Bayesian design for physical models using computer experiments

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Design of experiments is an "a-priori" activity making the Bayesian approach particularly attractive. Bayesian inference allows any available prior information to be included in both design and analysis, yielding posterior distributions for quantities of interest that are more interpretable by researchers. Furthermore, the design process allows the precise aim of the experiment to be incorporated. Mathematically, a Bayesian design is given by the maximisation of an expected utility function over all unknown quantities. While straightforward in principle, finding a Bayesian design in practice is difficult. The utility and expected utility functions are rarely available in closed form and require approximation, and the space of all designs can be high dimensional. These problems are compounded when the data-generating process is thought to depend on an analytically intractable physical model, i.e. an intractable likelihood model. This talk will review a recent research programme that has developed methodology to find practically-relevant Bayesian designs for a range of physical models. The methodology uses several layers of computer experiments to both approximate quantities of interest (utilities and expected utilities) and to use these approximations to find Bayesian designs.