

CRUNCH Seminars at Brown, Division of Applied Mathematics

Friday – November 9, 2018

An introduction to multi-fidelity ensemble smoother and my ongoing projects

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Ensemble-based methods have been widely used for characterization of model parameters. Due to their Monte-Carlo nature, these methods can be easily implemented but usually need relatively large ensemble sizes to guarantee the accuracy, resulting in a high computational cost. To address this issue, we propose an adaptive multi-fidelity ensemble smoother (AMF-ES) for data assimilation, which takes advantage of both the accuracy of high-fidelity (HF) model and efficiency of low-fidelity (LF) model. In our work, an ensemble smoother-based multiple data assimilation (ES-MDA) scheme is employed. In the forecast step, a large number of LF simulations and a small number of HF simulations are implemented. By exploring the correlations between the predictions of HF and LF models, a multi-fidelity Gaussian process (GP) is established to serve as a surrogate for the original system without sacrificing accuracy. After each analysis step, the multi-fidelity GP surrogate is locally refined in the posterior region. In summary, the expensive HF model evaluations are implemented only if necessary. The efficiency of the proposed method is illustrated by a synthetic case and a real-world experiment.