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Argumentation and graph properties

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ABSTRACT

Argumentation theory is an area of interdisciplinary research that is suitable to characterise several diverse situations of reasoning and judgement in real world practices and challenges. In the discipline of Artificial Intelligence, argumentation is formalised by reasoning models based on building and evaluation of interacting arguments. In this argumentation framework, the semantics of acceptance plays a fundamental role in the argument evaluation process. The determination of accepted arguments under a given semantics (admissible, preferred, stable, etc.) can be a time-consuming and tedious (in number of steps) process. In this work we try to overcome this substantial process by providing a method to compute accepted arguments from an argumentation framework. The principle of this method is to combine mathematical properties (e.g. symmetry, asymmetry, strong connectivity and irreflexivity) of graphs built from the argumentation system to compute sets of accepted arguments. In this work, we combine several graph properties to provide three main propositions; one for identifying accepted arguments under the admissible, preferred semantics and the other to easily identify *stable extension*. The proofs of the suggested propositions are detailed and this is part of an approach designed to increase collaborative decision-making by improving the effectiveness of reasoning processes.

1. Introduction

Argumentation, precisely abstract argumentation has been introduced by Dung (1995) in the 1990s. An argumentation system consists of a couple (*A*, *R*), where *A* is a set of elements called also arguments and *R* a binary relation representing attack relation between arguments. Argumentation and acceptability are themes common to all our activities, and we deal with them in an interdisciplinary fashion. Today, the complex projects have become even more collaborative and online. In collaborative working environment, competencies such as information communication and knowledge sharing, providing a service as well as a product and the aptitude to reason in an interdisciplinary manner become decisive. Particularly, in remote collaborative activities (Doumbouya et al., 2015a; Doumbouya et al., 2015b; Doumbouya et al., 2015c) (like e-heath), professionals work regularly and methodically together in an interdisciplinary way to ensure that actions and practices are well-harmonised and of high quality. Argumentation systems have been used in several works to help in decisions making process for example in Doumbouya et al. (2015a), Amgoud and Prade (2009), Amgoud and Vesic (2014), Villata et al. (2013) and Cayrol and Lagasquie-Schiex (2013). The process of decisions making consists of knowing arguments that should be accepted under a given semantics (admissible, preferred, stable, etc.) in an effort to consolidate the elements of decisions.

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In most of these published papers, before knowing the arguments that should be accepted under a given semantics, one has to build first extensions or labellings, because in the literature, there are several approaches (Baroni & Giacomin, 2009) to build argumentation semantics. The most common are:

- Extension-based approach is a theoretical reasoning in which the semantics specification concerns the generation of a set of extensions from an argumentation framework.
- Labelling-based approach is a theoretical reasoning in which the semantics specification concerns the generation of a set of labellings (e.g. possible alternative states of an argument) from an argumentation framework.

In the extension-based approach, there are several steps to follow for determining the acceptable arguments, namely:

1. Determination of conflict-free sets.
2. Determination of extensions:
   - admissible extensions,
   - preferred extensions;
   - complete extensions;
   - stable extensions ...

We think that the process is too tedious, given that our previous works (Doumbouya et al., 2015a; Doumbouya et al., 2015b; Doumbouya et al., 2015c) uses the extension-based approach, it is why we propose this work to overcome this heavy process whenever it is possible. Our approach is based on the properties (strong connectivity, symmetric, asymmetric, irreflexive) of the graph theory, given that the argumentation systems use the visual representation framework with a directed graph modelling the attack relations between arguments. This process will permit to bypass the computation of extensions when it is possible. In other words by these properties of the graph we can compute easily the acceptable arguments under a given semantics (admissible, preferred, stable).

In the following, we firstly recall some basic notions of argumentation system and graph theory, we secondly explain our work in the materials and methods section followed by a discussion section, and finally we end this work by a conclusion with perspectives.

2. Background

2.1. Argumentation system

2.1.1. What is argumentation?

Argumentation is a reasoning model based on building and evaluation of interacting arguments. Argumentation theory is generally applied to non-monotonic reasoning, decisions making or for types of dialogue modelling such as negotiation. Most of developed models are based on Dung argumentation system (Dung, 1995). This methodological framework is composed of a set of arguments and binary relations emphasising potential conflicts between arguments.

2.1.2. Definitions and properties related to argumentation system

Definition 1. An (argumentation-based) decision framework AF is a couple (A, D) where:

- A is a set of arguments
- D is a set of actions, supposed to be mutually exclusive
- *action*: $A \to D$ is a function returning the action supported by an argument

Definition 2. From an argumentation-based decision framework (A, D), an equivalent argumentation framework $AF = (A, R)$ is built where:

- A is the same set of arguments
- $R \subseteq A \times A$ is a binary attack relation (α attacks β is denoted $\alpha R \beta$ or $(\alpha, \beta) \in R$)

Definition 3. Let $AF = (A, R)$ be an argumentation framework, and let $B \subseteq A$

- B is conflict-free if there are no $\alpha, \beta \in B$ such that $(\alpha, \beta) \in R$
- B defends an argument α iff $\forall \beta \in A$, if $(\beta, \alpha) \in R$, then $\exists \gamma \in B$ such that $(\gamma, \beta) \in R$

Definition 4 (**Acceptability semantics**). Let $AF = (D, A, R)$ be a decision system, and B be a conflict-free set of arguments.

- B is admissible extension iff it defends any element in B.
- B is a preferred extension iff B is a maximal (w.r.t set $\subseteq$) admissible set.
- B is a stable extension iff it is a preferred extension that defeats any argument in $A \backslash B$.

Definition 5 (**Argument status**). Let $AF = (D, A, R)$ be a decision system, and $\varepsilon_1, \ldots, \varepsilon_x$ its extensions under a given semantics. Let $a \in A$.