THE UNIVERSITY OF CHICAGO

Department of Statistics

DISSERTATION PROPOSAL

SOMAK DUTTA
Department of Statistics
The University of Chicago

Statistical Inference and Computation with Gaussian Approximate Intrinsic Matérn and Related Models

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ABSTRACT

We consider Gaussian spatial mixed linear models on a regular array where the sampling design is such that we only observe data values on a subset of the grid points. We first focus on the case where the underlying or the latent spatial field follows a first order intrinsic autoregression (IAR) process and later generalize to approximate intrinsic Matérn model to allow for flexibility in modeling the smoothness of the field. For frequentist analysis we develop an h-likelihood method for their statistical inference. We contrive several matrix-free computation methods that drastically reduce the storage and computation requirements by orders of magnitude in sample size. The key ingredients of these methods are (1) exact spectral decomposition of the precision matrix of the intrinsic approximate Matérn (IAM) process where the matrix of eigenvectors correspond to the 2-dimensional discrete cosine transformation matrix thus allowing fast matrix-vector multiplication in a matrix-free way, (2) the Lanczos algorithm that exploits fast matrix-vector multiplications to solve matrix equations, and (3) the Hutchinson estimator of the trace of a matrix, which again can be computed in a matrix-free way. Ongoing research is focused on resolving issues with optimizing the non-convex residual log-likelihood for the IAM model and deriving the asymptotic properties of the estimates. We provide applications in agriculture field experiments and in mapping arsenic concentration in ground water in Bangladesh. Future projects include constructing sensible objective priors for the model parameters and perform Bayesian inference with the model. Our first objective is to study the properties of these priors in terms of scaling limit among others. Our matrix-free computation methods can be generalized and extended to construct MCMC algorithms for sampling from the posterior via approximate square-root computation of covariance matrices and also construct an algorithm for marginal likelihood evaluation via conditional simulation from a multivariate Gaussian distribution.
