This paper presents a new idea for designing a match filter for processing time-lapse seismic data in a surface consistent manner. The surface consistent model is extended to designing match filters to equalize two seismic surveys in least square sense. The frequency-domain surface-consistent equations are similar to those for surface consistent deconvolution except the data term is the spectral ratio of two surveys (monitor and baseline). We built a time-lapse synthetic dataset (baseline and monitor) whose subsurface (the reservoir) is unchanged but which show surface-consistent variability. Initial results are encouraging but suggest that our software is not yet optimal.

The four-component surface consistent decomposition:

\[ P_{ijkl}(\omega) = S_i(\omega)R_j(\omega)H_k(\omega)Y_l(\omega) \]

where \( P_{ijkl} \) = the seismic trace \( \omega \) = angular frequency \( S_i \) = represent source consistent effect \( j = \) source index \( R_j \) = represent receiver consistent effect \( j = \) receiver index \( H_k \) = offset component \( k = |j| \) \( Y_l \) = midpoint component \( l = (j + k)/2 \)

The surface consistent match filter

Survey #1: \[ P_{ij1}(\omega) = S_{i1}(\omega)R_{j1}(\omega)H_{k1}(\omega)Y_{l1}(\omega) \]  
Survey #2: \[ P_{ij2}(\omega) = S_{i2}(\omega)R_{j2}(\omega)H_{k2}(\omega)Y_{l2}(\omega) \]

Taking the logarithm of both sides and for simplicity substituting \( S_i \) for \( S_{i1}/S_{i2} \) and so on for the other terms:

\[ \ln \left( \frac{P_{ij2}(\omega)}{P_{ij1}(\omega)} \right) = \ln(S_i(\omega)) + \ln(R_j(\omega)) + \ln(H_k(\omega)) + \ln(Y_l(\omega)) \]  

Following Wiggins et al. (1976), equation (4) can be written:

\[ \frac{P_{ij2}(\omega)}{P_{ij1}(\omega)} \rightarrow p(\omega) = Gx(\omega) \text{ with } x(\omega) = \begin{bmatrix} s(\omega) \\ r(\omega) \\ h(\omega) \\ y(\omega) \end{bmatrix} \]  

where \( p \) is the data vector, \( x \) represents the unknown parameter vectors, and \( G \) is the geometry matrix which contains the positions of the four-components.

This is a new idea for designing a match filter in a surface consistent manner. The surface consistent model is extended to designing match filters to equalize two seismic surveys. We have built a very useful synthetic dataset that contains a baseline and a monitor survey with surface consistent seasonal variations built into the model. Initial results are encouraging but suggest that our software is not yet optimal.

Correct for the time delay problem which is currently not accounted for by the operators. Review the offset and midpoint operators and reduce the noise observed above and below the center of the operators. Once the code is working, apply to a real dataset.

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