UNIVERSITY OF EXETER
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COLLEGE OF ENGINEERING, MATHEMATICS AND PHYSICAL SCIENCES

Near Real-Time Detection and Approximate Location of Pipe Bursts and Other Events in Water Distribution Systems

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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ABSTRACT

The research work presented in this thesis describes the development and testing of a new data analysis methodology for the automated near real-time detection and approximate location of pipe bursts and other events which induce similar abnormal pressure/flow variations (e.g., unauthorised consumptions, equipment failures, etc.) in Water Distribution Systems (WDSs). This methodology makes synergistic use of several self-learning Artificial Intelligence (AI) and statistical/geostatistical techniques for the analysis of the stream of data (i.e., signals) collected and communicated on-line by the hydraulic sensors deployed in a WDS. These techniques include: (i) wavelets for the de-noising of the recorded pressure/flow signals, (ii) Artificial Neural Networks (ANNs) for the short-term forecasting of future pressure/flow signal values, (iii) Evolutionary Algorithms (EAs) for the selection of optimal ANN input structure and parameters sets, (iv) Statistical Process Control (SPC) techniques for the short and long term analysis of the burst/other event-induced pressure/flow variations, (v) Bayesian Inference Systems (BISs) for inferring the probability of a burst/other event occurrence and raising the detection alarms, and (vi) geostatistical techniques for determining the approximate location of a detected burst/other event.

The results of applying the new methodology to the pressure/flow data from several District Metered Areas (DMAs) in the United Kingdom (UK) with real-life bursts/other events and simulated (i.e., engineered) burst events are also reported in this thesis. The results obtained illustrate that the developed methodology allowed detecting the aforementioned events in a fast and reliable manner and also successfully determining their approximate location within a DMA. The results obtained additionally show the potential of the methodology presented here to yield substantial improvements to the state-of-the-art in near real-time WDS incident management by enabling the water companies to save water, energy, money, achieve higher levels of operational efficiency and improve their customer service.

The new data analysis methodology developed and tested as part of the research work presented in this thesis has been patented (International Application Number: PCT/GB2010/000961).

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