Introducing the Special Issue on 20 Years of Argument-Based Inference

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The publication of Dung's landmark paper [24] twenty years ago marked the start of a great research interest into formal argumentation theory. Dung's work did not come in isolation, however, as different scholars were already exploring the topic of argument-based inference. Simari and Loui were laying the foundation of a formalism that would eventually evolve to DeLP [42]. Vreeswijk wrote his work on Abstract Argumentation Systems [44, 45], which would later be followed up by Baroni et al [5]. Dimopoulos and Magirou rewrote Reiter's Default Logic as a form of graph-based inference [23]. Overall, Dung's approach fitted in a particular research trend of that time.

One of the key ideas of Dung's theory, which greatly contributed to its popularity, is that of *abstraction*. The idea is to define non-monotonic entailment using three steps. In the first step, one starts with a particular knowledge base and determines what are the possible defeasible derivations (called *arguments*) one can make using this knowledge base. These derivations then become the nodes of a directed graph called an *argumentation framework*. The edges of such a graph represent the *attack*-relation. The idea is that an argument A attacks an argument B iff what A derives somehow invalidates the derivation B.

Once the argumentation framework has been constructed, the second step is to determine which of the arguments to accept. The fundamental idea of Dung's theory is to determine this based purely on the structure of the graph, without looking at the actual contents of the arguments. Different selection criteria (called *argumentation semantics*) have been stated, often allowing for more than one possible set of accepted arguments (called an *extension*).

After determining the set (or sets) of accepted arguments, the third step in the argumentation process is to determine the set (or sets) of accepted *conclusions*. This can be done in a fairly straightforward way. For each accepted argument, the conclusion supported by its derivation will be an accepted conclusion.

Dung's approach to non-monotonic inference, as sketched above, is essentially modular. Aspects of positive inference (steps 1 and 3) are separated from aspects of exception handling and reinstatement (step 2). Moreover, the non-monotonic aspects are isolated in step 2. This is because step 1 is monotonic (a larger knowledge base can only lead to more or the same possible defeasible derivations) and step 3 is monotonic (a larger set of accepted arguments can only lead to a larger or equal set of associated accepted conclusions) whereas step 2 is non-monotonic (adding more arguments and attacks to the graph can result in *less* arguments being accepted). It is this modularity that allows step 2 to be studied on its own, for instance by stating new criteria for argument acceptance and examining how these relate to each other [3, 4].

One of the early research questions related to Dung's theory is concerning its generality: to what extent is it possible to reformulate existing formalisms for non-monotonic inference as instances of Dung's three-step process? Dung himself examined this question for default logic and for logic programming under stable and well-founded semantics [24]. He found for instance that when constructing arguments based on a logic program (step 1) and applying the principle of *grounded semantics* (step 2), the accepted conclusions (step 3) are precisely the same as the well-founded model of the logic program one started with. In a similar way, Dung's three-step process has been shown to model Nute's Defeasible Logic [28], Pollock's OSCAR system [30] and logic programming under the 3-valued stable [46] and regular [16] semantics.

Apart from rewriting existing formalisms for non-monotonic inference as instances of Dung's theory, some research has also focused on applying Dung's theory to define potentially novel forms of non-monotonic entailment, as is for instance done in [41, 27] and in the various versions of the ASPIC formalism [10, 33, 47, 14].

The advantages of the argumentation approach for defining non-monotonic inference are not just limited to modularity and other aspects of technical elegance. It also provides opportunities to bring formal entailment closer to the kind of informal reasoning most humans are intuitively familiar with. For instance, formal argumentation theory allows the modelling of concepts like argument schemes [38] and discussion [18, 15, 12]. This makes formal argumentation theory suitable for situations in which forms of non-monotonic entailment need to be explained and verified by human users [13].

The principle of abstraction, being one of the greatest strengths of Dung's theory, also brings with it what is arguably one of the greatest challenges of the field: while Dung's theory was originally meant as an abstraction of *real existing* formalisms for non-monotonic entailment, the possibility of developing theory purely on the abstract level (step 2) may also lead to the risk that such theory does not really encompass any concrete context. This is the reason why some critiques have been raised on part of abstract argumentation research. In particular, three kinds of criticism can be found in the literature.

A first kind of criticism involves some of the works incorporating additional elements in Dung's framework w.r.t. the binary attack relation. For instance, in [39] it is argued that a proper modelling of preferences requires the structure of arguments and the nature of attacks to be made explicit, showing that the approaches that have been proposed to introduce preferences at the abstract level (such as PAFs [2] and VAFs [7]) face significant modelling problems. In [40] and similarly in [31] it is investigated whether frameworks for abstract argumentation with support relations [20, 21, 35] can be instantiated with the ASPIC formalism, arguing that this is not generally the case for bipolar argumentation frameworks [20, 21] and questioning the significance of evidential argumentation systems [35] as far as attacks from sets of arguments are concerned. Similar observations are raised in [31] concerning collective attacks [34]. More generally, it is claimed in [39] that "for any extension of abstract argumentation that does not make the structure of arguments or the nature of attack explicit, such as extensions with constraints [22] or with weighted attacks [26], a careful analysis is needed whether these phenomena can indeed be modelled at the abstract level". On the other hand, in [31] a partially positive answer seems to be given, i.e. relations additional to binary attacks are "more properly motivated under the assumption that they are required to model the way humans reason and debate".

A second criticism involves works that, while not modifying the definition of Dung's framework, propose alternative ways of selecting accepted arguments w.r.t. Dung's original argumentation semantics. If selecting the accepted arguments is done purely at the abstract level (step 2) based on the structure of the graph and without considering the actual contents of the arguments, then how does one know that what one selects actually makes sense from a logical perspective? After all, when using argumentation theory for the purpose of non-monotonic inference, an argument is essentially a defeasible derivation for a particular conclusion. How does one ensure that the set (or sets) of arguments one selects to be accepted will yield conclusions that are for instance classically consistent? Of course, one can avoid, say, selecting arguments that attack each other (thus applying a semantics that satisfies *conflict-freeness*) but this still does not solve the problem since it only rules out pairwise conflicts, whereas inconsistency can involve more than two arguments (see [19] for an example).[1] In general, one would like argument-based inference (or even non-monotonic inference in general) to satisfy particular *rationality postulates*, like direct consistency, indirect consistency and closure [10] as well as non-interference and crash-resistence [11]. This turns out to require a careful combination of how to construct the graph (step 1) and how to evaluate

[1]Even if one stays purely on the abstract level, it can be that a set of more than two arguments is in collective conflict [44, 45]. Although it is still possible to model this using Dung-style argumentation theory, doing so requires the careful construction of meta-arguments and the associated attacks, and restricts one's choice regarding the argumentation semantics. See [17] for details.

the graph (step 2) [10, 27, 14, 33]. This is not just a purely technical problem. When people argue, they often do so over what to believe or what to do. Some beliefs, however, are mutually exclusive, just like some actions cannot be performed collectively. Therefore, one would like to avoid obtaining recommendations that are absurd or impossible. Hence the need for satisfying rationality postulates also follows from practical requirements. Yet, not all abstract argumentation research is vulnerable to this kind of criticism. It has been shown, for instance, that several formalisms for argument-based inference [10, 27, 33] derive reasonable conclusions (satisfying the rationality postulates) under any complete-based semantics, i.e. under a semantics that selects one or more complete extensions[2], like preferred [24], grounded [24], ideal [25], eager [9] and semi-stable [43, 11]. On the other hand, while semantics departing from the notion of admissibility such as CF2 [6] do not guarantee the extensions satisfy rationality postulates, one may use these semantics as a complement to complete-based ones in order to obtain additional information on argument status, which may be significant in the presence of odd-length attack cycles [6].

Finally, a third more radical criticism concerns Dung's model itself, e.g. in [1] Dung's framework is claimed to be "problematic when applied over a logical formalism, specifically a deductive one". On the other hand, [39] argues that "work on classical and, more generally, deductive argumentation is of limited applicability".

This is not the place to discuss all of these issues, let alone to take a position on them. We would only like to point out that work on instantiated argumentation overcomes some of the criticism against pure abstract approaches, by being able to model intuitive concepts like argument schemes (rules), claims (conclusions) and discussion (dialectical protocols), and by being able to provide an answer regarding what it is that some of the abstract argumentation theory is an abstraction of.

In the current special issue, we present two papers that aim to push the envelope on what we know about instantiated argumentation. The first paper, by Toshiko Wakaki, deals with the topic of argument-based preferences in the specific context of logic programming. As mentioned above, although some of the work in the literature aims to handle preferences purely on the abstract level [2, 7], this has been claimed to have serious disadvantages when it comes to entailing reasonable conclusions [19, 39]. This is the reason why formalisms like ASPIC handle preferences when constructing the argumentation framework, without any need for further graph transformations [33, 14]. An alternative approach, as is proposed in the paper of Wakaki, is to define preferences not at the argument level but at the conclusion level. This has the advantage of modularity — after computing the sets of accepted conclusions (which can be done using a traditional preferences-free argumentation theory) simply select among these according to preferences. As long as all sets of accepted conclusions yielded by the traditional preferences-free argumentation theory satisfy rationality postulates (which can be done using traditional means) it directly follows that the most preferred sets of accepted conclusions will satisfy rationality postulates as well.

The second paper, by Yining Wu and Mikołaj Podlaszewski, deals with defining a hybrid formalism that combines classical logic with defeasible rule-based reasoning. The idea is that classical logic enables strict entailment whereas defeasible rules enable defeasible entailment. However, it turns out that the *ex-falso quodlibet* principle of classical logic causes significant difficulties. Some of the existing approaches of dealing with this, such as [36, 37], aim for solutions on the purely abstract level (step 2). However, as pointed out in in [8], this still does not solve the problem. The paper of Wu and Podlaszewski takes the alternative approach of dealing with things on the level of graph construction (step 1) and provides a formal proof that this actually solves the observed problems.[3]

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[2]Yet, one of such semantics is criticized in [32] for similar reasons underlying the first kind of criticism above.
[3]Other recent work that deals with ex-falso quodlibet problem on the graph construction level is [29].

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