Beating Nyquist by randomized sampling

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SUMMARY

Seismic exploration is rooted in the paradigm of regular Nyquist sampling. Recent developments in the area of “compressive sensing” have shown that regular-Nyquist sampling may not be most favorable for signals that are compressible, e.g., by curvelets. In that case, appropriate randomization of the acquisition; such as by jittered¹ sampling, creates favorable recovery conditions from data collected at a limited number of randomly placed sources and receivers. By virtue of the randomization, and the subsequent nonlinear recovery by transform-domain sparsity promotion, significant improvements can be made in the frequency content and quality of regularly sampled data volumes obtained from highly undersampled randomized measurements. In this new paradigm, the effective sampling rates are no longer dictated by Nyquist but by transform-domain sparsity. Consequently, twice as compressible signals can be recovered from only half the randomized sample points. This removes a major impediment of acquisition where costs are proportional to sample rates and survey areas. During this talk, we will discuss multidimensional and continuous² (opposed to gridded) extensions of randomized jitter sampling. These will include investigations of Poisson disk sampling³ and Farthest Point sampling⁴ and we will demonstrate that these randomized schemes perform better than the well-established regular sampling protocol.

¹ G. Hennenfent and F. J. Herrmann. Simply denoise: wavefield reconstruction via jittered undersampling. *Geophysics*, 73(3) V19 2008.

² G. Hennenfent and F.J. Herrmann. Seismic denoising with nonuniformly sampled curvelets. *Computing in Science and Engineering*, Vol 8, 3. 16-25, 2006.

³ R. L. Cook, “Stochastic sampling in computer graphics,” *ACM Transactions on Graphics*, 1986.

⁴ Y. Eldar, M. Lindenbaum, M. Porat, Y.Y. Zeevi, “The farthest point strategy for progressive image sampling”, *IEEE Transactions on Image Processing*, Sept. 1997.