Kaiser Bessel gridding kernel for seismic data regularization

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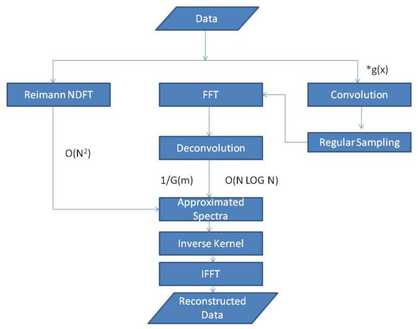
Summary

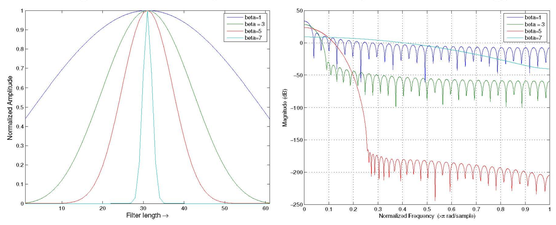
- Data regularization is an important aspect of seismic processing.
- Many regularization techniques exist, but many are impractical for use on large data sets, due to their dependency on simple Discrete Fourier transform (DFT), which has complexity of $O(N^2)$
- Non uniform fast Fourier transform (NFFT) that use Gaussian filters are being used in industry, but are not able to effectively estimate Fourier components in presence of high decimation.
- We adopt a modification of the NFFT from the medical imaging field that uses Kaiser Bessel functions as a filter instead of a Gaussian.
- Compared to the Gaussian NFFT, Kaiser Bessel NFFT performs better in cases of high trace decimation.
- The algorithm is tested on a synthetic section of three seismic events with different dips and amplitudes.

How it works

- Direct Fourier transform responsible for major computational cost, which is replaced by Kaisr Bessel NFFT.
- NFFT is based on convolution of irregular grid with the Kaiser Bessel filter $g(x)$, followed by Fast Fourier transform.
- In Fourier domain deconvolution is carried out with Inverse Kaiser Bessel filter $1/G(m)$ for correction to convolution in spatial domain.



- Fig.1: Flow chart representation for Proposed Methodology.

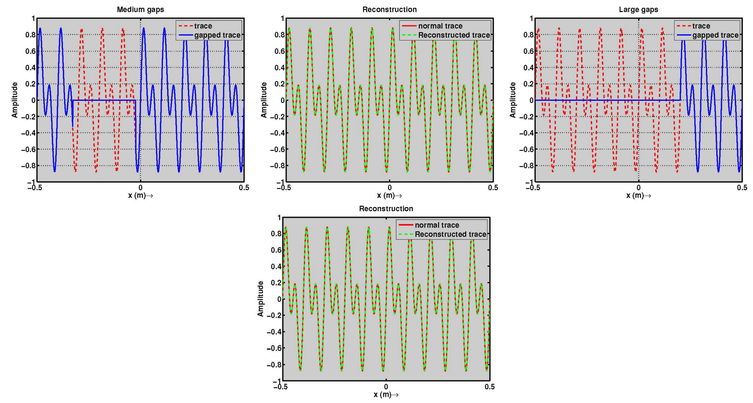


- Fig.2: Kaiser Bessel window for various value of β in spatial domain and its Fourier domain representation.

Methodology

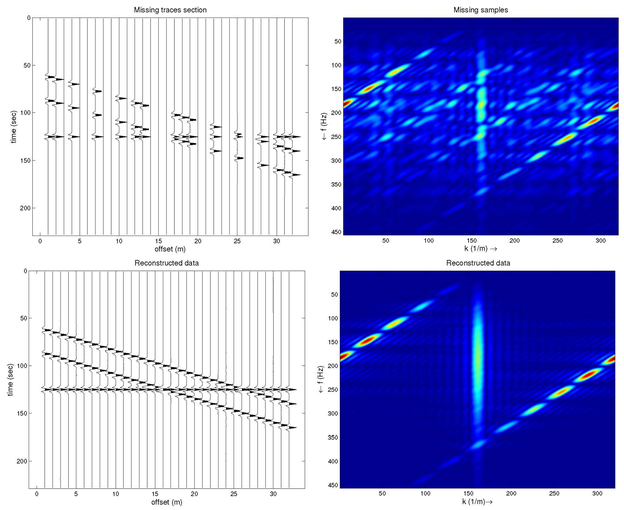
- Calculate the direct forward transform of the irregular data via NFFT using Kaiser Bessel.
- Compute Hessian operator of the NFFT
- Solve the normal equation formed from the Hessian.
- Compute the inverse Fast Fourier transform attain the regularized data.

Gap and Extrapolation test

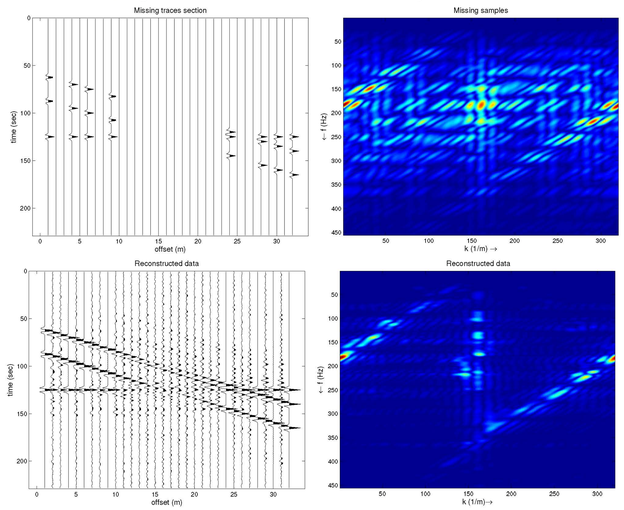


- Fig.3: Reconstructed and Extrapolated gaps for Harmonics.

Reconstruction for Random decimation

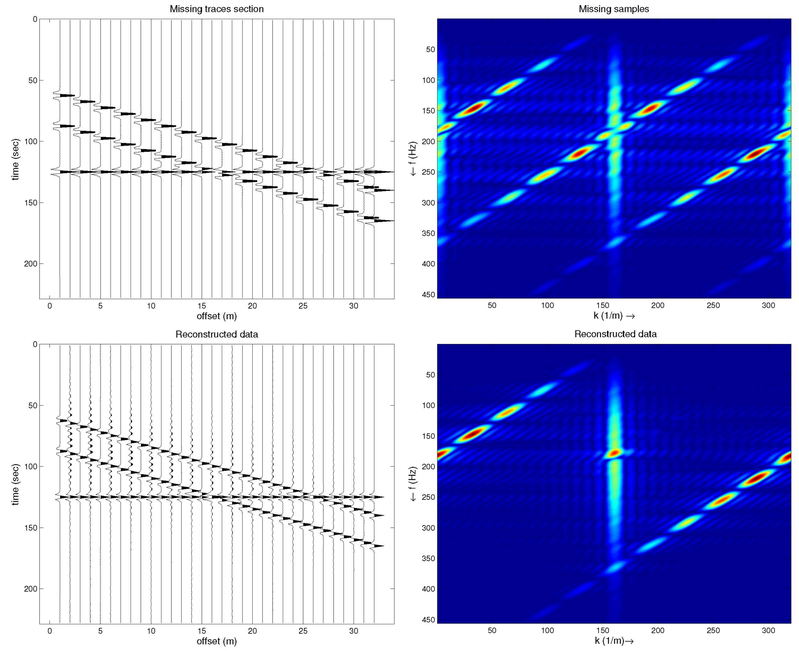


- Fig.4: Reconstruction for 60% randomly decimation.

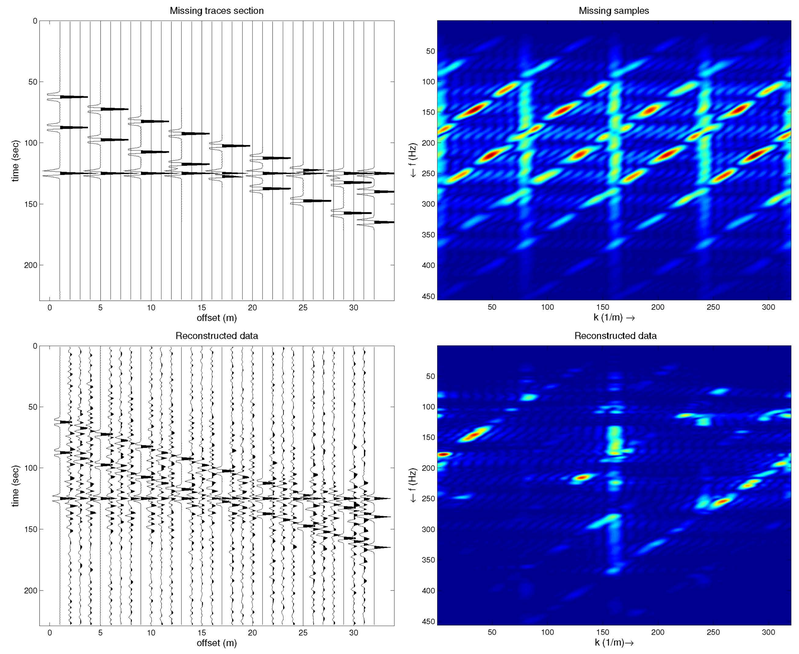


- Fig.5: Reconstruction for 80% randomly decimation.

Reconstruction for uniform decimation



- Fig.6: Reconstruction for uniformly decimation by factor of 2.



- Fig.7: Reconstruction for uniformly decimation by factor of 4.

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