Abstract

Although *Geostatistic* tools have become standard for the characterization of the spatial distribution of geological subsurface structures, the related inference problems for low acquisition levels still pose a complex issue only tractable by simulation tools. Against that background, in the last decade several methods for low-rate sampling and sparse representation were developed providing insights in the use of additional prior information to achieve better performance in reconstruction and characterization tasks.

Based on these achievements, the new challenge is to incorporate several tools from the *state of art* in signal processing and stochastic modeling to improve this kind of inference problems. We propose a comprehensive study of inverse problems at low-rate sampling with strong focus in Geosciences and in particular for the reconstruction of binary permeability channels.

For the first part of this work, we will work on theoretical formulation and experimental analysis of the problem of *Optimal Well Placement* (*OWP*). This problem tries to find the best way of distributing measurements to optimize sensing/locating resources in areas of mining and drilling. This work aims at obtaining the optimal positions for a given amount of available measurements. The characterization of the uncertainty will be a central piece of this formulation. In particular, the *OWP* problem will be addressed from the perspective of minimizing the remaining field uncertainty and sequential algorithms will be proposed to solve it. We conjecture that *OWP* based locations will be distributed on transition zones, and we will then assess this behavior for common sensing schemes.

For the second part of this work, we propose to derive image restoration/reconstruction techniques by using sparse regularization techniques such as Noisy Compressed Sensing (Dantzig Selector and *Basis Pursuit DeNoising*). We focus specifically at incorporating spatial correlations by experimental covariance matrices and we derive several approaches to simplify scenarios with thousands of unknowns. The Subsurface characterization problem for binary channels will be addressed from sparse representation perspective, incorporating Multi-Point Simulations (*MPS*) and training images as an additional source of spatial dependence.

Finally, we propose the integration of these two topics (adaptive sampling design and inference by Noisy Compressive Sensing) to improve subsurface characterization techniques based on adaptive sampling and sparsity promotion by the use of Adaptive Compressive Sensing approaches.