Karlsruhe Institute of Technology

Institute of Information Security and Dependability (KASTEL)
Department of Philosophy (PHILO)

Classical Probabilistic Argumentation

Praxis der Forschung / Practice of Research

Motivation

In everyday and scientific reasoning, people exchange arguments for and against claims. Such debates are not merely collections of independent statements: an argument constrains which combinations of claims can be consistently accepted, while a counterargument may challenge its conclusion. Classical logic provides a precise language to encode constraints of arguments, but it does not by itself express *degrees of justification* or the effect of uncertain evidence.

Following Gregor Betz' account [1], a *debate* is a structured body of arguments over a shared set of statements. An argument consists of premises and a conclusion and is interpreted as the implication from the conjunction of its premises to its conclusion. Arguments may support a claim or attack another argument by concluding the negation of one of its claims. Thus, a debate captures the inferential and conflictual relations that determine which belief states are compatible with the arguments put forward.

In Betz' original framework, debates are treated qualitatively: classical logic determines which combinations of claims are compatible with the arguments. While this captures many aspects of debates, a probabilistic extension can represent uncertainty and degrees of belief more finely.

The goal of this PdF project is to investigate how a probabilistic semantics can extend debates while retaining their classical-logical foundations. Such a semantics assigns a probability measure to the worlds compatible with a debate, thereby representing uncertain belief while respecting its arguments. This connects debates to established methods from graphical models, model counting, and probabilistic inference.

Goals

The project will investigate the opotions for, formulate and analyse a probabilistic framework for classical debates. Possible research directions include:

- formalising debates as propositional constraints and characterising the probability measures compatible with them;
- studying whether non-uniform priors can be represented by extending a debate with hidden statements and arguments, while retaining a uniform distribution on the extended debate;
- analysing how beliefs change when a debate grows through new arguments, or when agents receive uncertain evidence, for example via Jeffrey conditioning;
- using factor graphs and primal graphs to identify conditional independences and to determine which beliefs can be affected by new arguments or evidence;

- comparing the resulting framework with probabilistic abstract argumentation, Markov logic networks, and weighted model counting.

During the first semester, participants will acquire the required background, survey possible mathematical foundations and related work, and select an appropriate basis for the framework. During the second semester, they will develop formal definitions, test conjectures on small examples, identify relevant properties, pursue proofs and computational experiments, and document the results in a research report or paper draft.

The project builds on Betz' theory of debate dynamics [1] and on work in probabilistic argumentation, probabilistic logic, and graphical models.

The project builds on a recently completed B.Sc. thesis that obtained preliminary results on making debates probabilistic, including a formalisation in the Isabelle/HOL theorem prover. This provides a solid starting point for further investigating and developing probabilistic formalisations of debates.

Prerequisites

- Interest in formal logic, probability theory, and rigorous mathematical reasoning.
- Interest in interdisciplinary exchange bridging computational philosophy and theoretical computer science.
- Helpful: successful completion of the "Stammmodul" *Formal Systems*.
- Basic programming experience is helpful for computational experiments, but is not required. [KEEP ? XXXXXXXXX]

Literature

1. G. Betz. *Debate Dynamics: How Controversy Improves Our Beliefs*. Springer, 2013.
2. D. Koller and N. Friedman. *Probabilistic Graphical Models: Principles and Techniques*. MIT Press, 2009. Chapter 4.
3. R. C. Jeffrey. *The Logic of Decision*. University of Chicago Press, 2nd edition, 1983. Chapter 11.
4. A. Hunter and M. Thimm. Probabilistic reasoning with abstract argumentation frameworks. *Journal of Artificial Intelligence Research*, 59:565–611, 2017.
5. M. Richardson and P. Domingos. Markov logic networks. *Machine Learning*, 62(1–2):107–136, 2006.

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