Gaussian Process Enabled Efficient Bayesian Inference

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ABSTRACT

This work presents a Gaussian process-enabled Bayesian inference framework for efficient inference of uncertain parameters in large-scale dynamic systems. The framework uses a high-fidelity physics-based numerical model of the underlying environmental dynamics (e.g., contaminant fate & transport model), which often requires significant computational resources to run, to create training points for learning Gaussian process-based emulator of the physics-based system. Training point creation can be done by some design of experiments methods (e.g., Latin hypercube, D-optimal, Maximum entropy sampling, Central composite design). Once learned, the Gaussian processes learner produces physics-based prior knowledge for the Bayesian inference process as a delegate to the original high-fidelity model. The Bayesian inference engine fuses the prior information and in situ sensor data to create more updated posterior knowledge about the system. This posterior information is the basic output of the proposed inference procedure. The posterior estimation can also be used to update the prior knowledge about the system. A numerical case study on contaminant source localization and characterization in a sensor-rich multi-story building is specifically considered for verification of the proposed framework.