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Cloud based machine learning approaches for leakage assessment and management in smart water networks

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Abstract

One-third of utilities around the globe report a loss of more than 40 percent of clean water due to leaks. By reducing the amount of water leaked, smart water networks can help reduce the money wasted on producing or purchasing water, and the related energy required to pump water and treat water for distribution. A UK demo site is presented focusing on leak management, integrating fixed flow and pressure instrumentation, advanced (smart) metering infrastructure and novel instruments (capable of high resolution monitoring). Example data analysis results for this site using the AURA-Alert anomaly detection system for Condition Monitoring are presented.

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Keywords: Leakage; Smart Networks; AMR; Neural Networks; Cloud computing.

1. Introduction

European water utilities face many problems related to their 3.5 million km's of distribution networks. Large parts of water distribution networks have to be rehabilitated requiring investments of € 20 billion/year. Prioritization and optimisation of investments is needed urgently. The European Innovation Partnership on Water

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has established priority areas related to the challenges in water supply distribution networks, focusing on resource efficiency, Smart Water Management and decision support systems. It is estimated that implementing Smart Water solutions could save water utilities and their customers up to $12.5 billion a year (Sensus, 2013). Smart Cities need to bring together hard infrastructure, social capital including local and community institutions, and technologies to fuel sustainable economic development and provide an attractive environment for all. The concept of a Smart City within the context of water means using technologies for optimising water resources and waste treatment, monitoring and controlling water, and providing real-time information to help water companies and households manage their water better. Although the technology components for Smart Water Cities are available, the route to application is uncertain. The main hurdles are: lack of integrated and open solutions; difficulty to comply with user and integration requirements; lack of clear and validated business cases for solutions; lack of business intelligence awareness and lack of political and regulatory support.

The quantity and complexity of sensor and environmental data is growing at an increasing rate whilst the demands for new solutions and tools to utilize and interpret this data are likewise growing due to financial and regulatory pressures. The phrase 'Big Data' may then become a reality for the water sector particularly on the customer side, since when smart metering becomes more prevalent a huge amount of data will be collected. If the UK goes to a point where the entire water industry is universally metered with Smart Metering there will be approximately 25 million water meters for customers. Organising, managing and supporting such massive ICT network infrastructure, however, is a substantial technical challenge. This data could be used, in conjunction with mapping software and hydraulic models to map consumption in DMAs where there are spikes in usage.

As demand for clean water increases with population growth in the coming decades and supply remains stagnant or shrinks due to climate change, solutions to manage and minimise leaks will become increasingly critical. Many water utilities are struggling to measure and locate leaks in their distribution networks beyond the Economic Level of Leakage, and there is a drive to efficiency by implementing leak reducing solutions. Leakage results in wasted energy costs (such as spent pumping water), water treatment costs (energy and chemicals), misdirected repair activities, regulatory penalization and environmental damage to city infrastructure. Smart water networks offer the potential to identify leaks early thus reducing the amount of water that is wasted and saving utilities money. These solutions include the use of flow and pressure sensors to gather data, analyse the data using algorithms to detect patterns that could reveal a leak in the network, and provide real-time data on the location of a leak. Mounce et al. (2014) review approaches for event detection in WDS measured time series data, with a focus on data driven methodologies for leak detection.

SmartWater4Europe (SW4E) is a four-year FP7 demonstration project (2014-17) funded by the European Commission (Demonstration of integrated smart water supply solutions at four sites across Europe, grant 619024). SmartWater4Europe consists of 21 participants including three water utilities, SMEs, research organisations and platform organization. The four demo sites (of varying in scale and located in the United Kingdom, Spain, The Netherlands and France) will allow demonstration of solutions incorporating sensors, data processing, modelling and ICT technologies.

The UK demo site (a large town on the outskirts of London) is focusing on leak management (as well as exploring energy optimisation and customer interaction): in particular the use of advanced metering infrastructure (AMI) smart metering. The demonstration sites objectives are to identify the pathways to transform network and customer property instrumentation to maximise the sustainable use of existing infrastructure, maximise network performance and improve water resource and energy efficiency. The demonstration site will investigate how new and emerging technologies can be used to create a 'smart network' with real time notification of performance and even asset condition to enable proactive management and intervention and a step change in social awareness of water used and infrastructure. This is no easy task and necessitates interdisciplinary working between researchers using techniques such as wireless distributed sensors, Grid and Cloud computing, hydro-informatics, data mining and machine learning and for understanding the implications of these in a social context in terms of privacy, trust, acceptability and utilisation. The IT aspects of integrating Grid and Cloud computing, hydro-informatics and machine learning for this case study are particularly explored in this paper.

The pervasive instrumentation and data mining that will be demonstrated in this project may well allow a move away from current DMA structure, with closed boundary valves, leading to more adaptive and resilient networks,