On Demonstrating the Impact of Defeasible Reasoning in Practice via a Multi-layer Argument-based Framework (Doctoral Consortium)

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ABSTRACT

Argumentation theory (AT) is an important area of logic-based artificial intelligence, which provides the basis for computational models of defeasible reasoning. Promising results have indicated AT as a solid research area for implementing defeasible reasoning in practice. However, applications are usually ad-hoc frameworks, not incorporating all the layers and steps required in an argumentation process, limiting their applicability in different domains. The aim of this research is to design a complete argument-based framework, from the construction of arguments, to the resolution of possible inconsistencies and the computation of the final conclusion or claim. This is proposed to be evaluated across practical application in the fields of knowledge representation and decision-making. In this study it is believe that, since AT is a relatively new field, the proposal of a more generally applicable solution, in the form of a computational framework, can likely inform its acceptance, widespread and encourage the development of argument-based technologies.

Keywords

Argumentation Theory, Decision-making, Knowledge Representation, Defeasible Reasoning

1. INTRODUCTION

Argumentation Theory (AT) is a paradigm that investigates how arguments can be represented, supported or discarded in a reasoning process and at the same time examines the validity of the conclusion reached. It has been widely employed in the field of Artificial Intelligence for modelling defeasible and non-monotonic reasoning [4]. In this research we specifically focus on the application of AT in the the fields of Decision-Making and Knowledge Representation.

A decision-making problem is equivalent to the selection of a course of action or belief among several possible alternatives, these sometimes being in contrast to each other. Examples include the decision-making under uncertainty that often occur in health-care and medicine, where medical diagnosis, treatment efficacy or outcomes need to be evaluated [5, 3]. Information accounted for in such reasoning processes is often heterogeneous, incomplete and complex. Additionally, the different pieces of information taken into account might be in contradiction with each other thus a method for resolving these is often necessary as final decision has to be taken.

A knowledge representation problem is concerned with how to formally represent available information into a computer program in order to enable inference [2]. For example, Mental Workload is a ill-defined psychological construct as there is no clear and widely accepted definition. In theory, a basic definition can be set as the amount of necessary effort devoted to a certain task within a period of time. In practice, due to its multi-faceted nature, the knowledge necessary for modelling mental workload is vast, complex, uncertain and contradictory, thus representing this construct is not a trivial problem [6, 7].

Decision-making and Knowledge Representation often go together, as in the case of Trust, another ill-defined psychological construct. A model of trust is required when a trustor entity, human or digital, has usually a knowledge-base of reasons, evidence and arguments, often contradicting, that needs to be aggregated and evaluated for enabling the interaction with a trustee entity. This evaluation can be seen as a form or defeasible reasoning activity made up of assertions, seen as presumptions, which are not deductively valid but whose validity can be attacked or supported by new evidence [9]. In this reasoning process, arguments have to be constructed, contradictions explicated and the resolution of conflicting information evaluated in order to produce conflict-free sets of arguments that need to be finally accrued for a final inference that can inform a decision. In practice, often applications only make use of a selection of the stages required to reach such final inference, providing ad-hoc solutions for a multitude of problems.

In summary, despite promising progresses have been made in several areas [1], demonstrating AT as a solid theoretical research discipline for implementing defeasible reasoning in practice, there are issues for applied research. State-of-the-art models of AT are usually ad-hoc and domain dependent, not often built upon all the layers of a full argumentative process (figure 2), as proposed in [7]. Due to this diversity, a clear structure that can be replicated and that allow models to be designed, built, evaluated and compared has not emerged yet [8].

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2. DESIGN AND EVALUATION

The aim of this doctoral research is to design, develop and evaluate a complete argument-based framework that includes the stages for knowledge representation, its elicitation, and final inference suggested in [7] (figure 2). The particular research question is:

RQ: Can a complete, multi-layer argument-based framework, built upon Argumentation Theory, offer enhancements when compared to other approaches for decision-making, knowledge representation and reasoning under uncertainty?

In order to answer the RQ a set of objectives are defined:

1. To design a multi-layer defeasible argument-based framework that includes the layers suggested in the literature [7], as per figure 2;
2. To implement such a framework employing modern web-based technologies to facilitate its use across different fields by different practitioners;
3. To adopt the framework for building and evaluating models for a selection of decision-making and knowledge representation problems, including medical diagnosis, mental workload modelling and trust inferences;
4. To evaluate the inferences generated by the framework and compare them against the ones produced by some of the existing approaches for handling uncertainty.

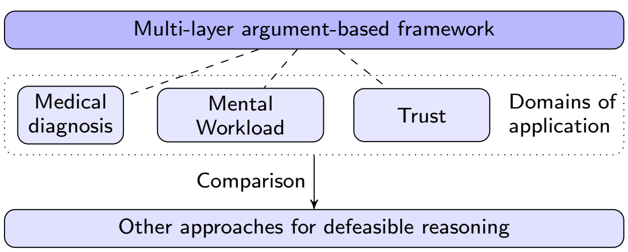

Figure 1: Evaluation strategy schema

The research hypothesis is that the inferences produced by models built upon this framework can enhance decision-making and knowledge representation as compared to a selection of state-of-the-art techniques for representing, reasoning over and handling uncertainty. These might include fuzzy non-monotonic reasoning, expert systems and/or Bayesian inference. Comparison properties have to be defined to enable comparison with other techniques for inference.

3. CONCLUSIONS

Some of the theoretical factors that make defeasible reasoning appealing are the lack of statistics or probability for inference, being this close to the way humans reason under uncertainty and the capacity to lead to explanatory reasoning. The main contribution expected in the proposed doctoral research is the demonstration of the inferential capacity of defeasible reasoning, implemented through computational Argumentation Theory, in practice. We believe that a multi-layer, argument-based framework can help demonstrate the positive impact of defeasible inference, enabling different applications and experiments to be carried out, replicated and compared. The proposed framework is expected to enhance reasoning over incomplete and inconsistent data, fragmented and vague knowledge when compared to other techniques for inference in the field of Artificial Intelligence.

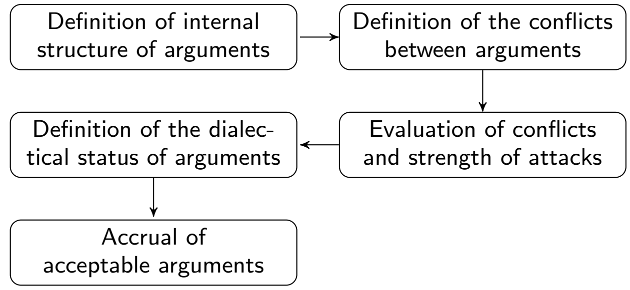

Figure 2: A multi-layer argument-based framework

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