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Evaluating interval-valued influence diagrams ☆

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ABSTRACT

Influence diagrams are probabilistic graphical models used to represent and solve sequential decision problems under uncertainty. Sharp numerical values are required to quantify probabilities and utilities. This might be an issue with real models, whose parameters are typically obtained from expert judgments or partially reliable data. We consider an interval-valued quantification of the parameters to gain realism in the modeling and evaluate the sensitivity of the inferences with respect to perturbations in the sharp values of the parameters. An extension of the classical influence diagrams formalism to support such interval-valued potentials is presented. The variable elimination and arc reversal inference algorithms are generalized to cope with these models. At the price of an outer approximation, the extension keeps the same complexity as with sharp values. Numerical experiments show improved performances with respect to previous methods. As a natural application, we propose these models for practical sensitivity analysis in traditional influence diagrams. The maximum perturbation level on single or multiple parameters preserving the optimal strategy can be computed. This allows the identification of the parameters deserving a more careful elicitation.

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1. Introduction

Influence diagrams (IDs) are popular probabilistic graphical models intended to represent and solve decision problems with uncertainty. IDs represent a sophistication of Bayesian networks to cope with sequential decision tasks. The parameters of an ID are not only, as in Bayesian networks, probabilities of conditional states of single variables given other variables, but also utilities of joint states of sets of variables. As Bayesian networks, IDs demand a sharp estimation of their parameters. Both probabilities and utilities might be quantified by expert knowledge or statistical data processing. Yet, sharp values can be unable to express a qualitative expert judgment or a statistical analysis based on scarce or missing data. E.g., which is the number modeling the probability for an option more probable than its negation? And the negative utility of a disaster scenario that never occurred in the past?

For reasons of this sort, in the last two decades, various extensions of Bayesian networks intended to support generalized probabilistic statements have been proposed. These models have been developed in the field of possibility theory [4], evi-

☆ This paper is an extended and revised version of material originally presented in [8].

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