Seismic 7—Migration II

3-D Migration Using the Causality Principle

S7.1

J. T. Fokkema, A. M. Ziolkowski, and G. J. M. Baeten, Delft University of Technology, Netherlands

Causal seismic data are composed of propagating and evanescent energy. In migration only the propagating part is used and this leads to an unfocused and noncausal image. We analyze this problem by considering the wave field of a point source in an infinite homogeneous isotropic acoustic medium. The wave field is known completely in some plane and then migrated. The migrated result should of course be a delta function at the source position. If only the propagating part is used the migrated result is unfocused and noncausal because the migration operator is noncausal. An exact causal operator can be found only when all propagating and evanescent contributions are taken into account using the causality principle. The migrated result is then the required spatial delta function at the source position, provided the source wavelet has collapsed to a temporal delta function by deconvolution prior to migration. It follows that the quality of the migrated result depends on the signature deconvolution.

In order to migrate real data with optimum resolution, deconvolution must be done with care to ensure that there is no mixing of the real and imaginary parts of the wave field in the frequency domain. We propose signature deconvolution to a noncausal 90-degree antisymmetric wavelet $m(t)$ prior to migration. Migration can then be performed using the propagating part only (that is, in the frequency-wavenumber domain), and the migrated result for the point source is then a zero-phase spatial wavelet centered on the source position. The resolution of the image is controlled by $m(t)$ which is, in turn, limited by the usual signal-to-noise ratio constraints. We prove all our results analytically.

Forward Modeling and Migration Using CPF transforms

S7.2

S. L. Zhang and G. H. F. Gardner, Seismic Acoustics Laboratory, University of Houston

Polynomial transforms were introduced by Nussbaumer in 1977 and have the distinctive feature that they can be computed in real-number arithmetic without multiplications using fast FFT-type algorithms. The present paper suggests that modeling and migration programs can be implemented more efficiently if multidimensional FFTs are replaced by a new transform with the acronym CPF which combines the Chinese remainder theorem, polynomial transforms, and 1-D Fourier transforms. It is shown that CPF transforms have convolutional, conjugate, and differential properties as do Fourier transforms. The number of multiplications in a CPF is about half that of an FFT, while the number of additions is about the same. On a VAX 11/780, the run time for a 2-D example was reduced by 30 percent by using CPF instead of a 2-D FFT. The savings should be greater for higher dimensional cases.

Shot Profile Dip Moveout Using Log-Stretch Transform

S7.3

Biondo Biondi, Stanford University; and Shuki Ronen, Saxpy Computer Co.

All the known dip moveout (DMO) methods require seismic data to be sorted in midpoint and half-offset coordinates. In this paper a DMO method for shot profiles is proposed. The DMO operator in shot profiles is defined in an analogous way of the well-known operator in constant-offset sections. The two operators are found to be equivalent and to have impulse responses with the same projection on the zero-offset plane, i.e., the stacking plane. Therefore, the application of DMO in constant-offset sections or in shot profiles gives the same stacked section. DMO transforms shot profiles to zero-offset data to which may be applied any poststack migration.

The shot profile DMO operator is unfortunately space and time-variant; thus, its direct application would be computationally expensive. Instead, after a logarithmic transformation of both coordinates the operator becomes time and space-invariant, and then the procedure may be performed very efficiently as a convolution in the Fourier domain. The performances of the algorithm are shown in field data examples and results are compared with conventional DMO in constant-offset sections.

Modeling with Uneven Spatial Sampling

S7.4

Joe Dellinger and Francis Muir, Stanford University

Some seismic data may not be recorded on a regular grid, and this poses special design problems for processes such as dip filtering, modeling, and migration. A common solution is to map the data onto a regular grid using some interpolation scheme, and in case of migration, another popular solution is to employ integral methods which, superficially, seem to steer around the problem. While these methods have served us well enough, it is still possible in the case of modeling and migration to use differencing schemes on the original, irregular grid. Doing this so as to guarantee unconditional stability and minimize the generation of artifacts requires careful construction of finite-difference operators. This is particularly important because, as a practical matter, grid irregularities will be on the scale of the finite difference grid and so cannot be handled as a perturbation problem. The math is somewhat more complex than in the regular case but in the end, the finite differencing star is the same size and shape as before, so that there is only about as much additional code complexity and computational cost as there is in adding lateral velocity variations. Our scheme appears quite robust against extreme variations in grid spacing, but spurious reflections will occur when spacing exceeds the Nyquist limit.

Practical Aspects of 3-D Prestack Migration

S7.5

C.P.A. Wapenaar, G. Blacquière, N. A. Kinneging, and A. J. Berkhout, Delft University of Technology, Netherlands

This paper starts with a brief review of the principle of prestack migration by single-shot record inversion (SSRI). Prestack migration by SSRI is very laborious when applied in three dimensions. However, in many practical situations seismic inter-