Surface-consistent Gabor deconvolution

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Outline

- Why could we need SCGABOR?
- Overview of Gabor deconvolution
- A surface consistent Gabor algorithm
- Example
- Conclusions
DIVETSCO TESTS
(From Perz et al., 2005, CSEG meeting)
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From Wiener to Gabor

1. Constant Q theory

2. Nonstationary convolutional model

3. Gabor transform

\[ G[s](\tau, f) = \int s(t) g(t - \tau) e^{-2\pi if t} \, dt \]
Nonstationary conv. Model in the Gabor domain

- Factorization of the nonstationary convolutional model

\[ \tilde{s}(f) = \tilde{w}(f) \int \alpha_Q(f, \tau) r(\tau) e^{-2\pi j f \tau} d\tau \]

Approximated factorization

\[ G[s](\tau, f) \approx \tilde{w}(f) \alpha_Q(\tau, f) G[r](\tau, f) \]

- Fourier of the wavelet
- Gabor of the trace
- Attenuation function
- Gabor of the reflectivity
Gabor deconvolution

Gabor transform of the trace

Deconvolutional operator:
- smoothing
- phase:
  using Hilbert transform

Wavelet removal and compensation for attenuation are simultaneous
Minimum phase, linearity, causality and Hilbert transform.

- Minimum phase
  - Explosive sources are also minimum phase.

Futterman (1962) showed that wave attenuation in a causal, linear theory is always minimum phase.
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Surface Consistency

\[ \sigma(s, r, x, h, t) = a(s, t) \otimes b(r, t) \otimes c(x, t) \otimes d(h, t) \]

\[ \tilde{\sigma}(s, r, x, h, \omega) = A(s, \omega)B(r, \omega)C(x, \omega)D(h, \omega) \]
Surface-consistent Gabor deconvolution

\[ G[\sigma](\tau, f) \approx \hat{w}(f)\alpha_Q(\tau, f)G[\rho](\tau, f) \]

\[ G\sigma(f, \tau, h, r, s) = [w_s(f, s)\alpha_Q(f, \tau, h)G\rho(f, \tau, h)]w_r(f, r) \]

\[ h, r, s: \text{ midpoint, receiver and source coordinates respectively} \]
Surface-consistent Gabor algorithm

For the i, j, k trace:

\[ h_1 h_2 h_3 \ldots h_i \ldots h_{Nm} \]

\[ r_1 r_2 r_3 \ldots r_j \ldots r_{Nr} \]

\[ s_1 s_2 s_3 \ldots s_k \ldots s_{Ns} \]

Sources array

Receivers array

Midpoints array

\[ w \]

\[ \sqrt{w} \]
Surface-consistent Gabor algorithm

For the i, j, k trace: 

\[ \sum_{m=1}^{M} |w_s(f, s_m)|_j \]

\[ \sum_{n=1}^{N_r} |w_r(f, r_n)|_k \]

\[ \sum_{l=1}^{L} |\alpha(f, \tau)|_l \]

\[ \theta_{ijk}(f, \tau) = A_i \ast \ast \left[ (w_s)_j \right] \ast \left[ (w_r)_k \right] \]
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Synthetic raw data
(Courtesy DIVESTCO)

The dataset is made up of 78 shots, 96 channels per shot, Q=40, sample rate=2ms, length=2 sec. Station interval=34 m.

Brute stack
Synthetic raw data
(Courtesy DI VESTCO)

Q=40

V=3500

Strong attenuation

Surf. Consist. wavelets

Strong random noise
After single channel Gabor
After Surf. Cons. Gabor
Conclusions

- A poor S/N could harm the estimation of the minimum phase Gabor deconvolution operator, introducing undesirables artefacts.

- The Surface-Consistent implementation of Gabor deconvolution allows a robust estimation of the minimum phase deconvolution operator in the presence of
  - Strong random noise
  - Strong variations of the near-surface features
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