Statistics > Applications

A Gaussian Process Emulator Approach for Rapid Contaminant Characterization with an Integrated Multizone-CFD Model

Piyush M. Tagade, Byeong-Min Jeong, Han-Lim Choi

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This paper explores a Gaussian process emulator based approach for rapid Bayesian inference of contaminant source location and characteristics in an indoor environment. In the pre-event detection stage, the proposed approach represents transient contaminant fate and transport as a random function with multivariate Gaussian process prior. Hyper-parameters of the Gaussian process prior are inferred using a set of contaminant fate and transport simulation runs obtained at predefined source locations and characteristics. This paper uses an integrated multizone-CFD model to simulate contaminant fate and transport. Mean of the Gaussian process, conditional on the inferred hyper-parameters, is used as an computationally efficient statistical emulator of the multizone-CFD simulator. In the post event-detection stage, the Bayesian framework is used to infer the source location and characteristics using the contaminant concentration data obtained through a sensor network. The Gaussian process emulator of the contaminant fate and transport is used for Markov Chain Monte Carlo sampling to efficiently explore the posterior distribution of source location and characteristics. Efficacy of the proposed method is demonstrated for a hypothetical contaminant release through multiple sources in a single storey seven room building. The method is found to infer

location and characteristics of the multiple sources accurately. The posterior distribution obtained using the proposed method is found to agree closely with the posterior distribution obtained by directly coupling the multizone-CFD simulator with the Markov Chain Monte Carlo sampling.

Comments: The paper is submitted to the journal "Building and Environment" for possible publication