Application of POCS interpolation to exploration
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Summary:

Powerful new algorithms have emerged in the last few years that are taking interpolation of sparse data sets to a new level of sophistication. Projection onto a Convex Set, or POCS, is one of these algorithms. In this paper we will briefly review the technique and demonstrate its usefulness and versatility in many areas of geophysical data processing. From extrapolation to zero offset for 3D SRME to regularization in the offset vector tile (OVT) domain to enhance imaging, we show that this powerful technique has many potential applications.

POCS Review

The need for accurate regularization and interpolation has never been more critical than now. The old simplistic methods do not deliver the quality results required for today’s processing and imaging needs. Even though acquisition techniques have greatly improved, and the numbers of channels and azimuths acquired have exploded, so have the demands for even more data. Regularization and interpolation go hand-in-hand as a means to reconstruct data not acquired or lost. (Trad, 2010)

These demands have given rise to several “smart interpolators” that have appeared in our industry recently, including the Antileakage Fourier transform (Xu, et. al., 2005). Another new algorithm that we have implemented goes by the name of POCS (Abma, 2008 and Abma, 2009). POCS stands for Projection onto a Convex Set and is a well understood and documented algorithm used primarily in image reconstruction (Jansson, 1997). The first application, to our knowledge, was reported in Abma and Kabir (Abma and Kabir, 2006). Our implementation of this algorithm is illustrated in Figure 1.

Examples

Post Stack Interpolation:

The algorithm, as implemented, can be applied in up to 5 dimensions. In this paper we will show a variety of application of the POCS algorithm and demonstrate its strength and versatility. These applications range from simple poststack interpolation to its use in 3D SRME and OVT based fracture detection. The power of POCS lies in its multidimensional approach to interpolation and its somewhat “global” view of the data. It utilizes data from all available domains to create the interpolated data.

Figure 1: Basic POCS Methodology and Algorithm

Figure 2: 3D Synthetic Data Set used for testing POCS

Figure 3: Results of POCS interpolation
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Zero Offset Shot Interpolation:
The second example is connected to the 3D SRME processing sequence. It is not the intention to explain 3D SRME. Suffice to say it is a powerful multiple elimination technique very effective in the marine environment. Amongst several things required for a successful application of this technique is the need to have regularized acquisition geometry that satisfies reciprocity (interchangeability of sources and receivers) as well as the presence of zero offset data. Zero offset data is not in general available for marine surveys so the need for “constructing” the zero offset data calls for the use of POCS. In the figures below we see a shot missing its zero offset data and the results of using a simple spline interpolator versus the POCS approach (figure 4).

Data Regularization using OVT:
Wide azimuth land and marine data require processing techniques that preserve, or even enhance, azimuthal information in order to utilize the valuable information acquired by this acquisition technique. One efficient way to do this is to form what are known as offset vector tiles. These objects are essentially constant offset constant azimuth minimal data sets that can be imaged and analyzed independently to produce a full 3D image of the subsurface, while preserving the azimuthal and anisotropic information. OVT are the ideal input into migration and a “new” domain to do interpolation in. Unlike the old constant offset interpolation, by staying in the OVT domain, we insured that no azimuthal information is mixed up during the interpolation.

In the figures below we observer an OVT time slice wherein the existence of large irregular holes is apparent. The following images show the effectiveness of the POCS algorithm at filling in these gaps.

Offset Interpolation for Migration:
Our last example uses POCS to interpolate data in the traditional offset domain prior to migration. Figures 10 and 11 how a near offset time slice before and after POCS. After the application of this interpolation, superior results can be achieved by the imaging step.
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Conclusions

Interpolation techniques are at the heart of regularization. Many data imaging processes can be severely impacted if big data holes are left untreated. The consequences vary from a fuzzy image to a completely false image capable of skewing interpretation that can lead to failure.

In recent years a new generation of “smart multidimensional t interpolators” has been appearing in the industry. In this paper we demonstrated how the use of one of this, namely Projection Onto a Convex Set or POCS is utilized in many areas of Seismic Data Processing.

Its versatility is amazing and its ease of use and power quite impressive as we have demonstrated above.

Research will continue and the efforts to transfer the technology from the Research and Development to the production realm reinvigorated.

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REFERENCES


