SPG-NA Fall Webinar 2020

Two-step velocity inversion using trans-dimensional tomography and elastic FWI

Reetam Biswas

Abstract: Full Waveform Inversion (FWI) has become a powerful tool to generate high-resolution subsurface velocity models. FWI attempts to solve a non-linear and non-unique inverse problem, and is traditionally based on a local optimization technique. As a result, it can easily get stuck in a local minimum. To mitigate this deleterious effect, FWI requires a good starting model, which should be close enough to the optimal model to properly converge to the global minimum. Here, we investigate a two-step approach for solving this problem. In the first step, we generate a starting model for FWI, that includes the low-wavenumber information, from first-arrival traveltime tomography of downward extrapolated streamer data. We solve the tomography problem using a trans-dimensional approach, based on a Bayesian framework. The number of model parameters is treated as a variable, similar to the P-wave velocity information. We use an adaptive cloud of nuclei points and Voronoi cells to represent our 2D velocity model. We use Reversible Jump Markov Chain Monte Carlo (RJMCMC) to sample models from a variable dimensional model space and obtain an optimum starting model for local elastic FWI. We also estimate uncertainty in our tomography derived model. We solve for the Eikonal equation using a shortest path method for ray tracing in tomography and we solve the elastic wave equation using a time-domain finite-difference method in FWI. To compute the gradient we used the adjoint method. We demonstrate our algorithm on a real 2-D seismic streamer dataset from Axial Seamount, which is the most volcanically active site of the northeastern Pacific. We ran 17 Markov chains with different starting number of nuclei and convergence for all chains was attained in about 1000 iterations. Marginal posterior density plots of velocity models demonstrate uncertainty in the obtained starting velocity models. We then ran a local FWI using the combined result from all chains.

Digital Enablers – Data-Driven Methods in Geophysics

Vishal Das

Abstract: Data-driven research is a paradigm shift and a new way of doing research. In this presentation, the primary focus will be on an introduction to the importance of data-driven methods in Geophysics. An introduction to deep learning methods and particularly Convolutional Neural Networks will be covered during the presentation. Some examples of using CNNs for seismic inversion problems will be highlighted.

Numerical Simulations of Seismic Wave Propagation in Fractured Media and Parameter Estimation

Janaki Vamaraju

Abstract: Natural fractures are frequently observed in rocks at all scales. Their characterization is critically important for all subsurface applications. Since fractures greatly influence the porosity and permeability of a reservoir, several techniques have been developed to identify and characterize them. In principle, seismic data can be effective to locate and characterize these fractures because of the sensitivity of wave velocities, amplitudes and spectral characteristics to fracture compliances. However, the detection of subsurface fractures from seismic data is a challenging problem. However, the detection of subsurface fractures from seismic data is a challenging problem. Besides the low seismic resolution and the complexities of geological bodies in the subsurface, the main contributing causes for the problems are the challenge of understanding the characteristic response of fractures in seismic data and the correct estimation of fracture properties from seismic data. Therefore, the motivation is to develop novel numerical methods that can accurately model seismic waves in presence of fractures and are computationally very efficient. Specifically, my talk will be about the following:

a) Development of enriched/hybrid finite elements to model seismic wave propagation in fractured elastic media at reduced computational costs.

b) Modeling seismic wave propagation in fractured poroelastic media to examine the effects of fluid filled cracks and pores on scattering.