Indian National Science Academy (INSA)
Overseas Chair Lecture

"Physics and ML for seismic data analysis"

Speaker

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Brief Bio-data

Mrinal K. Sen is a professor of Geophysics and holder of Jackson Chair in Applied Seismology at the Department of Geological Sciences , Shell Companies Foundation Centennial Chair in Geophysics and concurrently serves as the associate director of the Institute for Geophysics at the University of Texas at Austin. During 2013 and 2014, Prof. Sen served as the director of the National Geophysical Research Institute, Hyderabad, India. He received his integrated M.Sc degree from ISM Dhanbad and Ph.D. from the University of Hawaii at Manoa, USA, in 1987. Prof. Sen is known internationally for his work on theoretical and computational seismology, and geophysical inversion. He has published over 200 peer-reviewed journal papers and two books on Geophysical Inversion. He has received many awards including the Honorary membership of the Society of Exploration Geophysicists "for extraordinary contributions as a geophysicist, educator, and author", the 'Joseph C. Walter award for research excellence, the 'distinguished educator award' at the University of Texas, Decennial Gold Medal of the Indian Geophysical Union, the Hari Narayan Award of the Geological Society of India, and the distinguished alumnus award from ISM and the University of Hawaii at Manoa. He is the recipient of the 2018 Virgil Kauffman gold medal of the Society of Exploration Geophysicists for making significant advancements in the sciences of exploration geophysics in the last five years. His recent works include: uncertainty quantification using trans-dimensional Hamiltonian Monte Carlo methods, error analysis of finite difference and finite element methods, and Physics-based machine learning for seismic data analysis.

Abstract

Inverse problems in Seismology are solved using model based approaches in that the physics of wave propagation is used to iteratively update a starting subsurface velocity model. Contrary to that, the machine learning approaches are purely data driven and are agnostic to physics. In order to take advantage of both approaches and extend their limits of applicability, we have developed several approaches to combine data-driven and model-driven approaches. For the least squares migration and AVA waveform inversion, we build Boltzmann machines that are designed based on their respective forward operators. In other words, the physics is used to design the architecture of the network and the inverse problem is solved by a variant of simulated annealing algorithm. We also use machine learning optimization methods for training of the network. Similarly, in our physics-assisted machine learning development, seismic data are used as input to a deep network, whose output is treated as the unknown model parameters. These parameters are then used to solve the physics based forward problem and the residuals are back propagated to train the network. In this approach, the deep NN is used as a regularizer and is made to learn the inverse operator. This helps to mitigate several shortcomings of the full waveform inversion, namely, the requirement of the choice of a good starting model and parameter cross-talks in multi-parameter inversion. The results from application of these algorithms on field data are quite encouraging.

18 March, 2025 (Tuesday)

GJLT, IIT(ISM) Dhanbad

5:00 PM Onwards

Prof. Saumen Maiti
Coordinator

Prof. Sanjit Kumar Pal
HOD (AGP)

Department of Applied Geophysics, IIT(ISM) Dhanbad