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Likelihood-free Simulation-based Optimal Design

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Simulation-based optimal design techniques are a convenient tool for solving a particular class of optimal design problems. The goal is to find the optimal configuration of factor settings with respect to an expected utility criterion. This criterion depends on the specified probability model for the data and on the assumed prior distribution for the model parameters. We develop new simulation-based optimal design methods which incorporate likelihood-free approaches and utilize them in novel applications.

Most simulation-based design strategies solve the intractable expected utility integral at a specific design point by using Monte Carlo simulations from the probability model. Optimizing the criterion over the design points is carried out in a separate step. M\"uller (1999) introduces an MCMC algorithm which simultaneously addresses the simulation as well as the optimization problem. In principle, the optimal design can be found by detecting the utility mode of the sampled design points. Several improvements have been suggested to facilitate this task for multidimensional design problems (see e.g. Amzal et al. 2006).

We aim to extend this simulation-based design methodology to design problems where the likelihood of the probability model is of an unknown analytical form but it is possible to simulate from the probability model. We further assume that prior observations are available. In such a setting it is seems natural to employ approximate Bayesian computation (ABC) techniques in order to be able to simulate from the conditional probability model. We provide a thorough review of adjacent literature and we investigate the benefits and the limitations of our design methodology for a particular paradigmatic example.

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