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Probabilistic qualification of attack in abstract argumentation

Anthony Hunter

Department of Computer Science, University College London, Gower Street, London, WC1E 6BT, UK

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ABSTRACT

An argument graph is a graph where each node denotes an argument, and each arc denotes an attack by one argument on another. It offers a valuable starting point for theoretical analysis of argumentation following the proposals by Dung. However, the definition of an argument graph does not take into account the belief in the attacks. In particular, when constructing an argument graph from informal arguments, where each argument is described in free text, it is often evident that there is uncertainty about whether some of the attacks hold. This might be because there is some expressed doubt that an attack holds or because there is some imprecision in the language used in the arguments. In this paper, we use the set of spanning subgraphs of an argument graph as a sample space. A spanning subgraph contains all the arguments, and a subset of the attacks, of the argument graph. We assign a probability value to each spanning subgraph such that the sum of the assignments is 1. This means we can reflect the uncertainty over which is the actual subgraph using this probability distribution. Using the probability distribution over subgraphs, we can then determine the probability that a set of arguments is admissible or an extension. We can also obtain the probability of an attack relationship in the original argument graph as a marginal distribution (i.e. it is the sum of the probability assigned to each subgraph containing that attack relationship). We investigate some of the features of this proposal, and we consider the utility of our framework for capturing some practical argumentation scenarios.

1. Introduction

Computational models of argument aim to reflect how human argumentation uses conflicting information to construct and analyse arguments. There is a number of frameworks for computational models of argumentation. They incorporate a formal representation of individual arguments and techniques for comparing conflicting arguments (for reviews see [4,10,48]).

In abstract argumentation, a graph is used to represent a set of arguments and counterarguments. Each node is an argument and each arc from α to β denotes an attack by α on β. It is a well-established and intuitive approach to modelling argumentation, and it offers a valuable starting point for theoretical analysis of argumentation [23].

However, abstract argumentation does not explicitly consider whether an attack by an argument is believed or not. It only represents the existence of arguments and counterarguments. Yet often there is uncertainty with regard to the attacks.

In this paper, we will consider uncertainty of attacks. So given an argument graph $(\mathcal{A}, \mathcal{R})$, we may wish to assess the probability of each attack in $\mathcal{R}$ holding. Hence some attacks might be believed, some might be disbelieved, and some might be unknown. To illustrate, consider the following example.

E-mail address: a.hunter@cs.ucl.ac.uk.

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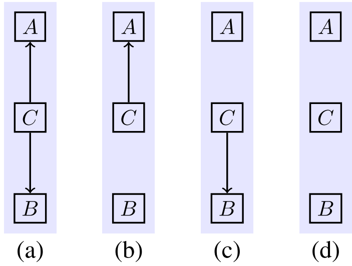

Fig. 1. For argument graph G_1, the subgraphs are (a) G_1, (b) G_2, (c) G_3 and (d) G_4.

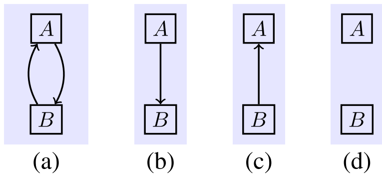

Fig. 2. For argument graph G_1, the subgraphs are (a) G_1, (b) G_2, (c) G_3 and (d) G_4.

Example 1. Consider the following arguments. The arguments A and B are arguments that each claim that the speaker is not involved in the robbery, and the argument C is by a potential witness casting doubt on the premises of arguments A and B by undercutting their premises. Also, we see that argument C attacks A with explicit certainty and C attacks B with explicit uncertainty.

- $A =$ "John says he was not in town when the robbery took place, and therefore denies being involved in the robbery."
- $B =$ "Peter says he was at home watching TV when the robbery took place, and therefore denies being involved in the robbery."
- $C =$ "Harry says that he is certain that he saw John outside the bank just before the robbery took place, and he also thinks that possibly he saw Peter there too."

If we consider both attacks made by argument C, then we get the argument graph given in Fig. 1a. However, if we also take into account the doubt in the attack by C on B, then we get the argument graph given in Fig. 1b. This means that there is uncertainty over whether the actual argument graph should be Fig. 1a or Fig. 1b. We can deal with this uncertainty by regarding the set of spanning subgraphs of Fig. 1a (i.e. the four subgraphs given in Fig. 1) as a sample space, and assigning a probability to each of them such that the sum is 1. For instance, if Harry has only weak confidence in C attacking B, then the probabilities might be 0.2 for Fig. 1a and 0.8 for Fig. 1b (i.e. $P(G_1) = 0.2$ and $P(G_2) = 0.8$).

In the example given above, there is explicit uncertainty expressed qualitatively in the attacks made by the arguments. Other situations where uncertainty arises is when there is ambiguity, a form of imprecision in the language used in the arguments, as illustrated in the following example.

Example 2. Suppose there are two witnesses to a criminal escaping in a car. Also, suppose the first witness says that the getaway car is red, and the other witness says that the getaway car is orange. If we take a strict interpretation of the colours, then we have two arguments A and B below, where each argument attacks the other.

- $A =$ "the getaway car is red"
- $B =$ "the getaway car is orange"

For these arguments, it may be inappropriate to treat "red" and "orange" as contradictory. There is some ambiguity, and hence some imprecision, in the use of these terms. And so, it may be possible to regard these two terms as consistent together. So if we consider the argument graph, there is some uncertainty as to whether A attacks B and vice versa. This means we have the four spanning subgraphs in Fig. 2. We could then for instance consider either Fig. 2a or Fig. 2d to be the actual argument graph, and so the sum of the probability assigned to these two graphs is 1. Furthermore, the more we consider them to be inconsistent together, the more we assign the probability to Fig. 2a, and the more we consider them to be consistent together, the more we assign the probability to Fig. 2d. For instance, if we believe with high probability that they are not inconsistent together, then we could let $P(G_1) = 0.1$ and $P(G_4) = 0.9$.