Demo Abstract: A Benchmarking Framework for Control and Optimization of Smart Stormwater Networks

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ABSTRACT

As storm events in cities are becoming more regular and more intense, urban watersheds and their stormwater networks are becoming stressed beyond their design capacities leading to more frequent and destructive urban flooding events. However, traditional engineering interventions to improve upon these systems are unfavorable as they entail large-scale and cost-prohibitive infrastructure construction, and are a static solution to a dynamic and evolving problem.

Recent accessibility of low-cost sensors, microcontrollers, and wireless communication technology has made it possible for the existing stormwater networks to be retrofitted with an assortment of cyber-physical technologies that allow for inexpensive, versatile, minimally-invasive, and fully-automated stormwater control interventions (e.g. hydraulic valve operated by cellularly-connected actuator) [4] [9] [12]. To give an example demonstrating the impact of this automation, one sub-system of a stormwater network that was retrofitted with sensor-actuators demonstrated a performance enhancement of 80% when compared with traditional passive systems [5], with other studies demonstrating similar enhancements [3][1][10][6][7][8].

With the demonstrated success of automating individual components of a stormwater network, there now exists the possibility for these individual components to be strategically coordinated and operated to achieve system-level automated control [2] [11] [10], potentially leading to dramatic changes in how entire urban watersheds are able to dynamically respond to storm events. However, given the emerging nature of the smart stormwater networks field, there currently does not exist a framework to (i) objectively compare the performance of the control algorithms behind these smart stormwater interventions, and (ii) assess the generalizability of the control algorithms across a diverse set of stormwater networks and weather events.

We have developed a benchmarking framework which provides a means to systematically and objectively compare performance of control algorithms for a variety of stormwater networks. This framework includes the following:

(1) A collection of anonymized stormwater networks (based on actual networks) used as case studies for control algorithms to be directly compared,
(2) Corresponding storm inputs to these stormwater networks to evaluate the performance of control algorithms across diverse types of storm events,
(3) A set of scoring metrics for analyzing the performance of network control and optimization interventions.

This benchmarking framework is an effort to make smart stormwater network control problems accessible to control experts outside of the field of water resources engineering. Creating this framework will facilitate future research to focus on the development and implementation of control algorithms, minimizing the prior need to first master stormwater simulation. The framework will be hosted online such that the testing and comparison of new control algorithms can occur effortlessly. Eventually, “competitions” will be coordinated to encourage solutions to novel smart stormwater problems.

This demo will present an overview of the computational benchmarking toolbox, implemented in Python, for smart stormwater networks. Example simulations of the stormwater networks will be carried out, demonstrating how new control algorithms can be developed and applied to the corresponding benchmarking problems. Additionally, it will be demonstrated how to submit the performance results of new algorithms to compare with previously submitted solutions. Prior experience in computational modeling of stormwater systems will not be necessary. Instead, to bridge knowledge gaps, we will lead a discussion on the complex nuances of stormwater systems (e.g. stochastic nature of precipitation events and system response; diversity of stakeholder participation and system-level goals) that influence the appropriateness of specific control strategies applied.

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Additionally, this demo will present a wireless hardware platform that allows for cost effective measurements and real-time control of stormwater systems. This hardware serves as a foundation for the assortment of cyber-physical technologies (e.g. wireless sensor nodes) that have been developed and deployed by the Real-time Water Systems Laboratory at the University of Michigan.

Our goal is to use this demo to build collaboration with the Cyber-Physical Systems community, a community who may be unfamiliar with the field of stormwater and urban watershed systems, but whose expertise in controls and optimization may contribute positively to continuing the advancement of smart stormwater networks.

CCS CONCEPTS

• **Applied computing → Environmental sciences**.

KEYWORDS

smart cities, real-time control, water infrastructure

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