AAPG Search and Discovery Article #90187 © CSPG/CSEG/CWLS GeoConvention 2013, Integration: Geoscience Engineering Partnership, 6-12 May 2013, Calgary, AB, Canada

5D Interpolation of Seismic Data with Combination of MWNI and POCs algorithm

Jianhua Pan*, Absolute Imaging Inc., Calgary, AB
jianhua@absoluteimaging.ca
and
Gerry Schlosser, Elvis Floreani and Robert Tilson , Absolute Imaging Inc., Calgary, AB

Summary

5D interpolation of seismic data is becoming an important tool in seismic processing since seismic data are seldom acquired with a sampling that is optimal for processing. Two of popular 5D seismic interpolation techniques in current industry are MWNI and POCS (Projection onto a Convex Set). Both methods have their own advantages and drawbacks. In this paper, we propose an algorithm which combines these two techniques. The computational cost of this algorithm is cheaper than the usual POCS method and it retains the advantage of MWNI, the ability to interpolate sparse datasets.

Introduction

Seismic surveys usually have irregular areas where data cannot be acquired, so missing data must be approximated from the acquired data, or interpolated. The 5D interpolation methods provide an opportunity to reduce acquisition costs and furthermore to improve the resolution of seismic images. One of the popular interpolation algorithms is minimum weighted norm interpolation or MWNI (Liu, 2004, Liu and Sacchi, 2004), which minimizes the wavenumber weighted norm by incorporating a prior spectral signature of the unknown wavefield. MWNI is able to interpolate very sparsely populated datasets, however this capability to interpolate sparse datasets does come with a price which tends to produce linear artifacts if not used carefully. The number of iterations used in MWNI must be set with a good deal of attention, since too many iterations will generate artifacts and too few will produce a poor interpolation. For denser datasets this is less of an issue, but care still needs to be taken in specifying the parameters. Additionally MWNI requires that a set of weights be calculated to control the inversion used to interpolate the data. If the weights are not carefully calculated to account for all the events of interest, weak events may be lost in the interpolated data.

The second algorithm in use goes by the name of POCS (Abma, 2006). POCS stands for Projection onto a Convex Set and is a well understood and documented algorithm used primarily in image reconstruction. POCS algorithm is easy to implement. Each iteration consists of a 4D Fourier transformation of the data, an application of a threshold to the transformed data removing low amplitudes, an inverse Fourier transformation of the results of the data with the threshold applied, and finally the reinsertion of the values of the original samples that do not need to be interpolated. POCS interpolation is a simple and effective way to produce multi-dimensional interpolations that can de-alias seismic data well. While POCS should have at least half the traces live on the input, POCS interpolation tends to be fairly robust in places where MWNI is difficult to parameterize. MWNI may require less computation than POCS, but in the cases where the POCS limitation of having at least half the traces live is met, POCS generally produces a more accurate result than MWNI. Although POCS is more computationally expensive than MWNI, overestimating the number of iterations required in POCS does not impact the results as it does with MWNI. This robustness reduces the testing time needed by eliminating much of the human intervention required to prepare the process.

In this abstract, we propose an algorithm to combine POCS with MWNI. Since POCS works well when the missing traces are less than half of traces in the input dataset, we first use MWNI to fill all missing traces before applying POCS interpolator. Comparing with MWNI, computational cost is almost the same since the only extra cost is to apply threshold or remove low amplitudes. The large number of iterations is not necessary.

The method

In the practical case, traces are either well-sampled in time or missing for all time samples. This allows data to be Fourier transformed in time only once before the first iteration and inverse Fourier transformed in time only after the last iteration. Each iteration in a 5D problem thus consists of 4D Fourier transforms in space for each frequency slice. The original POCS and POCS with MWNI are described as follows.

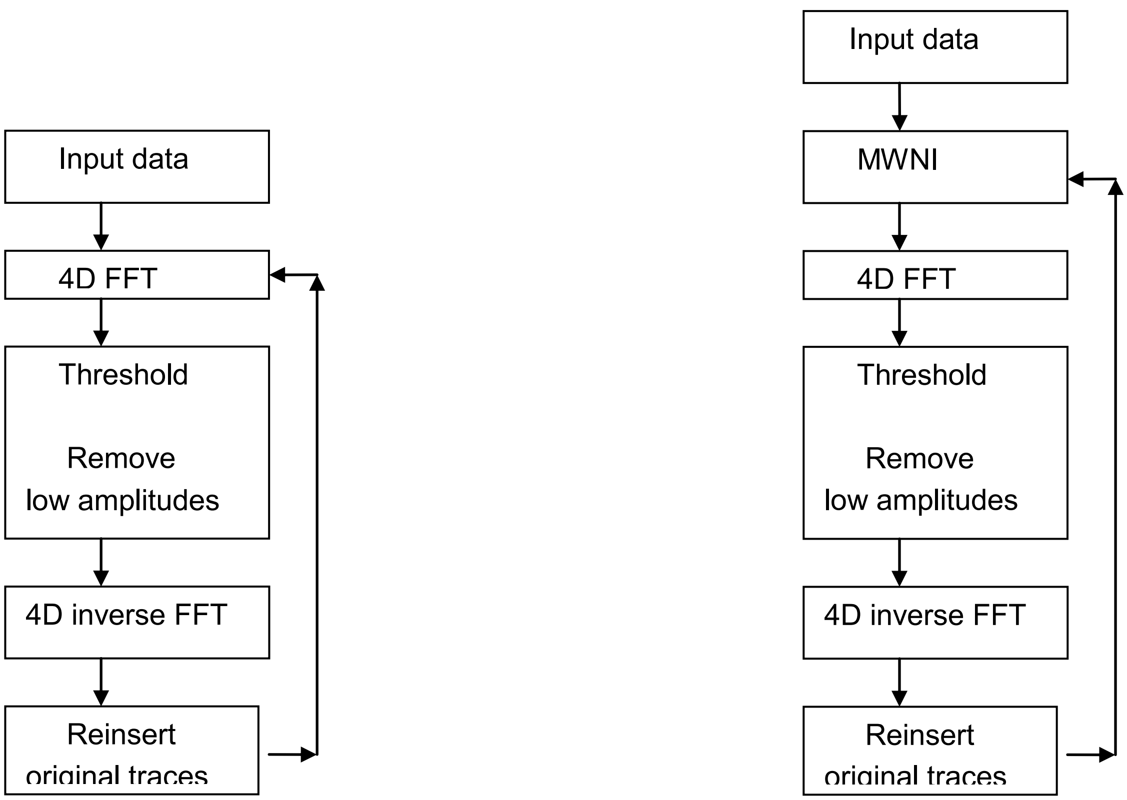

Figure 1: The original POCS process (left side) and POCS with MWNI (right side).

In practice, MWNI contains 4D FFT and 4D inverse FFT and thus forward and inverse FFT for POCS can be involved in MWNI so that the extra computational cost is trivial.

Conclusions

A combination of MWNI and POCS for seismic interpolation can reduce drawbacks of each method such as the large number of iteration in POCS and sensitivity of the number of iterations in MWNI.

Acknowledgements

We would like to thank Absolute Imaging Inc for permission to submit this paper.

References

Abma R., and N. Kabir, 2006, 3D interpolation of irregular datra with a POCS algorithm: Geophysics, 71, no. 6, E91-E97

Liu, B., and M. Sacchi, M., 2004, Minimum weighted norm interpolation of seismic records: Geophysics, 69, 1560-1568.

Larry, S. M., Curly, H., and Moe, W. W., 1955, Prestidigitation, strabismic filtering and ocular violations in the San Andreas strike slip fault zone: Geophysics, **24**, 338-342.