Evaluating Credal Set Theory as a Belief Framework in High-Level Information Fusion for Automated Decision-Making

av

Alexander Karlsson

Akademisk avhandling

Avhandling för teknologie doktorsexamen i datavetenskap, som enligt beslut av rektor kommer att försvaras offentligt fredagen den 22 oktober 2010 kl. 13.15,
Insikten, Högskolan i Skövde

Opponent: Professor Galina Rogova
School of Engineering and Applied Sciences
SUNY University at Buffalo, NY, USA

Örebro universitet
Akademin för naturvetenskap och teknik
701 82 ÖREBRO
Abstract

High-level information fusion is a research field in which methods for achieving an overall understanding of the current situation in an environment of interest are studied. The ultimate goal of these methods is to provide effective decision-support for human or automated decision-making. One of the main proposed ways of achieving this is to reduce the uncertainty, coupled with the decision, by utilizing multiple sources of information. Handling uncertainty in high-level information fusion is performed through a belief framework, and one of the most commonly used such frameworks is based on Bayesian theory. However, Bayesian theory has often been criticized for utilizing a representation of belief and evidence that does not sufficiently express some types of uncertainty. For this reason, a generalization of Bayesian theory has been proposed, denoted as credal set theory, which allows one to represent belief and evidence imprecisely.

In this thesis, we explore whether credal set theory yields measurable advantages, compared to Bayesian theory, when used as a belief framework in high-level information fusion for automated decision-making, i.e., when decisions are made by some pre-determined algorithm. We characterize the Bayesian and credal operators for belief updating and evidence combination and perform three experiments where the Bayesian and credal frameworks are evaluated with respect to automated decision-making. The decision performance of the frameworks are measured by enforcing a single decision, and allowing a set of decisions, based on the frameworks’ belief and evidence structures. We construct anomaly detectors based on the frameworks and evaluate these detectors with respect to maritime surveillance.

The main conclusion of the thesis is that although the credal framework uses considerably more expressive structures to represent belief and evidence, compared to the Bayesian framework, the performance of the credal framework can be significantly worse, on average, than that of the Bayesian framework, irrespective of the amount of imprecision.

Key words: High-level information fusion, belief framework, credal set theory, Bayesian theory