

Simultaneous Random plus Erratic Noise Attenuation with Interpolation for Land Seismic Data by Joint Low-Rank and Sparse Inversion

Raphael Sternfels¹, Ghislain Viguier¹, Régis Gondoin¹, David Le Meur¹

¹CGG, Massy, FRANCE

ABSTRACT

Improving the signal-to-noise ratio through noise attenuation and missing trace interpolation is key for certain seismic processes, especially for land wide-azimuth data which are acquired with larger volumes than ever. It is well known that strong noise and suboptimal spatial sampling can be detrimental to the final migrated image, creating undesired noise and migration smiles. The recent advent of 5D processes allows for a better characterization of the signal coherency along multiple spatial dimensions, thus providing an improved separation of incoherent noise and a better recovery of missing data. In this work, we focus on recent developments in the field of compressive sensing which enable us to take a new look at the multi-dimensional Cadzow/SSA (singular spectrum analysis) filtering model and its robust and interpolation derivatives. We formulate the problem of simultaneous random plus erratic noise attenuation and interpolation as a well-posed joint low-rank and sparse inversion (JLRSI) convex optimization problem. The strength of the JLRSI formulation results from the explicit handling of sparse erratic noise via an L1 norm term, while maintaining the low-rank requirement of the signal model stemming from Cadzow/SSA methods via a nuclear norm term. The JLRSI problem thus consists in joint minimization of a nuclear norm term and an L1 norm term, constrained by the fit to the available data, to recover the low-rank signal component and separate strong erratic noise from incomplete and noisy data. We use an efficient alternating directions method of multipliers (ADMM) scheme to solve this minimization problem. Numerical results on wide-azimuth field data illustrate the effectiveness of our approach at recovering missing data and increasing the signal-to-noise ratio.