ABSTRACT

Despite the recent data explosion, many optimization and decision making processes are constrained with detailed and/or expensive simulation runs. Therefore, original simulation models are replaced with a light-weight model that captures the underlying input-output relationship plausibly nonlinear and complex, known as proxy. The focus of this study is to develop a Gaussian Process based proxy model and apply it to porous media flows. Porous media flows are ubiquitous and, the study of groundwater virus transport and petroleum reservoir flows, are crucial for health and economic impacts. Experimental design plays an important role in extracting the most information from limited data. Optimization is always required for selecting the best design. On the other hand ‘covariance function’ or ‘kernel’ is the most important ingredient for constructing a Gaussian process model. In this study, all these elements are carefully considered and new methods or modifications to the existing method(s) are proposed. A new and efficient method for experimental design is proposed. Modification to an existing heuristic optimization technique is also implemented to improve its performance. An algorithm is proposed to produce composite kernels, which can select the optimal kernel given some base kernels and the initial design. Eventually, the proposed methods are applied to different case studies. Parameters of 1-dimensional groundwater virus transport problem and the porosity of a small-size industrial reservoir are estimated successfully using a limited number of simulation runs. In the optimal well placement problem, despite limited data, optimal well locations were calculated for two production wells of a real reservoir. The locations predicted using proxy models were found to be reasonably close to the original well sites of the reservoir, validating the proposed proxy models.