A hierarchical Bayesian framework for discrepancy in physical models

We present a hierarchical Bayesian framework for capturing the uncertainty in parameter inference and prediction due to model discrepancy in physical models. Our framework associates the variability in inferred model parameters with the corresponding variability in experimental data even when the underlying model is consistent with only a subset of the observed data. By partitioning the observed data into subsets where the physical model is most consistent with the data, we can obtain an ensemble of inferred model parameters, which are then combined to produce a "portable" description of model uncertainty. We demonstrate the suitability of our hierarchical approach on several model misspecification scenarios. More generally, the framework can be described using a hierarchical mixture model, which allows discontinuous or multiple-membership of observations. By enforcing certain restrictions on the mixture model, we can recover several existing treatments of model discrepancy. Furthermore, we consider nonparametric extensions of the hierarchical mixture model that allows automatic discovery and classification of consistent sub-populations within the observed data.