Arguments, Scenarios and Probabilities:
Connections between Three Normative Frameworks for Evidential Reasoning[1]

Bart Verheij[a]   Floris Bex[b]   Sjoerd T. Timmer[b]   Charlotte S. Vlek[a]

John-Jules Ch. Meyer[b]   Silja Renooij[b]

Henry Prakken[b,c]

[a]*Institute of Artificial Intelligence, University of Groningen*
[b]*Department of Information and Computing Sciences, Utrecht University*
[c]*Faculty of Law, University of Groningen*

Abstract

Due to the uses of DNA profiling in criminal investigation and decision-making, it is ever more common that probabilistic information is discussed in courts. The people involved have varied backgrounds, as fact-finders and lawyers are more trained in the use of non-probabilistic information, while forensic experts handle probabilistic information on a routine basis. Hence, it is important to have a good understanding of the sort of reasoning that happens in criminal cases, both probabilistic and non-probabilistic. In the present paper, we report results on combining three normative reasoning frameworks from the literature: arguments, scenarios and probabilities. We discuss a hybrid model that connects arguments and scenarios, a method to probabilistically model possible scenarios in a Bayesian network, a method to extract arguments from a Bayesian network, and a proposal to model arguments for and against different scenarios in standard probability theory. These results have been produced as parts of research projects on the formal and computational modelling of evidence. The present paper reviews these results, shows how they are connected and where they differ, and discusses strengths and limitations.

1 Summary

In the full paper [8], of which the present text is a compressed contribution at BNAIC 2016, we study connections between arguments, scenarios and probabilities as normative frameworks in reasoning with evidence. Such a study is relevant given the different backgrounds of the people involved in criminal investigation and decision-making: Arguments and scenarios are familiar among fact-finders and lawyers, whereas probabilities are prominent in reports by forensic experts. By studying connections between arguments, scenarios and probabilities, we aim to enhance the understanding of these three tools for evidential reasoning in the law, thereby contributing to the reduction of reasoning errors and miscommunication caused by these different backgrounds.

Our work builds on recent developments to study reasoning with forensic evidence probabilistically, and in particular using Bayesian networks [5, 2]. Since it is known that it is easy to misinterpret Bayesian networks, for instance causally, we have started the exploration of the combined modelling of arguments and scenarios. Our approach continues earlier work on the design of structured probabilistic models and their explanation [4, 3].

We review research on the formal and computational connections between three normative frameworks for evidential reasoning based on arguments, scenarios and probabilities, respectively. We study pairwise connections, and connections between all three.

Specifically, we discuss a hybrid model connecting arguments and scenarios, showing how reasoning with arguments can be combined with reasoning to the best explanatory scenario (see also [1]). We show how scenarios can be embedded in Bayesian networks, thereby connecting the role of the global coherence of scenarios with degrees of uncertainty (see also [9] where a case study evaluation is performed). We show how arguments can be extracted from a Bayesian network (see also [6]). We propose a view on arguments to and from scenarios in the context of probability theory (see also [7]). The paper explains the motivation for the different parts of the research and discusses strengths and weaknesses of each part.

There are many remaining hard questions about the safe handling of probabilistic and non-probabilistic evidence in criminal investigation and decision-making. Still we hope that the lessons that we have learnt by studying the different connections between arguments, scenarios and probabilities, will gradually contribute to the prevention of reasoning errors, and a reduction of miscommunication between fact-finders and forensic experts.

Acknowledgments

References

[1] F. J. Bex. *Arguments, Stories and Criminal Evidence: A Formal Hybrid Theory*. Springer, Berlin, 2011.

[2] N. E. Fenton. Science and law: Improve statistics in court. *Nature*, 479:36–37, 2011.

[3] N. E. Fenton, M. D. Neil, and D. A. Lagnado. A general structure for legal arguments about evidence using Bayesian Networks. *Cognitive Science*, 37:61–102, 2013.

[4] A. B. Hepler, A. P. Dawid, and V. Leucari. Object-oriented graphical representations of complex patterns of evidence. *Law, Probability and Risk*, 6(1–4):275–293, 2007.

[5] F. Taroni, C. Aitken, P. Garbolino, and A. Biedermann. *Bayesian Networks and Probabilistic Inference in Forensic Science*. Wiley, Chichester, 2006.

[6] S. T. Timmer, J. J. Meyer, H. Prakken, S. Renooij, and B. Verheij. Explaining Bayesian Networks using argumentation. In *Symbolic and Quantitative Approaches to Reasoning with Uncertainty - 13th European Conference, ECSQARU 2015, Compigne, France, July 15-17, 2015. Proceedings*, pages 83–92. Springer, Berlin, 2015.

[7] B. Verheij. To catch a thief with and without numbers: Arguments, scenarios and probabilities in evidential reasoning. *Law, Probability and Risk*, 13:307–325, 2014.

[8] B. Verheij, F. J. Bex, S. T. Timmer, C. S. Vlek, J. J. Meyer, S. Renooij, and H. Prakken. Arguments, scenarios and probabilities: Connections between three normative frameworks for evidential reasoning. *Law, Probability and Risk*, 15:35–70, 2016.

[9] C. S. Vlek, H. Prakken, S. Renooij, and B. Verheij. Building Bayesian Networks for legal evidence with narratives: a case study evaluation. *Artifical Intelligence and Law*, 22(4):375–421, 2014.