5D Interpolation of Seismic Data Using a Hybrid MWNI and POCS Algorithm

Summary

The 5D interpolation of seismic data is becoming an important tool in seismic processing since data is seldom acquired with a spatial sampling that is optimal for processing. Two popular interpolation techniques currently used in the industry are MWNI (Minimum Weighted Norm Interpolation) and POCS (Projection onto a Convex Set). Both methods have their own advantages and disadvantages. In this poster, 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 which has the ability to interpolate sparse datasets.

Introduction

Pre stack interpolation allows one to interpolate small gaps in seismic surveys and/or approximate a geometrically regular output from an irregular input. Benefits include the reduction of pre stack migration artifacts, resolving sampling differences when merging 3Ds, reducing acquisition footprint, and regularization of azimuths before fracture detection work. MWNI is an algorithm that has been shown to be useful for multi-dimensional seismic wavefield interpolation. MWNI is able to interpolate very sparsely populated datasets; however, this capability 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 multiple iterations can 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). The 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 with the threshold applied, and finally, the re-insertion of the original sample values 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 (Abma, 2009). While POCS should have at least half the traces live on the input, the POCS interpolation tends to be fairly robust in places where MWNI is difficult to parameterize. MWNI may require less computation than POCS, but in 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 poster, we propose an algorithm to combine POCS with MWNI. Since POCS works well when the missing traces are less than half of the traces in the input dataset, we first use MWNI to fill all missing traces before applying the POCS interpolator, and thus the large number of iterations for POCS is not necessary.

The Method

Data is Fourier transformed to frequency domain. Each iteration in a 5D problem thus consists of 4D Fourier transforms in space for each frequency slice. The original POCS and POCS + MWNI methods are described as follows:

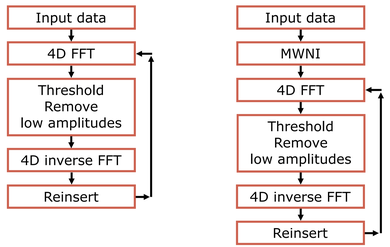

Figure 1: The original POCS process (left side) and POCS + MWNI (right side). The iteration stops to output when a specified maximum number of iterations is reached.

Data Examples

One synthetic and two real data examples are shown to indicate the advantage of MWNI + POCS over MWNI.

In Figure 2, (a), (b), (c) and (d) are 2D synthetic data, data with missing traces, reconstruction by MWNI and MWNI + POCS, respectively. The events in (d) interpolated by MWNI + POCS are more continuous than (c) interpolated by MWNI only.

Figure 3 is a selected inline from a 3D stack, which consists of interpolated data only of MWNI, MWNI + POCS and the original stack. The linear noise in MWNI interpolation disappeared in MWNI + POCS interpolation.

Figure 4 is a selected inline from a 3D stack, interpolated data only of MWNI, MWNI + POCS and the original stack. In the highlighted area, the resolution of MWNI + POCS interpolation is better than MWNI only interpolation.

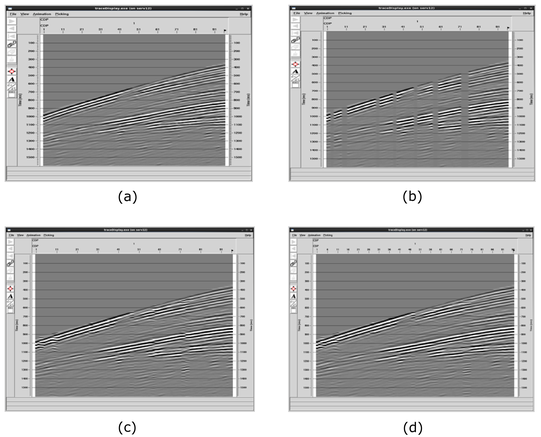

Figure 2. The synthetic data examples; (a) is original data, (b) is data with missing traces, (c) is reconstructed by MWNI, and (d) is reconstructed by MWNI + POCS.

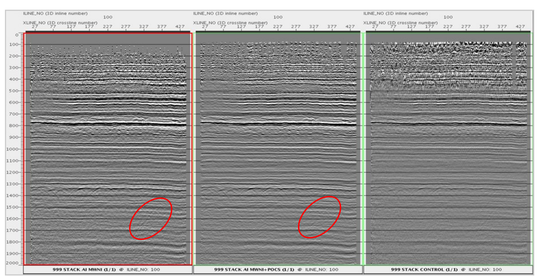

Figure 3. A selected inline in a 3D stacked data, interpolated data only (MWNI), interpolated data only (MWNI + POCS), and the original stack.

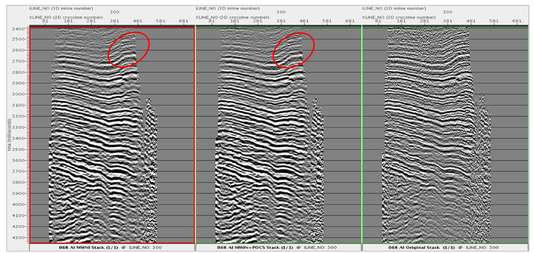

Figure 4. A selected inline in a 3D stacked data, interpolated data only (MWNI), interpolated data only (MWNI + POCS), and the original stack.

Conclusion

This hybrid technique (MWNI + POCS) for seismic interpolation can retain the advantages of each method while reducing their limitations. Our observations on both synthetic and real data show that the MWNI + POCS approach has advantages over an individual approach for interpolating sparse datasets and reducing noise artifacts.

Acknowledgement

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References

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