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A Tool for the Generation of Arguments from Bayesian Networks

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Abstract. This demonstration shows how arguments, formalised in a well defined framework, can be automatically constructed from a given Bayesian network.

Keywords. Argumentation, ASPIC+, Probabilistic Reasoning, Bayesian networks, CE-Logic

We present an implementation of our Bayesian Argumentation framework [1] that allows us to automatically generate arguments from Bayesian networks (BNs). A BN represents a joint probability distribution in a structured way and is a popular model for reasoning with statistical information. Our tool takes a BN as input and produces an ASPIC+ [2] argumentation framework. An ASPIC+ framework defines attack and defeat relations between arguments given the logical language, the rules and a preference relation. Our tool can show the resulting dung extensions as well. We construct rules based on a given BN. The resulting arguments are presented visually.

Our system was developed with applications to legal reasoning about evidence in mind, where statistical evidence is becoming more and more prevalent by the rise of DNA evidence. BNs can represent, and allow one to reason with, such evidence. However, for the correct interpretation of BNs by legal experts, explanation methods need to be developed. It is our aim to extract arguments from a BN representation of the evidence in order to facilitate the correct interpretation of statistical evidence in court.

To generate rules from a BN we apply a measure of strength that captures the incremental value contributed to the conclusion by the premises. As primitive statements (elements of our logical language) we use value assignments to variables from the networks. Rules are extracted that combine a number of premises with a conclusion. In the current implementation, we limit the premises for a conclusion to assignments of direct neighbours and parents of children of the conclusion node. We can handle some of the characteristic features of probabilistic reasoning such as explaining away which we will see in the example further on. We assign strengths and undercutters to rules according to the following measure of strength:

$$strength(N_1 = v_1 \wedge \ldots \wedge N_n = v_n \Rightarrow N_c = v_c) = \frac{P(N_c = v_c | N_1 = v_1 \wedge \ldots \wedge N_n = v_n)}{P(N_c = v_c)}$$

We use this strength to define a preference relation on rules. The rules with the preferences are used as input to the ASPIC+ framework, which then defines arguments.

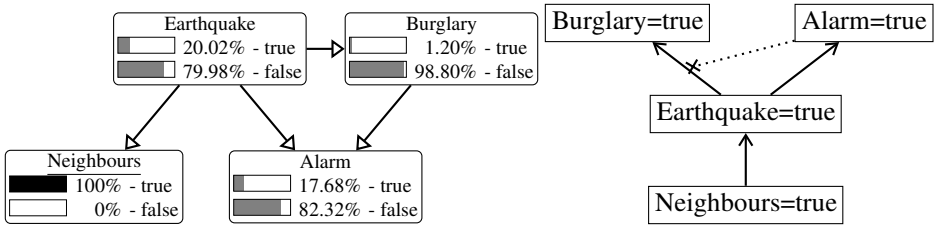

Figure 1. A very small BN and the extracted arguments.

On these arguments ASPIC+ also defines attack and defeat relations such that Dung extensions [3] of acceptable arguments can be calculated. The constructed arguments take the form of inference graphs with the observed variable instantiations in the roots.

All of the above has been implemented in this demo. Arguments can be explored through a simple user interface. Figure 1 shows a very small BN with one of the constructed arguments to the right.

This model can be used to answer the question whether or not a burglary has taken place. Two variables can be observed as evidence. A phone call about an earthquake by a neighbour ('Neighbours' node) or by an automated alarm ('Alarm' node). It is known that earthquakes can trigger false alarms and to make the case interesting we have accounted for the fact that burglars strike more often during earthquakes because they know that less attention will be paid at such times (represented by the edge between the two nodes). When the observation $Neighbours = true$ is entered, the argumentation can be built up via Earthquake to arguments for both $Alarm = true$ and $Burglary = true$. The latter two are predictive arguments in the sense that knowing something about the presence of an earthquake raises support for either of the two. Given also the alarm, the Burglary would 'explain away' the earthquake, which can be seen in the form of undercutting attacks from the Alarm node to the Earthquake node. The attacks are drawn in the figure above as dotted lines with crossed arrowhead.

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References

[1] Sjoerd T. Timmer, John-Jules Ch. Meyer, Henry Prakken, Silja Renooij, and Bart Verheij, 'Inference and attack in Bayesian networks', in *Benelux Conference on Artificial Intelligence 2013*, pp. 199–206, (2013).

[2] Sanjay Modgil and Henry Prakken, 'A general account of argumentation with preferences', *Artificial Intelligence*, **195**, 361–397, (2013).

[3] Phan Minh Dung, 'On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games', *Artificial Intelligence*, **77**, 321–357, (1995).