Seislet transform and seislet frame: tools for compressive representation of seismic data

Sergey Fomel, University of Texas at Austin, and Yang Liu, Jilin University

Digital wavelet transform (DWT) is a well-known tool for characterizing piecewise-smooth signals and is based on predicting smooth signals. Seismic signals are not smooth. However, they are predictable. Seislet transform is a digital wavelet-like transform, which is tailored specifically for representing seismic data. Its construction is based on the notion of signal prediction. Seislet transform uses predictions of sinusoids (applicable to seismic data in the F-X domain), plane waves (applicable to 2-D or 3-D seismic data in the T-X domain), or reflection events (applicable to prestack seismic data). We combine statistical or physical predictability of seismic signals with the lifting scheme of DWT to define the seislet transform.

One can view the seislet transform as decomposition into multiscale orthogonal basis functions aligned with seismic events. When multiple interfering events are present in the data, it is also possible to follow all of them simultaneously by turning the seislet basis into an overcomplete representation (a tight frame). Even though the seislet frame is overcomplete, it can be constrained to have only a small number of significant coefficients and, therefore, to provide an optimally sparse representation. The sparsity is easily demonstrated by comparing the seislet transform and frame with the classic transforms, such as Fourier and DWT. The classic DWT is equivalent to the seislet transform with a zero frequency (in 1-D) or zero slope (in 2-D).

The sparsity of the transform domain provides not only an effective seismic data compression tool but also a way for designing efficient data analysis algorithms. Traditional geophysical data analysis tasks, such as signal-noise separation and data regularization, are conveniently formulated in the transform domain, where the signal is sparse. When applied in the offset direction on prestack data, the seislet transform finds an additional application in optimal stacking of seismic records.

REFERENCES

- Fomel, S., 2006, Towards the seislet transform, in 76th Ann. Internat. Mtg. Soc. of Expl. Geophys., 2847–2850.
- Fomel, S., and Y. Liu, 2010, Seislet transform and seislet frame: Geophysics, 75, V25–V38.
- Liu, Y., and S. Fomel, 2010, OC-seislet: seislet transform construction with differential offset continuation: Geophysics, 75, WB235–WB245.