Stochastic Local Interaction Models for Spatiotemporal Data

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Abstract

The problem of missing spatiotemporal data is common to many signal and image processing applications. In the Geosciences, many data sets include gaps, either due to incomplete time coverage or to measurement problems. For example, parts of remotely sensed images may be obscured by clouds, aerosols, or heavy precipitation. The continuously increasing volume of spatial information (geographical, natural resources, land use, and environmental remote sensing images), calls for efficient methods of missing data reconstruction. This presentation will focus on the interpolation and simulation of scattered spatial observations as well as missing data on regular grids by means of the so-called *Spartan spatial random fields (SSRFs)*. SSRFs can be derived from a Gaussian statistical field theory that includes both gradient and curvature terms [1], or equivalently, from stochastic (Langevin) partial differential equations driven by Gaussian white noise. In contrast with field theory, the focus of SSRFs is on short-range correlations instead of long-range properties near critical points. SSRF covariance models are characterized by sparse structure of the precision matrix (the inverse covariance matrix), at least for lattice geometries. The sparseness derives from the locality of the operators in the respective "energy" functional and leads to explicit spectral density forms. In certain cases, the correlation functions in real space can be derived analytically by direct integration of the spectral representation, given by the Hankel transform of the spectral density [2]. The availability of explicit, albeit approximate, expressions for both the covariance and the precision matrix can help to overcome the curse of dimensionality in the numerical procedures of parameter inference, spatial interpolation and conditional simulation [3,4]. Applications of SSRFs to real and simulated data sets will be presented. Extension of the SSRF interaction-based concept for handling data with non-Gaussian probability distributions, using discretized random field models with either Ising "spin-type" or curvature-like interactions will be motivated [5]. Ongoing research that extends SSRFs to spatiotemporal data and perspectives for future developments will be discussed.

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