



Physical Research Laboratory, Ahmedabad

COLLOQUIUM - 13 – 13

Speaker: Prof. Mrinal K. Sen

Director, CSIR - National Geophysical Research Institute, Hyderabad, India.

Title: Uncertainty Quantification in Geophysics

Abstract

Geophysical inverse problems involve estimating earth model parameters from remotely sensed measurements. The observations are almost always insufficient, inadequate and inconsistent. Thus the inverse problems are highly ill-posed resulting in non-unique estimates of the model parameters. In other words, often multiple models are proposed that can explain the observations equally well. Mathematical techniques such as regularization can be imposed to obtain average or smooth models but they may result in geologically unrealistic solutions. One other approach is to examine all possible models and attempt to estimate uncertainty in the answer. A Bayesian formulation of the inverse problems appears fairly attractive for achieving this goal.

In a Bayesian framework, prior information in the model (independent of observations) is combined with observation using a likelihood function to estimate a posteriori probability density (PPD) function in model space. The PPD is indeed the answer to our inverse problem. Unfortunately, for highly non-linear geophysical inversion problems, the PPD does not have an analytic form and is generally multi-modal. It has been demonstrated that the Markov chain Monte Carlo (MCMC) method is asymptotically convergent for sampling from such a PPD. Unfortunately, MCMC methods based on Metropolis-Hastings or Gibbs' sampler is computationally expensive for our problems. We have developed several meta-heuristics that offer practical ways for sampling from multi-modal PPDs. These include multiple very fast simulate annealing (MVFSa) and multi-chain genetic algorithms. More recent approaches include Hamiltonian Monte Carlo and Langevin Monte Carlo methods, which make efficient use of local gradient information. Several examples of these methods from geophysical inverse problems will be discussed.

The Speaker

Prof. Mrinal K. Sen received M.Sc (integrated) in Applied Geophysics from the Indian School of Mines and Ph.D. from the University of Hawaii at Manoa. Prof. Sen's research areas include seismic wave propagation, inverse problems, seismic imaging, reservoir characterization and computational geophysics. He is an expert on seismic wave propagation including anisotropy and fracture characterization, and develops analytic and numerical techniques for forward and inverse modeling. Prof. Sen is well known for his work on global optimization methods for geophysical inversion. Prof. Sen has supervised over fifty doctoral and post-doctoral students. He and his students have carried out rigorous error analysis of finite difference and finite element methods. They have also developed new methods for computing synthetic seismograms based on path integral formulation, full waveform inversion and reservoir characterization including time lapse seismics. Prof. Sen serves on several national and international committees and is an associate editor of some leading journals such as Geophysics, Journal of Seismic Exploration and International Journal of Geophysics. He routinely serves on the SEG and SPG technical committees. He has been an instructor of several industry short courses including an SEG short course on 'Full Waveform Inversion'. Since, January 2012, Prof. Sen took over as Director of CSIR-NGRI, Hyderabad, on leave from UT Austin, Texas, USA.

Wednesday: 03 April, 2013, 16:00 hrs.

K.R. Ramanathan Auditorium, PRL

Tea at 15:30 hrs

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