Control and Testing on a Smart Water Infrastructures Laboratory

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Over the past few decades, Water Resource Management (WRM) has become an extremely complex problem due to rapid urbanization, the new threats of climate change and the increasing water demand from industry. The concept of Smart Water Infrastructure Management (SWIM) considers water infrastructures where operational management is necessary and can be improved, supported or even replaced with using high-level control techniques. However, real-time field testing of newly-developed monitoring, control and fault detection techniques are typically very restrictive in WRM applications due to the high safety requirements. For that reason, a laboratory environment where methods are tested on real water and real flow can significantly improve the support of decision making and enable the methods to be deployed on the real systems. The Smart Water Infrastructures Laboratory (SWIL) at Aalborg University is a modular test facility that can be configured to emulate Water Distribution Networks, Wastewater Collection and District Heating Systems. The modularity of the laboratory allows performing experiments with different network topologies, multiple hydrological scenarios and to emulate leakages and overflows, which in a real-case scenario would possibly harm the infrastructure and would cause discomfort to end-users. The laboratory focuses on how control technology can provide new solutions to problems in the water cycle management. The current research areas include: Leakage detection and isolation, safe-learning for network management and overflow prevention in open-channel sewer applications. For water distribution networks, a leakage detection and isolation algorithm is developed which utilizes a self-adaptive reduced order network model to predict nominal pressure in the network. These predicted pressures are used to generate pressure residuals, which are further compared to expected residual signatures to isolate a leakage. Moreover, machine learning methods like Reinforcement Learning can provide an optimal-adaptive policy to network operators when an extensive network information is not available. This technique can reduce the commissioning and calibration cost with respect to classic control methods. However, the learning of these controllers threatens the robust operation. In Wastewater applications, self-calibrating and data-driven identification methods are tested by utilizing height sensor data along gravity-driven sewer pipes, and control models are developed for keeping track of the backwater phenomena. Currently, there is research focusing on using these data-driven modelling techniques in stochastic predictive control for overflow prevention. The SWIL is a realistic environment to train and validate data-driven algorithms in a safe manner.

Figure 1- Smart Water Infrastructures Laboratory at Aalborg University.