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3D Design for Interpolation: A Decimation Case Study

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Summary

Can increased processing effort be used to reduce field effort on large regional 3D seismic surveys? Is it feasible to acquire small infill 3Ds within a sparsely acquired regional 3D survey and interpolate the merged dataset to obtain a well sampled dataset? In this case study, ten individual decimated datasets and two combined sparse/infill datasets were reprocessed with and without 5D interpolation in order to evaluate the effectiveness of acquiring multi-year 3D seismic surveys. Comparisons made with the original input dataset indicate that depending on the target objectives, selective sparse acquisition geometry combined with 5D interpolation can be used for regional exploration surveys. Furthermore, by designing selective infill surveys with complimentary offset/azimuth distributions and applying 5D interpolation to the merged sparse/infill surveys, data comparable to a regularly sampled survey was observed.

Introduction

With the advent of 5D interpolation, the question of whether or not processing effort can replace acquisition field effort is becoming more relevant. Although high density surveys are recommended in areas with complex geology, are they necessary for regional surveys in areas with well-defined geology? Is it possible to acquire an infill survey that when merged with a regional survey and interpolated in processing results in data comparable to a regularly sampled survey?

In order to answer these questions, a regularly sampled data set was decimated and then re-processed with 5D interpolation (Zheng, et al, 2013). Three types of decimations were compared: regular/random station decimation, regular/random line decimation and a combination of station/line decimation. Results from the decimation tests were then combined to mimic a multi-year survey where Year A represented a sparse regional survey and Year B represented an infill survey within the Year A survey.

Theory and Method

The first step in comparing acquisition designs for interpolation was to decimate a regularly sampled dataset into field appropriate geometries using the available data. The dataset chosen for the study was an orthogonal survey with source and receiver station intervals of 60m, a receiver line interval of 180m and a source line interval of 300m. From a field perspective, minimizing line kilometres by increasing the line interval will result in more cost savings than reducing the number of stations by increasing the station interval. However, larger line intervals result in fewer near offsets and lower (bin size dependent) fold. Theory also indicates that randomization may improve interpolation results. Using these guidelines along with minimum fold/trace density and attribute requirements, six decimated

datasets (D1 - D6) were generated for analysis (Figure 1). These datasets examined source station/line decimation, source and receiver station/line decimation, and selective randomized source/receiver station decimation at one half and one quarter the trace density of the original survey.

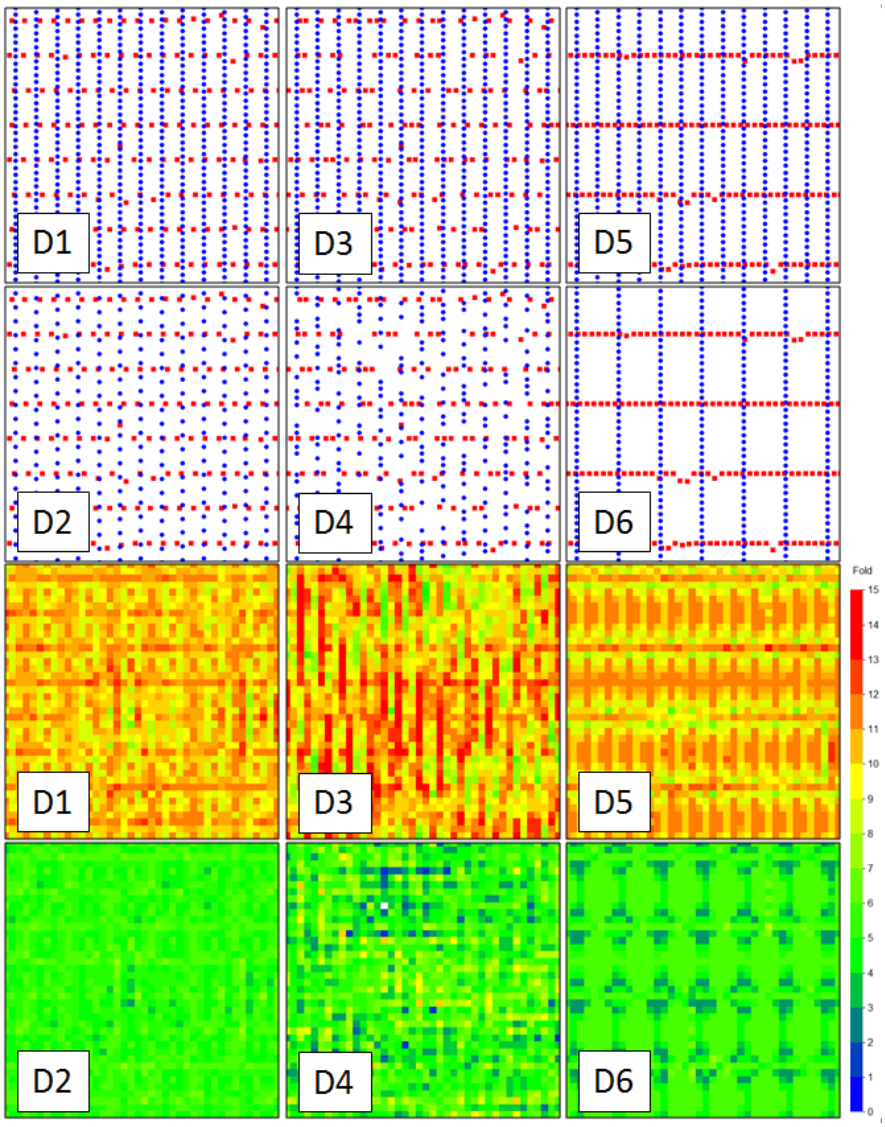

Figure 1: Geometry and Offset Fold (60m x 60m Bin

Each decimated dataset was processed at both the regular bin size and double the bin size with comparisons made before and after migration, with and without 5D interpolation. Preliminary processing results indicated that station decimation provided reasonable results at a larger bin size. Therefore, a decision was made to generate four further datasets in order to test increased station decimation (station intervals were tripled). These datasets were migrated, but not interpolated.

After examining the processing results for all datasets, a sparse dataset that combined both station decimation and line decimation was generated. This dataset was then used to test the practicality of acquiring an infill survey within a regional survey. Two different infill geometries (one with station decimation and one with line decimation) were selected from the initial decimation tests, and each one was merged with the sparse dataset. The combined datasets were then each processed with and without 5D interpolation.

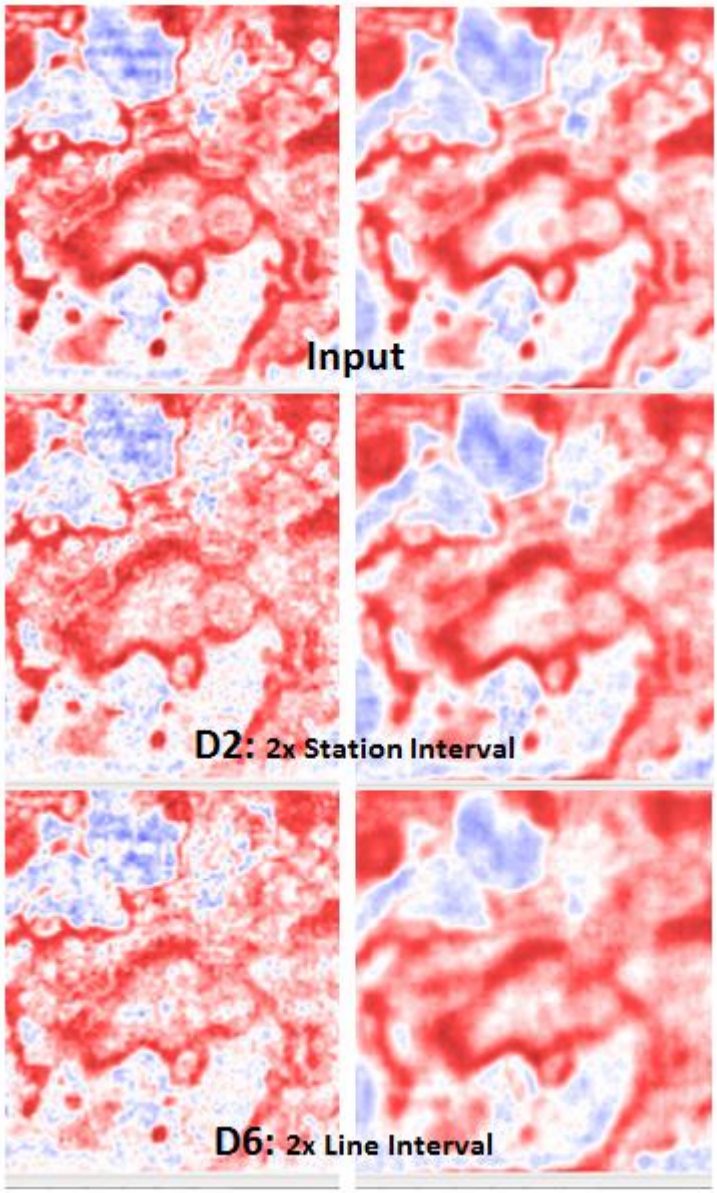

Figure 2: 5D Interpolation Comparison (Left: without interpolation, Right: with interpolation)

Results

Both the input dataset and the decimated datasets were compared with and without 5D interpolation. All 5D interpolated datasets had a marked decrease in acquisition footprint with the best results obtained from station decimations. In general, station decimation provided better structural imaging results than line decimations (Figure 2). Selective station randomization provided some benefits in migration, but only when designed for the natural bin size. As expected, for the un-interpolated data, resolution improved with decreasing bin size and increasing trace density. Although important, these were less critical for the 5D interpolated data than improving the offset/azimuth distribution (Figure 3). Similar results were observed for the combined sparse 3D / infill 3D tests. Infilling with a decimated source station survey produced better results than infilling with a decimated source line 3D (Figure 4). However, the key factor for a successful infill survey was to ensure that the merged offset and azimuth sampling from both the sparse 3D survey and infill 3D survey were complimentary and met the minimum target sampling criteria. Note that minimum sampling requirements may vary significantly from area to area.

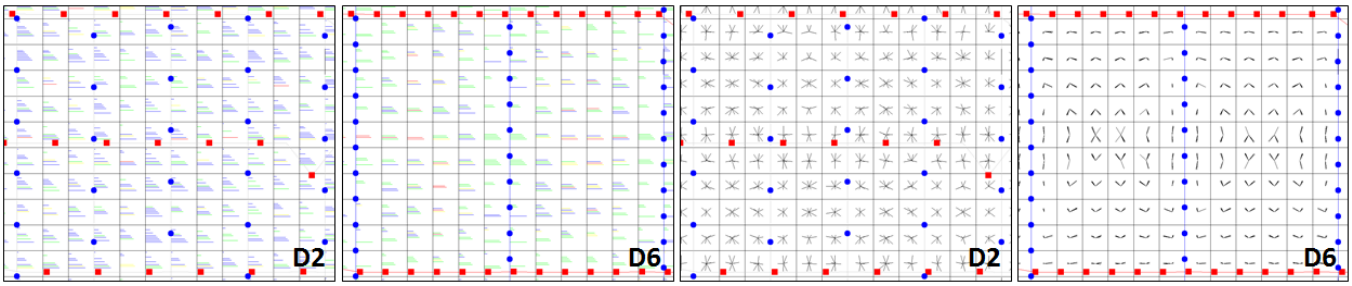

Figure 3: Offset (Left) and Azimuth (Right) Distribution plots for un-interpolated data; D2: Source & Receiver Station Decimation, D6: Source & Receiver Line Decimation

Conclusions

In this case study a regularly sampled dataset was decimated into different reduced source effort and/or reduced receiver effort surveys and then re-processed with or without 5D interpolation in order to determine the optimal method of acquiring sparse regional 3D surveys and target specific infill surveys. Test results showed that for the study area, decimating stations to achieve sparse geometry resulted in better 5D interpolated data than decimating lines. However, to improve operational efficiency during acquisition, a combined station/line decimation with selective randomization that maintains minimum trace density and offset/azimuth distribution may be preferred. Furthermore, 5D interpolation can be used to merge complimentary infill surveys with sparse 3D geometry in order to obtain data that is comparable to a regularly sampled survey.

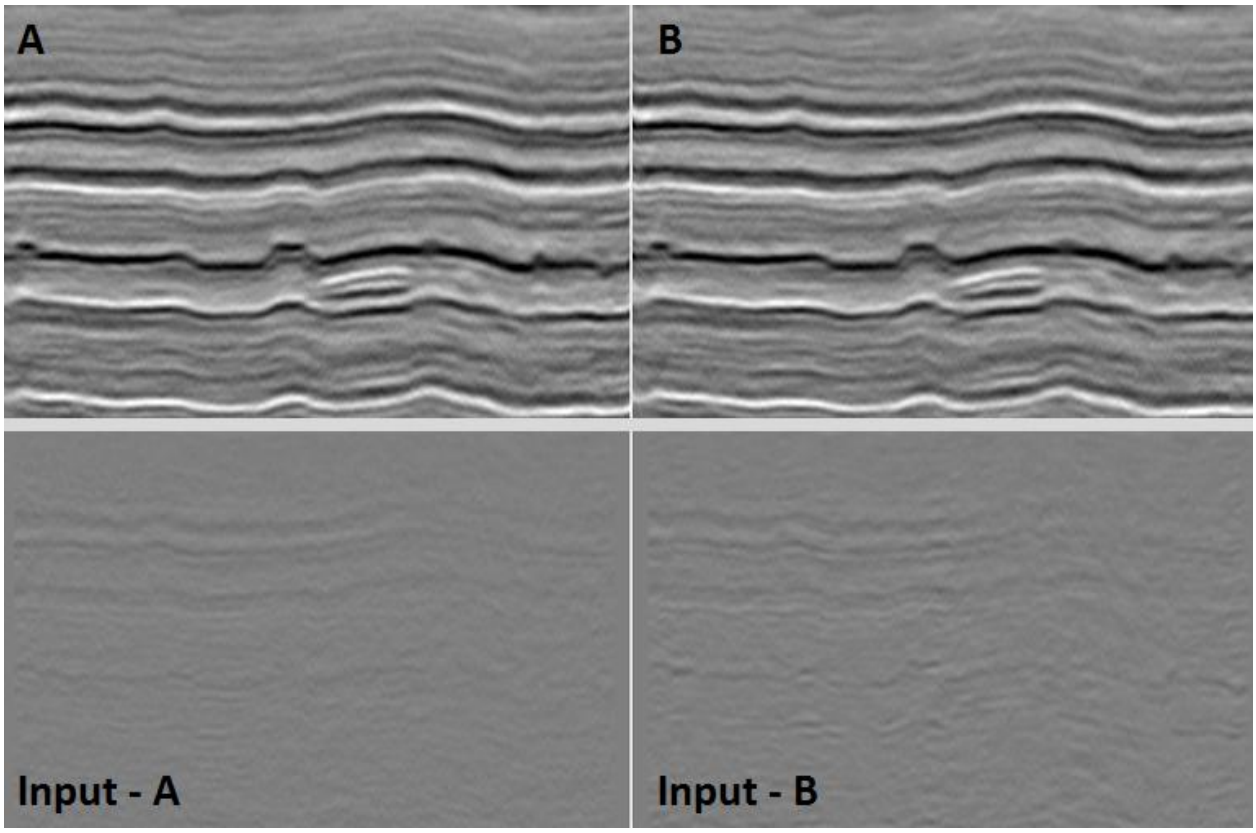

Figure 4: Top - for interpolating a combined sparse regional 3D with a source station decimated infill survey (A) and a source line decimated survey (B). Bottom – Differences from the Input survey.

Acknowledgements

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References

Zheng, Y., B. Nemeth, C. Escalante, A. Crook, L. Ross, Y. Zheng and K. Millis, 2013, Can interpolation help reduce acquisition costs? A case study: presented at GeoConvention, Calgary, Alberta.