

Intertranslatability of Abstract Argumentation Frameworks

Sylwia Polberg

University College London, United Kingdom

Abstract

Abstract argumentation is a rich research subfield of AI and till today, numerous frameworks for it have been proposed. It is thus natural to ask whether one can translate between these structures, and what are the price and consequences of undergoing this process. Although every study explains how a given structure relates to the cornerstone of abstract argumentation – Dung’s framework – there are less results available concerning the connections between more advanced formalisms. Moreover, the existing research is not particularly systematized or classified in a way that would clearly show us the properties of a given transformation. In our work, we address these issues by creating an in–depth compendium on the intertranslatability of argumentation frameworks, describing approximately eighty translations. Furthermore, we provide a system for analyzing a given transformation in terms of its functional, syntactical, semantical and computational properties and the underlying methodology.

Over the last years, argumentation has become an influential subfield of artificial intelligence, with applications ranging from legal reasoning (Bench-Capon, Prakken, and Sartor 2009) to dialogues and persuasion (McBurney and Parsons 2009; Prakken 2009) to medicine (Fox et al. 2010; Hunter and Williams 2012) to eGovernment (Atkinson, Bench-Capon, and McBurney 2006). Within it, we can distinguish the abstract argumentation approaches, at the heart of which lies Dung’s argumentation framework (Dung 1995). Since the structure itself was relatively limited, as it took into account only the conflict relation between the arguments, it inspired the search for more general models (Brewka, Polberg, and Woltran 2014). Throughout the years, many of its extensions were proposed, ranging from the ones employing various strengths and preferences to those that focus on researching new types of relations between arguments (Baroni et al. 2011; Cayrol and Lagasquie-Schiex 2013; Nielsen and Parsons 2007; Nouioua 2013; Polberg and Oren 2014; Brewka and Woltran 2010; Amgoud and Vesic 2011; Bench-Capon 2003; Modgil 2009).

Such an amount of frameworks should not come as a surprise. Argumentation is a wide area with numerous applications, in which one has to face different classes of problems. Frameworks of a given type can be seen as tools to model particular issues and concepts, which on one side gives us more insight into how to approach the problems, but on the

other affects the framework’s design. Nevertheless, with so many available structures, it is only natural to ask whether one can translate one framework into another, and what are the price and consequences of undergoing this process.

The ability to transform one framework into another is both of theoretical and practical value. The majority of the existing formalisms does not have a dedicated solver. Therefore, a translation into one that does, such as Dung’s framework or abstract dialectical framework (Egly, Gaggl, and Woltran 2010; Ellmauthaler and Strass 2014), can facilitate the development of argumentation–based applications. Moreover, if our purpose is to solve a variety of problems for which different frameworks are suitable, translations would allow us to choose the most adequate one to work “in the background”.

Our study can be seen as more research–oriented. The behavior of the semantics and what structural changes a framework has to undergo gives us an insight into how e.g. a given relation between arguments works and how it can or cannot be simulated by other concepts. For example, we can try to transform one form of support into another, support into attack or preference into an argument. However, the ability to perform a conversion is one thing; what is also important is the price we need to pay for it, and by this we do not mean just the computational cost of the process. Depending on how intrusive the modifications are, our source framework can be represented in a way that it is no longer possible to retrieve the original structure from it. We can be forced to assume some structure of arguments, drop or add – possibly exponentially many – elements of the framework. As a result, we can reach a point in which propagating the change in the source structure to the target one can become nearly impossible without repeating the translation altogether. This can make using translations in a dynamic setting quite problematic. Finally, even if we manage to create a non–intrusive, well–behaved translation, it might be the case it is such only for a subclass of the possible source frameworks. Similarly, an intricate transformation can be significantly simplified if certain assumptions are made. Therefore, the efficiency, semantics behavior, structural changes and domain coverage attributed with a given translation can be used to compare both the transformations and different argumentation frameworks.

The result of our work is an in–depth compendium on

the intertranslatability of argumentation frameworks, consisting of approximately eighty translations. Our focus will be on the Dung’s framework (Dung 1995), frameworks with joint attacks (Nielsen and Parsons 2007) and recursive attacks (Baroni et al. 2011), extended argumentation framework and its collective generalization (Modgil 2009; Modgil and Bench-Capon 2011), bipolar argumentation framework (Cayrol and Lagasque-Schiex 2013), argumentation framework with necessities (Nouioua 2013), evidential system (Polberg and Oren 2014) and abstract dialectical framework (Brewka and Woltran 2010). We not only propose a number of new approaches, but also complete and, if necessary, correct, the existing ones (Nielsen and Parsons 2007; Oren, Reed, and Luck 2010; Baroni et al. 2011; Cayrol and Lagasque-Schiex 2009; Nouioua 2013; Brewka et al. 2013; Modgil and Bench-Capon 2011; Oren, Reed, and Luck 2010; Polberg and Oren 2014; Cayrol and Lagasque-Schiex 2013). As a result of our study, the abstract dialectical frameworks emerge as perhaps the most general structures, capable of handling even the extended argumentation framework, for which the existing results were more limited (Modgil and Bench-Capon 2011).

In order to be able to compare our approaches and speak of their quality, we also introduce a classification system for describing a given translation in terms of functional, syntactical, semantical and computational properties. These attributes are meant to grasp different aspects of a transformation that we have discussed previously. Furthermore, we identify certain common patterns behind various translations and thus also propose to categorize them with respect to the underlying methodology. Finally, when possible, we use the existing research on semantics signatures (Dunne et al. 2015; Dyrkolbotn 2014) in order to show whether the proposed translations can or cannot be replaced by methods with more desirable semantical aspects.

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