JavaQCredo: A Software for Qualitative Credal Networks

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Abstract

Credal networks enhance robustness and modelling power of Bayesian networks by allowing for the specification of *credal sets* (*i.e.*, convex sets of probability mass functions), instead of single conditional mass functions in the model definition [2]. Unlike the case of Bayesian networks, for which a large number of software tools with graphical interface are available (*e.g.*, Hugin, Netica, Samiam, JavaBayes), no tools of this kind have been developed so far for credal networks. The Java software we present, called *JavaQCredo*, and based on Fabio Cozman's code originally developed for JavaBayes, should be regarded as a first step in this direction. Its implementation has been granted by the Swiss army, with the goal of supporting military experts in their strategic decision tasks. Model variables and conditional dependencies are associated to nodes and arcs of a graph in the same way as any other tool for Bayesian networks. The distinctive feature of JavaQCredo concerns the quantification of the conditional models for the different variables: no numbers have to be explicitly assessed to express expert knowledge [3]. The user is simply required to formulate qualitative judgements about the (conditional) states of the variables like, for instance, *"if Y is y, X is likely to be x"*. This is achieved by scrolling drop-down lists to select the quantifier (*i.e.*, likely, probable, etc.), which, at the system level, becomes a linear constraint for the probability (*e.g.*, $l \leq P(X = x|Y = y) \leq u$). If no judgement is reported for a state, only a vacuous constraint (*i.e.*, probability belonging to $[0, 1]$) is assumed. Given the judgements specifications, the system computes the credal set of all the distributions consistent with the constraints implicitly specified by the user. To prevent inconsistencies in the user's judgements, the system removes from the drop-down lists judgements leading to empty credal sets. We also support *comparative judgements* like, for instance, *"Y is more likely to be y than $\tilde{y}$"*. These can be specified in a similar way, with drop-down lists to select the states to be compared and the comparison operator (*i.e.*, much more probable, less probable, etc.). Also these judgements are translated into linear constraints (*e.g.*, $P(y) > \gamma P(\tilde{y})$), with the system still preventing inconsistencies. The default numerical translation for the verbal quantifiers (*i.e.*, values of parameters like l, u, γ) can be customized for a better elicitation. For variables with many parents, a compact specification of the conditional credal sets can be achieved by an imprecise version of the *noisy-OR* gate [1]. Inferences about a variable are computed just by clicking on it, after having specified the observations. In this release, whose focus was on the graphical interface, an inner approximation of the posterior credal set for the queried variable is simply obtained by randomly picking the vertices of the different credal sets, and iteratively updating the corresponding Bayesian networks. Other algorithms for credal networks should be implemented in the next releases. The system displays the optimal states for the queried variable according to the *maximality* criterion. A geometric view of the posterior credal set as a polytope in the probability simplex is also given for binary and ternary variables.

Keywords. Credal networks, credal sets, probability intervals.

References

[1] Alessandro Antonucci. The imprecise noisy-OR gate. *Proceeding of Fusion 2011*, IEEE, 2011.

[2] Fabio Cozman. Credal networks. *Artificial Intelligence*, 83:1–58, 1996.

[3] Alberto Piatti, Alessandro Antonucci, Marco Zaffalon (2010). Building knowledge-based systems by credal networks: a tutorial. In Baswell, A. R. (Ed), *Advances in Mathematics Research 11*, Nova Science Publishers.