sets of arguments that are jointly acceptable given some properties. Additionally to the extension-based reasoning different approaches to reason based on arguments were introduced. One popular approach are the *argument-ranking semantics* [3], which define a total preorder over arguments. Based on these preorders we can reason, which argument is "stronger" than another argument.

Up to this point *argument-ranking semantics* are only defined on AFs and SETAFs [6]. However the question which argument is the stronger one between two arguments is also interesting to investigate in the area of IAFs. Hence in this paper we propose a first idea to rank arguments in this setting. We use already proposed argument-ranking semantics as well as *preference aggregation functions* to define a ranking over arguments in an IAF.

2 Ranking in Incomplete Argumentation Frameworks

Reasoning in IAFs are done by selecting uncertain elements of the IAF and constructing a *completion*, then applying extension semantics to these completions. In this section we use a similar approach, but instead of applying extension semantics we will use argument-ranking semantics on each completion to construct a preorder over the arguments. So we will generate one ranking for each completion. To reason on this set we apply preference aggregation functions like the *Borda rule* (for more information [4]). With these functions we can construct a single preorder based on a set of preorders. The *Borda rule* awards points to each candidate, in this case each argument, based on the position in the preordering. So the lowest-ranked candidate in a ranking will get 0 points, the next 1 point and so on until the best ranked candidate receives $n-1$ points for n candidates. To calculate a winner we sum up all points for each candidate and the candidate with the most points wins. We will use the *categoriser ranking-based semantics* defined by [2]. This ranking considers the direct attackers of an argument to calculate its value.

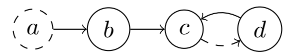

Fig. 1. IAF from the Example 1. The dashed arguments and attacks are uncertain.

Definition 1. *Let* $\mathsf{AF} = (\mathsf{Arg}, \mathsf{R})$*. The* categoriser function $Cat : \mathsf{Arg} \rightarrow]0, 1]$ *is defined as:*

$$Cat(a) = \begin{cases} 1 & \textit{if } R_1^-(a) = \emptyset \\ \frac{1}{1+\sum_{b \in R_1^-(a)} Cat(b)} & \textit{otherwise} \end{cases}$$

The ranking-based semantics categoriser *defines a ranking* $\succeq^{Cat}_{\mathsf{AF}}$ *on* Arg *such that for* $a, b \in \mathsf{Arg}$*,* $a \succeq^{Cat}_{\mathsf{AF}} b$ *iff* $Cat(a) \leq Cat(b)$*.*

Example 1. Consider the IAF from Figure 1. This IAF has four completions, C1: both a and (c, d) not included, C2: only a included, C3: only (c, d) included and C4: both a and (c, d) included. Hence we can calculate four preorders using the categoriser ranking-based semantics.

$$c1 : b \sim^{Cat}_{\mathsf{Arg}} d \succ^{Cat}_{\mathsf{Arg}} c \succ^{Cat}_{\mathsf{Arg}} a \qquad c2 : a \sim^{Cat}_{\mathsf{Arg}} d \succ^{Cat}_{\mathsf{Arg}} b \succ^{Cat}_{\mathsf{Arg}} c$$
$$c3 : b \succ^{Cat}_{\mathsf{Arg}} d \succ^{Cat}_{\mathsf{Arg}} c \succ^{Cat}_{\mathsf{Arg}} a \qquad c4 : a \succ^{Cat}_{\mathsf{Arg}} d \succ^{Cat}_{\mathsf{Arg}} b \succ^{Cat}_{\mathsf{Arg}} c$$

Note that argument a is part of ranking $c1$ and $c3$ despite not being included. We add all not included argument to the end of the ranking on the same level to construct a total ranking over the set of arguments. Applying the Borda rule on this set of ranking will result in the following ranking:

$$d \succ b \succ a \succ c.$$

So the "best" argument is d and the "worst" c.

Interestingly this ranking is different to all the rankings generated by the completions. Hence applying a preference aggregation function will influence the reasoning process.

Both methods (Categoriser semantics and Borda rule) can be replaced by any other method. For this replacement the properties of both methods should be considered. For argument-ranking semantics and preference aggregation functions a number of properties were proposed and each approach can only satisfy a certain number of these properties at the same time. So it will be interesting to investigate the properties of the resulting ranking of arguments in IAF and check if these properties are in conjunction with properties satisfied by the methods used to construct the ranking. Another future work idea is to extend the rankings in IAF to ranking in *control argumentation frameworks* [5] which is an extension of IAFs with another level of uncertainty. For that the idea presented above can be used in a similar fashion. By calculating rankings as above we will get a set of rankings, but by applying preference aggregation function again we can reduce this set of rankings to a single ranking.

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