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Fast Bayesian Inference of Multivariate Block-Nearest Neighbor Gaussian Process (NNGP) Models for Large Data

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Abstract : Several spatial variables collected at the same location that share a common spatial distribution can be modeled simultaneously through a multivariate geostatistical model that takes into account the correlation between these variables and the spatial autocorrelation. The main goal of this model is to perform spatial prediction of these variables in the region of study. Here we focus on a geostatistical multivariate formulation that relies on sharing common spatial random effect terms. In particular, the first response variable can be modeled by a mean that incorporates a shared random spatial effect, while the other response variables depend on this shared spatial term, in addition to specific random spatial effects. Each spatial random effect is defined through a Gaussian process with a valid covariance function, but in order to improve the computational efficiency when the data are large, each Gaussian process is approximated to a Gaussian random Markov field (GRMF), specifically to the block nearest neighbor Gaussian process (Block-NNGP). This approach involves dividing the spatial domain into several dependent blocks under certain constraints, where the cross blocks allow capturing the spatial dependence on a large scale, while each individual block captures the spatial dependence on a smaller scale. The multivariate geostatistical model belongs to the class of Latent Gaussian Models; thus, to achieve fast Bayesian inference, it is used the integrated nested Laplace approximation (INLA) method. The good performance of the proposed model is shown through simulations and applications for massive data.

Keywords : Block-NNGP, geostatistics, gaussian process, GRMF, INLA, multivariate models.
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