Abstract

Seismic interpretation is a process to extract geophysical subsurface information by analyzing seismic data. Seismic fault detection and sparse layer inversion (SLI) are two important techniques for efficient seismic interpretation. Seismic faults provide the most important information on the probable possibility of hydrocarbon deposition on the earth's subsurface. In SLI, thin layers are delineated from estimated RC to identify rock properties. However, seismic interpretation in large volumes is a challenging problem and conventional algorithms are computationally expensive. Moreover, the presence of noise in the dataset also degrades the performance of seismic interpretation.

This thesis aims to address the fault detection problem and presents a multi-stage framework with an ensemble of algorithms, keeping in mind the computational expenses. First, seismic denoising is accomplished with preservation of faults. Next, an augmented trace-based fault extraction method is proposed followed by fault path estimation. The superior performance of proposed fault extraction method is demonstrated with state-of-the-art algorithm.

High-Performance computing (HPC) has gained considerable interest for the improved computational performance of algorithms over conventional computing approaches. Recently, the computational performance is accelerated using Graphical Processing Unit (GPU) powered with Compute Unified Device Architecture (CUDA) in HPC paradigm. This thesis proposes a workload balancing and memory management strategy for the fast computation of fault detection algorithms through GPU. Significant computational improvement and drastic reduction of runtime is achieved by massive parallelization of algorithms and demonstrated superior performance over conventional implementation and commercial software.

Next, the issue of layer continuity in estimated RC along with large-scale linear programming (LP) optimization of SLI problem are addressed. This thesis proposes an improvisation of the optimization problem by incorporating suitable regularization. The fast computation of optimization is accomplished with parallel implementation of large matrix inversion of LP method through GPU. The proposed formulation efficiently delineates thin layers from estimated RC over the state-of-the-art algorithm with less than 0.25% reconstruction error. The performance improvement of LP through GPU is also illustrated.

Finally, software is developed to use the proposed seismic interpretation algorithms for industrial purposes. This software provides an interactive opportunity for the user to select appropriate algorithms for seismic denoising, fault detection, manual fault annotations, sparse layer inversion, various post-processing, and visualization of results.

Keywords: Seismic Fault Detection, Sparse Layer Inversion, Denoising, High-Performance Computing, GPU, CUDA, Reflectivity coefficients, Linear Programming.