EGU2020-22273, updated on 27 Oct 2020
https://doi.org/10.5194/egusphere-egu2020-22273
EGU General Assembly 2020

Surrogate-based Simulation-Optimization Scheme for Designing Water Retention Measures under Rainfall Uncertainty

Wei Lu and Christine Shoemaker
National University of Singapore, Singapore

The increasing climatic extremes and urbanization have led to escalated frequency of extreme rainfall events and also higher risk of urban floods. Water Retention Measures (WRMs) are proposed as one of the countermeasures for controlling urban flood risks. WRMs involve a series of decentralized stormwater management facilities, such as bio-retention cell (BC) and green roof (GR). Simulation-optimization approaches are developed by combing hydrological models and optimization algorithms for identifying cost-effective layouts of WRMs. Traditional evolutionary algorithms (e.g. genetic algorithm, GA) are generally time-consuming for computationally expensive simulation-optimization problems and are difficult to reach the global optimum in high-dimensional decision spaces. On the other hand, rainfall plays a key role among various climate inputs in driving hydrological models, and uncertainties associated with rainfall characteristics (e.g. rainfall depth and temporal pattern) would have a great impact on the reliability of the simulation-optimization results.

Through a case study, we propose a robust surrogate-based simulation-optimization scheme for designing the layout of two types of WRMs (i.e. GR and BC) under rainfall uncertainties. Those WRMs are embedded in a hydrological model (i.e. Storm water management model, SWMM). The objective is to maximize the reduction of flood damage costs with a limited budget for WRMs. Design rainfalls are developed on the basis of local IDF curve and 30-year length of daily rainfall records, with various depths and patterns considered for driving the SWMM model, which make each WRM simulation expensive (i.e. around 4 mins). For solving this expensive global optimization problem, we adopted an improved surrogate global optimization algorithm namely DYnamic COordinate search using Response Surface models (DYCORS), where the surrogate is designed to reduce the number of expensive function evaluations. With the budget for WRM simulations (i.e. function evaluations) capped at 500, DYCORS manages to find a good optimal solution in 32 hours of CPU run time. It was shown that when uncertainty inputs (like rainfall) increase the complexity and computational cost of the hydrological simulation-optimization problem, the proposed scheme becomes a promising way to support urban water managers for a more science-based WRM design towards flood risk mitigation.