Compressive sensing, compressive inversion? Investigating the potential of sparsity-promoting schemes for geophysical inverse problems

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The concept of compressive sensing has promised a revolution in data collection. Rather than the traditional sampling of a temporal or spatial signal with uniformly distributed samples, compressive sensing promises an exact recovery of the signal with fewer but randomly chosen samples. Provided that the target signal is 'sparse', i.e. has only a few non-zero Fourier components, it can be recovered with high fidelity using inversion algorithms designed to minimize the L1 norm of the recovered solution. Compressive sensing allows signal recovery beyond the Nyquist limit (which requires the signal sampling rate to be at least twice the highest frequency component), allowing high-frequency information to be recorded using relatively few samples.

We explore the concept of 'compressive inversion', applying the mathematical principles that underpin compressive sensing to inverse problems of the form commonly encountered in geophysics. We performed two experiments; one where the measurements are direct and one more complex where the measurements are indirect. We compare the performance of two different regularization methods - L1 and L2 minimization for data recovery. We show that the data can be exactly recovered with a very small number of randomly chosen samples by using L1 minimization.

We also explore the feasibility of developing compressive sensing concept for tomographic imaging problems. Here, a key question is whether the target structure has a sparse representation in some known basis. We show that it is feasible for some geophysical problems, but not all.

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