Semi-Automated Detection and Extraction of Seismic Objects

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Akademisk avhandling

För vinnande av Filosofie Doktorsexamen i Marin Geologi (examinator Professor Björn Malmgren) som enligt beslut av Lärarförslagsnämnden, institutionen för Geovetenskaper vid Göteborgs Universitet, kommer att offentligen försvaras fredagen den 2 april 2004, kl. 13.00 i Hörsalen, Geovetarcentrum, Guldhedsgatan 5B, 413 20 Göteborg.

Fakultetsopponent är Dr. Rob Arts, Nederlands Instituut voor Toegepaste Geowetenschappen TNO, Nederländerna.

Abstract

Economic drivers and advances in acquisition, processing, and computing technology have in recent years caused a data explosion in the seismic industry, which in turn has created a need for new interpretation methods. The overall objective of this thesis is to develop fast and accurate seismic interpretation techniques that can handle multiple 3D seismic data volumes.

The study focuses on two main aspects of seismic interpretation: object detection and object extraction, notably mapping of horizons and faults. The first three out of the four papers on which this doctoral thesis is based deal with seismic object detection. The method used in these papers is based on patented technology in which multi-volume seismic attributes and interpreter's insight are combined by artificial neural networks into meta-attributes, which highlight objects of interest. In this study the patented technology is improved and generalized by the development of a method here called dip-steering (Paper I). The essence of dip-steering is that the local dip and azimuth of the seismic data are utilized to create a virtual horizon around the point of investigation by simply following the local dip and

azimuth of the seismic data outwards. Dip-steering is used for filtering seismic data, for calculating attribute responses along seismic reflectors, and for tracking seismic horizons and faults. Several new seismic attributes based on dip-steering are described, such as dip-steered similarity, dip-variance, and a new edge-preserving smoothing filter. Dip-steering also allows curvature attributes to be computed at every seismic sample position, whereas conventionally, such attributes can only be computed along mapped horizons. The introduction of dip-steering, in combination with new attributes and filters improve the detection of seismic objects in general and chimneys and faults, in particular, as described in Papers II and III, respectively.

The second part of the thesis focuses on extracting horizons and faults from the seismic data and is described in Paper IV. The objective is to develop a method that tracks multiple fault- and horizon-surfaces simultaneously in a geometrically consistent manner. A new paradigm is introduced that emulates the working process of a thin metal worker and comprises three consecutive steps:

1. Extending a surface to a new position.

2. Matching the extended surface to the data at the new position.

3. Cutting the surface to make it consistent with other surfaces.

The method is semi-automated. The interpreter sets up a seed interpretation, controls the direction of surface extensions, and corrects where and when necessary. Dip-steering is used in the process of extending surfaces, while the seismic object detection method is used to track faults and for quality control purposes. The new tracking method has the potential to be faster and more accurate than conventional seismic interpretation methods, which often require extensive post-interpretation editing. This, however, remains to be benchmarked in due time.

Software development constitutes a major part of this study. The software developed in the context of this thesis is now integrated in "OpendTect", an open source seismic interpretation and development environment.

Keywords: seismic interpretation, 3D seismic, attributes, meta-attributes, artificial neural networks, seismic objects, horizons, faults.