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NETWORK ANALYSIS FOR RESILIENCE EVALUATION IN WATER DISTRIBUTION NETWORKS

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Abstract

Resilience is meant in this paper as the capability of a networked infrastructure to provide its service even if some components are failed: it depends both on net-wide measures of connectivity and the role of a single component. This paper has two objectives: first to show how a set of global measures can be obtained using techniques from network theory, in particular how the spectral analysis of the adjacency and Laplacian matrices allows us to obtain a characterization of global connectivity which is both mathematically sound and operational. Second, how a clustering method in the subspace spanned by the *l* smallest eigen-vectors of the Laplacian matrix allows us to identify the edges of the network whose failure break down the network (vulnerabilities). Even if most of the analysis can be applied to a generic networked infrastructure, specific references will be made to Water Distribution Networks (WDN). The operational value of the proposed method is demonstrated on both a benchmark and three real-world cases. However, this paper represents just a first step in the development of tools for supporting the analysis of resilience at global and local level, based upon an abstract graph setting. In particular, the current state of the work is aimed at define graph-based measures associated to network wide resilience and methods to detect vulnerabilities with respect to the connectivity of the physical infrastructures. Ongoing work is considering to combine the proposed framework with hydraulic simulation in order to: *a)* evaluate how much the supply service will be affected by a failure – in particular a fault of the vulnerable elements identified through the proposed framework – and *b)* estimate the hydraulic stress/strain on the pipes to rank it through a combination of its relevance for the connectivity and probability of breakages/leakages due to the current supply behaviour.

Key words: network analysis, resilience, vulnerability, water distribution network

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