Arbitrarily Sampled Fourier Transform (ASFT) for 5D interpolation

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ABSTRACT

Seismic trace interpolation, which spatially transforms irregularly sampled acquired data to regularly sampled data or to any desired grid in general, is an important step in seismic data processing. A class of algorithms, such as Minimum Weighted Norm Interpolation (MWNI), Projection Onto a Convex Set (POCS), Anti-Leakage Fourier Transform (ALFT), and Matching Pursuit (MP), are based on the Fourier theory in the f-k^4 domain by computing the estimated spatial frequency content of irregularly sampled data.

We present the **A**rbitrarily **S**ampled **F**ourier **T**ransform (**ASFT**) method for 5D interpolation, which incorporates several enhancements. First, true positions of the input data are used for computation; second, the spatial frequency content is allowed to be at an arbitrary point in the f-k^4 domain. ASFT was tested on Western Canadian Sedimentary Basin (WCSB) data and produced excellent interpolation results.

THEORY

All the Fourier based interpolation schemes try to first estimate the spatial frequency content distributions in the f-k^4 domain. This is done either by snapping traces to the closest "bin" position and then applying FFT, such as in POCS, or by a more elaborated method such as computing weighted DFT in ALFT.

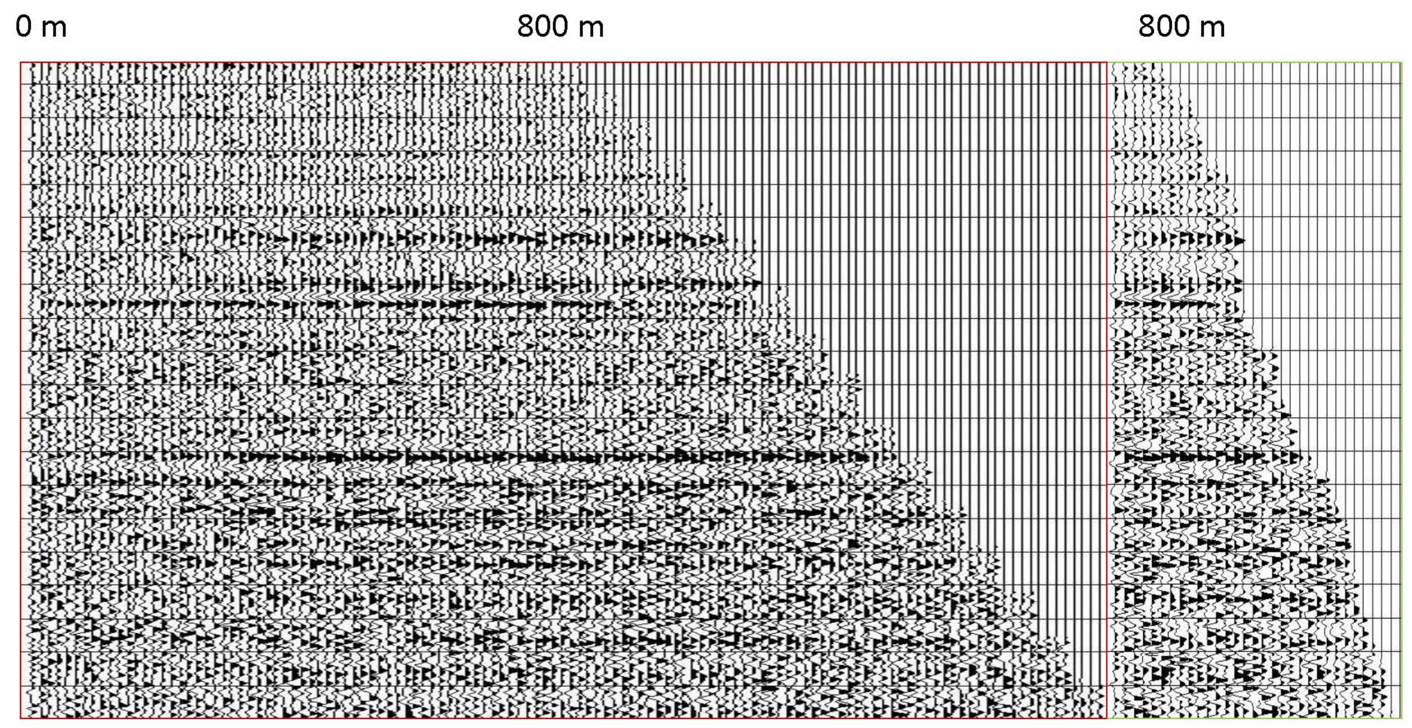
Then either a cut-off threshold is applied such that only the spatial frequencies with energy greater than the threshold are kept, or only the largest spatial frequency contents are selected. The former approach could cause leakage so newer methods such as ALFT and MP use the latter approach.

However, ALFT and MP only estimate the frequency contents at regular grid points in the f-k^4 domain, so their selection could be suboptimal as the spatial frequency with the highest energy could lie at an arbitrary point in the f-k^4 domain. ASFT addresses this problem by iteratively solving a gradient-based optimization problem for accurate frequency representation.

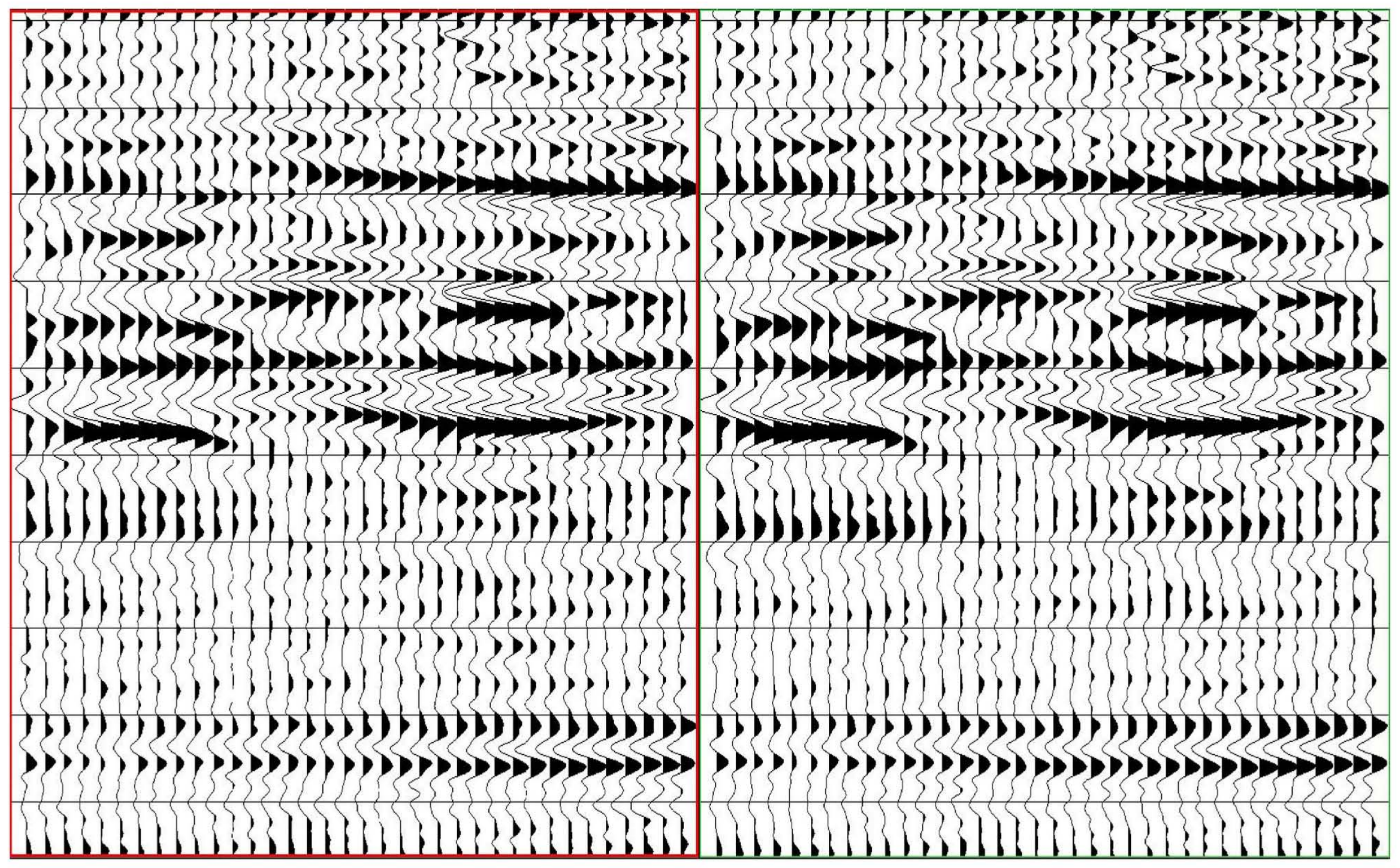
	Uses exact input trace positions	Allows arbitrary spatial frequency in the f-k^4 domain
MWNI	○	○
POCS	○	○
ALFT	●	○
MP	●	○
ASFT	●	●

ASFT is able to compute frequency contents at arbitrary points in the f-k^4 domain, resulting in better frequency representation

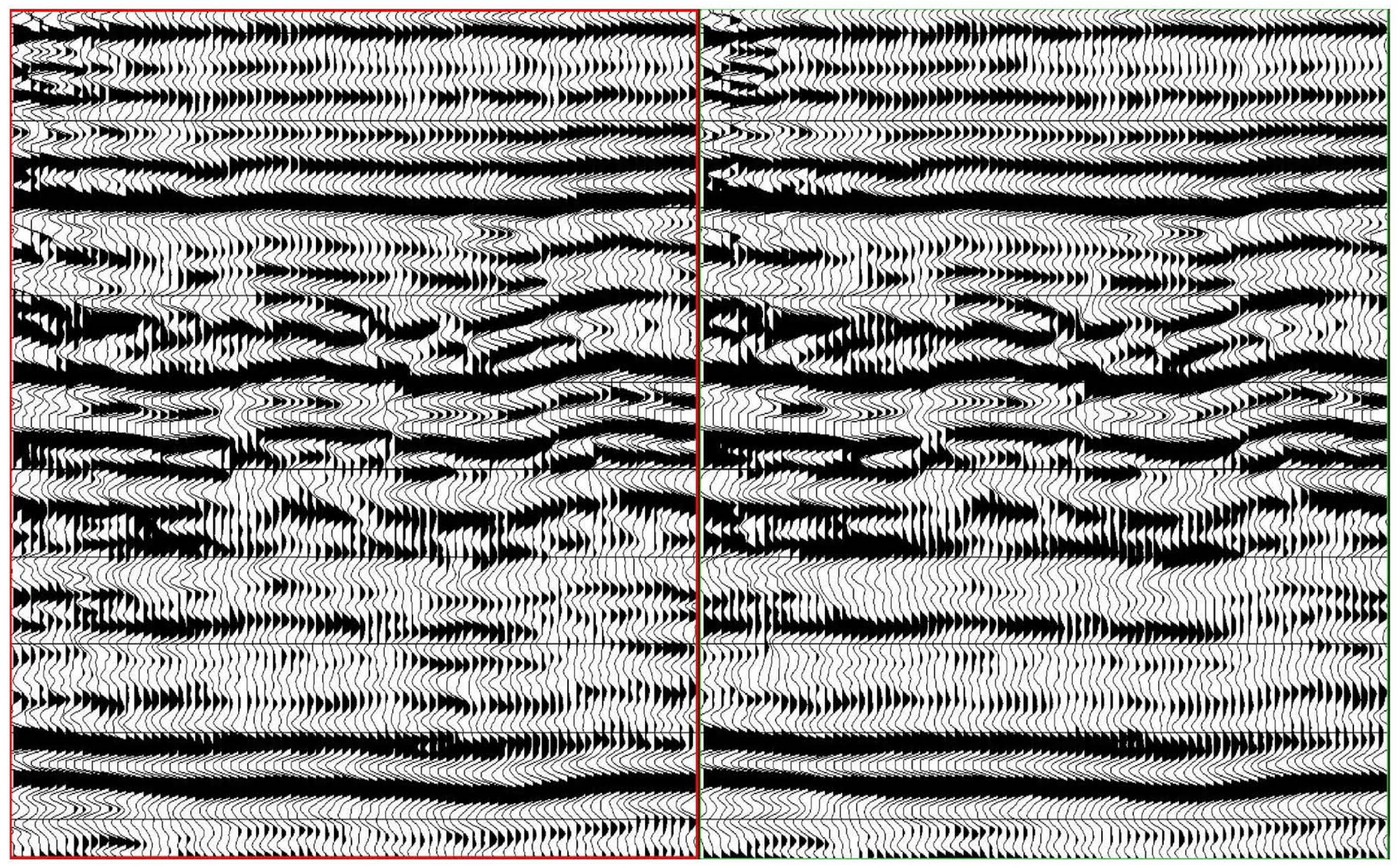
INTERPOLATION RESULTS PROVIDED BY GEO-X



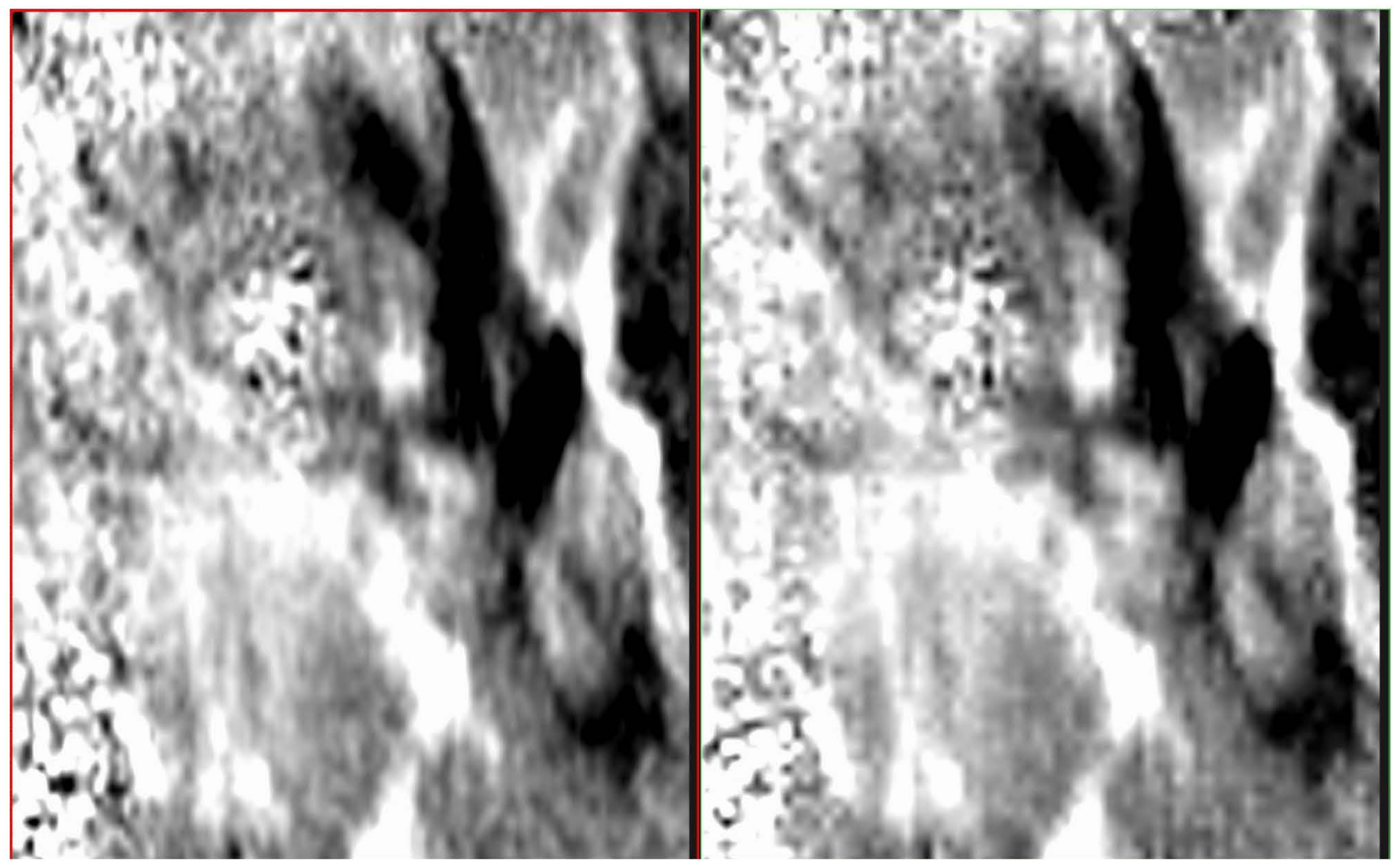
Comparison of CDP gather after (left) and before (right) ASFT interpolation, sorted by offset



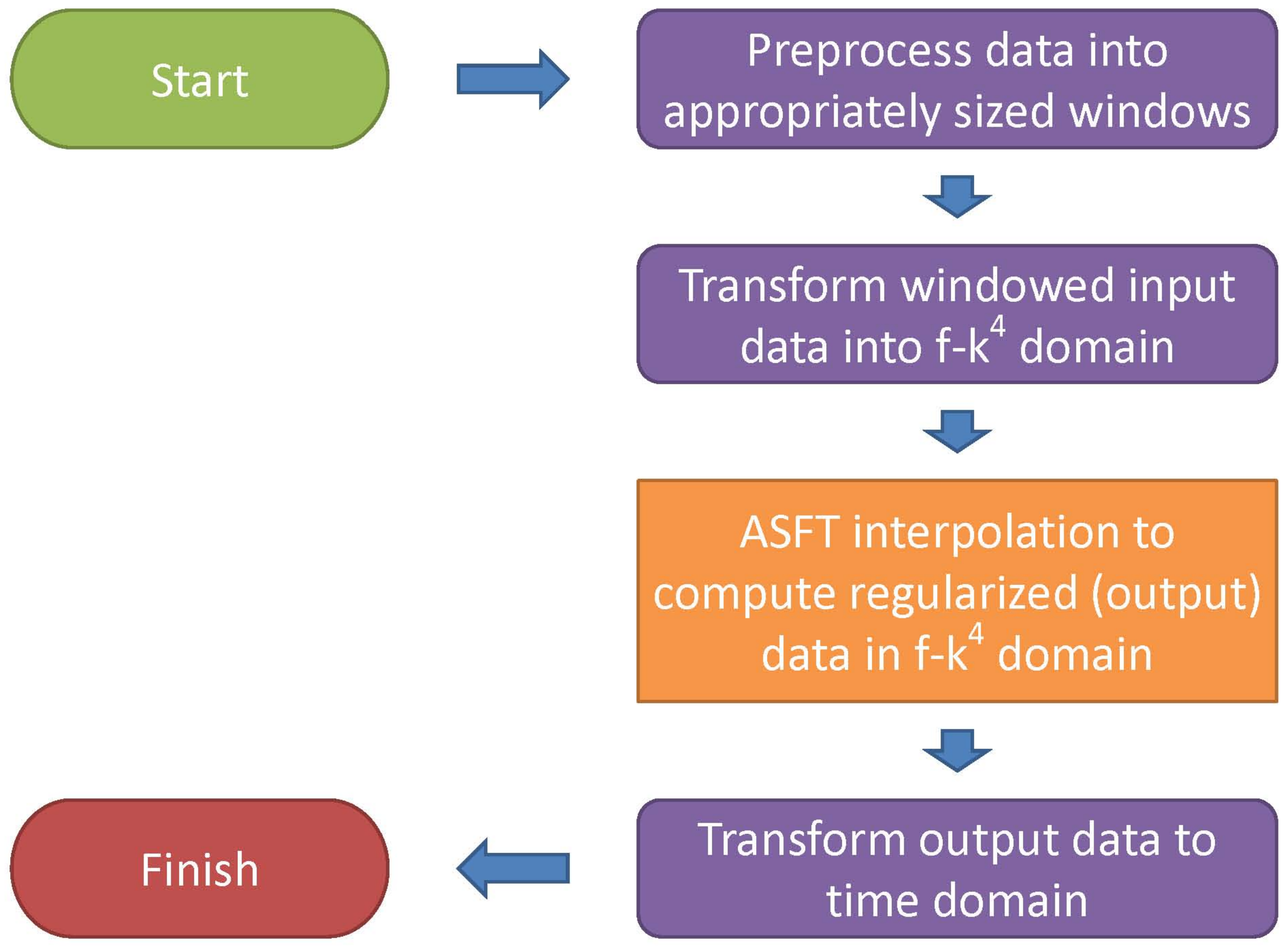
Comparison of inline stack after (left) and before (right) ASFT interpolation



Comparison of xline stack after (left) and before (right) ASFT interpolation



Comparison of time slice after (left) and before (right) ASFT interpolation



Flowchart of ASFT Interpolation

CONCLUSIONS AND FUTURE WORK

From the results it can be seen that ASFT effectively interpolates seismic traces and preserves geological structures.

We will do AVO, AVAZ, and prestack migration analysis and compare the results before and after ASFT interpolation.

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