Analysis of converted-wave extended images for migration velocity analysis

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what are extended images?

redundant representations of migrated images

Rickett and Sava (Geophysics, 2002)
Sava and Fomel (Geophysics, 2006)
Sava and Vasconcelos (Geophysical Prospecting, 2010)
conventional imaging condition

\[ R(\mathbf{x}) = \sum_{\text{shots}} \sum_{t} W_s(\mathbf{x}, t) W_r(\mathbf{x}, t) \]

- \( W_s(\mathbf{x}, t) \): source wavefield
- \( W_r(\mathbf{x}, t) \): receiver wavefield
extended imaging condition

\[ R(x, \lambda, \tau) = \sum_{\text{shots}} \sum_{t} W_s(x - \lambda, t - \tau) W_r(x + \lambda, t + \tau) \]

- \( \lambda \): space-lag extension
- \( \tau \): time-lag extension
how do we analyze extended images?

consider subsets of the image

Sava and Vasconcelos (Geophysical Prospecting, 2010)
Sava and Vlad (Geophysics, 2011)
CIGs: fixed \( \{x, y\} \) coordinates
CIPs: fixed $\{x, y, z\}$ coordinates
how do the extended CIPs look?

*image “cubes” at fixed space positions*
correct velocity
how do we use the extended CIPs?

extract information for migration velocity analysis
correct velocity
high velocity
low velocity
migration velocity analysis

\[ J(\nu) = \frac{1}{2} \| P[R(\nu)] \|^2 \]

- \( J(\nu) \): objective function
- \( P[\cdot] \): penalty operator
- \( R(x, \lambda, \tau) \): extended image

Symes (Geophysical Prospecting, 2008)
what is the penalty operator?

penalizes image distortion from an ideal shape
simplified reflection geometry
conventional imaging condition

\[ p_s \cdot (x - x_s) = (t - t_p) \]
\[ p_r \cdot (x - x_r) = (t - t_s) \]

\[ R(x) = \sum_{\text{shots}} \sum_t W_s(x, t) W_r(x, t) \]
extended imaging condition

\[
\mathbf{p}_s \cdot (\mathbf{x} - \mathbf{x}_s - \lambda) = (t - t_p - \tau)
\]

\[
\mathbf{p}_r \cdot (\mathbf{x} - \mathbf{x}_r + \lambda) = (t - t_s + \tau)
\]

\[
R (\mathbf{x}, \lambda, \tau) = \sum_{\text{shots}} \sum_{t} W_s (\mathbf{x} - \lambda, t - \tau) W_r (\mathbf{x} + \lambda, t + \tau)
\]
\[(q \cdot \lambda) [\sin \theta] = v \tau\]
\[(\mathbf{n} \cdot \lambda) \left[ \gamma \cos (\theta - \delta) - \cos (\theta + \delta) \right] + (\mathbf{q} \cdot \lambda) \left[ 2 \sin (\theta + \delta) \right] = 2v_p \tau\]
PS
conventional image
CIPs for one shot
CIPs for all shots
CIPs for all shots
penalty function for all shots
objective function for various velocities
summary

- extend CIP moveout function
- penalty operator for MVA
- smooth objective function
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