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A Shazam-like household water leakage detection method

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Abstract

Watnomics is a European Union-funded research project aspiring to develop and introduce Information and Communication Technology (ICT) as an enabling technology to manage water as a resource, increase end-user conservation awareness, affect behavioural changes and avoid water losses through leak detection. Existing leakage detection methods are generally focused on scrutinising large diameter pipes in water supply distribution networks or transmission pipes. However, it has been estimated that the average household's leaks can be as much as 35m³ of water per year. In order to solve the problem, analysis of different types of data in the household piping system is required, including detection and identification. One conventional approach is to use flow sensors installed at several locations within the household piping system and perform a mass balance approach to detect leakage. However, this method is expensive and difficult to implement.

This research proposes a novel approach to household leakage detection by means of sound signal recordings. The approach consists of recording the sound signals that are produced by water fixtures and appliances, and then use these recordings to detect any abnormal situation which may be an indication of a leak. The method comprises three major steps: recording, storing and processing of sound signals. The recording step is done by means of a non-intrusive sound sensor that sends records remotely; the storage step is made in a database of sound signals for different types of uses; finally, the processing step is made through a sound signal identification software tool that is able to search the database libraries for related sounds, in a similar way as the Shazam app for music. Tests of the leak detection method are presented for data collected in laboratory conditions. Results show that this detection method has a potential to help reducing leakages through an easy-to-install and non-intrusive sensor.

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1. Introduction

Although household water consumption can increase substantially due to leakage, small and medium sized leaks in household plumbing are generally ignored. The leaks may be undetected below ground, through dripping taps and toilet cisterns. When considered individually, leaks may seem insignificant; however, taken collectively over a long period they result in a major loss of water. [1] reported that the rate of water loss could vary depending on the type and severity of the leak. Generally, dripping taps can lose between 3-30 litres per day, leakage from toilet cisterns can range from 10 litres per day for invisible leaks to 340 litres per day or more for leaks large enough to be seen and/or have an audible refilling sound. Mayer, et al. [2] found out in their Residential End Uses of Water Study that leak constitute 13.7% of the indoor per capita consumption of a single residential house in North America. Therefore, identifying internal leak enable customers to fix the problem, saving water and money.

Detecting and identifying leakage in the household levels requires the analysis of different type of censored data in the household piping system. One of the traditional approaches is to use flow sensors and perform a mass balance approach to detect leakage. Researchers in Australia use automated meter reading technology to identify household water leakage in residential properties located within a selected district metered area [1]. Another novel approach could be to use sounds recording to detect leakage. There exist several techniques for leak detection, which concentrate generally on finding leaks in main pipes. However, many leaks at the domestic level contribute significantly to unaccounted-for water in many water distribution networks. In general, these leaks are minor but numerous and they go unnoticed by conventional monitoring techniques.

Leakage Management comprises four main components [3] quantifying water loss, 2) leakage monitoring, 3) network pressure and asset management and 4) leak detection, location, and repair. While 1) and 2) are activities that aim at quantifying and measuring the amount of water that is lost in an area of the distribution network, the leak detection is an active effort to pinpointing the exact position of a leak. Due to the fact that these activities are costly, water utilities concentrate on reducing water losses by detecting and locating leaks generally in the main pipes of the distribution network. For this reason, the development of sensor devices has been concentrated almost exclusively on professional monitoring of big diameters by a range of different equipment that mainly based on acoustic principles, such as listening devices, noise loggers, and leak noise correlators [4]. Recent advances of these devices address problems such as user bias (e.g., [5, 6]), uncertainty reduction by considering multiparameter measurements such as flow, pressure, and noise [7] and even vibration [8] and active pipe inspection via wireless technologies with video cameras, microphones, acoustic sensors, and smart balls in large-diameter pipes ([9-11]).

Leak detection methods are broadly classified in terms of internal and external monitoring methods: internal methods involving intrusive measurements to monitor fluid state, and external methods applied to the environmental condition of a pipe [12]. Pipelines are designed and engineered for full load operations assuming steady state flow conditions. Operational parameters will range from maximum allowable operating pressure in exceptional circumstances to a depressurized state corresponding to a no-flow situation. Normal pipeline operations may involve day-to-day transients such as pump start/stop operations, the operation of control valving and changes in delivery rates. Internal leak detection system must therefore operate over wide range of process conditions, some of which may appear to have the characteristic of leak patterns.

We propose an innovative leak detection method for households, which comprises hardware and software advances: a new low cost acoustic sensor and a Shazam-like detection algorithm. The idea is that during the night, the sound in the pipes inside households is listened to with the new sensor, when the background noise is low and the pressure in the system is high, and then analysed with the new algorithm in order to get leakage reports. In this paper

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