THE "DELIVERY" OPEN-SOURCE SEISMIC-INVERSION TOOLKIT

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Abstract

We present an overview of the "Delivery" open-source toolkit for (1) stochastic seismic inversion, (2) wavelet extraction, and (3) production of geo-models from "Delivery" inversion models. These three major open-source pieces of software have been produced by CSIRO with support from BHP Billiton in the last 5 years. The first two of these components have been introduced at previous EAGE meetings, the last is a submitted abstract for the present meeting. Here we outline how the whole package fits together and how it interfaces with other open-source projects like SU and the BHP viewer. We believe that significant factors in the success of these developments are the backbone design, the modularity and parellizability of the workflow, and the advantages of the controversial decision to code major components in java.

Brief descriptions of the three components are as follows:

(1) "Delivery" is a model-based Bayesian seismic inversion code. It uses a layer-based prior model with rock physics information takenfrom log analysis as the basic structure that generates reflection seismic data. The model allows for uncertainty in both the fluid type and saturation in reservoir layers: variation in seismic responses due to fluid effects are taken into account via Gassman's equation. Multiple stacks are supported, so the software implicitly performs a full AVO inversion using approximate Zoeppritz equations. Uncertainties and irresolvabilities in the inverted models are captured by the generation of multiple stochastic models from the Bayesian posterior, all of which acceptably match the seismic data, log data, and rough initial picks of the horizons. Post-inversion analysis of the inverted stochastic models then facilitates the answering of commercially useful questions, e.g. the probability of hydrocarbons, the expected reservoir volume and its uncertainty, and the distribution of net sand. The Delivery software is java-based and thus platform independent. Input and output is driven via XML, Seismic Unix1 (SU) and BHP_SU data formats, and the output interfaces naturally with the free BHP viewer. The assumption of independent traces means that the inversion can be massively parallelized, and distributed across cluster computing systems.

(2) The "Wavelet-Extractor" code is a Bayesian wavelet extraction program for deriving wavelets from seismic and well-log information. This code is designed as a companion program to "Delivery" in that the wavelet is extracted using exactly the same forward modelling assumptions as that used in the inversion code. Our program approaches the well-tie problem from a Bayesian view, which is the most natural way to integrate prior knowledge

about the well tie in the form of marker constraints, checkshot data, phase prejudices, and plausible interval velocities. The code can perform simultaneous extractions at multiple (possibly deviated) wells, for multiple offsets in AVO applications (using a linearized Zoeppritz reflectivity), and can estimate additional uncertainty parameters such as time-registration errors for stacks or well-location errors caused by imaging problems. The code produces distribution details for the mis-tie (noise) amplitude, which is critical for inversion studies, and can produce multiple realisations of the extracted wavelets from the Bayesian posterior, showing the uncertainty in the wavelet scaling and extent, the time-to-depth map, and the noise parameters for each stack.

(3) The "Delivery-Massager" module integrates the probabilistic seismic inversion information generated by "Delivery" with reservoir simulation models commonly used in modelling and flow-simulation packages like Petrel. This modelling tool is able to integrate the full range of complex knowledge inferable from probabilistic seismic inversion with auxiliary geological and petrophysical information to produce an integrated model; a process we call "massaging". The major innovative achievement of this code is the synthesis of multi-layer multi-property correlations inferable by the inversion with the transverse correlations induced by geological processes. The massaged model(s) are then directly suitable for uncertainty studies of volumetrics, scenarios explorations, or fluid recovery risking. The Delivery-Massager code is essential for the task of propagating the complex information available from seismic inversion further into reservoir engineering models. Reservoir models honouring the full multi-layer, inter-property constraints available from seismic inversion with well data and geological continuity requirements yield greatly improved estimates of reservoir architecture and uncertainty.