Statistics > Methodology

Approximate Propagation of both Epistemic and Aleatory Uncertainty through Dynamic Systems

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When ignorance due to the lack of knowledge, modeled as epistemic uncertainty using Dempster-Shafer structures on closed intervals, is present in the model parameters, a new uncertainty propagation method is necessary to propagate both aleatory and epistemic uncertainty. The new framework proposed here, combines both epistemic and aleatory uncertainty into a second-order uncertainty representation which is propagated through a dynamic system driven by white noise. First, a finite parametrization is chosen to model the aleatory uncertainty by choosing a representative approximation to the probability density function conditioned on epistemic variables. The epistemic uncertainty is then propagated through the moment evolution equations of the conditional probability density function. This way we are able to model the ignorance when the knowledge about the system is incomplete. The output of the system is a Dempster-Shafer structure on sets of cumulative distributions which can be combined using different rules of combination and eventually transformed into a singleton cumulative distribution function using Smets' pignistic transformation when decision making is needed.

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