Estimating Anisotropy from Seismic Data Via Velocity Analysis Methods.

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Introduction

Seismic processing takes raw seismic data and attempts to produce an image of the sub-surface. There are many obstacles when processing seismic data that hinder the final image quality and fidelity. One such issue is anisotropy. This can loosely be defined as the directional dependence of a measured property in a medium. To better process the data, we need to account for Anisotropy. To do so we must quantify and track variations associated with anisotropy. Disregarding anisotropy can lead to miss-ties, smeared dipping reflectors, defocusing and erroneous depictions of the subsurface. The error in the final image may transfer to the interpretation stage leading to miss-placed wells and potential financial losses. To quantify anisotropy we need to analyse Amplitude and velocity variation with offset and azimuth. The objective of my PhD is to quantify anisotropy associated with velocity variation by building a workflow to apply anisotropic velocity analysis to different complexities of anisotropic media.

Developments

Developments I have made to facilitate accurate analysis of velocity variations are:

.Weighted semblance methods for high-resolution velocity analysis

Weighting Regimes from: (Luo and Hale, 2010), (Chen et al. 2015) and (Abbad and Ursin 2012) were utilised to create hybridized weighted semblance for greater spectral resolution.

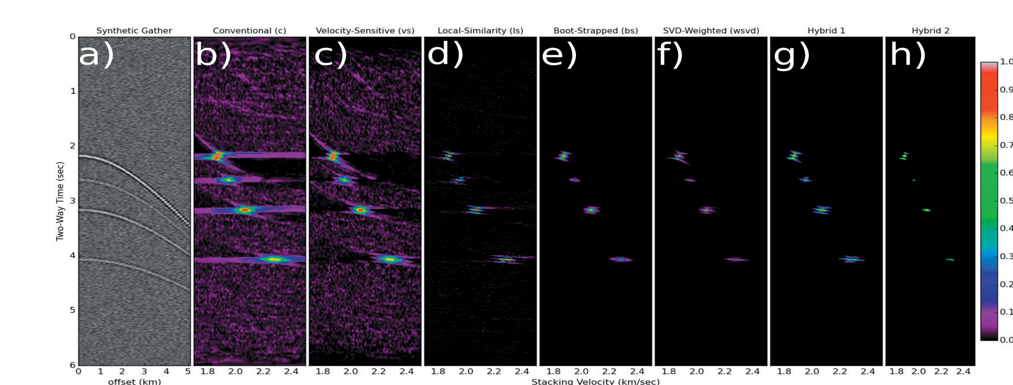

Figure 1 : A comparison of six different semblance schemes on; a) a CMP with 4 interfaces. b) using Conventional semblance, c) using velocity-sensitivity semblance, d) using local-similarity weighted semblance, e) using boot-strap differential semblance,f) using SVD weighted semblance g) using the new hybridized-weighted boot-strap differential semblance after 5 iterations, h) using hybridized-weighted boot-strap differential semblance with SVD weighting

.High-resolution AVO - compatable semblance analysis

We utilize the concept of AVO accountable semblance (AB semblance) (Fomel 2009) combined with boot-strapping (Abbad and Ursin 2012) to create a high resolution AVO friendly semblance operator.

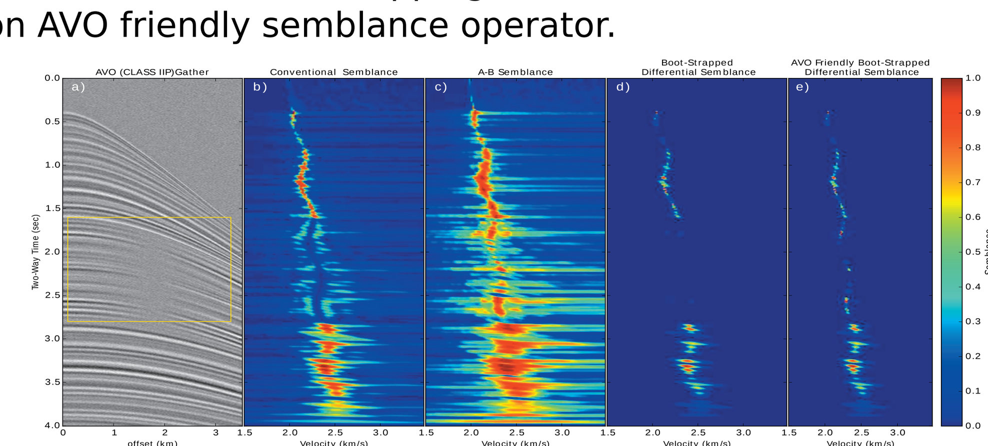

Figure 2: Illustrates the different semblance spectra for comparison. From left to right: a) The uncorrected CMP gather on which all methods of semblance was applied. The area within the yellow box depicts the region in which a class IIP AVOanomaly is present, b) conventional semblance, c) AB semblance, d) bootstrapped differen-tial semblance, e) AVO-friendly bootstrapped differential semblance

.Azimuthal velocity analysis with new visualisation tools

We utilize polar coordinate sectorized semblance time slices to track velocity variation with azimuth to better correct data where azimuthal variation exists.

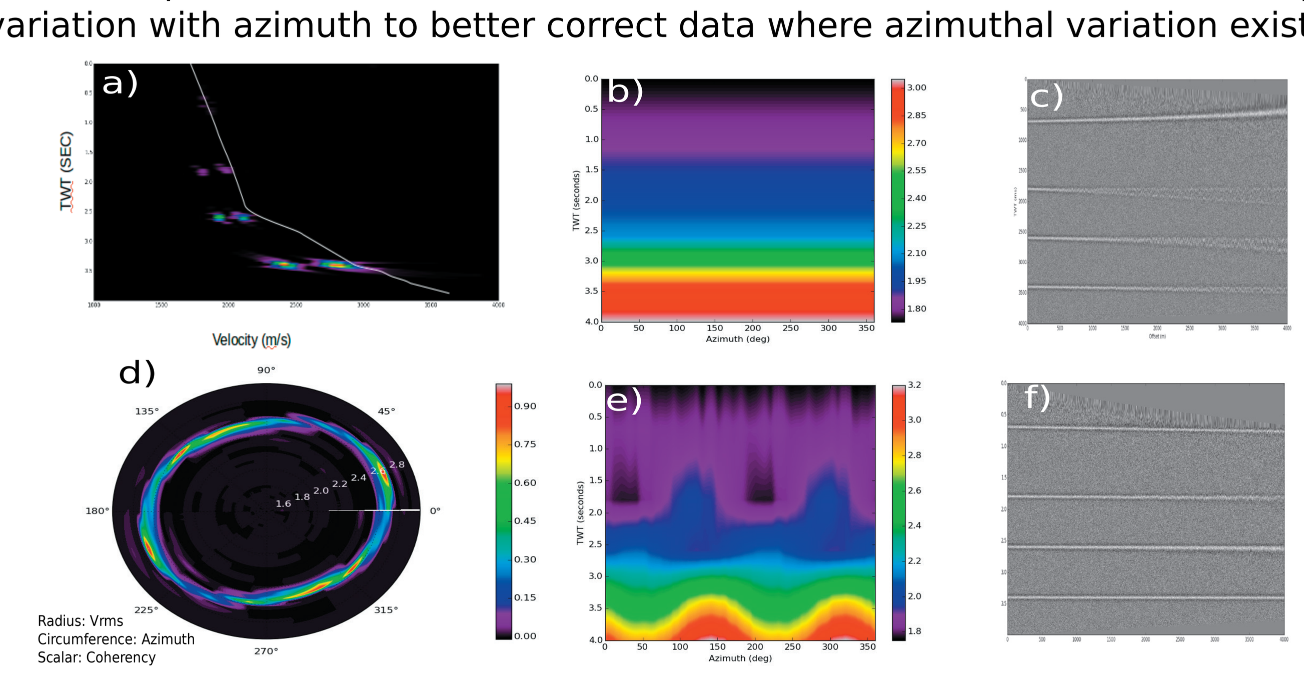

Figure 3: a) Conventional semblance with picked velocities, b) conventional gather velocity model, c) moveout correction using conventional NMO correction, d) polar time-slice semblance for VVAZ analysis (radius = Velocity, circumference unit = Azimuth, scalar = semblance, e) azimuthally dependant velocity model f) corrected gather using Azimuthally dependant velocities.

Further Developments

.Non-hyberbolic moveout analysis with new weighted high-resolution semblance and visualisation tools

We utilize Non-hyperbolic moveout with the semblance weighting schemes we developed to pick parameters Vnmo and η (Alkhalifah 1997) to account for anisotropy

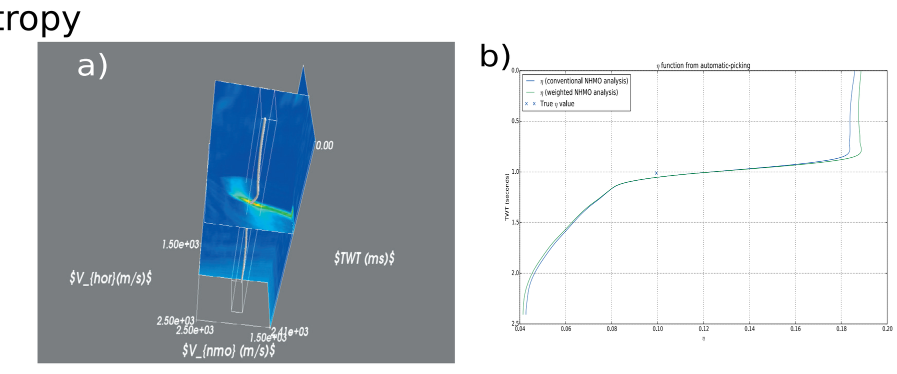

Figure 4: a) Unconventional 3D Non-Hyperbolic semblance analysis, b) comparison of derived η functions for weighted and conventional NHMO semblance analysis in relation to true η, where η is a time processing parameter that accounts for anisotropy in all time-domain processing.

.Automatic reflection detection using high-resolution semblance as a guide

We utilize high-resolution semblance and soft-thresholding to detect reflectors in gathers with low signal to noise ratio (SNR).

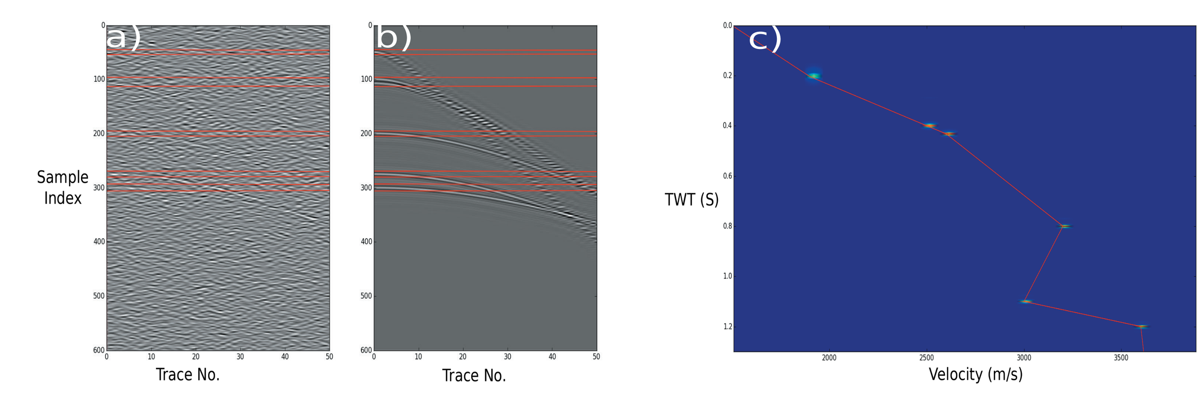

Figure 5: a) Gather with 6 reflectors polluted by noise (SNR = 1.3) , the red lines depict windows automatically detected using high-resolution semblance with soft-thresholding, b) Gather in a) with no noise but with automaticly detected windows overlayed , c) high-resolution semblance spectra with overlayed picks from auto picking.

.Noise suppresion and SNR enhancement with local similarity weighting on corrected gathers

We utilize the local-similarty metric (Fomel 2007) to create a map of weights, with high weighting for regions of similar character (signal) and low weight for areas with no similar character (noise).

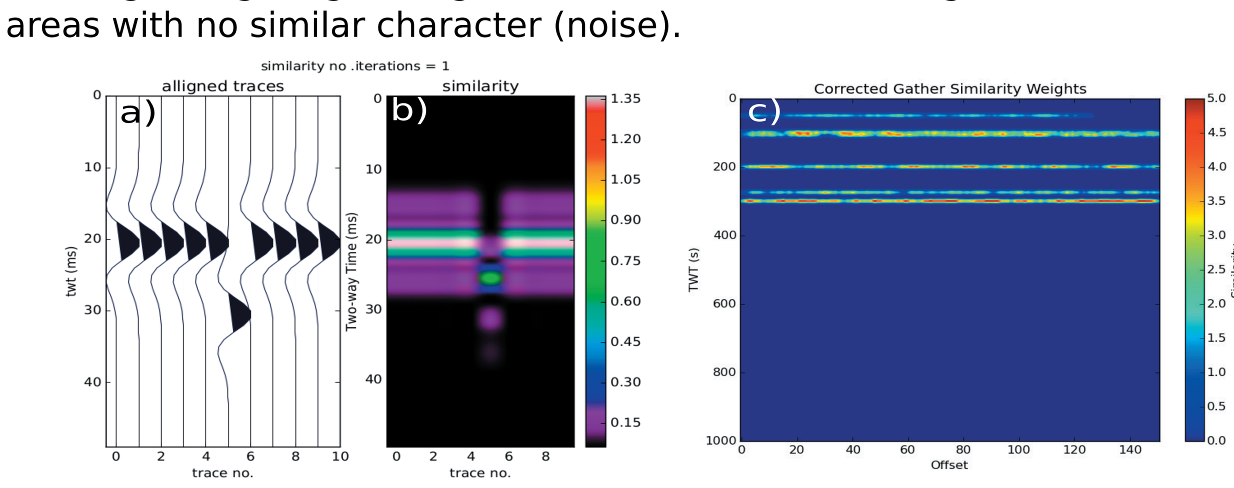

Figure 6: a) series of 9 alligned impulses and one mis-alligned impulse, b) the local similarity metric depicting good similarity where signal is aligned and poor similarity in other regions (after 1 iteration of conjugradient optimization), c) the local similarity metric applied to the gather in figure 5 after NMO correction with newly developed non-stretch NMO.

.Non-stretch NMO correction and application of local similarity for SNR enhancement

Using Automatic picking via Dynamic time-warping, coupled with high-resolution semblance, automatic reflector detection and local similarity weighting we have created a moveout correction schema that uses linearly varying velocity intervals to correct gathers without stretching at the far-offsets.

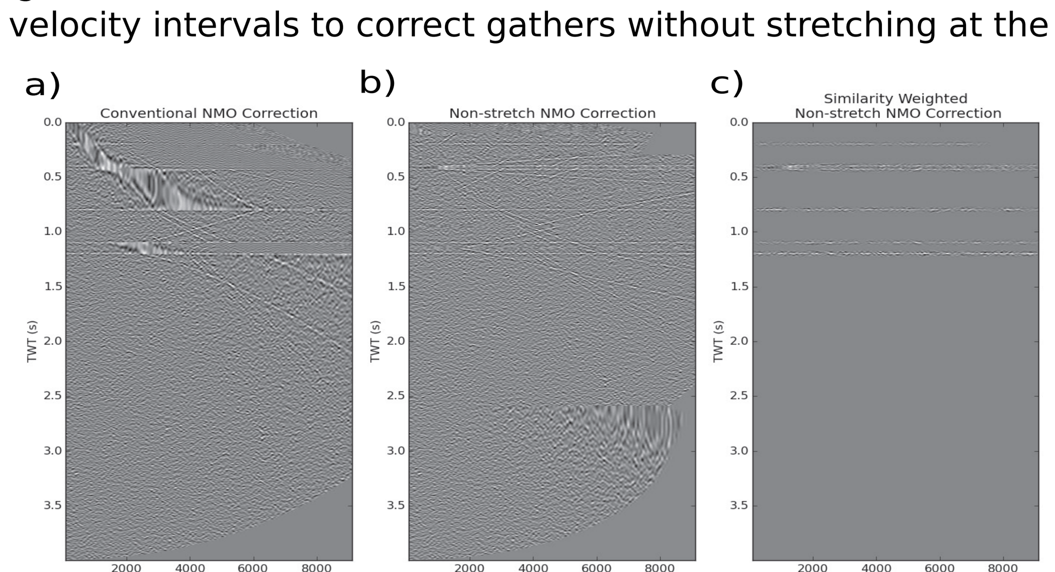

Figure 7: a) Conventional NMO correction of gather in Figure 5 (notice the smearing and stretching at singularities and far offsets), b) Application of newly developed Non-stretch NMO correction to gather in Figure 5 (smearing and stretching has been removed from flattened gather), c) corrected non-stretch gather b) with the local similarity weighting map (Figure 6c) applied (large reduction in noise and redundant information is evident).

References

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Future Work

The plan is to take my newly developed semblance, and velocity analysis techniques and amalgamate them into a velocity analysis workflow to facilitate the creation of velocity models in time and depth for Migration and full waveform inversion.

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