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Deciding Koopman’s qualitative probability. (English) Zbl 07418682

Summary: In their recent paper in this journal, Delgrande, Renne and Sack study qualitative probability and discuss its role in Artificial Intelligence. Building on related work by de Finetti, Scott, Segerberg and others, the authors provide general axioms for qualitative probability. In this paper we investigate Koopman’s conditional qualitative probability from the computational viewpoint. An important part of his work, published in the Annals of Mathematics in 1940–1941, deals with finite conjunctions $\mathcal{K}$ of statements of the form “the probability of $a$ given $h$ does not exceed the probability of $b$ given $k$”, with $a, b, h, k$ elements of a boolean algebra. Upon coding these elements by boolean formulas, we provide a decision procedure to check the consistency of any such $\mathcal{K}$. As an immediate consequence, also inferences in Koopman’s probability theory are shown to be computable. These problems of qualitative probability theory significantly generalize Boole’s (typically quantitative) problem of estimating the possible probabilities of a new event given the probabilities of other events. Boole’s classical problem today is known as the optimization version of the probabilistic satisfiability problem PSAT. In 1986 Nilsson published an influential paper on this subject in this journal. The scope of our results is much larger than that of PSAT, because Koopman’s conjunctions $\mathcal{K}$ also formalize the key notion of independence. Some familiarity with boolean logic and finite boolean algebras is the only prerequisite for this paper.

MSC: 68Txx Artificial intelligence

Keywords:
Koopman comparative conditional probability; qualitative probability; independence; de Finetti Dutch book theorem; Boole probabilistic inference problem; PSAT; probabilistic satisfiability; uncertainty management; probabilistic consistency; probabilistic inference; measure on Boolean algebra; knowledge representation

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References:


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