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Virtual Sensors in Seismic Acquisition

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ABSTRACT

In the last few years, significant progress has been made in the field of sampling theory. New data sampling methods which totally depart from the Shannon's sampling theorem have been developed. One such method is based on the idea that we can create virtual sensors from actual sensors by using the fact that seismic data are generally non- Gaussian. The virtual sensors can be used, to fill up gaps in the receiver distributions and hence reduce spatial aliasing.

In seismic acquisition, the seismic trace associated with a given receiver station results from the combination of seismic signals recorded on individual sensors in a receiver array. The number of sensors in the receiver array can vary between 6 and 24. Within the receiver array, the data is generally well sampled. However, because of the sparse receiver spacing that maybe imposed by acquisition constraints, the overall wavefield may not be well sampled. The classical approach for overcoming this poor sampling of the wavefield is to filter events associated with the aliased energy. This filtering process may not be optimal, due to sparse spatial sampling or narrow array aperture.

Seismic data, like many real-life signals and processes are non-Gaussian. Therefore, some of their higher-order cross-cumulants, including their fourth-order cross-cumulants, are nonzero. Seismic-data analysis is essentially based on the second-order statistics (i.e., covariance cross-correlation, and autocorrelation). We can use information from higher-order statistics to form virtual sensors by exploiting the mathematical equivalence between fourth-order cross- cumulants of the actual seismic trace from individual sensors of the receiver array and the covariance matrix of a group of sensors made of actual and virtual sensors. The ability to add these virtual sensors helps overcome some inherent gaps in the acquisition. We call the combination of real and virtual sensors as virtual seismic-receiver array.