Technical Report

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Leak Localization in Water Distribution Networks using Pressure and a Data-Driven Classifier Approach

IRI Technical Report

Benjamí Parellada Calderer
Congcong Sun
Vicenç Puig Cayuela
Gabriela Cembrano Gennari

Institut de Robòtica i Informàtica Industrial

Abstract

The following document is proposing a new data-driven method based on limit pressure measurements to deal with leak localization problem in WDNs, or in partitioned zones called District Metered Areas (DMAs).

Institut de Robòtica i Informàtica Industrial (IRI)
Consejo Superior de Investigaciones Científicas (CSIC)
Universitat Politècnica de Catalunya (UPC)
Llorens i Artigas 4-6, 08028, Barcelona, Spain
Tel (fax): +34 93 401 5750 (5751)
http://www.iri.upc.edu

Corresponding author:
Congcong Sun
tel: +34 93 401 5786
csun@iri.upc.edu
http://www.iri.upc.edu/people/csun

Índex

1 Problem presentation

Water scarcity, leak detection and network efficiency are the main factors driving implementation of smart water solutions across the globe. Particularly water leaks inside a Water Distribution Network (WDN) which cause a loss in a very valuable resource. In many WDNs, losses due to leaks are estimated to account up to 27% of the extracted water [5], which is an important amount in a world struggling to supply water for a growing population. So that, finding techniques to minimize the loss of water is important.

Several works relate to leak detection and localization for WDN [6][2]. The main approach relies on estimating the hydraulic network model. However, the parameter estimation is not an easy task [3] as the non-linear nature of network model and the few available measurements. More recently, in [1], a mixed hydraulic and data-based model relies on pressure measurements and leak sensitivity analysis is proposed. This methodology consists in analyzing the difference between measurements and their estimation using hydraulic network model, these residuals are compared against the leak sensitivity matrix to discover possible leaks. This idea was worked upon in [4] where hydraulic model was replaced by a data-driven approach using Kriging spatial interpolation to predict pressure at points with no information.

However, the approach at [4] which supposed the maximum value of the residual is the most probable leak location is not always correct, rendering the calculation of reference model redundant. As WDN is graph structure, for a leak located at nodes closer to the inlet or have many consecutive nodes, the effect will be cascaded throughout the descendants of the leak node causing higher differences in pressure. In order to accurate the results and avoid computing a reference model, this report proposes a new data-driven method based on limit pressure measurements to deal with leak localization problem in WDNs, or in partitioned zones called District Metered Areas (DMAs).

Assuming the leak detection task is already done, the key ideas are: 1) Use historical data of the measured pressure at internal nodes, the pressure and flow at the inlets, as well as the true leak location to build a classifier; 2) Use Kriging spatial interpolation to estimate the pressure at the nodes that are not equipped with sensors based on hydraulic proximity; 3) Use Linear Discriminant Analysis (LDA) as the classifier to compute probabilities of each node being the leak location based on only the raw pressure without estimating a hydraulic model nor a reference; 4) Use the fitting accuracy and the Average Topological Distance (ATD) as performance indicators, where ATD is the average value of the minimum distance in nodes between node with the leak and candidate node proposed by the leak localization method.

2 Case Study

The Hanoi WDN is used as case study. Possibility of a leak appearing in any of the nodes is considered. Assume different number of sensors are placed according to Table 1. Demand at each node is assumed to be uncertain with unknown instantaneous values inside known limits. Real measurement data are read from the EPANET simulations.

Taula 1: Applications and results with different sensor placements

Nodes with sensor	Accuracy(%)	ATD
12, 21, 27	62.67	0.67
12, 16, 21, 27	85.83	0.31
12, 21, 27, 24	50.92	1.02
12, 14, 21, 27	53.57	0.85
12, 16, 27, 21, 29	54.03	0.91

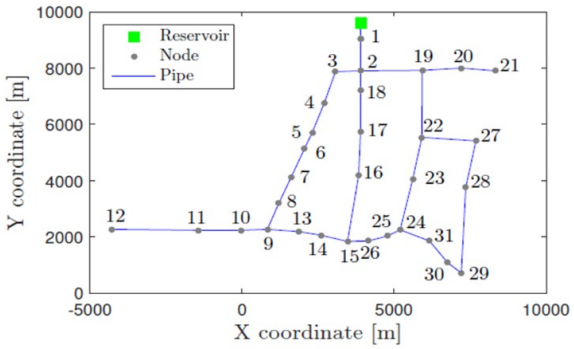

Figura 1: Hanoi WDN

Table 1 proves that: 1) Data-driven classifier based on pressure has more than 50% accuracy with less than 2 nodes of ATD; 2) Number of sensors and their placements affect the performance. More DMAs with different classifiers will be tested in future.

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