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Application of an Artificial Neural Network and Stochastic Simulation at the Schuyler Falls Landfill, NY

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EXTENDED ABSTRACT

Stochastic conditional simulation techniques have been developed to address issues of risk and uncertainty associated with spatially distributed phenomena in earth sciences (e.g. hydraulic conductivity, contaminant concentration, *etc.*). These techniques (*e.g.* Gaussian simulation, p-field simulation, turning bands algorithm, *etc*) are used to assess risk and uncertainty resulting from sparsely sampled field measurements, high measurement variability and incomplete site knowledge. Scientists and engineers are able to model the spatial continuity and quantify uncertainty associated with spatially distributed phenomena through the generation and analysis of many equiprobable stochastic simulations.

Uncertainty in contaminated site characterization is of serious concern in environmental engineering. Stochastic conditional simulation is often used in environmental engineering to generate many equiprobable realization fields of hydraulic conductivity and/or hydraulic head gradient. These realization fields are then used as inputs to groundwater flow and contaminant transport models to estimate the flow of contamination under different stressor conditions. Once the risk and uncertainty have been quantified, optimal remediation strategies are developed to minimize societal and environmental impacts caused by contamination.

We have developed a method of generating stochastic conditional simulations by combining the traditional framework of spatial dependencies witnessed in geostatistics with the pattern recognition capabilities of the artificial neural network (ANN) algorithm known as counterpropagation. The counterpropagation ANN is a supervised learning algorithm that self-adapts to create statistical mappings of predictor vectors and associated response vectors. The execution of the counterpropagation ANN is defined by two phases: a calibration phase (training) and an operational phase (interpolation/estimation). Once trained, the network maps a set of input predictors $\boldsymbol{x}=(x_1, x_2,\ldots)$ to an associated response $\boldsymbol{y}=(y_1, y_2,\ldots)$ defined by some nonlinear function $\boldsymbol{y}=\varphi(\boldsymbol{x})$. We have enhanced the original counterpropagation ANN by incorporating spatial dependencies described by geostatistics through the utilization of radial basis functions.

The functionality of this method is demonstrated through its application on two separate case studies. The first involves estimating electrical resistivity (*ohm-m*) in 2-dimensional space on a slab of Berea sandstone using limited, sparse point measurements. This test case provides a unique opportunity to quantitatively compare simulation techniques as the “true” electrical resistivity field is considered known at the desired scale. The second case study involves generating realizations of soil lithology and hydraulic conductivity (*m/day*) at a full scale, 3-dimensional field site. Site characterization data (*i.e.* pumping tests and well borings) from the Schuyler Falls Landfill, located in Clinton County NY, is used in this second case study.

By nature of the algorithm, all generated simulations respect the observed sample data and the data’s underlying spatial structure (as described by semi-variogram analysis). Our developed method proves to be comparable to traditional conditional simulation techniques and yet is capable of incorporating multiple predictor variables. Results of this research illustrate the feasibility of using the counterpropagation algorithm to conduct a probabilistic assessment, while increasing interpretational value of site characterization data.