

# Formal argumentation and epistemic logic: what can they do for each other?

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Arguing and believing are two central cognitive dimensions of both human beings and artificial intelligent agents. The interrelation of these two notions (or groups of notions) is at the root of classic debates in epistemology and argumentation theory. During this talk, we will critically review recent literature on combining two well-known families of formalisms that account respectively for argumentation and beliefs, these are, formal argumentation and epistemic logic.

Formal argumentation [2] is nowadays a well-established research area within the field of artificial intelligence that attracts the attention of scholars coming from different disciplines and traditions. It has moreover a strong potential for dealing with different theoretical and practical problems. Following [15], the history of formal argumentation can be analysed as split into two main branches: the study of *argument-based inference* and the study of *argument-based dialogues*. Regarding the former, that will be our main focus here, another broad distinction between abstract and structured approaches is usually made. *Abstract argumentation* disregards the nature of arguments and conflicts between them, treating both of them as primitive entities, and focusing on the so-called *evaluative tier* of argument strength [4], that is, how to resolve conflicts between arguments so as to sort out subsets of acceptable ones. The work of [8] is usually considered as a landmark in this sub-field. The main proposal there was to model arguments as nodes of a directed graph, and conflicts as edges between them. Although very simple, this model, called *abstract argumentation frameworks*, has been shown to be a strongly intuitive, and

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powerful tool for many purposes. *Structured argumentation*, on the contrary, explicitly accounts for the nature and structure of both arguments and conflicts, capturing the so-called *support* and *dialectic* tiers of argument strength [4], that focus respectively, on how strong the premisses of an argument support its conclusion and on how arguments attack and defeat each other. To this respect, [14] could be mentioned as an influential, seminal paper among structural approaches, from which the ASPIC family, and notably ASPIC<sup>+</sup> [12], have received important attention.

Modern epistemic logic started with the works of [21] and [11]. Epistemic logic studies the notions of knowledge and belief (as well as related epistemic attitudes) using modal logic as the main mathematical tool. Since then, the field has evolved through the exploration of different alternatives (as non-Kripkean semantics [13]), and the solution of excessive idealizations of the model, e.g. the problem of logical omniscience. In its basic setting, to which we limit ourself here for the sake of simplicity, multi-agent epistemic models are just Kripke models (multi-directed graphs together with an atomic valuation), containing one accessibility relation  $R_i$  for each agent. Agent  $i$  believes (knows) that  $p$  is the case at a point  $w$  of the model if and only if at every  $R_i$ -successor of  $w$ ,  $p$  holds as well. Epistemic models are in turn described with a multi-modal language, that adds a modality  $\Box_i$  for each agent  $i$  to the language of propositional logic, informally interpreted as “agent  $i$  believes (knows) that...”. Hence, epistemic logic can be seen as a formal model for representing higher-order, qualitative epistemic attitudes, such as “I believe that you don’t believe that I believe that  $p$ ”.

**What can formal argumentation do for epistemic logic?** In a nutshell, formal argumentation can provide epistemic logic with technical and conceptual insights for studying the notion of *argument-based belief*. This connection is better understood if contextualized within the relatively recent effort of the epistemic logic community to equip their models of knowledge and belief with the heretofore excluded justification component. This effort has crystallized in very heterogeneous proposals, such as justification logic [1] or neighbourhood semantics for evidence logics [20]. During the talk, we will compare semantic approaches to the notion of argument-based belief, as those developed in [18, 19] and [22], to syntactic approaches, as the one of [5, 6] (a combination of ASPIC<sup>+</sup> and epistemic logic), pointing out the advantages and shortcomings of each of them.

**What can epistemic logic do for formal argumentation?** In few words, epistemic logic can be used as a powerful tool to deal with epistemic reasoning about abstract argumentation frameworks (and possibly other argumentation constructs). In this direction, [17] is an important antecedent, where abstract argumentation frameworks were embed-

ded in multi-agent epistemic models under different assumptions. During the talk, we will present recent results [16, 9, 10], that establish epistemic logic as a very general framework for modelling qualitative uncertainty and multi-agency with respect to argumentation structures, as well as their dynamics, making explicit by the way what are the epistemic assumptions underlying other existing formalisms, such as incomplete argumentation frameworks [3], and control argumentation frameworks [7].

## References

- [1] Sergei Artemov and Melvin Fitting. Justification logic. In Edward N. Zalta, editor, *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University, 2016.
- [2] Pietro Baroni, Dov M Gabbay, Massimiliano Giacomin, and Leendert van der Torre. *Handbook of formal argumentation*. College Publications, 2018.
- [3] Dorothea Baumeister, Matti Järvisalo, Daniel Neugebauer, Andreas Niskanen, and Jörg Rothe. Acceptance in incomplete argumentation frameworks. *Artificial Intelligence*, 295:103470, 2021.
- [4] Mathieu Beirlaen, Jesse Heyninck, Pere Pardo, and Christian Straßer. Argument strength in formal argumentation. *IfCoLog Journal of Logics and their Applications*, 5(3):629–675, 2018.
- [5] Alfredo Burrieza and Antonio Yuste-Ginel. Basic beliefs and argument-based beliefs in awareness epistemic logic with structured arguments. In Henry Prakken, Stefano Bistarelli, Francesco Santini, and Carlo Taticchi, editors, *Proceedings of the COMMA 2020*, pages 123–134. IOS Press, 2020.
- [6] Alfredo Burrieza and Antonio Yuste-Ginel. An awareness epistemic framework for belief, argumentation and their dynamics. In Joseph Y. Halpern and Andrés Perea, editors, *Proceedings Eighteenth Conference on Theoretical Aspects of Rationality and Knowledge (TARK)*, volume 335 of *EPTCS*, pages 69–83, 2021.
- [7] Yannis Dimopoulos, Jean-Guy Mailly, and Pavlos Moraitis. Control argumentation frameworks. In Sheila A. McIlraith and Kilian Q. Weinberger, editors, *Proceedings of the Thirty-Second AAAI Conference on Artificial Intelligence*. AAAI Press, 2018.
- [8] Phan Minh Dung. On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games. *Artificial Intelligence*, 77(2):321–357, 1995.

- [9] Andreas Herzig and Antonio Yuste-Ginel. Multi-agent abstract argumentation frameworks with incomplete knowledge of attacks. In Zhi-Hua Zhou, editor, *Proceedings of the Thirtieth International Joint Conference on Artificial Intelligence, IJCAI-21*, pages 1922–1928. IJCAI Organization, 2021.
- [10] Andreas Herzig and Antonio Yuste-Ginel. On the Epistemic Logic of Incomplete Argumentation Frameworks. In M. Bienvenu, G. Lakemeyer, and E. Erdem, editors, *Proceedings of the 18th International Conference on Principles of Knowledge Representation and Reasoning*, pages 681–685, 11 2021.
- [11] Jaakko Hintikka. *Knowledge and belief: an introduction to the logic of the two notions*. Cornell University Press, 1962.
- [12] Sanjay Modgil and Henry Prakken. The ASPIC+ framework for structured argumentation: a tutorial. *Argument & Computation*, 5(1):31–62, 2014.
- [13] Eric Pacuit. *Neighborhood semantics for modal logic*. Springer, 2017.
- [14] John L Pollock. Defeasible reasoning. *Cognitive science*, 11(4):481–518, 1987.
- [15] Henry Prakken. Historical overview of formal argumentation. *IfCoLog Journal of Logics and their Applications*, 4(8):2183–2262, 2017.
- [16] Carlo Proietti and Antonio Yuste-Ginel. Dynamic epistemic logics for abstract argumentation. *Synthese*, 2021.
- [17] François Schwarzentruher, Srdjan Vesic, and Tjitze Rienstra. Building an epistemic logic for argumentation. In Luis Fariñas del Cerro, Andreas Herzig, and Jérôme Mengin, editors, *Logics in Artificial Intelligence*, volume 7519 of *LNCS*, pages 359–371. Springer, 2012.
- [18] C Shi, S Smets, and FR Velázquez-Quesada. Argument-based belief in topological structures. In J Lang, editor, *Proceedings of the Sixteenth Conference on Theoretical Aspects of Rationality and Knowledge (TARK)*, EPTCS. Open Publishing Association, 2017.
- [19] Chenwei Shi. No false grounds and topology of argumentation. *Journal of Logic and Computation*, 31(4):1079–1101, 2021.
- [20] Johan van Benthem, David Fernández-Duque, Eric Pacuit, et al. Evidence logic: A new look at neighborhood structures. volume 9 of *Advances in modal logic*, pages 97–118. College Publications, 2012.

[21] George H Von Wright. An essay in modal logic. 1953.

[22] Yì N Wáng and Xu Li. A logic of knowledge based on abstract arguments. *Journal of Logic and Computation*, 2021.