A Step Change: Faster Land Seismic Acquisition with Blended Source Compressive Sensing in the Sultanate of Oman

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Abstract

This paper showcases a step change that was achieved in 2023 in the land seismic acquisition technology through a series of field trials and verification of compressive sensing (CS) in a blended source acquisition mode with the objective to develop a fit-for-purpose faster seismic acquisition, i.e., less cost without an impact on data quality output.

The survey design CS seismic acquisition program started with assessing various compressive sensing schemes, focusing on understanding the relationship between the decimation rate of sources, data quality, cost, and operational factors. The CS decimation scheme was developed in-house with constraints on the maximum allowable gap in the source grid, and the field trial's locations were chosen to cover the various terrains, from flat gravel plains to outcrops areas known for good and challenging data quality, e.g., complex weathered layers, high multiple contamination, and strong ground roll. This was essential as many large-scale projects would involve a combination of surface terrains, which impacts key processing steps at later stages, e.g., first-break picking and linear noise attenuation, and an in-depth understanding of the impact of decimation and reconstruction is required.

The acquisition trial learnings have been adapted to design the first large-scale compressed source geometry covering more than 4500 km2 with a four-block design. The design was based on the source and receivers' carpet geometry, with grids of 75x75 m for the receivers and 25x25 m for the sources. The use of this underlying source base grid was based on reconstruction requirements, as a finer base grid would require an extensive processing effort to re-populate the decimated sources for later processing stages. The decimation rate used in the project was a hybrid combination of 25% decimation for the primary source patch and a 50% decimation that is based on depth analysis from processing long offset land seismic data with wide azimuth geometry showing data redundancy for far offsets with minimum to negligible impact on imaging the geophysical target. Thus, far offset decimation for the sources has been employed using a 50% decimation beyond the primary shallow target offsets in the source overlap areas without impacting the data quality. Along with the decimation scheme, an adaptive in-fill scheme accounts for areas that have obstacles by maintaining the trace density and fold to obtain high S/N traces that will be later used for reconstruction. The re-allocation scheme is set to enhance the data quality around any obstacle in a buffer of 750m. This decimation scheme based on pseudo-random compressive sensing reduced project cost and duration by more than 25% as an overall gain while maintaining the same data quality as that of a high-density carpet geometry.

In conclusion, this paper presents a case study of adapting source compressive sensing for large-scale seismic acquisition in the Sultanate of Oman with a direct positive impact on the seismic data quality and a significant reduction in the project cost and duration that can be extended for upcoming land seismic surveys.

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