P037
Automatic Dense High Order RMO Picking

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SUMMARY

The semblance based, automatic dense pickings of Residual Move Out curves (RMO) proved to be a very efficient technique, but they are generally limited to the estimation of their curvature. The estimation of the misfocusing of the migrated seismic reflection is routinely done during the prestack imaging process, but the anisotropy is not fully resolved using only the RMO curvature. So, we are turning to the multi-parameter scan, thus gaining the benefit of uncorrelated scanning parameters, which fully describes any complexity in the RMO curves. In order to increase the reliability of estimated RMO curves, we are using an embedded 1D tomography inversion, which rejects any unacceptable velocity and anisotropy values at the early stage. This allows skipping from one RMO curve solution to another. Moreover a simultaneous 3D filtering of all RMO coefficients gives the ultimate editing of conflicting high order RMO curves. This technique is able to provide reliable high order RMO curves to the 3D prestack tomography, taking into account the anisotropy, as well as to perform the final flattening of image gathers necessary for AVO studies.
Introduction

The prestack imaging process attempts to reconcile the validity of the geological model to the focusing of the prestack seismic data at the same reflection location, regardless of the direction of the wave field propagation (reflection angle) or offset and azimuth of source receiver acquisition. The inspection of the alignment of reflections on the prestack image gathers is considered as an excellent control of the validity of the migration model. Moreover, it provides crucial information necessary to the prestack tomography update of the velocity model. The technology for the automatic parabolic residual moveout picking through the prestack image gathers is well known. This approximation is due to the limitation of the second order of the Taylor series expansion of the residual moveout traveltimes, which corresponds to the curvature of the RMO curves. (Adler and Brandwood 1999), (Ratcliffe and Roberts 2003). However, the complexity of the subsurface and the anisotropy behavior of the strata drastically affect the shape of the residual reflections, especially at the large angle of incidence. One parameter description of RMO curves is not enough to fit the observations, and the high order terms of Taylor series expansions have to be considered:

$$\text{RMO}(X) = C_2 X^2 + C_4 X^4 + C_6 X^6 + \ldots \text{ where } X \text{ is the offset.} \quad (e.1)$$

Generally the even-terms are sufficient to describe the residuals, nevertheless some odd-terms such $C_1$ seems to be useful in the case of complex traveltimes.

The following section of this paper proposes a robust technique for the automatic dense estimation of high order RMO curves, without using the series expansion functions.

High Order RMO decomposition using uncorrelated functions

The automatic picking of RMO curves through the prestack image gathers requires scans of the parameters describing the RMO curve. In the case of the parabolic approximation, the scan of $C_2$ is straightforward: the scan of all possible residual misfits at the largest offset is sufficient. Nevertheless, the scan of two or more parameters is more critical. Since we know that $C_2$ and $C_4$ are strongly correlated, due to the fact that the polynomial basis ($X^2$, $X^4$) is too far from the orthogonality; can we develop a scanning method? A very simple experiment can demonstrate this correlation. The figure 1 shows a $C_2$-$C_4$ crossplot of all RMO curves fitting to a given RMO curve, when the fitting error is only $\pm 4$ ms.

In fact $C_2$ and $C_4$ are naturally correlated. If the residual curvature, expressed by $C_2$ into the Taylor series development of the residuals from the non-hyperbolic moveout correction, depends only on the velocity error, $C_4$ depends on both velocity and anellipticity errors:

$$C_2 = \frac{1}{2t_0^2} \left[ \frac{1}{V_{\text{true}}^2} - \frac{1}{V_{\text{wrong}}^2} \right] \quad C_4 = \frac{1}{8 t_0^2} \left[ \frac{1+8 \eta_{\text{true}}}{V_{\text{true}}^4} - \frac{1+8 \eta_{\text{wrong}}}{V_{\text{wrong}}^4} - \frac{2}{V_{\text{true}}^2} \left( \frac{1}{V_{\text{true}}^2} - \frac{1}{V_{\text{wrong}}^2} \right) \right] \quad (e.2)$$

where $t_0$ is the zero offset time and $V_{\text{wrong}}$ and $\eta_{\text{wrong}}$ are the velocity and anellipticity causing the residual moveout. $V_{\text{true}}$ and $\eta_{\text{true}}$ are the correct velocity and anellipticity at $t_0$ location.

Siliqi and al. (2003) have shown in the context of high order normal moveout that the use of uncorrelated parameters to perform the bispectral scans is highly beneficial. In order to perform a reliable multi-parameter scan, this paper extends this concept to the high order
residual moveout. The goal is to set up a robust automatic dense multi-parameter RMO picking algorithm. In the same way as Siliqi and al. (2003) establish a relationship between the uncorrelated parameters used for the picking and the conventional parameters (velocity and anellipticity), we establish the required correspondence between the conventional $C_i$ coefficients (e.1) and the coefficients $A_i$ in front of the uncorrelated functions $F_i(X)$ of (e.3).

$$\text{RMO}(X) = A_1F_1(X) + A_2F_2(X) + A_3F_3(X) + \ldots$$  \hfill (e.3)

The customized uncorrelated functions are well balanced and can better control the complexity of the RMO curve, which is not the case for the conventional decomposition. The lack of correlation between estimated $A_i$ coefficients is perfectly visible, even in the case of real data, when both crossplots of conventional $C_2$-$C_4$ and new coefficients $A_1$-$A_2$ are superimposed (figure 2). Moreover, the magnitude of successive uncorrelated coefficients decreases, which points out the realistic number of coefficients required for the RMO description.

The reliability of this automatic estimation of the dense RMO coefficients is increased by a permanent control of the updated velocity and anellipticity, using 1D assumption of the prestack tomography. This process benefits by avoiding unacceptable values of the updated model at the early stage and proposing other solution that fits at the current location. The comparison of updated velocity and anellipticity proposed by the automatic dense high order RMO picking and the velocity and anellipticity picked straightforward using automatic dense high order NMO analysis (Siliqi and al. 2003) shows the perfect compatibility of both methods (figure 4).
Thanks to the quality of the inversion, the NMO kinematics using the inverted V, $\eta$ and the original RMO curves are equivalent (figure 5).

![Figure 5: Moveout corrections using C2,C4,C6 RMO curves or the inverted V, $\eta$ NMO curves](image)

The main difficulty of the high order RMO picking is the mix of the prestack seismic events. The semblance alone is not sufficient to discriminate a pure event through a very complex image gather. A combination of different correlation functions is necessary. It is very often desirable to automatically limit the RMO curves in offset and to not compromise the quality of the near offset picking, when the far offset is noisy or the seismic reflection is simply missing. In order to enhance the stability of the automatic dense picker, a wavelet based filtering allows preserving the wavelet shape from the near to the far offset traces of the image gather for every seismic event. Thus this method could enhance the flattening and could be used for the AVO preconditioning of the image gather. Figure 6 illustrates the flattening improvement due to the picking of dense RMO curves with different orders.

![Figure 6. Flattening due to the picking of C2-near-offset (top), C2-C4 (middle), C2-C4-C6 (bottom)](image)

The high density of the RMO coefficients fields contains the necessary redundancy to perform the editing of inconsistent RMO curves due to a simultaneous filtering process. The filtering of any uncorrelated coefficient field (figure 7) allows the editing of conflicting RMO curves, without destroying the coherent high order RMO curves (figure 8).

![Figure 7. Filtering of uncorrelated attributes](image)
3D prestack tomography as well as any processing step, requiring the flattening of image gathers, benefits from the robust technique of the automatic dense picking and filtering of high order RMO curves.

![Figure 8. High order RMO corrections before (top) and after (bottom) filtering of the RMO curves](image)

**Conclusion**

This paper introduces a robust technique for the automatic dense estimation of high order RMO curves. With the introduction of uncorrelated scanning coefficients, the semblance based RMO picking of complex prestack migration residuals becomes realistic, without any limitation in the order of Taylor series expansion. Checking the validity of any RMO curve, using a 1D tomography inversion, we avoid the inconsistent picks at the early stage. Taking advantage of the high density of the RMO curves, we proposed an editing of mispicks by a simultaneous filtering of all coefficients describing the RMO.

This multipurpose powerful technique (CCG patent) helps provide input to 3D prestack tomography with dense high order RMO curves; necessary of anisotropy model building.

**References**

