Interpolation and unwrapping of sparse-grid InSAR data

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Applications such as SAR interferometry \cite{1} are increasingly used in “sparse” contexts, in which information about some geophysical parameters (e.g. millimetric terrain deformations) are only available over some of the imaged pixels, corresponding to stable objects \cite{2}. In such cases, it is often necessary to adapt processing algorithms, developed and optimized for regular data grids, to work on sparse samples. One of such algorithms, at the basis of several InSAR processing chains, is the so-called phase unwrapping (PU), consisting of obtaining absolute phase values (i.e. defined over the whole real interval) from the corresponding principal values, i.e. limited to the interval \([-\pi, \pi]\).

Recently, a method to reduce the unwrapping problem of a sparse-grid field to one corresponding to a regular grid, has been proposed \cite{3}, based on a preliminary nearest-neighbor interpolation step. The solution to the sparse problem is shown to be mathematically equivalent to that of a corresponding regular grid problem, properly derived from the former. The approach allows to employ existing algorithms for regular-grid PU, such as those based on network theory (e.g. the so-called Minimum Cost Flow, or MCF).

In this work, stemming from an analysis of the above-mentioned methodology, giving as a solution an absolute phase significant only over the sampled pixels, we propose an alternate procedure, in which the principal phase interpolation step is based on algorithms more advanced than the simple nearest-neighbor scheme. Such interpolation can be performed over the unit-magnitude complex field obtained from the wrapped phase. In this way, the obtained wrapped phase field results more similar to the original, “physical” regular field from which the sparse samples have been obtained.

In the case in which this latter field can be assumed to satisfy general conditions of smoothness and homogeneity \cite{4}, this allows to exploit at best such characteristics, and to have finally an absolute phase regular matrix more representative of the real data, and then more effective to use in the subsequent processing steps \cite{5}.

In the paper, several interpolators are considered, such as radial basis functions (RBF), as well as, more generally, Kriging \cite{6}, and their performances and application limits are evaluated in simulation, as a function of both the regularity conditions of the original sampled surface, and the sampling density.

References


