REPRESENTATION AND VISUALIZATION OF 3D VELOCITY-DEPTHS MODELS

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Building velocity-depth models for structural imaging requires combining information about layer boundaries and interval velocities in a geologically consistent manner. This requires working with seismic data and model objects in a single environment and is best done on an interactive workstation. The complexity of a software system designed to support such an activity increases dramatically when moving from 2-D to 3-D velocity-depth models. We present a system for 3-D interactive velocity-depth model building and visualization.

3D velocity-depth models are represented by volumes linked to surfaces through topological entities. This representation is similar to models used by Guiziou et al (1990) and is a generalization to 3D of the approach used by Sword (1991) on 2D models. This representation supports models that are geometrically complex without imposing restrictions on either the shape, or the orientation of surfaces in the model. It also supports the association of velocity fields with volumes. Velocity fields can be represented by constants, scattered sets of velocity nodes, cartesian grids, and two- and three-dimensional tessellated grids. Vertical and lateral velocity gradients are included in the representation. The surfaces used to build models consist of meshes of triangles, an approach also used by Wyatt et al (1991). This representation allows surfaces that are multivalued in depth, or in any other direction, to be manipulated without having to split them into single-valued segments -- a common requirement in many systems. In addition, surfaces do not have to extend over the entire survey area.

Geophysical entities like seismic sections in depth, well trajectories, horizons and velocity nodes can be visualized and handled in 3-D space. Interactive panning and zooming, and a 3-D cursor facilitate navigation in complex geometries. For example, velocity nodes can be positioned in space with the 3-D cursor, and contours delineating reflector geometries can be digitized on any seismic section. Surface fitting algorithms based on skinning techniques generate multi-valued horizons represented by meshes of triangles. Additionally, the system provides tools for interactively deforming and sculpting surfaces.

Selected functions of the system are illustrated in figure 1. Figure 1a shows a seismic section from a 3D volume of depth migrated data with a digitized contour delineating a salt body. In figure 1b, the corresponding salt surface has been built from several contours by using a surface fitting algorithm. In figure 1c, the same surface has been interactively deformed by the user, a procedure used to correct mismatches between surfaces and seismic data.

The system provides utilities to prepare the constructed velocity-depth model for numerical computations. For example, regular velocity grids can be generated for 3-D poststack depth migration. When efficient and accurate ray tracing is required, a 3-D mesh generator may be used to divide volumes into connected tetrahedra that honor internal and external boundaries of the velocity-depth model.

We will illustrate 3-D modeling, visualization and editing capabilities of the system using a field data example from the North Sea. We shall demonstrate how layer velocity fields are built from velocity nodes derived from prestack traveltimes inversion and combined with reflector geometries from 3-D poststack depth migrated volume of data imported to the system.

References

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A

B

C

D

Figure. 1: This figure illustrates the steps used in surface development; (a) a contour digitized on a seismic image; (b) a surface built from several contours including the one shown in (a).; (c) the surface shown in (b) adjusted to better fit all of the seismic data; (d) the same surface as in (c) with two seismic sections.