Tuning Spatial Interpolation Under Non-Space-Filling Designs for Unmanned Surface Vehicle Applications

Authors: You LI (Laboratoire d'Informatique, Signaux et Systèmes de Sophia-Antipolis (I3S)), Mario Joao Rendas (Laboratoire d'Informatique, Signaux et Systèmes de Sophia-Antipolis (I3S))

Primary area of focus / application: Design and analysis of experiments

Keywords: Spatial interpolation, Cross validation, Space-filling design, Line survey, Unmanned surface vehicle

Abstract

Spatial interpolation is the procedure of estimating the value of properties of a field at unsampled sites using the measured values at a set of positions. All interpolation algorithms require the definition of a set of user-defined parameters, whose value should reflect the available knowledge about the spatial coherency of the field. In the absence of prior knowledge, Cross-Validation (CV) is often used to select "best" parameters. Leave-One-Out Cross-Validation (LOOCV), the most common form of CV, removes one data point at a time, and estimates its value using the
remaining samples. The “best” interpolation parameters is then chosen as the one that leads to the minimum value of the residual between the actual and estimated values, assuming that the CV residuals is a representative sample of the residuals when interpolating over the entire area of interest.

Many factors including sample size, design geometry and data properties affect statistical distribution of the LOOCV residuals. When the sampling designs are "space-filling-like”, the CV residuals distribution is close to the actual distribution of the interpolation algorithm and CV ALLOWS to good interpolator tuning. However, this property is violated for liner designs, frequent when a spatial field is observed using a sensor carried in a mobile platform, like
an oceanographic sensor or an airplane. In this case the sampled points are closely spaced along the one-dimensional vehicle trajectory, but most often with a much lower spatial sampling rate in the directions orthogonal to it. This induces a strong bias on the statistical distribution of the CV residuals, since each point always has at least one near-by sample.

We proposed a randomised CV method that corrects the bias of the residuals distribution, enabling a better estimation of the expected interpolation error, even for strongly non-space-filling designs like line-transects. Results of numerical tests on simulated data and a diverse set of

interpolators (inverse distance weighting, local weighted polynomial regression) show that leads to algorithm tuning offering better field reconstruction.

[1], L. Pronzato et W. Muller, "Design of computer experiments: space filling and beyond" in Journal of Statistics and Computing, 2012.