A Logical Framework for Modeling Argumentation using Labelled Deduction

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1 Introduction and motivations

Classical methods for representing and reasoning with knowledge rely on the assumption that the available information is complete, certain and consistent. In real-world problems this is usually not the case, and AI has long dealt with the issue of finding a suitable formalization for commonsense reasoning. Defeasible argumentation [SL92, CML00, PV99] has proven to be a successful approach in many respects, since it naturally resembles many aspects of human commonsense reasoning. Our intention is to find a logical framework in which the diverse aspects of defeasible argumentation can be formally captured, in order to analyze their emerging properties.

The issue of defining a logical framework for defeasible argumentation with labels has been tackled before in alternative ways. Hunter proposed a framework for characterizing structural information using labelled formulas combined with argumentation [Hun94]. Fox & Parsons [FP97] defined a Logic of Argumentation, a qualitative approach to decision making which makes use of labelled formulae, presented as an alternative to standard formalisms in order to overcome some of the limitations imposed by them.

Our approach focuses on formalizing an argumentative framework using Defeasible Logic Programming [Gar97] as a theoretical basis, combined with labelled deductive systems [Gab96]. In this presentation we describe the main aspects of our formalization.

2 The logical framework: an outline

Figure 1 gives an outline of our formalization. A knowledge base with potentially inconsistent information will be represented in a KR language $\mathcal{L}_{Arg}$. We will formalize two inference relations: $\mathrel{|\!\sim}_{Arg}$ (used to derive labelled wffs corresponding to *arguments*) and $\mathrel{|\!\!\!\curlyvee}$ (used to derive labelled wffs corresponding to dialectical trees). The consequences of these inference relations are wffs in $\mathcal{L}_{Arg}$, *i.e.* the agent's object language. In the next subsections we will briefly describe the main features of our approach.

2.1 Natural deduction rules

In the proof theory of defeasible argumentation there are two elements which deserve attention: *arguments* and *dialectical trees*. Arguments can be conceptualized as proofs involving defeasible information from a given knowledge base. Since information is defeasible, given an argument A there may be

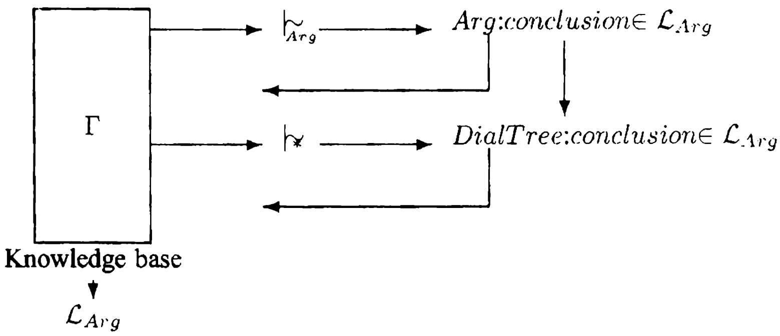

Figure 1: Sketch of the proposed framework

counterarguments $B_1 \ldots B_n$ which *defeat* A. These defeaters can on its turn be defeated. This results in a recursive characterization, called *dialectical tree*, in which arguments correspond to nodes of the tree, and the root corresponds to the main argument at issue. If that main argument remains ultimately undefeated, it is called a *warranted argument*, or just *warrant*.

Natural deduction rules along with extra conditions (such as consistency checking, dialectical constraints, etc) allow to formalize the process of both building arguments and dialectical trees. As we will see, these rules will characterize the inference relations $\mid\!\sim_{Arg}$ and $\mid\!\sim_{\star}$.

2.2 Logical properties. Cummulativity

Our formalization allows us to characterize different logical properties in argumentative systems. One of them is *cummulativity*, which basically expresses that simple conclusions inferred by an intelligent agent can be later used in proving more complex ones (formally, if α, β are wffs, and Γ is a set of wffs, cummulativity states that if $\Gamma \mid\!\sim \alpha$, then $\Gamma \cup \{\alpha\} \mid\!\sim \beta$ iff $\Gamma \mid\!\sim \beta$). As we will show in our presentation, cummulativity holds for argument construction as well as for warranted belief.

2.3 Distinguishing justification from warrant

Since reasoning is defeasible, a belief may be justified at one stage, unjustified at a later stage, and so on. Warrant is a less transitory notion of justification, being understood as "justification in the limit". A warranted proposition is one that eventually becomes justified and stays justified. As pointed out by John Pollock [Pol95], justification and warrant are concepts closely related to each other, but different. In our formalization we capture both concepts. We show how warrant can be defined as the deductive closure of the inference rules for computing justification.

2.4 Capturing semantics

Part of our current work involves defining a model-based approach for giving a formal semantics to our framework. Our approach involves determining *frames* (or classes of distinguished models) corresponding to the different proof-theoretic notions in our framework. This work was initially started in [SL92]. However, many new issues (such as dialectical constraints, which emerged in later research work) were not considered at that time. We are focused on finding an adequate formulation of these constraints within our formalization.

3 Conclusions

Labelled Deductive Systems offer a powerful tool for formalizing different logical frameworks. In this presentation we have described the main aspects of our formalization of defeasible argumentation using Labelled Deduction. On the one hand, the notion of label allows to capture the concept of *argument* as a set of wffs supporting a given proposition. On the other hand, the concept of *dialectical tree* can be also captured by a complex label. We mentioned that the proof procedure for wffs can capture both the notions of justification and warrant. This issue is directly linked with the definition of suitable *protocols* for argumentation, which allow us to reach warranted conclusions without spending unnecessary computational resources. Our current research work is namely focused on these aspects.

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