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Designing robust stormwater drainage systems with data-driven emulators

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Abstract: Population growth, urbanization, and climate-driven changes in rainfall patterns expose cities to increasing flood risks. Stormwater drainage systems are essential to limit such risks during extreme rainfall events. Their design generally relies on simulation-based optimization, where hydrological-hydraulic models are coupled with evolutionary algorithms or other metaheuristics. However, such an approach has high computational requirements owing to the complexity of the simulation models and the large number of iterations required by the evolutionary algorithms. This prevents its application to a large number of rainfall events. Hence, drainage systems are usually optimized with respect to a design storm and may not be robust with respect to different rainfall events. To overcome this issue, we adopt a data-driven emulation approach. First, we generate multiple rainfall events with a copula-based stochastic model, and then select representative rainfall events using clustering. Next, we identify a data-driven dynamic emulator (based on Gaussian Processes) that replaces the high-fidelity hydrological-hydraulic simulation model in the optimization process. The emulator predicts the performance of solutions under the representative rainfall events, gaining speed albeit losing some unneeded accuracy. The framework is applied to a case study in the Nhieu Loc-Thi Nghe watershed, a 33-km\textsuperscript{2} area located in the central part of Ho Chi Minh City (Vietnam). We demonstrate that this framework finds robust design alternatives with limited computational requirements.

Keywords: Urban drainage; data-driven emulators; extreme rainfall; optimization; robustness