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Realistic Fault Simulation Platform for Testing Monitoring Strategies in Wastewater Treatment Plants

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Instrumentation, control and automation for industrial chemical and biochemical processes to attain cost-effective and safe process operation are highly dependent on reliability of the real-time measurements. Despite considerable development of online sensors during the past decades, their dependability is still impaired due to various fouling and failing issues. Occasionally unsatisfactory measurement performance can prevent full instrumentation of plant-wide control systems. This is especially important for wastewater treatment plants (WWTPs) where often fault-tolerant control systems needs to be implemented. Small WWTPs generate up to 500 signals (including on-line and off-line signals), whereas larger ones typically register over 30,000. Despite a large number of available signals, data reconciliation and validation for online instrumentation has remained a largely unexplored field with a lack of standardized approaches. Most data are stored unstructured, with lots of gaps, repetition, ambiguity and uncertainty. This has led to "data-rich, information-poor"situations in which data sets are often too large and complex for processing and analysis to be used for decision-making. To turn raw data into useful and actionable information, data need to be validated. This can be achieved through a fault detection procedure.

The aim of this study is to extend an existing benchmark simulation tool for wastewater treatment processes by including "realistically"different sensor/actuator and process faults which are compatible and unified with the previous developments (influent generator, process models, sensor and actuator models, simulation procedure, evaluation criteria). Different sensor/actuator and process faults were modelled using a Markov-chain approach, given the probability of fault occurrence and probability of transitions from one state to another. The output includes different scenarios which is suitable to test univariate/multivariate statistical monitoring methods as well as fault-tolerant control strategies. Using this platform, one can test the performance of a fault detection method. The method should ideally distinguish between various faults, isolate highly consequential deviating. To demonstrate this in an example, an adaptive-dynamic fault detection was tested using dynamic principal component analysis (dPCA) with a moving window. The model and the database are both freely available online, and we are extending an invitation to people to test their fault detection methods on our provided dataset, which also includes labels.

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