Ph.D. in Information Technology
Thesis Defense

September 9th, 2026
At 10:30 a.m.
Room Alessandra Alario - Building 21

Elvio DAMONTI – 39th Cycle

NEW APPROACHES TO DETECT AND LOCATE LEAKS IN WATER DISTRIBUTION NETWORKS
Supervisor: Prof. Giancarlo Bernasconi

Abstract:

This thesis addresses the problem of leak detection in water distribution networks, a problem that, especially in recent years, has become increasingly relevant. As matter of fact, in recent years, global warming phenomena have exacerbated the issues related to the availability of drinking water. Its increased demand is not fully met in many areas, also due to the aging and deterioration of Water Distribution Networks (WDNs) and to the consequent leaks. All these factors have led to intensified research aimed at reducing leaks in WDNs, which in Italy average 40% of the nominal flow of corresponding WDN, but which are present to varying degrees also in other countries.
We have attempted to address the problem of leak detection and localization by adopting various approaches. Specifically, we initially focused on developing a new method based on the analysis of pressure transients in Water Distribution Networks (WDNs), and subsequently we shifted our attention to methods based on the steady-state analysis of pressure in WDNs.
Regarding the first approach, we used a commercial software simulator, and, regarding the second approach, we developed instead our in-house own software simulator of WDNs, using Python and some publicly available software libraries.
With regard to leak detection and localization methods based on steady-state pressure analysis in WDNs, we first designed an algorithm based on Multi-Layer Perceptron (MLP) neural networks. In the configuration we tested, MLPs are very fast, but regretfully they lack of any temporal memory.
We then moved on to methods based on Convolutional Neural Networks (CNNs), configured to retain a historical memory of the input data, thus enabling them to exploit the statistical information contained in the steady-state pressure time series measured within the WDNs.
Ideally, in the context of steady-state analysis, one would need a steady-state pressure sensor at each junction of the WDN, however, since these junctions can number in the thousands, such an approach is clearly economically unfeasible. Therefore, we developed a method to optimize the placement of the available pressure sensors, whose number is limited, in order to preserve the capability to detect and localize leaks, even when the number of sensors is significantly lower than the total number of junctions in the WDN.

Finally, to analyse the water demand patterns at the junctions of the WDN, given the known steady-state pressure time series, we have developed a method based on MLP neural networks to estimate these demands from the steady-pressure data.

PhD Committee

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