Non-linear Modeling of Schlumberger Resistivity Sounding Data of Koyna Region: A Hybrid Monte Carlo Based Neural Network Approach

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Koyna area is well known for its seismic activities since December 10, 1967 earthquake. Shallow distribution of resistivity pattern is important in such seismically active area, for mapping of fault, fractures and lineaments. However, true resistivity distribution from the apparent resistivity data is not precise due to the high non-linearity exists between geophysical observables and model parameters. A novel attempt based on the Bayesian neural network theory using the concept of Hybrid Monte Carlo (HMC)/ Markov Chain Monte Carlo (MCMC) simulation has been made for rapid interpretation of Direct Current (DC) vertical electrical sounding data collected over Koyna region. We generated a large number of synthetic DC apparent resistivity data from a different combination of true resistivity and true thickness value. Objective/Cost function is optimized following the Hybrid Monte Carlo (HMC)/ Markov Chain Monte Carlo (MCMC) sampling based algorithm. In this algorithm, each trajectory is updated by approximating the Hamiltonian differential equations through a leapfrog discrimination scheme. After successful completion of validation, a network is applied to new/unseen data of 26-electrical sounding points from Chiplun to Patan. Uncertainty of the inversion results is estimated via the developed Bayesian code. We estimated true resistivity distribution from apparent resistivity using the HMC-based neural network over Koyna region (Chiplun-Koyna- Patan, Maharashtra, India). We compared the HMC-based BNN inversion approach to the singular value decomposition (SVD)–based conventional resistivity inversion results. Comparisons suggest that HMC-based BNN approach is promising inversion tool to solve non-linear resistivity inversion problem. The precise true distribution of resistivity is appeared to be quite interesting in interpreting the fracture and lineament of this seismically active region.

Keywords: Schlumberger sounding, inversion, damped least-squares, SVD, Bayesian neural networks, Hybrid Monte Carlo simulation, Koyna