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A Simple and Practical Way to Interpolate Sparse Velocity along Structures

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ABSTRACT

Velocity estimation is a very critical and important concept in seismic exploration. Wave propagation velocity in media plays a key role in seismic imaging. Reliable velocity estimates during imaging can improve the accuracy subsequent structural interpretation and the consistency of stratigraphic analysis. Velocities are crucial links during the early stages of time processing, which are often estimated on widely separated common midpoint gathers. We propose a new approach where initial velocities serve as seed points and are then interpolated to fill each grid point in a 3D volume. One simple approach for interpolation is to smooth the velocities horizontally, although such smoothing can intersect with structure or subsurface interfaces and degrade the accuracy of the interpolated velocity in areas of complex geology. In contrast, smoothing the velocity along structure is highly desirable and can provide improved interpolated results. We present a novel practical approach to interpolate (and extrapolate) sparsely sampled velocity values into fully-populated grid points of a 3D velocity cube. The interpolation estimates velocity values sampled at arbitrary locations to all grid points along structural trends defined in seismic images. The key new idea is to introduce a mask whose initial values are set to be one where the input velocity is defined, and zero elsewhere. Based on the anisotropic diffusion equation, we apply structure-oriented smoothing (SOS) to the sparsely defined velocities and the mask weights. Since diffusion is a physical process that simulates movement of molecules or atoms from a region of high concentration (or high chemical potential) to a region of low concentration (or low chemical potential), the velocity is interpolated automatically and efficiently under the guidance of structural information. Finally, the 3D velocity cube is fully populated by using the point-to-point division of the smoothed velocity using the mask. Our structure-oriented velocity interpolation (SOVI) method has been applied to a 3D Red Sea dataset. Since the structures in the area are quite complicated, it is very challenging and time consuming to pick velocity functions accurately that honor the complex subsurface features. Our interpolation methodology works very well, producing an interpolated velocity volume that is consistent with subsurface structure, significantly reduces manpower and processing cycle time while improving the quality of the final stack.