Processing of Land Seismic Data Acquired Via Compressive Sensing: Latest Update

Mohammad S. Farooqui[1]

[1]CGG

Abstract

Compressed sensing (CS) improves the efficiency of seismic acquisitions. By utilizing sparsity, seismic data are acquired on a pseudo-random grid rather than a standard regular grid. However, the expected efficiency gains will not be realized without modified processing workflows which can overcome the challenges of irregular or sparse data imposed by CS acquisition. Recent studies by Culianez et al. (2023) and Al Balushi et al. (2024) have demonstrated the feasibility of processing land seismic data acquired via CS technique. In this study, we show the latest developments in data reconstruction, and highlight the impact of the irregular or sparse geometry on both intermediate data reconstruction and final imaging.

The results of this study are based on several surveys with different source and receiver spacings that were acquired with regular sampling and then re-acquired or simulated via CS. These surveys cover various geological setting from within the Sultanate of Oman. All the data used in our study were 3D land broadband WAZ with a sparsely sampled source grid and a fully populated receiver grid. The source decimation factor ranged from 25% to 87.5%.

For CS data, an intermediate data reconstruction is often used to regularize the data before the linear noise attenuation (LNA) step. In this study, we used a new method for data reconstruction based on work by Pesudo (2024) which simultaneously interpolates both the surface and the reflected waves. This method, based on joint low rank and sparse inversion, provided good results for relatively big holes. We also evaluated the impact of the source spacing on the quality of the data reconstruction.

For each survey, the data acquired via regular sampling and CS scenarios were processed by similar PSDM flows including a 5D interpolation step before imaging. The only exception was at the LNA stage where we added an intermediate data reconstruction for the CS data. The final products were compared by using quantitative attributes such as signal to noise ratio (SNR) and normalized root mean square (NRMS) amplitude to evaluate the impact of the different geometry on the quality of final images.

The results have demonstrated the effectiveness of the new data reconstruction technique compared to other methods such as multi-dimensional Fourier regularization, especially in the case where effective interpolation is required for both surface and reflected waves. The testing also demonstrated that CS data acquired with a denser geometry and with reasonable maximum data holes (less than 75 m) can provide a better final imaging quality than the data acquired via regular sampling, while still maintaining the efficiency benefits of CS.
These acquisition and processing trials have validated that CS can be implemented for larger seismic surveys. As CS becomes the standard for seismic acquisition in Oman, operators will benefit from lower cost and/or efficiency gain without compromising imaging quality.