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Enhancement of the migrated results with the deblurring filter

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In this paper we introduce a method that uses the deblurring filter to further improve the migrated GPR results. While applying migration to near range radar systems such as GPR, we may suffer from the imaging artifacts or low resolution due to the limited aperture size or coarsely sampled data. In order to solve this problem, least square approach can be applied.

It can be presented with the following equations:

The forward modelling can be presented as a linear calculation as (1)

$d = Lm$ (1)

The real inverse processing should be (2)

$m = L^{-1}d$ (2)

Here d is the acquired GPR data, L is the forward modelling matrix and m is the reflectivity model of the survey area. Since the inverse matrix L^{-1}

is almost impossible to determine, we normally use the simplified method that use the adjoint matrix as the estimation of the inverse matrix. And it is proved that migration is just the adjoint matrix of the forward modelling matrix. Hence the migration processing can be written as (3)

$m* = L^T d$ (3)

The analytic least square solution can be given as (4)

$m* = (L^T L + \mu I)^{-1} \quad L^T d$ (4)

The least square results give much higher resolution and most of the artifacts can be eliminated. But this method requires extremely large computation so it is not really practical.

Here we propose another approach, by combining (1) and (3) we can also get (5)

$m = (L^T L)^{-1} \quad m*$ (5)

It indicates that we may further improve the migrated results with an inverse filter $(L^T L)^{-1}$. Actually, this is known as the deblurring processing for imaging problem. This deblurring filter is still very difficult to solve for the whole imaging area, but we can use the local filters at different position instead of a whole filter. In order to realize this method, a dictionary needs to be reconstructed correspond to the antenna configuration and the background velocity first. At each local window we put a point scatter in the middle and calculate the forward modelling result and the migrated result of this local window. Then the local deblurring filter can be estimated with (5) by a matched filter. After we construct this dictionary for a certain survey area, we can apply the filters to the acquired dataset. In order to improve the imaging quality, the filters at different local windows should be overlapped properly.

We applied our method to the simulated GPR dataset which is spatially coarse sampled. The results show that the migration artifacts caused by the coarse sampling can be well eliminated and the target can be reconstructed with high resolution. The imaging feature is very similar to the least square migration result but our method do not need iteration.