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Enhancing technology transfer by combining data-driven and model-based leakage detection in drinking water distribution networks

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With 120 Mio. m^3 per year of lost water globally, leakages in drinking water distribution networks (WDN) still pose a major challenge to water utilities, furthermore, resulting in a multitude of cascading effects such as operational disruptions, environmental hazard, property damage, and sanitary issues. In the last decades there has been a growing focus on leakage detection within the scientific community leading to the development of numerous computer-based solutions for leakage detection. Despite these developments, practical approaches employed by water utilities in their leak management routines still primarily rely on in-situ acoustic devices in combination with periodic water audits, altogether falling short of ensuring continuous system monitoring and leaving much further potential for leakage reduction. Conclusively, further dissemination and widespread implementation of automatic leakage detection technology in the near future will be paramount to contain water losses and foster robust and climate-resilient water supply systems.

Currently available computer-based technologies for leakage detection can be categorized either as data-driven or model-based, primarily depending on their requirement of a hydraulic model. Algorithms for leakage detection based on hydraulic models may accurately detect the occurrence and location of leakages, yet they are highly sensitive to model inputs and, thus, are required to be well calibrated. On the other hand, data-driven models operating on the premise of anomaly detection merely require data without any anomaly, i.e., leakage, for their calibration. However, these data-driven models cannot compete with the localisation accuracy of model-based leakage detection, as they do not incorporate geophysical information about the underlying WDN. Altogether, while yielding great improvement over in-situ technology, the requirements of automatic leakage detection technology still hamper its practical implementation. While both model-based and data-driven approaches have different requirements, their combination may ultimately enable mitigation of high technical requirements and, thus, enhance its practical applicability, thereby potentially facilitating a more efficacious, robust, and widespread implementation of leakage detection technology in water distribution networks.

In this work, we explore the trade-off between model-based and data-driven leakage detection on the basis of two award-winning state-of-the-art leakage detection algorithms developed by our consortium in previous research, i.e., the data-driven LILA and the model-based Dual

Model. Through the integration of both algorithms into a unified application, we aim to mitigate technical barriers and bolster detection robustness. To validate our approach, we quantitatively evaluate its performance regarding false alarms, time-to-detection, and localisation accuracy against the individual algorithms while considering different levels of confidence and availability regarding the input data, i.e., hydraulic model, water demand estimation, and pressure data.