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Title: A Computationally Flexible Approach to Population-Level Inference and Data Integration

Abstract: We propose a multistage method for making inference at all levels of a Bayesian hierarchical model (BHM) using natural data partitions to increase efficiency by allowing computations to take place in parallel form using software that is most appropriate for each data partition. The full hierarchical model is then approximated by the product of independent normal distributions for the data component of the model. In the second stage, the Bayesian maximum a posteriori (MAP) estimator is found by maximizing the approximated posterior density with respect to the parameters. If the parameters of the model can be represented as normally distributed random effects, then the second- stage optimization is equivalent to fitting a multivariate normal linear mixed model. We consider a third stage that updates the estimates of distinct parameters for each data partition based on the results of the second stage. The method is demonstrated with two ecological data sets and models, a generalized linear mixed effects model (GLMM) and an integrated population model (IPM). The multistage results were compared to estimates from models fit in single stages to the entire data set. In both cases, multistage results were very similar to a full MCMC analysis.