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Facies Reconstruction by hidden Markov models

M Panzeri (1), E Della Rossa (2), L Dovera (2), M Riva (1), and A Guadagnini (1)

(1) Politecnico di Milano, Dipartimento di Ingegneria Idraulica Ambientale e del Rilevamento, Piazza L. Da Vinci, 32, Milan, 20133 Italy. , (2) ENI S.p.A. – Exploration & Production Division Via Emilia, 1, 20097 San Donato Milanese

The inherent heterogeneity of natural aquifer complex systems can be properly described by a doubly stochastic composite medium approach, where distributions of geomaterials (facies) and attributes, e.g., hydraulic conductivity and porosity, can be uncertain. We focus on the reconstruction of the spatial distribution of facies within a porous medium. The key contribution of our work is to provide a methodology for evaluating the unknown facies distribution while maintaining the spatial correlation between the geological bodies. The latter is considered to be known a priori. The geostatistical model for the spatial distribution of facies is defined in the framework of multiple-point geostatistics, relying on transition probabilities (Stien and Kolbjornsen, 2011). Specifically, we model the facies distribution over the domain by employing the notion of Hidden Markov Model. The hidden states of the system are provided by the value of the indicator function at each cell of the grid, while the the petrophysical properties of the soil (e.g., the permeability) are considered as known. In this context, the key issue is the assessment of the spatial architecture of the geological bodies within the domain of interest upon maximizing the probability associated with a given permeability distribution. This objective is achieved through the Viterbi algorithm. This algorithm was initially introduced for signal denoising problems (e.g., Rabiner, 1989) and has been extended here to a two-dimensional system, following the approach proposed by Li et al. (2000) according to the following steps: (1) the parameters of the transitional probabilities of the facies distribution are estimated from a given training image; (2) the facies distribution maximizing the probability of occurrence considering the probability of (i) facies distribution, (ii) conductivity distribution and (iii) their joint conditional probability is then reconstructed. We demonstrate the reliability and advantage of our methodology by comparison against typically used reconstruction methods (including k-Means clustering, expectation-maximization and minimum-variance algorithm) by means of an extensive numerical analysis performed on several test cases.

References

Li, J., A. Najmi, R. M. Gray (2000), Image Classification by a Two-Dimensional Hidden Markov Model, IEEE T. Signal Proces. 48(2), 517-533.

Rabiner, L.R. (1989), A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition, P. IEEE 77(2) 257-286.

Stien, M., and O. Kolbjornsen (2011), Facies modeling using a Markov mesh model specification, Math. Geosci., 43(6), 611-624, doi:10.1007/s11004-011-9350-9.