Parameter-oriented CRS imaging

German Hoecht, OPERA, Patrice Ricarte, Institut francais du petrole, currently OPERA

Summary

The operators used for common-reflection-surfaces stack or interpolation are redundant in view of their information. In addition, each operator is usually uniquely used for a target sample. Our aim is to make use of this redundancy in order to gain more information for each target sample. In addition, we reduce the redundancy by distinguishing between the target grid and a coarser parameter grid. Having estimated an operator on the parameter grid, we can use it as stacking or interpolation operator for each sample of the target grid that falls into its range of validity. In this manner each sample of the target grid is alimented with numerous operators. This parameter-oriented scheme has a reliable smoothing effect and overcomes the problem that a single operator estimation for a target sample fails. For the illustration of the method we use the common-reflection-surface interpolation for 2D and apply the target and the parameter-oriented schemes to the Sigsbee data. Although we present the parameter-oriented imaging for the 2D case the scheme applies similar to the 3D case.

Introduction

Common-reflection-surface (CRS) time imaging parametrizes the data space by the most coherent operators in data. Unlike Kirchhoff-type operators that use the constructive contributions of different operators for a target sample, CRS imaging methods usually make use of a single operator per target sample. Similar to a conventional velocity analysis, CRS imaging estimates the operators prior to make use of them. However, CRS operators extend over several gathers and therefore provide some redundant or additional information.

Let us in the following explain the conventional CRS imaging scheme to which we refer as target-oriented imaging. CRS operators are usually constructed for each sample of a target trace and serve as stacking or interpolation operator in order to simulate a target sample. This principle applies as well as for the ZO CRS (Jäger et al., 2001) where the target is grid is located at zero offset (ZO) as well as for the CRS interpolation where the target grid fills the whole data space (Hoecht et al., 2004). Figure 1 shows an example of a CRS interpolation operator in a data cube. Because the CRS method identifies these operators for each sample of a target grid that is much denser than the search aperture, the surfaces are expected to overlap along reflection events. In addition, the operator is usually estimated by an unweighted semblance analysis that does not consider where the operator actually fits best to the data in the search aperture.

As mentioned above, CRS methods estimate the operator for each target sample. This scheme is slightly different for the CRS interpolation. The latter already distinguishes between a parameter and the target grid: the target (traces that have to be interpolated) can be arbitrarily located in the data space, whereas the parameter traces have to be located within the gathers of the

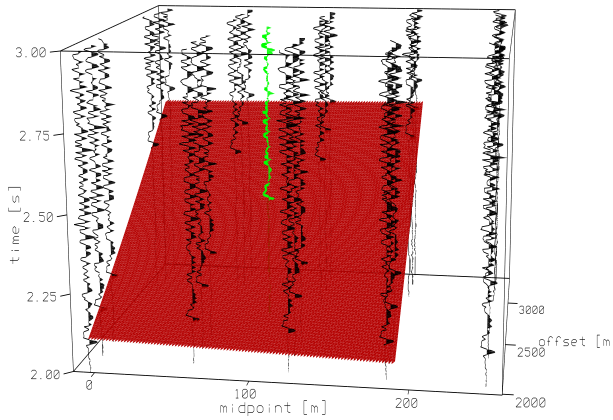

Fig. 1: CRS interpolation operator (brown surface) for a target sample of a target trace (green) in the 3D data cube of a 2D acquisition.

prestack data. This is due to the fact that the required five parameters are determined in subsequent steps with a first step in the input gathers. For details of the parameter estimation see Hoecht et al. (2004). Since the target-oriented interpolation scheme requires the parameters at the target trace, the parameters are interpolated horizontally (and not along the operators) from the surrounding parameter traces to a target trace. This makes sure that a parameter-set (that defines the interpolation operator) is available for each target sample. Note that the horizontal interpolation of parameters requires a dense parameter grid in order to obtain accurate parameters on the target grid.

Parameter-oriented interpolation

The presented parameter-oriented interpolation directly constructs the operators on the parameter grid. Such an operator is subsequently used for all target traces in its range of validity. This range is roughly defined by the corresponding search aperture used for the estimation of the parameters. In practice we use a range that is slightly inferior to the search aperture (Figure 2). Just like for the target-oriented interpolation, we use the three nearest data traces for each target trace and assign the amplitudes along the operator to the latter. The amplitudes are weighted linearly according to the distances between a target trace and the surrounding three data traces. As in general an operator constructed at the parameter trace does not cut a target trace exactly at a target sample, we shift the operator in time to the sample below and above the intersection point.

Figure 3 and Figure 4 compare the target and the parameter-oriented interpolation for two target samples. The corresponding operators are displayed in a common-shot gather and in a common-offset section of the Sigsbee data. As mentioned above, the target-oriented interpolation uses one parameter set per sam-

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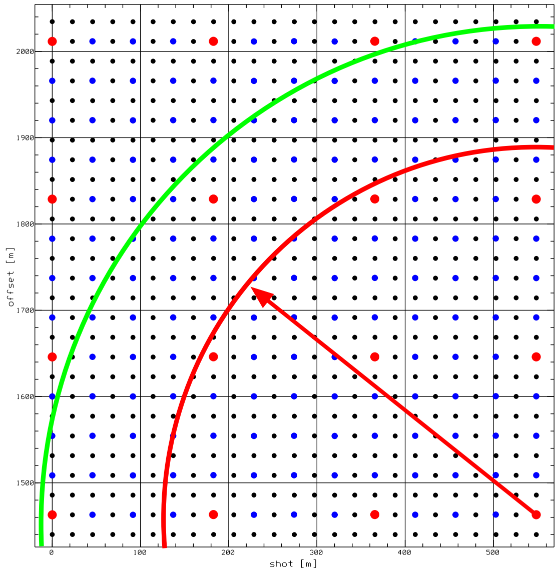

Fig. 2: The location of the target traces is denoted by the black points, the parameter-grids for the target-oriented and the parameter-oriented interpolation schemes are shown in blue and red, respectively. The location of the data traces coincides with the location of all parameter traces. The red circle indicates all target traces affected by the parameter trace at the lower right corner for the parameter-oriented scheme. The green circle indicates the search aperture involved in the estimation of the parameters for this trace.

ple to construct the operator. Obviously, the operator for the sample at 4.15s is aliased in the common-offset direction. This may be caused by the estimation of the operator in different steps. Figure 3b and Figure 4b show the involved operators of the parameter-oriented interpolation for these two target samples. These contributions stem from all parameter traces that contain the target trace in their range of validity. For this example, we chose a circular range with radius 420m around a parameter trace. Figure 2 as wells as the parameter traces displayed in red within the common-shot and common offset section give an idea of their locations. The sample at 4s has 73 operator contributions whereas the samples at 4.15s gets 22 contributions. Only about the half of these (shifted) operators are shown, namely all operators that intersect between the investigated sample and the next sample. Finally, the amplitude assigned to a target sample is given by the sum of all operator contributions divided by the number of contributions.

Data examples

For illustration we use the Sigsbee data set which offers numerous complex reflection patterns. From this data we extracted each second trace within a shot, so that the receiver spacing equals the shot spacing (45.72m). Our aim was to reconstruct the initial receiver-spacing as well as to create a new shot between two exiting shots, so that the target grid equals 22.86m in shot and receiver direction.

For the target-oriented interpolation we chose a parameter grid that is equal to the data grid, hence 45.72m in shot and receiver direction. For the parameter-oriented interpolation we reduced the previous parameter grid by retaining only every fourth parameter trace within every fourth shot. This yields a parameter spacing of 182.88m in shot and receiver direction and reduces the amount of parameters by 16. Figure 2 illustrates the different geometries.

Figure 5 shows the original data and the results of the target and parameter-oriented interpolation. As one can observe the target-oriented interpolation shows noisy areas in regions with numerous complex reflection patterns. Although the target-oriented interpolation can also not properly construct this area and weakens the reflection patterns, it provides a much cleaner image.

Conclusions

In contrast to construct a single operator at the target by assigning the parameters to a target sample, a parameter-oriented imaging allows implicitly several operator contributions to a target sample. This provides a reliable smoothing of a stack or interpolation and thereby increases the stability in areas with several complex reflection patterns.

CRS operators involve more than one parameter that have to estimated from the data. Due to the computational expense the parameters are usually estimated separately in different steps. Since the parameter-oriented scheme allows the use of a coarser parameter grid it encourages the more stable and accurate simultaneous search (at least for subsets of the parameter space).

Conflicting dips often pose a problem when using (local) stacks and a single operator. The parameter-oriented scheme provides various operator contributions. However, for a more properly handling of conflicting dips, these contributions would have to be selected or weighted. In case of a local interpolation, the involved data traces are often affected by the conflicting dip and thereby introduce some conflicting dip behavior.

The presented method applies similar in the 3D case. In this case the data space has five dimensions and the CRS operators form four-dimensional hyper-surfaces.

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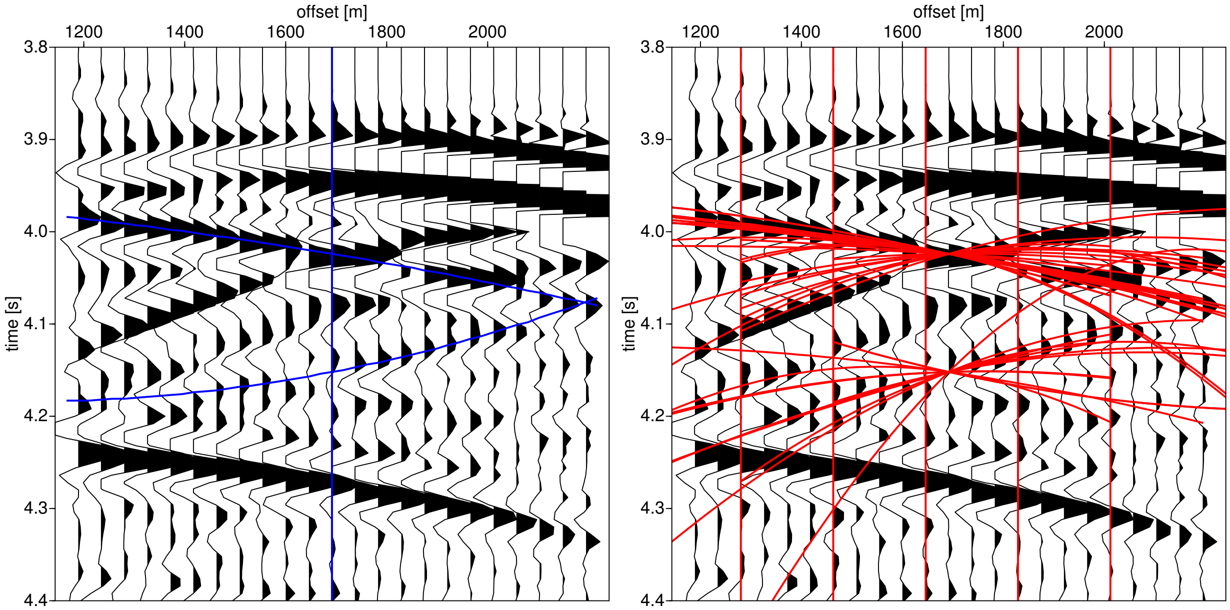
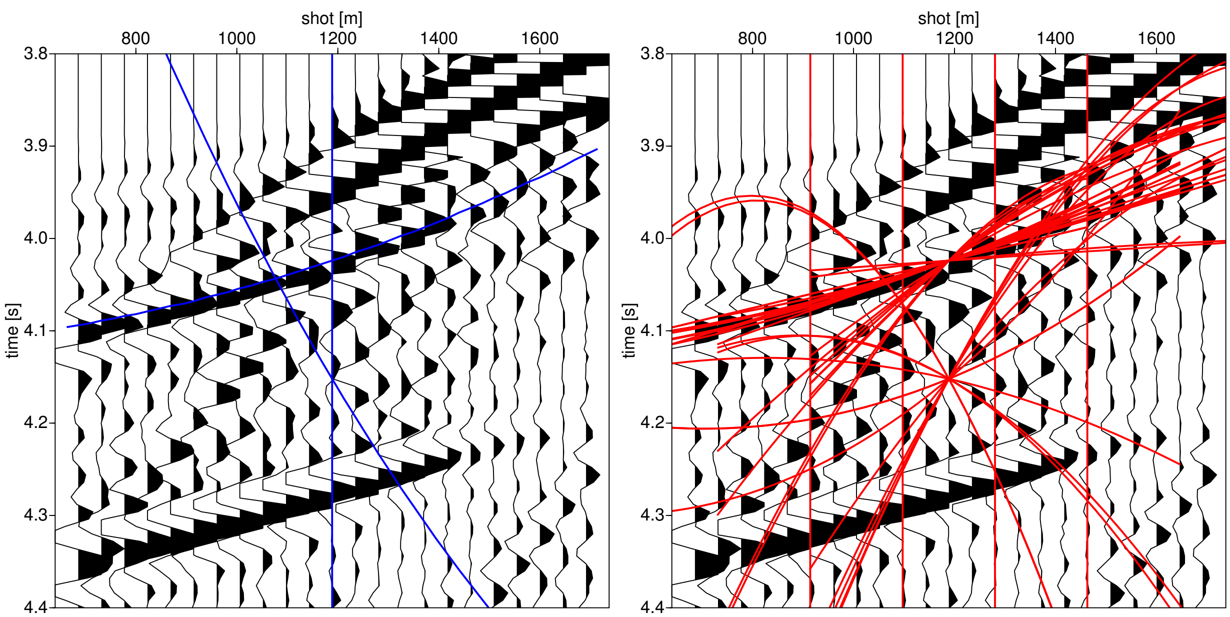


(a) Target oriented interpolation

(b) Parameter-oriented interpolation

Fig. 3: Interpolation Surfaces in the (traces-reduced) shot section 101 for two target samples at offset 1691m and times 4.024s, and 4.152s.



(a) Target oriented interpolation

(b) Parameter-oriented interpolation

Fig. 4: Interpolation Surfaces in the CO section 1691m for two target samples in shot 101 (at 1189m) and times 4.024s, and 4.152s.

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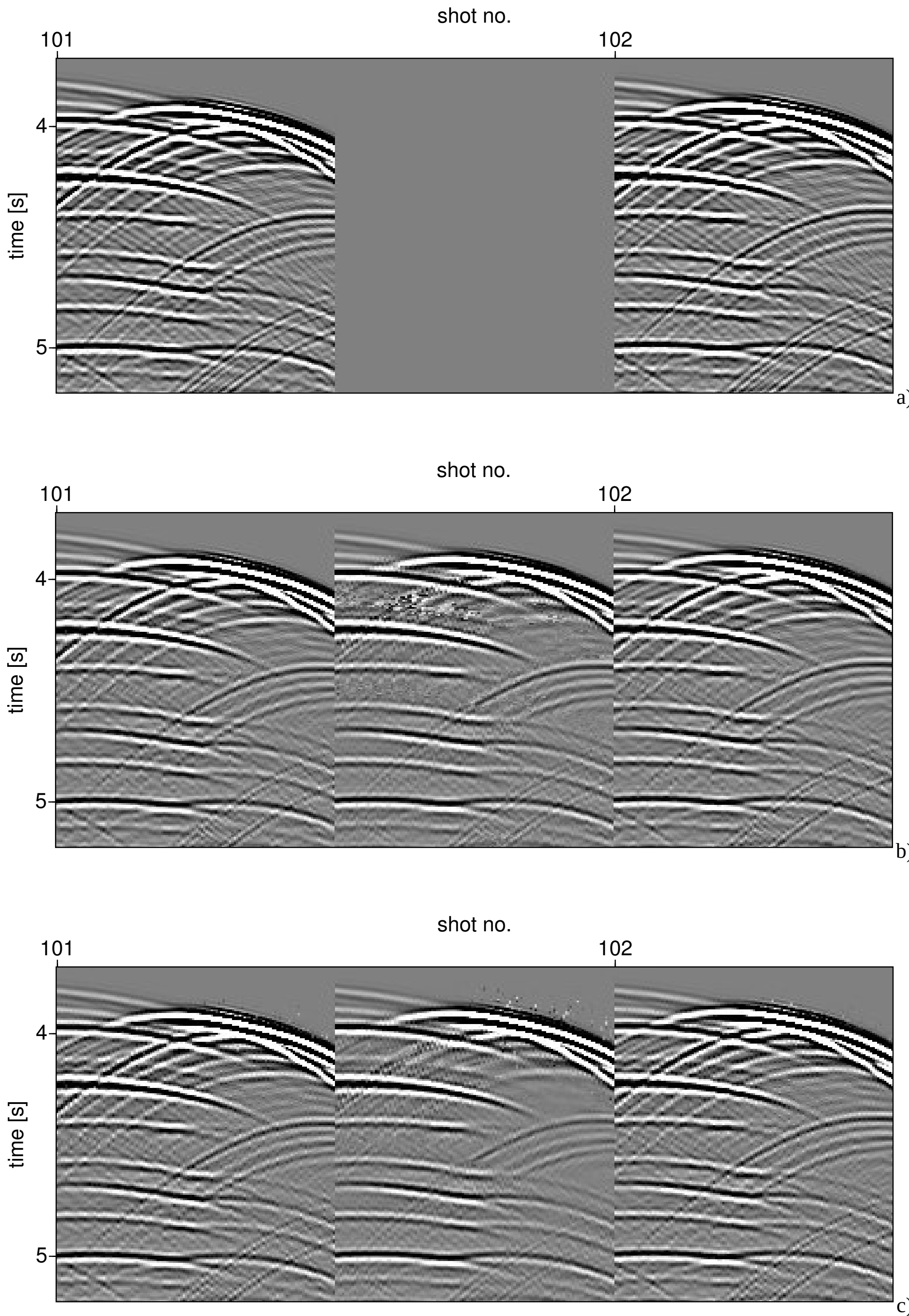

Fig. 5: a) original (not reduced) data, b) target-oriented interpolation and c) parameter-oriented interpolation.

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