The Soft Propagation Algorithm: a Proposal for Responsive Belief Revision with Bayesian Networks

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Poster Abstract

Bayesian Networks are graphical statistical models representing and efficiently exploiting the pattern of dependencies among a set of relevant variables. They are particularly effective within complex systems, where the inference tasks on the joint probability distribution exploit the modular representation of local dependencies. When a subset of variables from the model is observed, evidence is propagated through the network via message-passing algorithms, based on conditionalization.

Due to a multiplicity of reasons, it is quite common to observe events of interest being affected by degrees of uncertainty. We characterize a number of situations that yield uncertain evidence and specify it accordingly for the purpose of belief revision, defined as the process of changing a probability distribution based on new constraints posed by epistemic peers. A revised probability distribution is responsive if it satisfies all such constraints simultaneously.

Based on Probability Kinematics, we propose the Soft Propagation algorithm as a belief revision procedure within the framework of Bayesian Networks, generalizing the well-known Junction Tree algorithm to the case of uncertain conditional observations. The Junction Tree algorithm reduces the model's structure to a simplified graphical representation and efficiently performs message-passing conditioning on observed evidence. We show how the latter is nothing but a special case of general *uncertain conditional evidence*, that our proposal accounts for via a distance-based Revision Rule, which is proved to be exact under certain conditions and invariant with respect to different revision schedules. We introduce the Oedipus Strategy as a generalization of the procedure to the relaxed case of *U-polytrees*, graphical structures that we conveniently introduce in our work.

The revised joint probability distribution resulting from the Soft Propagation algorithm satisfies all the constraints provided by epistemic peers when the information they provide does not overlap. When overlapping of information occurs, the procedure generalizes to the imprecise setting and provides as output a credal root clique which is consistent with both precise and imprecise uncertain evidence constraints, according to an exact routine.